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THE FEDERAL REPUBLIC OF NIGERIA

REPORT

ON

ALTERNATIVE SITES FOR THE NEW OCEAN TERMINAL IN THE EASTERN COAST

-TOPOGRAPHIC AND OCEANOGRAPHIC SURVEY-

JULY 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. OUTLINE OF THE SURVEY

1-1 Purpose of the Survey

The survey is aimed at carrying out studies referring to the topographical and oceanographical aspects among the natural conditions related to the development of The New Ocean Terminal at the 3 project sites (Ibeno, Opobo and James Town) proposed by the Nigerian Ports Authority.

1-2 Location of the Project Area

The area covered by the survey is located at the East Coast of the Federal Republic of Nigeria, and extends over the states of Rivers and Cross River.

The survey was carried out at the 3 areas proposed by the Federal Republic of Nigeria, namely, Opobo, Ibeno and James Town. The scope of survey is shown in the Figure 1-1.

1-3 Contents of the Survey

Information referring to the items and quantitative details of the survey are summarized in Table 1-1.

1-4 Period of the Survey

The period of the survey extended from February 16th 1981 through July 25th 1981. During the said period, the field survey was carried out from February 25th through May 21st. The timetable of the survey is shown in Table 1-2.

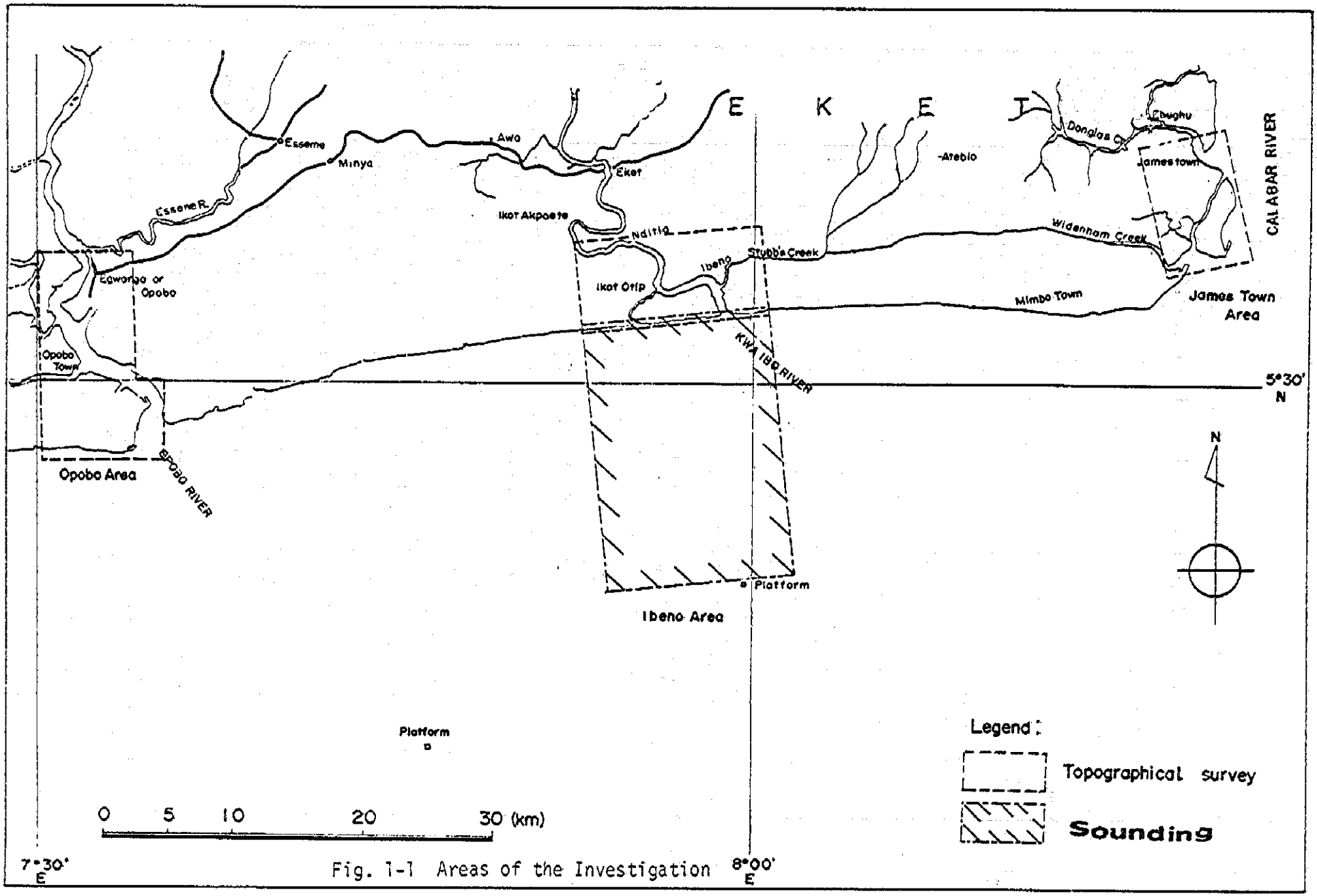


Fig. 1-1 Areas of the Investigation

Table 1-1 Survey Items and Quantitative Details per Area

Survey area	Survey items	Quantitative details	Main results
Opobo area	Purchase of the existing aerial photographs	105 km^2	Contact prints, Photo-index
	Traversing	18 points	List of co-ordinates
	Aerial triangulation and mapping	105 km^2	1/10,000 topographic map
	Tide level observation	8 days	Table of observation
	Sampling	6 points	Grain-size analysis
Ibeno area	Aerial photography	140 km^2	Contact prints, Photo-index
	Traversing	26 points	List of co-ordinates
	Aerial triangulation and mapping	105 km^2	1/10,000 topographic map
	Shoreline surveying	13 surveying lines	Topographical cross section of shoreline
	Sounding	13 surveying lines Approx. 148 km	Sea topographic map, Track chart
	Tide level observation	52 days continuous recording	Harmonic analysis for tides
	Sea condition observation	8 days	Results of meteorologic, wave and water velocity
	Sampling	9 points	Grain-size analysis
	Collection of meteorologic information	4 months	Tables and graphs containing gathered information
James Town area	Aerial photographing	100 km^2	Contact prints, Photo-index
	Traversing	27 points	List of co-ordinates
	Aerial triangulation and mapping	70 km^2	1/10,000 topographic map
	Tide level observation	7 days	Table of observation
	Sampling	7 points	Grain-size analysis

Table 1-2 Timetable of the Survey

Item \ Data	1981 2/16 – 2/25	5/21	7/25
Planning & preparation	▭		
Field investigation	▭		
Mapping	▭		
Oceanographic survey	▭		
Report preparation	▭		

1-5 Survey Equipment

The names and specifications of the main equipment used in the present survey are listed in Table 1-3.

Table 1-3 List of the Main Survey Equipment

Name of survey equipment	Quantity	Maker	Specifications	Remarks
Theodolite	2	Nikon (Japan)	5 second reading	NT-3
Level	2	Nikon (Japan)	1mm reading	NIKON-AE
Optical distance measuring instrument	1	K.E., Co. (USA)	±(10mm + 2PPM)	
Ditto	1	Yokogawa Hewlett Packard (Japan)	±5mm + D/1500m	3800B
Echo sounder	1	Rasa Electronic Industry (Japan)	Directional beam Width: Approx. 30° Range: 0∿60m	RS-61
Ditto	1	Furuno (Japan)	Range: 0∿170m (shallow range)	FE502

(Table 1-3 continued)

Tidal gauge recorder	1	Kyowa Shoko (Japan)	Reading accuracy: ±2.5cm Recording scale: 1/20	LPT-III
Current meter	1	Toho Dentan (Japan)	Measurement range: 0.05~3.0m/sec	CM-1B
Wind meter	1	Ota Keiki (Japan)		
Stereo plotter	3	Wild (Swiss)	2nd class	A8
Computer	1	Fujitsu (Japan)	2M byte	FACOM-M150F

1-6 Ships and Aircraft

The ship and the aircraft used in the present survey are listed in Table 1-4.

Table 1-4 Survey Ship and Aircraft

Type	Quantity	Specification	Remarks
Tug-boat	1	Draft 2.95m Net 113 ton	Used for sounding of offshore areas. Ship name: M.K. KHAN
Passenger boat	8	Length 10m Net Approx. 1 ton	Used for inshore sounding and traversing.
Glass-fiber boat	4	Length 3m Net Approx. 0.5 ton	Used for traversing and sounding of the inshore area.
Aircraft	1	Twin engine	Used for aerial photography (D-IDIH).

1-7 Survey Team

The members of the survey team of the present project are listed below.

Takehiko Hirano	Chief engineer	(Kokusai Kogyo Co., Ltd.)
Tomoyuki Hashimoto	Topographic and oceanographic survey	(Kokusai Kogyo Co., Ltd.)
Kenji Sakai	ditto	(ditto)
Yoshimichi Hayasaka	ditto	(ditto)
Kenji Saiki	ditto	(ditto)
Takaki Hirose	ditto	(ditto)
Hiroyuki Nagayoshi	Coordinator	(ditto)

2. METHOD OF THE SURVEY

2-1 Aerial Photography

Considering the meteorological conditions at the beginning of the rainy season, the photography plan was prepared in such a way so as to match effectively with the control point plan and the aerial triangulation plan, and the actual photography was delegated to Messrs. Survey and Mapping Geodata Ltd.

2-1-1 Flight plan

(1)	Airport	Calabar Airport, Cross River State	
(2)	Aircraft to be used	Aerocommander	
(3)	Camera to be used	Wild RC9 F = 88.50mm	
(4)	Film to be used	Kodak Double X 2405	
(5)	Scale of photography	1/10,000	
(6)	Datum of flying altitude	Sea level	
(7)	Surface to be covered	(a) Ibeno area	140 km^2
		(b) James Town area	100 km^2

2-1-2 Purchase of existing photographs

Since the Opobo area was photographed in 1977 at 1/6,000 and in 1968 at 1/40,000, the corresponding photographs were purchased from the Federal Survey Department, Lagos, Federal Republic of Nigeria.

2-2 Traversing

Since existing control stations, bench marks, etc., are not available in the project area, the coordinate system was arbitrarily chosen, and the control point survey was carried out by setting provisional origin points in the various areas and by traversing. As for the selection of the routes patterns, the open route, forked routes, circular routes, etc., were adopted, and the accuracy was confirmed by photographing on the return trip also.

The azymuth was determined by solar observation, and the elevation was determined by means of indirect levelling.

2-2-1 Accuracy and limits of the traversing

Observation method (horizontal angle)	0°, 90° (Two sets of observation)
Observation difference	40"
Double angle difference	50"
Vertical angle constant	60"
Assumed azymuth restriction	$20" + 15" \sqrt{N}$ (N: No. of observation points)
Error of closure	$10cm + 15cm \sqrt{S}$ (S: Distance to be closed in km)
Error of closure of the elevation	$10cm + 5m \sqrt{M}$ (M: No. of sides)

2-2-2 Establishment of induction points

The induction points for guiding the survey ship were established along the shoreline of the Ibeno area, and were also used as control points for mapping work, by including them in the traversing network.

2-2-3 Field investigation

Field investigation was made with reference to items difficult or impossible to identify in the photographs, aiming at assisting easy interpretation when mapping. The main items covered by the field investigation were public buildings, specific areas and facilities, roads and waterways, vegetation, arable land, farms, names of places, etc.

2-3 Aerial Triangulation

The analytical aerial triangulation was carried out by means of the block adjustment method. The pass points, sub-points and tie points were selected on the contact print and pricked on the positive film,

and were converted into the project coordinate system using the computer after the measurement of the coordinates in the photographs.

2-3-1 Accuracy and restriction of the aerial triangulation

(1) The fiducial mark measurement error at the occasion of determining the inner orientation is ±0.03mm maximum.

(2) The residual paralax error after the relative orientation is 0.03mm maximum on the positive film.

(3) The discrepancy of pass points between neighbouring models after the junction of the models is within 0.05% (50cm) of the flying altitude at the corresponding point in both plane position and height.

(4) The residual at the ground control point used for geodetic coordinate conversion is within 0.08% (80cm) of the flying altitude in both plane position and height.

(5) The discrepancy of the plane position and elevation of the tie points observed mutually in neighbouring courses is within 0.08% (80cm) of the flying altitude.

2-3-2 Main equipment

Point transfer device	Wild PUG
Co-ordinate measuring instrument	Stereo comparator
Computer	FACOM 230-45S

2-4 Mapping

2-4-1 Mapping

The ground control points (traversing points) in the mapping area, pass-points, tie-points and sub-points were plotted on the map manuscript using the coordinategraph, and the maps were drawn using stereo plotters after the absolute orientation, with special attention to accuracy.

2-4-2 Mapping accuracy

(1)	Plane position	±0.7mm on a 1/10,000 map
(2)	Height	1/2 of the contour interval
(3)	Contour lines	1m
(4)	Spot height	5cm spaces on the map

2-4-3 Main equipment

(1)	Coordinategraph	Microplotter
(2)	2nd class stereo plotter	Stereo plotter A8, Metrograph

2-5 Compilation

The overall maps of the respective surveyed areas were compiled by photographic reduction and enlargement of the newly prepared 1/10,000 topographical map, the existing 1/50,000 topographical map and marine charts.

2-6 Shore Survey

This survey was carried out in the Ibeno area. The induction points were established for guiding the survey ship at the places where the shore surveying was scheduled, connecting the traversing points established at the shore section. The cross section survey of the shoreline was carried out by means of the direct levelling method, based upon the induction points mentioned above. The survey lines were taken perpendicular to the shoreline, and in addition, coinciding with the sounding lines. The number of measured lines is 13 lines at intervals of 20m, and the heights were also measured at the points where the topography changed.

2-7 Sounding

Sounding was carried out at the Ibeno area. Water depth was measured along the lines extended from those used for the shoreline survey. As for the positioning method of the survey ship on the sea, either the intersection method using a theodolite or the one way observation method using a theodolite and a sextant was adopted at places where the

ship was visible from the ground, and the bearing navigation method using the compass of the ship when it could not be confirmed from the shore.

In the bearing navigation method the Mobil Oil petroleum platform located offshore of the survey area was used as visual mark. The position of the survey ship on the sea was measured at intervals of 2 through 5 minutes. The survey area extended over approximately 15km on the shore and approximately 20km offshore, as shown in Figure 1-1.

2-8 Tidal Observation

The tidal observation was carried out aiming at determining the datum level, at the three areas of the project, i.e., Opobo, Ibeno and James Town. In the present survey the Ibeno area was selected as reference for the 3 areas, and a continuous observation with a duration of 52 days was carried out from March 19th through May 9th, by installing an automatic tide gauge (LPT-III) at the far extremity of the Mobil Oil Pier.

Comparative observations were carried out at the Opobo area and at the James Town area by means of a pole from April 10th through April 16th in James Town and from May 1st through May 8th in Opobo area in order to compare the types of tides, and so on among the 3 areas.

2-9 Sea Condition Survey

The conditions of the seas were observed at the shoreline of the Ibeno area and on the survey ship. Observations were made on the meteorologic conditions, waves, the flow in the rivers and at the vicinity of the estuaries, etc.

2-10 Bottom Materials Sampling

The sea bottom sampling was carried out at the 3 project areas, i.e., Opobo, Ibeno and James Town. A cylinder type sampler was used for mud sampling purposes, with sampling of 200 through 300 gram of sea bottom materials at each point.

2-11 Collection of Meteorological Data

In order to grasp the meteorological conditions during the survey period, the monthly meteorological observation table for 1976 ∿ 1980 was obtained from The Department of Meteorological Services of Port Harcourt.

3. SURVEY RESULTS

3-1 Topographic Mapping

3-1-1 Aerial photography

(1) Aerial Photography

The aerial photography work started on February 27th, 1981, but photoflights were not successful till the end of March because of the unstable weather in the beginning of the rainy season. Fortunately, on March 29th, April 1st, April 2nd and April 5th, photographs were taken and the photoflights completed.

The films taken were developped and printed at the temporary laboratory of Survey and Mapping Geodata Ltd. located in Calabar. The results of the flights were confirmed to be satisfactory for the mapping work after checking for scratches on films, overlap, sidelap, tilt, tip, etc.

(2) Photographs Used for Mapping

As for the photography of the Ibeno area, the flight lines were extended from the original plan and accordingly the mapping of the whole Ibeno area using new photographs became possible. The photographs used in the present survey are listed in Table 3-1, including those obtained from the Federal Survey Department.

(3) Others

In accordance with the stipulations of the Survey Co-ordination Act, the negative films of the above-mentioned photographs were delivered to the Federal Survey Department.

Table 3-1 Photographs Used for Mapping

Area	Line No.	Photograph No. and quantity		No. of models		Scale	Year of photo-grapy	Remarks
Ibeno	1	16∿ 18 3 sheets	28∿ 49 22 sheets	23 models	25 sheets	1/10,000	1981	
	2	72∿ 86 5	94∿103 10	23	25	"	"	
	3	60∿ 51 10	73∿ 87 13	21	23	"	"	
	4	130∿127 4	37∿ 54 18	20	22	"	"	
	5	31∿ 9 23		22	23	"	"	
	Sub-total	55 sheets	63 sheets	109 models	118 sheets			
James Town	1	132∿142 11 sheets		10 models	11 sheets	1/10,000	1981	
	2	126∿117 10		9	10	"	"	
	3	108∿114 7	98∿ 94 5 sheets	10	12	"	"	
	4	81∿ 90 10		9	10	"	"	
	5	75∿ 65 11		10	11	"	"	
	6	50∿ 61 12		11	12	"	"	
	7	35∿ 31 5		4	5	"	"	
	Sub-total	66 sheets	5 sheets	63 models	71 sheets			
Opobo	5	91∿110 20 sheets		19 models	20 sheets	1/6,000	1977	
	6	240∿221 20		19	20	"	"	
	7	173∿191 19		18	19	"	"	
	8	164∿145 20		19	20	"	"	
	9	96∿114 19		18	19	"	"	
	10	89∿ 70 20		19	20	"	"	
	11	288∿271 18		17	18	"	"	
	12	222∿239 18		17	18	"	"	
	13	206∿188 19		18	19	"	"	
	14	135∿153 19		18	19	"	"	
	15	128∿110 19		18	19	"	"	
	16	57∿ 75 19		18	19	"	"	
	L·2	95∿ 93 3		2	3	1/40,000	1968	
	Sub-total	233 sheets		220 models	233 sheets			
Total		354 sheets	68 sheets	392 models	422 sheets			

3-1-2 Traversing and induction points

The 3 areas covered by the survey face the Atlantic Ocean, are composed mostly of swamp area inundated due to the action of the tides, and include rivers and estuaries. All 3 areas present a flat topography and are covered by dense forests of mangrove and nipa palm, hence do not provide any points with good visibility which enables traversing and triangulation, and have very few roads. Accordingly, control points were set up by traversing along the rivers, and exceptionally, along the existing roads.

Traversing was carried out in accordance with the routes shown in Figure 3-1, Figure 3-2 and Figure 3-3, while the induction points were established in accordance with Figure 3-4.

The volume of work of the surveyed areas are shown in Table 3-2, while the traversing results are summarized in Table 3-3, Ibeno area; Table 3-4, James Town area; and Table 3-5, Opobo area.

Table 3-2 Traversing Work Volumes in the Respective Surveyed Areas

Item \ Area	IBENO	JAMES TOWN	OPOBO
Traverse stations	26 points	27 points	18 points
Number of pin-pricked points	15 points	12 points	9 points
Route length	Approx. 32 km	Approx. 24 km	Approx. 32 km
Solar observation points	2 points	2 points	2 points
Induction point for sounding	13 points	-	-
Positioning of the boring points	2 points	2 points	2 points

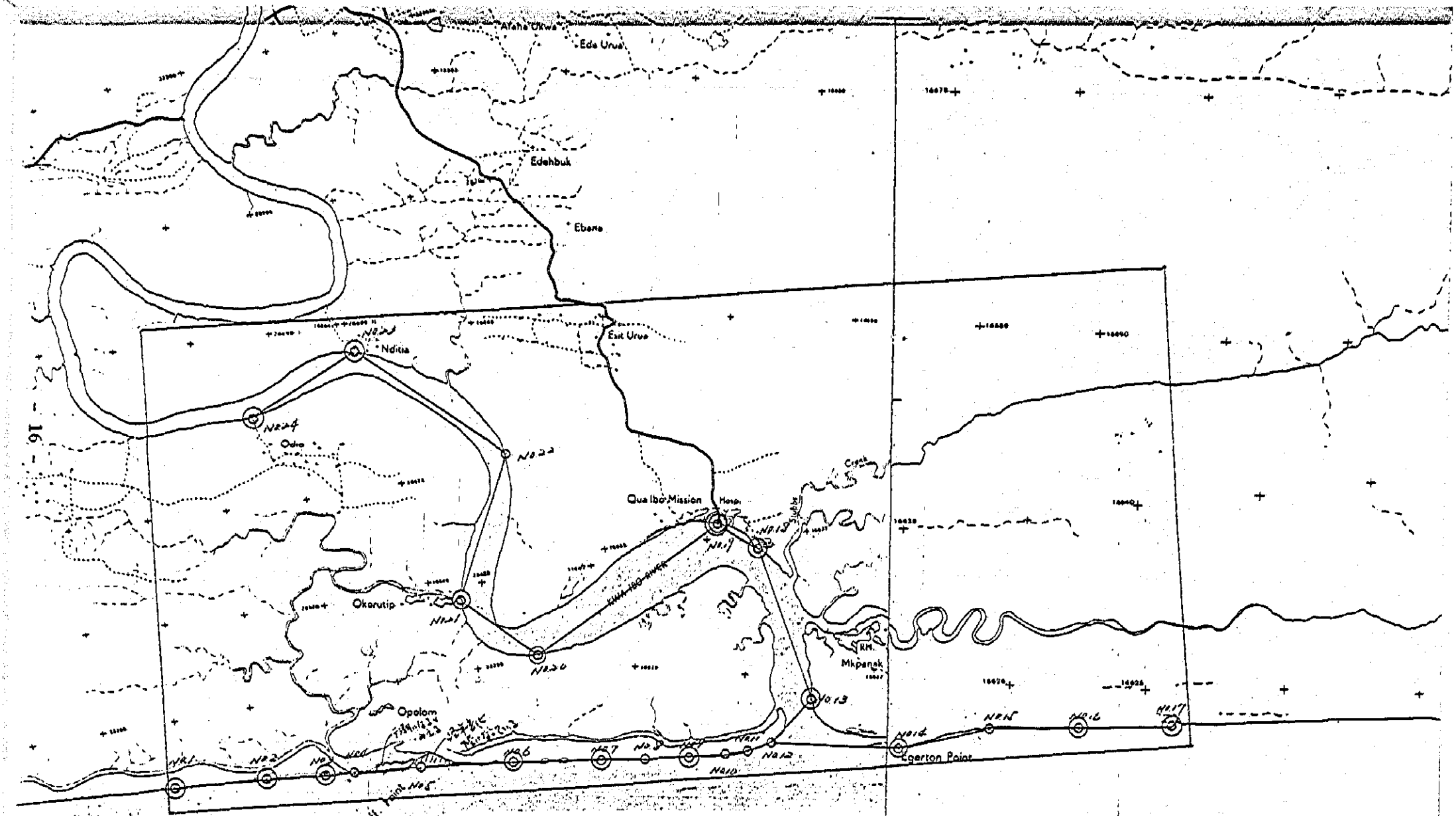


Fig. 3-1 Control Point Ibeno

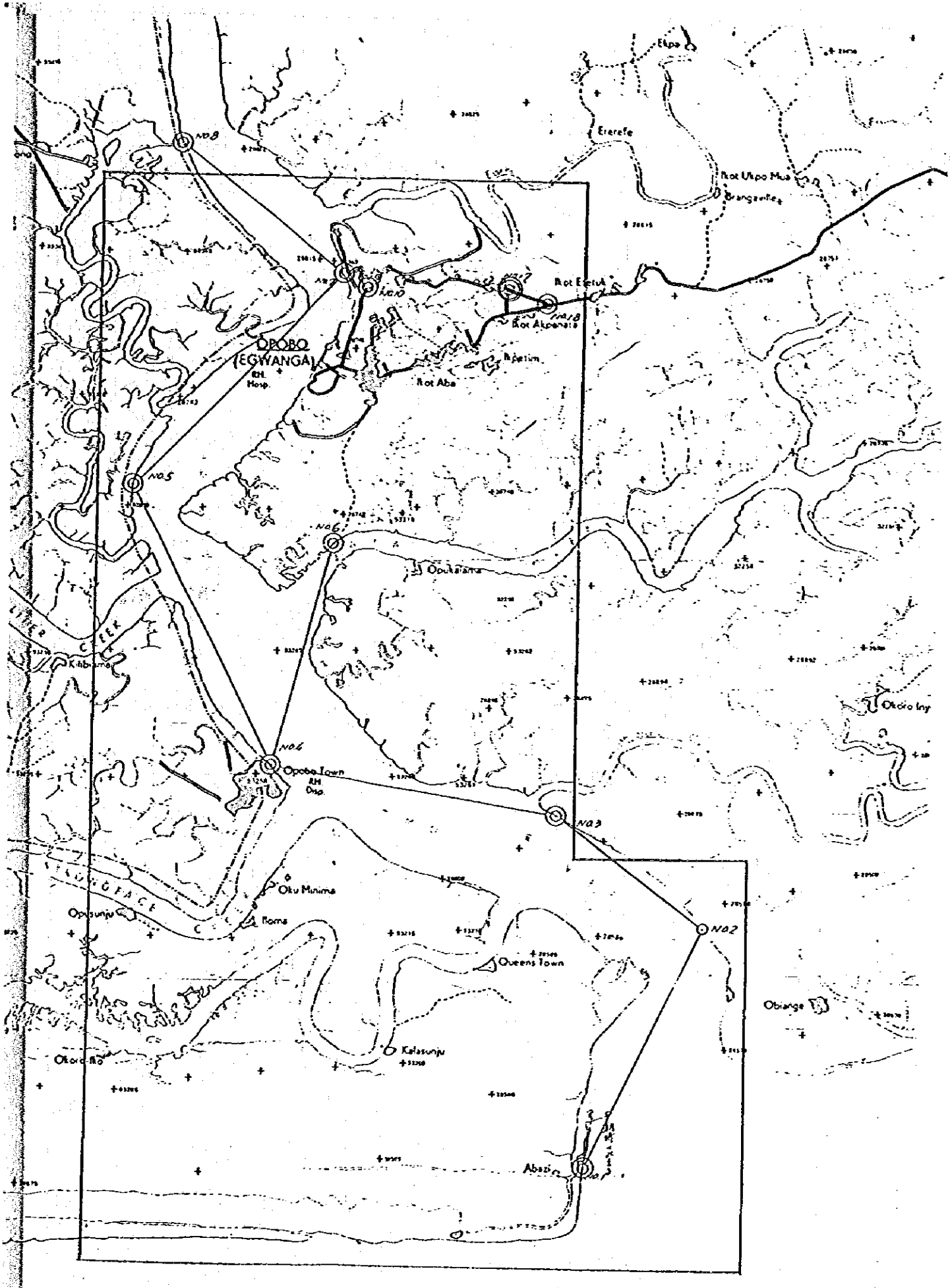


Fig. 3-2 Control Point Opobo

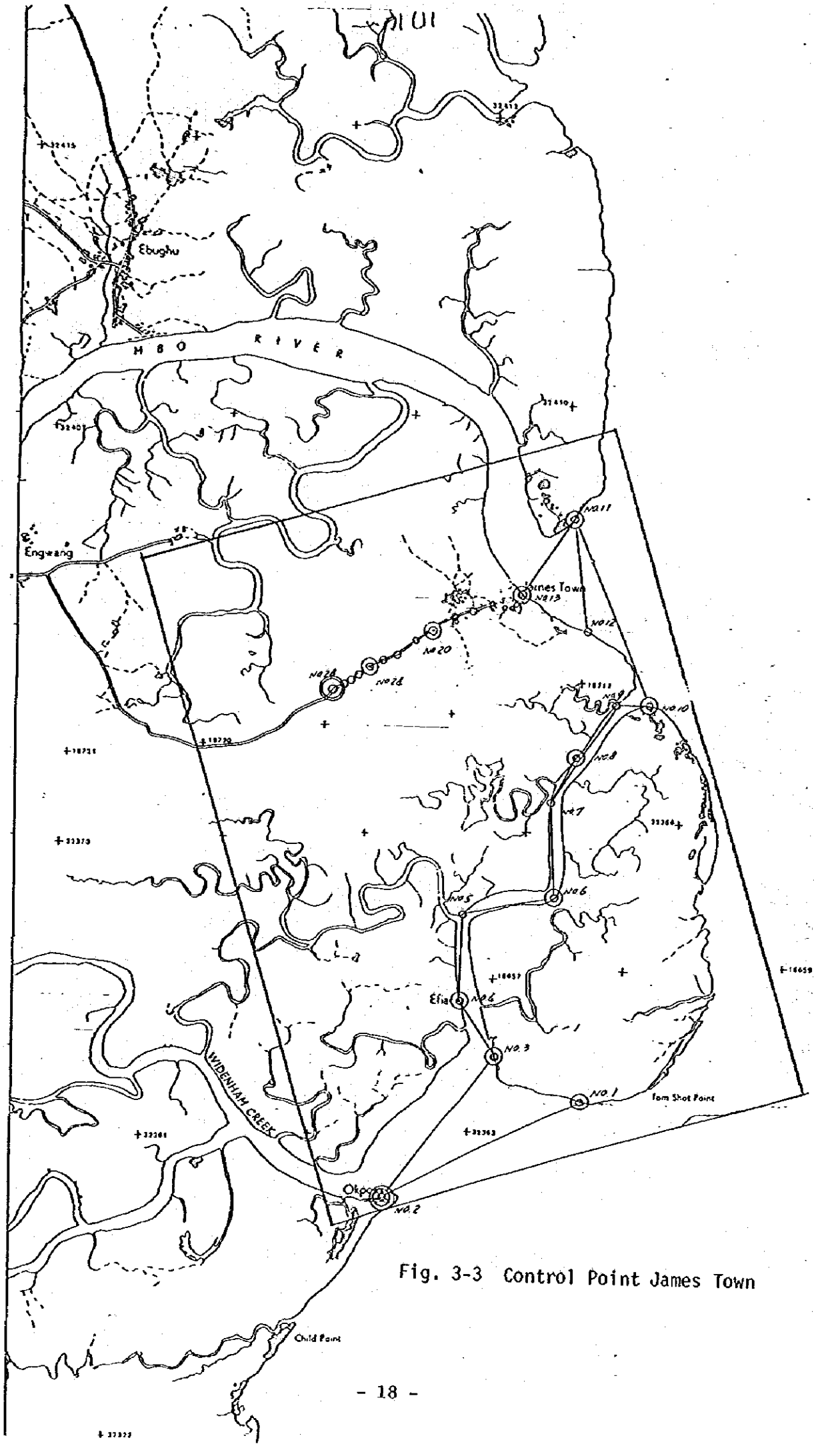


Fig. 3-3 Control Point James Town

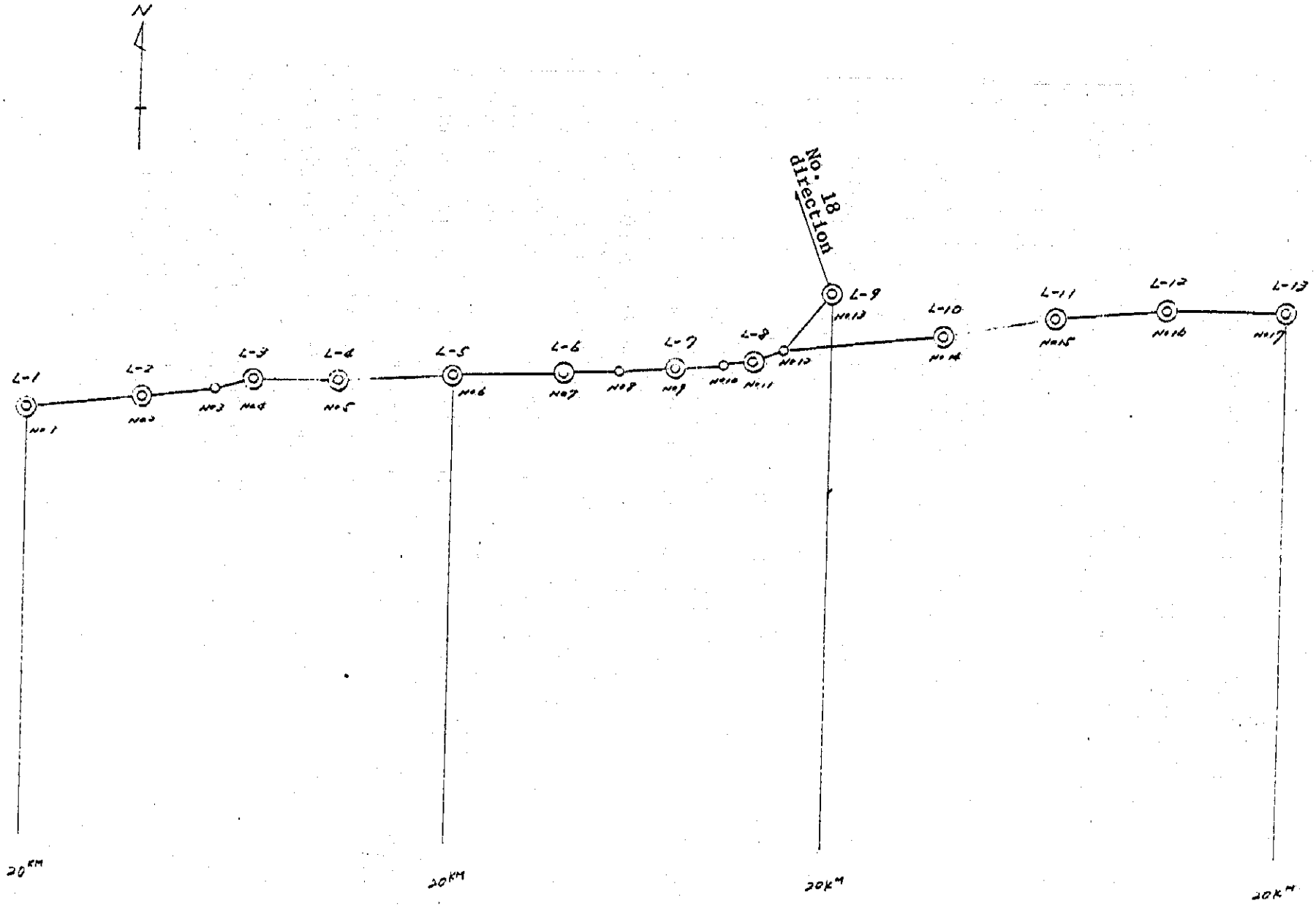


Fig. 3-4 Control Point for Sounding

Table 3-3 Traversing Results of the Ibeno Area

(Shore line of the Ibeno area:
In common with induction point)

Point name	X coordinate	Y coordinate	Elevation	Remarks
L-1 (No.1)	+ 96 048.85	+ 93 140.64	3.42	Elevation in DL
L-2 (No.2)	+ 96 191.90	+ 94 476.39	2.94	
(No.3)	+ 96 286.75	+ 95 354.06	3.13	
L-3 (No.4)	+ 96 399.42	+ 95 798.88	2.50	
L-4 (No.5)	+ 96 409.06	+ 96 793.52	3.04	
L-5 (No.6)	+ 96 508.55	+ 98 154.05	3.48	
L-6 (No.7)	+ 96 549.83	+ 99 451.55	3.40	
(No.8)	+ 96 570.00	+ 100 100.00	3.36	
L-7 (No.9)	+ 96 601.38	+ 100 748.76	3.38	
(No.10)	+ 96 641.05	+ 101 319.51	3.23	
L-8 (No.11)	+ 96 693.43	+ 101 646.84	3.23	
(No.12)	+ 96 832.90	+ 102 001.51	3.30	
L-9 (No.13)	+ 97 504.94	+ 102 536.72	2.68	Temporary tidal observation point
L-10 (No.14)	+ 97 017.14	+ 103 863.36	3.64	
L-11 (No.15)	+ 97 206.25	+ 105 192.65	3.25	
L-12 (No.16)	+ 97 281.44	+ 106 515.01	3.34	
L-13 (No.17)	+ 97 282.17	+ 107 906.70	3.24	

Note: The coordinate system is arbitrary.
The provisional origin of the Ibeno area is added to be B = 4°34', L = 7°58'.
+100 km is added to both X and Y coordinate of the provisional origin point.

(Table 3-3 continued)

(In the riverside of the Ibeno area)

Paint name	X coordinate	Y coordinate	Elevation	Remarks
No.18	+ 99 718.04	+ 101 682.80	4.15	
No.18-1	+ 99 864.71	+ 101 622.72	3.77	
No.19	+ 100 025.77	+ 101 100.52	3.26	
No.20	+ 98 037.12	+ 98 440.73	3.07	
No.21	+ 98 861.86	+ 97 255.11	2.02	
No.22	+ 100 930.09	+ 97 928.29	2.04	
No.23	+ 102 460.76	+ 95 781.61	4.03	
No.24	+ 101 467.89	+ 94 170.63	1.86	
No.24-2	+ 101 444.55	+ 94 220.59	2.42	

Boring Point Position (Ibeno)

Boring No.I-1	+ 100 014.96	+ 101 146.36	3.64	
Boring No.I-2	+ 96 327.62	+ 95 513.40	2.98	

Table 3-4 Traversing Results in the James Town Area

Point name	X coordinate	Y coordinate	Elevation	Remarks
No.1	+ 96 644.55	+ 102 571.37	2.72	Elevation in DL
No.2	+ 95 150.00	+ 99 740.00	2.78	
No.3	+ 97 291.34	+ 101 309.33	2.70	
No.4	+ 98 146.20	+ 100 741.24	2.30	
No.5	+ 99 374.44	+ 100 838.06	2.02	
No.6	+ 99 515.39	+ 102 195.18	2.06	
No.7	+ 100 898.06	+ 102 016.94	2.11	
No.8	+ 101 575.05	+ 102 418.51	2.06	
No.9	+ 102 379.72	+ 102 962.74	1.65	
No.10	+ 102 245.29	+ 103 414.09	1.73	
No.11	+ 105 038.31	+ 102 323.72	2.70	
No.12			2.38	Temporary tidal observation point
No.13	+ 103 922.72	+ 101 594.70	3.72	
No.14	+ 103 805.80	+ 101 519.11	4.54	
No.15	+ 103 739.46	+ 101 327.26	7.22	
No.16	+ 103 829.19	+ 101 226.97	7.17	
No.17	+ 103 748.18	+ 100 997.70	9.08	
No.18	+ 103 635.84	+ 100 695.29	18.70	
No.19	+ 103 553.42	+ 100 520.67	16.46	

Note: The coordinate system is arbitrary.
The provisional origin of the James Town area is added to be B = 4°37', L = 8°18'.
+100 km is added to both X and Y coordinate of the provisional origin point.

(Table 3-4 continued)

(James Town Area)

Point name	X coordinate	Y coordinate	Elevation	Remarks
No.20	+ 103 438.67	+ 100 346.79	16.72	
No.21	+ 103 305.21	+ 100 165.76	19.23	
No.22	+ 103 039.24	+ 99 781.19	12.19	
No.23	+ 102 930.90	+ 99 531.30	11.07	
No.24	+ 102 891.24	+ 99 415.96	10.81	
No.25	+ 102 800.34	+ 99 288.14	10.70	
No.26	+ 102 688.50	+ 99 177.23	10.88	
No.27	+ 102 600.32	+ 99 037.21	11.35	
No.28	+ 102 552.78	+ 98 908.30	11.12	

Boring Point Position (James Town)

Boring No.J-1	+ 103 944.29	+ 101 597.83	3.92	
Boring No.J-2	+ 95 116.07	+ 99 794.56	2.52	

Table 3-5 Traversing Results in the Opobo Area

(Temporary tidal observation point measurement results BM, 6 = 2.56)

Point name	X coordinate	Y coordinate	Elevation	Remarks
No.1	+ 92 000.00	+ 103 500.00	2.63	Elevation in DL
No.2	+ 95 463.53	+ 105 312.98	1.74	
No.3	+ 97 112.30	+ 103 185.08	1.95	
No.4	+ 97 844.06	+ 99 017.25	3.14	
No.5	+ 101 963.83	+ 96 983.74	2.25	
No.6	+ 101 148.16	+ 99 837.74	4.16	
No.7	+ 105 019.86	+ 100 050.72	10.02	
No.8	+ 106 927.06	+ 97 593.40	2.03	
No.9	+ 105 032.32	+ 100 231.34	10.25	
No.10	+ 104 827.98	+ 100 310.29	6.59	
No.11	+ 104 724.64	+ 100 481.50	8.32	
No.12	+ 105 103.18	+ 100 549.56	10.02	
No.13	+ 105 073.71	+ 100 811.56	9.08	
No.14	+ 105 041.51	+ 100 937.23	9.74	
No.15	+ 105 043.45	+ 101 213.30	7.36	
No.16	+ 104 996.79	+ 101 577.75	9.43	
No.17	+ 104 863.39	+ 102 338.08	8.17	
No.18	+ 104 660.03	+ 102 968.49	7.23	

Note: The coordinate system is arbitrary.
The provisional origin of the Opobo area is added to be B = 4°32', L = 7°33'.
+100 km is added to both X and Y coordinate of the provisional origin point.

(Table 3-5 continued)

Boring Point Position (Opobo)

Point name	X coordinate	Y coordinate	Elevation	Remarks
Boring No.O-1	+ 101 328.54	+ 100 094.34	2.87	
Boring No.O-2	+ 91 986.26	+ 103 406.91	2.75	

3-1-3 Field investigation

The photographs were brought to the survey site and inquiries required to confirm the details which could not be interpreted in the photographs referring to locations, names of places, etc. were made. With reference to the coastal area of Opobo, exsisting 1/40,000 scale photographs were used. Topographic changes were accordingly surveyed by precise measurement of these locations.

3-1-4 Aerial triangulation

The number of models totalled 392, - 109 models of the Ibeno area, 63 models of the James Town area and 220 models of the Opobo area - fewer than those planned because the newly taken 1/10,000 scale photographs were used as much as possible. The aerial triangulation was conducted with the block adjustment method.

3-1-5 Mapping

The mapping area totalled 280 km^2 - 105 km^2, Ibeno area; 70 km^2, James Town area; and 105 km^2, Opobo area. The mapping work included the production of the map manuscript, editing and final map drawing.

3-1-6 Compilation

The comprehensive map of the Ibeno, James Town and Opobo areas was prepared by merging and photographic reductions and enlargements of the newly prepared 1/10,000 scale topographic map, the existing 1/50,000 topographic map and the marine chart.

3-2 Shore Surveying

The topographical cross-section map of the shoreline was prepared based upon the results of the shoreline survey. The obtained map is presented in appended herewith.

3-3 Sounding

The 1/50,000 scale track chart was prepared based upon the data obtained from the ship positioning work. The depth reading work was carried out matching the above mentioned track chart with the sounding records. The actual water depths were determined by applying draft correction, tidal level correction and sound velocity correction to these records. The 1/50,000 scale sounding chart and the contour map were prepared based upon the depth values and the results of the shore survey described above,

3-4 Tidal Observation

Tidal observation was carried out at the observation points shown in Figure 3-5.

The readings of the tide levels recorded from March 20th through April 19th in the Ibeno area are summarized in Table 3-6. For a comparative study of the tide tendency at the 3 areas, the results of the simultaneous tidal observation are listed in Table 3-7 through Table 3-9.

3-5 Observation of the Sea Conditions

The results of the observation of the sea conditions in the Ibeno area are shown in Table 3-10. The current velocity was observed at points No. 1 through No. 6 shown in Figure 3-6. The examination of the water quality was also made at the observation points No. 2 and No. 3. The results of the observations of the currents are summarized in Table 3-11 through Table 3-13, while the results of the water examination in the rivers are presented in Table 3-14.

3-6 Bottom Sampling

The sampling points from which the bottom samples were taken both in for the rivers and the sea are shown in Figure 3-7 through Figure 3-9.

The collected samples were submitted to mechanical analysis, in conformity with the JIS (Japanese Industrial Standard) A 1204. The mesh of the sieve was divided into 25 grades, ranging from 4mm through 0.063mm, and samples sized less than 0.063mm were submitted to the sedimentation analysis test. The characteristics of the bottom materials obtained from the test results are summarized in Table 3-16, under "List of the Characteristics of the Bottom Materials". The analysis of the characteristics of the bottom materials was carried out in accordance with the following methods.

(1) Classification of the Bottom Materials

The classification of the bottom materials was determined by using the triangular coordinate classification of the Japanese Society of Mechanics and Foundation Engineering.

(2) Specific Gravity

The soil test was carried out in accordance with the stipulations presented in JIS A 1202.

(3) Medium Diameter

The size corresponding to 50% of the added weight percentage of the grain size distribution curve is presented here.

(4) Mean Diameter

The mean diameter is calculated by using the equation which is one ordinarily known for this purpose i.e.

$$M\phi = 1/2\ (\phi 84 + \phi 16)$$

(5) Diameter at 25%

The diameter corresponding to 25% of the grain size distribution curve is presented here.

(6) Diameter at 75%

The diameter corresponding to 75% of the grain size distribution curve is presented here.

(7) Coefficient of Uniformity

The coefficient of uniformity is the parameter which expresses numerically the distribution of the grain size of the bottom material, and is calculated by means of the following equation.

$$Uc = D_{60}/D_{10}$$

Where, D_{60} and D_{10} are the diameters corresponding to 60% and 10% of the grain size distribution.

(8) Sorting Index

The sorting index is the parameter which indicates whether the diameters of the bottom material are uniform or not, and is calculated with the following equation.

$$S_0 = \sqrt{D_{75}/D_{25}} \quad \text{..... TRASK 1932}$$

* When the diameters are perfectly uniform we have $D_{25} = D_{75}$, resulting consequently into $S_0 = 1$.

(9) Skewness

The skewness, which is also called degree of asymmetry, is the parameter which indicates whether the grain size distribution of the bottom material has its mean or medium diameter tends toward the coarse side or to the fine side, and is calculated by means of the following equation.

* In case of SK < 1.00 Offset to the fine side
  In case of SK > 1.00 Offset to the coarse side

$$S_K = \frac{D_{25} \times D_{75}}{D_{50}^2}$$

(10) Mud Contents

The mud content is calculated in terms of the percentage of the components size 0.074mm or less with reference to the grain size distribution curve.

OPOBO AREA

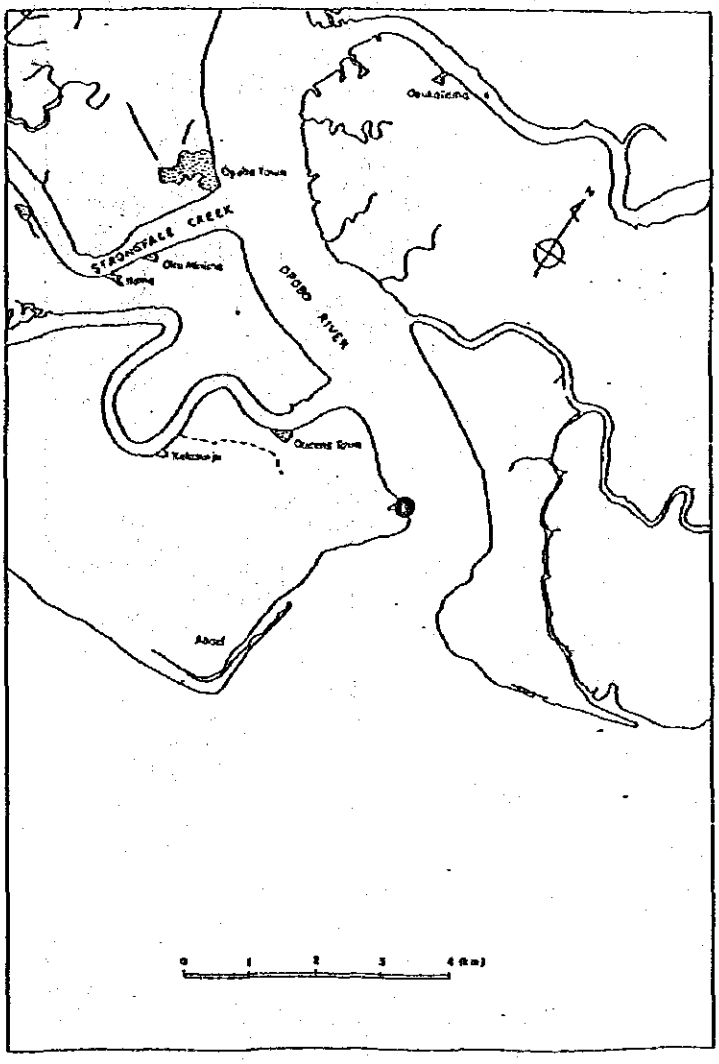
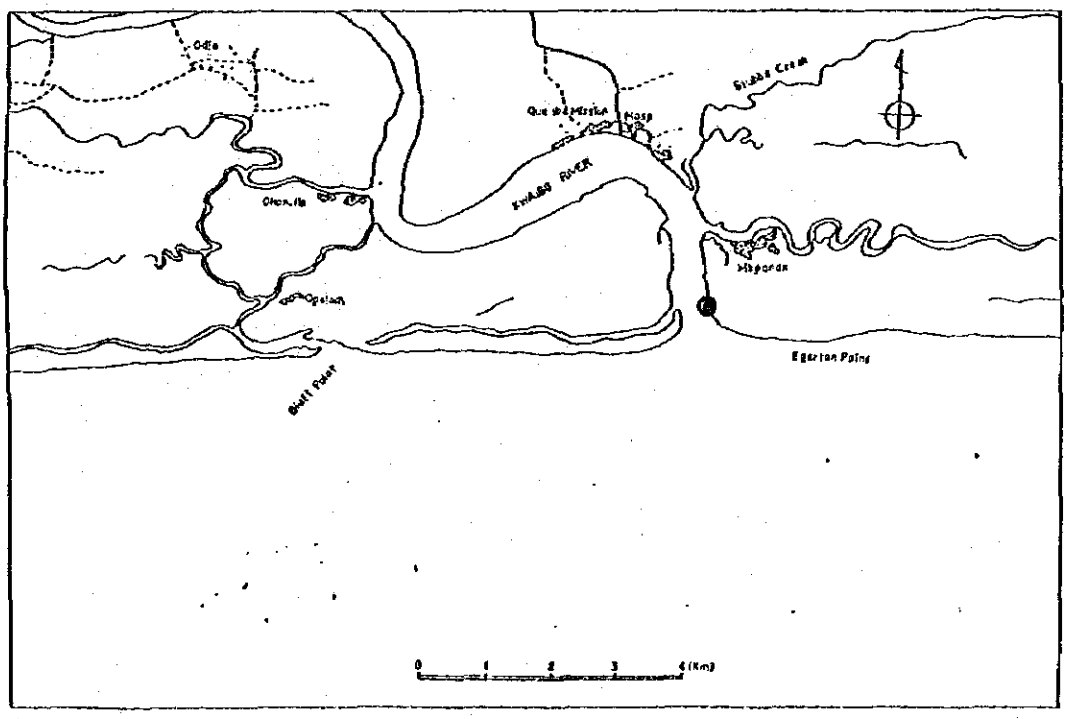


Fig. 3-5

Locality Map of Tidal Observation Point

● -----OBSERVATION POINT

IBENO AREA



JAMES TOWN AREA

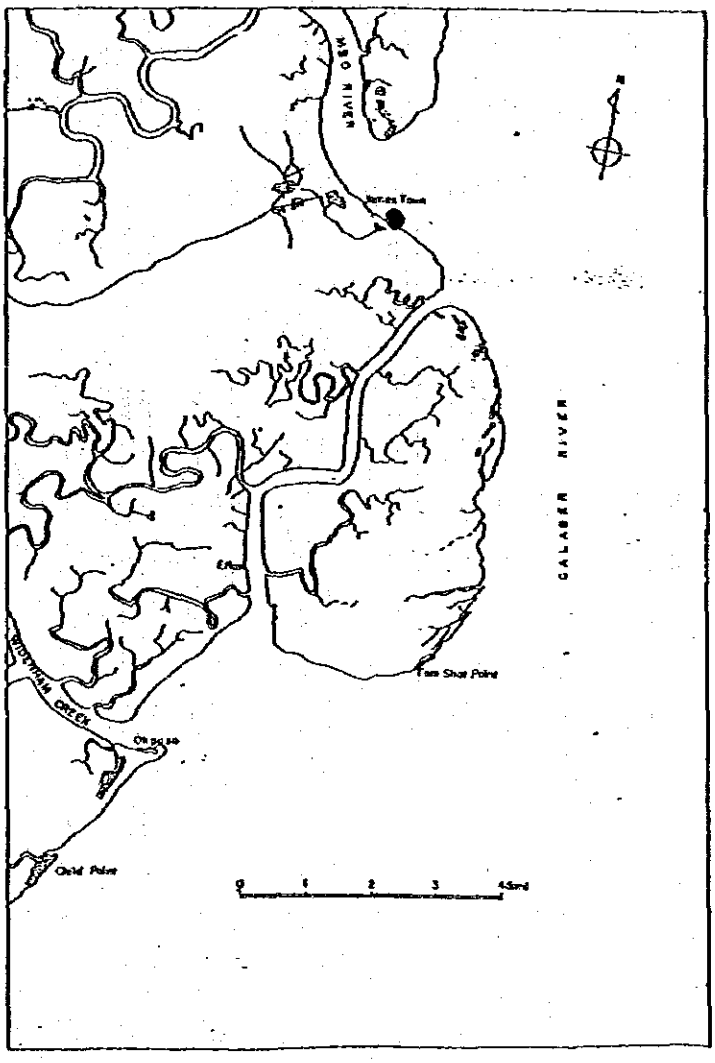


Table 3-6

*** TIDAL RECORD (OBSERVED HOURLY HEIGHT) ***

STATION ** NIGERIA KWA IBO RIVER DURATION ** ONE MONTH TIME KEPT ** -1 H
LAT. 4-32- 0 N, LONG. 7-58- 0 E EPOCK ** 1981/ 4/ 4 00-00 UNIT OF HEIGHT ** CM

NO.	DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	SUM	MEAN
1	3/20	291	330	360	385	408	415	396	364	335	298	263	250	268	312	350	380	407	425	421	392	362	332	291	265	8300	346
2	3/21	268	310	345	375	400	412	419	387	357	321	288	256	250	288	335	369	396	425	427	408	380	345	304	262	8327	347
3	3/22	263	291	320	353	383	410	420	402	367	340	310	273	250	265	317	355	381	408	428	427	389	358	331	292	8333	347
4	3/23	260	259	309	344	362	391	415	413	387	357	326	291	262	255	290	338	369	390	417	428	407	370	345	313	8298	346
5	3/24	278	257	278	322	352	372	397	410	402	368	340	317	281	262	280	324	351	376	403	417	412	387	356	322	8264	344
6	3/25	290	265	266	296	327	349	377	397	395	371	354	336	299	270	270	299	334	359	381	402	409	389	366	345	8146	339
7	3/26	318	278	263	283	317	337	351	379	390	382	367	347	322	295	281	291	321	349	372	393	400	395	380	365	8176	341
8	3/27	337	307	281	281	301	323	337	357	378	383	370	359	348	320	298	300	313	333	352	373	386	391	390	368	8186	341
9	3/28	348	328	305	287	287	310	320	331	355	374	370	361	357	346	321	305	309	321	337	349	362	375	383	378	8119	338
10	3/29	363	349	325	307	297	300	308	316	332	352	365	368	370	368	352	330	319	319	325	335	337	338	370	380	8145	339
11	3/30	379	368	353	335	311	295	295	300	307	321	346	363	372	376	372	358	338	322	312	311	320	331	348	368	8101	338
12	3/31	380	378	372	363	340	312	294	285	283	296	321	345	366	382	388	381	364	344	321	308	302	301	322	348	8096	337
13	4/ 1	367	380	387	385	366	338	308	282	265	272	291	314	342	371	391	399	389	371	345	318	300	292	306	330	8109	338
14	4/ 2	355	376	394	405	395	367	344	310	280	270	280	305	335	363	395	408	410	395	366	339	305	280	283	308	8268	344
15	4/ 3	334	356	385	405	410	395	365	331	295	267	261	268	308	344	377	415	434	431	397	362	322	280	257	264	8263	344
16	4/ 4	297	334	370	405	429	429	399	357	320	280	244	240	278	321	360	401	437	449	437	393	352	304	265	248	8349	348
17	4/ 5	261	312	352	383	421	440	433	395	352	311	268	240	245	297	342	380	420	448	453	433	382	337	293	255	8453	352
18	4/ 6	242	270	330	360	385	423	441	424	383	344	294	253	236	255	313	353	388	431	452	448	410	367	321	272	8397	350
19	4/ 7	242	237	284	331	357	390	425	432	407	374	339	292	250	241	281	331	362	395	432	447	439	402	363	317	8370	349
20	4/ 8	267	241	253	310	337	353	393	423	423	393	367	337	287	250	253	302	342	366	397	422	432	419	383	348	8298	346
21	4/ 9	306	260	244	273	320	337	366	404	425	419	403	376	346	303	277	287	330	361	376	400	427	432	412	387	8471	353
22	4/10	355	313	276	269	300	326	338	362	392	407	398	386	374	346	307	291	309	337	355	372	392	406	408	392	8411	350
23	4/11	369	345	312	287	281	302	324	335	353	382	392	392	389	377	354	326	317	324	336	348	366	378	395	403	8387	349
24	4/12	374	376	349	325	297	289	303	315	327	349	374	387	391	394	387	358	332	327	327	331	343	353	367	383	8358	348
25	4/13	389	385	374	362	331	302	296	303	309	325	347	367	381	395	397	386	366	346	325	311	316	326	342	357	8338	347
26	4/14	371	382	387	381	358	330	302	289	293	304	321	342	366	389	399	397	390	368	336	312	306	308	318	337	8288	345
27	4/15	357	375	387	395	379	354	332	303	277	287	307	324	348	384	397	403	405	387	357	331	303	274	295	325	8286	345
28	4/16	340	364	382	399	393	372	348	319	293	277	277	308	338	365	389	405	407	395	372	347	315	285	274	300	8264	344
29	4/17	328	353	375	397	406	393	366	338	312	282	268	282	319	356	386	407	417	412	393	365	336	300	274	274	8339	347
30	4/18	308	345	367	395	412	407	385	358	332	297	268	265	295	337	372	396	414	419	406	377	348	310	274	260	8347	348
31	4/19	277	314	347	376	397	402	393	369	338	306	273	255	263	307	352	375	395	410	408	383	354	324	285	250	8153	340

NUMBER OF LOST DATA ** 0

Table 3-7. *** TIDE POLE (OBSERVED HOURLY HEIGHT) ***

STATION ** JAMES TOWN
LAT. •LONG.
DURATION **
TIME KEPT ** -1 H
UNIT OF HEIGHT ** CM

NO.	DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	SUM	MEAN
1	4/10	247	210	164	115	103	130	136	207	231	259	280	265	250	230	192	152	126	145	179	210	235	260	278	280	4934	205
2	4/11	259	228	201	163	115	114	139	166	187	221	255	270	260	253	240	202	153	142	155	172	193	220	242	269	4819	201
3	4/12	282	274	244	204	164	137	132	145	168	195	220	246	260	262	258	245	222	196	177	176	185	200	219	236	5047	210
4	4/13	254	261	256	226	193	157	138	134	140	160	187	217	242	260	268	268	254	233	204	182	164	160	174	192	4924	205
5	4/14	216	236	254	268	261	234	189	155	129	132	156	184	213	245	270	278	272	251	224	193	162	147	156	175	5004	208
6	4/15	202	220	231	260	272	256	228	195	153	123	124	150	190	225	260	279	288	283	260	229	194	150	115	143	5030	210
7	4/16	172	196	222	252	277	272	248	220	180	144	112	122	160	200	242	268	289	295	284	262	223	170	130	110	5050	210

Table 3-8

*** TIDAL RECORD (OBSERVED HOURLY HEIGHT) ***

STATION ** IBENO
LAT. 4-32-0 N, LONG. 7-58-0 E,
DURATION **
TIME KEPT ** -1 H
UNIT OF HEIGHT ** CM

NO.	DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	SUM	MEAN
1	5/ 1	310	341	384	413	404	370	332	299	275	274	295	323	358	396	424	436	440	420	374	325	290	270	280	304	8337	347
2	5/ 2	337	370	395	416	424	395	360	325	282	261	270	300	330	375	415	440	453	440	404	361	317	280	263	279	8492	354
3	5/ 3	315	355	387	411	430	431	404	369	326	290	265	264	293	334	380	423	449	461	439	390	343	310	272	259	8600	358
4	5/ 4	278	310	345	386	417	441	434	390	350	318	265	251	280	330	365	401	450	460	453	420	373	320	272	249	8558	357
5	5/ 5	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
6	5/ 6	247	248	285	318	354	390	426	434	400	372	338	288	257	262	305	343	365	408	439	443	420	382	346	306	8376	349
7	5/ 7	262	240	259	293	325	354	397	428	415	394	365	335	287	260	280	315	345	375	401	417	421	410	379	338	8295	346
8	5/ 8	296	258	247	266	294	324	355	385	415	410	388	366	336	300	280	290	330	348	365	386	408	408	385	362	8202	342

Table 3-9

*** TIDE POLE (OBSERVED HOURLY HEIGHT) ***

STATION ** OPOBO

LAT. •LONG. DURATION **

TIME KEPT ** -1 H

UNIT OF HEIGHT ** CM

NO.	DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	SUM	MEAN
1	5/ 1	519	547	586	627	639	609	566	528	499	493	519	553	592	622	652	668	656	624	585	548	515	492	496	520	13655	569
2	5/ 2	550	584	611	634	650	637	600	562	509	482	489	518	558	600	647	671	692	675	640	597	550	512	488	490	13946	581
3	5/ 3	528	566	600	623	648	660	643	600	550	514	490	485	525	565	610	650	666	682	680	640	590	546	507	482	14050	585
4	5/ 4	488	515	555	591	621	655	664	630	590	548	505	473	483	528	573	601	649	677	685	659	616	563	512	478	13859	577
5	5/ 5	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
6	5/ 6	480	465	490	526	560	602	640	661	649	616	563	512	484	477	511	560	579	620	660	669	657	620	583	546	13730	572
7	5/ 7	505	469	470	515	563	600	643	678	686	650	612	380	533	499	492	516	558	587	615	636	647	639	614	580	13887	579
8	5/ 8	540	496	470	484	514	550	589	623	665	665	646	613	576	545	523	519	557	579	592	609	627	637	622	598	13839	577

Table 3-10 Meteorologic and Wave Observation Results (Ibeno Area)

Date	Obaervation time	Observation place	Weather	Temp.	Wind direction	Wind speed	Pressure	Wave direction	Wave height	Period	Remarks
3/30	10^h00	West 9km from KWA 1BO	Clear	31°C	SW	1m/s	-	SW	1.0m	11 sec	
	15^h00	West 8km from KWA 1BO	Clear	36°C	SSW	0.5m/s	1015.7 mb	SW	0.5m	9 sec	
3/31	9^h30	East 6km from KWA 1BO	Clear	31°C	SSW	3m/s	1017.0 mb	SSW	0.6m	10 sec	
	16^h00	South 6km from KWA 1BO	Clear	31°C	S	7m/s	1014.3 mb	SSW	0.6m	10 sec	
4/1	8^h00	South 8km from KWA 1BO	Cloudy	29°C	NW	3m/s	1017.0 mb	SW	0.6m	10 sec	
	12^h30	South 4km from kWA 1BO	Rain	32°C	SW	6m/s	1015.7 mb	SSW	0.7m	9 sec	Temporary squall
	16^h00	South 8km from KWA 1BO	Cloudy	31°C	SSW	7m/s	1013.0 mb	SW	0.7m	10 sec	
	16^h30	South 8km from KWA 1BO	Cloudy	30°C	SSW	6m/s	1013.0 mb	S	0.7m	10 sec	
	17^h00	South 8km from KWA 1BO	Rain	30°C	SSW	6m/s	1013.0 mb	SSW	0.6m	10 sec	
	17^h30	South 8km from KWA 1BO	Rain	30°C	SSW	7m/s	1013.0 mb	SSW	0.7m	10 sec	
4/2	8^h00	South 8km from KWA 1BO	Cloudy	29°C	SSW	7m/s	1015.7 mb	SSW	0.7m	10 sec	
	11^h40	West 8km from KVA 1BO	Cloudy	31°C	SSW	2m/s	1017.0 mb	SSW	0.3m	9 sec	
	12^h30	West 8km from KWA 1BO	Rain	31°C	SSW	11m/s	1015.7 mb	SSW	0.8m	10 sec	Temporary squall
5/4	10^h30	West 3km from KWA 1BO	Rain	26°C	S	6m/s	1014.3 mb	S	1.5m	10 sec	
5/5	9^h30	West 3km from KWA 1BO	Clear	31°C	SE	1m/s	1014.3 mb	SSW	0.5m	9 sec	
5/6	10^h30	West 3km from KWA 1BO	Rain	28°C	NW	0.3m/s	1017.0 mb	SSW	1.5m	11 sec	
5/7	11^h40	West 3km from KWA 1BO	Cloudy	27°C	SSE	5m/s	1013.7 mb	SE	1.8m	10 sec	

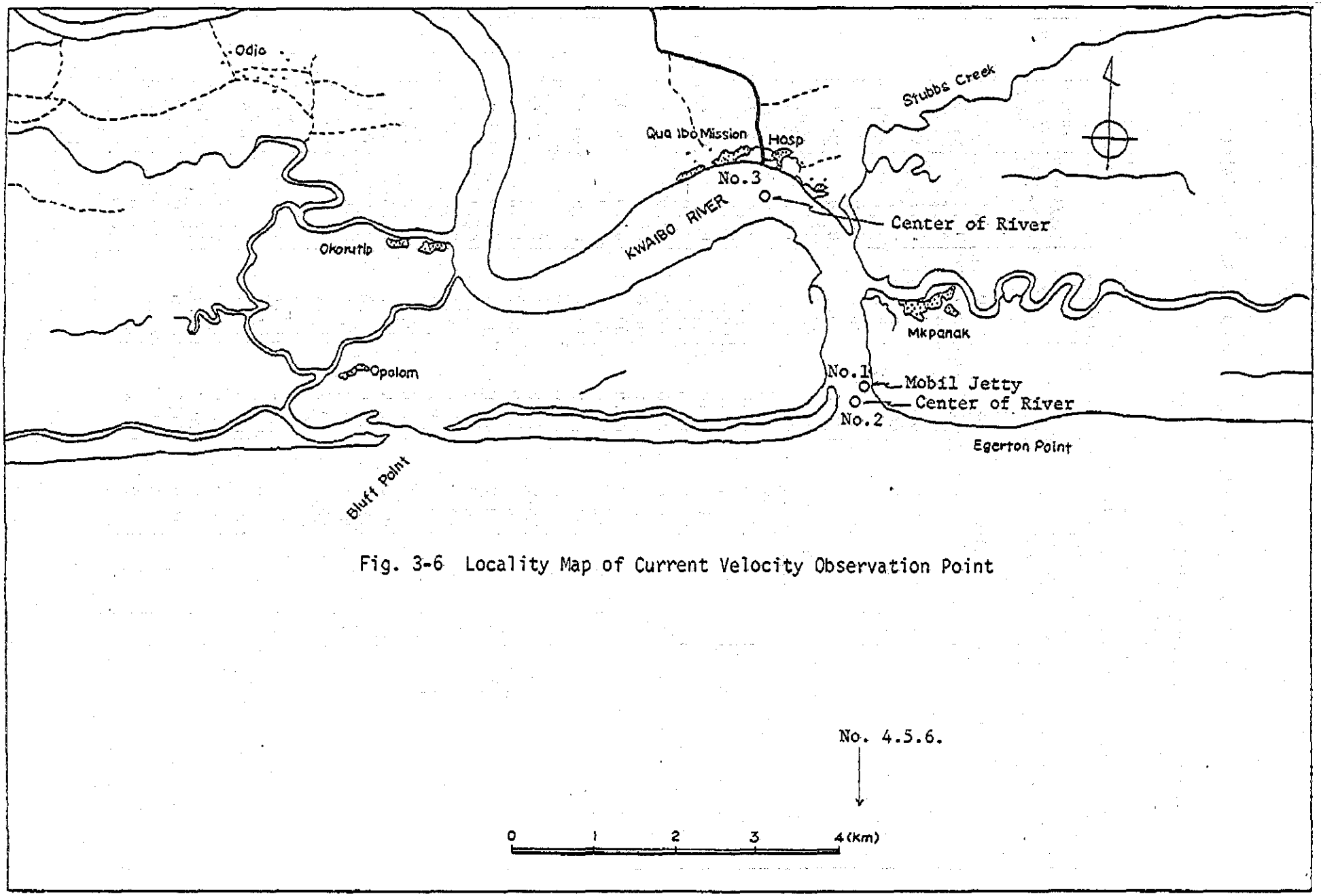


Fig. 3-6 Locality Map of Current Velocity Observation Point

Table 3-11 Water Current Observation Results (Ibeno Area)

No.1 Point: At Mobil Jetty (River mouth of KWA IBO RIVER)

Upper: Average value
Lower: Maximum value Unit: m/sec

Date	Observation time	Surface layer	2m	4m	6m	River flow direction	Tide curve during the observation period
3/20	9h00	1.10 max 1.20	0.80 max 1.00	0.80 max 1.00	0.80 max 0.90	Down-stream	
	10h30	1.10 1.15	0.85 0.90	0.60 0.70	0.30 0.35	"	
	11h00	0.95 1.00	0.65 0.75	0.35 0.40	0.15 0.20	"	
	11h30	0.67 0.70	0.42 0.45	0.24 0.25	0.05 0.10	"	
	12h30	0.25 0.29	0.25 0.30	0.20 0.25	0.20 0.25	Up-stream	
	13h00	0.30 0.35	0.30 0.35	0.40 0.50	0.50 0.55	"	
	13h30	0.30 0.40	0.55 0.65	0.50 0.60	0.60 0.70	"	
	14h00	0.35 0.45	0.40 0.55	0.50 0.65	0.60 0.70	"	
	14h30	0.35 0.45	0.50 0.60	0.50 0.60	0.50 0.60	"	
	15h10	0.35 0.45	0.35 0.45	0.40 0.50	0.45 0.50	"	
	15h30	0.30 0.40	0.25 0.35	0.15 0.20	0.25 0.30	"	
	16h00	0.40 0.45	0.45 0.50	0.55 0.60	0.55 0.65	"	
	16h30	0.40 0.60	0.60 0.70	0.55 0.65	0.55 0.65	"	
	17h00	0.45 0.70	0.45 0.70	0.45 0.70	0.50 0.65	"	
	17h20	0.55 0.75	0.60 0.75	0.55 0.75	0.60 0.80	"	
3/21	8h30	1.15 1.20	1.05 1.10	0.95 1.00	1.00 1.05	Down-stream	
	9h00	1.25 1.30	1.20 1.25	1.05 1.15	0.95 1.10	"	
	9h30	1.15 1.18	1.10 1.15	1.00 1.10	0.65 0.70	"	
	10h10	1.10 1.13	1.05 1.10	0.90 1.00	0.65 0.70	"	
	12h10	0.55 0.55	0.25 0.25	0.12 0.15	0.10 0.10	"	
	12h30	0.25 0.25	0.15 0.15	0.15 0.15	0.15 0.15	"	

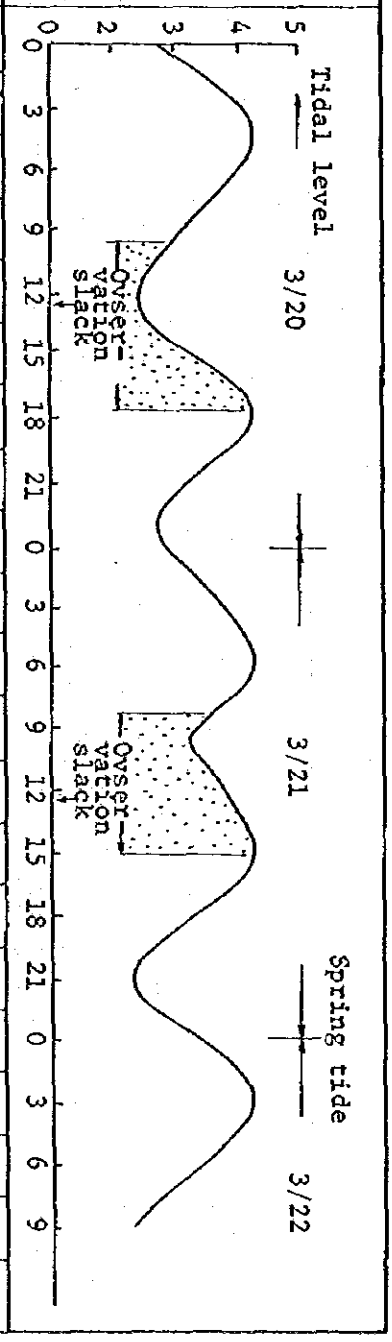


Table 3-12 Current Observation Results (Ibeno Area)

No.1 Point: At Mobil Jetty (Estnary of KWA IBO RIVER)

Upper: Average value
Lower: Maximum value Unit: m/sec

Date	Observation time	Surface layer	2m	4m	6m	River flow direction	
3/21	13^h00	0.30 max 0.25	0.25 0.30	0.30 0.30	0.30 0.30	Up-stream	
	13^h30	0.30 0.45	0.45 0.55	0.60 0.75	0.60 0.60	"	
	14^h00	0.35 0.40	0.45 0.50	0.45 0.50	0.45 0.50	"	
	14^h30	0.50 0.55	0.70 0.75	0.75 0.80	0.60 0.65	"	
	15^h00	0.40 0.45	0.60 0.65	0.60 0.65	0.60 0.65	"	

(Ibeno Area)

No.2 Point: At the Front of Mobil Jetty (Centerof River)

Date	Observation time	Surface layer	2m	4m	6m	8m	10m	River flow direction	Remarks
3/21	10^h30	1.50 max 1.50	1.20 1.20	1.00 1.10	1.00 1.00	0.80 0.90	0.80 0.90	Down-stream	

(Ibeno Area)

No.3 point: At the Front of Qua Ibo Mission's Mobil Jetty (Center of River)

Date	Observation time	Surface layer	2m	4m	5.5m	River flow direction	Remarks
3/21	11^h00	0.67 max 0.70	0.80 0.82	0.75 0.80	0.70 0.75	Down-stream	

Table 3-13 Observation Results of the Current (Ibeno Area)

Unit: m/sec

No. 4 Point: 10 km south from KWA IBO RIVER mouth

Date	Observation time	2m	7m	13m	Wind direction and wind speed	Flowing direction at the surface layer	Meteorologic and other conditions at the observation time
3/30	16h45	0.20	0.15	0.15	SWS, 0.5m/s	NNE	Weather: Cloudy
	17h15	0.20	0.15	0.10	" , 0.6m/s	"	Atomospheric: 31°C
	17h45	0.20	0.15	0.10	" , 0.5m/s	EVE	Pressure: 1014.3mb
	18h15	0.20	0.20	0.10	" , 0.7m/s	"	Water depth: Approximately 15m

No. 5 Point: 6 km south from KWA IBO RIVER mouth

Date	Observation time	2m	7m	13m	Wind direction and Wind speed	Flowing direction at the surface layer	Meteorologic and other conditions at the observation time
3/31	16h00	0.25	0.25	0.10	S, 7m/s	NNE	Weather: Clear
	16h30	0.30	0.25	0.10	SSW, 7m/s	"	Atomospheric: 31°C
	17h00	0.25	0.20	0.10	SW , 6m/s	"	Pressure: 1014.3mb
	17h30	0.30	0.25	0.10	" , 7m/s	"	Water depth: Approximately 15m

No. 6 Point: 8 km south from KWA IBO RIVER mouth

Date	Observation time	2m	7m	13m	Wind direction and Wind speed	Flowing direction at the surface layer	Meteorologic and other conditions at the observation time
4/1	16h00	0.20	0.15	0.20	NW , 3m/s	WNW	Weather: Cloudy
	16h30	0.25	0.20	0.20	SSW, 7m/s	N	Atomospheric: 29°C
	17h00	0.20	0.10	0.15	" , 6m/s	"	Pressure: 1017.0mb
	17h30	0.25	0.15	0.20	" , 7m/s	NNE	Water depth: Approximately 15m

Tide curve during the observation period (Neap tide)

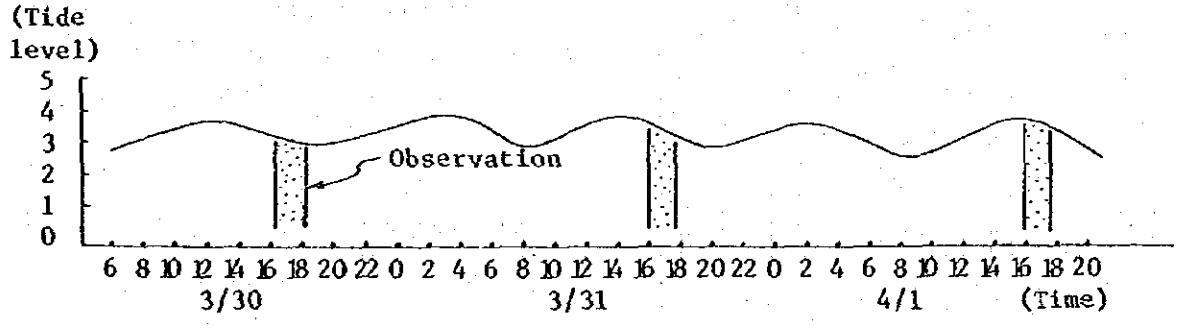


Table 3-14 Results of the Water Quality Examination at the River (Ibeno area)

Point	Date and time	Atmospheric temperature	Water temperature	P.H	D.O	Velocity			River flowing direction	Remarks
						Surface layer	2m	4m		
No. 3	3/25 11^h30 ∿ 12^h00	26.6°C	28.3°C	6.6PPM	5.7PPM	0.35m/s	0.65m/s	0.65m/s	Downstream	Water: Cloudy
No. 2	3/25 12^h45 ∿ 13^h05	27.1°C	28.0°C	7.4PPM	6.3PPM	1.30m/s	1.10m/s	0.80m/s	"	"

Note 1:

Method of calculation of the DO

Actually measured value at No.3: 15.5%

Actually measured value at No.2: 17.0%

The value of the DO was calculated by substituting the values above in the expression below and by referring to the figure below.

$$DO\ (ppm) = \frac{\text{Actually measured \%}}{\text{\% in the air}} \times \left[\begin{array}{l}\text{Value corresponding to the temperature occurring at the time of the measurement (Table 3-15)}\end{array}\right]$$

The denominator in the expression above is assumed to be 21%, because the saturation value in the air is 21%, due to the DO calibration value of the measurement instrument (21%).

Note 2:

The measurement of the water examination is carried out by sampling water of the surface layer.

Table 3-15

Saturated Oxygen Dissolved in Water

Temp. (C°)	Chlorine ioncontained in the water (ppm)					Quality (ppm) of dissolved oxygen to be reduced per each 100 ppm of chlorine ion
	0	5000	10000	15000	20000	
0	14.15	13.40	12.63	11.87	11.10	0.0153
1	13.77	13.03	12.29	11.55	10.80	0.0148
2	13.40	12.68	11.97	11.25	10.52	0.0144
3	13.04	12.35	11.65	10.95	10.25	0.0140
4	12.70	12.03	11.35	10.67	9.99	0.0135
5	12.37	11.72	11.06	10.40	9.74	0.0131
6	12.06	11.42	10.79	10.15	9.51	0.0128
7	11.75	11.15	10.52	9.90	9.28	0.0124
8	11.47	10.87	10.27	9.67	9.06	0.0120
9	11.19	10.61	10.03	9.44	8.85	0.0117
10	10.92	10.36	9.79	9.23	8.66	0.0113
11	10.67	10.12	9.57	9.02	8.47	0.0110
12	10.43	9.90	9.36	8.82	8.29	0.0107
13	10.20	9.68	9.16	8.64	8.11	0.0104
14	9.97	9.47	8.97	8.46	7.95	0.0101
15	9.76	9.27	8.78	8.29	7.79	0.0099
16	9.56	9.06	8.60	8.12	7.63	0.0096
17	9.37	8.90	8.44	7.97	7.49	0.0094
18	9.18	8.73	8.27	7.82	7.36	0.0091
19	9.01	8.57	7.12	7.67	7.22	0.0089
20	8.84	8.41	7.97	7.54	7.10	0.0087
21	8.68	8.26	7.83	7.40	6.97	0.0086
22	8.53	8.11	7.70	7.26	6.85	0.0084
23	8.39	7.98	7.57	7.16	6.74	0.0082
24	8.25	7.85	7.44	7.04	6.65	0.0081
25	8.11	7.72	7.32	6.95	6.52	0.0079
26	7.99	7.60	7.21	6.82	6.42	0.0078
27	7.87	7.48	7.10	6.71	6.32	0.0077
28	7.75	7.37	6.99	6.61	6.22	0.0076
29	7.64	7.26	6.88	6.51	6.12	0.0076
30	7.53	7.16	6.78	6.41	6.03	0.0075
31	7.43	7.06	6.66	6.31	5.93	0.0075
32	7.32	6.96	6.59	6.21	5.84	0.0074
33	7.23	6.86	6.49	6.12	5.75	0.0074
34	7.13	6.77	6.40	6.03	5.65	0.0074
35	7.04	6.67	6.30	5.93	5.56	0.0074

Table 3-16 Characteristics of Bottom Materials

Gs: Specific Gravity Uc: Coefficient of Uniformity
Sk: Skewness Da: diameter at a%
So: Sorting index Mc: Mud contents

Sample No.	Bottom materials	Gs	D_{50} mm	D_m mm	D_{25} mm	D_{75} mm	Uc	So	Sk	Mc
K-1	Sand	-	0.21	0.195	0.19	0.22	1.51	1.063	0.926	0.001
K-2	Sand	-	0.22	0.200	0.19	0.24	1.76	1.124	0.942	0.004
K-3	Sand	-	0.21	0.190	0.19	0.22	1.69	1.076	0.948	0.002
K-4	Sandy silt	2.662	0.023	0.058	0.013	0.090	5.85	2.631	2.212	0.681
K-5	Sandy silt	2.619	0.039	0.056	0.015	0.092	32.94	2.477	0.907	0.654
K-6	Silty sand	2.669	0.086	0.073	0.073	0.089	2.45	1.104	0.878	0.242
K-7	Clay	2.618	0.0044	0.031	0.0036	0.022	4.83	2.472	4.091	0.861
K-8	Sand	-	0.45	0.765	0.29	0.85	2.50	1.712	1.217	0.002
K-9	Sand	-	0.24	0.255	0.23	0.26	1.41	1.063	1.038	0.000
O-1	Sand	2.643	0.33	0.276	0.24	0.44	72.00	1.354	0.970	0.164
O-2	Sand	-	0.32	0.350	0.24	0.39	1.53	1.275	0.914	0.001
O-3	Sand	2.620	0.44	0.640	0.26	0.78	8.41	1.732	1.048	0.104
O-4	Sand	-	0.115	0.150	0.105	0.15	1.42	1.195	1.191	0.021
O-5	Sand	-	0.40	0.520	0.34	0.55	1.66	1.272	1.169	0.004
O-6	Sand	-	0.45	0.450	0.39	0.50	1.39	1.132	0.963	0.000
T-1	Sand	-	0.26	0.390	0.24	0.38	1.42	1.258	1.349	0.000
T-2	Claily silt	2.673	0.0060	0.025	0.0049	0.013	2.91	1.629	1.769	0.935
T-3	Sand	-	0.22	0.255	0.22	0.25	1.12	1.066	1.136	0.000
T-4	Sand	-	0.24	0.250	0.23	0.26	1.24	1.063	1.038	0.006
T-5	Claily silt	2.631	0.018	0.041	0.0048	0.056	88.88	3.416	0.830	0.795
T-6	Silty sand	2.661	0.079	0.058	0.010	0.10	34.61	3.162	0.160	0.467
T-7	Sand	-	0.22	0.180	0.14	0.23	2.20	1.282	0.665	0.003

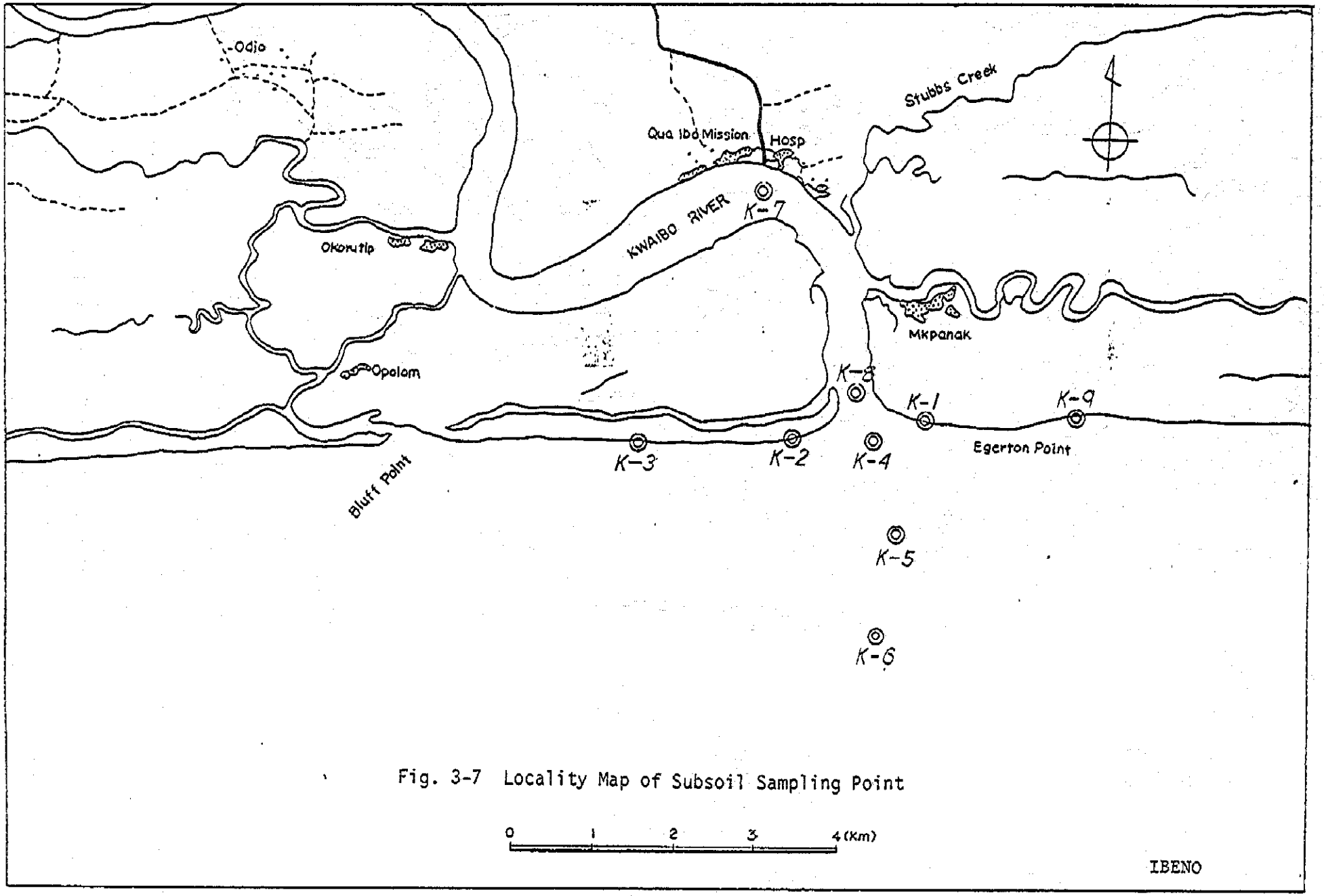


Fig. 3-7 Locality Map of Subsoil Sampling Point

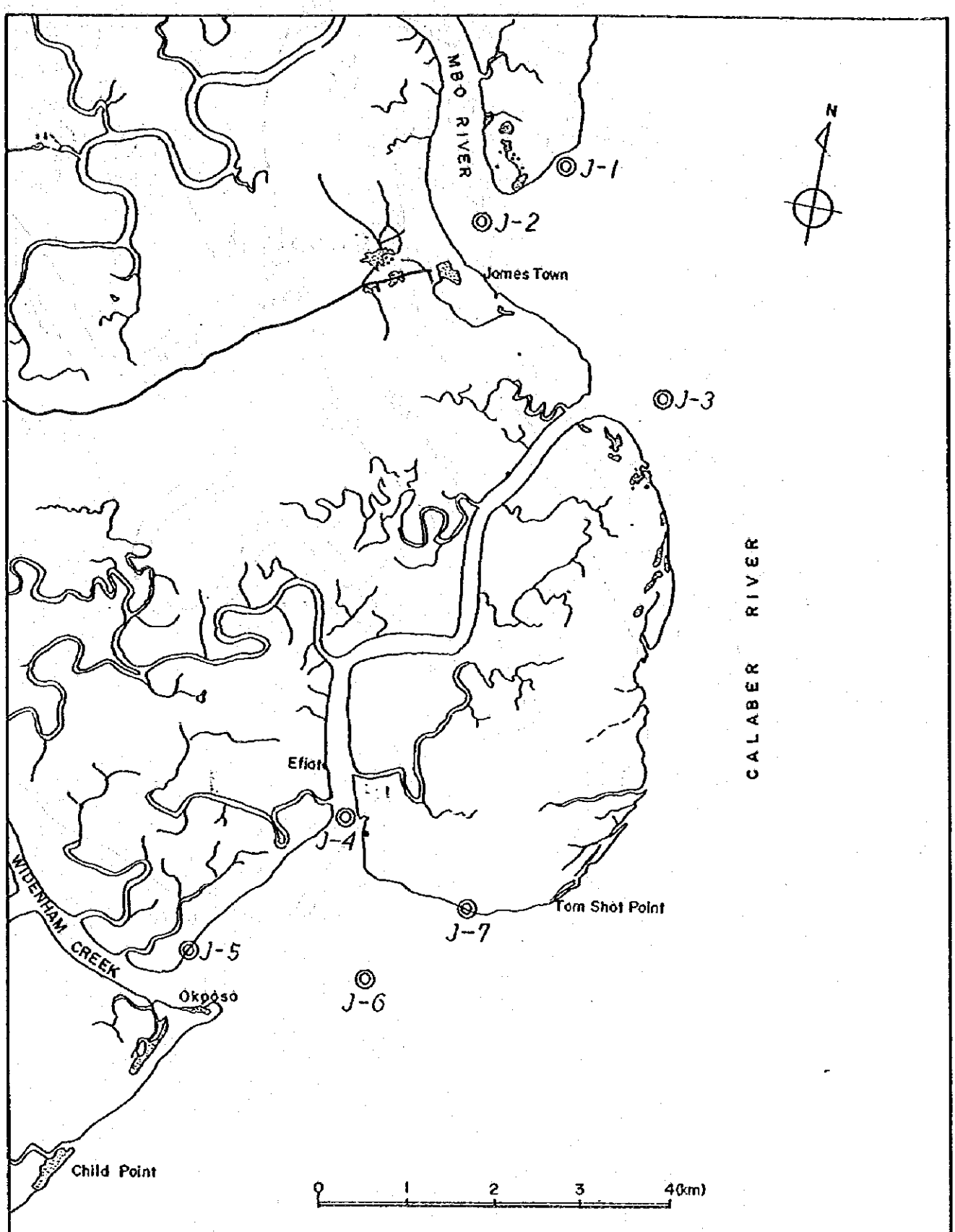


Fig. 3-8 Locality Map of Subsoil Sampling Point

JAMES TOWN

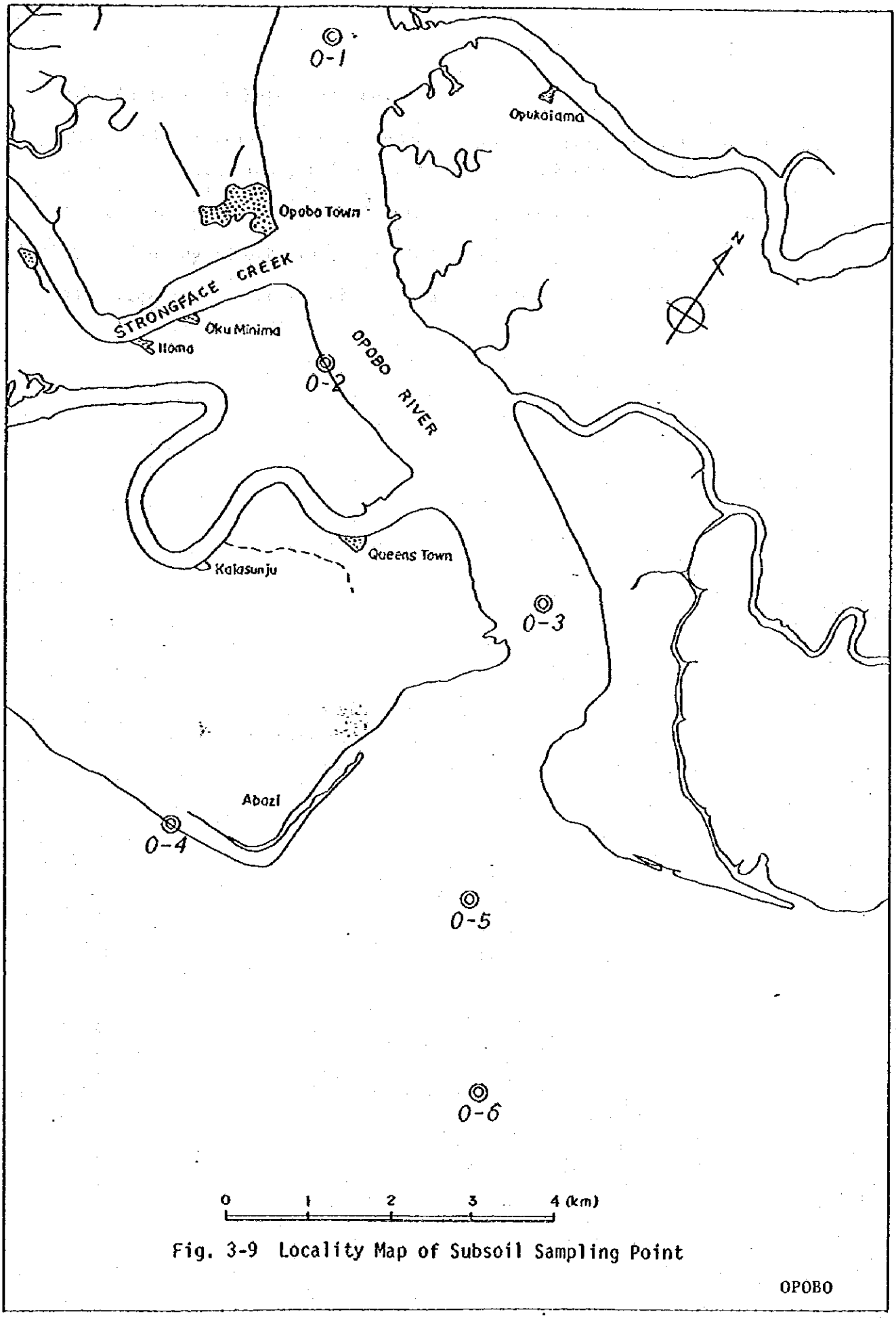


Fig. 3-9 Locality Map of Subsoil Sampling Point

OPOBO

3-7 Analysis of Meteorological Data

The following graphs, tables and diagrams were prepared based upon the data and information provided by the Department of Meteorology.

1) Frequency of occurrence of wind direction (Fig. 3-10)

2) Frequency of occurrence of wind (Fig. 3-11)

3) Frequency of occurrence of wind direction and wind velocity class (Fig. 3-12)

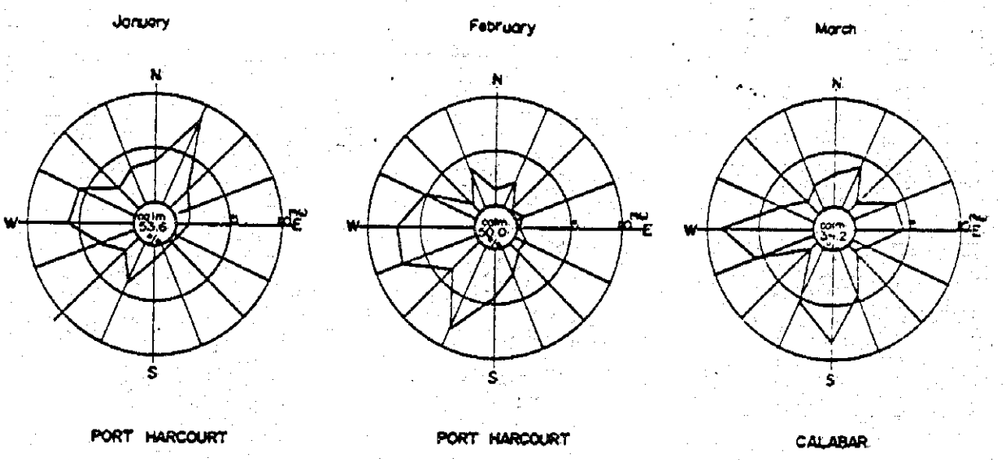


Fig. 3-10 Frequency of Occurrence of Wind Direction

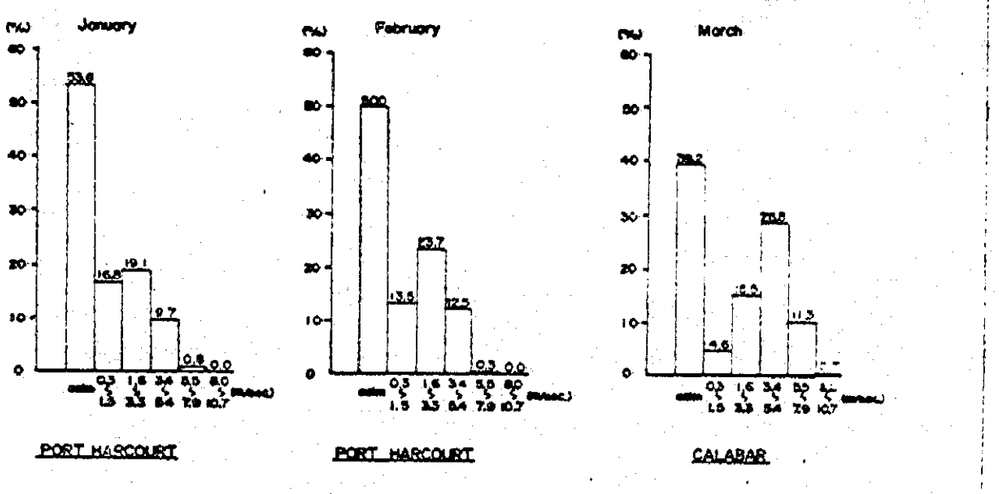


Fig. 3-11 Frequency of Occurrence of Wind Direction

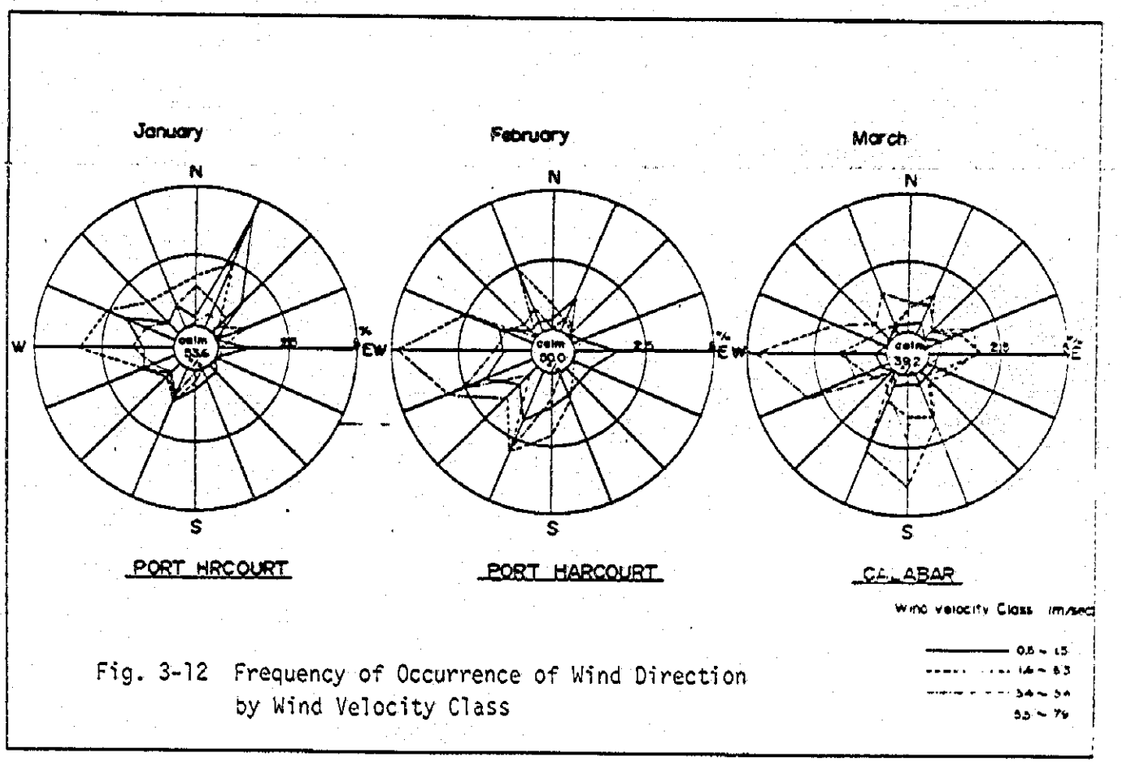


Fig. 3-12 Frequency of Occurrence of Wind Direction by Wind Velocity Class

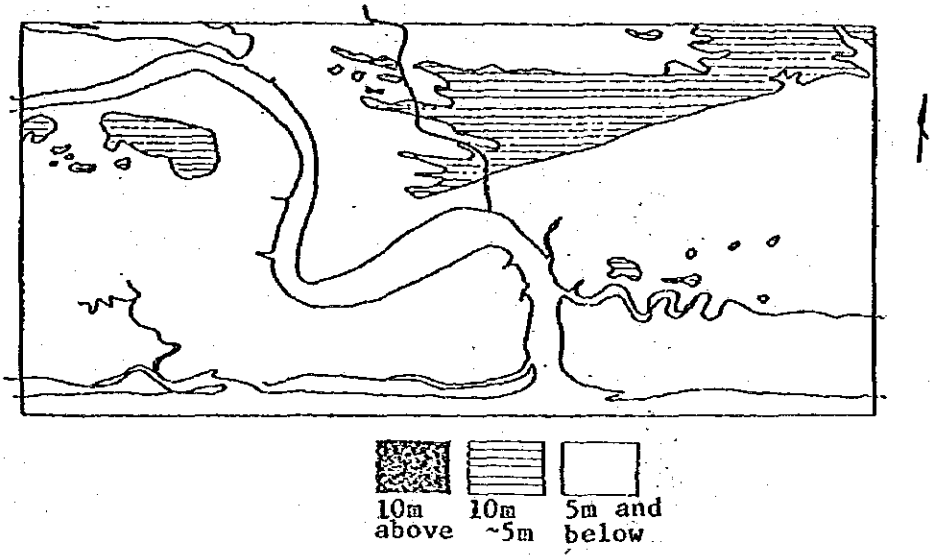
4. RESULTS OF THE ANALYSIS

4-1 Topographical Characteristics of the Project Area

4-1-1 Topographical characteristics of the terrain

The project area terrain was mapped at a scale of 1/10,000, with the contour interval of 1 meter. In the 3 project areas, the terrain extending from the shoreline to the inland area is composed of low wet-grounds covered with dense forests of mangroves and nipa palms, with the same peculiarities being observed along the rivers located in the inland region of the project area. For the topographic analysis, each area was classified by the elevation of 0 - 5m, 5 - 10m and more than 10m respectively and the particulars of each are described as follows:

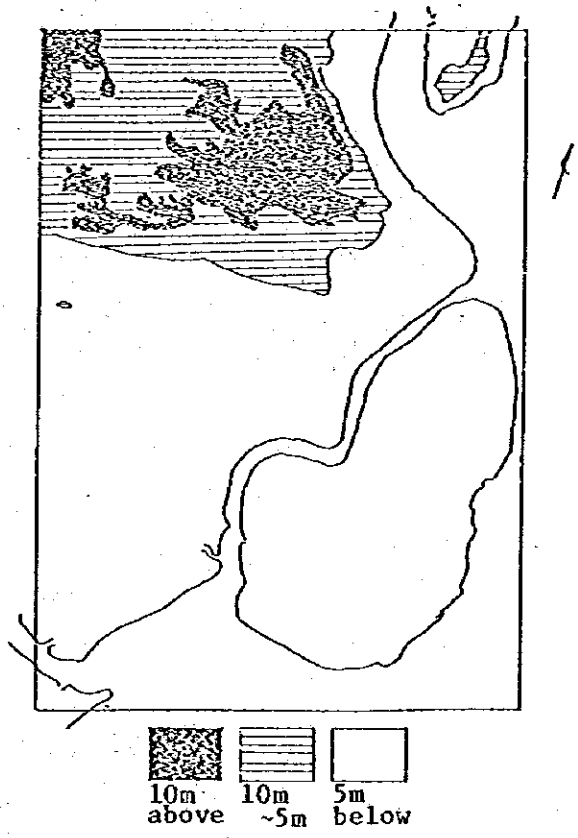
a) IBENO area



Area with elevation not exceeding 5m extends in the coastal region and along the banks of the KWA IBO river, and area with heights of the order of 5m through 10m exists in stripes in the E-W direction, and at some other rare spots. The area with elevation exceeding 10m is found only very seldom at the NW side of the project area, and the highest point in the IBENO area being the spot with the elevation of 11.9m.

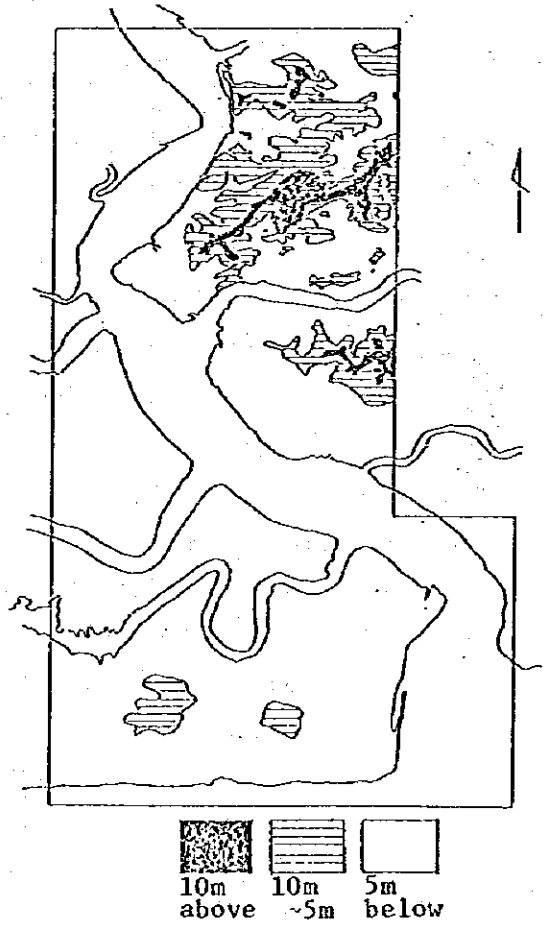
b) JAMES TOWN area

The area with elevation not exceeding 5m extends widely from the shoreline to the inland. However, most of the West side of the hamlet of James Town has an elevation of 5m through 10m and more, composing a plateau. Relatively high elevation of the order of 20m through 24m is found at the NW side of the said hamlet, and the highest point in JAMES TOWN being 25m located at the NW extremity of the project area. The hamlet of JAMES TOWN is distribute over areas with heights varying from 3m through 20m, and the plateau is utilized to palm plantations and farms. Compared with the other two areas, JAMES TOWN has the highest elevation.



c) OPOBO area

Elevation not exceeding 5m are widely found along the IMO river, foward the shoreline. Altitudes ranging from 5m through 10m and those exceeding 10m appear mainly at the NW wide of the project area, where the hamlets of IKOT ABASI, EGWANGE, IKOT ABA, etc., are located. The highest point in the OPOBO area has an elevation of 12.8 meters.



4-1-2 Topography of the shore

a) Opobo area

At the Opobo area the shore can be divided into the estuary section and the beach section. At the estuary section the shore is covered with a dense forest of mangroves and nipa palm. Especially at the river channel they compose directly the water edge line, hence, the naked beach or the shore is very rane. On the other side, which faces the ocean, the beach has a considerable width, and the topography of the shore has an extremely gentle slope.

Particulary the shore located south west of Abazi has a beach width of 150m through 200m at the high tide and reaching approximately 300m at the low tide.

In front of Abazi there is the formation of a sand spit in the North-South direction. There is a very pronounced erosion at the extremity of this sand spit, resulting into a wave-erosion cliff with a relative height of approximately 0.5m. On the other hand, at the South of Abazi there is another sand spit developped in the East-West direction, obstructing the navigation of fishing boats.

b) Ibeno area

Unlike the other two areas, the seashore in the Ibeno area presents a straight configuration. The material composing the seashore is a fine sand with uniform granulation. The topographical cross section of this seashore evidences that the topographical gradient from the in shore to the fore shore has a very gentle slope. There is a small topographical transition area between the fore shore and the back shore, however, back shore is falt. At the vicinity of the KWA IBO river, a beach cliff is developed at the back shore section. Particularly at the right bank of the KWA IBO river there is a wave-erosion cliff with a relative height of approximately 200m and a width of approximately 200m.

The topographical gradient of the fore shore section of the various courses, obtained as aresult of the shore line survey are presented in Table 4-1.

Table 4-1 Topographical Gradient of the Fore Shore Section

Course	1	2	3	4	5	6	7	8	9	10	11	12	13
Gradient	8/100	8/100	2.5/100	6/100	6/100	7/100	8/100	6/100	3/100	10/100	8/100	8/100	6/100

c) James Town area

The James Town area is located at the right bank of the Calabar River. The banks of the MBO river and the Creek existing in front of James town are covered with a dense vegetation up to the water edge line, forming as a result a damp ground. The width of the beach of the parts facing the ocean is small in comparison with the other two areas. However, the seashore topography does not present pronounced differences, and the topographical gradient has a very gentle inclination.

The beach is formed by a fine sand of uniform composition. However, at the river channel and at the creeks, the water edges are covered with a thick surface layer of silt.

4-1-3 Sea bottom topography

a) OPOBO area

In the vicinity of the estuary the sand bank is quite developed, and the water depth is shallower by 1.8m through 2.0m. This and bank is delta shaped, and its front can be observed approximately 5.5km offshore, SSW to the Opobo river estuary. On the other hand, the river channel relatively deep running from 7m through 13m, and the navigation of ships is relatively easy. The water depth in front of the sand bank is approximately 6m, and after that the depth increases gradually toward the direction of the open sea, reaching approximately 19m at point 20km offshore. The topographic gradient from the sand front of the sand bank to a point approximately 20km offshore is of the order of approximate-y 0.8/1,000 through

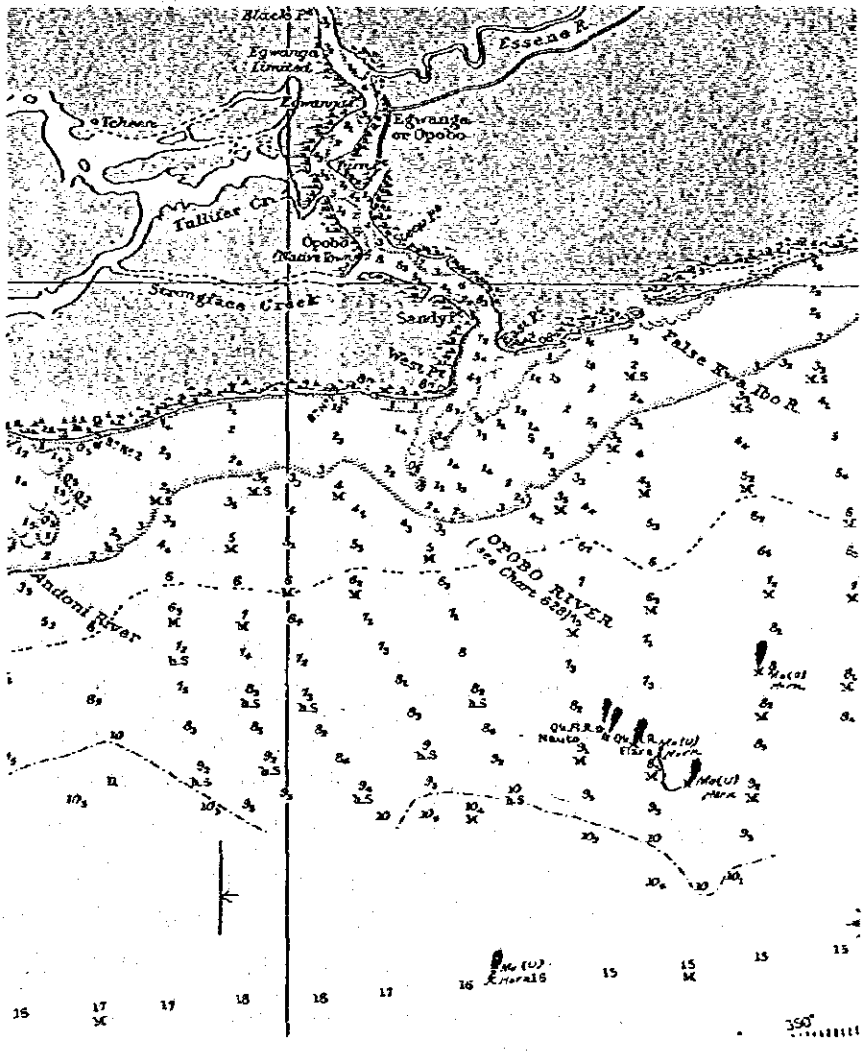


Fig. 4-1 Marine Chart of the Opobo Area

Scale 1:360,625

(SOUNDINGS IN FATHOMS - From the marine chart 1860)

1/1,000. The existence of navigation channel signs can be observed at the estuary of the Opobo river, but no shipping traffic was observed.

b) IBENO area

The sounding chart was prepared for this area. The strike of bed of the coutour line of the sea bottom topographic map indicated that with exception of the estuary, the strike of bed has E-W orientation parallel to the shoreline. In the estuary of the KWA IBO river there is a delta shaped sand bank developed. The sand bank is located in the SE, and approximately at the center of the said sand bank, there is a gutter with the same orientation, with a water depth of approximately 3m. It is presumed that this gutter was formed due to the influence of the current, and we presume that the actual river water flow is dominantly in the SE direction. (Approximatley 4km to the SE of the estuary, an open sea point with a water depth of 7m through 10m, the coutour line present some curves.) The said curves are presumed to influence of the configuration of the valley formed by the KWA IBO river in acient times upon the topography of the sea bottom.

The sea bottom topographic gradient of the surveyed area presents an inclination of 1/1000 from the shoreline to a depth of 10m, and from that point to a depth of 20m the slope is of the order of 0.5/1000. Generally speaking, there are few undulations, and the topography has a very gentle slope. The distance from the shoreline to points with a water depth of the order of 20m is approximately 25km. On the other hand, at the river the water is relatively deep, approximately 6m through 9m, and the navigation of ships is relatively easy. The tug boats of Mobil Oil carry out the transportation of commodities by utilizing the high tide, when they advance into the river channel. The ship used at for the present survey succeeded also at entering into the estuary, by utilizing the high tide on April 2nd. Following data the concerning the specifications of the survey ship is provided as a reference.

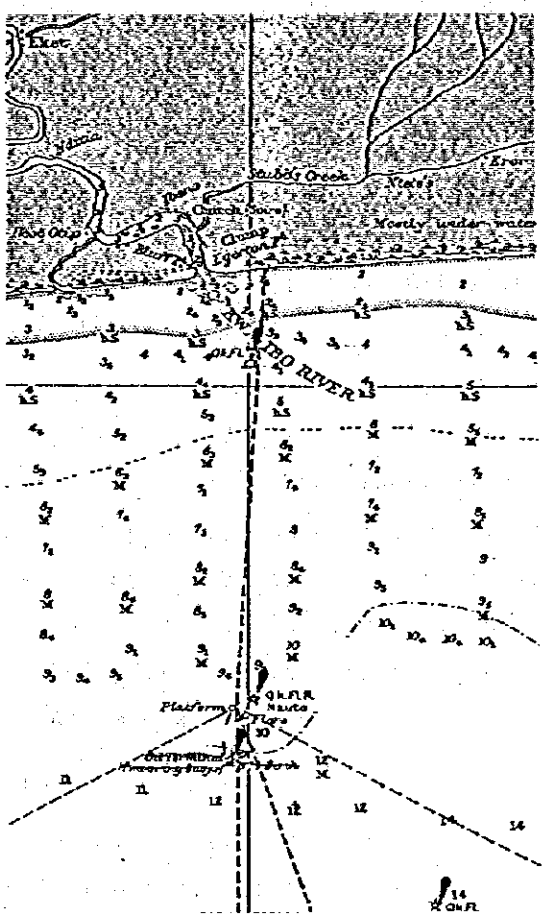


Fig. 4-2 Marine Chart of the Ibeno Area

Scale 1:360,625

(SOUNDINGS IN FATHOMS -
From the marine chart 1860)

<M.K. KHAN Specifications>

Depth	3.6m
Draft	2.95m
Length	35.0m
Breadth	8.5m
Gross tonnage	238.94t
Net tonnage	113t

The comparison of the sounding data obtained at occasion of the present survey and the topographic cross section of the marine charts (Marine chart No. 1860, BONNY RIVER TO RIVIERE CAMEROUN) is presented in Figure 4-3.

The data obtained as a result of the present survey and the topographic cross section configuration presented in the marine chart are similar, and the topographic gradients coincide. Data referring to the water depth present a difference of the order of 1.5m at some points. The strike of the coutour line bed of present some differences at points with the depth of water around 20m and at the vicinity of the river estuary, but generally they coincide at other areas.

c) James Town area

The distribution of a large scale sand bank is observed at the South of Tom Shot point. At the East of James Town there are places with gut depth at the right bank of the CALABAR river, but the areas in front of James Town and the river channel of the MBO river have relatively small water depth. The large creek located on the South side of James Town is deep, but it gets rather shallow, around 2m in the vicinity of the point where the creek enters the ocean, at the South side of Efiat. The existence of navigation channel signs at this shallow sea area was confirmed, but no shipping traffic was observed.

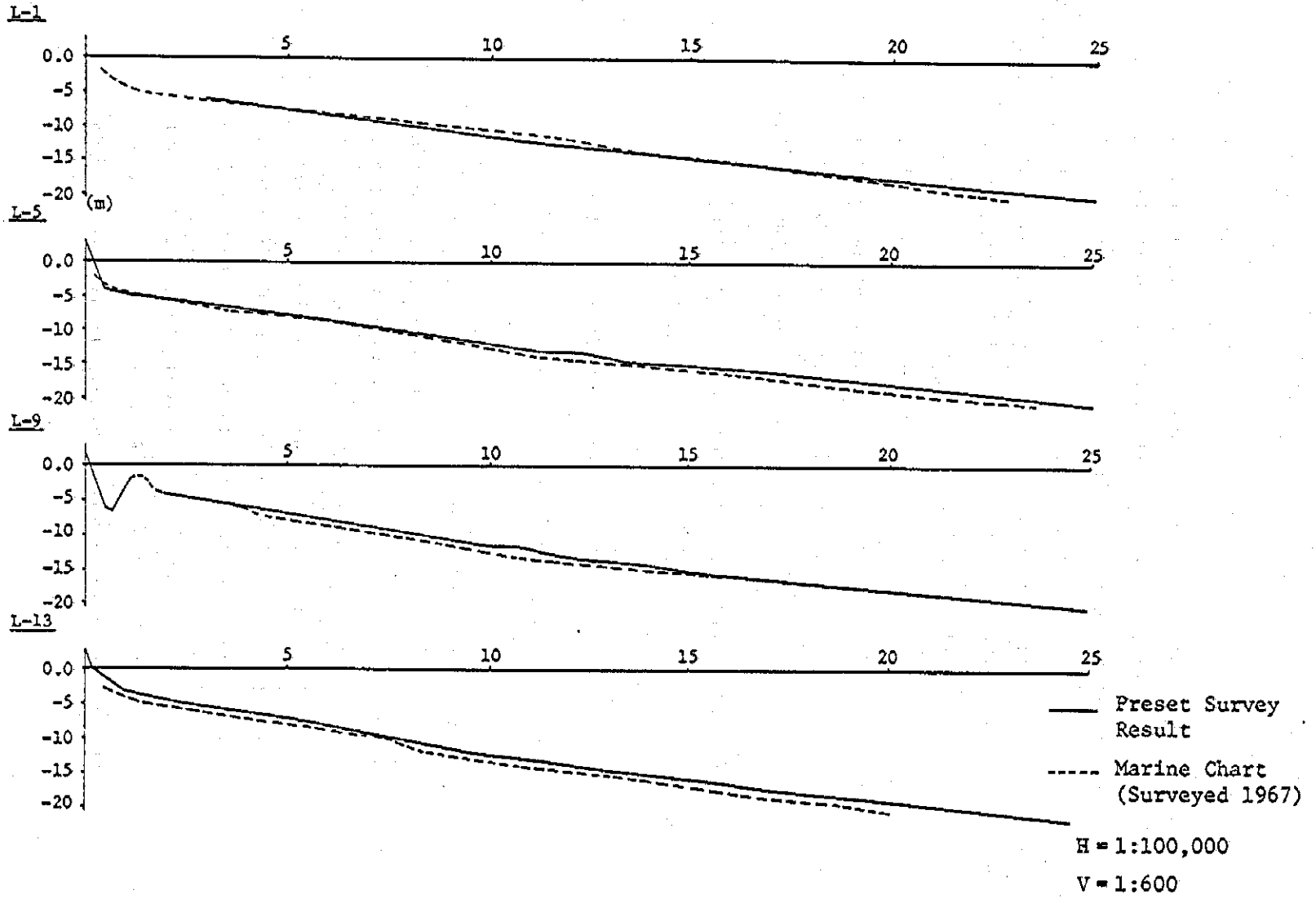


Fig. 4-3 Comparison of Topographical Cross-Section (Sea bottom)

4-2 Sea Conditions in the Survey Area

4-2-1 Tides

a) Tidal harmonic analysis

The values of the various elements shown in Table 4-2 are calculated as a result of the harmonic analysis utilizing the hourly tide height values (Table 3-6) obtained as a result of the tidal level observation (March 20th through April 19th) carried out at the Ibeno area. Among the various elements presented in the mentioned table, particularly the values of M_2 and S_2 of the principal 4 constituent tides (K_1 , O_1, M_2, S_2) are larger compared with the other constituent tides.

It is possible to have a general idea of the tidal type in the area in question, by means of the tide harmonic constants of the principal 4 constituent tides.

Tidal type coefficient $F = (K_1 + O_1)/(M_2 + S_2)$

$F < 0.25$	Semidiural tide (twice; high and low tide a day)
$0.25 \leqq F < 1.50$	Mixed tide
$1.50 \leqq F$	Diurnal tide (once; high and low tide a day)

The tide type coefficient $F = 0.22$ is obtained by substituting the values corresponding to the principal 4 component tides obtained by the present survey in the equation above, evidencing that the tide of the area in question is semidiurnal. This tendency is observed also in the characteristics of the occurrence intervals of the daily high tide and low tide and in the tide height recorded in the daily observation of the tide level (Table 3-6).

The surveyed area presents a typical semidiurnal tide cycle type tide. As shown in Table 4-4, the maximum value of the difference between high water and low water recorded at the occasion of the

Table 4-2 Results of the Tide Harmonic Analysis

Component tide symbol	Half tide difference (H)	Delay angle (K)
Mean sea level	m	
S0	3.4538	0.0
Long period tide		
Mm	0.0471	60.25
Msf	0.0066	91.69
Diurnal period tide		
Q1	0.0027	243.98
O1	0.0308	330.56
M1	0.0044	78.46
K1	0.1443	12.06
J1	0.0045	49.72
OO1	0.0050	142.63
P1	0.0478	8.95
Semidiurnal tide		
M2	0.0197	19.03
N2	0.1153	115.92
M2	0.5961	123.42
L2	0.0253	97.97
S2	0.2002	154.37
2SM2	0.0015	7.25
K2	0.0545	156.88
V2	0.0224	116.93
T2	0.0118	153.13
Terdiurnal tide		
MO3	0.0022	237.72
M3	0.0031	183.38
MK3	0.0095	82.07
Quater-diurnal tide		
MN4	0.0216	246.73
M4	0.0357	305.90
SN4	0.0060	242.27
MS4	0.0238	11.92
1/6 day cycle tide		
2MN6	0.0143	47.08
M6	0.0261	77.39
MSN6	0.0042	122.76
2MS6	0.0356	151.19
2SM6	0.0085	224.04

tidal level observation is 2.19m. (Minimum level observed at 10.50 hrs of April 4th and maximum level observed at 17.50 hrs of April 5th). The comparative tidal observations carried out in Opobo and in James Town evidence that these two areas have also semidiurnal tides

b) Tide level relation diagram

Figure 4-5 presents the tidal level relation prepared based upon the tidal level observation results referring to the survey area. The methods of calculation for the various water levels are as follows.

i) Mean sea level (M.S.L)

The short term mean sea level corresponding to the period March 20th to April 19th was calculated based upon the tidal observation data collected at the Ibeno area. The seasonal changes of mean sea level occurring in Lagos was added to the short term mean sea level mentioned above, in order to calculate the mean sea level of the surveyed area.

$A_0 = S_0 - Se$

$= 3.45 - (+0.10)$

$= 3.35$m (on the zero level of the tidal gauge)

A_0: Mean sea level

S_0: Short term mean sea level

S_e: Seasonal changes of mean sea level in LAGOS.

Table 4-3 Seasonal Changes of Mean Sea Level

Jan.I	Feb.I	Mar.I	Apr.I	May I	Jun.I	Jul.I	Aug.I	Sep.I	Oct.I	Nov.I	Dec.I
0.0	0.0	+0.1	+0.1	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0

Unit: m

Lagos: Lat. 6°24'N
Long. 3°24'E

ii) Datum level (D.L.)

The datum level is the value obtained by subtracting from the mean sea level (M.S.L.). The sum of the 4 principal constituent tides $Z_0 = (K_1 + O_1 + M_2 + S_2)$ obtained as a result of the tidal harmonic analyses.

$$D.L = A_0 - Z_0$$
$$= 3.35 - 0.97$$
$$= 2.38m \text{ (above zero for tidal gauge)}$$

iii) Highest high water and lowest low water (H.H.W and L.L.W)

These are the maximum high water and the minimum low water recorded during the tidal level observation period. The maximum value 2.16m was observed at the high tide which occurred on April 5th, while the minimum value of -0.03m was observed on April 4th. Both figures mentioned above refer to the D.L.

iv) Mean high water (M.H.W) and mean low water (M.L.W)

The harmonic constants calculated by means of the tidal harmonic analysis are used as for the estimation the mean high water and mean low water of the spring tide and neap tides. The various tide levels are calculated by using the following expressions, because the tide type in the survey area is semidiurnal one.

Mean high water level of the spring tides:	Mean sea level + (Hm + Hs)
Mean low water level at the spring tides:	Average sea level - (Hm + Hs)
Mean high water level of the neap tides:	Mean sea level + (Hm - Hs)
Mean low water level of the neap tides:	Mean water level - (Hm - Hs)

Mean sea level = D.L + 0.97m

Hm: Amplitude of M_2 constituent

Hs: Amplitude of S_2 constituent

As a result of the above considerations, the relation between the ground control point of the 3 survey areas and the tidal level can be summarized as shown in Figure 4-4.

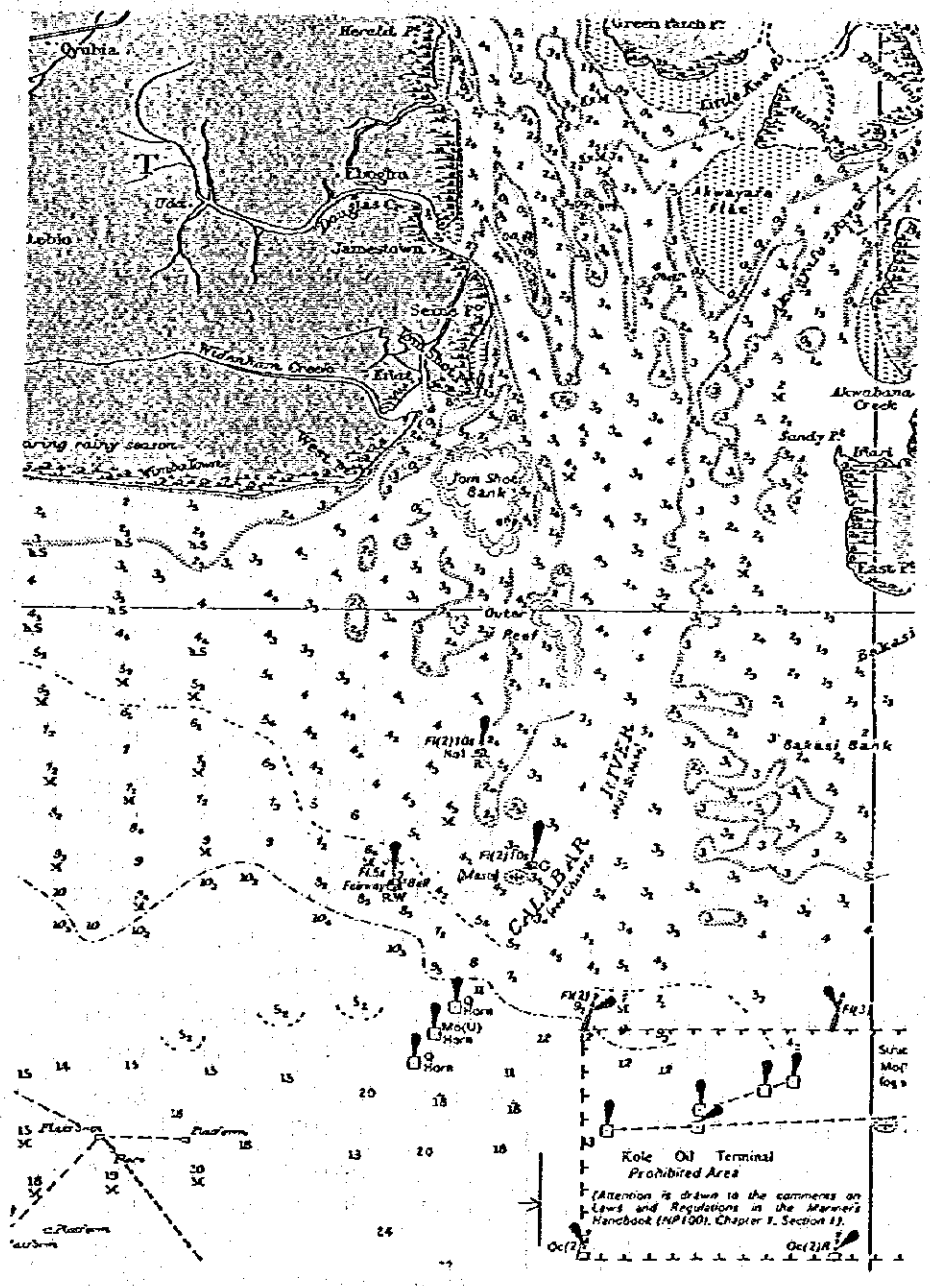


Fig. 4-4 Marine Chart of the James Town Area

Scale 1:360,625

(SOUNDINGS IN FATHOMS -
From the marine chart 1860)

Table 4-4 Daily High Water and Low Water (Ibeno Area)

Date	High water		Low water	
	Time	Tide level	Time	Tide level
3.19	16:50	1.81	22:40	0.20
20	5:00 17:30	1.77 1.91	11:00 23:30	0.12 0.24
21	4:40 17:50	1.84 1.91	11:40 23:20	0.10 0.20
22	6:00 18:20	1.81 1.91	12:00	0.12
23	6:30 19:00	1.78 1.88	0:40 12:40	0.14 0.14
24	7:20 19:30	1.73 1.83	1:10 13:20	0.19 0.21
25	7:30 20:00	1.62 1.71	1:20 13:20	0.22 0.27
26	8:10 20:30	1.50 1.64	2:10 14:00	0.25 0.44
27	9:10 21:20	1.45 1.53	2:30 14:30	0.39 0.58
28	9:00 22:00	1.36 1.45	3:50 15:20	0.47 0.65
29	12:20 23:30	1.32 1.42	4:20 16:30	0.59 0.79
30	13:20	1.39	5:50 18:20	0.57 0.72
31	0:20 14:05	1.42 1.52	7:30 20:30	0.45 0.62
4. 1	2.28	1.53	8.20 20:55	0.25 0.53
2	3:00 15:20	1.67 1.75	9:00 21:30	0.32 0.39
3	3:40 16:20	1.72 2.00	22:20	0.16
4	4:30 17:10	1.94 2.12	10:50 23:00	*0.03 0.09

Date	High water		Low water	
	Time	Tide level	Time	Tide level
4. 5	5:30 17:50	*2.02 *2.16	11:30 23:45	0.00 0.02
6	5:55 18:30	2.04 2.15	12:10	-0.02
7	6:45 19:10	1.96 2.11	0:30 12:50	-0.02 0.02
8	7:30 20:20	1.91 1.94	1:20 13:25	0.01 0.06
9	8:20 21:00	1.88 1.92	2:00 14:00	0.06 0.37
10	9:00 21:55	1.67 1.70	2:35 15:00	0.25 0.51
11	11:00 23:10	1.52 1.65	4:00 15:35	0.41 0.75
12	13:20	1.55	5:00 17:50	0.50 0.87
13	0:15 13:55	1.53 1.61	5:50 19:25	0.57 0.71
14	2:10 14:35	1.49 1.61	7:15 19:40	0.51 0.67
15	2:50 15:30	1.59 1.68	8:30 21:05	0.39 0.34
16	3:30 15:35	1.64 1.71	9:35 22:00	0.29 0.36
17	4:00 16:25	1.68 1.79	10:00 22:30	0.31 0.31
18	4:30 16:50	1.74 1.81	10.40 23:05	0.23 0.22
19	4:55 17:30	1.64 1.76	11:15 23:20	0.14 0.09
20	5:40	1.62	11:40	0.13

* Water level (m) above the D.L.

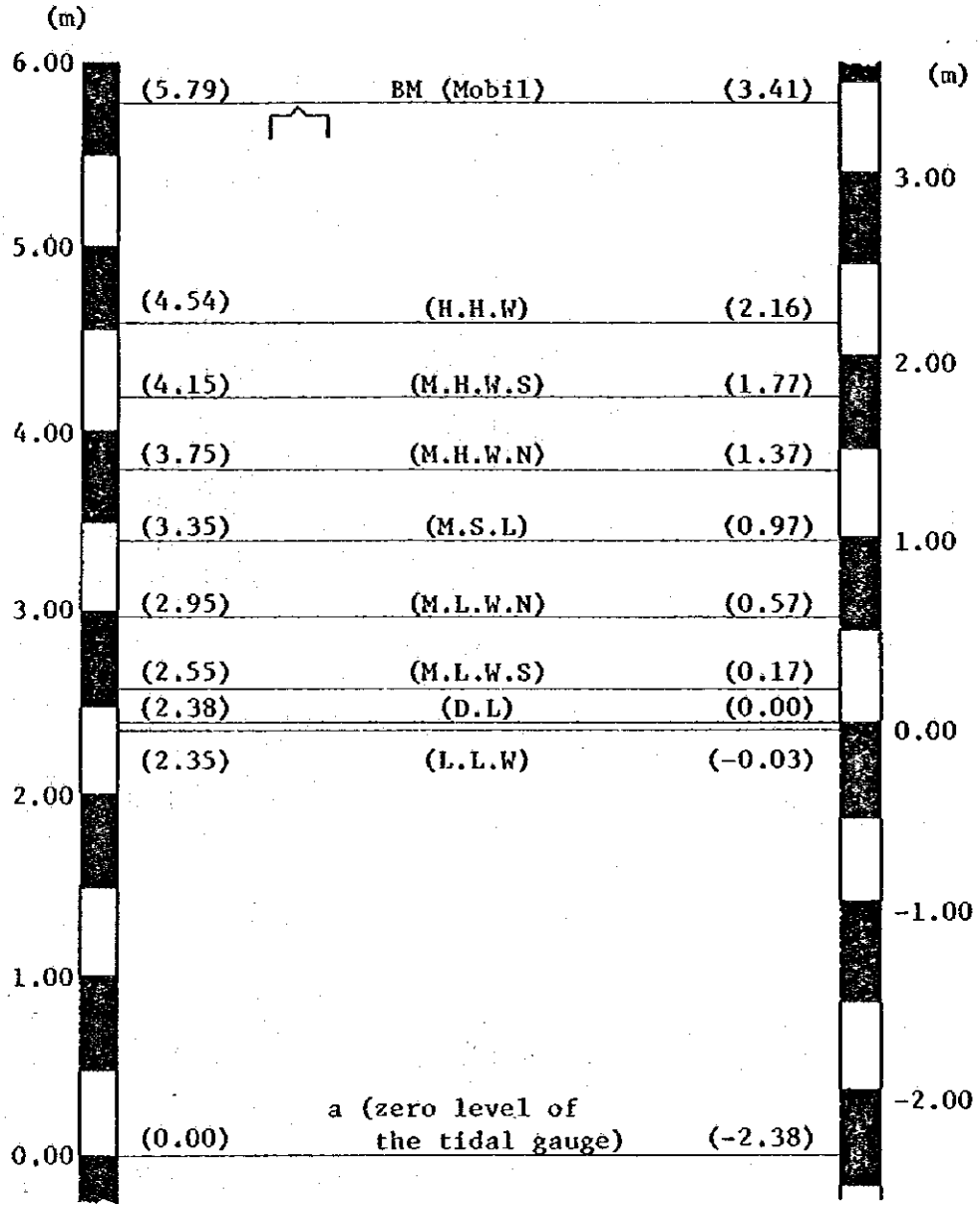


Fig. 4-5 Tidal Diagram

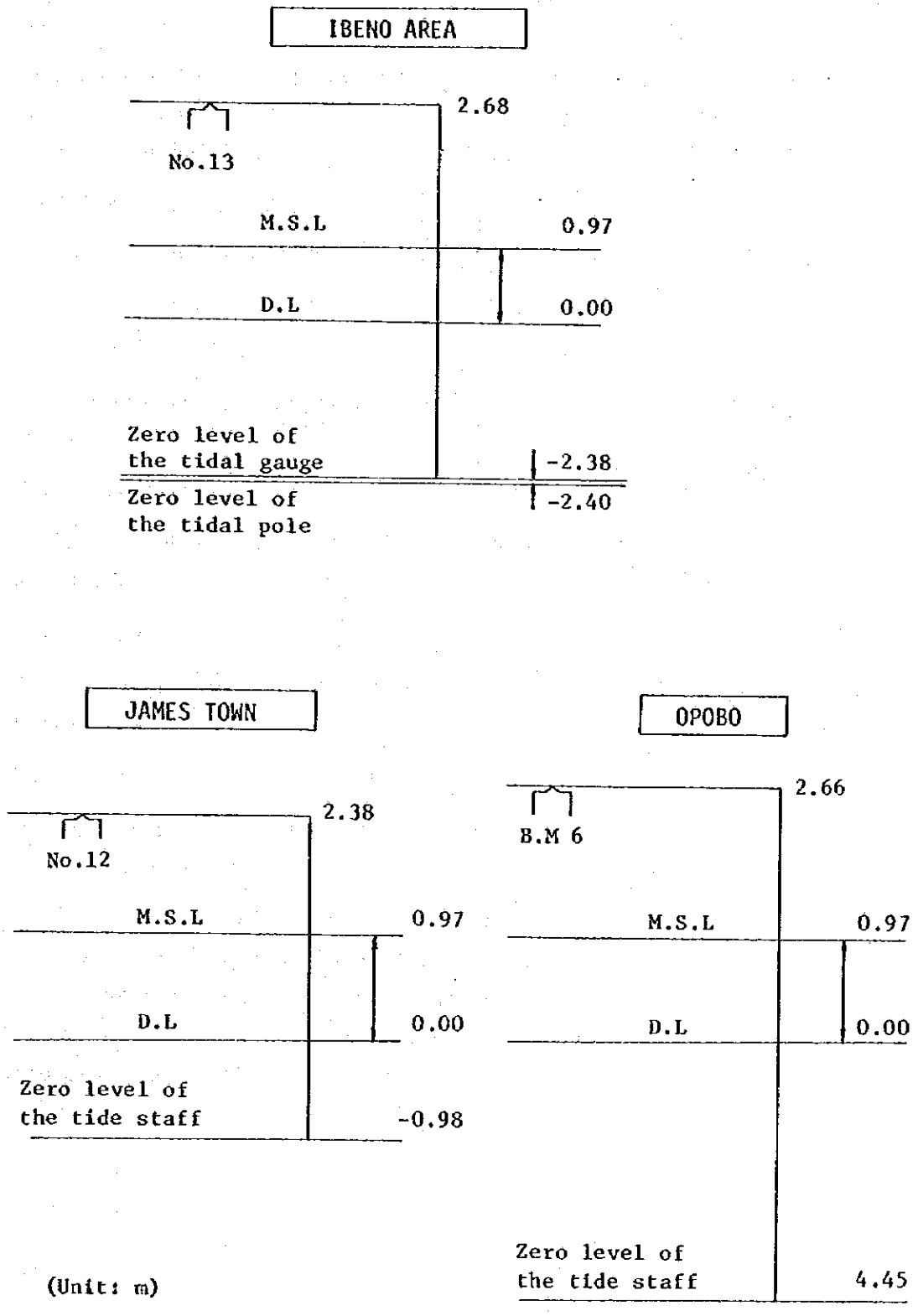


Fig. 4-6 Diagram of Relation to the Ground Control Point

4-2-2 Waves

The meteorological conditions and waves on the sea at the shore of the Ibeno area were observed during the period of 8 days extending March 20th and May 7th. The results of the observations are shown in Table 3-10.

i) Wind direction

During the observation period the wind direction was dominantly S and SW.

ii) Wind speed

A maximum wind speed value of 11m/sec was recorded during a squall.

iii) Wave direction

During the observation period the wave direction was dominatnly S and SW.

iv) Wave height

During the period of observation the maximum value of the wave height was 1.5m.

v) Wave period

During the period of observation the wave period was dominantly 9 sec. through 10 sec.

At the vicinity of the river estuary the sand banks developed at its front side plays the role of wave breaker. Particularly at the low water time, the sea inside the river channel and at the estuary of the river is calm. Tendencies similar to that occurring in Ibeno were also observed in the other 2 areas.

4-2-3 Currents

The current at the estuary and on the sea in the Ibeno area was observed during the period of 5 days of March 20th, 21st, 30th, 31st and April 1st. (The results of observation are shown in Table 3-11 through Table 3-13).

The direction of the current at the estuary of the river is in the upstream direction at the high water time and in the downstream direction at the low water time, evidencing the influence of the tide effect. The velocity is higher in the downstream direction, a maximum value of 1.30m/sec. was recorded.

The distribution of the water current in accordance with the measurement depth presents the following peculiarity: when the river flows in the downstream direction the upper layers present higher speeds compared with the lower layers, while when the river flows in the upstream direction, the inverse takes place, i.e., the lower layers present higher speeds compared with the upper layers.

During the period of observation, the direction of the marine current in the offshore area of the estuary was predominantly in the NNE direction. The velocity was of the order of 0.10m/sec through 0.30m/sec.

4-2-4 Water quality

The water quality was analized at the points No. 2 and No. 3, aiming at grasping the outline of the water environmental conditions prevailing at the estuary of the KWA IBO river. The results of the said measurements are summarized in Table 3-14.

According to the said data, the water temperature is of the order of 28°C, the pH is alkaline at the No. 2 point (estuary) and acid at the No. 3 point. As for the DO, this is a parameter prone to be influenced by factors like the conditions of contact with the atmosphere, the changes of temperature, quantity and nature of the dissolved matter, proliferation of the marine flora and fauna, etc. Assuming the river

conditions presented in Table 3-15, i.e., water temperature of 28°C and chlorine ion quantity of Oppm, the values measured by us were lower compared with the DO of fresh water, i.e., 7.75ppm. However, in view of the proximity of the measurement point to the estuary of the river and the fact that there is a sufficient influence of the sea water, the value mentioned above is just slightly lower compared with fresh water, evidencing that the area in question has a relatively good water quality.

4-3 Meteorology of the Survey Area

Aiming at grasping the meteorological conditions at the vicinity of the survey area, the monthly average values of the meteorological data of PORT HACOURT corresponding to the period of 6 years extending from 1976 through 1981 was calculated. The figures expressing the rainfall, humidity, average wind speed (maximum, minimum and average) are summarized in Table 4-5.

According to the data presented in the said table, the annual rainfall exceeds 2300mm, and 76% of the annual value is concentrated in the period extending from May to October, when the ITCZ moves to the Northern part of Africa. The relative humidity is very high, exceeding 80% throughout the year, particularly in September, when it exceeds 90%. As for the wind speed, it is of the order of 22m/sec. in March and April. On the other hand, with reference to the temperature, it presents a small change throughout the year, and the difference between the maximum temperature and the minimum temperature is of the order of 10°C. Summarizing the monthly meteorological elements of the various years, the monthly maximum wind speed and wind direction presented in Figure 4-7 and Figure 4-8 can be summarized as shown in Figure 4-9.

Table 4-5 Mean Values of Meteorological Data from 1976 to 1981 at PORT HARCOURT

Month	Rainfall (mm)	Humidity (%)	Maximum wind velocity (m/sec)	Temperature (°C)		
				Max.	Min.	Mean
Jan.	17.0	80.7	12.1	32.3	21.4	26.9
Feb.	89.5	82.5	17.3	32.9	22.9	27.9
Mar.	137.8	83.1	22.9	32.4	23.2	27.8
Apr.	184.1	85.4	22.3	31.7	23.4	27.6
May	215.6	86.4	18.0	31.0	23.2	27.1
Jun.	319.1	89.1	11.7	29.3	22.9	26.0
Jul.	247.9	89.5	9.2	28.3	22.4	25.4
Aug.	300.2	88.8	8.7	28.2	22.6	25.4
Sep.	359.1	90.2	14.4	29.3	22.6	25.9
Oct.	33.40	89.1	14.5	29.8	22.7	26.3
Nov.	127.4	85.6	15.7	31.0	22.5	26.7
Dec.	10.8	80.2	9.6	31.7	21.3	26.5
Total or Mean	2342.5 195.2	85.9	14.7	30.7	22.6	26.6

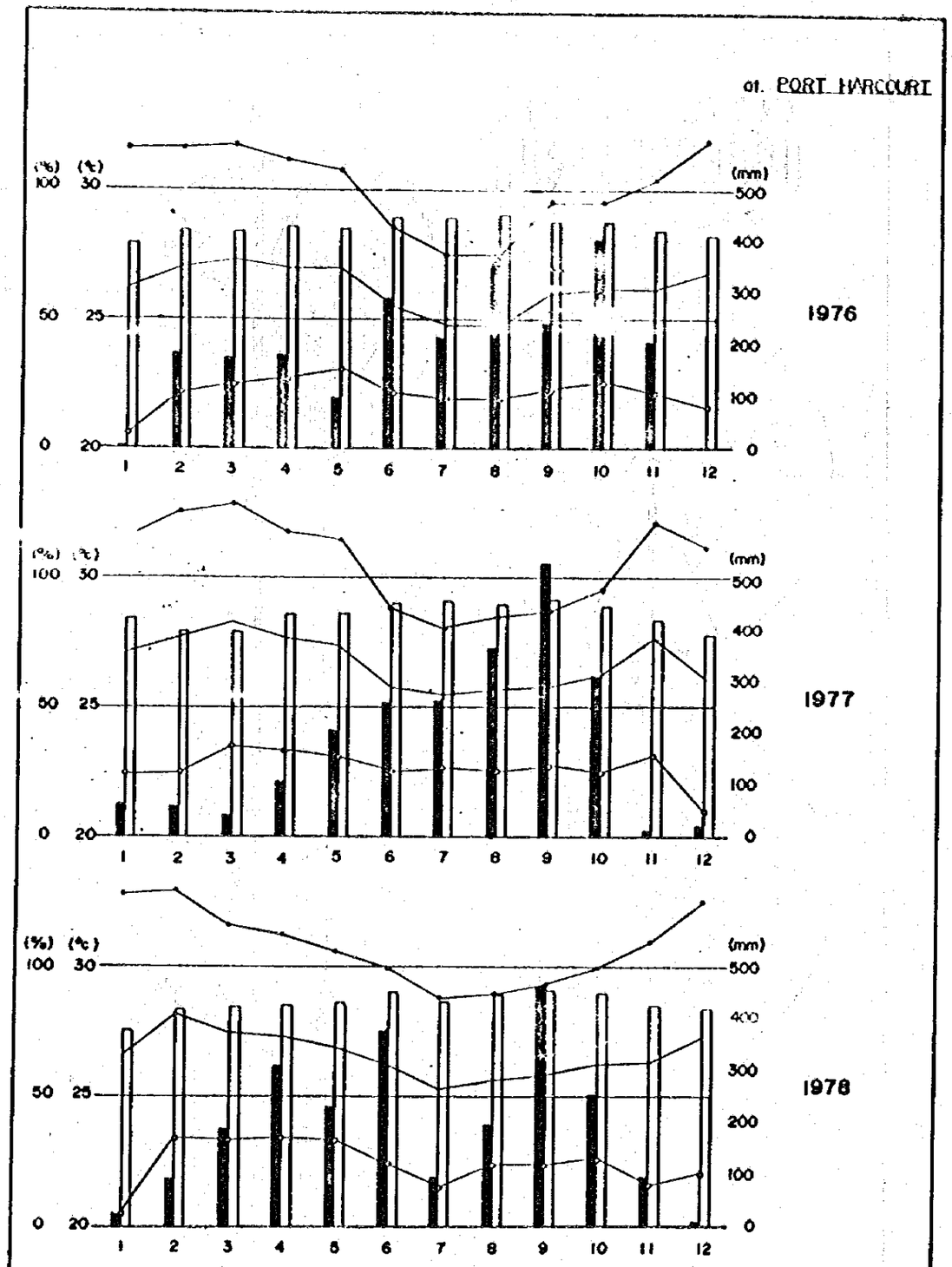


Fig. 4-7 Monthly Meteorological Variation (1976 ∿ 1978)

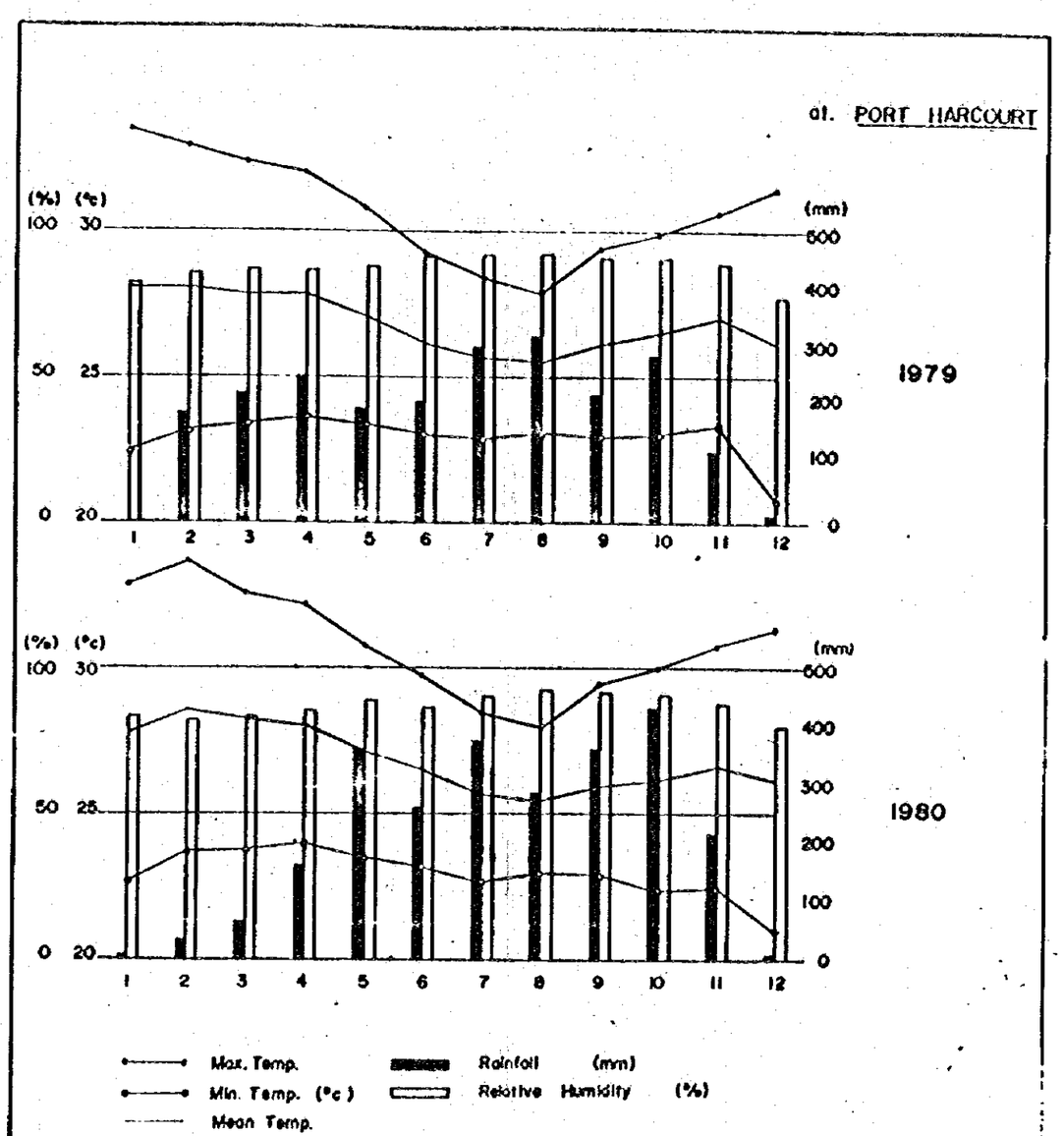


Fig. 4-8 Monthly Meteorological Variation (1979 ∿ 1980)

at. PORT HARCOURT

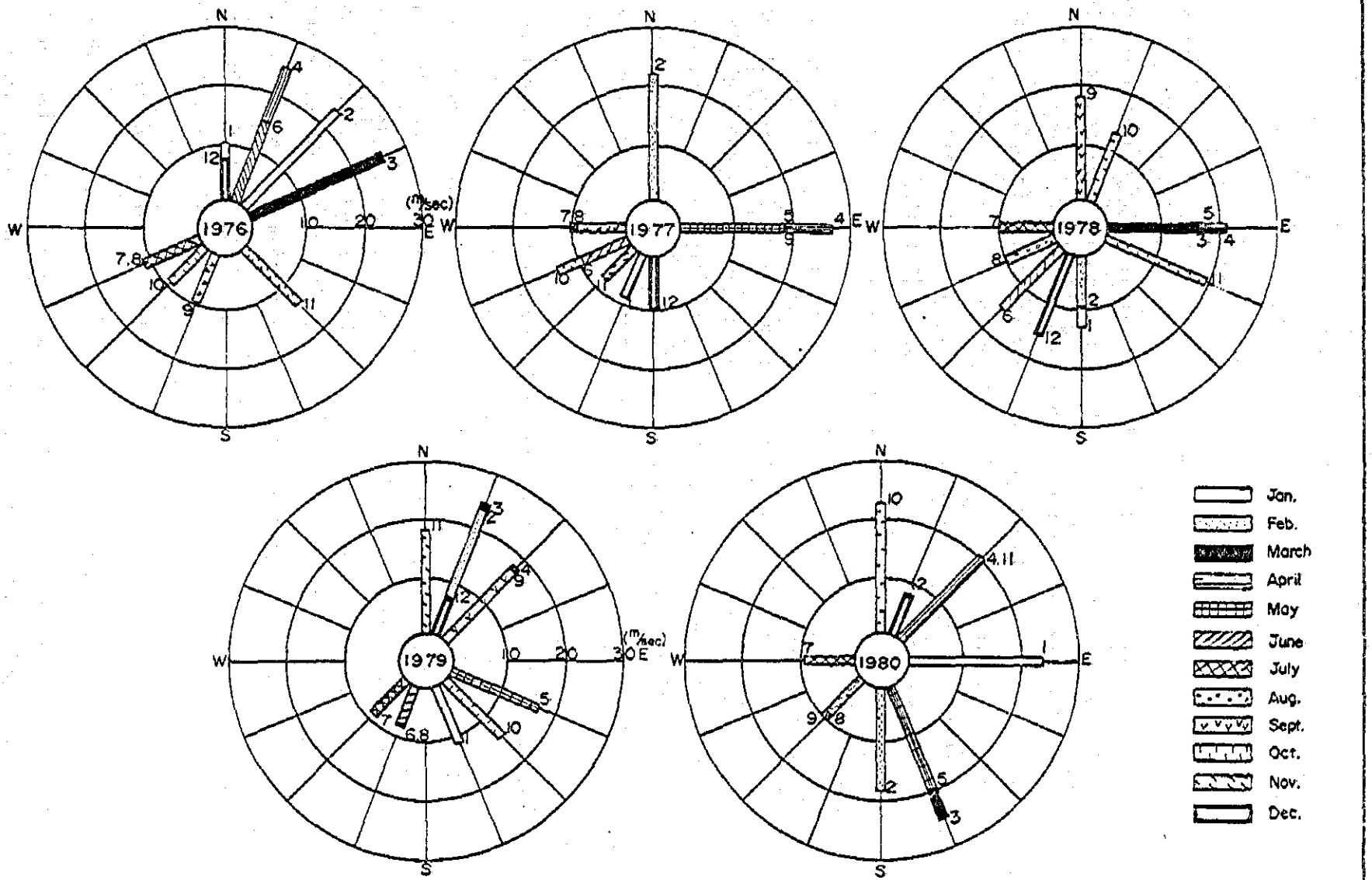


Fig. 4-9 Monthly Max Speed and Direction (1976 ∿ 1980)

5. SUMMARY

Aiming at examining the aspects referring to the adequacy of the port development and the functions and scale of the port development, we carried out the survey of the 3 proposed project areas (Ibeno, Opobo and James Town), including the topographical mapping at the scale of 1/10,000, the sounding and the oceanographic observation. The observation of the tide level was carried out aiming particularly at determining the zero altitude point, and that point was determined based upon the results of the said observations.

1. 1/10,000 topographical map.

   At all project areas the topographical map was drawn with 1m principal contour by using stereo plotter, after determining arbitrarily the origin point of the coordinate system, setting the control point by means of the traversing, measuring the altitude by means of the indirect levelling and carrying out the aerial triangulation.

2. The sounding was carried out along 13 surveying lines, over an extension of 15 km on the shore. Among the 13 surveying lines, the survey was carried out up to 20 km offshore in 4 of them. The survey results and the topographical cross section of the marine chart are similar, and they coincide also with the topographical slope. Differences of the order of 1.5m were observed at some points in the comparison of the depth. The direction of the isobath presented some differences at depths of approximately 20m and at the neighbouring of the river estuary, but they coincided at the other areas.

3. Oceanographic characteristics

(1) Tide

The observation of the tide was carried out in the Ibeno area from March 20th through April 19th, and the obtained results

indicated that a typical semidiurnal cycle type tide occurs in this area. The maximum difference of level between the low tide and the high tide is 2.19m. (The minimum level took place at the 10:50 o'clock of April 4th, while the maximum level took place at 17:50 o'clock of April 5th. The results obtained at Opobo and James Town indicate that the semidiurnal cycle type tide occur also in those areas.

(2) Waves

The observation of the meteorologic characteristics and waves was carried out on the sea and at the seashore for 8 days during the period extending from March 20th through May 7th. The obtained results are as follows.

i)	Wind direction	Dominantly from S and SW
ii)	Wind speed	Maximum 11m/sec during the squall
iii)	Wave direction	Dominantly from S and SW
iv)	Wave height	Maximum 1.5m
v)	Period	Dominantly 9 sec. through 10 sec.

The sand bank developed in front of the river estuary area have wave absorbing effects, and accordingly, the river estuary and the interior of the river channel were very calm at the low tide. Similar tendencies were observed also in the Opobo and James Town areas.

(3) Ocean currents

The measurement of the speed of the ocean currents was carried out at the river estuary and on the sea in the Ibeno area. The direction of flow of the water was in the downstream direction during the low tide time and in the upstream direction during the high tide time, with a maximum speed of 1.3m/sec. in the downstream

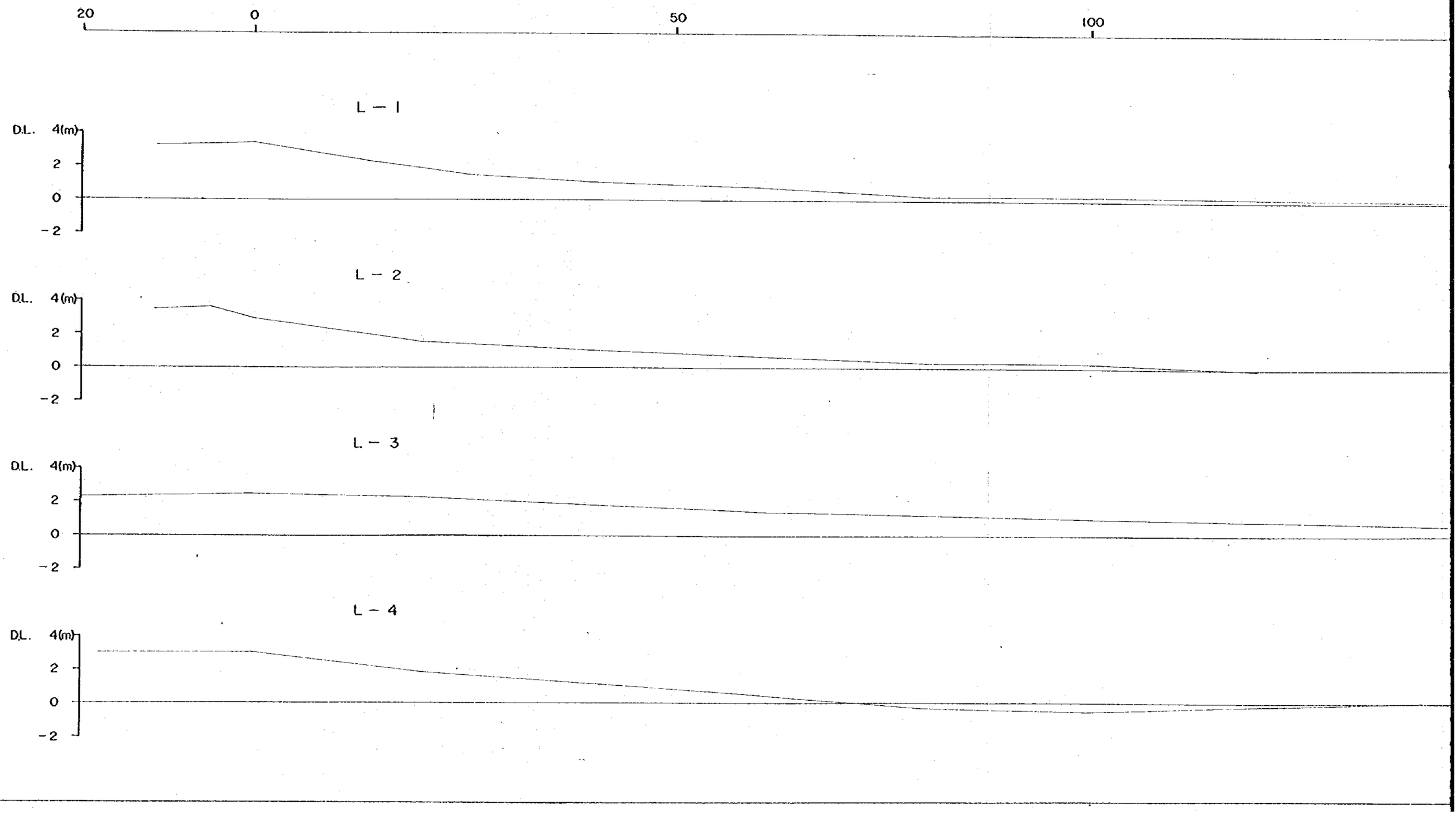
direction. As for the variation of the speed according to the water depth, the upper layers present higher speeds in the downstream direction, while the lower layers are more rapid in the upstream direction.

The ocean current in the sea area (offshore of the river estuary) has dominantly NNE direction, and the speed is of the order of 0.10 through 0.30m/sec.

(4) Meteorologic characteristics

The monthly averages values of the meteorologic data referring to the period of 6 years, extending from 1976 through 1981 were calculated from the collected information. Rainfall is concentrated in the period extending from May to October, with approximately 76%, the humidity has a high average of 80% throughout the year and in September is reaches more than 90%. The maximum wind speed was 22m, recorded in March and in May. The variation of the temperature is small throughout the year, and the difference between the maximum and minimum is of the order of 10°C.

Fig-1 Topographical Cross-Section (shoreline area)



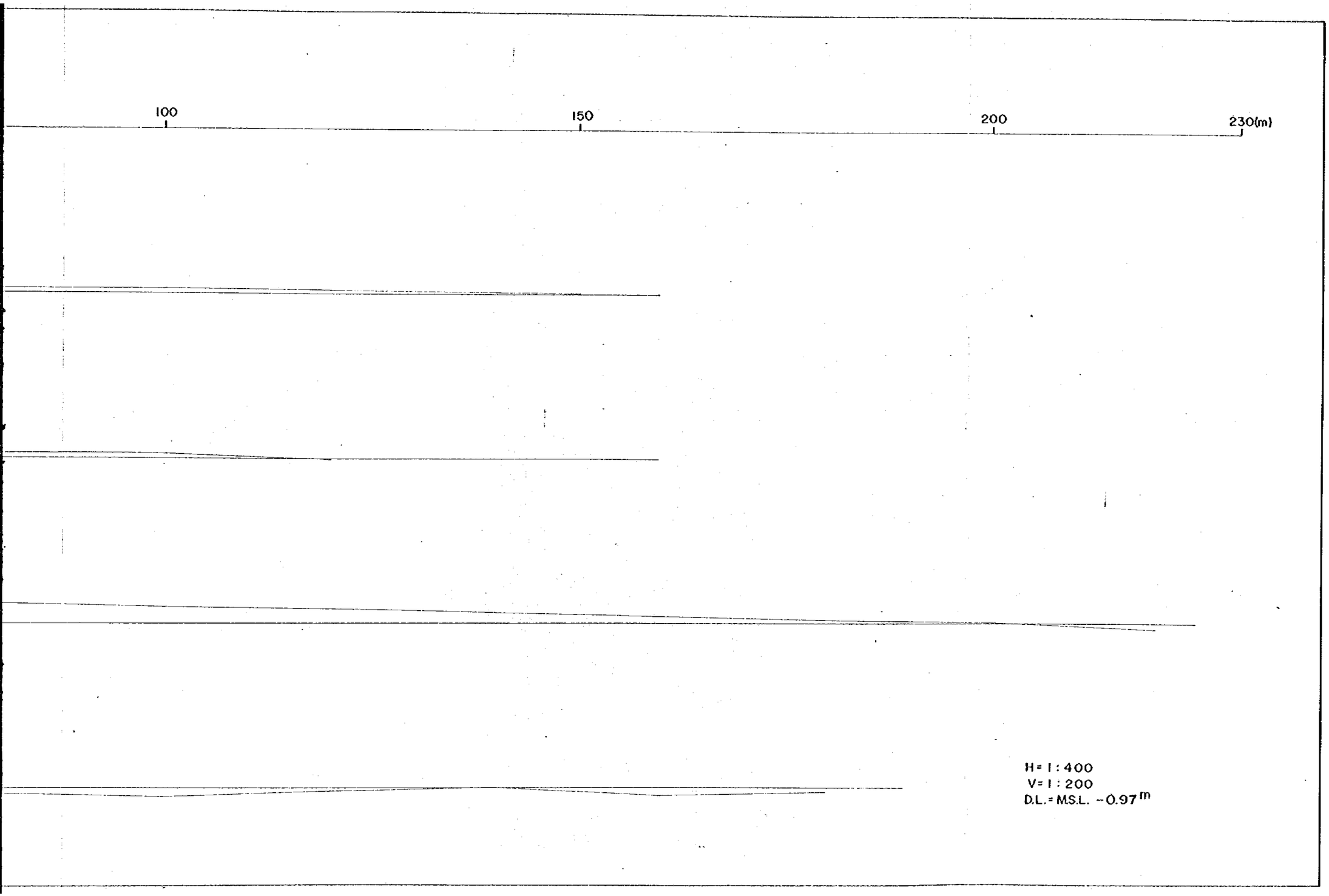
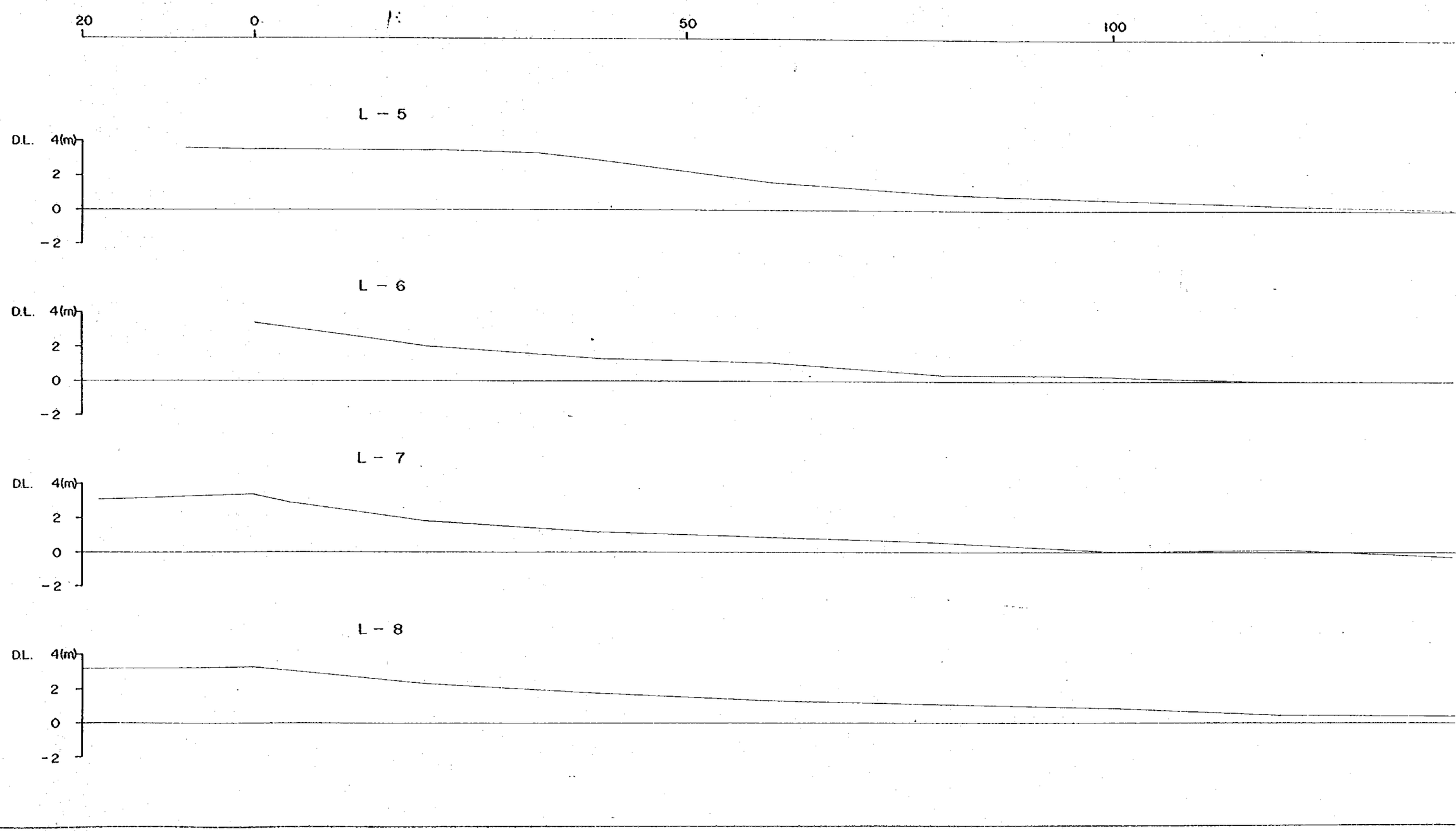

100
150
200
230(m)
H = 1 : 400
V = 1 : 200
D.L. = M.S.L. -0.97 m

Fig - 2 Topographical Cross - Section (shoreline area)



eline area)

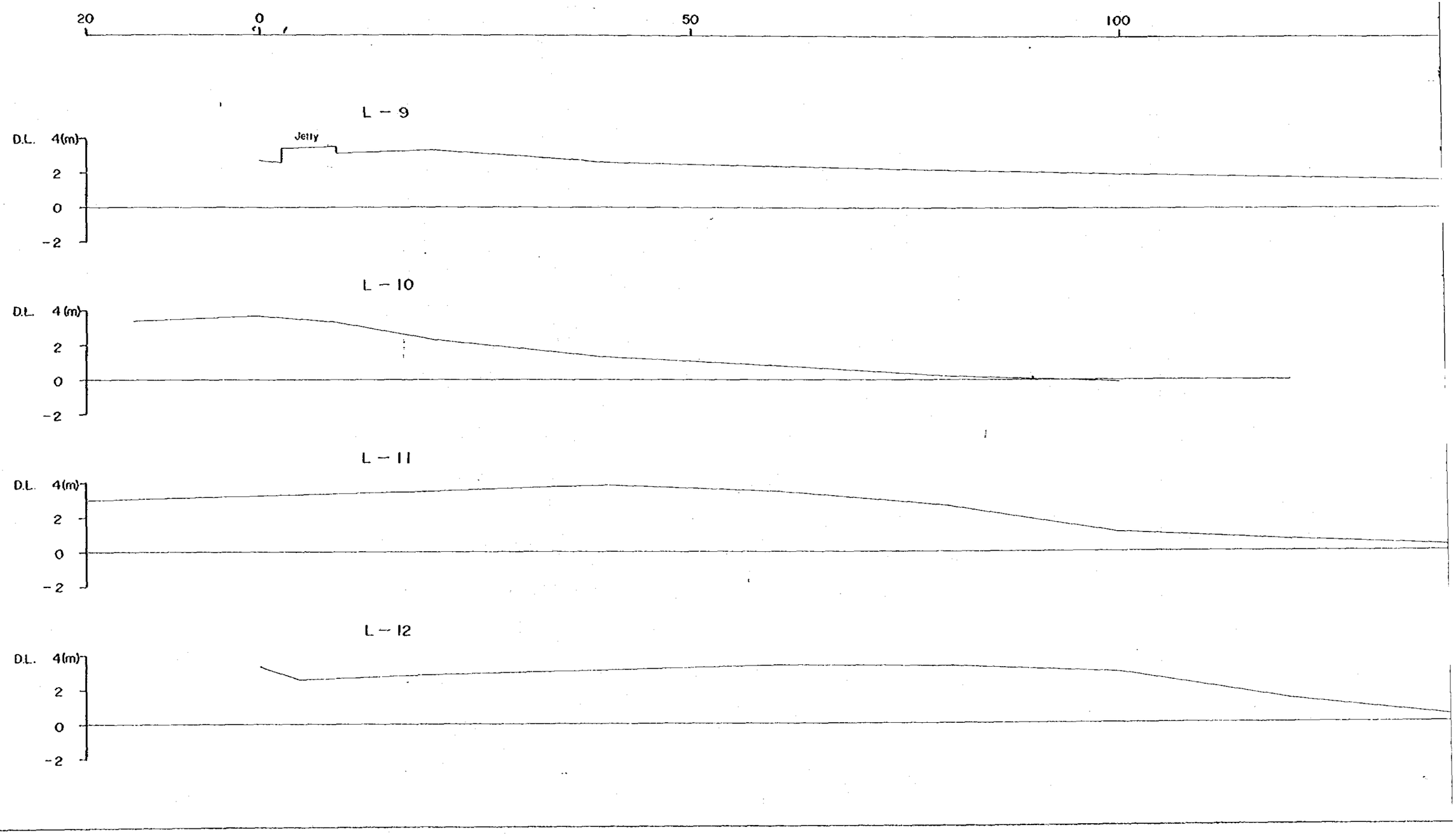
100

150

200(m)

H = 1 : 400
V = 1 : 200
D.L = M.S.L - 0.97 m

Fig - 3 Topographical Cross - Section (shoreline area)



eline area)

100

150

200

250

200

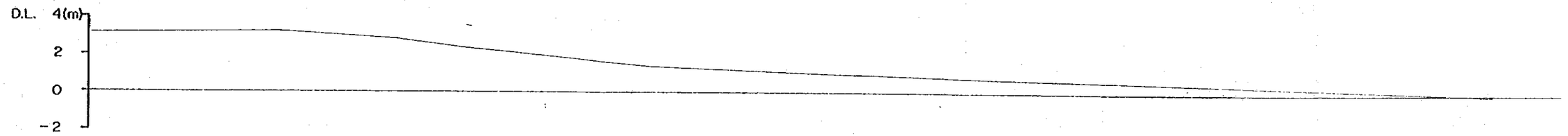
250

300 (m)

H = 1 : 400
V = 1 : 200
D.L. = M.S.L. − 0.97 m

Fig-4 Topographical Cross-Section (shoreline area)

L-13



Topographical Cross – Section (shoreline area)

50

100 (m)

H = 1 : 400
V = 1 : 200
D.L. = M.S.L – 0.97 m