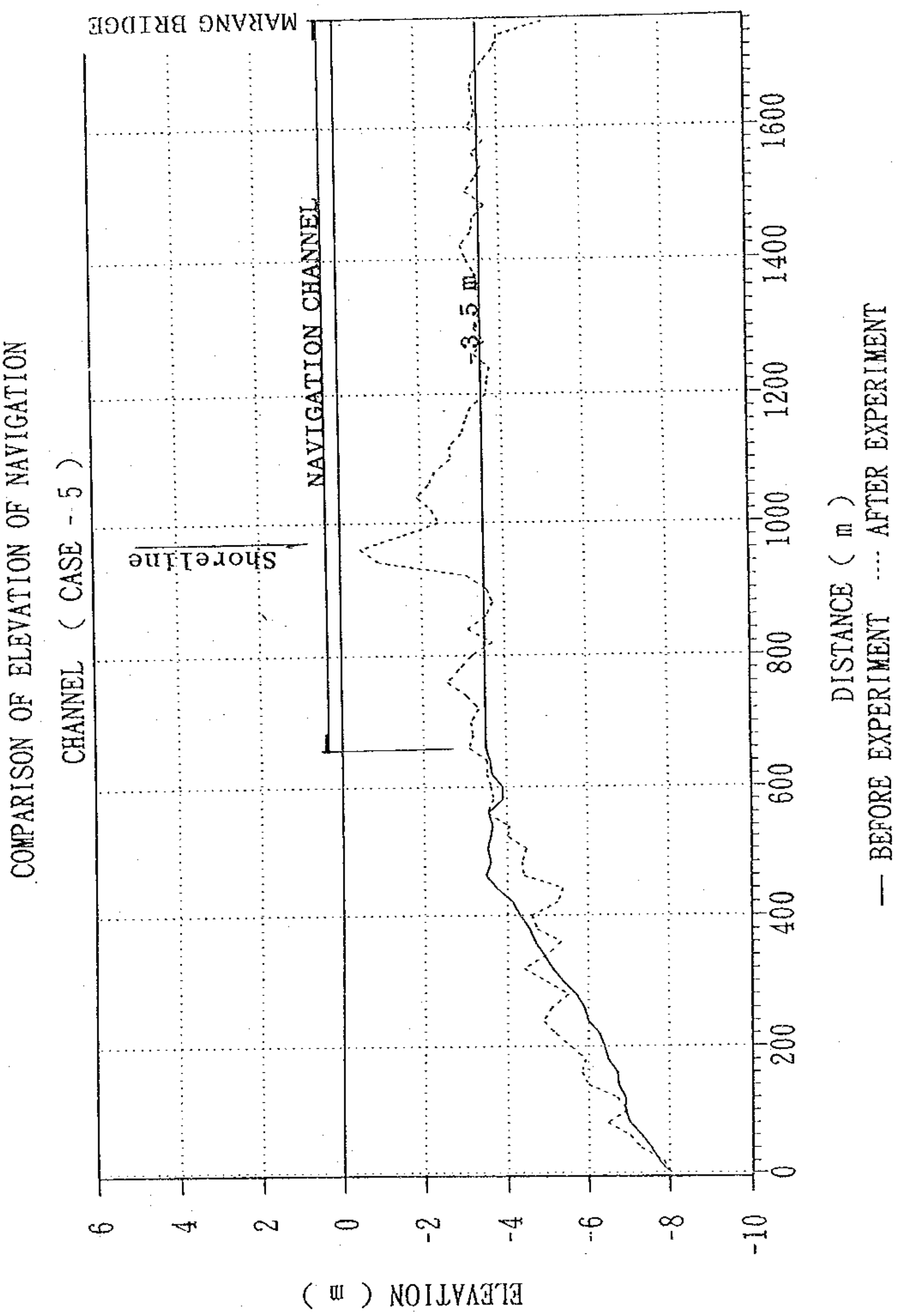
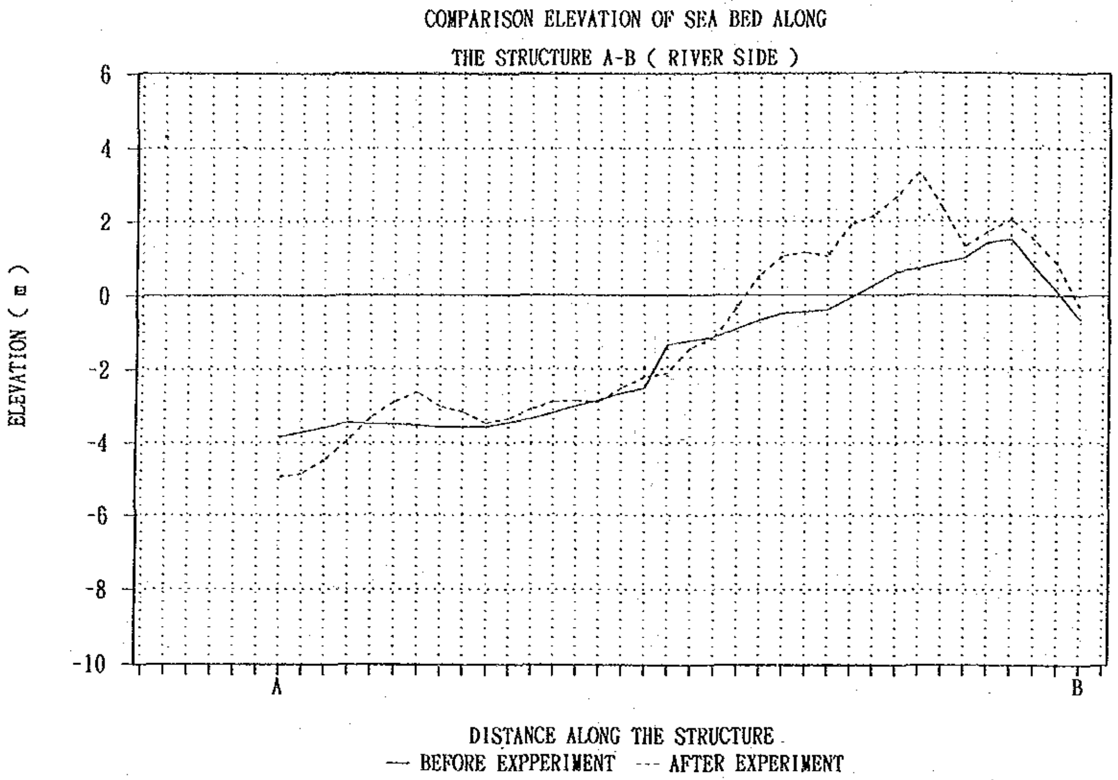
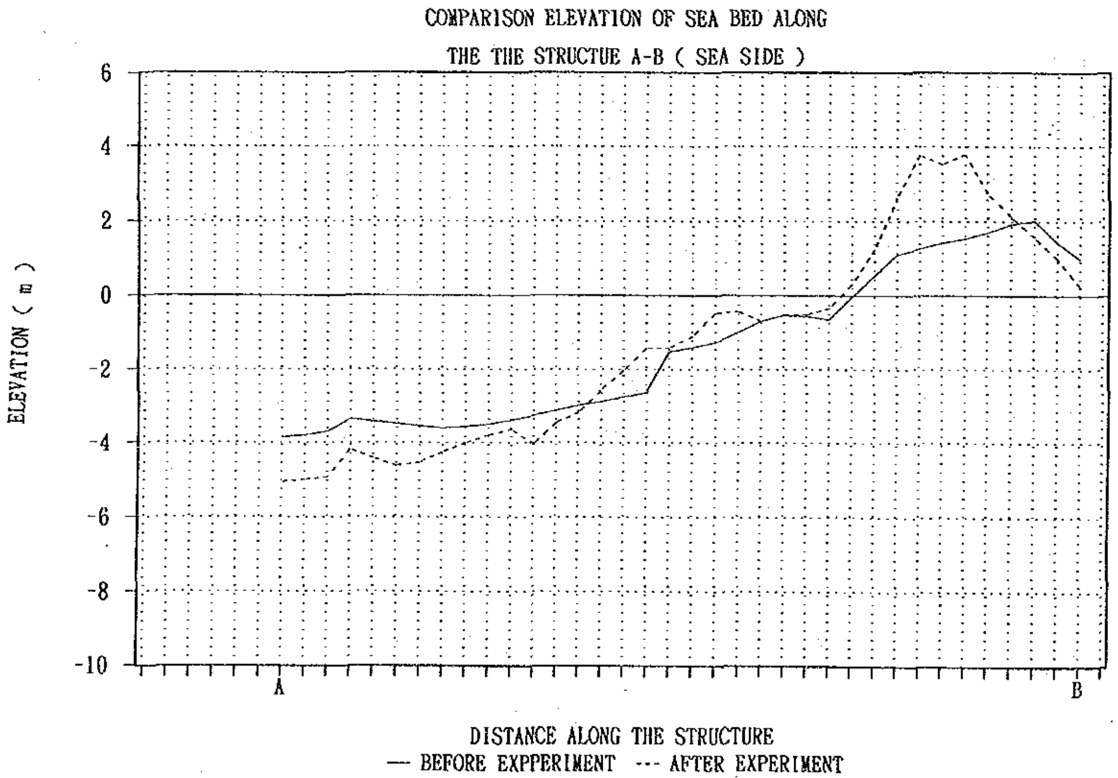


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SEA BED CHANGE ALONG THE NAVIGATION CHANNEL
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3. 8-20

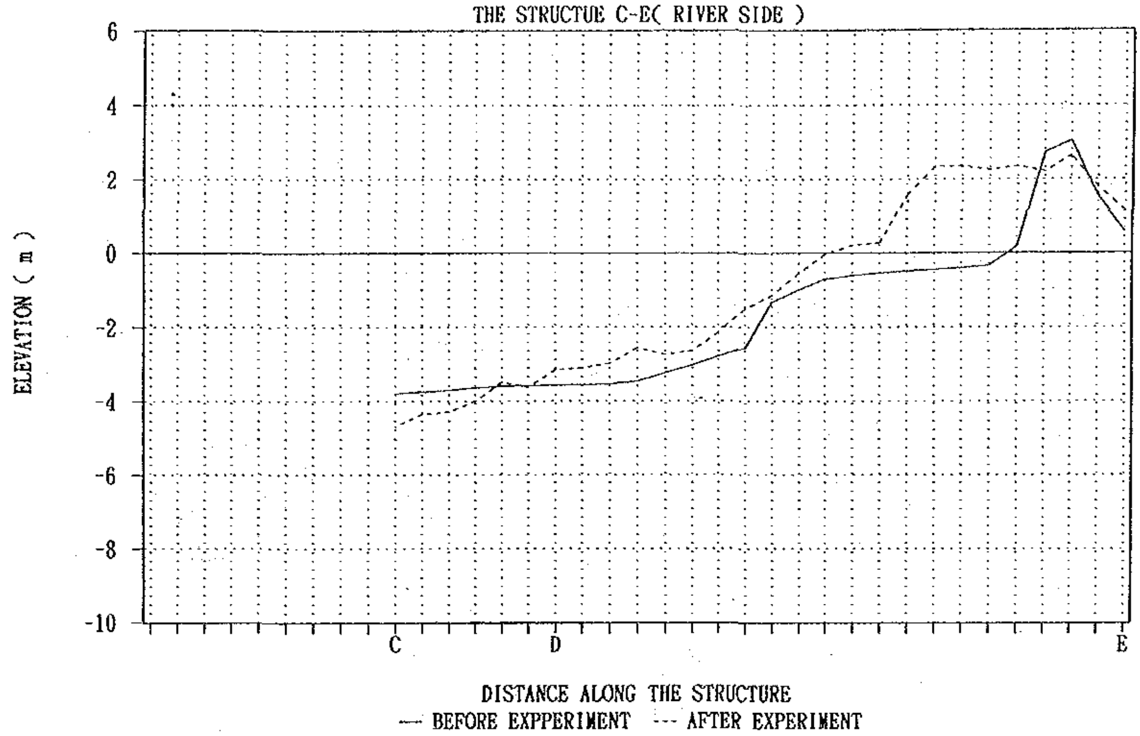




THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SEA BED CHANGE ALONG THE STRUCTURE A-B
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.8-21

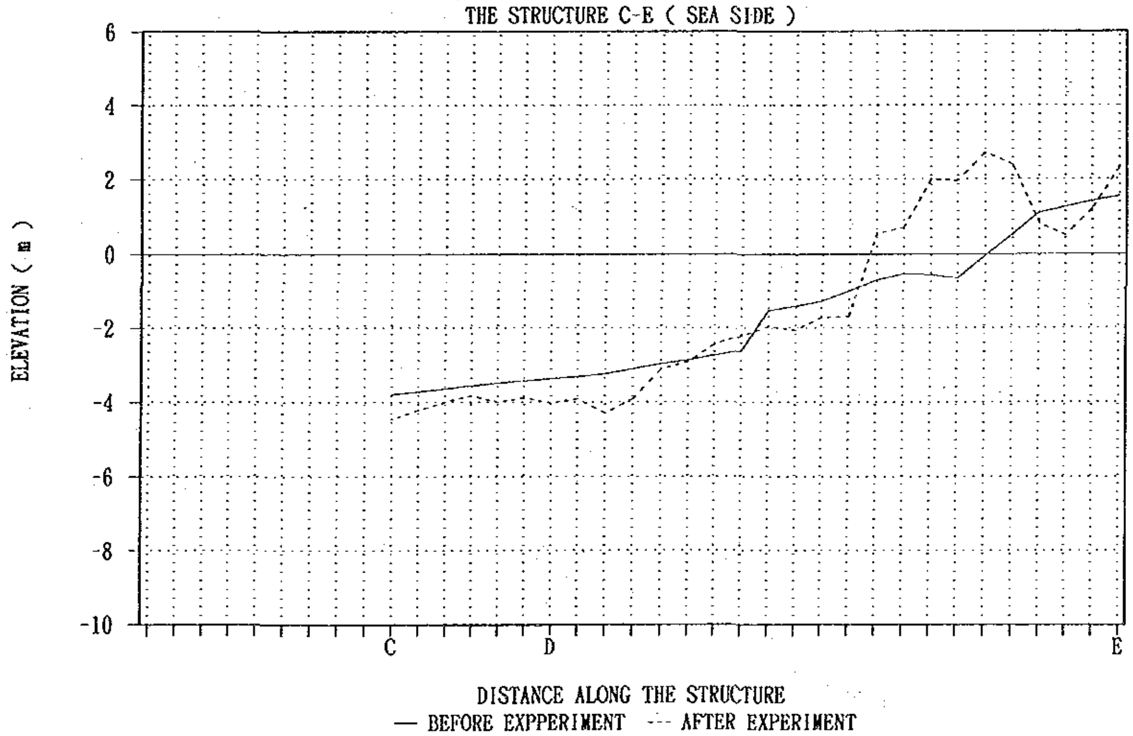
COMPARISON ELEVATION OF SEA BED ALONG

THE STRUCTUE C-E(RIVER SIDE)

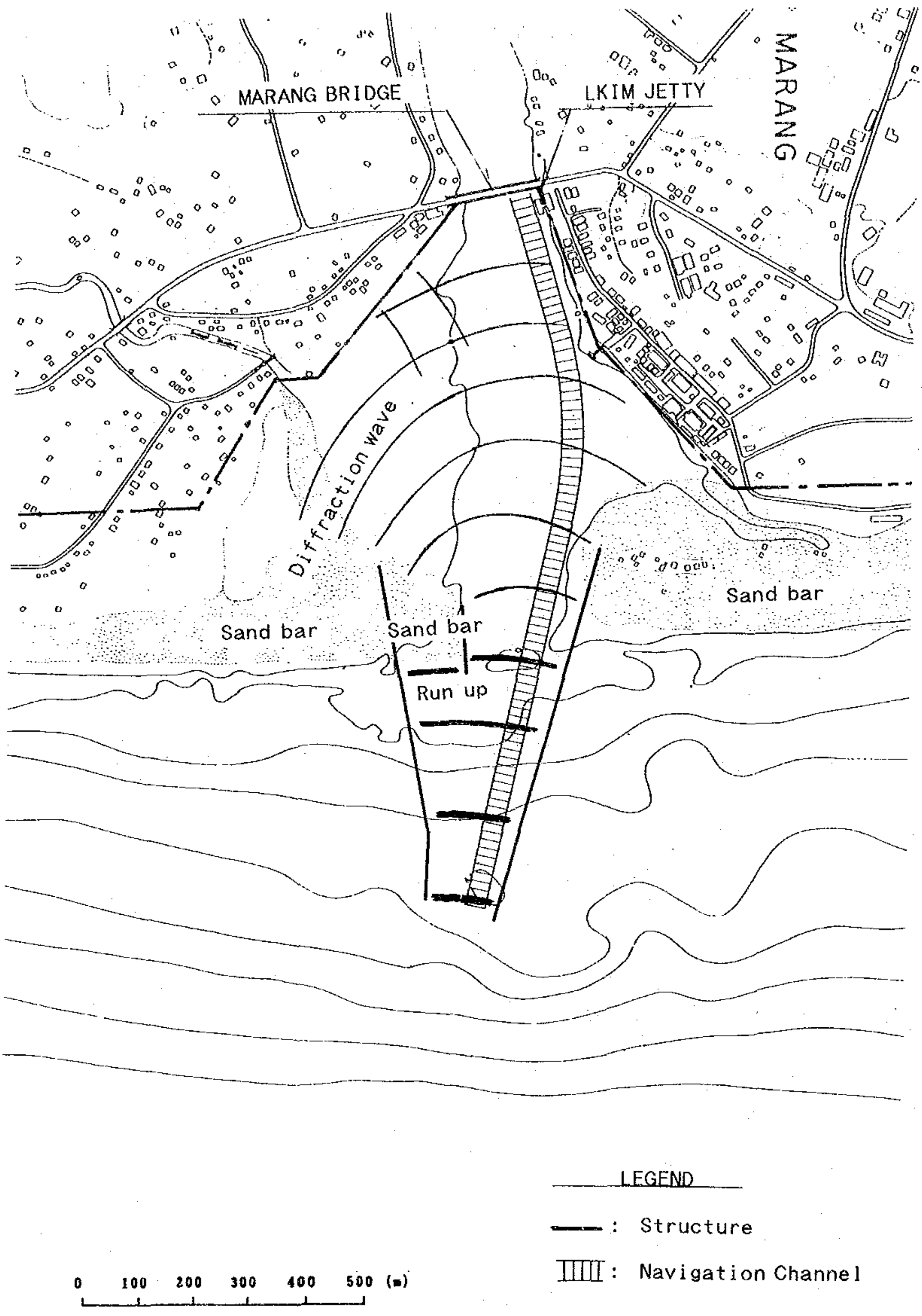


COMPARISON ELEVATION OF SEA BED ALONG

THE STRUCTURE C-E (SEA SIDE)



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SEA BED CHANGE ALONG THE STRUCTURE C-D
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.8-22

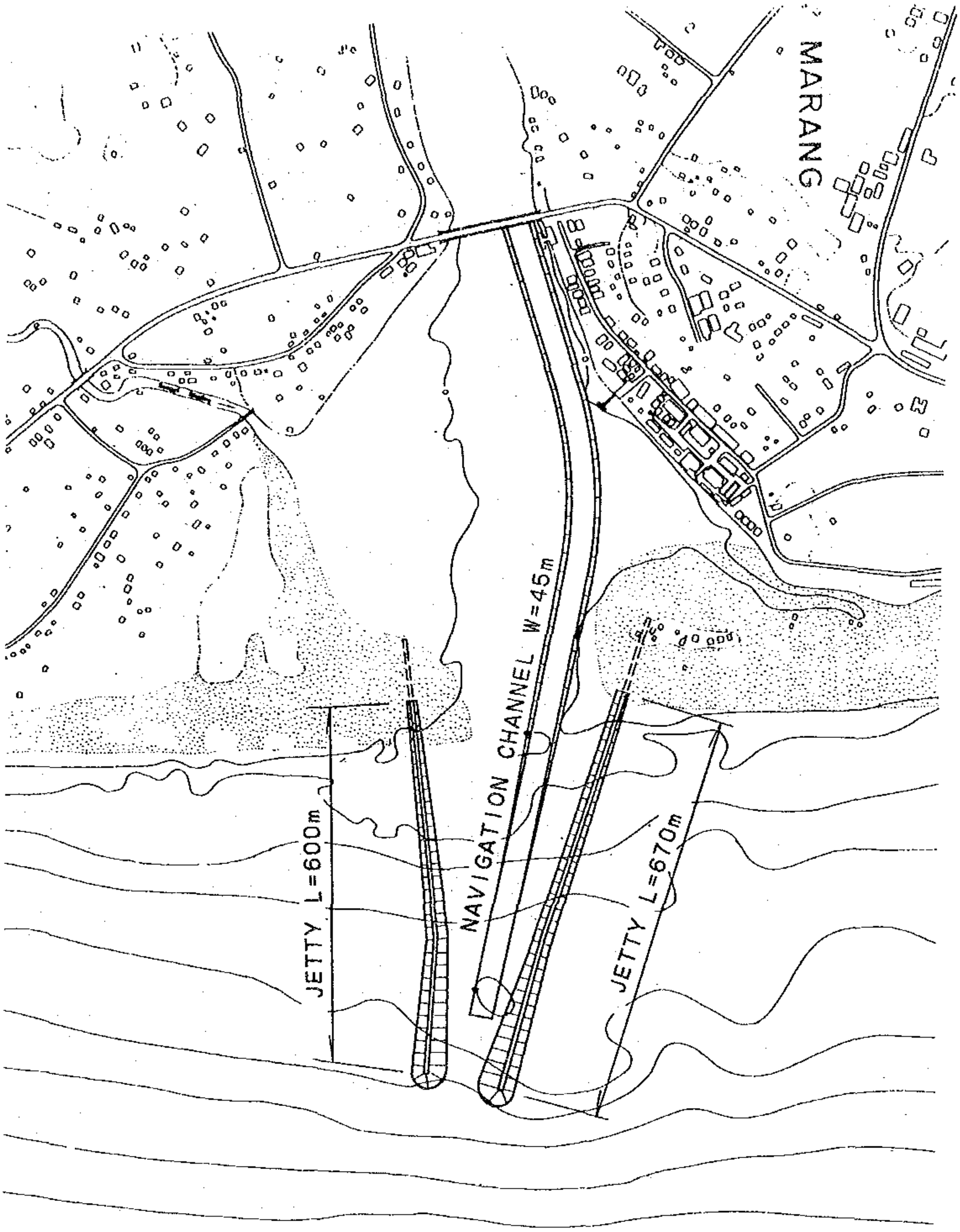


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

INTRUDED WAVE CONDITION
(SUBSEQUENT EXPERIMENT CASE - 5)

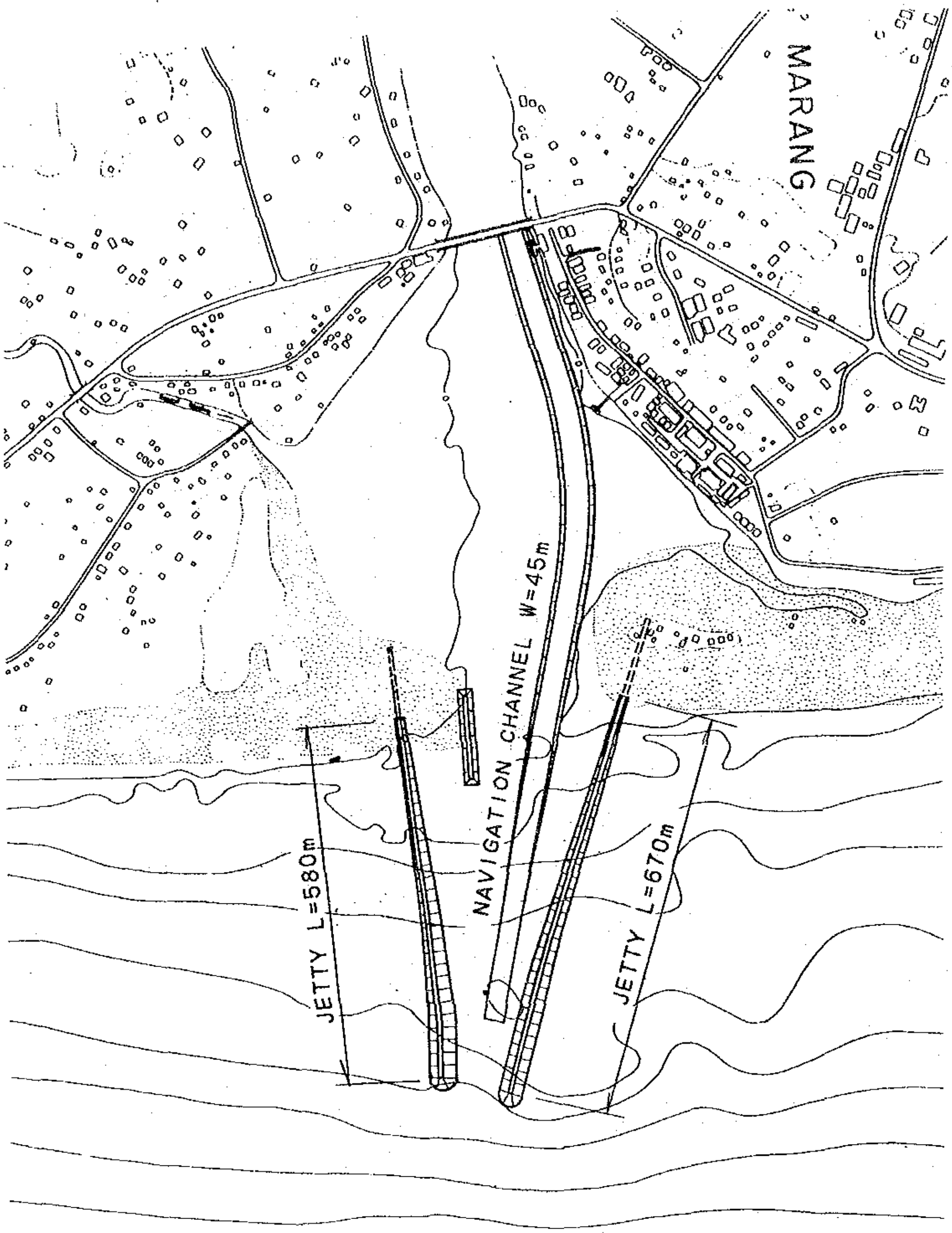
Fig. 3. 8-23



NOTE; IN THE EXPERIMENT, JETTYS ARE EXTENDED BROKEN LINE PARTS FOR THE SAFETY OF BEACH EROSION

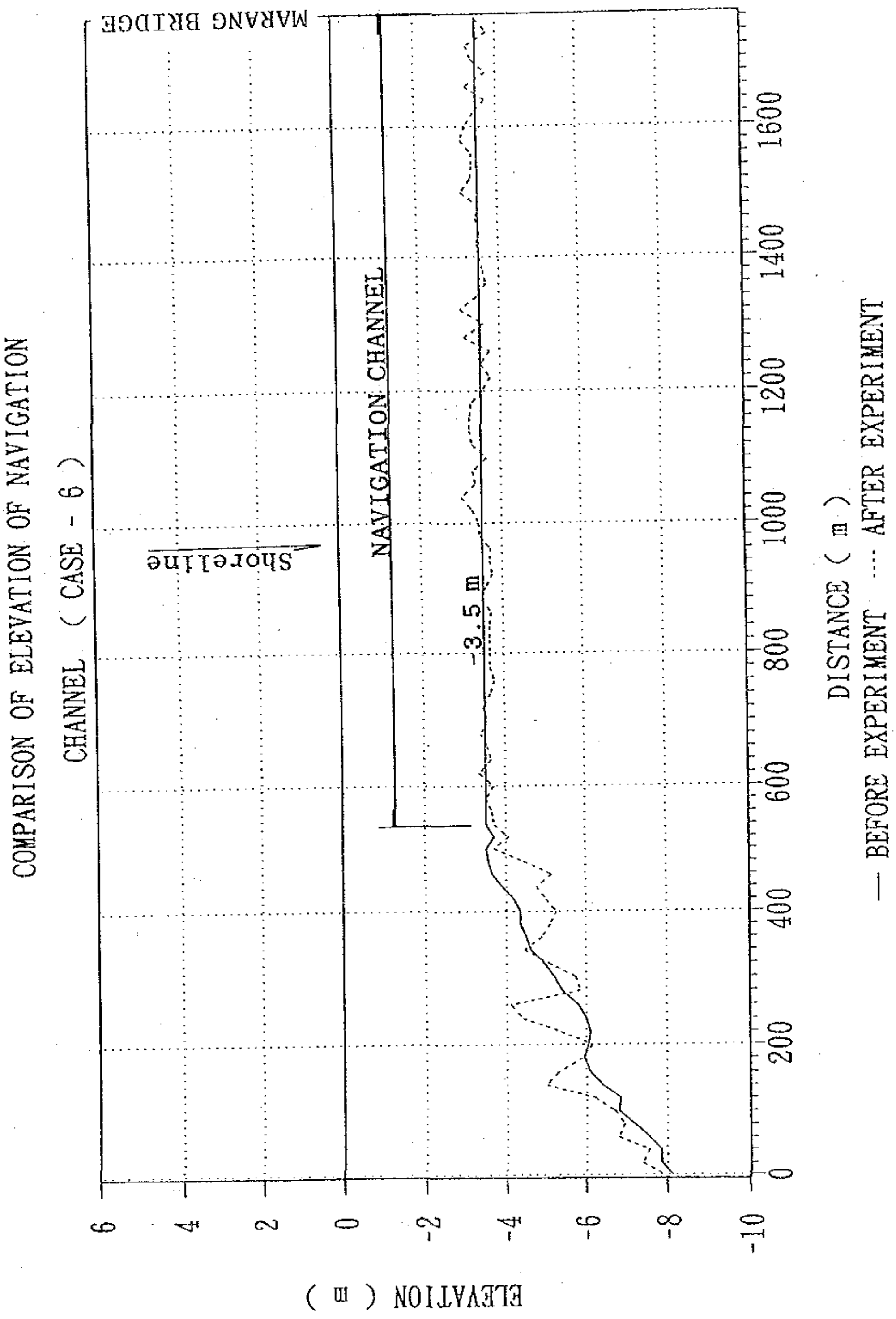
0 100 200 300 400 500 (m)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	LOCATION OF NAVIGATION CHANNEL AND STRUCTURES Fig. 3. 8-24
JAPAN INTERNATIONAL COOPERATION AGENCY	(SUBSEQUENT EXPERIMENT CASE - 6)

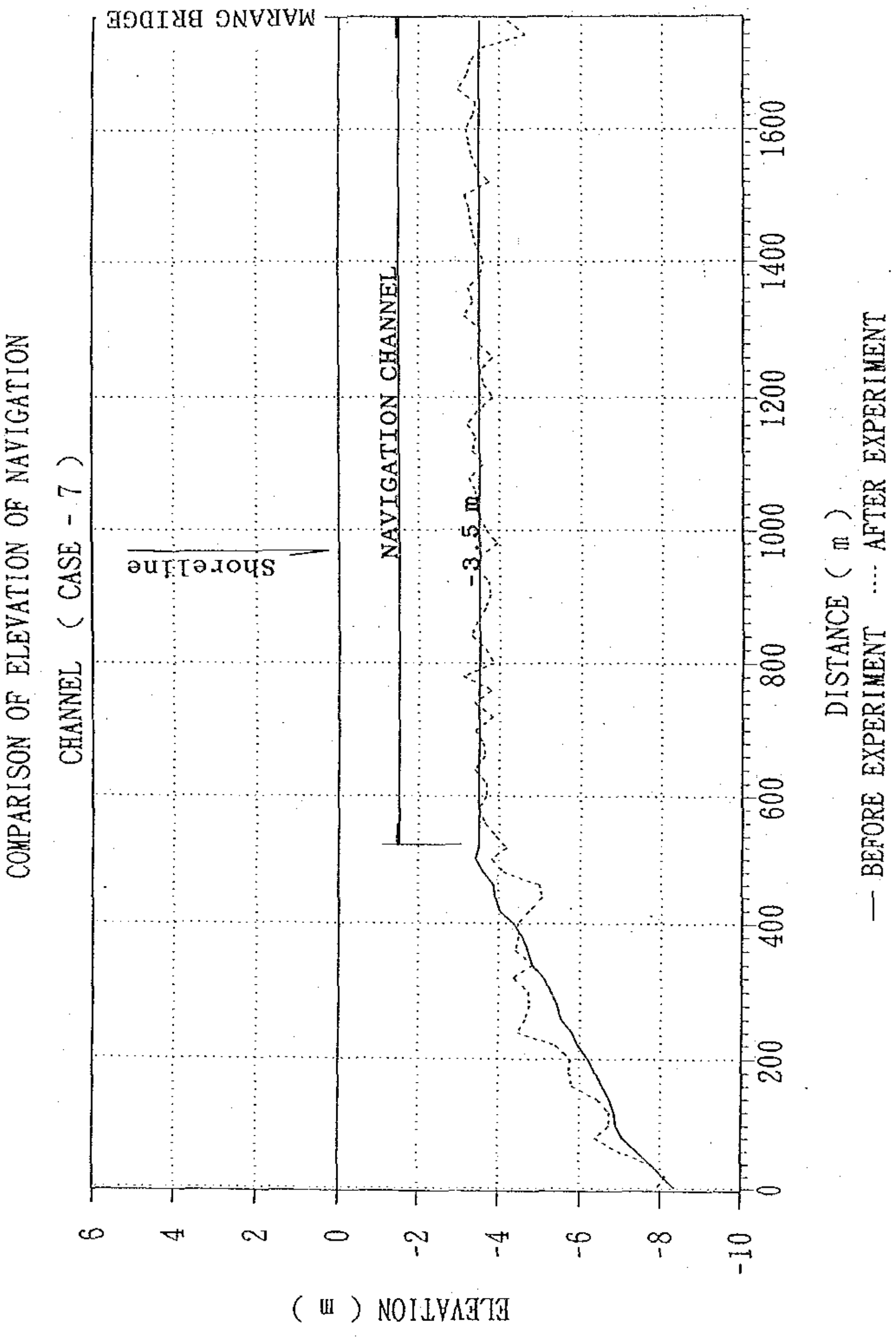


NOTE; IN THE EXPERIMENT, JETTYS ARE EXTENDED BROKEN LINE PARTS FOR THE SAFETY OF BEACH EROSION

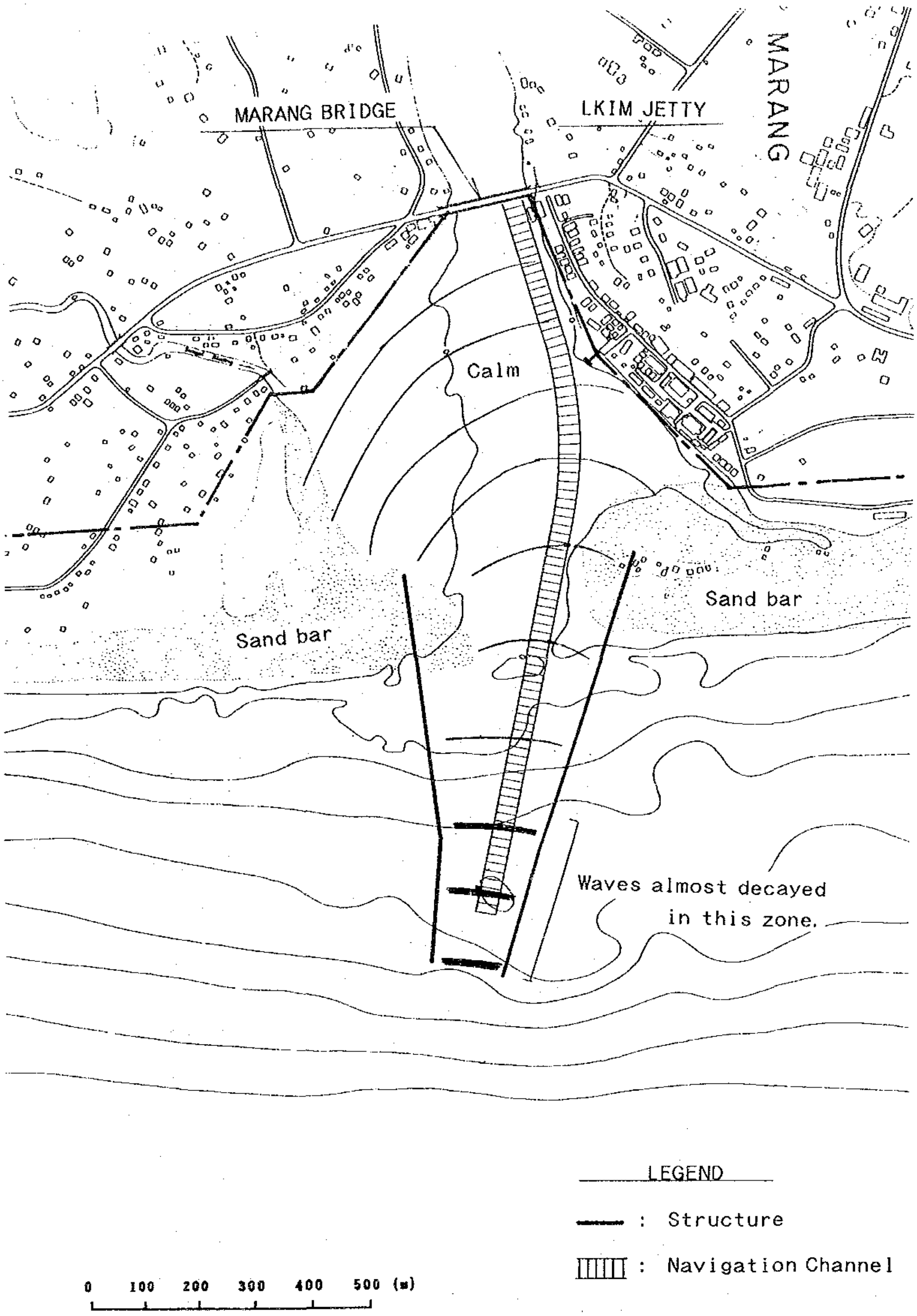
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	LOCATION OF NAVIGATION CHANNEL AND STRUCTURES Fig. 3.8-25
JAPAN INTERNATIONAL COOPERATION AGENCY	(SUBSEQUENT EXPERIMENT CASE - 7)



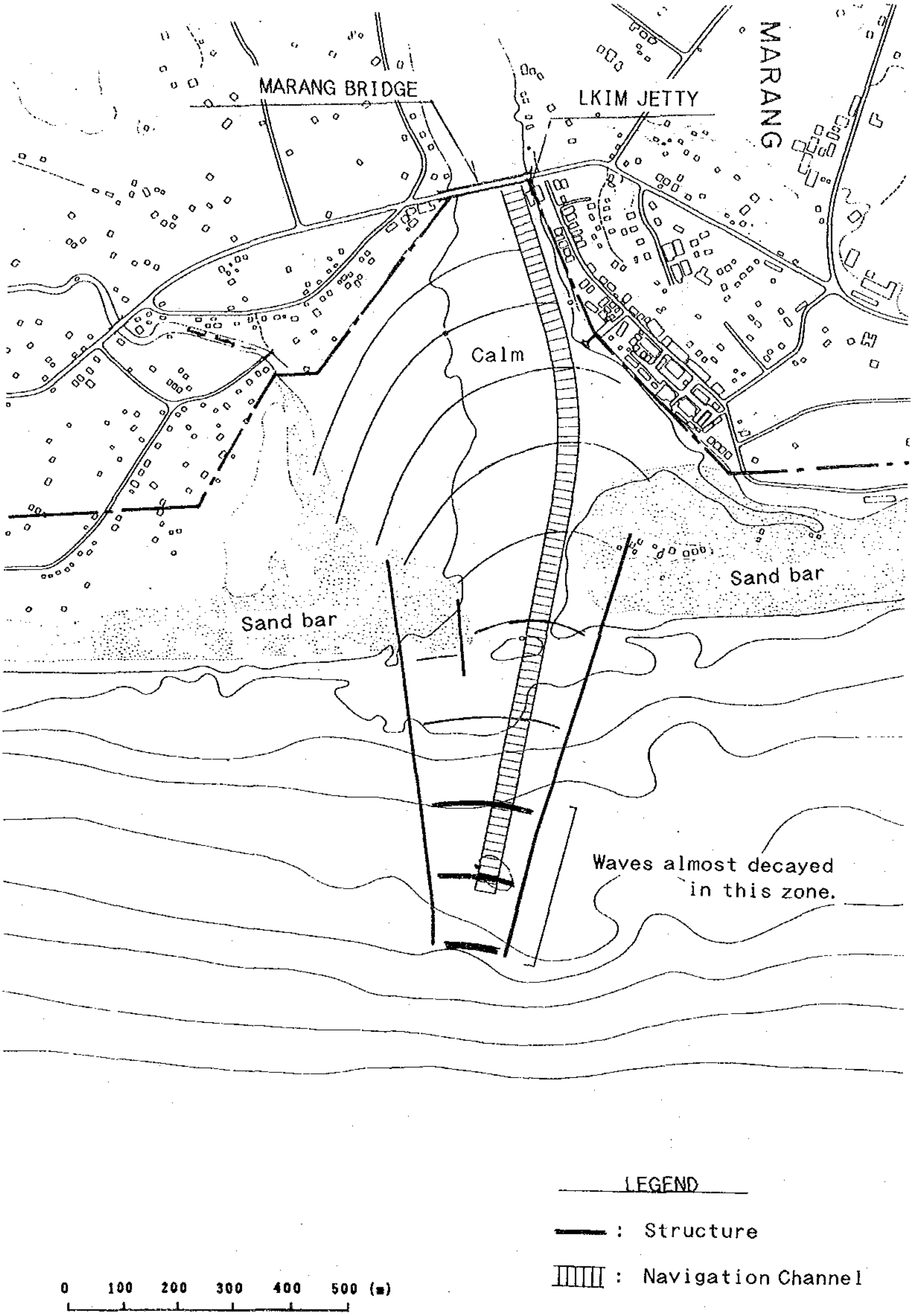
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SEA BED CHANGE ALONG THE NAVIGATION CHANNEL (SUBSEQUENT EXPERIMENT CASE - 6)	Fig. 3.8-26
JAPAN INTERNATIONAL COOPERATION AGENCY		



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SEA BED CHANGE ALONG THE NAVIGATION CHANNEL (SUBSEQUENT EXPERIMENT CASE - 7)	Fig. 3. 8-27
JAPAN INTERNATIONAL COOPERATION AGENCY		



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INTRUDED WAVE CONDITION (SUBSEQUENT EXPERIMENT CASE - 6)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3. 8-28



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INTRUDED WAVE CONDITION (SUBSEQUENT EXPERIMENT CASE - 7)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 3.8-29

PHOTOGRAPHS

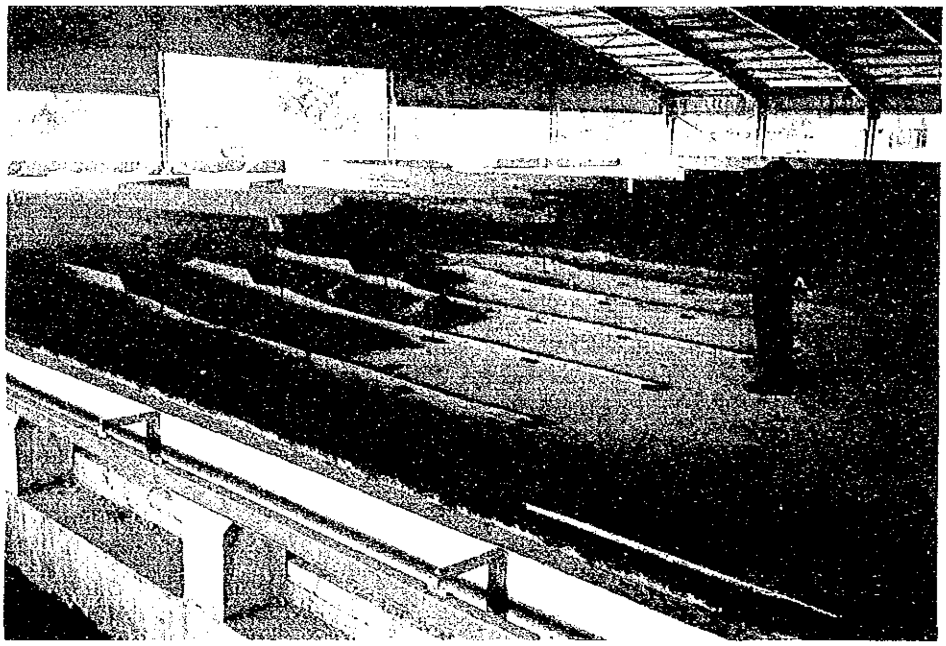


Photo 3. 5-1 TEMPLATE SETTING

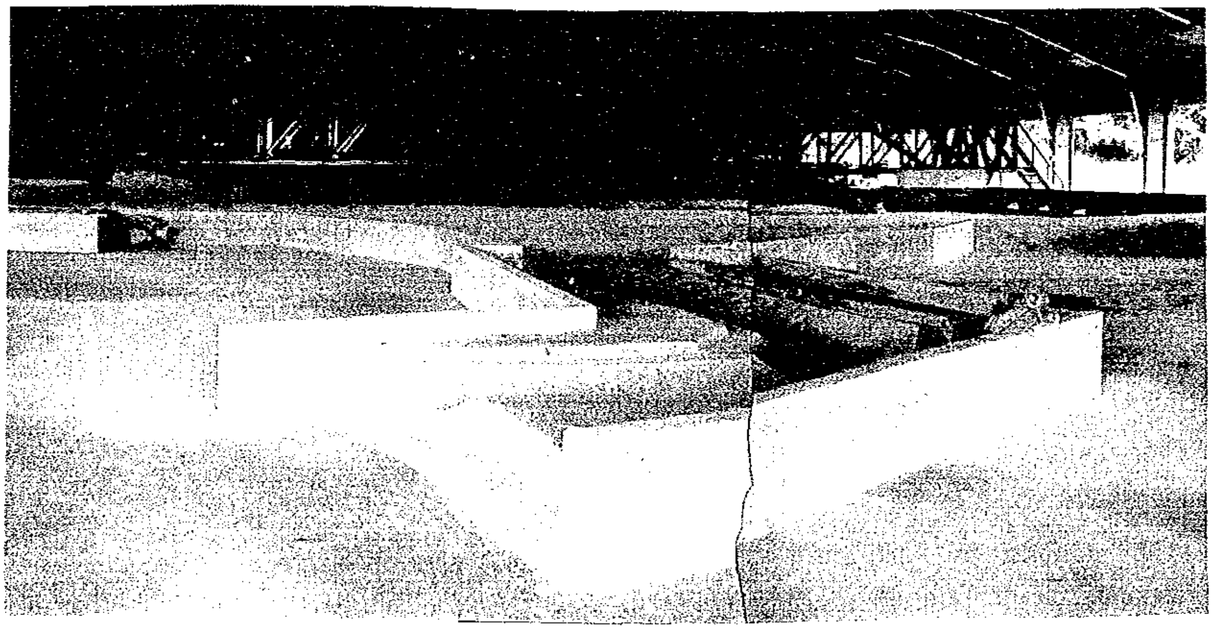


Photo 3. 5-2 MOLDED CONDITION

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TEMPLATE SETTING MOLDED CONDITION
JAPAN INTERNATIONAL COOPERATION AGENCY	Photo 3. 5-1 Photo 3. 5-2

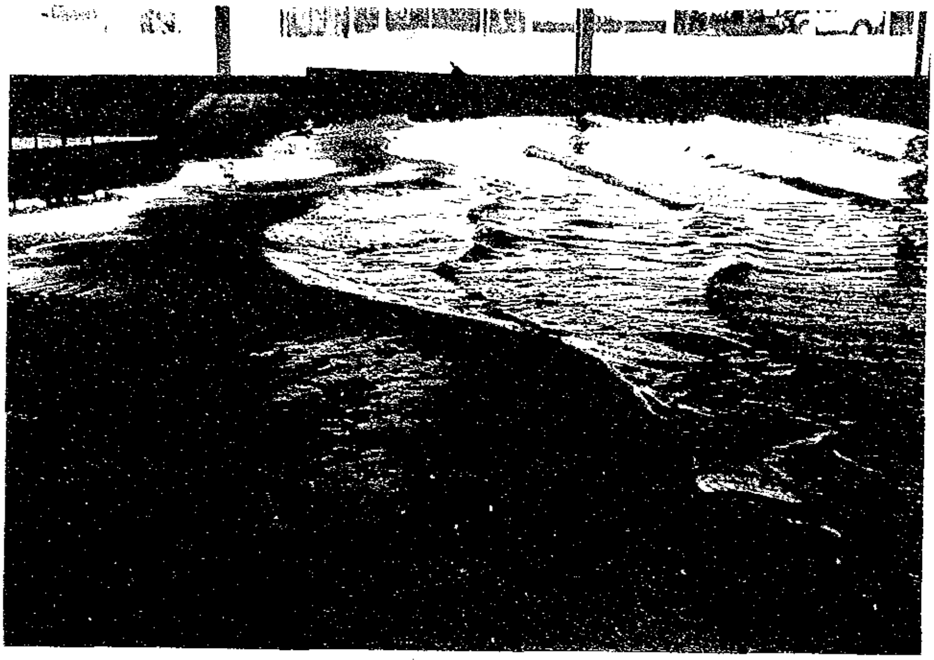


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Photo 3. 8-2 MAINTAINED NAVIGATION CHANNEL (CASE - 2)

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JAPAN INTERNATIONAL COOPERATION AGENCY	Photo 3. 8. 1 Photo 3. 8-2

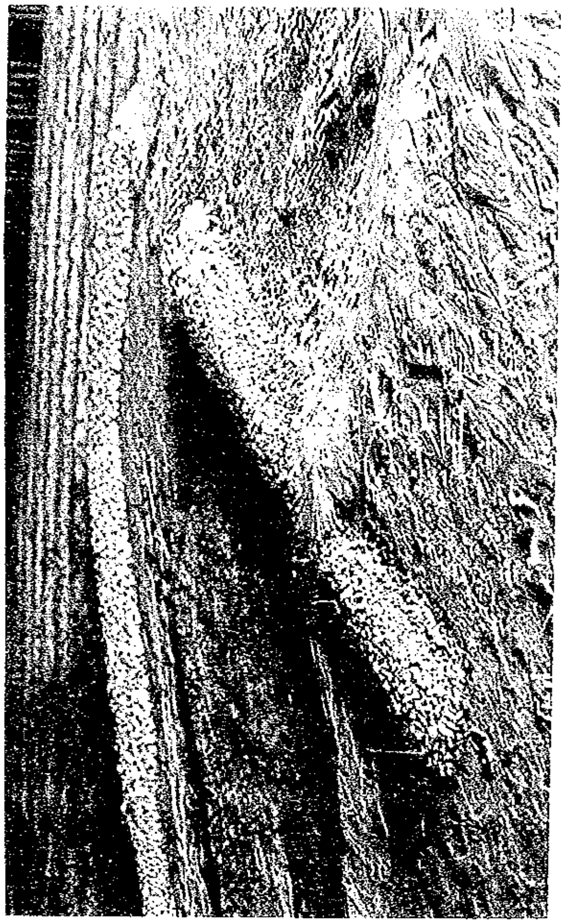

Photo 3. 8-3 DEPOSITED SAND (CASE - 2)

Photo 3. 8-4 INTRUDING WAVES (CASE - 2)

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JAPAN INTERNATIONAL COOPERATION AGENCY	Photo 3. 8-3 Photo 3. 8-4

Photo 3. 8-5 MOLDED CONDITION (CASE - 4)

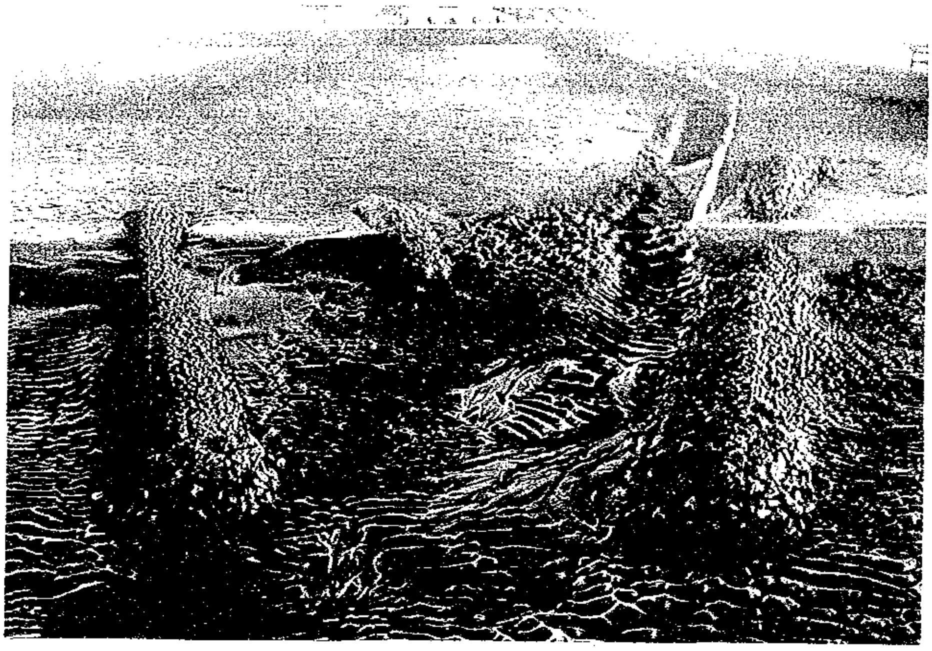


Photo 3. 8-6 AFTER 6 TIDAL CYCLES (CASE - 4)

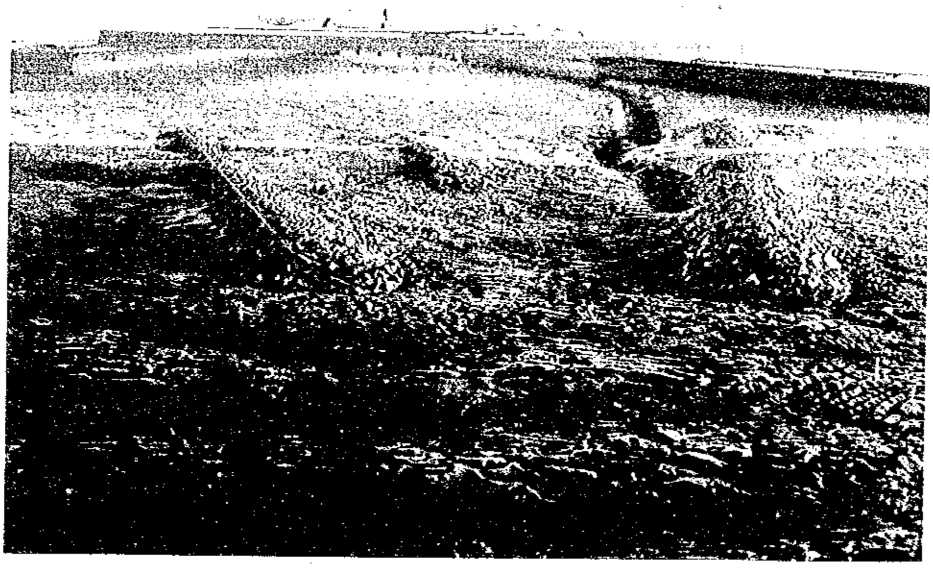
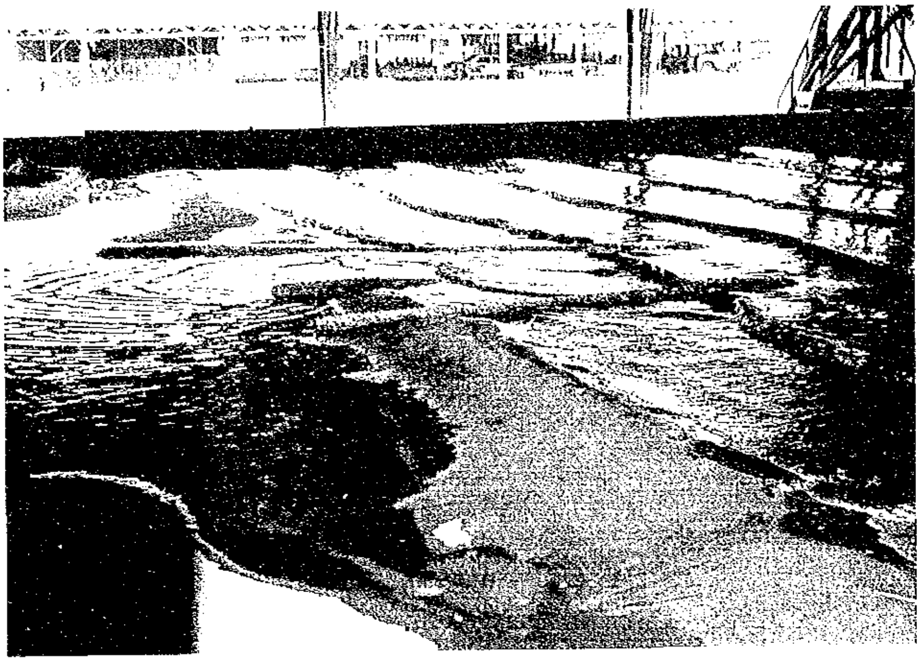


Photo 3. 8-7 AFTER EXPERIMENT (CASE -4)

Photo 3. 8-8 DEPOSITED SAND (CASE - 4)



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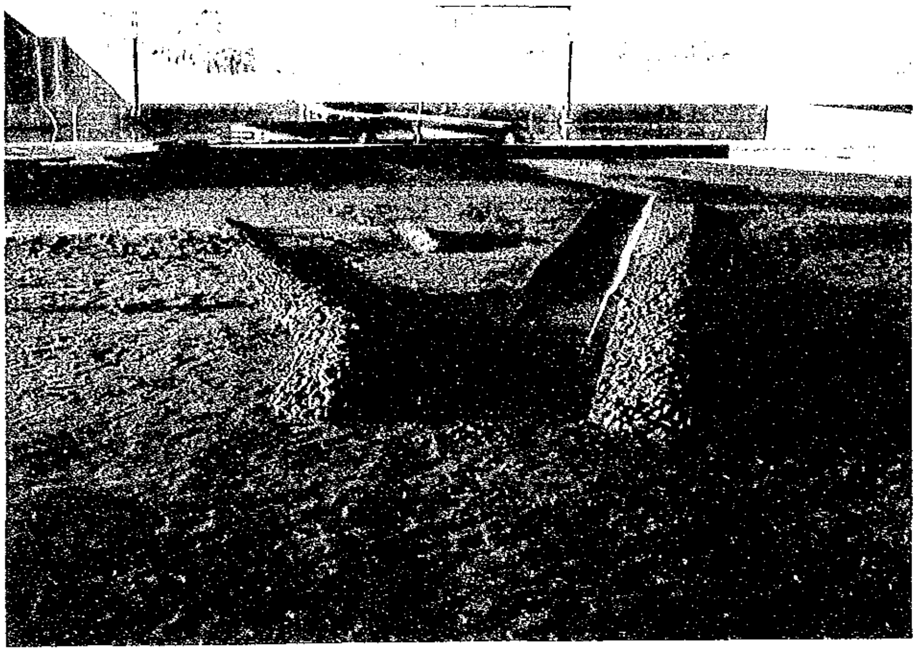

Photo 3. 8-10 MOLDED CONDITION (CASE - 5)

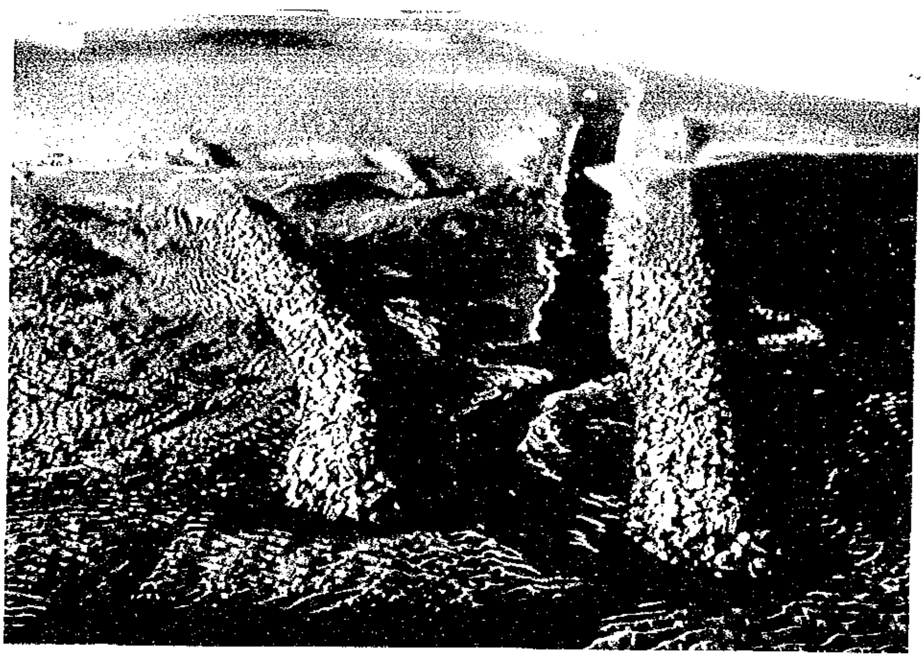

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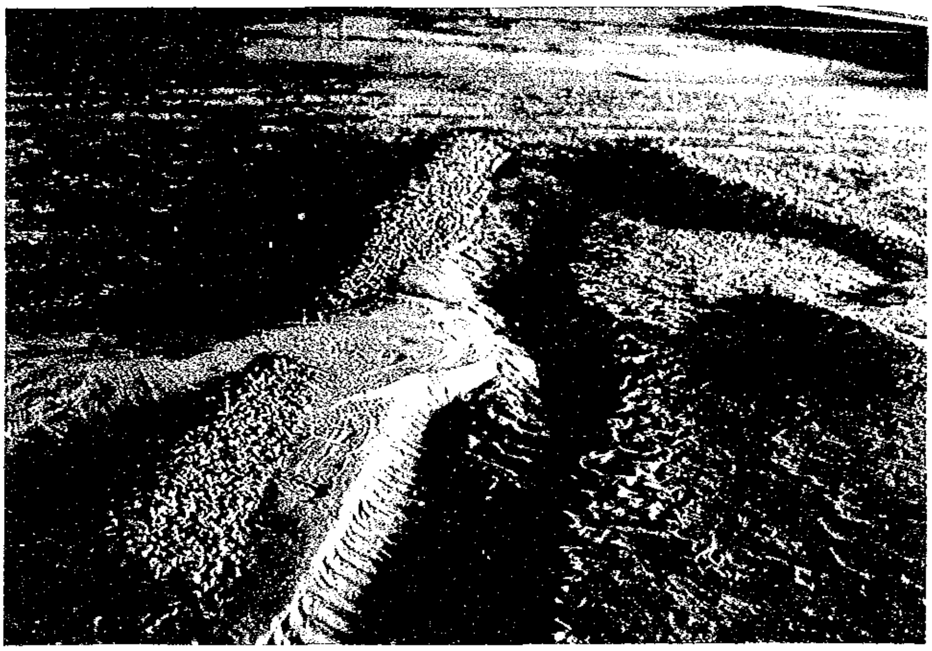
Photo 3. 8-12 AFTER EXPERIMENT (CASE - 5)



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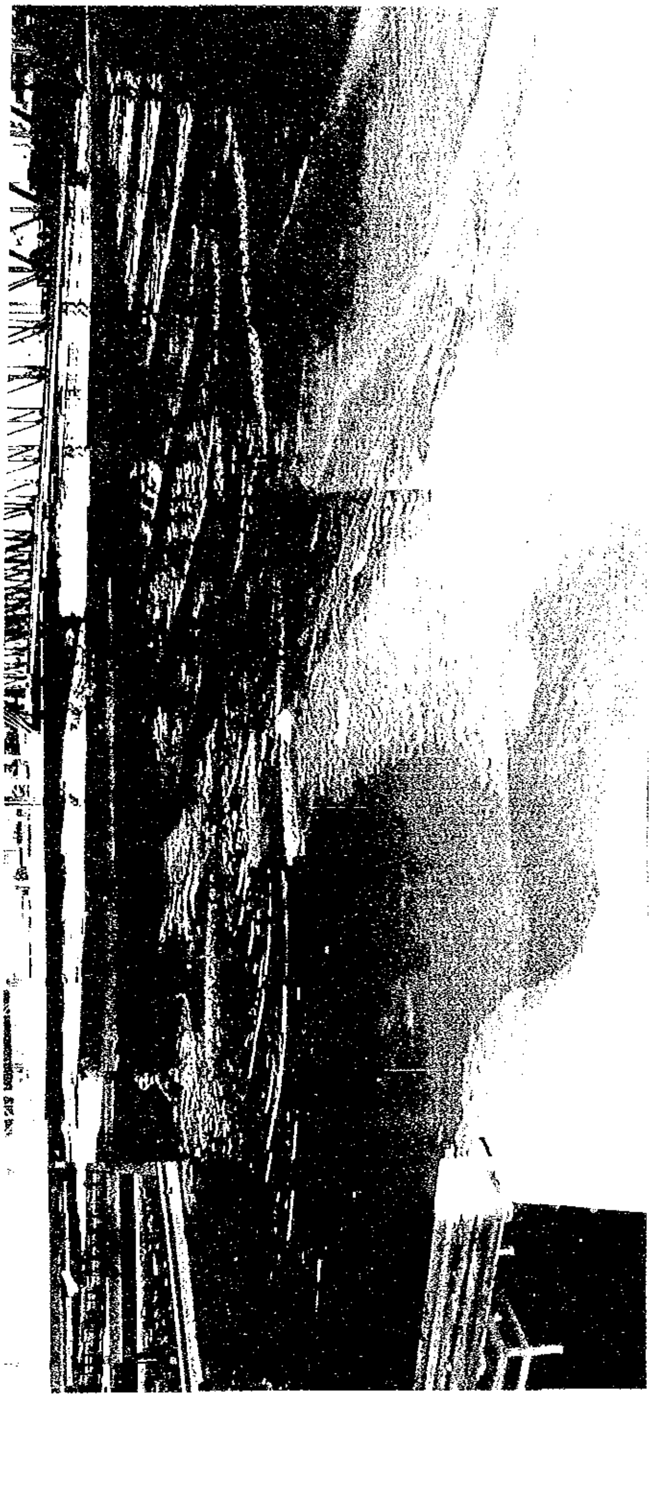

Photo 3. 8-14 INTRUDING WAVES (CASE - 5)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INTRUDING WAVES (CASE - 5)
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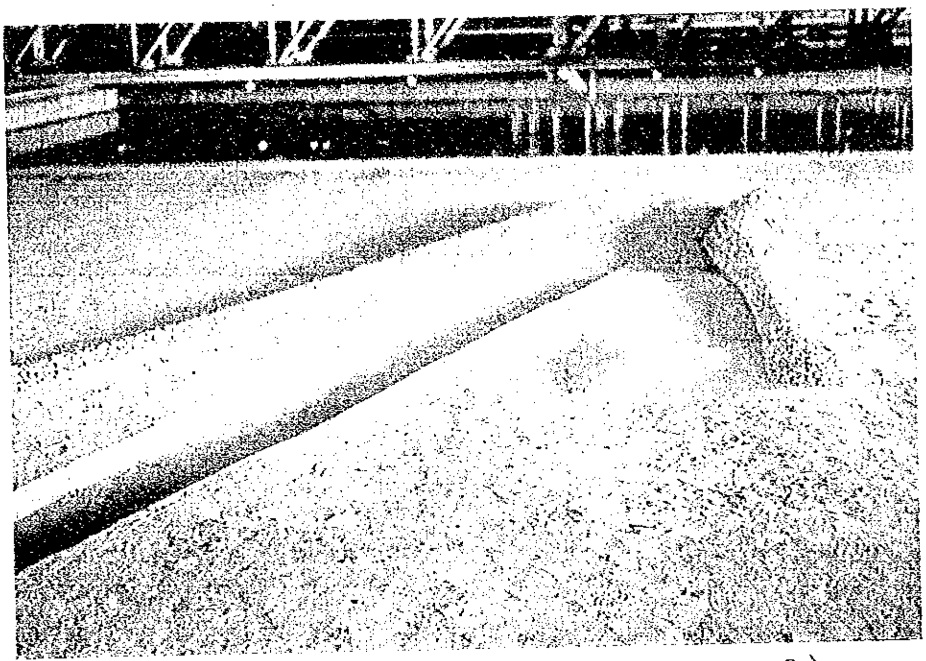

Photo 3. 8-15 MOLDED CONDITION (CASE - 6)

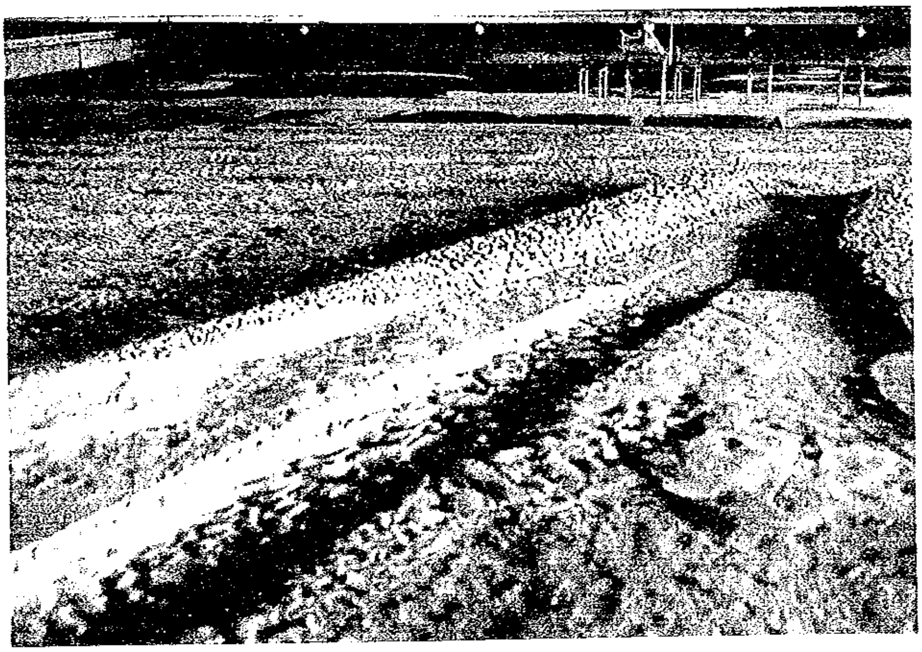

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Photo 3. 8-17 DEPOSITED SAND (CASE - 6)

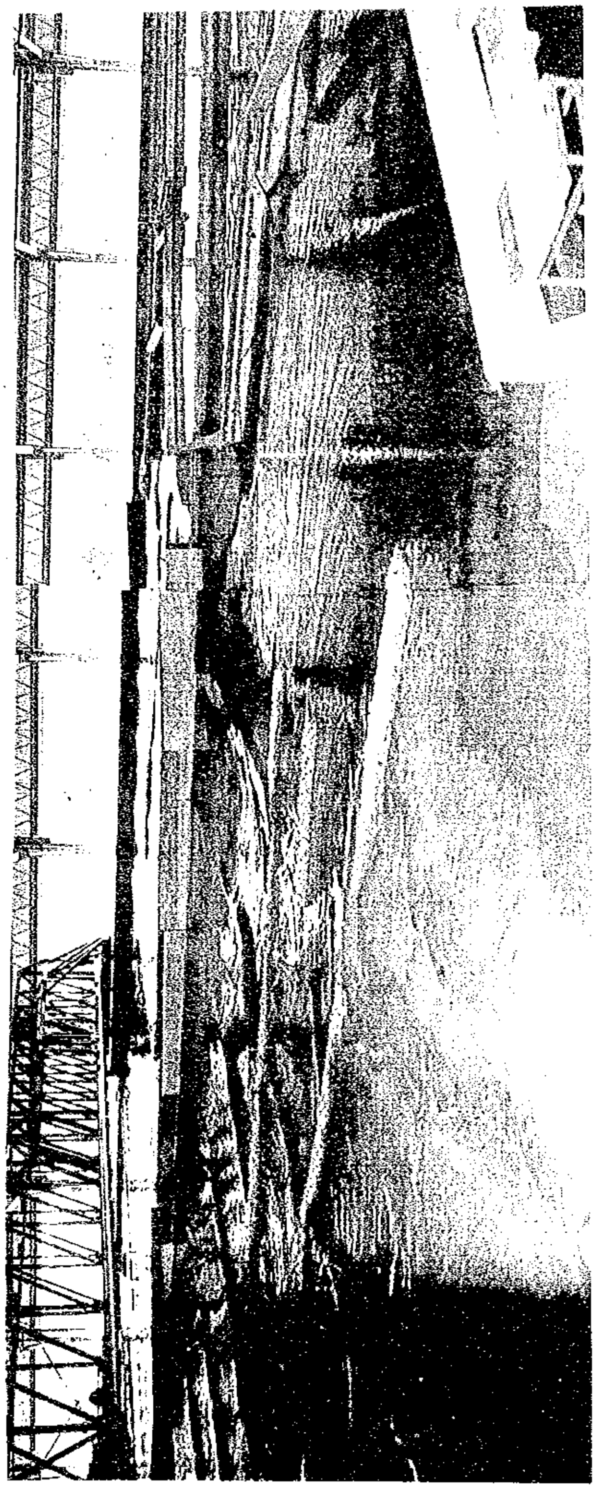

Photo 3. 8-18 INTRUDING WAVE (CASE - 6)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	DEPOSITED SAND (CASE - 6) INTRUDING WAVE (CASE - 6)
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4. NUMERICAL ANALYSIS

THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

SUPPORTING REPORT NO. 4

NUMERICAL ANALYSIS

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SUPPORTING REPORT NO. 4

NUMERICAL ANALYSIS

1. INTRODUCTION

Numerical analysis was conducted to estimate the siltation rate at the navigation channel of Tg. Piandang River Mouth and the coastline change adjacent to Marang River Mouth. The siltation rate was estimated from the calculation of tidal current and dispersion of bed materials. The change of coastline around the Marang River Mouth was also calculated by one-line model.

2. TIDAL CURRENT ANALYSIS

2.1 General

To estimate the siltation rate of the navigation channel at Tg. Piandang River Mouth, tidal level and current velocity were calculated by numerical method. To confirm the tidal current pattern around the river mouth, observed results at the mouth were used. Two calculation areas were used for reducing the computer time and memory.

2.2 Basic Equation

Since the water movement at the mouth is derived mainly by tide, the following shallow water equation is applied.

(a) Equation of Motion

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + g\frac{\partial \zeta}{\partial x} = 0$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + g\frac{\partial \zeta}{\partial y} = 0$$

(b) Equation of Continuity

$$\frac{\partial \zeta}{\partial t} + \frac{\partial Hu}{\partial x} + \frac{\partial Hv}{\partial y} = 0$$

where;

u	:	current velocity for x-direction
v	:	current velocity for y-direction
h	:	water depth
ζ	:	tidal amplitude
H	:	$h + \zeta$
g	:	gravity acceleration

Tidal level and current were calculated numerically by finite element method, giving appropriate boundary conditions.

2.3 Calculation Condition

(1) Calculation Area

To estimate the siltation rate in the navigation channel, the calculation area should cover the whole length of the navigation channel, which is 1,900 m long at the outer channel and 900 m at the inner channel as shown in Fig. 4.2-1.

The tidal level and current velocity were observed by a pressure type wave gauge and an electromagnetic current meter at the wave gauge station about

3 km offshore from the mouth. The observed results were used to determine the tidal condition.

Two calculation areas, namely large scale area and small scale area were used in considering the range of navigation channel and the position of the wave gauge as shown in Fig. 4.2-2.

The large scale area was arranged, as shown in Fig. 4.2-2, almost parallel to the current direction. The tidal current flows between two closed boundaries which correspond to the coast and the shallow Outer Kra Bank of about 0.0 m deep, respectively. The tidal level was given at both open boundaries.

The small scale area was arranged to cover the navigation channel and the upper reach of the river, where the tidal gate is located. The tidal level at the boundaries were given from the results in the large area calculation.

(2) Tidal Condition

Harmonic analysis was carried out using the observed results at the wave gauge from October, 1992 to May, 1993. Ten components were separated by the least square method using 2,681 data of two hours interval.

The results are shown in Table 4.2-1 and Table 4.2-2. The main components of the tide and currents are M2, S2, K1 and N2. The M2 amplitude of the tide is 48 cm and the M2 current amplitude is 12.6 cm/s. Predominant currents are along the coast and the direction is 160 degrees clockwise from the north. For comparison, the tidal components at Pulau Pinang are also shown in Table 4.2-3. The amplitude at Tg. Piandang is about 20% lower than those at Pinang.

Table 4.2-1. HARMONIC CONSTANTS OF TIDE AT TG. PIANDANG

Tidal Comp.	Ang.Vel.	COS	SIN	AMP.	PHASE
		m	m	m	rad
	0.0000	8.320	0.000	8.320	0.000
Q1	0.2339	-0.009	0.000	0.009	3.147
O1	0.2434	-0.034	0.023	0.041	2.560
K1	0.2625	-0.154	-0.146	0.213	3.901
MYU2	0.4881	-0.027	-0.004	0.027	3.293
N2	0.4964	-0.067	-0.072	0.099	3.966
M2	0.5059	-0.310	0.371	0.483	2.267
L2	0.5154	-0.012	-0.001	0.012	3.251
S2	0.5236	0.001	0.258	0.258	1.566
M4	1.0117	-0.015	0.019	0.024	2.237
MS4	1.0295	-0.001	0.021	0.021	1.612

Table 4.2-2. HARMONIC ANALYSIS OF TIDAL CURRENT AT TG. PIANDANG

TG. PIANDANG CURRENT E-W COMP

TIDAL ELLIPSOID		W1: 1st COMP.		W2: 2nd COMP.		PHASE
Tidal Comp.		W1	From N	W2	From N	
		cm/s	deg	cm/s	deg	rad
Q1	0.2339	0.12	18.1	0.04	288.1	2.671
O1	0.2434	0.34	15.8	0.03	285.8	0.743
K1	0.2625	1.23	147.0	0.18	237.0	2.143
MYU2	0.4881	0.26	130.9	0.08	220.9	2.662
N2	0.4964	2.15	337.8	0.03	67.8	0.162
M2	0.5059	12.60	159.8	0.53	249.8	1.748
L2	0.5154	0.29	333.5	0.06	243.5	1.296
S2	0.5236	5.98	158.1	0.48	248.1	1.252
M4	1.0117	0.78	81.8	0.05	351.8	0.438
MS4	1.0295	0.64	255.8	0.10	165.8	2.941

Table 4.2-3 HARMONIC CONSTANTS OF TIDE AT PULAU PINANG

Tidal Comp.	Amp(cm)
K1	19.1
N2	11.6
M2	62.6
S2	36.6

The tide and current at the wave gauge were decided to reproduce the current in the numerical model. The period was given as the M2 component, which is the maximum amplitude, and the amplitude is the summation of the amplitude of the M2, N2 and S2 components.

	Tide	Current
Amplitude	84 cm	20.7 cm/s
Phase	2.26 rad	1.75 rad
Period	12.42 hr	12.42 hr

(3) Calculation Case

For the large scale area, the tidal condition at both boundaries was calibrated so as to reproduce the given tide and current at the wave gauge.

For the large scale area, two cases were calculated, one is without the navigation channel, and the other is with the navigation channel.

2.4 Results

To decide the boundary condition for the small scale area, time series of tide and current were calculated by adjusting the tidal level of the north and south boundaries to the observed results at the wave gauge. The current is reproduced correctly as shown in Fig. 4.2-3 which shows the calculated tidal level and current velocity at the wave gauge. The current direction is along the shoreline as shown in Fig. 4.2-4.

Temporal changes of the tidal level and current velocity in the small scale area are shown in Fig. 4.2-5. The current velocity decreases corresponding to the increase of the water depth of the navigation channel. Fig. 4.2-6 shows the current pattern at the mouth with and without navigation channel.

2.5 Conclusion

To estimate the siltation rate of the navigation channel at Tg. Piandang River Mouth, tidal level and current velocity were calculated by numerical method. The tide and current outside of the mouth are reproduced using the observed results at the wave gauge. Velocity decreases as the current approaches the coast, and the direction is along the coastline. In the channel, the velocity also decreases from mouth to upstream. With a dredged channel, the velocity deceases according to the increase of flow area.

3. DISPERSION ANALYSIS

3.1 General

The refilling of the navigation channel is caused by the advection and dispersion of bed materials by mainly tidal currents. The transport equation was used to estimate the refilling rate in the navigation channel.

3.2 Basic Equation

To estimate the siltation rate in this Study, the following advection-dispersion equation was adopted.

$$\frac{\partial \bar{c}}{\partial t} + u\frac{\partial \bar{c}}{\partial x} + v\frac{\partial \bar{c}}{\partial y} =$$

$$\frac{1}{h}\frac{\partial}{\partial x}\left(hD_x\frac{\partial \bar{c}}{\partial x}\right) + \frac{1}{h}\frac{\partial}{\partial y}\left(hD_y\frac{\partial \bar{c}}{\partial y}\right) + Q_L C_L\frac{1}{h} - S$$

where;

$\bar{c}$	:	depth averaged concentration (g/m^3)
u, v	:	depth averaged flow velocities (m/s)
D_x, D_y	:	dispersion coefficients (m^2/s)
h	:	water depth (m)

S	:	deposition/erosion term ($g/m^3/s$)
Q_L	:	source discharge per unit horizontal area ($m^3/s/m^2$)
C_L	:	concentration of the source discharge (g/m^3)

The rate of deposition is expressed by:

$$S = \frac{W_c}{h_a} \left\{ 1 - \left(\frac{V}{V_{cd}}\right)^2 \right\} \quad , \qquad V > V_{cd}$$

where;

W_c	:	mean settling velocity of suspended particles
h_a	:	average velocity through which the particles settle
V	:	depth averaged flow velocity
V_{cd}	:	critical deposition velocity

$$\frac{ha}{h} = \frac{\int_0^1 s\left(\frac{1}{s} - 1\right)^R ds}{\int_0^1 \left(\frac{1}{s} - 1\right)^R ds}$$

where;

$s = h/y$: relative depth, h: water depth, z: rouse number

$$V_{cd} = 1.25W \frac{h^{1/6}}{n\sqrt{g}}$$

where, n: Manning's roughness coefficient

The rate of erosion is expressed by:

$$S = \frac{E}{h} \left\{ 1 - \left(\frac{V}{V_{ce}}\right)^2 \right\} , \qquad V > V_{ce}$$

where;

E : erodibility of the bed ($g/m^2/s$)

V_{ce} : critical erosion velocity (m/s)

3.3 Calculation Condition

The tidal current flows across the dredged outer channel and along the dredged inner channel. One-dimensional calculation can be applied to simulate the refilling process because the current pattern is simple.

In the outer channel, the calculation was carried out across the channel. In the inner channel, it was carried out along the channel.

In the calculation, the coefficients were determined by referring to the previous studies, as follows:

Dispersion coefficients D_x and D_y were determined from the following equation:

$$\frac{D}{hu_*} = 340$$

where;

h : water depth

u_* : friction velocity = $\dfrac{n*g^{(1/2)}}{h^{(1/6)}} * V$

n : Manning's n

g : gravitational acceleration

Critical erosion velocity is set at 0.1 m/s and critical deposition velocity is calculated by the following Turuya's formula:

$$V_{cd} = A_1 * C \qquad (C<C_H)$$

$$V_{cd} = 0.0026\ m/s \qquad (C>C_H)$$

where, $A_1 = 0.6\ m^4/g/s$ and $C_H = 4{,}300\ g/m^3$

Erodibility of the bed was calibrated to reproduce the refilling rate of 0.7 m/yr and the mud concentration from 300 g/m^3 to 2,000 g/m^3 at the test pit of the outer channel in Tg. Piandang River Mouth.

3.4 Results

For the calibration of the coefficient, the refilling process of the test pit result of the outer channel was simulated. As the calculation condition, the amplitude of the tidal current was 15 cm/s, bed level was -1.0 m and the dredged depth was -2.0 m. Three cases were calculated by changing the erodibility; namely, $E = 0.01$, 0.02, and 0.025.

The concentration changes according to the tidal cycle, as shown in Fig. 4.3-1, from 400 mg/l to 1700 mg/l. The refilling rate which was obtained from 3 tidal cycle calculations depends on the erodibility of the bed, as shown in Fig. 4.3-1. The resulting rate of 0.02 coincides with the observed one, as shown in the Table.

Comparison of Observed and Calculated Results

Results	Refilling Rate (m/yr)	Concentration (g/m^3)
Observed	0.7	300 to 2,000
Calculated	0.7	500 to 1,400

The refilling rate and the concentration of the outer channel is shown in Fig. 4.3-2. The rate changes from 0.6 m/y to 0.9 m/y and the concentration is from 500 gr/l to 1600 gr/l. In the calculation, the amplitude of the current velocity is 15 cm/s and erodibility is 0.02 $g/m^2/s$.

The refilling rate and the concentration of the inner channel is shown in Fig. 4.3-3. The refilling in the test pit of the inner channel is mostly caused by boat navigation rather than tidal currents. The resulting erodibility of 0.04 is also shown considering the agitation by boats.

The refilling rate of the dredged channel is summarized in the following table.

Refilling Rate of Dredged Channel

Place	Dredging Depth	Erodibility	Refilling Rate
Outer Channel	2.5 m	0.02 g/m2/s	0.9 m/yr
Inner Channel	2.5	0.02	0.05 - 0.15
Inner Channel	2.5	0.04	0.2 - 0.4

3.5 Conclusion

The refilling of the navigation channel was calculated by the advection and dispersion equation. The calculation condition was calibrated by the test pit results. The refilling rate was estimated at 0.9 m/yr in the outer channel and 0.3 m/yr in the inner channel. In the inner channel, the rate had some changes because the agitation by boat was not fully considered.

4. COASTLINE CHANGE ANALYSIS

4.1 General

Construction of jetties at the Marang River Mouth has some possibilities to cause coastline changes. One-line model was applied to estimate the influence to the adjacent coastline.

4.2 One-line Model

One-line model which is commonly used for the calculation of coastline changes by littoral transport was applied for the evaluation of influence of the structures. The basic assumption of the model is that the active beach profile moves in parallel to itself within a certain range of the depth, beyond which the profile does not change, as shown in Fig. 4.4-1.

The one-line model is expressed in the following equations:

(a) Equation of Continuity

$$\frac{dy}{dt} + \frac{1}{(1-n)hi}\frac{dQ_x}{dx} = 0$$

where;

y	:	distance from the baseline to the shoreline
hi	:	depth of beach profile involved in shoreline change
n	:	porosity of sediment
Q_x	:	rate of littoral drift
x	:	longshore coordinate

(b) Equation of Longshore Transport

$$Q_x = K * \frac{pg}{8} (H_{sb}^2) \cdot Cgb \; Sin \; \alpha b \; Cos \; \alpha b$$

$$= F \; Sin \; \alpha b \; Cos \; \alpha b$$

where;

K	:	constant
g	:	gravitational acceleration
Hsb	:	breaking wave height
αb	:	breaking angle

4.3 Calculation Condition

The calculation area covers about 25 km long sandy coastline from the Chedering Port at the north end to the headland of the south. The Marang River Mouth is located 9 km from the north end and the headlands at both ends seem to intercept longshore transport. The baseline is set to the northwest direction, as shown in Fig. 4.4-2.

The constant F of 11,000,000 m^3/yr was adopted based on the Master Plan Study.

The breaking wave angle was calibrated to simulate the coastline changes from 1973 to 1987, as shown in Fig. 4.4-3.

The depth h_i of 8 m was adopted from the sandbar height of 3 m and the active transport depth of 5 m.

The boundary condition at the north end was given as no longshore transport, and at the south no movement of the shoreline.

4.4 Results

Fig. 4.4-4 and Fig. 4.4-5 show the results of the coastline change due to the construction of structures. According to the results, the northern part of the river mouth expects accretion by about 35 m in 30 years, while the southern part retreats directly opposite the north side. Therefore, it is necessary to consider some measures for beach erosion prevention.

4.5 Explanations

The accuracy of the estimation mainly depends on the rate of the longshore transport. The rate is a function of wave energy and wave direction which control the speed of the shoreline change and the stable shoreline formation.

At the Marang River Mouth, Kapus Island modifies wave direction and the shoreline becomes convex. From the shoreline formation, the wave direction can be estimated. Wave has a constant direction off the island and changes its direction along the coast by the island. If the directional distribution of the wave energy is assumed, the change of the mean wave direction is estimated.

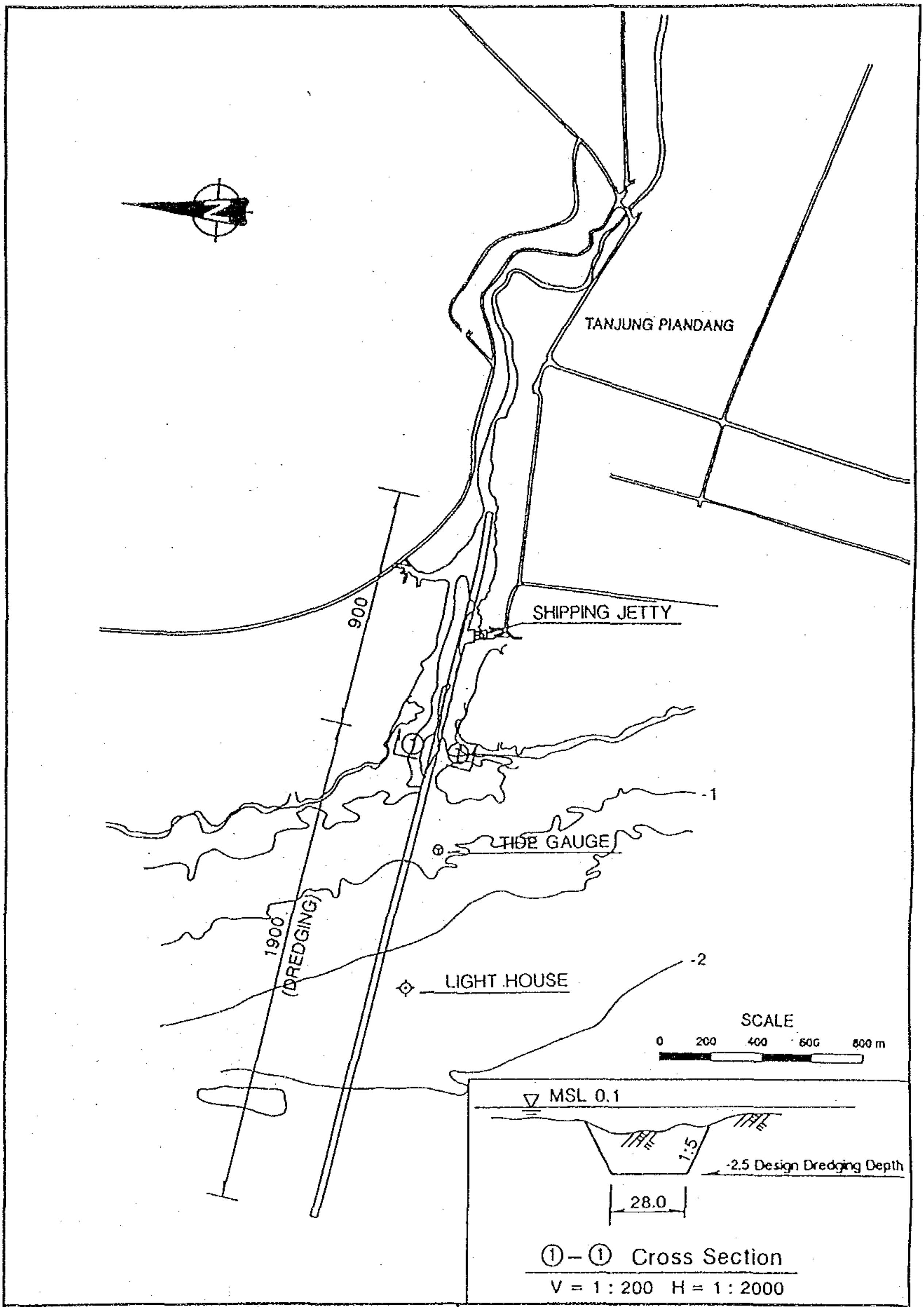
The shoreline formation is calculated by the one-line model assuming the principal wave directions off the island are -1.0, -1.5, and -2.0 degrees to the normal of the baseline. The results are shown in Fig. 4.4-6 and Fig. 4.4-7. Small changes of the offshore wave direction causes rather significant shoreline changes. The rate of longshore transport along the coast is also shown. In the figure, the "plus" means southward transport and the "minus" means northward. The direction of longshore transport changes according to the small changes of wave direction.

In the actual situation, incoming wave energy and direction changes from year to year and the coastline at the Marang River Mouth seems to be dynamically stable.

4.6 Conclusion

The influence caused by the construction of jetties at the Marang River Mouth was estimated by one-line model. The calculation results give a change of 35 m near the structures. The change is also sensitive to the variation of wave conditions.

F I G U R E S

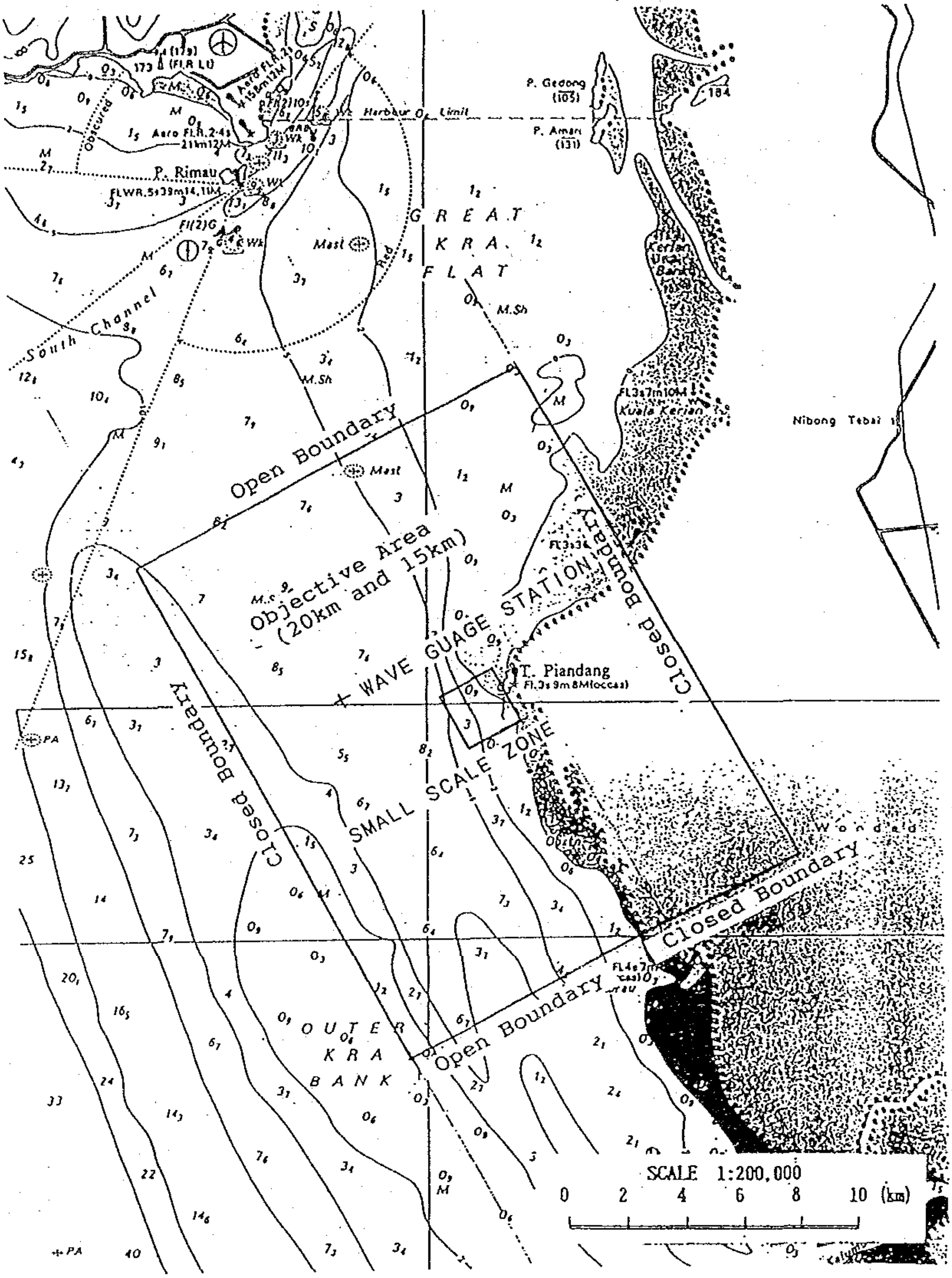


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

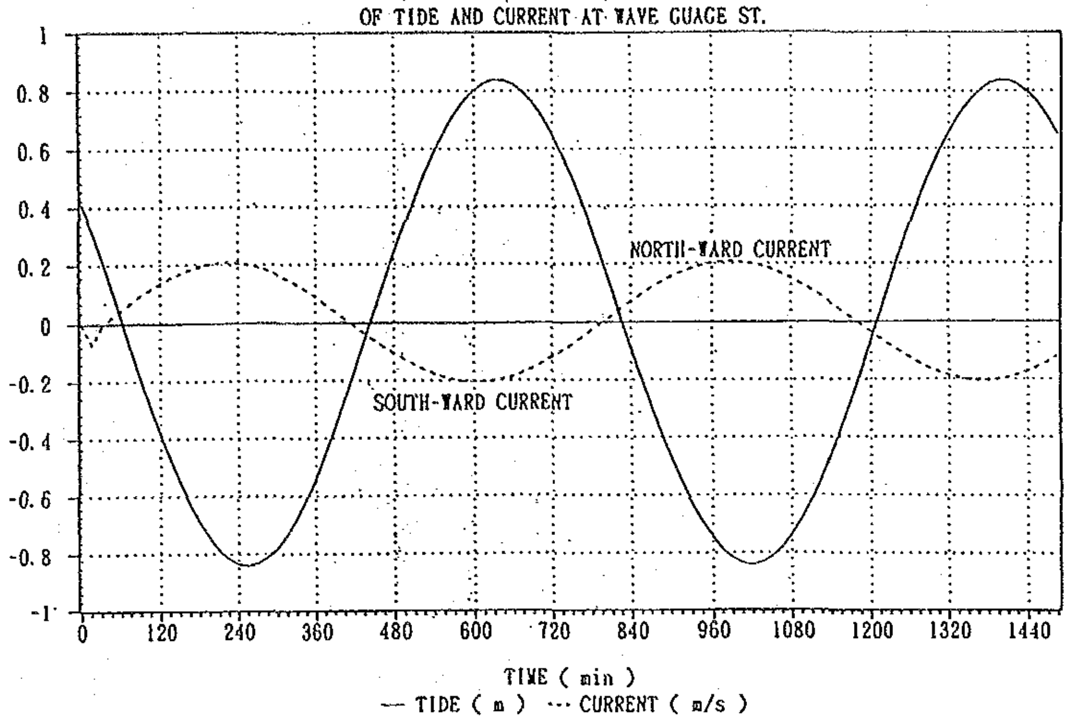
LAYOUT OF COUNTERMEASURES AT TG.PIANDANG RIVER MOUTH

Fig. 4.2-1

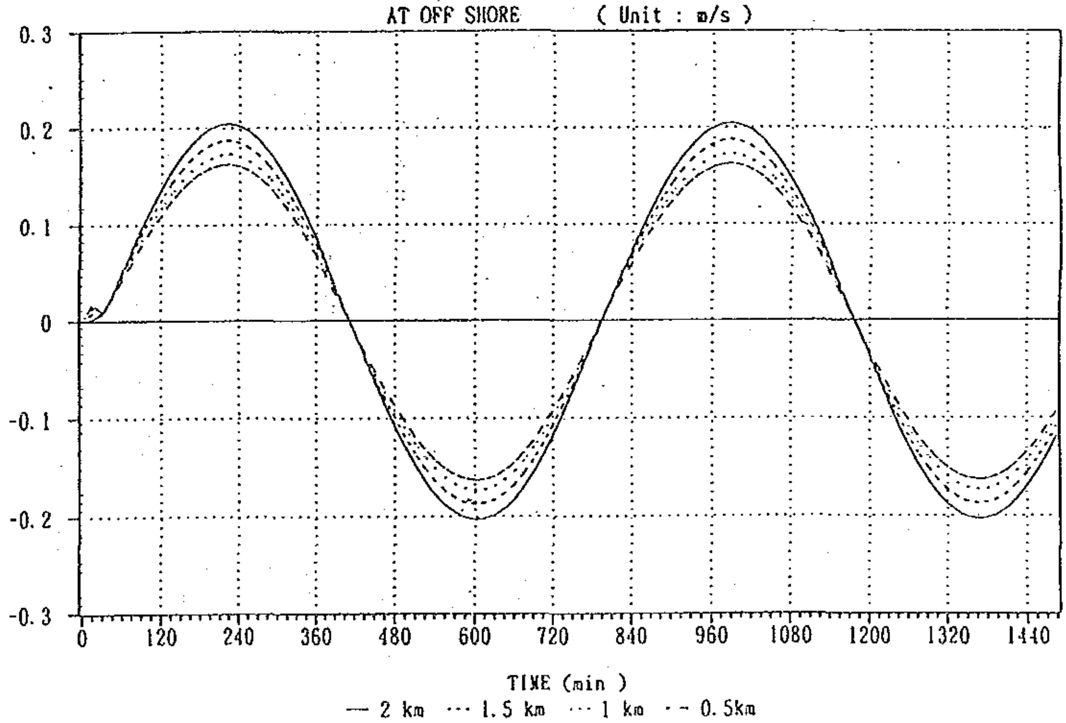


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CALCULATION AREA FOR TIDAL CURRENT	Fig. 4.2-2
JAPAN INTERNATIONAL COOPERATION AGENCY		

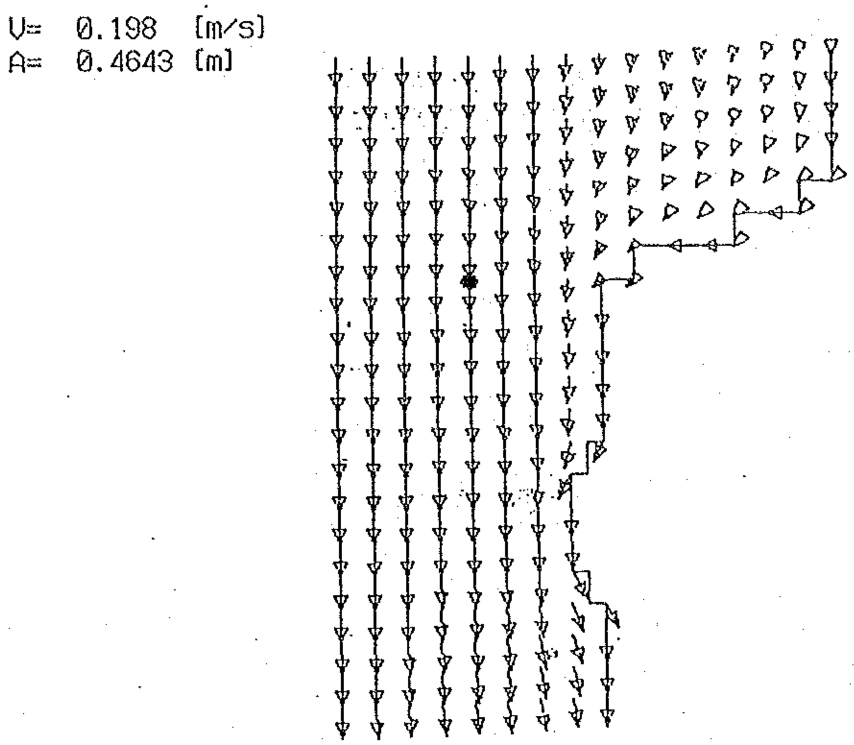
RESULT OF REPRODUCTION OF TIME SERIES
OF TIDE AND CURRENT AT WAVE GUAGE ST.

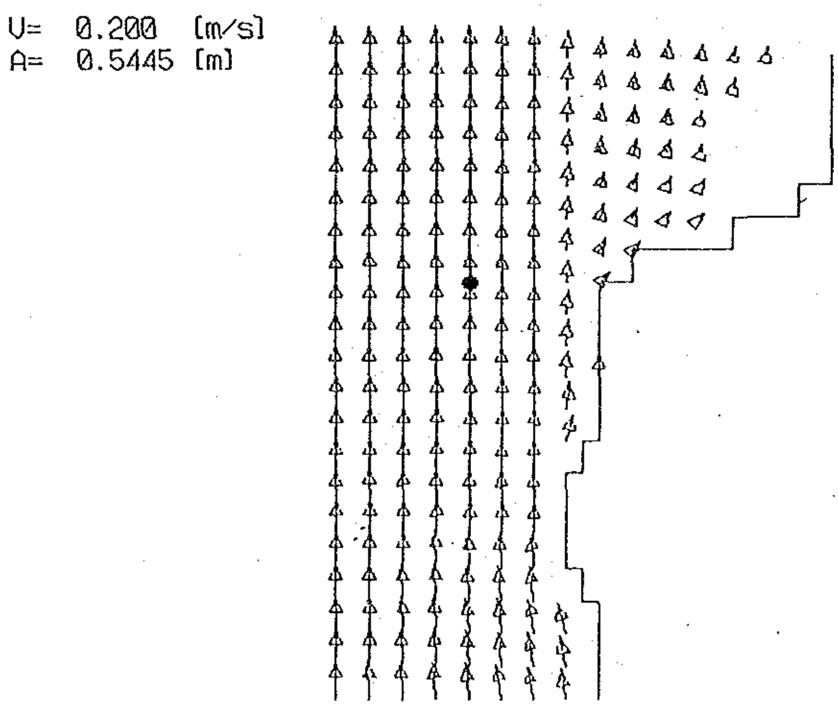


COMPARISON OF TIME SERIES OF CURRENT
AT OFF SHORE (Unit : m/s)



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	RESULT OF TIDAL CURRENT FOR LARGE SCALE AREA Fig. 4.2-3
JAPAN INTERNATIONAL COOPERATION AGENCY	

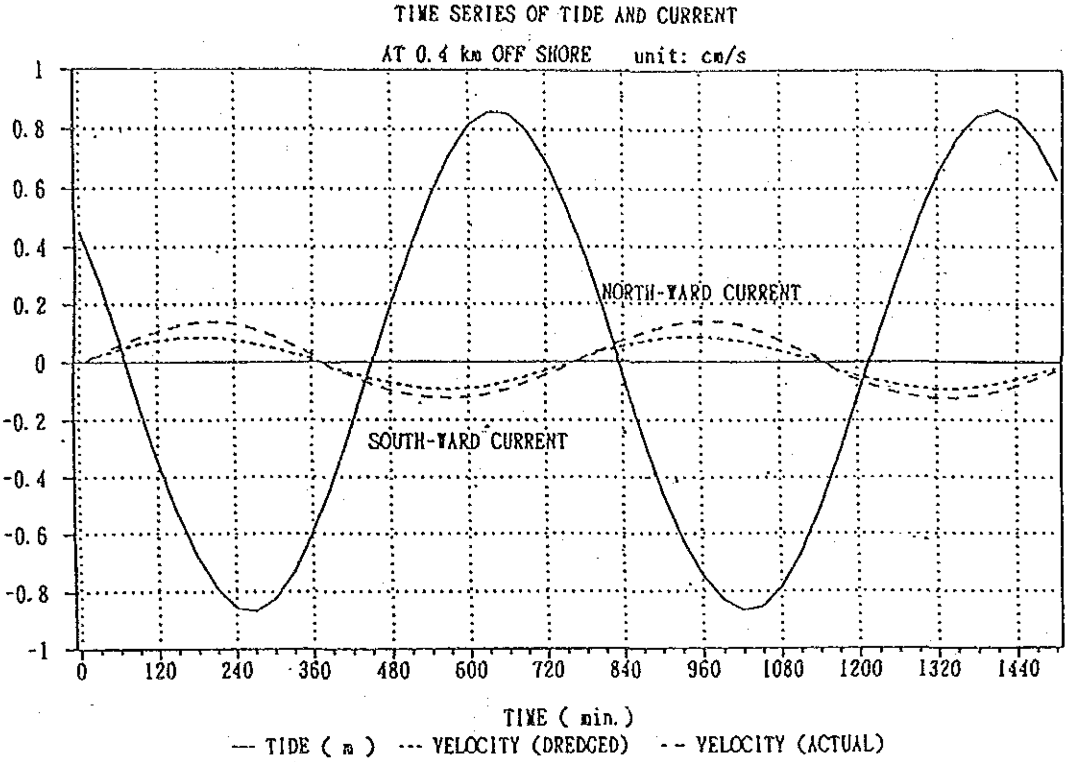


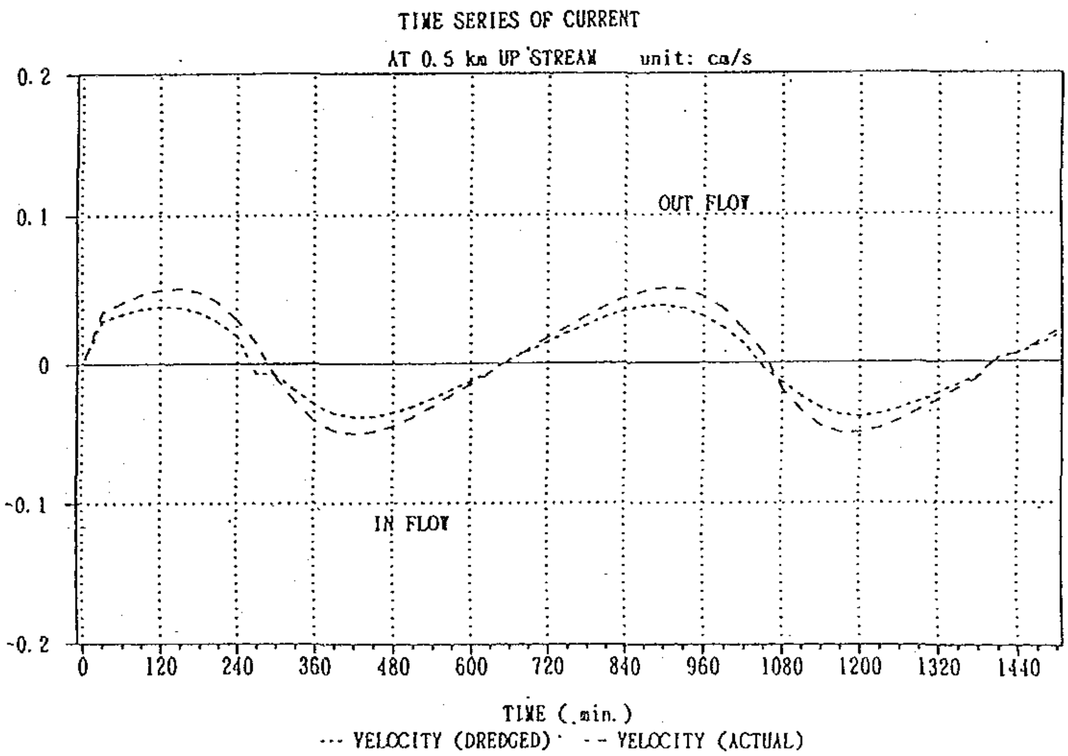


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

CURRENT DISTRIBUTION FOR LARGE SCALE AREA Fig. 4.2-4





THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	RESULT OF TIDAL CURRENT FOR SMALL SCALE AREA Fig. 4.2-5
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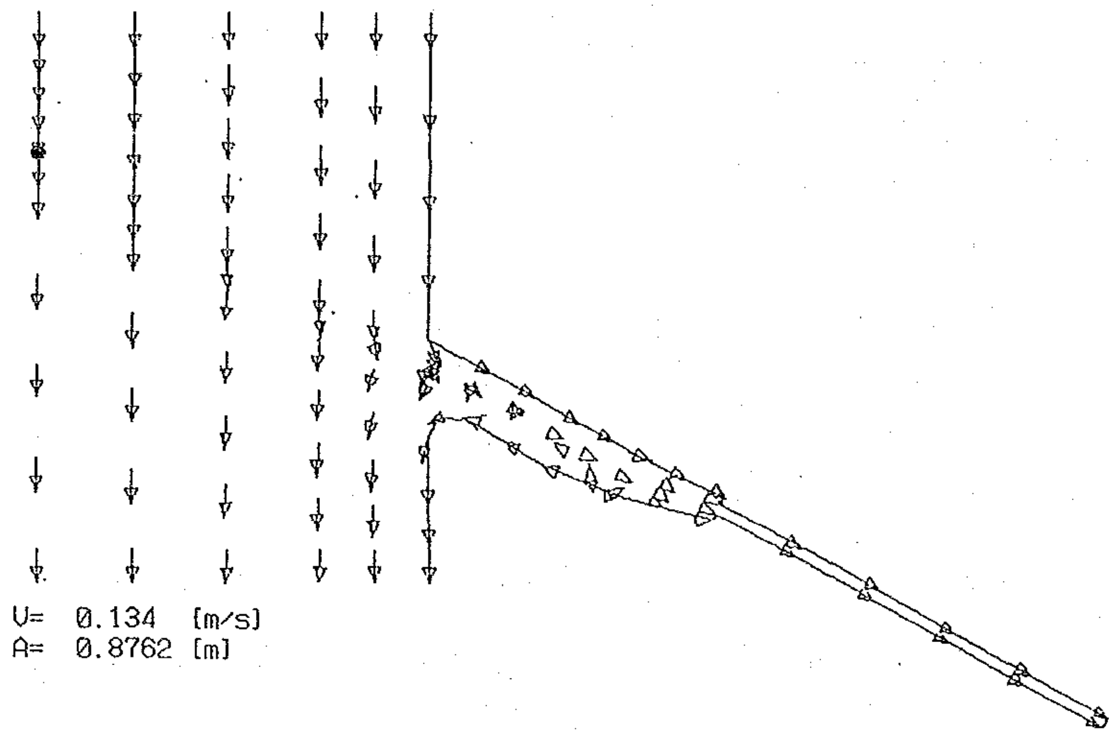
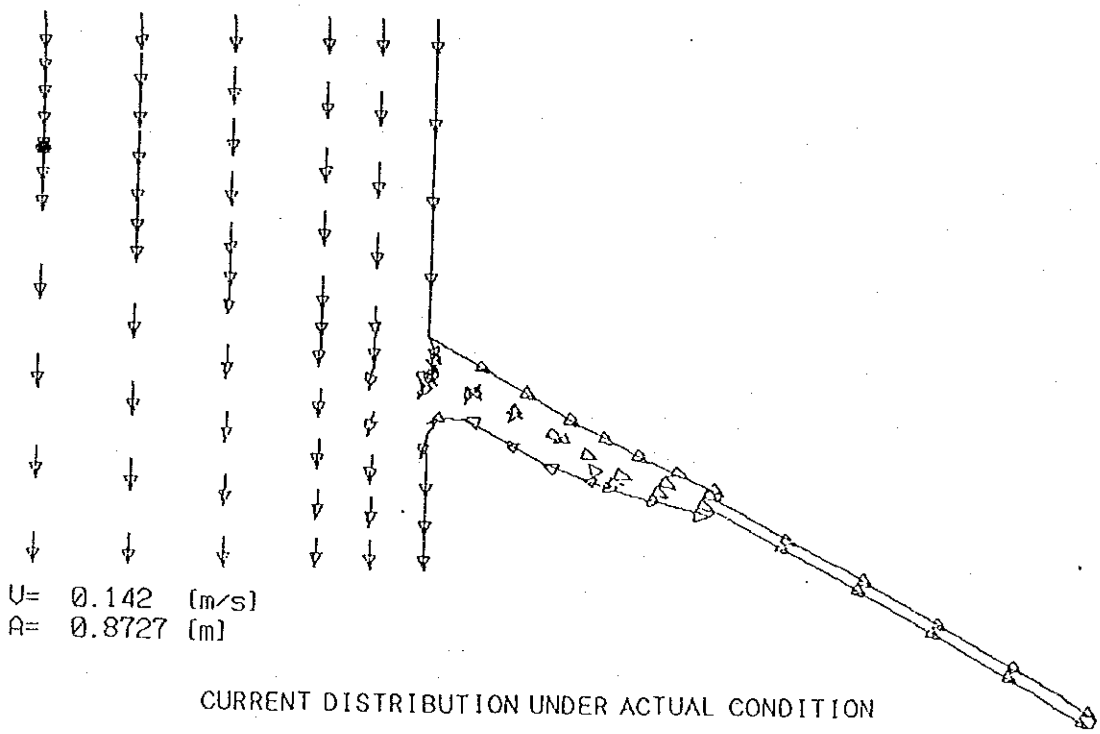


CURRENT DISTRIBUTION UNDER DREDGED CONDITION



CURRENT DISTRIBUTION UNDER ACTUAL CONDITION

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CURRENT DISTRIBUTION FOR SMALL SCALE AREA Fig. 4.2-6
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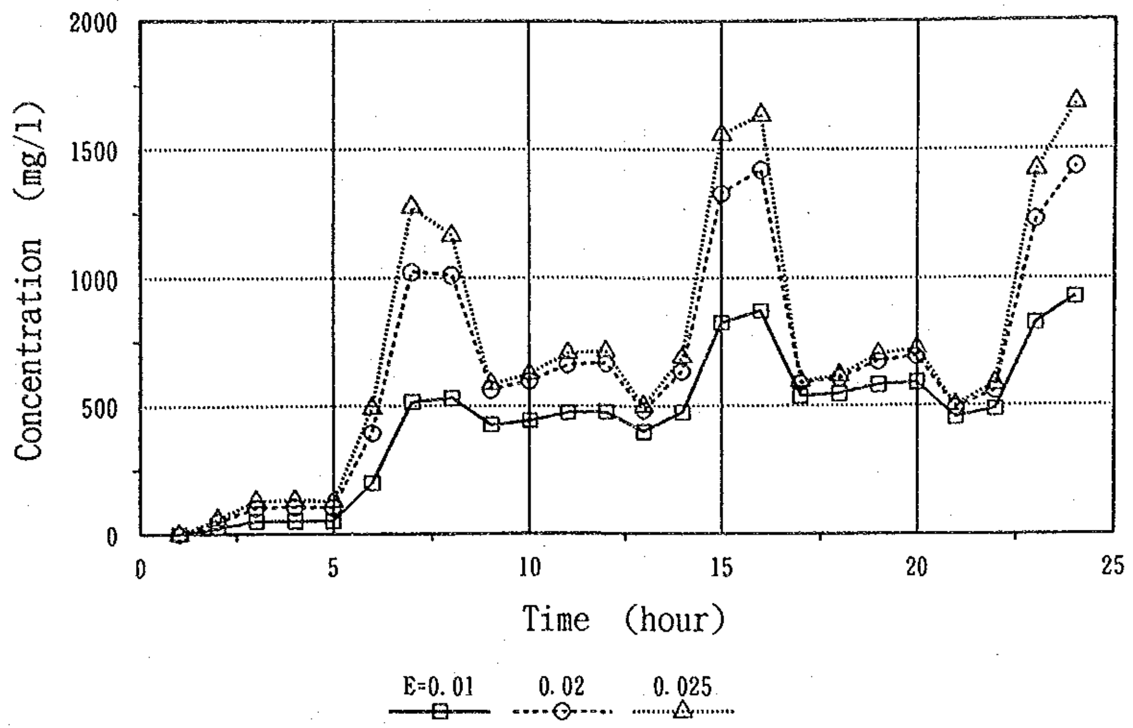
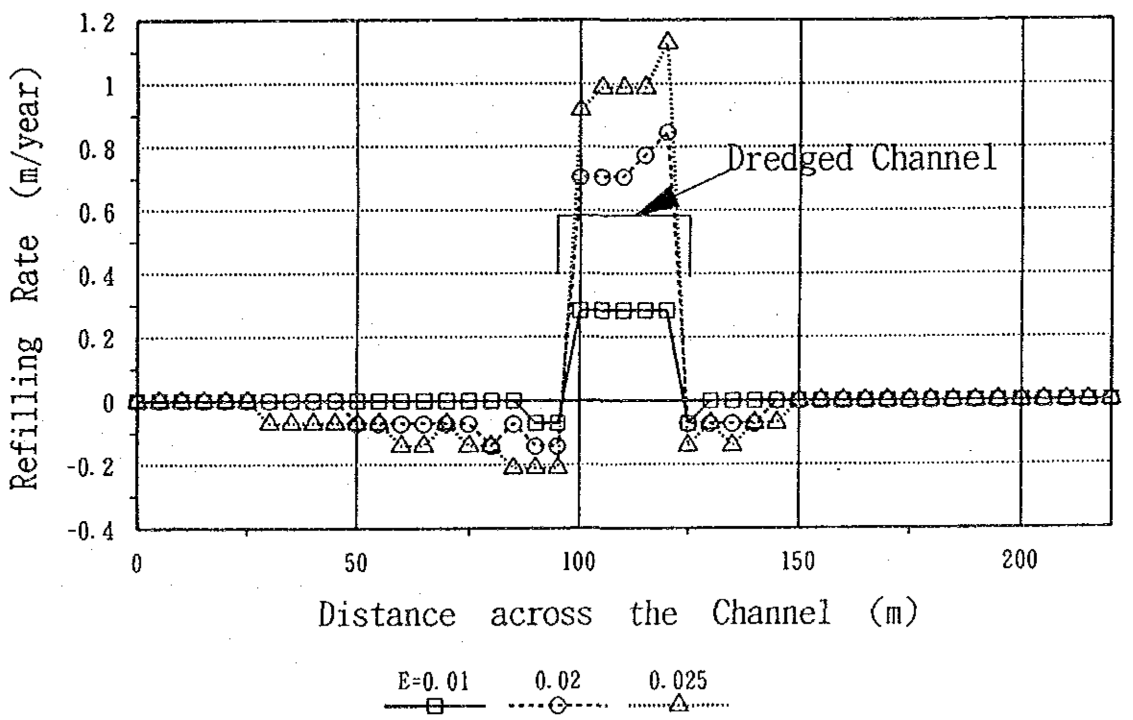
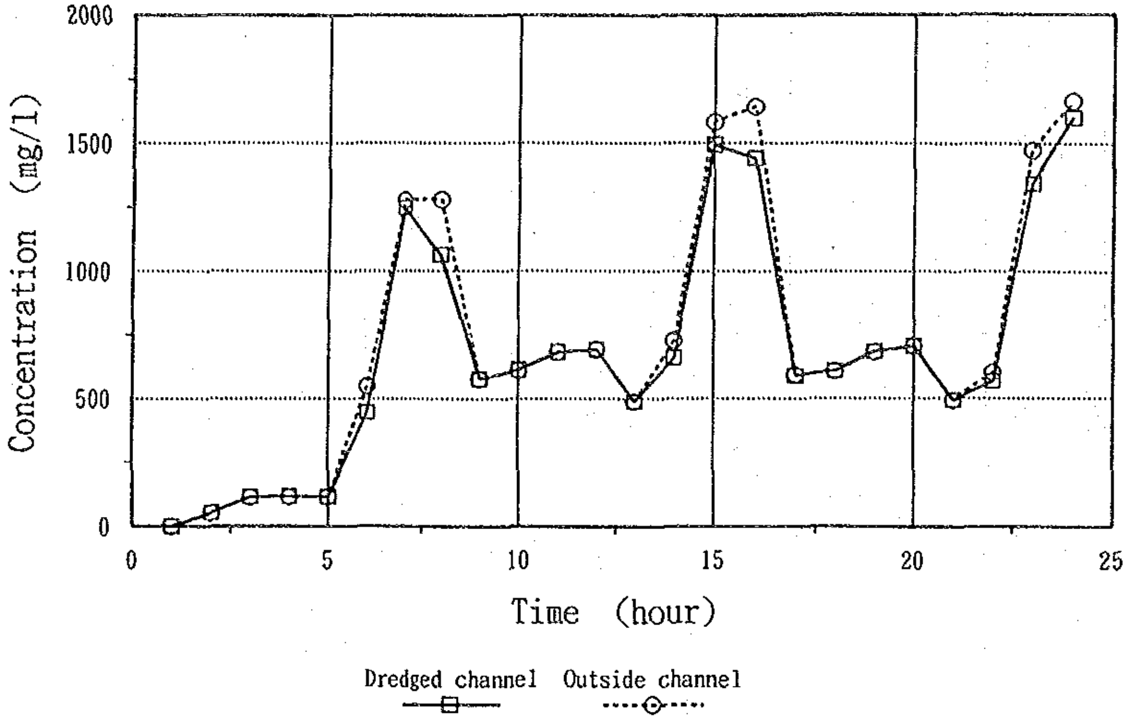
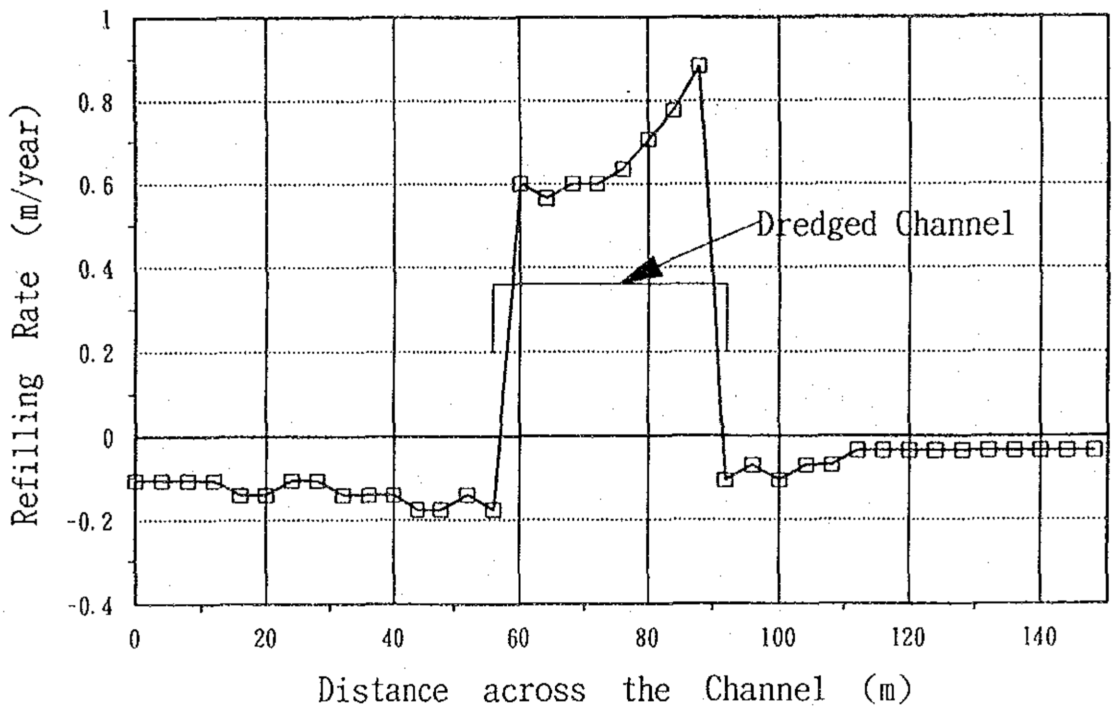


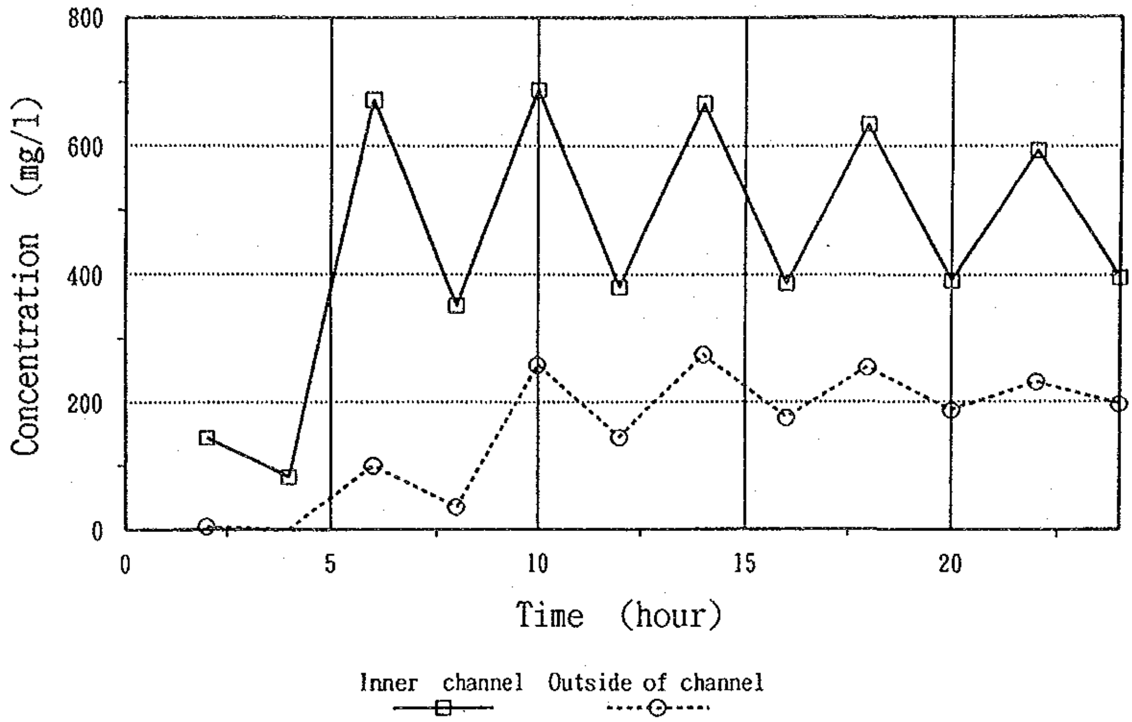


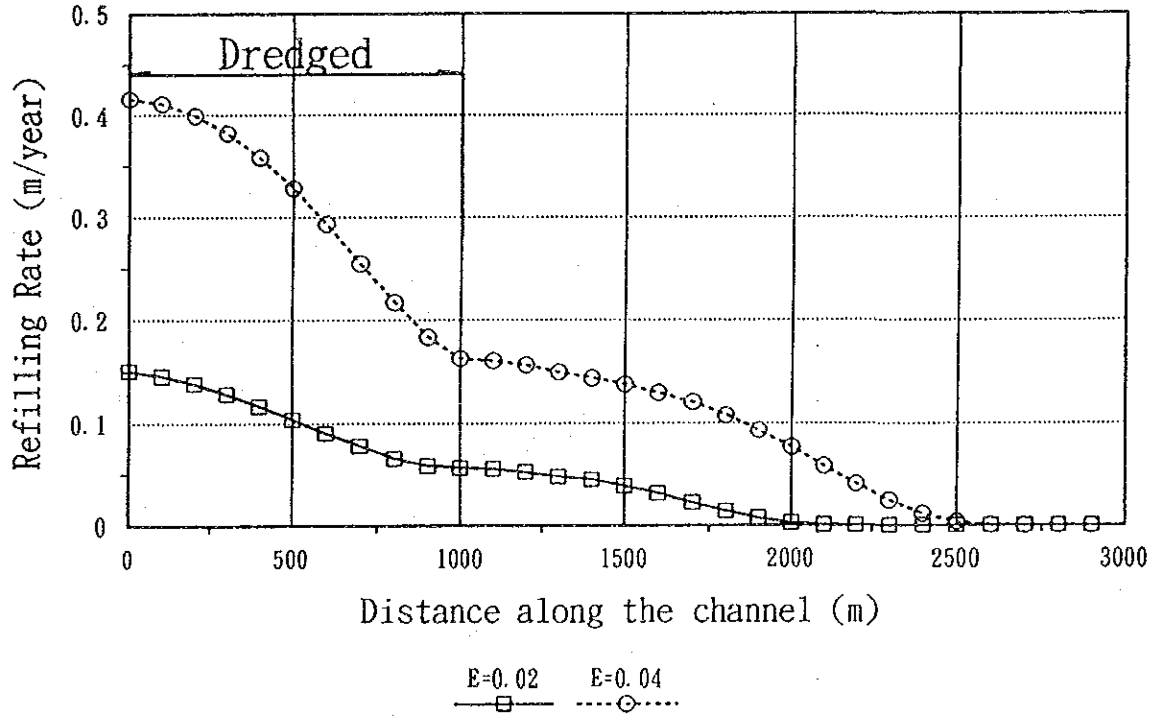
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CONCENTRATION AND REFILLING RATE (TEST PIT)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.3-1





THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CONCENTRATION AND REFILLING RATE (OUTER CHANNEL)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.3-2





THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CONCENTRATION AND REFILLING RATE (INNER CHANNEL)
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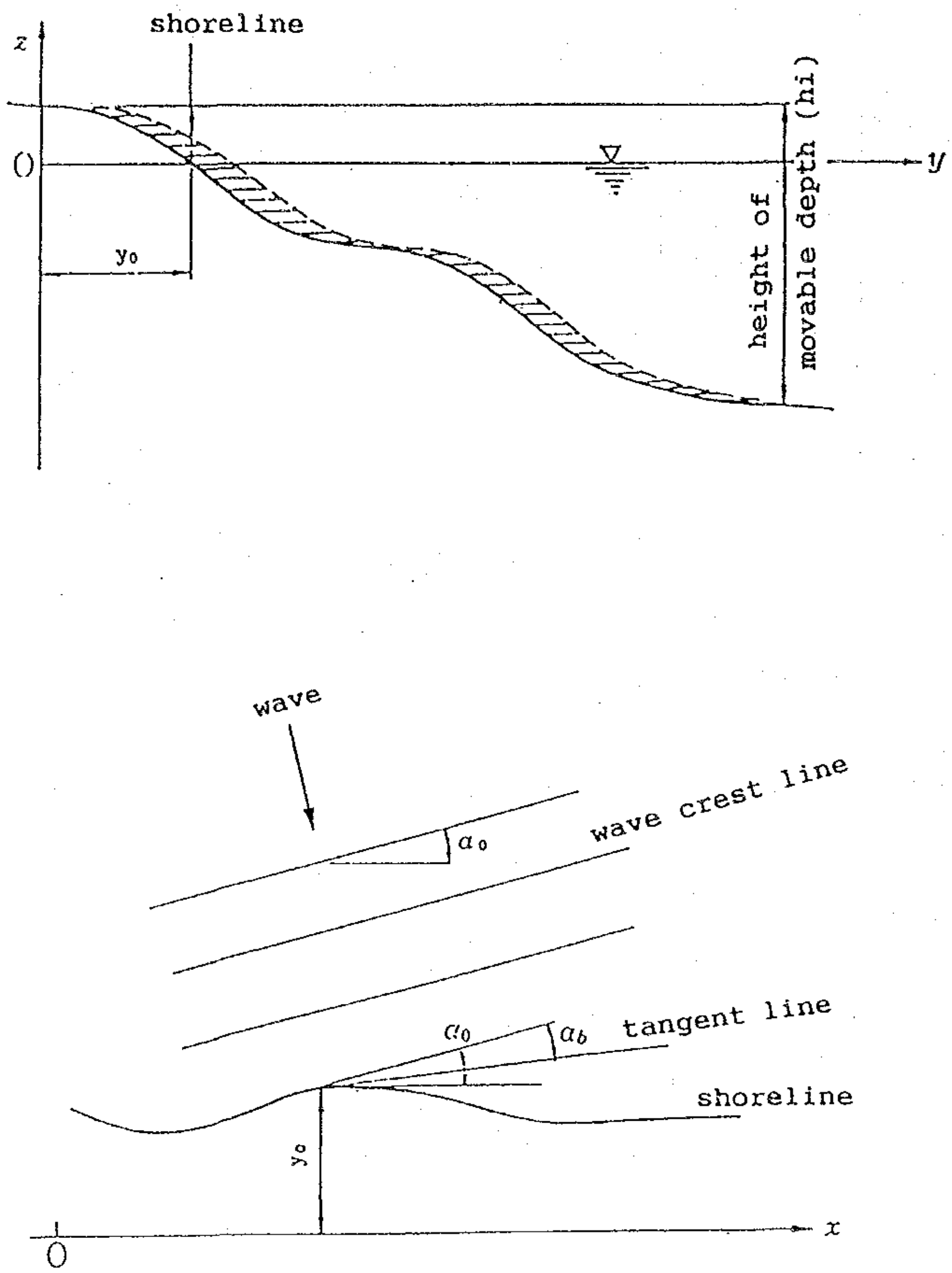
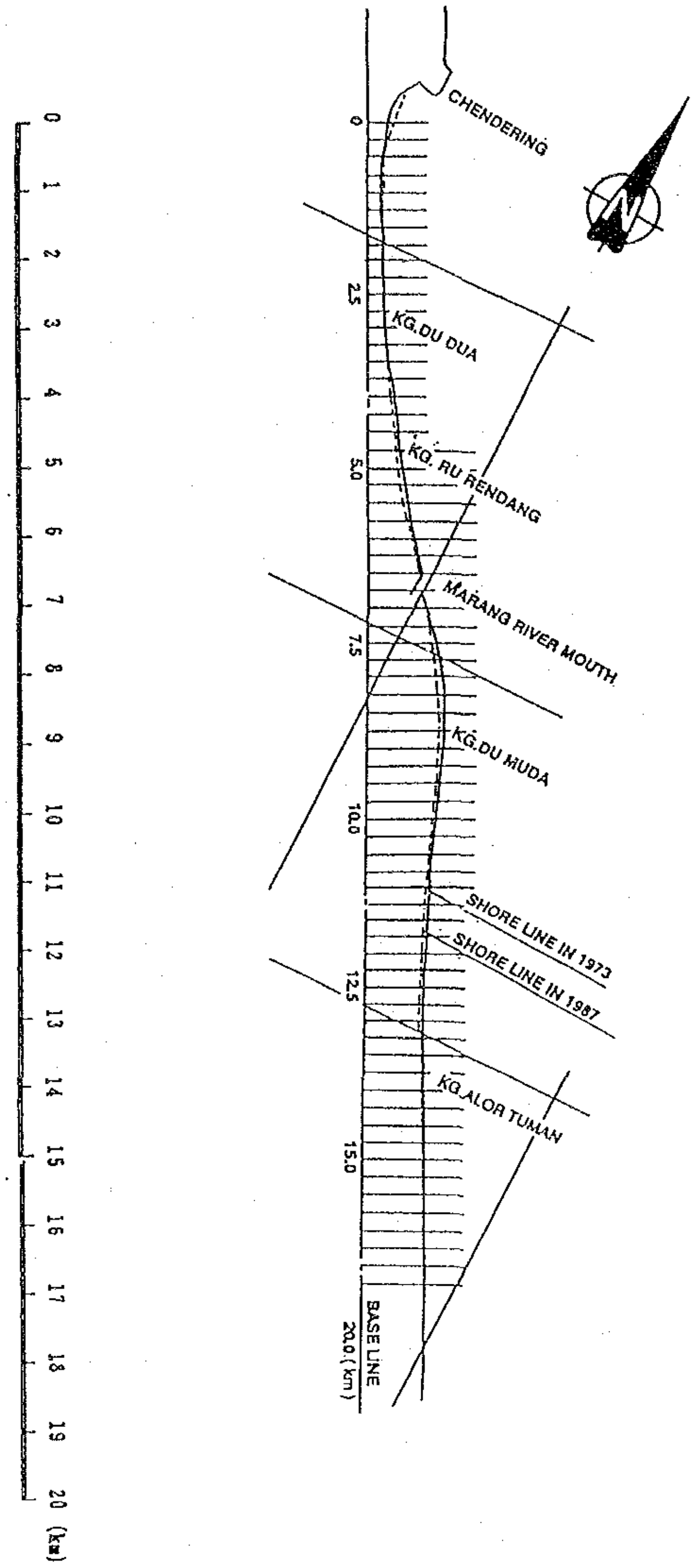


THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

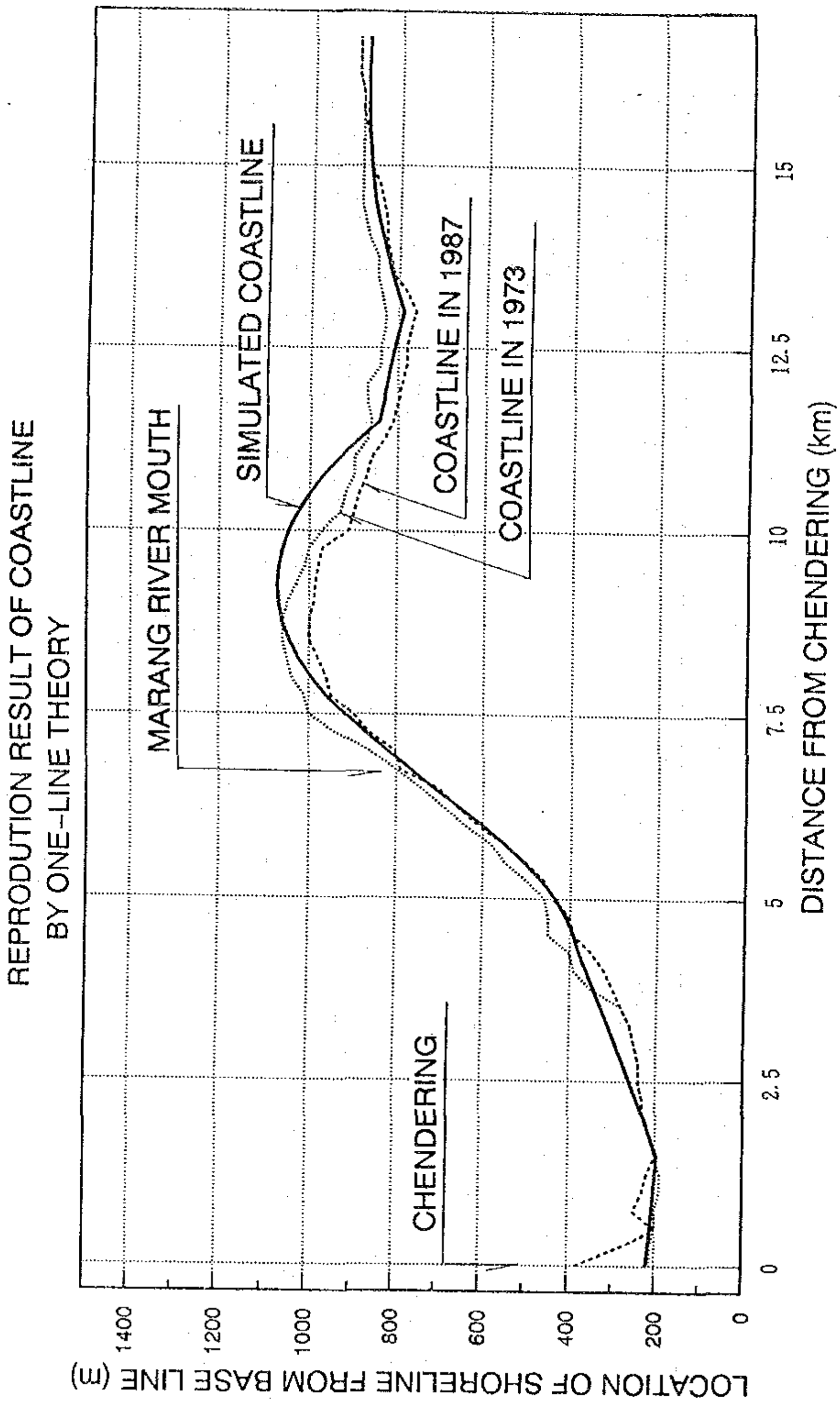
JAPAN INTERNATIONAL COOPERATION AGENCY

CONCEPT OF SHORELINE MOVEMENT
AND ANGLE OF INCIDENT WAVES

Fig. 4.4-1



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	ACTUAL SHORELINE AND ARRANGEMENT OF BASE LINE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.4-2



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	REPRODUCTION OF SHORELINE IN 1987
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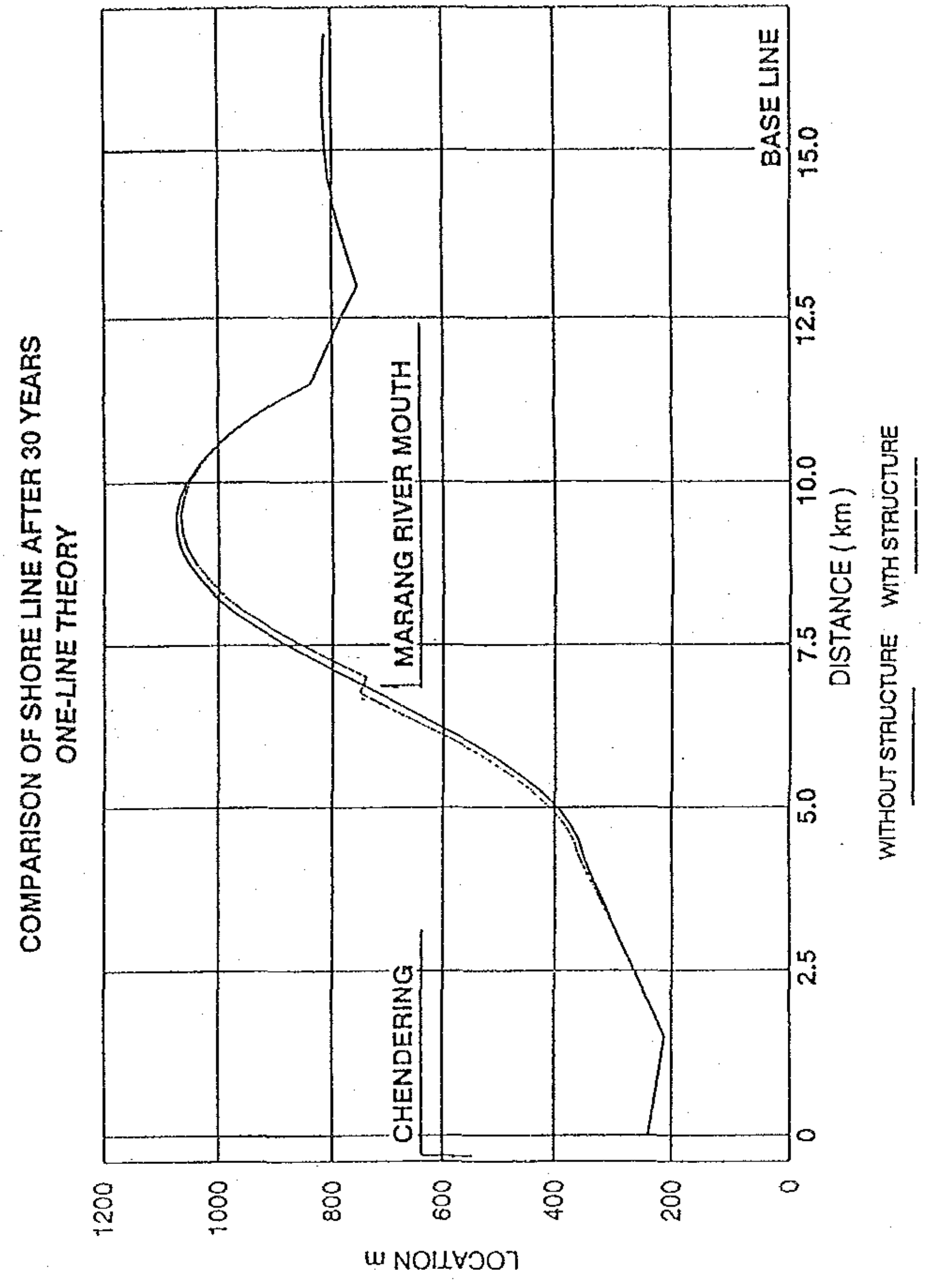

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	COMPARISON OF SHORELINE AFTER 30 YEARS Fig. 4.4-4
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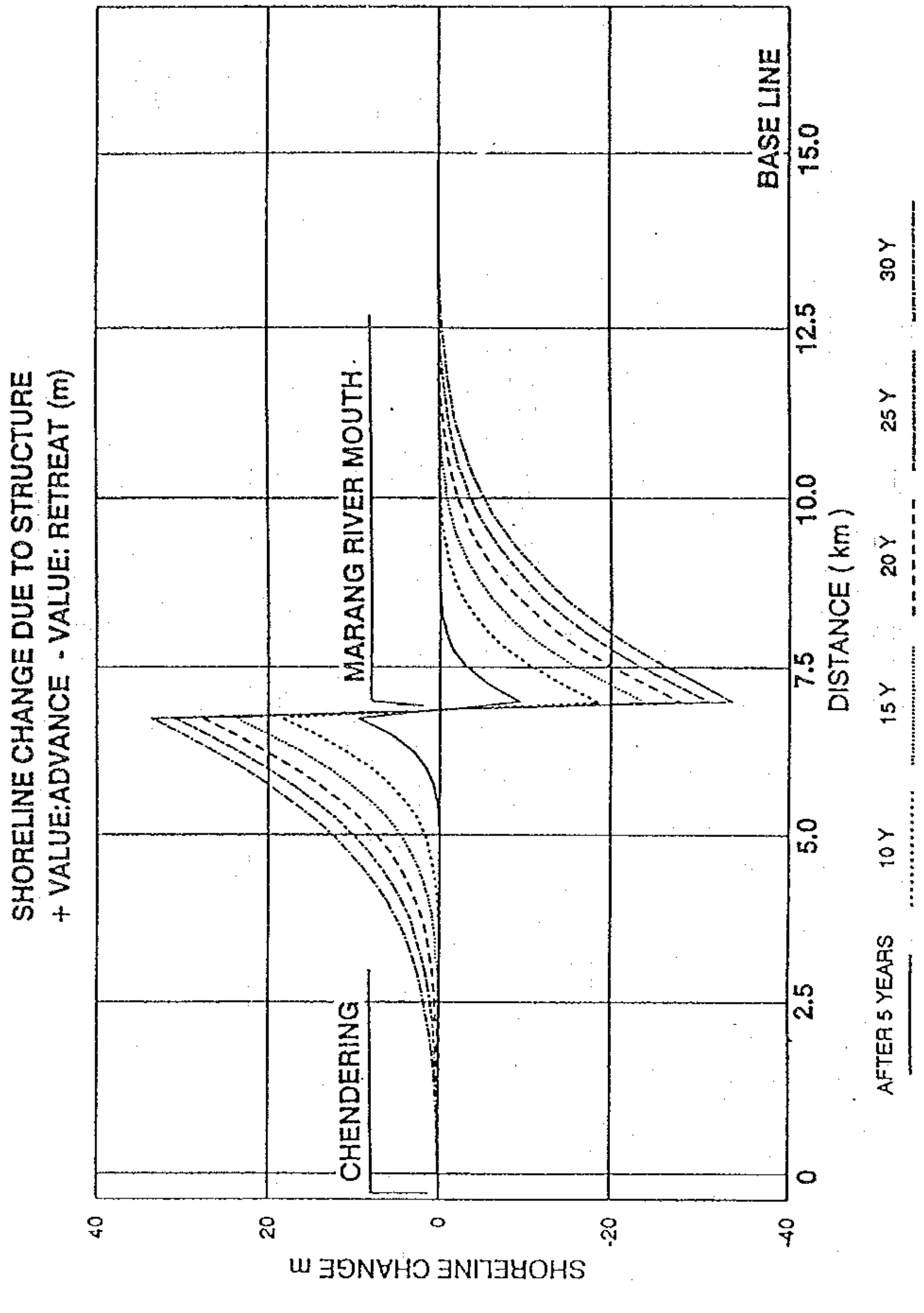

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	SHORELINE CHANGE DUE TO STRUCTURES Fig. 4.4-5
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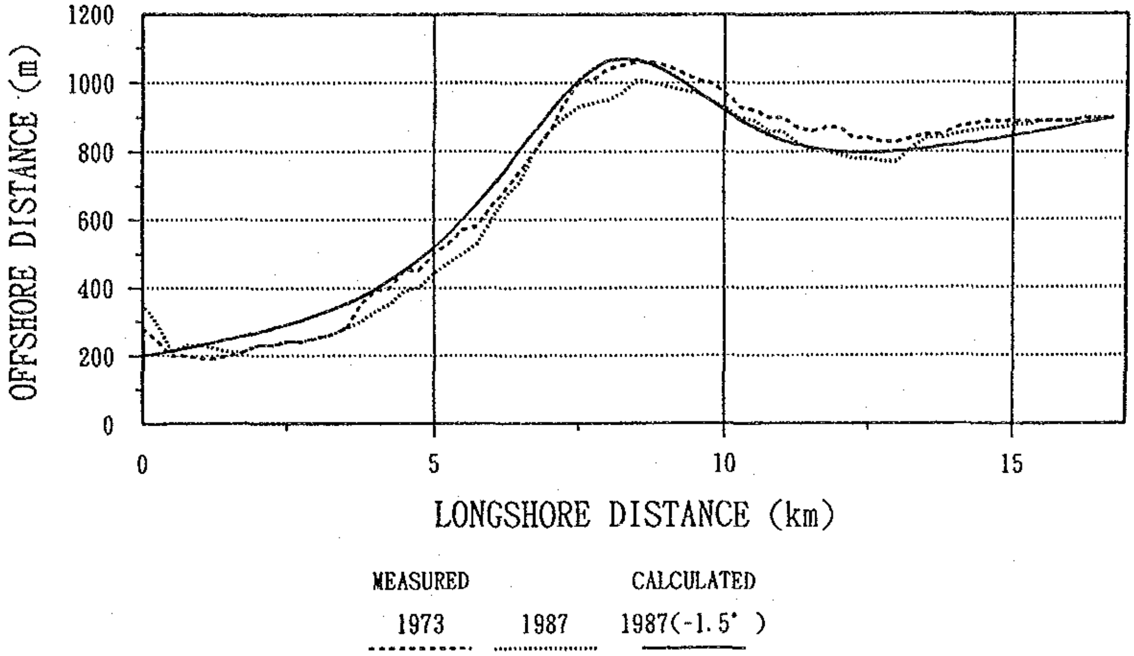
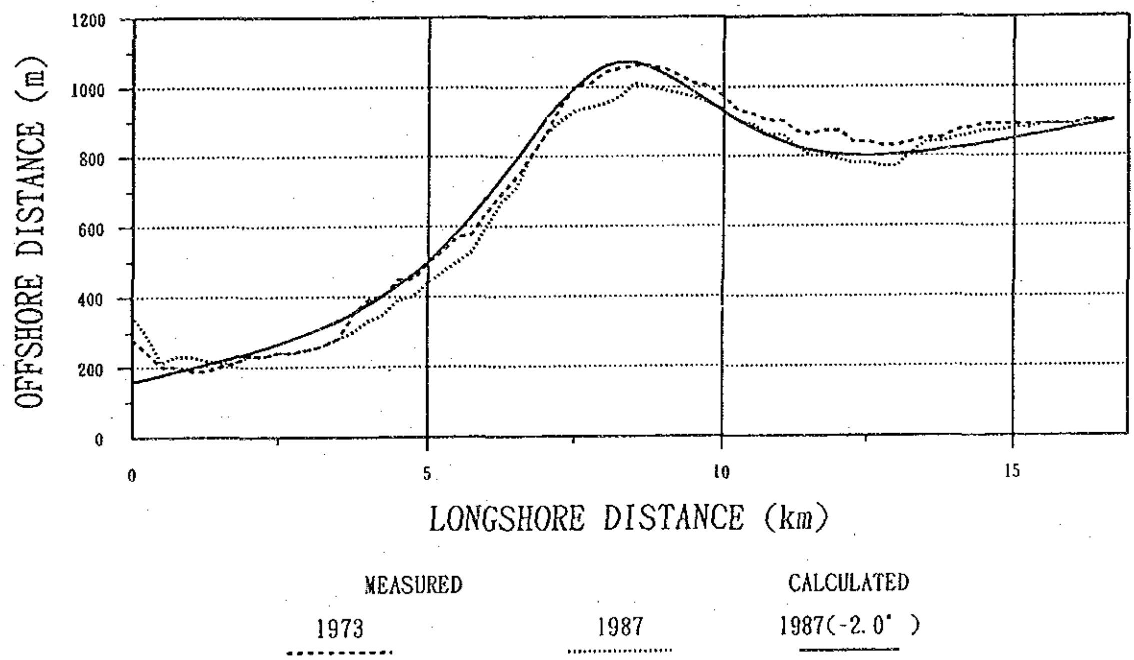
COMPARISON OF SHORELINE:WAVE ANGLE -1.5°



COMPARISON OF SHORELINE:WAVE ANGLE -2.0°



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	COASTLINE CHANGE BY WAVE DIRECTION
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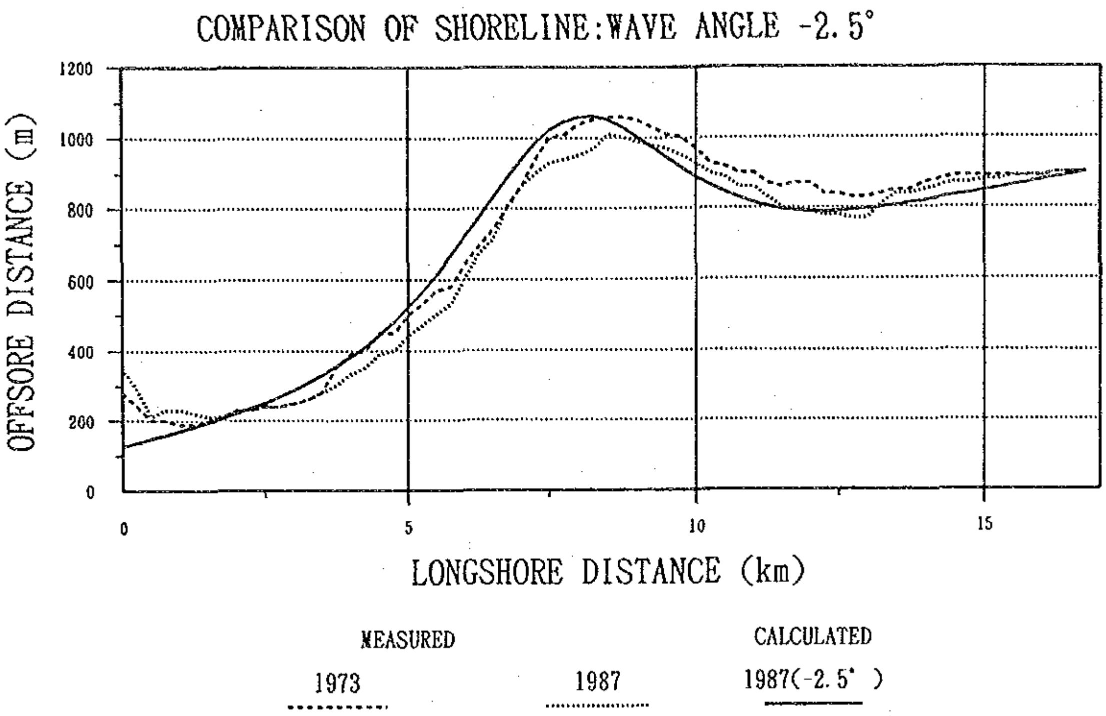

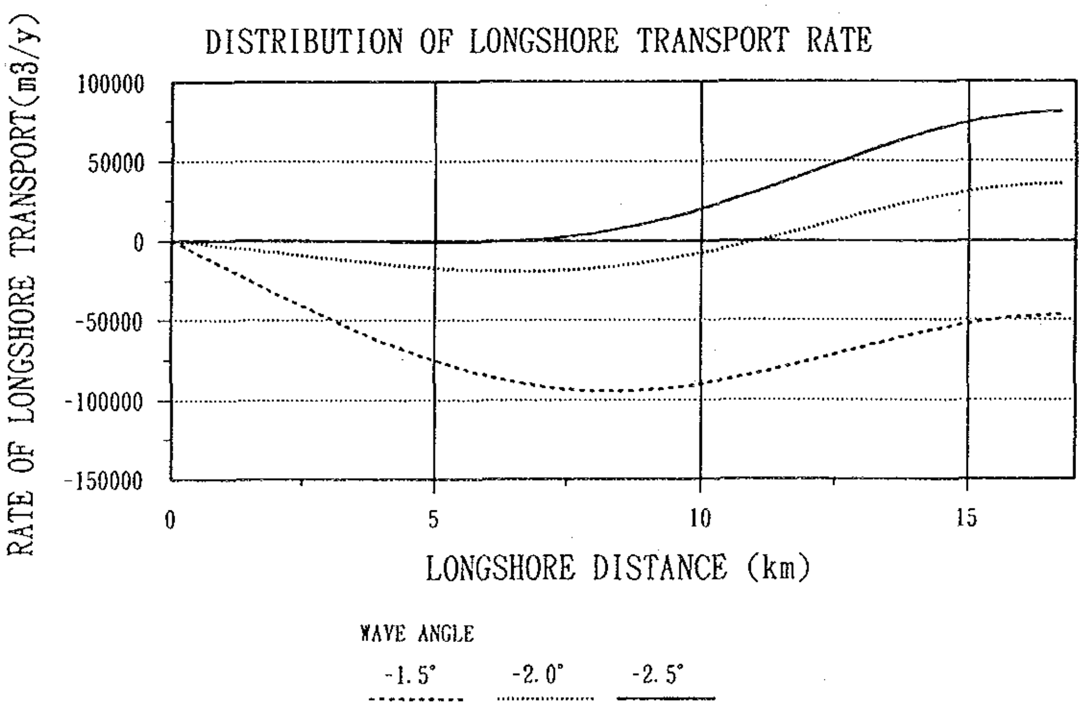

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	COASTLINE CHANGE BY WAVE DIRECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.4-7

5. RIVER MOUTH IMPROVEMENT PLAN

THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

SUPPORTING REPORT NO. 5

RIVER MOUTH IMPROVEMENT PLAN

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SUPPORTING REPORT NO. 5

RIVER MOUTH IMPROVEMENT PLAN

1. PROBLEMS AND MEASURES TAKEN

1.1 Problems on River Mouth Siltation

River mouths which have a physically complex phenomena in the interference between river and sea vary in form as a result of the interaction of several factors such as river flow, wind, wave, current, tide and sediment. River mouth siltation and the shifting of river mouth location are caused by different factors as well, and they present *navigation and inundation problems in the study area (see Table 5.1-1).*

Problems on Navigation

Most of the river mouths in the study area are heavily silted. As a result, fishing boats cannot navigate during low tide and fishermen have to wait until the next high tide to bring in their catch or go out into the sea. This problem is further aggravated if the river mouth has shifted to a new location because fishermen find difficulty in locating the navigation channel.

Commercial and passenger boats have navigation problems also during low tide. With the change in transportation system, however, some ports for transportation purposes have been relocated from the river mouth to the shore and the need for ports at river mouths has diminished. Some of such ports still existing have substantially no more activity for transportation purposes and, among the objective river mouths used for this purpose, only 16 have problems related to commercial navigation.

Problems on Inundation

Inundation by river floods is another serious problem concerning river mouth siltation, although inundation can be caused also by the poor flow capacity inherent to the river. Since land around river mouths is not always urbanized or used for agriculture, inundation does not always bring serious flood damage and the number of river mouths identified to have inundation problems due to siltation is not so much.

1.2 Measures Taken

To solve the navigation and inundation problems at river mouths, the following measures have been implemented by offices concerned.

Dredging

Since the 1960's, dredging work in river mouths has been conducted by the MD and the DID. Some private enterprises have conducted dredging work also for their own purposes.

The MD, which carries out the work using its own four dredgers or the state-owned dredgers, maintains the river mouths for commercial navigation purposes such as Perlis, Kedah, Mersing, Terengganu and Kelantan (refer to Table 5.1-2).

The DID dredges river mouths mainly on contract basis in accordance with the requests from the special committee chaired by Ministry of Agriculture. When the river mouth is small, the DID sometimes uses the dragline to excavate it.

The effect of dredging normally does not last so long. After the following monsoon season or sometimes within a few months after dredging, the river mouth is again heavily silted up. Maintenance dredging is, however, seldom done due to financial restrictions.

Since dredging is costly compared to the economic return as mentioned in the report "Mission to Malaysia, ESCAP, 1987," and because it also requires maintenance work, the DID had undertaken a study on the possibility of introducing low-cost dredging by agitation as recommended by the said Mission to remove silt at the muddy western coasts of Peninsular Malaysia.

Construction of Structures

Table 5.1-3 lists up the structures existing at river mouths. The first breakwater was constructed in the 1950's at the mouth of Sg. Melaka, and this was followed in 1989 by those at Sg. Pengkalan Datu, Kemasin and Gali for the purpose of flood mitigation under the Kemasin-Semerak Integrated Rural Development Project. A breakwater was also constructed in 1992 at the mouth of Sg. Cenang for the purpose of river mouth stabilization, and another breakwater is under construction at the mouth of Sg. Semerak for flood mitigation. The construction work is managed by the DID.

Several studies regarding breakwaters are going on. A breakwater was proposed in 1980 by the Terengganu Coastal Region Study to be constructed at the mouth of Sg. Terengganu, and those proposed at the river mouths of Sg. Golok and Besut are now in the detailed design stage.

As for the effect of breakwaters, those at the mouths of Sg. Kemasin and Pengkalan Datu are said to be self-maintained after construction, while that at the mouth of Sg. Gali is silted up in the dry season due to the insufficient low water discharge to flush out siltation. Also, the construction of a breakwater is said to bring about adverse influence to the surrounding area as in the case of the Pengkalan Datu River Mouth.

A training dike was constructed at the mouth of Sg. Terengganu to stabilize the river mouth and to prevent erosion of the river bank. A breakwater together with a training wall is being constructed by fishermen at the Kerteh River Mouth, and some jetties that function to maintain the river mouth have been constructed by the JKR.

2. SELECTION OF OBJECTIVE RIVER MOUTH FOR THE MASTER PLAN

2.1 Classification of River Mouth

The subject river mouths are classified firstly into groups according to natural and socioeconomic conditions. This classification is necessary to provide the basic data to screen the objective river mouths for the Master Plan, to select the representative river mouths for the Master Plan Study, and to examine the measures for river mouth improvement.

2.1.1 Natural Conditions

It is essential to know the process at which the river mouth has undergone to form its current configuration in order to clarify the cause and behavior of river mouth siltation and to determine the countermeasure for the river mouth problem. Factors which characterize natural conditions are taken up among others for the classification of river mouths; namely, (1) coastal geomorphology, (2) oceanographic and hydrological conditions, (3) configuration of river course, (4) shoreline formation, (5) coastal materials, and (6) river mouth condition.

The first three factors are considered to belong to the external factors forming the river mouth configuration, while the latter three belong to the results coming from the external factors. As shown in Table 5.2-1, the river mouths are classified according to these factors which are explained briefly as follows:

(1) Coastal Geomorphology

Coastal geomorphology is one of the important factors to understand the characteristics and development of the river mouth. The objective river mouths are classified according to the type of coast where they are located; namely, (a) straight coast, (b) protruding coast, (c) embayed coast, (d) estuary, (e) headland, (f) sheltered by island, (g) delta formation, and (h) sand spit.

(2) Oceanographic and Hydrological Conditions

Oceanographic conditions, namely wave and tide, are the essential factors from the ocean side to form the river mouth configuration. Waves create littoral current and subsequent sandbar formation, and tidal prism contributes in maintaining the river mouth open by the current due to tidal fluctuation.

Hydrological condition represented by river flow is also an essential factor for the river mouth condition. If the catchment area is large, the river flow is strong and it maintains the river mouth open, although it brings larger sediments from the river basin.

Wave is classified as either a high straight wave, a high oblique wave, or a low wave; while, tide is either a large tidal prism or a small tidal prism. On the other hand, river flow may be high or low from a large catchment area or a small catchment area.

(3) Configuration of River Course

The river course expressed in a manner of meandering or straight is also one of the factors to consider in order to know the river mouth condition.

(4) Shoreline Formation

Due to the inequilibrium of sediments from river flow, tidal current and littoral drift, the shoreline at the river mouth could show a certain form such as convex, straight, concave or one-side bar. A convex shoreline at the mouth means sufficient supply of sediment discharge from the river, and a straight shoreline means low sediment discharge from the river. If longshore transport by waves is predominant, a sandbar develops at one side of the river mouth, and artificial dredging in the river mouth sometimes brings a concave shoreline.

(5) Coastal Materials

Coastal materials which are sensitive to the variation of external factors, are essential to know the predominant external one. They are classified broadly into four; namely, sandy, muddy, mixed (sand predominant), and mixed (mud predominant).

(6) River Mouth Condition

To understand river mouth problems and find proper solutions, knowing the river mouth condition is important. River mouth condition is classified according to configuration into four categories; namely, completely closed by sandbar, partially closed by sandbar, shallowed by submerged bar, and open to the sea.

2.1.2 Socio-Economic Conditions

Two main factors are taken up under the socioeconomic condition; namely, land use condition and navigation condition (refer to Table 5.2-2). These are further classified into the following items, mainly to identify the significance of the inundation problem when it occurs and the navigation problem when the river mouth is silted up.

	Factors	Items
(1)	Land Use Condition	- Urban area - Village - Agriculture - Forest - Swampy area - Unused land
(2)	Navigation Condition	- Fishing boat only - Fishing and commercial boat

2.2 Categorization of River Mouth

To select the river mouths for the Master Plan Study, the proposed 100 river mouths are categorized according to the seriousness of the existing problems into three; namely, Category 1 (Critical), Category 2 (Significant), and Category 3 (Acceptable). River mouths in Category 1 and Category 2 are the objective river mouths for the Master Plan Study.

2.2.1 River Mouth Problem

River mouth problems due to siltation are presented in Table 1.1-1. This table reflects the condition that problems on navigation of fishing boats prevail in all the river mouths, while problems on navigation of commercial and passenger boats occur on 16 river mouths which include those which were once dredged. On the other hand, problems on inundation are found on several river mouths. Since it is difficult to *identify the seriousness of a river mouth problem in a numerical manner*, several factors based on physical, economic and social conditions are considered.

2.2.2 Factors and Criteria for Categorization

As mentioned above, problems on inundation appear on several river mouths; hence, information regarding this matter is not useful for the categorization. More consideration is given to the seriousness of the navigation problem of fishing, commercial and passenger boats determined according to the physical, economic and social aspects, as follows:

(1) Physical Aspect

Seriousness of the navigation problem due to siltation can be identified by comparing the river mouth configuration, specifically water depth, with the draft of boats plying the river mouth. Since water depths differ by section, and they also change according to time and season because of the change in tide, river flow and wave, while draft is based on size of boat, data on water depth at different sections, times and seasons are necessary to identify the seriousness of the navigation problem.

Since only water depth observed at one time and at one section and draft of boats were obtained by the field investigation in this study, the observed water depth is to be adjusted to assume the minimum depth (see Note 1) at the river mouth. Boats plying each river mouth are classified according to draft into large, medium or small (see Table 5.2-3) and, using the data on water depth, the physical condition at each river mouth is evaluated as either very serious, serious, or fair according to the following criteria (refer to Table 5.2-4 and 5.2-5):

(a) Very Serious

The assumed minimum depth is shallower than the draft of the largest boat.

(b) Serious

The assumed minimum depth is in the range between the draft of the largest boat and the clearance plus draft of the largest boat (see Note 2 below.).

(c) Fair

The assumed minimum depth is deeper than the draft of the largest boat plus clearance.

Note 1:

The factors considered to assume the minimum depth from the observed water depth at the river mouth are (a) the time change of water depth, (b) the seasonal change of cross section due to change of river flow, and (c) the change of water depth toward offshore, as follows:

(a) Time Change of Water Depth

Water depth at the river mouth fluctuates due to tidal action. Water depth at ebb tide, the minimum water depth, is obtained by adjusting the observed water depth according to the tide level curve.

(b) Seasonal Change of Cross Section

Seasonal change of river mouth cross section is supposed to be influenced by the change of discharge. Judging from the flow regime, river discharge at the time of this *field investigation is expected to decrease by about 30% in the dry season, which corresponds to a 20% decrease of water depth. This can be verified from the seasonal change between the observed water depth in March 1992 and that observed in November 1992 for the representative river mouths mentioned in Chapter 5. As shown in Table 5.2--6, the seasonal change of water depth is about 15%, while that of river discharge is about 20%.*

(c) *Sectional Change of Water Depth Toward Offshore*

Sounding survey results at representative river mouths reflect the following features (refer to Chapter 3):

- *In the west coast, water depth once becomes slightly shallow gradually increases afterwards toward offshore. Accordingly, the water depth at the river mouth seems to be nearly the minimum offshore water depth.*

- *In the east coast, water depth at the river mouth fluctuates depending on the development of a sandbar which is affected by geomorphological condition, wave condition, run-off condition, etc. In general, however, the water depth at the river mouth is deeper than that at the shore and, based on the sounding survey results at Terengganu, the minimum water depth at the shore corresponds to 40% of that at the river mouth. This can be verified from the bathymetric survey results for the representative river mouths shown in Table 5.2-7.*

Judging from the above conditions, the minimum water depth is assumed in the following manner:

- *The minimum water depth at a river mouth located in a muddy coast or similar condition is assumed by reducing the observed river mouth water depth by 20%.*

- *The minimum water depth at a river mouth located in a sandy coast or similar condition is assumed by multiplying the observed river mouth water depth by 0.3, considering the seasonal change of 20% and the sectional change of 60%. [Hm=(Ho)(1.0-0.2)(1.0-0.6)=Ho(0.3); Hm: minimum water depth, Ho: observed water depth]*

Note 2:

In considering the clearance for the draft of boat, the main factor taken is the influence of wave. According to the statistical analysis in the NCES, wave sometimes reaches the height of 1.0 m in ordinary days, excluding severe monsoons, and about 10% to 20% of the wave generated comes toward the river mouth. Therefore, a clearance of 1.0 m is employed for the comparison between the draft of boat and the minimum water depth.

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(2) Economic Aspect

Among the available data, factors related to the economic aspect mainly include the number of fishermen and the number of fishing, commercial and passenger boats. On this regard, the number of fishermen is taken up, because the magnitude of economic influence caused by the navigation problem depends on the people involved in fishing activities which may be in proportion to the number of fishermen. As for the commercial activities, it is clear that such activities are confined in the ports which also have vivid fishing activities and thus, only fishing activities are considered in the economic aspect.

Since it is difficult to classify the magnitude of economic influence into three levels, very serious, serious and fair, river mouths are divided into three groups based on the number of fishermen, as follows: