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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION AND DRAINAGE
MINISTRY OF AGRICULTURE
MALAYSIA

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

VOL. IV

SUPPORTING REPORT – 1

AUGUST 1994

CTI ENGINEERING CO., LTD.

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THE COST ESTIMATE IS BASED ON NOVEMBER 1992

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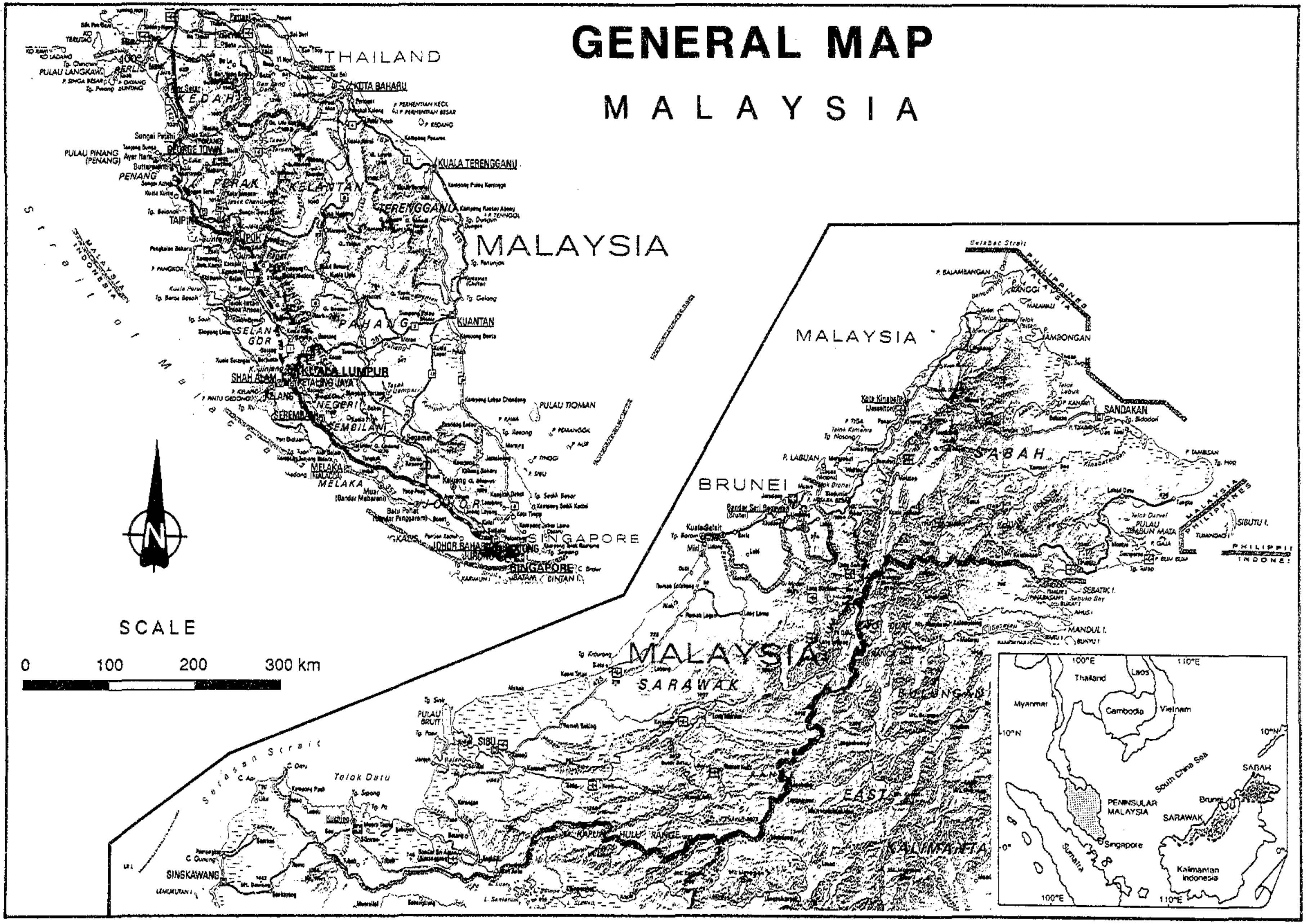
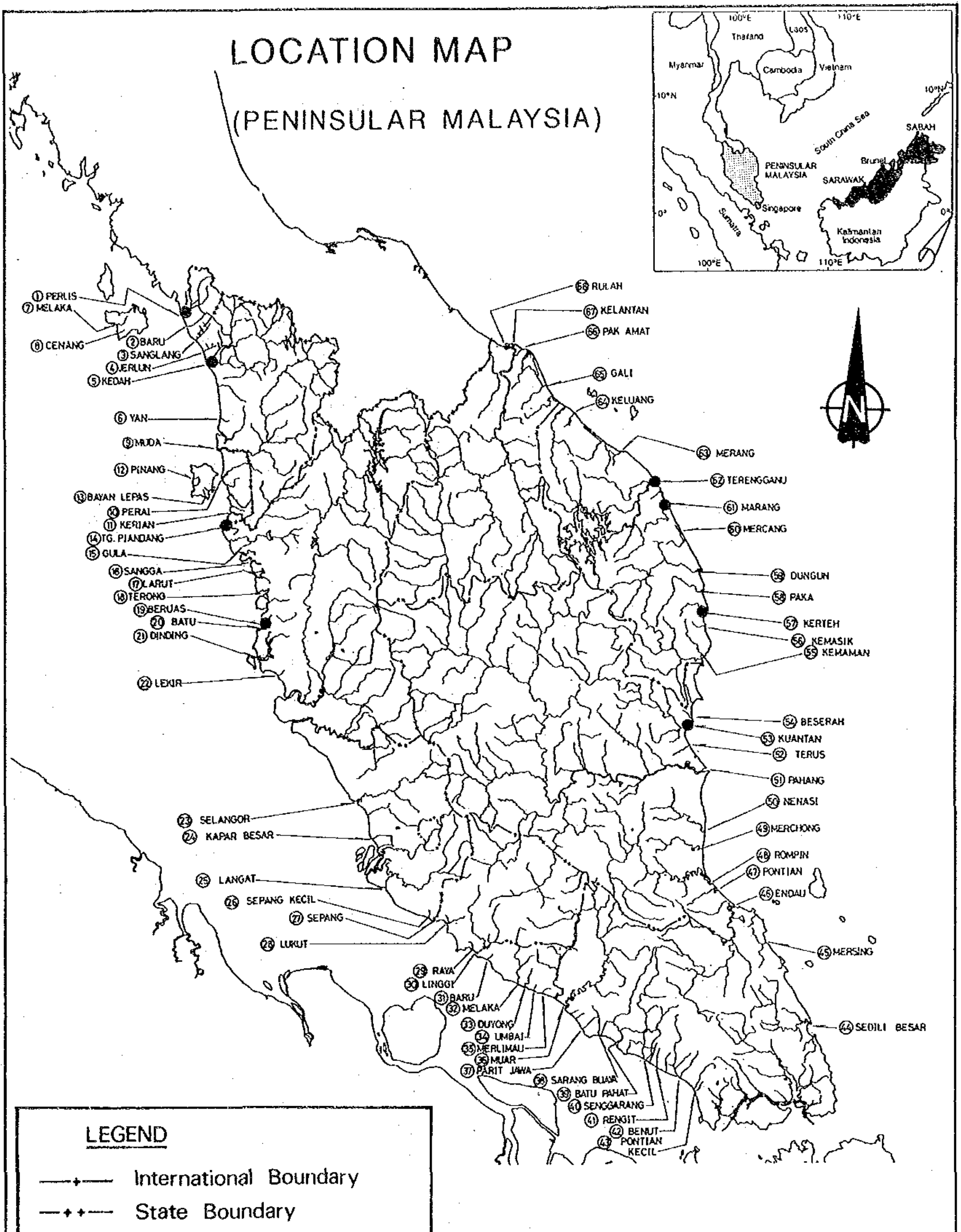
GENERAL MAP

M A L A Y S I A





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Laos
Myanmar
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South China Sea
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Singapore
Sumatra
Brunei
SABAH
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Kalimantan Indonesia
100°E
110°E
10°N
0°
N
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60 MERCANG
61 MARANG
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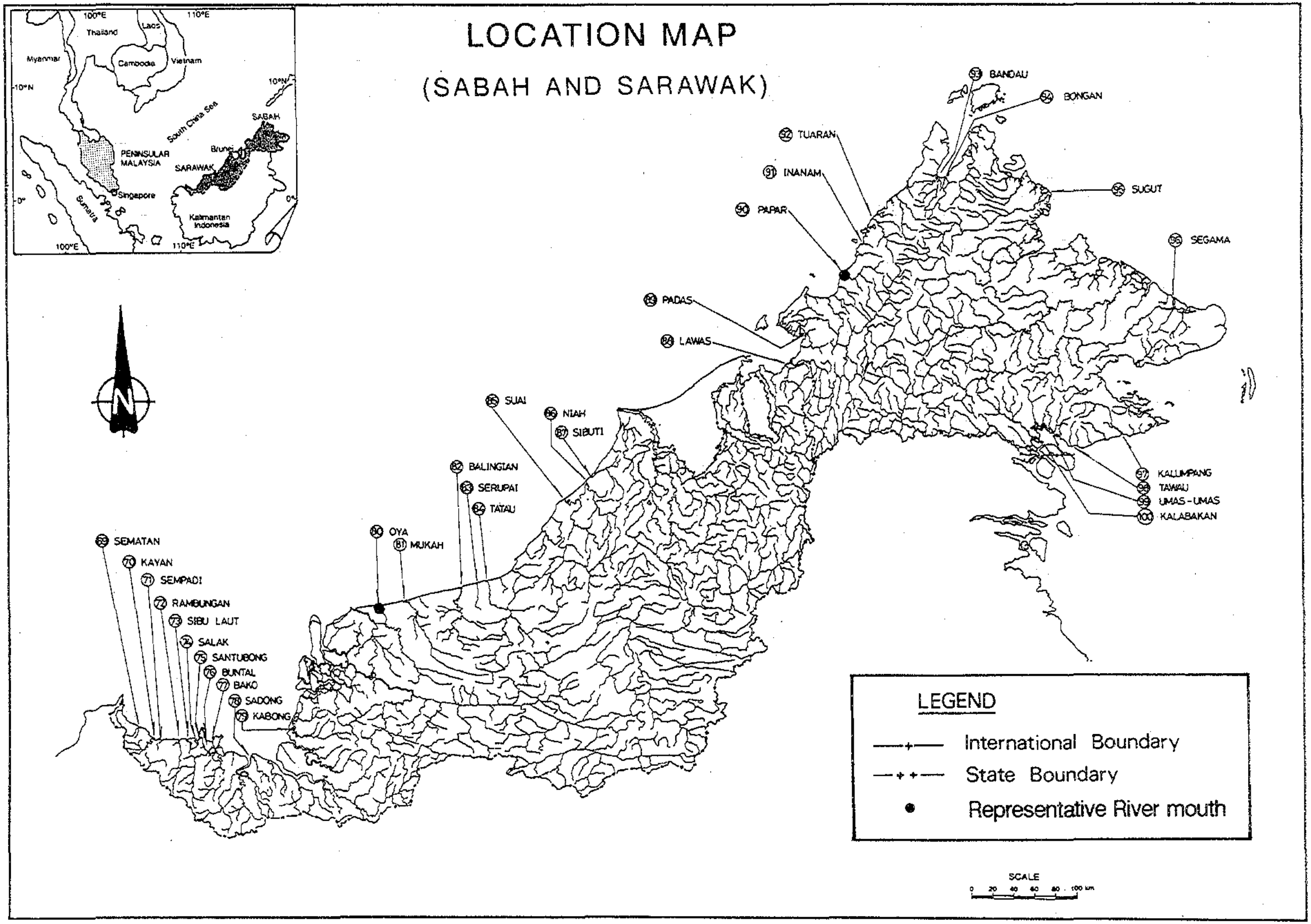
63 MERANG
64 KELUANG
65 GALI
66 PAK AMAT
67 KELANTAN
68 RULAH
LEGEND
International Boundary
State Boundary
Representative River mouth
SCALE
0 20 40 60 80 100 km

LOCATION MAP
(SABAH AND SARAWAK)



1. HYDROLOGY AND OCEANOGRAPHY

THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

SUPPORTING REPORT NO. 1

HYDROLOGY AND OCEANOGRAPHY

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HYDROLOGY AND OCEANOGRAPHY

1. GENERAL

The purpose of the hydrologic and oceanographic study is to provide the basic information and conditions to formulate a river mouth improvement plan. This supporting report presents the study including the hydrologic and oceanographic observations.

Section 2 presents the existing condition of the 100 river mouths proposed for the Study, and the environment is discussed from a nationwide point of view. A more detailed study for the 10 representative river mouths for the Master Plan is carried out in Section 3. Flooding conditions of the river mouths are examined, and longshore transport rates are estimated by the energy flux method.

In Section 4, the Feasibility Study concentrates on two river mouths, Tanjung Piandang and Marang. To collect additional hydrologic and oceanographic data, new water level and wave gauges were installed at the river mouths. At Tg. Piandang River Mouth, an in situ pit survey was conducted.

2. NATIONWIDE NATURAL SETTING

2.1 Topography and Geology

<u>Topography</u>

Malaysia consists of Peninsular Malaysia and East Malaysia. East Malaysia occupies the northern part of Borneo Island and is divided into the states of Sabah and Sarawak. The area of Peninsular Malaysia is 131,598 km^2, while those of Sabah and Sarawak are 73,711 km^2 and 124,449 km^2, respectively.

The topography of Peninsular Malaysia is characterized by a central mountain range, the Main Range. The mountain range splits the Peninsula into the east and west coasts and is surrounded by coastal flat plains. Flat plains are developed widely in the southern part of the Peninsula.

The Crocker Range which runs parallel to the northwest coast divides the State of Sabah into two regions, the narrow northwest coastal low belt and the central and eastern plain areas. Swampy low areas adjacent to the northeast coast are densely covered with mangroves. In Sarawak, alluvial coastal plains have developed northward and westward from the mountain ranges of the interior of Borneo Island.

Geology

Peninsular Malaysia, as a part of the stable crotonic block which covers the Sunda Shelf and Borneo, is composed mainly of Paleozoic and early Mesozoic sedimentary rocks as well as intrusive granite masses. The western margin of this block is located off Sumatra Island in the Indian Ocean. While Sumatra Island is seismically and volcanically active in the recent age, Peninsular Malaysia is fairly stable in both aspects.

Borneo Island is geologically composed of Paleozoic to Mesozoic meta-sedimentary rocks associated with intrusive and extrusive rocks ranging from acidic to ultra-basic. Sabah and Sarawak are situated on the belt of the cretaceous Northwest Borneo Geosyncline, or the Sibu and Miri zones.

2.2 Meteorology and Hydrology

Climate

Malaysian climate is equatorial with high uniform temperature, high humidity and copious rainfall, influenced by the northeast and southwest monsoons. Northeast monsoons prevail from November to February and bring heavy rainfalls to the east coast of the Peninsula and to Sabah and Sarawak. Southwest monsoons usually start in April or May and end in September.

Wind

Wind over Malaysia is generally light and variable. There are, however, some uniform periodic changes in the wind flow patterns and four seasons can be identified; namely, southwest monsoon, northeast monsoon and two shorter inter-monsoon seasons.

During the northeast monsoon the prevailing wind flow is easterly or northeasterly with a speed of 5 to 10 m/s. The more affected areas are the east coast of Peninsular Malaysia, where the winds may reach 15 m/s or more during periods of intense surges of cold air from the north.

In the later half of May, the southwest monsoon comes to the west coast of Peninsular Malaysia. The prevailing wind flow is generally light, below 5 m/s, due to the shelter effect of Sumatra Island. The winds during the two inter-monsoon seasons are light and variable. Thunderstorm is common during these seasons.

During the months of April to November, typhoons frequently develop over the west Pacific and move westward across the Philippines. Southwesterly strong winds with a speed of 10 m/s or more often blow over the northwest coast of Sabah and Sarawak as the typhoons approach the regions.

The seasonal wind flow patterns are presented in Fig. 1.2-1.

Rainfall

Malaysia receives comparatively abundant rainfall with an annual mean rainfall of 2,420 mm at Peninsular Malaysia, 2,630 mm at Sabah and 3,830 mm at Sarawak. Such heavy rainfall has contributed to the development of dense networks of rivers and streams.

The rainfall distribution pattern of Malaysia is dependent on the seasonal wind patterns and the local topographic features. According to the National Water Resources Study by JICA (hereinafter referred to as the NWRS), Peninsular Malaysia and East Malaysia are divided into 5 and 7 rainfall regions, respectively, as shown in Fig. 1.2-2.

Heavier rainfall has been experienced in the east coast region of Peninsular Malaysia and the coastal regions of Sabah and Sarawak during the northeast monsoon season. More than 1,000 mm of monthly rainfall has been recorded in these regions. Rainfall is generally less during the southwest monsoon season than during the northeast monsoon due to the shelter effect of Sumatra Island.

2.3 Oceanography

Tide

Malaysian coasts are influenced by three types of tides, diurnal, semi-diurnal and mixed, according to location and time of occurrence.

Tide levels at standard ports have been predicted and are tabulated in Tide Tables by the Directorate of Hydrography, Royal Malaysian Navy. The major features of the tides are summarized in Table 1.2-1 and the astronomical maximum tidal ranges along the coasts are shown in Fig. 1.2-3.

The maximum tidal ranges are in a scope of 2 to 6 m. The maximum ranges greater than 5 m are observed along the coastlines near the Port Klang of the west coast of Peninsular Malaysia and near Kuching of Sarawak.

Wave

Statistical analyses of deepwater waves were carried out in the NCES to construct wave roses for 10 square sea areas surrounding the territory of Malaysia, as shown in Fig. 1.2-4, 1.2-5 and 1.2-6.

Along the east coast of Peninsular Malaysia, northeast waves are predominant during the northeast monsoon. Over 65% of the waves are northeasterly with a maximum height of 4 to 5 m.

The southern part of the west coast of Peninsular Malaysia receives comparatively calm waves because of the short fetch length across the Strait of Malacca.

Northwesterly waves from the Andaman Sea are predominant along the northern part of the west coast during the southwest monsoon. The wave heights are usually 0.5 to 1.0 m with a maximum height of 2 to 3 m.

The coast of Sarawak and the northwest coast of Sabah are affected by the northeast monsoon waves with a maximum height of more than 4 m. The northeast and southeast coasts of Sabah also receive the northeasterly wave during the monsoon, but the wave heights are comparatively low because the shorter fetch length due to the presence of the Philippine Islands prevents the waves to develop very much. In addition, during the months of April to November, typhoons often pass off the northeast coast and develop the waves.

2.4 River Features

Although the number of the rivers in Malaysia is not clear, the river feature for the 100 objective river mouths related to the Study such as the size of river basin, riverbed gradient, flow capacity and sediment are described as follows.

Size of River Basin

The size of river basin relates to the supply of sediment and maintenance flow. The catchment area of the objective rivers in the study area vary in size from 3 km^2 to 28,492 km^2, as shown in the following table.

Class	Catchment Area (km^2)	No. of River Basins in the Class
1	< 10	9
2	10 - 50	15
3	50 - 100	13
4	100 - 500	25
5	500 - 1,000	8
6	1,000 - 5,000	26
7	5,000 - 10,000	2
8	10,000 <	2

Riverbed Gradient

Riverbed gradient relates to the tidal prism and the discharge velocity necessary to flush the river mouth of siltation. Most of the objective rivers are presumed to have gentle gradients of less than 1/5,000 from the condition that the river stretch showing a tidal influence is longer than 20 km as shown in Table 1.2-2.

Flow Capacity

Data on flow capacity related to the flooding problem and the flush water against river mouth siltation are available only in Sg. Terengganu (3,500 m^3/s), Kelantan (3,000 m^3/s) and Pahang (1,000 m^3/s). The NWRS shows that most of the rivers have the flow capacity corresponding to a 2 to 3-year return period flood discharge.

Sediment

Annual erosion rates by major river basins were estimated in the NWRS based on land use condition. The results are presented in Table 1.2-3 and in Fig. 1.2-7.

The average annual erosion rate is 359 ton/km^2/yr for Peninsular Malaysia, 510 ton/km^2/yr for Sabah, and 1,496 ton/km^2/yr for Sarawak. Sarawak has a very high erosion rate compared with the other two regions, and this is attributed mainly to the activities of shifting cultivation. The areas covered by shifting cultivation are already over half of the total area in several districts of Sarawak.

2.5 Coastal Condition and River Mouth Formation

Location

The coastline of Malaysia is about 4,800 km in total length. This is composed of 860 km in the east coast of the Peninsula, 1,110 km in the west coast, 1,040 km in Sarawak and 1,800 km in Sabah.

The Peninsula is bounded by the South China Sea on the east and the Strait of Malacca on the west. Sabah and Sarawak face the South China Sea on the west. Northern and eastern boundaries of Sabah are the Sulu and Celebes seas. The South China Sea is the largest body of water incident to the Malaysian coasts. The effective minimum and maximum fetches for Sabah-Sarawak and the east coast of the Peninsula are 360 and 1,240 km, respectively.

The body of water lying to the west coast of Peninsular Malaysia is the Strait of Malacca, a narrow, shallow channel lying between the Peninsula and Sumatra Island. Fetches in the Strait are 500 km to the north and 40 km in the south, averaging about 130 km.

Coastal Geomorphology

The east coast of Peninsular Malaysia is less irregular than the west coast. Much of the coast is a series of large and small hook-shaped bays. Almost the entire length of coastline is fully exposed to direct wave attack from the South China Sea. The coastal landscape is dominated by low elevation coastal plains, interrupted by numerous upland spurs and river outlets. The major rivers are the Kelantan, Besut, Terengganu, Kuantan and Pahang. The coastline has very gentle slope ranging from 1/400 to 1/600 with 5 m depth contour at 2 km to 3 km from the coastline. The depth contours generally run parallel to the coastline.

The west coast of Peninsular Malaysia is relatively long and irregular. A majority of the coast is open to the waters of the Strait of Malacca. Exceptions to this condition are the island sheltering effects of the islands of Langkawi and Pinang. A majority of the coast is comprised of low elevation coastal plains. The plains are formed from a deep marine clay strata. The presence of this clay material reflects the relatively calm seas in the Strait. In the Perak area, the plain is dissected by numerous rivers and estuaries.

The Sarawak coastline is characterized by long and straight sandy beaches on the east half and mangrove fringed shoreline on the west half. The entire coastline is open to wave attack from the South China Sea during the Northeast Monsoon. The mangrove shore is punctured by wide estuaries at fairly regular intervals and by pocket beaches bounded between rock outcrops and headlands. Most of the deltaic and estuarine areas are fringed by mangrove forests. Sand buildup is evident at most of the estuarine areas due to the sediments brought down by the many rivers.

Sabah has the longest shoreline of all the coastal states in Malaysia. The coastline is rugged and faces the South China Sea to the Northwest, the Sulu Sea to the Northeast and the Celebes Sea to the Southeast. Numerous offshore islands shelter the coastline from the open sea at its western tip, the northern coast and the southeastern coasts. Coral reefs abound in the waters off the southeastern coast attending protection against wave attack. The coastline is also characterized by bays of various shapes and sizes; the notable ones being Kimanis Bay, Marudu Bay, Labuk Bay, Lahad Datu Bay and Tawau Bay.

Bed Material

As the fact that a majority of the coastland in Malaysia consists of alluvial low flat lands shows, beaches are composed mainly of sandy to muddy materials. The distribution of shoreline material is illustrated in Fig. 1.2-8.

Along the entire stretch of the coastline in the east coast of Peninsular Malaysia, sandy beaches dominate. The notable exception is the stretch of coast north of Kuala Pahang where mangrove and nipa palms grow profusely.

On the contrary, very few sand beach areas can be found on the west coast. The areas that do exist include Pulau Langkawi, the north and south coast of Pulau Pinang, south from the mouth of Sg. Muda to Butterworth, north and south of Lumut, in the Port Dickson to Tanjung Tuan area and in the Tanjung Keling area north of Melaka, and at the mouths of some other rivers. In general, sand beaches are formed as pocket beaches between prominent rocky headlands.

The Sarawak coastline generally consists of sandy beaches on the east half and mangrove-fringed muddy shores on the west half. In Sabah, sandy beaches dominate the northeastern coastline; whereas, clay material is more commonly encountered on the northeastern and southeastern coasts.

Longshore Sediment Transport

Net longshore sediment transport direction and relative rates presented in the National Coastal Erosion Study (NCES) are shown in Fig. 1.2-9. As shown in the illustration, there is no distinct tendency of longshore sediment transport direction in the west coast of Peninsular Malaysia where no high waves attack. On the contrary, the east coast of Peninsular Malaysia is attacked by high waves during the northeast monsoon season and a clear tendency is found; namely, in the northern east coast, longshore sediment transport directions are to the north and south from the mouths of Sg. Kelantan and Terengganu, respectively, whereas, in the southern half, southward sediment transport is more distinct.

In the west coast of Sabah and Sarawak, westward longshore sediment transport is dominant. This corresponds to the wave direction during the northeast monsoons.

Coastal Change

In Malaysia, a larger part of coastal erosion/accretion is a natural phenomenon and some by human action. Coastal erosion is persistent and serious, as well as extensive, occurring in every state and along at least 1,300 km of the 4,800 km coast of the country. The major cause of erosion and accretion in Malaysia is longshore transport by storm waves.

The rate of erosion varies widely from year to year at any given location and from location to location at any given time. Over long terms of 25 years or more, the average rate is usually less than 10 m/year. In the short term, the erosion rate is often as much as 20 m/year. Along 140 km of shore, coastal erosion seriously threatens important facilities. Along another 240 km, it may seriously threaten other important facilities in the foreseeable future.

River Mouth Formation

The formation of river mouths in Malaysia corresponds well to the coastal material distribution. The east coast of Peninsular Malaysia is composed mainly of sandy material and the river mouths there are distinguished by sand bar development caused by littoral current and subsequent siltation. This tendency is found also in river mouths in the northeastern shore of the Sarawak coast and the western shore of the Sabah coast.

The west coast of the Peninsula, on the other hand, consists mainly of muddy shallow beach extending several hundred meters to a few kilometers from the coastline, and long and narrow channels develop in the muddy beach from the river mouth to the sea. This formation is also found in the western coast of Sarawak and the eastern and southern coasts of Sabah. Rivers with a relatively larger catchment area and a larger tidal prism in this area generally maintain wider and deeper river mouths.

The location of the river mouth is directly affected by the coastal change mentioned above. Where the coast is eroded, the river mouth is retreating and vice versa. Artificial influence to the river mouth is by the construction of structures. A lot of barrages for irrigation and drainage, as well as for the prevention of tidal inflow, have been constructed in the west coast of Peninsular Malaysia, especially in the northern and southern districts where river mouths are generally shallow due to the regulation of high discharges. In the east coast of the Peninsula, breakwaters have been constructed in several river mouths for the purpose of maintaining them in good condition for navigation and passage of flood flow.

3. STUDY ON REPRESENTATIVE RIVER MOUTH

Ten (10) river mouths are selected as the representative river mouths for the Master Plan Study. They are Perlis, Kedah, Tg. Piandang, Bernas, Kuantan, Kerteh, Marang, Terengganu, Oya and Papar. The hydrologic and oceanographic studies for these 10 representative river mouths are carried out as follows.

3.1 Hydrological Analysis

3.1.1 River Discharge

River discharge is one of the major factors to determine the river mouth configuration.

River Basin

The river basins of the 10 representative river mouths are identified from the topographical maps, as shown in Fig. 1.3-1. The catchment areas range from 9 km^2 for Tanjung Piandang to 4,650 km^2 for Terengganu.

River Mouth Catchment		River Area (km^2)	Channel Length (km)
Serial	Name		
1	Perlis	600	45
5	Kedah	*4,040	110
14	Tg. Piandang	9	10
19	Beruas	240	45
53	Kuantan	1,710	80
57	Kerteh	240	40
61	Marang	460	50
62	Terengganu	4,650	180
80	Oya	1,820	150
90	Papar	770	70

* Catchment area of Muda Dam (980 km^2) is included.

Observations

River discharge has been measured by DID for a long period along the four rivers, i.e., Perlis, Kuantan, Terengganu and Papar. In addition, water level observations have been conducted in Kerteh and Marang. The location and observed discharges are shown in Fig. 1.3-1, Fig. 1.3-2 and Table 1.3-1, respectively.

Flood Discharge

Probable flood discharges are estimated for the representative river mouths based on the results of the NWRS. The probable flood discharges are compared with the flow capacity of the river channel in Subsection 3.1.2 to examine the flood inundation problems caused by river mouth siltation.

Previously, the NWRS had developed the regional flood curves which will enable approximation of probable flood discharges. Peninsular Malaysia and East Malaysia were divided into four and two areas, respectively, in view of flood magnitude. The flood discharge curves of 50 and 100-year return periods for Peninsular Malaysia and 20, 50 and 100-year return period for East Malaysia were obtained against the catchment area for each flood area.

Smaller flood discharges of shorter return periods such as 2, 5, 10 and 20-year were determined by assuming the log normal distribution. The results are shown in Fig. 1.3-3 and Table 1.3-2.

As for the Perlis, Kedah and Terengganu river mouths, flood regulation effects by dam reservoirs shall be further considered. The effect is estimated by a flood reduction ratio determined according to the catchment area of the whole basin and the dam site, as well as the discharge cut ratio of the dam (Table 1.3-3).

The probable flood discharges by return period for the representative river mouths are given as follows:

River Mouth		Catchment Area	Flood Discharge (m^3/s)					
Serial	Name	(km^2)	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
1	Perlis	600	90	150	190	240	280	330
5	Kedah	4,040	510	690	790	920	1,070	1,200
14	Tg. Piandang	9	9	12	14	16	18	20
19	Beruas	240	50	80	110	140	170	200
53	Kuantan	1,710	1,000	1,600	2,000	2,400	3,000	3,500
57	Kerteh	240	450	600	690	780	900	1,000
61	Marang	460	580	820	1,000	1,100	1,300	1,500
62	Terengganu	4,650	2,300	4,100	5,300	6,600	8,600	10,100
80	Oya	1,820	1,400	2,400	3,200	4,000	5,300	6,400
90	Papar	770	700	1,000	1,300	1,600	1,900	2,200

Source: NWRS

Long term run-off characteristics are often expressed in a flow duration curve. Fig. 1.3-4 shows the flow duration curves of the representative river mouths, which were obtained by modifying the non-dimensional duration curves constructed for the main discharge stations in the NWRS.

3.1.2 *Flooding Problem*

Excessive siltation at a river mouth may raise water level and cause overflow to adjacent low areas. If flood damage is attributed to such a rise of water level in the river mouth, some countermeasures shall be taken into consideration.

<u>Non-Uniform Flow Calculation</u>

In the Study, non-uniform flow calculation is carried out to estimate the flood water levels of the representative river mouths. The water level profiles were obtained, as shown in Fig. 1.3-5, under the following conditions:

(a) River Channel: Existing channels surveyed in the Study

(b) Water Level at Downstream End: Mean High Water Springs or Mean Higher High Water (Table 1.3-4)

(c) Manning's Roughness Coefficient: 0.030

A sudden rise of water level is seen at the river mouths of Kerteh, Marang, Terengganu, Oya and Papar, where well developed sand spits block flood flow. The river mouths at the west coast and Kuantan are so wide that flood water level is hardly affected by siltation.

<u>Flooding Problem</u>

The calculated water levels were compared with the elevations of the river banks to estimate the flow capacities, and the results are shown in the following table. In this table, also given are the flow capacities estimated in the NWRS, which could be regarded as those of the upper reaches from the river mouths.

River Mouth		Existing Flow Capacity			
		Near River Mouth*		Upper Stretches**	
Serial	Name	(m^3/s)	Return Period	(m^3/s)	Return Period
1	Perlis	280	50 years	-	3 years
5	Kedah	1,070	50 years	-	3 years
14	Tg. Piandang	56	more than 100 years	No Data	
19	Beruas	730	-do-	No Data	
53	Kuantan	3,700	-do-	-	2 years
57	Kerteh	1,000	50 years	-	2 years
61	Marang	1,300	50 years	-	2 years
62	Terengganu	2,600	2.4 years	3,500	3.8 years
80	Oya	2,000	3.6 years	-	1 year
90	Papar	840	3.0 years	-	1 year

* Estimated in this Study
** Estimated in the NWRS

The river mouths, except Terengganu, Oya and Papar, have a large capacity of not less than the 50-year floods. In particular, those of Tg. Piandang, Beruas and Kuantan exceed the 100-year flood discharges. Kerteh and Marang's large flow capacity at their river mouths is because of the higher banks along the channel, although the water level is increased by the existence of sand spits. For the seven river mouths, flooding is considered to be negligible.

Near the river mouths of Oya and Papar the flow capacity is as small as a 3-year flood, but it is greater than those of the upper reaches. This means that a flood overflows in the upper reaches before reaching the river mouth and, consequently, flood damage is attributed to the lesser flow capacity in the upper reaches and not to siltation at the river mouth.

The situation of the Terengganu river mouth differs from the others. The flow capacity near the river mouth is 2,600 m^3/s, 900 m^3/s less than 3,500 m^3/s capacity of the upper reaches. A maximum of 3,500 m^3/s flood could possibly reach the lower channels near the river mouth without overspill from the upper channels and this results in the inundation of low areas near the river mouth. The cause of the inundation is the insufficient flow capacity due to the southeasterly expanding sand spit at the river mouth, and some countermeasures shall be taken to mitigate the flooding problem.

Based on the river cross section survey results, the inundation area by the 3,500 m^3/s maximum probable flood has been identified, as shown in Fig. 1.3-6. A total of 45 ha of land and some 530 houses are estimated to be inundated.

3.1.3 Sediment

A river is one of the biggest suppliers of sediment around the river mouth. Therefore, it is very important to estimate the quantity of sediment transported into the river mouth to clarify the river mouth configuration.

Observation

At the discharge gauging stations mentioned in the preceding subsection, suspended load has been also periodically measured by DID. The results are given in Table 1.3-1 and summarized in Fig. 1.3-2. The following table shows the annual suspended loads. Bed load has not been systematically observed in Malaysia.

Station Name	River System	Catchment Area (km^2)	Annual Suspended Load* (ton/yr)	
			(ton/yr)	($ton/km^2/yr$)
Titi Baru	Perlis	126	3,000	24
Bt. Keneu	Kuantan	582	260,000	447
Kg. Tanggol	Terengganu	3,340	1,492,000	447
Kagopan	Papar	536	42,000	78

* Wash load included.

Annual Sediment Discharge

(1) Sediment Rating Curve

To determine the sediment supply volume to the sandy river mouths, except those in the muddy west coast, sediment discharge is calculated. This supply volume is used to estimate the siltation rate of the dredged navigation channel proposed.

Sediment discharge consists of bed load, suspended load and wash load. However, wash load particles are so small that they are transported farther into the sea not falling near the river mouth. In other words, wash load hardly contributes to siltation in the river mouth, and sediment discharge calculation is conducted only for bed and suspended loads.

The following Brown's formula is employed to calculate the total sediment discharge of bed and suspended loads. Necessary hydraulic parameters such as friction velocity are obtained through the non-uniform calculation.

Brown's Formula:

$$q_B / (u_* d) = 10 \cdot [u_*^2 / \{ (\sigma / \rho - 1) \cdot g \cdot d \}]^2$$

where,

q_B	:	total sediment volume
u_*	:	friction velocity
d	:	grain size of sand
σ	:	density of sand
ρ	:	density of water
g	:	gravitational acceleration

The calculation is conducted for several magnitudes of water discharge (Table 1.3-5), and the sediment rating curves for the river mouth are obtained by regression analysis of water and sediment discharge as shown in Fig. 1.3-7.

(2) Annual Sediment Discharge

The annual sediment discharge can be estimated by a combination of sediment rating curve and duration curve. The results are given as follows:

River Mouth		Catchment	Annual Sediment Discharge	
Serial	Name	Area (km^2)	(1000 m^3/yr)	(m^3/km^2/yr)
53	Kuantan	1,710	12	7
57	Kerteh	240	11	45
61	Marang	460	37	81
62	Terengganu	4,650	230	50
80	Oya	1,820	72	40
90	Papar	770	9	12
Average		1,608	62	39

3.1.4 One-Dimensional Dispersion Analysis

As discussed in Section 2.5, the west coast of Peninsular Malaysia is almost wholly covered with muddy material. The movement of muddy material is very complicated because of many factors such as flocculation, deposition, consolidation and erosion. The location of the river mouth where wave, tidal flow and river flow are existing and interfering with each other, makes the phenomenon more difficult to understand.

In this section, a numerical approach is tried to estimate the siltation rate in the river channel of Tg. Piandang by introducing the results of the recent studies.

The catchment area of the Tg. Piandang river mouth is as small as 9 km^2, and a tidal gate located about 2.8 km upstream of the river mouth is kept closed in most parts of the year. Therefore, the sediment supply from the upstream is negligible and the source of sediment to the closed inner channel is considered to be the surf zone. Namely, bottom materials stirred up by waves come up and enter the inner channel with flood tide and then fall there.

The one-dimensional dispersion model can be applied to simulate such comparatively simple phenomena. First, the unsteady flow analysis is carried out to determine hydraulic parameters such as velocity, discharge area and shear stress. Then, using the parameters, the dispersion analysis is conducted to chase the movement of bottom materials.

Calculation Model

(1) One-Dimensional Unsteady Flow Model

The one-dimensional unsteady flow model is presented by the following equations:

(a) Equation of Motion

$$\frac{\partial H}{\partial x} + \frac{1}{g}\frac{\partial u}{\partial t} + \frac{1}{2g}\frac{\partial u^2}{\partial x} + \frac{n^2 u|u|}{R^{4/3}} = 0$$

(b) Equation of Continuity

$$\frac{\partial A}{\partial t} + \frac{\partial (Au)}{\partial x} = 0$$

where,

t	:	time
x	:	distance
H	:	water level
u	:	velocity
A	:	discharge area
R		hydraulic radius
n	:	Manning's roughness
g	:	gravitational acceleration

(2) One-Dimensional Dispersion Model

The one-dimensional dispersion model is expressed by the following equations:

(a) One-Dimensional Dispersion Equation

$$\frac{\partial (AC)}{\partial t} + \frac{\partial (AuC)}{\partial x} = \frac{\partial}{\partial x}\{AE_L \frac{\partial C}{\partial x}\} + E_r - F_r$$

(b) Erosion Rate E_r

$$E_r = B \cdot M \cdot \{ \frac{\tau}{\tau_c} - 1 \}$$

(c) Falling Rate F_r

$$F_r = A \times C \times W_s / R$$

where,

t	:	time
x	:	distance
u	:	velocity
A	:	discharge area
R	:	hydraulic radius
B	:	water surface width
C	:	mud concentration
E_L	:	longitudinal dispersion coefficient
τ	:	shear stress
τ_c	:	critical shear stress for erosion
M	:	constant
W_s	:	settling velocity

(3) Setting of Coefficients

The coefficients such as E_L, τ_c, M and W_s are determined by referring to the previous studies.

(a) Longitudinal Dispersion Coefficient E_L

The average value of Fisher's observation results *($E_l/(Ru_*)$ = 340)* is adopted.

River Channel	$E_l/(Ru_*)$
Clinch River, Virginia	50
River Derwent, England	131
Copper Creek, Virginia	355
South Platte River, Colorado	510
Powell River, Tennessee	654
Average	340

u_* : friction velocity
Data Source: Fischer, H. B.; Analytical Prediction of Longitudinal Dispersion Coefficients in Natural Streams, Proc. 12th Congress, IAHR, 1967

(b) Critical Shear Stress for Erosion τ_e

Adopted is a value of 0.1 Pa which was used by Tsuruya for the Kumamoto Port in Japan.

(c) Coefficient M

According to Van Leussen and Dronkers, the value of M is in a scope of 0.006 - 0.24 kg/m^2/min. In this study the value of 0.05 kg/m^2/min is applied.

(d) Settling Velocity

As in the Tsuruya's study, the following equation is adopted as presented in Fig. 1.3-8.

$$W_s = A_1 \times C \qquad (C < C_H)$$

$$W_s = 2.6 \times 10^{-1}\ cm/s \qquad (C \geq C_H)$$

where,

A_1 = $0.6 \times 10^{-3}\ m^4/kg/s$
C_H = $4.3\ kg/m^3$

(4) Boundary Condition

The calculation is carried out for the 2.8 km long stretch from the river mouth (0.0 km) to the tidal gate (2.8 km) as shown in Fig. 6.2-9. The boundary conditions are summarized as follows:

Boundary	Boundary Condition	
	Item	Applied Condition
Downstream End (0.0 km)	Water Level	Sine curve with the mean tide amplitude (Fig. 6.2-10)
	Mud Concentration	C = 500 mg/l
Upstream End (2.7 km)	Water Discharge	Q = 0
	Mud Concentration	C = 0

<u>Results</u>

The 24-hour calculation is conducted for both the existing and the proposed dredged channel. A 3.53 km long and 45 m wide navigation channel with a base elevation of LSD -3.7 m is proposed to be constructed by dredging in this Master Plan Study, as shown in Fig. 1.3-9. Through this calculation, the siltation rate of the inner dredged channel is estimated.

The results of the unsteady flow and dispersion analyses are presented in Fig. 1.3-10 and Fig. 1.3-11, respectively. The annual siltation rate is obtained by multiplying the 24-hour estimated rate by 365 days, and the findings are given as follows:

(1) As shown in Fig. 1.3-10, velocity will decrease according to the dredging depth. In the existing channel 12 cm/s of the maximum velocity is expected, but only 4 cm/s in the proposed dredged channel. Discharge itself, however, will not change even after dredging because of the increase of cross sectional area.

(2) Siltation is remarkable near the river mouth. Siltation rates of 40 and 30 cm/yr at the lowest sections of the existing and proposed dredged channels, respectively, are estimated. In the upper stretches, siltation rate is in the order of 10 cm/yr for both channels although erosion is seen at 1.3 km.

(3) Considering that the existing channel has been practically stable, the obtained rates seem to be over-estimated. The inner channel is expected to be stable even after dredging.

(4) The dispersion analysis is governed by several coefficients of varying values due to local conditions. In this present study, the coefficient values assumed in preceding studies are adopted, but the available data is not enough to examine the assumptions. To upgrade accuracy, further data collection such as observation of mud concentration should be conducted.

3.2 Oceanographic Analysis

3.2.1 Tides

Malaysian coasts are influenced by three types of tides, i.e., diurnal, semi-diurnal and mixed tides according to the location and time of occurrence. The Strait of Malacca has a mixed, prevailing semi-diurnal tide, while a diurnal tide is predominant in the

South China Sea. Fig. 1.3-12 shows the observed tidal fluctuations of Pulau Pinang, Chedering of Terengganu and Kota Kinabalu.

Tide levels at standard ports have been predicted and are compiled in Tide Tables by the Directorate of Hydrology, Royal Malaysian Navy. The predictions were based on 6 to 12 months of recorded observations. In addition, DSM has established a network of tide gauges along the Malaysian coast for purposes of recording water level. A yearly record book entitled "Tidal Observation Records" is published.

Tidal levels of the 10 representative river mouths are determined with reference to the above-mentioned data. The closest stations to the representative river mouths are selected, and their tidal levels are substituted for those of the river mouths, as shown in Table 1.3-4. All the tidal levels are reduced to the Land and Survey Datum (LSD) established at Pelabuhan Kelang in 1912 by the British Admiralty. Such reduction makes it possible to compare elevations of the tide levels and the topographic survey.

The astronomical maximum tidal ranges are in a scope of 2 to 4 m for the representative river mouths. Large tidal ranges greater than 3.5 m are observed in Perlis, Kedah, Kuantan and Kerteh. On the other hand, small tidal ranges lesser than 2.5 m can be found in Papar.

3.2.2 Waves

Waves are the principal causes of littoral processes. The significant characteristics of waves affecting sediment transport near a beach are height, period and direction of breaking waves.

<u>Available Data</u>

(1) Shipboard Observation

DID has a database of deepwater waves around the territory of Malaysia which were observed on shipboard for a long period from 1949 to 1983. Wave statistics were obtained for each square area called Marsden Square measuring 1 degree (latitude) by 1 degree (longitude). In the Master Plan Study, these deepwater wave statistics are used in principle.

The statistical analyses of deepwater waves were carried out in the NCES to construct wave roses for 10 sea areas as shown in Fig. 1.2-4, 1.2-5 and 1.2-6. Each of the 10 sea areas is composed of 7 to 15 Marsden squares, and the combination of representative river mouths and NCES sea areas is given as follows:

River Mouth		Sea Area by NCES*	Number of Wave Data
Serial	Name		
1	Perlis	E	11,235
5	Kedah	-do-	-do-
14	Tg. Piandang	-do-	-do-
19	Beruas	D	13,600
53	Kuantan	B	43,458
57	Kerteh	-do-	-do-
61	Marang	A	17,585
62	Terengganu	-do-	-do-
80	Oya	F	9,414
90	Papar	H	7,914

* Refer to Fig. 1.2-4.

The wave statistics are summarized in Table 1.3-6, in which the approaching wave frequency is tabulated by wave height, period and approaching direction.

(2) LEO Program

DID established the Littoral Environmental Observation (LEO) Program in 1988 to provide data on coastal phenomena at low cost. At present, there are 17 LEO stations along the Malaysian coast. Breaker height, wave period, direction of wave approach, wind speed, wind direction, longshore current velocity and beach slope, as well as the presence of beach cusps and rip currents have been observed almost daily.

Among the 17 stations, two stations, C01 and T01, are close to the representative river mouths of Kuantan and Terengganu, respectively, as shown in Fig. 1.3-13. The observed data of these two stations are expected to provide valuable information on waves, currents and longshore sand transport.

Refraction Analysis

The deepwater waves are transformed into the shallow water condition by wave refraction analysis. Deepwater waves with several combinations of the approaching directions and the wave period of 6, 8 and 10 seconds are considered for each river mouth.

The results are summarized in Table 1.3-6 and examples of the wave refraction diagram are shown in Fig. 1.3-14. The wave height at any location, H_d is given by:

$$H_d = K_s \times K_r \times H_o$$

where,

K_s : shoaling coefficient

K_r : refraction coefficient

H_o : deepwater wave height

Breaker Index

The breaker height index is used to determine the location along any wave orthogonal at which a particular approaching deepwater wave breaks. The breaker index is estimated by using the following Weggel's formula.

$$\gamma_b = H_b / D = b - c \cdot [H_b / (g \times T^2)]$$

$$b = 1.56 / (1 + e^{-19.5 \times \tan \beta})$$

$$c = 43.8 (1 - e^{-19.5 \times \tan \beta})$$

where,

γ_b	:	breaker index
H_b	:	breaking wave height
T	:	wave period
σ	:	density of sand
β	:	beach slope
g	:	gravitational acceleration
D	:	water depth

The estimated breaker indices for the representative river mouths are presented in Table 1.3-7. Since the beach slopes of the representative river mouths are in common very gentle, less than 1/100, the estimated indices are all in a scope of 0.77 to 0.79. The value of 0.78 is adopted as a common breaker index for all the river mouths.

3.2.3 Longshore Transport Rate

Longshore transport is a principal factor to govern the river mouth configuration. At the sandy river mouths of Kuantan, Kerteh, Marang, Terengganu, Oya and Papar, the longshore transport rates are estimated. These transport rates are used to estimate the siltation rates of the dredged navigation channel proposed.

<u>Energy Flux Method</u>

The energy flux method is an acceptable practice when sufficient data showing historical changes in the topography of the littoral zone (bathymetric survey charts, dredging records) are not available. This method is based on the assumption that the longshore transport rate depends on the longshore component of energy flux in the surf zone.

The estimation formula is expressed as follows:

$$P_{ls} = \frac{\rho \cdot g}{16} (H_{sb})^2 \cdot C_{gb} \cdot \sin 2\alpha_b$$

$$Q = K \cdot P_{ls}$$

where,

Q	:	longshore transport rate
P_{ls}	:	longshore energy flux factor
K	:	coefficient
ρ	:	mass density of water
α_b	:	angle between breaking wave crest and shoreline
g	:	gravitational acceleration
H_{sb}	:	significant breaking wave height
C_{gb}	:	group velocity at breaking

The coefficient K is usually to be determined by observation. In this Study, K is estimated based on the observed siltation rate of the dredged outer channel of the Mersing River Mouth.

Calibration of Coefficient K

As discussed in Supporting Report No. 2, River Mouth Morphology, the siltation rate in the dredged outer channel of the Mersing River Mouth is estimated at 130,000 m^3/yr by comparing the bathymetric survey results of July 1981 and April 1982. If the silted volume is assumed to be the sum of the longshore transport and the sediment transport by the river (this assumption is considered reasonable if the dredged channel is long enough and deep), the balance of the sediment is expressed as follows:

$$K \times (P_{lsr} + P_{lsl}) + Q_r = 130,000\ m^3/yr$$

where,

Q_r	:	annual sediment discharge by the river
K	:	coefficient
P_{lsr}	:	longshore energy flux factor from observer's left to right
P_{lsl}	:	longshore energy flux factor from observer's right to left

If the annual sediment discharge by the river is assumed to be equal to 39 $m^3/km^2/yr$, the averaged rate of the sandy representative river mouths, $Q_r = 250\ km^2 \times 39\ m^3/km^2/yr = 9{,}750\ m^3/yr$.

The longshore energy flux factor P_{lsr} and P_{lsl} are determined through the refraction analysis of the deepwater waves as presented in Fig. 1.3-15 and Table 1.3-8 and 1.3-9. $P_{lsr} = 408.9\ J/m/s$ and $P_{lsl} = 270.6\ J/m/s$, and then finally K is obtained as follows:

$$K = (130{,}000 - 9{,}750) / (408.9 + 270.6) = 177\ m^3.m.s/yr/J$$

<u>Longshore Transport Rate</u>

Using the obtained coefficient K, the longshore transport rates are estimated for the six sandy representative river mouths of Kuantan, Kerteh, Marang, Terangganu, Oya and Papar. The breakdown of the calculation is presented in Table 1.3-10, and the transport rates are summarized as follows:

River Mouth		Longshore Transport Rate (1000 m^3/yr)		
Serial	Name	Q_r	Q_l	Q_r+Q_l
53	Kuantan	205	0	205
57	Kerteh	202	2	204
60	Marang	287	194	481
61	Terengganu	238	191	429
80	Oya	186	257	443
90	Papar	22	85	107

Q_r : Longshore transport rate from observer's left to right.
Q_l : Longshore transport rate from observer's right to left.

Use of LEO Data

An alternative method of calculating the energy flux factor P_{ls} is to use the LEO data. To evaluate the obtained transport rates at the representative river mouths, the available LEO data is used.

According to Walton, the longshore flux factor P_{ls} is expressed with LEO data as follows:

$$P_{ls} = \frac{\rho \cdot g \cdot H_{sb} \cdot W \cdot V_{LEO} \cdot C_f}{\left(\frac{5\pi}{2}\right) \cdot \left(\frac{V}{V_o}\right)_{LH}}$$

where,

$$\left(\frac{V}{V_o}\right)_{LH} = \left[0.2\,\frac{X}{W}\right] - \left[0.714\,\frac{X}{W}\right] \cdot \left[\ln\,\frac{X}{W}\right]$$

and,

ρ	:	fluid density
g	:	gravitational acceleration
H_{sb}	:	breaking wave height
W	:	width of surf zone
V_{LEO}	:	average longshore current due to breaking waves
C_f	:	friction factor (assume 0.01)
X	:	distance to dye patch from shoreline

As discussed in Subsection 3.2.2, the two LEO Stations C01 and T01 are close to the representative river mouths of Kuantan and Terengganu, respectively (Fig. 1.3-13). The estimation is, however, conducted for only the C01 station because the T01 observation is found to be less accurate. The results are summarized as follows:

Station	Data Period	No. of Data	Energy Flux Factor (J/s/m)		Longshore Transport Rate (1000 m^3/yr)		
			P_{lsr}	P_{lsl}	Q_r	Q_l	Q_r+Q_l
C01	Jun. '88 to Dec. '90	375	395	346	70	61	131

P_{lsr}	:	longshore energy flux from observer's left to right.
P_{lsl}	:	longshore energy flux from observer's right to left.
Q_r	:	longshore transport rate from observer's left to right.
Q_l	:	longshore transport rate from observer's right to left.

The total rate of 131,000 m^3/yr is fairly smaller than the 205,000 m^3/yr for the Kuantan River Mouth, but still remains in the same order. The reason why $Q_r$and Q_l are almost balanced is that the shoreline at the station faces more perpendicularly to the approaching wave. The obtained transport rate of the representative river mouths is reasonable, taking the accuracy of such estimation into consideration.

4. STUDY ON FEASIBILITY STUDY RIVER MOUTH

The Tg. Piandang and Marang river mouths are selected as the objective river mouths for the Feasibility Study. In this section, hydrologic and oceanographic analyses are made to give the basic information and conditions to formulate the river mouth improvement plan.

4.1 Tanjung Piandang River Mouth

4.1.1 Hydrologic and Oceanographic Observation

Installation of Water Level and Wave Gauges

A water level gauging station was constructed at the river mouth and a wave gauge equipped with an automatic recorder of wave height, direction and tidal current was installed about 5 km off the river mouth. Their observation operation started at the end of October 1992, but the wave observation was suspended due to damage of the pressure sensor in July 1993. Their locations are as shown in Fig. 1.4-1 and summarized in the following table, while the observation records are compiled in the Data Book.

Gauge	Location	
	Latitude	Longitude
Water Level Gauge	5° 4.51' N	100° 22.15' E
Wave Gauge	5° 4.37' N	100° 19.76' E

Discharge and Electrical Conductivity Measurement

To know the scale of the tidal prism, a 24-hour discharge measurement was carried out twice at the river mouth: on the 13th and 27th of October 1992. Simultaneously, electrical conductivity was measured along the river channel. The location of the measuring sites is given in Fig. 1.4-2, and the observed hydrographs are shown in Fig. 1.4-3. The records of electrical conductivity observation are compiled in the Data Book.

A tide gate is located about 2.8 km upstream of the river mouth to prevent saline water from going up into the upper paddy fields. The gate is kept closed in most parts of the year and is opened only to drain floodwaters during heavy rainfall. This results in a short stretch of tidal influence, a low velocity and a small tidal prism.

4.1.2 Study on Intrusion of Wave into River Mouth

In Tg. Piandang River Mouth, a combination of capital and maintenance dredging has been selected as the optimum countermeasure for river mouth siltation. In addition, a shipping facility is proposed to be constructed 0.65 km inward from the river mouth to ensure the landing of fishermen's catch even during low tide. The location and cross section of the proposed dredging are presented in Fig. 1.4-4.

The intrusion of waves is examined by wave refraction analysis. The calculation conditions are as follows:

(1) Tide Level

The mean high water springs of 1.0 m above LSD is applied as the tide level.

(2) Intruding Wave

The initial waves with a height of 2.5 m and a period of 6, 8 and 10 seconds are given in parallel with the proposed dredged channel at minus 0.5 km. The wave height of 2.5 m is the breaking wave height at this section, namely; the probable maximum wave height.

Through 4-step wave chasing, the wave refraction diagram is obtained, as shown in Fig. 1.4-5, and the wave height at the proposed shipping facility is as follows:

Intruding Waves		Refraction Coefficient *Kr*	Wave Height at Landing Facility (0.65K) (m)
Initial Height (m)	Period (sec)		
2.5	6	0.12	0.30
2.5	8	0.10	0.25
2.5	10	0.10	0.25

Intruding high waves are refracted and attenuated to smaller waves. The wave height at the proposed facility is 0.3 m at the highest, which is the allowable wave height limit for port activities. Therefore, the inner channel of Tg. Piandang is calm enough for fishing port activities such as mooring of boats, and loading and unloading of fish catch and equipment.

Wave Height Limit for Fishing Port Facilities

Place	Water Depth at the Place	
	3 m>	3 m<
Navigation Channel	0.9 m	1.2 m
Loading Place	0.3 m	0.4 m
Mooring Place	0.4 m	0.5 m

Source: Manual for Design of Fishing Port, Japan Port Association

Wave Height Limit for Loading Work

Place	Wave Height Limit
Mooring Place	0.3 m
Other Places	0.5 - 0.7 m

Source: Design Standard for Port Facilities, Japan Port Association

4.1.3 In Situ Siltation Monitoring

Siltation of muddy materials is a very complicated process because of many factors involved such as flocculation, deposition, consolidation and erosion. The river mouth is where waves, tidal flow and river flow exist and interfere with each other, making the siltation process in the river mouth more difficult to understand.

One of the ways to understand siltation is to conduct an in situ survey. To find a clue to the siltation phenomenon in Tg. Piandang River Mouth, mud concentration survey and test pit monitoring were carried out.

Mud Concentration Survey

(1) Objective

The objectives of the mud concentration survey were to know the distribution of mud concentration and the influence of boat navigation to the erosion and stirring up of muddy bed materials. A turbidity meter was used to measure mud concentration. When water is too dense beyond the meter capacity, the density of the water sample is measured and converted into mud concentration.

(2) Location

The concentration measurement was done not only for Tg. Piandang River Mouth but also for Sg. Betul River Mouth. At Tg. Piandang River Mouth, where fishing boats go out and come in very frequently, a navigation boat survey was also conducted. The measuring sites are as shown in Fig. 1.4-6.

(3) Results

The measurement was conducted three times for each river mouth. Together with the predicted tide at Kedah Pier, Pulau Pinang and the traffic volume of navigation boats, the mean mud concentrations observed are as given in Fig. 1.4-7.

The findings of this survey are summarized as follows:

(a) In Tg. Piandang River Mouth, mud concentration at the outer channel (-1.0K and 0.5K) is as low as 300 to 2,000 mg/l and comparatively constant during the day.

(b) On the other hand, mud concentration at the inner channel (0.0k, 0.5K, 1.0K and 1.5K) fluctuates between 300 and 40,000 mg/l. The highest concentration of more than 10,000 mg/l appeared on 25 July 1993 at 12:00 noon when the tide was low and boat traffic was heavy. A similar tendency was observed on 23 July 1993.

(c) Mud concentration in the inner channel seems to be low when the tide level is high, because cleaner seawater comes in. Boat navigation stirs up bed materials, in particular, when the tide level is low. The reason why mud concentration was low at about 15:00 on 21 July 1993 in spite of the heavy navigation was the high tide.

(d) In Sg. Betul River Mouth, mud concentration is as low as the outer channel of Tg. Piandang River Mouth. Although time and spatial change of the concentration is small, the concentration at the inner channel (0.0k, 0.5k, 1.0k and 1.5k) becomes fairly high on the ebb tide, as seen on 15 July and 19 July 1993. Erosion may be caused by ebb flow.

Test Pit Monitoring

(1) Objective

Five test pits were excavated in the Tg. Piandang and Sg. Betul river mouths in July 1993. Since then, monitoring composed of measurements of water depth and density of bed materials has been conducted periodically. The objectives of the monitoring are to know the siltation rate in the test pits and the consolidation process of settled sediment.

(2) Location and Dimension of Test Pit

Two test pits in the inner channel and two in the outer channel of Tg. Piandang River Mouth, and one in the inner channel of Sg. Betul River Mouth were excavated, as shown in Fig. 1.4-6. The dimension of the five pits are as presented in Fig. 1.4-8.

Test pit No. 2 and No. 4 are sheltered by a tin box, as shown in Fig. 1.4-8, to prevent dense fluid mud from passing into the pits.

(3) Results of Water Depth Measurement

To monitor the change of pit bottom by siltation, water depth measurements were done using a 2.7 kg lead with 113 cm^2 of base area. The lead passes through the upper fluid and settles on the harder mud layer.

Based on the results of the water depth measurements by the lead, cross sectional profiles of the pits were drawn, as shown in Fig. 1.4-9. The gradual change of the average bed elevation is as shown in Fig. 1.4-10.

The findings of the water depth measurements are given as follows:

(a) Test pit No. 1 and No. 2 in the inner channel of Tg. Piandang River Mouth have refilled fast at the rate of about 100 cm per 200 days (180 cm/yr).

(b) In the outer channel, the refilling rate is much smaller than that of the inner channel. In 140 days the average bed levels of Test Pit No. 3 and No. 4 rose by about 25 cm; namely, the rate is about 70 cm/yr.

(c) The refilling rate of the test pit in Sg. Betul was as low as 25 cm per 180 days (50 cm/yr).

(d) The installation of a shelter seemed to be effective to prevent fluid mud from passing into the test pit as long as the surroundings of the shelter were deep enough for fluid mud to fall in. The effect, however, became less according to the progress of siltation around the shelter box, as shown in the case of Test Pit No. 2.

(e) The high refilling rate in the inner channel and the low rate in the outer channel of Tg. Piandang can be attributed to the high and low mud concentration, respectively.

(f) The refilling rates of the test pit in Sg. Betul were also low because mud concentration was usually kept low since boat navigation was negligible.

(4) Results of Mud Density Measurement

To monitor the consolidation process of deposited sediment at the test pits, the density of bottom materials was measured. Five or four samples from different depth of the sampling point were subjected to density measurement. The first sample was a fluid mud sample 25 cm above the surface of the harder mud layer. The second one was from the surface, and two or three more samples were from the points of 25, 50 and 75 cm below the surface, as shown in Fig. 1.4-11.

The results of mud density measurement are presented in Fig. 1.4-13 and 1.4-14. The findings are summarized as follows:

(a) The density of fluid mud samples taken 25 cm above the mud surface ranges from 1.07 to 1.16 g/cm3 for the inner channel (Test Pit No. 1

and No. 2) and from 1.00 to 1.06 g/cm3 for the outer channel (Test Pit No. 3 and No. 4) and Sg. Betul (Test Pit No. 5). This high density of fluid mud in the inner channel corresponds to the mud concentration measurement results.

(b) In taking samples using a bamboo pole at the sites, mud samples were observed. The mud surface, the boundary between fluid mud and the harder mud layer is clearly distinguished, and the lead settled on this surface as shown in Fig. 1.4-11.

(c) The density of the mud surface (the second sample) is in the range of 1.2 to 1.3 g/cm3 for all the test pits.

(d) According to the previous study report, the nautical depth which is defined as the minimum depth where boats can navigate without any damage, is proposed to be from the bottom layer with density greater than 1.2 g/cm3. In other words, fluid mud with smaller density does not damage boat bodies but denser mud damage them (refer to Fig. 1.4-12).

In Tg. Piandang, the density of the mud surface is greater than 1.2 g/cm3 and the mud surface can be defined as the channel bottom for navigation. In addition, the lead can be used for measuring water depth from the mud surface.

(e) Fig. 1.4-14 shows the change of mud density at a certain elevation estimated from Fig. 1.4-13. The density increases through the consolidation process. In general, the rate of increase depends on the elevation, i.e., the higher the elevation, the greater is the rate.

The density increased by 0.10 to 0.25 g/cm^3 per 200 days at the inner channel and 0.10 to 0.15 g/cm^3 per 140 days at the outer channel of Tg. Piandang, and 0.06 to 0.20 g/cm^3 per 180 days at Sg. Betul.

4.2 Marang River Mouth

4.2.1 Hydrologic and Oceanographic Observation

Installation of Water Level and Wage Gauges

A water level gauging station was constructed at the Marang Bridge, and a wave gauge was installed at the sea bottom about 2.6 km off the river mouth. The wave gauge is equipped with an automatic recorder of wave height, direction and tidal current. The locations of the gauges are as shown in Fig. 1.4-15 and summarized in the following table.

Gauge	Location	
	Latitude	Longitude
Water Level Gauge	5° 12.15' N	103° 12.50' E
Wave Gauge	5° 13.29' N	103° 13.92' E

The operation of the two gauges started at the end of October 1992, but the wave gauge was found missing in December of the same year. It is suspected that the gauge was pulled out and taken away by an illegal trawler. The observation records are compiled in the Data Book.

Discharge and Electrical Conductivity Measurement

A 24-hour discharge measurement was carried out twice at the Marang River Mouth like in the Tg. Piandang River Mouth on the 6th and 23rd of October 1992. Simultaneously, electrical conductivity along the river channel was measured using an EC meter. The measuring sites are as shown in Fig. 1.4-16, and the observed hydrolographs are shown in Fig. 1.4-17. The records of electrical conductivity are compiled in the Data Book.

According to the electrical conductivity measurement, seawater goes up to the EC-7 Site about 23 km upstream from the river mouth. This long stretch of tidal influence results in a high velocity and large tidal prism, as shown in Fig. 1.4-17.

4.2.2 Study on Outlet Opening of River Mouth

As an optimum countermeasure of river mouth siltation, a combination of one breakwater, two jetties, groins and dredging is proposed, as shown in Fig. 1.4-18. Two jetties will be constructed seaward from the left and right sides. From the end of the left jetty, a curved breakwater will be extended right to prevent high waves from coming into the inner channel.

The outlet opening of the channel is desired to be so narrow that high waves will be blocked by the breakwater and jetties. On the other hand, a narrow opening may raise flood water level and cause overflow to the adjacent low areas. In view of flood mitigation, the opening shall be designed with enough width.

The optimum opening is determined to be the minimum opening to confine the existing flow capacity of 1,300 m^3/s (refer to Subsection 3.1.2). Non-uniform flow calculation is carried out to estimate flood water levels along the inner channel.

The optimum opening is obtained at 90 m through several numerical trials for various openings. The estimated water level profile when the discharge is 1,300 m^3/s is as shown in Fig. 1.4-19.

4.2.3 Review on Longshore Transport Rate

In the Master Plan Study, the longshore transport rate was estimated by the energy flux method using the deepwater waves of shipboard observation, as follows:

Item	North to South	South to North	Total
Energy Flux Factor (J/s/m) P_{ls}	1,620	1,090	-
Longshore Transport Rate (m^3/yr) Q	287,000	194,000	481,000

Note: $Q = 177 \times P_{ls}$

The longshore transport rate is a very important factor to determine the optimum countermeasure for river mouth siltation. The rate is reviewed in this section using additionally collected data.

Observed Wave Data

The observed wave data at the newly installed gauge are useful for estimating the longshore transport rate, although the available data period is as short as 29 days from October 26 to November 23, 1992 because the wave gauge was lost. Table 1.4-1 shows the observed data.

The energy flux method was applied to estimate the rate as presented in Table 1.4-2, and summarized as follows:

Item	North to South	South to North	Total
Energy Flux Factor (J/s/m) P_{ls}	970	243	-
Longshore Transport Rate (m^3/yr) Q	172,000	43,000	215,000

Note: $Q = 177 \times P_{ls}$

The annual total amount of 215,000 m^3/yr was obtained based on the available data at the beginning of the northeast monsoon assuming that the wave conditions of the data available period would continue through a year. It is fairly smaller than the previous estimation of 481,000 m^3 but still in the same order.

LEO Data

After the loss of the wave gauge, DID started Littoral Environmental Observation (LEO) at the beach close to the river mouth to substitute for the lost gauge. The same method mentioned in Subsection 3.2.3 was applied for the obtained data from April to October 1993. The longshore energy flux factor of -14.5 J/m/s was obtained using the effective 58 data (refer to Table 1.4-3). The energy flux of -14.5 J/m/s was converted into the southerly longshore transport rate of 2,600 m^3/yr.

This value is much smaller than the previous value. Considering the fact that all the data were from the non-monsoon season and 102 out of the 160 observed data were abandoned because of low reliability, it seems to be difficult to use the obtained data for the estimation.

Siltation in Kerteh River Mouth

In 1992, dredging works was conducted at the Kerteh River Mouth using a suction type dredger. The dredging volume was estimated at 53,000 m^3 although the exact dredging stretch was not clear. It is useful to monitor the dredged section to know the magnitude of longshore transport.

Fig. 1.4-20 shows the location of sounding surveys conducted in November 1992 and December 1993, and Fig. 1.4-21 shows the changes of the cross sections. According to Fig. 1.4-21, the dredged channel got fully refilled with sediment in one year, implying that the total volume of longshore transport and sediment supply from the river is greater than 53,000 m^3. That of Marang River Mouth is considered to be in the same order as Kerteh River Mouth.

Summary of Review

In the Feasibility Study Stage, the longshore transport rate at Marang River Mouth was reviewed using the additionally obtained data. Consequently, the previous value of 481,000 m^3/s was adopted in the study, too, because the review study did not indicate any reason to change this value.

TABLES

Table 1.2-1 TIDAL LEVEL AT STANDARD PORTS

Location	Standard Port	LAT (m)	MLWS /MLLW (m)	MLWN /MHLW (m)	MSL (m)	MHWN /MLHW (m)	MHWS /MHHW (m)	HAT (m)	Tidal Range = HAT-LAT (m)	Chart Datum (below LSD)	Remarks
West Coast	Teluk Ewa	0.0	0.6 *1	1.5 *3	1.9	2.2 <5	3.1 <7	3.8	3.8		
	Kuah	0.0	0.2 *1	1.0 *3	1.4	1.7 <5	2.6 <7	3.0	3.0		
	Kuala Perlis	0.0	0.6 *1	1.5 *3	1.9	2.2 <5	3.1 <7	3.8	3.8		
	Pulau Pinang	0.0	0.6 *1	1.3 *3	1.6	1.8 <5	2.6 <7	3.2	3.2	1.4 m	
	Lumut	-0.1	0.5 *1	1.2 *3	1.6	2.0 <5	2.7 <7	3.3	3.4		
	Bagan Datoh	0.0	0.4 *1	1.2 *3	1.7	2.1 <5	2.9 <7	3.4	3.4	1.7 m	
	Pelabuhan Klang	-0.1	0.8 *1	2.2 *3	2.9	3.6 <5	5.0 <7	5.8	5.9	2.7 m	
	Beting Sedepa	-0.2	0.6 *1	1.8 *3	2.4	3.1 <5	4.3 <7	5.0	5.2		
	Port Dickson	-0.1	0.3 *1	1.1 *3	1.5	1.9 <5	2.8 <7	3.4	3.5	1.5 m	
	Tanjung Kling	0.0	0.6 *1	1.2 *3	1.5	1.8 <5	2.4 <7	3.1	3.1		
	Kuala Batu Pahat	-0.2	0.3 *1	1.1 *3	1.5	1.9 <5	2.7 <7	3.3	3.5		
	Pulau Pisang	-0.2	0.5 *1	1.3 *3	1.8	2.3 <5	3.1 <7	3.9	4.1		
	Raffles Lighthouse	-0.1	0.5 *1	1.2 *3	1.7	2.1 <5	2.9 <7	3.5	3.6		
	Keppel Harbour	-0.3	0.4 *1	1.1 *3	1.6	2.1 <5	2.7 <7	3.4	3.7	1.6 m	
	Pasir Gudang	0.0	0.9 *1	1.6 *3	2.1	2.6 <5	3.3 <7	4.0	4.0		
	Sembawang Shipyard	-0.2	0.7 *1	1.3 *3	1.9	2.4 <5	3.1 <7	3.9	4.1	1.8 m	
	Sungai Belungkor	0.0	0.8 *1	1.4 *3	1.9	2.3 <5	3.0 <7	3.7	3.7		
East Coast	Horsburgh Lighthouse	-0.3	0.6 <2	1.3 <4	1.5	2.1 <6	2.2 <8	2.8	3.1		
	Teluk Tekek	0.0	0.6 <2	1.4 <4	1.6	1.8 <6	2.6 <8	3.4	3.4		
	Tanjung Gelang	-0.1	0.9 <2	1.7 <4	1.9	2.1 <6	2.8 <8	3.8	3.9	1.6 m	
	Tanjung Berhala	-0.1	0.7 <2	1.5 <4	1.6	1.7 <6	2.4 <8	3.2	3.3	1.3 m	
	Kertih	-0.1	0.4 <2	0.8 <4	0.9	1.0 <6	1.4 <8	1.9	2.0	0.8 m	
	Chendering	-0.1	0.8 <2	1.5 <4	1.5	1.5 <6	2.2 <8	3.2	3.3		
	Kuala Terengganu	-0.4	0.4 <2	1.0 <4	1.0	1.0 <6	1.7 <8	2.6	3.0		
	Geting	0.0	0.6 <2	0.9 <4	0.9	0.9 <6	1.2 <8	2.4	2.4		
Sarawak & Burnei	Lundu, Kuala	0.2	1.0 <2	1.7 <4	2.4	3.6 <6	3.8 <8	4.4	4.2		
	Santubong, Kuala	0.2	1.3 <2	1.9 <4	2.9	4.1 <6	4.3 <8	5.2	5.0		
	Lakei, Pulau	0.0	1.4 <2	2.4 <4	3.1	4.2 <6	4.5 <8	5.7	5.7	3.1 m	
	Kuching	0.2	1.2 <2	2.2 <4	3.1	4.4 <6	4.7 <8	5.8	5.6	3.0 m	
	Pending	0.2	1.3 <2	2.3 <4	3.4	4.9 <6	5.2 <8	5.9	5.7	3.4 m	
	Sri Aman	0.0	0.7 <2	1.0 <4	2.2	3.6 <6	4.4 <8	5.9	5.9	0.5 m	
	Kanowit	-0.1	0.4 <2	0.8 <4	0.9	1.2 <6	1.4 <8	2.6	2.7		
	Sibu	0.5	1.4 <2	2.0 <4	2.4	2.9 <6	3.3 <8	3.9	3.4	0.4 m	
	Leba an	0.1	1.3 <2	2.2 <4	2.8	3.8 <6	4.0 <8	4.8	4.7		
	Sarikei	0.0	0.9 <2	2.1 <4	2.9	4.2 <6	4.5 <8	5.5	5.5		
	Manis, Tanjung	0.0	1.1 <2	2.2 <4	3.4	4.5 <6	4.9 <8	5.8	5.8		
	Paloh, Kuala	0.1	1.1 <2	2.0 <4	2.7	3.6 <6	4.0 <8	4.6	4.5		
	Kut, Muara	0.0	0.8 <2	1.6 <4	1.7	2.1 <6	2.7 <8	3.3	3.3		
	Igan, Kuala	0.0	0.6 <2	1.6 <4	1.7	2.0 <6	2.3 <8	2.9	2.9		
	Mukah, Kuala	-0.1	0.8 <2	1.5 <4	1.6	1.9 <6	2.2 <8	2.6	2.7		
	Balingian, Kuala	-0.1	0.6 <2	1.2 <4	1.3	1.6 <6	1.7 <8	2.2	2.3		
	Tatau, Kuala	0.1	0.7 <2		1.3		1.6 <8	2.3	2.2		<9
	Bintulu, Pelabuhan	0.2	0.6 <2		1.4		1.7 <8	2.4	2.2	1.5 m	<9
	Miri	0.0	0.6 <2		1.2		1.7 <8	2.1	2.1	1.0 m	<9
	Baram, Kuala	-0.2	0.3 <2		0.9		1.5 <8	2.0	2.2		<9
	Limbang, Kuala	0.2	0.9 <2	1.5 <4	1.7	1.8 <6	2.4 <8	2.9	2.7		
	Lawas, Kuala	0.3	0.8 <2	1.5 <4	1.5	1.6 <6	2.2 <8	2.7	2.4		
Sabah & Labuan	Labuan	0.1	0.8 <2	1.5 <4	1.5	1.6 <6	2.1 <8	2.8	2.7		
	Muara Harbour	0.0	0.6 <2	1.2 <4	1.3	1.5 <6	2.0 <8	2.7	2.7		
	Kota Kinabalu	-0.1	0.5 <2	1.1 <4	1.1	1.2 <6	1.7 <8	2.3	2.4		
	Sandakan	-0.1	0.4 <2	0.9 <4	1.1	1.2 <6	1.9 <8	2.7	2.8		
	Tawau	-0.3	0.1 <1	1.1 <3	1.5	1.8 <5	2.8 <7	3.0	3.3		

Note <1:MLWS, <2:MLLW, <3:MLWN <4:MLHW <5:MHWN <6:MHLW <7:MHWS <8:MHHW <9:usually diurnal

Abbrevations;

LAT : Lowest Astronomical Tide
MLLW : Mean Lower Low Water
MHLW : Mean Higher Low Water
MHWN : Mean High Water Neaps
MHWN : Mean High Water Springs
Hat : Highest Astronomical Tide
MLWS : Mean Low Water Springs
MLWN : Mean Low Water Neaps
MSL : Mean Sea Level
MLHW : Mean Lower High Water
MHHW : Mean Higher High Water
LSD : Land Survey Datum

Data Source : Tide Tables 1992

Table 1.2-2 STRETCH OF TIDAL INFLUENCE

Serial No.	River Mouth	Catchment Area (km2)	Stretch of Tidal Influence (km)
1	Perlis	600	15
5	Kedah	3,060	35
9	Muda	4,300	20
10	Perai	450	20
23	Selangor	1,820	25
25	Langat	1,815	90
30	Linggi	1,270	20
32	Melaka	500	5
36	Muar	6,160	130
39	Batu Pahat	2,230	40
44	Sedili Besar	1,445	70
46	Endau	4,740	80
48	Rompin	3,980	100
51	Pahang	29,140	25
53	Kuantan	1,710	25
55	Kemaman	1,775	25
59	Dungun	1,875	20
62	Terengganu	4,650	25
67	Kelantan	12,900	20
70	Kayan	1,020	65
78	Sadong	3,100	75
80	Oya	1,820	95
81	Mukah	2,150	80
82	Balingian	2,520	100
84	Tatau	4,780	45
86	Niah	1,270	30
87	Sibuti	830	20
88	Lawas	930	30

Source : National Water Resouces Study, 1982, JICA

Table 1.2-3 ANNUAL EROSION RATE BY MAJOR RIVER BASIN

Basin No.	Location / Name of Basin	Catchment Area(km2)	TASSL (ton/yr)	AASSL (ton/km2/yr)
	Peninsular Malaysia			
1	Perlis	790	277	351
2	Pulau Langkawi	475	85	179
3	Kedah	3,695	1,533	415
4	Merbok	520	326	627
5	Muda	4,300	1,928	448
6	Perai	895	815	911
7	Pulau Pinang	300	380	1,267
8	Kerian	1,420	1,428	1,006
9	Kurau	3,255	955	293
10	Perak	14,700	5,507	375
11	Bernam	3,335	1,299	390
12	Tengi	565	17	30
13	Selangor	1,820	1,320	725
14	Buloh	560	160	286
15	Kelang	1,425	578	406
16	Langat	1,815	1,535	846
17	Sepang	640	363	567
18	Linggi	1,420	373	263
19	Melaka	1,010	536	531
20	Kesang	705	255	362
21	Muar	6,595	3,385	513
22	Batu Pahat	2,600	1,157	445
23	Pontian Kechil	2,660	1,407	529
24	Johor	3,250	2,406	740
25	Sedili Besar	1,820	982	540
26	Mersing	880	171	194
27	Endau	4,740	1,357	286
28	Rompin	4,285	1,138	266
29	Bebar	1,895	15	8
30	Pahang	29,300	8,269	282
31	Kuantan	2,025	398	197
32	Kemaman	2,570	214	83
33	Paka	850	367	432
34	Dungun	1,875	259	138
35	Marang	760	320	421
36	Trengganu	4,650	2,042	439
37	Setiu	1,035	140	135
38	Besut	1,230	432	351
39	Kemasin	1,020	579	568
40	Kelantan	13,100	1,803	138
41	Golok	895	794	887
	Sub-total	131,680	47,305	359
	Sabah			
201	Pensiangan	5,971	550	92
202	Serudong	1,308	35	27
203	Kalabakan	1,371	553	403
204	Brantian	741	389	525
205	Umas Umas	553	308	557
	(Sabah)			
206	Merutai Besar	558	526	943
207	Tawau	888	442	498
208	Kalumpang	2,792	1,203	431
209	Silabukan	2,714	2,329	858
210	Segama	5,558	1,840	331
211	Kinabatangan	16,755	6,718	401
212	Segalid	2,335	1,425	610
213	Labuk	6,829	3,525	516
214	Sugut	3,094	1,254	405
215	Paitan	1,474	1,279	868
216	Bengkoka	1,866	1,981	1,062
217	Bongan	2,126	3,777	1,777
218	Kadamaian	1,336	3,183	2,382
219	Tuaran	1,247	2,742	2,199
220	Putatan	629	553	879
221	Papar	805	31	39
222	Kimanis	607	38	63
223	Membakut	736	31	42
224	Padas	9,180	2,010	219
225	Labuan	86	82	953
226	Lakutan	1,291	331	256
	Sub-total	72,850	37,135	510
	Sarawak			
227	Lawas	1,080	1,327	1,229
228	Trusan	2,768	2,024	731
229	Limbang	3,920	6,092	1,554
230	Baram	22,325	15,681	702
231	Miri	788	1,573	1,996
232	Sibuti	935	2,893	3,094
233	Niah	1,345	2,269	1,687
234	Suai	1,440	816	567
235	Similajau	1,268	169	133
236	Kemana	6,000	8,633	1,439
237	Tatau	5,150	4,423	859
238	Balingian	2,518	3,678	1,461
239	Mukah	2,625	4,853	1,849
240	Oya	2,005	6,543	3,263
241	Rajang	51,053	63,516	1,244
242	Kerian	1,675	6,829	4,077
243	Saribas	1,900	5,501	2,895
244	Lupar	6,813	22,489	3,301
245	Sadong	3,645	10,335	2,835
246	Sarawak	3,358	13,542	4,033
247	Kayan	1,838	3,045	1,657
	Sub-total	124,449	186,231	1,496
	Total	328,979	270,671	823

Source : National Water Resources Study, 1982, JICA
Note TASSL : Total annual surface soil loss. AASSL : Average annual surface soil loss.

Table 1.3-1 OBSERVED MONTHLY MEAN DISCHARGE AND SUSPENDED LOAD

Serial	River Mouth	Catchment Area (km2)	Station No.	Station Name	River	Catchment Area (km2)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
							Upper : Monthly Mean Discharge (m3/s) / Lower : Monthly Mean Suspended Load (ton/day)												
1	Perlis	600	6502432	Titi Baru	Tasoh	126	0.1	0.1	0.1	1.0	1.1	0.4	1.0	1.4	1.8	2.5	2.0	1.6	1.1 <1
								5.4	1.3	3.5	11.1	1.4	0.4	9.7	5.7	5.3	37.8	8.1	8.2 <1
53	Kuantan	1,710	3930401	Bukit Keneu	Kuantan	582	27.2	11.2	53.3	29.5	28.3	20.1	15.7	15.1	24.2	30.9	33.6	83.1	31.0 <1
							506.9	733.2	1260.5	688	591.2	398.2	296.9	265.8	467.5	706.7	865	1764.6	712 <1
62	Terengganu	4,650	5130432	Kg. Tanggol	Terengganu	3,340	405.4	244.1	151.8	198.9	133.8	170.1	196.2	181.4	214.1	237.7	302.6	579.9	251.3 <2
							8284	1747.3	815.5	873.3	658.1	1162.4	1623.8	1313.3	2749.1	2410	4473.1	22943.9	4087.8 <2
90	Papar	770	5760401	Kagopan	Papar	536	84.6	62.6	52.8	67.4	91.9	77.3	66.4	59.6	80.9	97.7	102.7	78.7	76.9 <1
																			115.1 <3

Data Source : <1 ; Streamflow and River Suspended Sediment Records 1981 - 1985, DID
<2 ; Streamflow and River Suspended Sediment Records 1986 - 1990, DID
<3 ; National Water Resources Study, 1982, JICA

Table 1.3-2 FLOOD DISCHARGE OF REPRESENTATIVE RIVER MOUTHS

Serial	River Mouth	Catchment Area (km2)	Flood Region by NWRS		Flood Discharge by Return Period (m3/s) 2yr.	5yr.	10yr.	20yr.	50yr.	100yr.
1	Perlis	600	I	(West Coast)	100	160	200	250	300	350
5	Kedah	4,040 *	I	(Ditto)	600	800	920	1,070	1,250	1,400
14	Tg.Piandang	9	I	(Ditto)	9	12	14	16	18	20
19	Beruas	240	I	(Ditto)	50	80	110	140	170	200
53	Kuantan	1,710	III	(Pahang-East)	1,000	1,600	2,000	2,400	3,000	3,500
57	Kerteh	240	IV	(Kelantan, Terengganu Perak (north))	450	600	690	780	900	1,000
61	Marang	460	IV	(Ditto)	580	820	1,000	1,200	1,400	1,600
62	Terengganu	4,650	IV	(Ditto)	3,000	5,200	6,800	8,500	11,000	13,000
80	Oya	1,820		F1	1,400	2,400	3,200	4,000	5,300	6,400
90	Papar	770		F2	700	1,000	1,300	1,600	1,900	2,200

* : The 980 km2 catchment area of the Muda Dam is included.

Table 1.3-3 FLOOD DISCHARGE AT RIVER MOUTH REDUCED BY DAM RESERVOIR'S EFFECT

Serial	River Mouth	A Catchment Area (km2)	Dam Reservoir Name	a C.A(km2)	m2 <1	(1-m2)*a/A	K <2	Reduced Flood discharge at River Mouth (m3/s) 2yr.	5yr.	10yr.	20yr.	50yr.	100yr.
1	Perlis	600	Timah-Tasoh	150	0.53	0.118	0.94	90	150	190	240	280	330
5	Kedah	4,040	Muda + Peda	1,155	0.15	0.243							
			Ahning	120	0.25	0.022							
					Sub-total	0.265	0.86	510	690	790	920	1,070	1,200
62	Terengganu	4,650	Kenyir	2,600	0.30	0.391	0.78	2,300	4,100	5,300	6,600	8,600	10,100

Note <1 : Discharge cut ratio at damsite
<2 : Flood reduction ratio at downstream end
K = sq.root(1 - (1 - m2) x a/A)

Table 1.3-4 TIDAL LEVELS OF REPRESENTATIVE RIVER MOUTHS

(1) Semi-diurnal Tide

Serial	River Mouth	Tidal Levels (m above LSD) LAT	MLWS	MLWN	MSL	MHWN	MHWS	HAT	Tidal Station referred to
1	Perlis	-1.9	-1.3	-0.3	0.0	0.3	1.3	1.9	Pulau Langkawi,Kedah
5	Kedah	-1.9	-1.3	-0.3	0.0	0.3	1.3	1.9	ditto
14	Tg.Piandang	-1.5	-1.0	-0.1	0.1	0.3	1.0	1.7	Kedah Pier,Penang
19	Beruas	-1.5	-1.0	-0.2	0.2	0.6	1.3	1.9	Lumut,Perak
80	Oya	-1.7	-0.8	-0.1 <1	0.0	0.3 <2	0.6	1.0	Mukah,Sarawak <3

Note;

<1 : MHLW, <2: MLHW

<3: Tidal levels are reduced to LSD by assuming MSL is equal to LSD.

(2) Diurnal Tide

Serial	River Mouth	Tidal Levels (m above LSD) LAT	MLLW	MLW	MSL	MHW	MHHW	HAT	Tidal Station referred to
53	Kuantan	-1.7	-1.1	-0.3	0.3	0.8	1.6	2.2	Tanjung Gelang,Kuantan
57	Kerteh	-1.7	-1.1	-0.3	0.3	0.8	1.6	2.2	ditto
61	Marang	-1.3	-0.8	-0.1	0.3	0.6	1.3	2.0	Chendaring,Terengganu
62	Terengganu	-1.3	-0.8	-0.1	0.3	0.6	1.3	2.0	ditto
90	Papar	-1.2	-0.9	-0.3	0.0	0.2	0.9	1.2	Kota Kinabalu,Sabah

Abbrevations;

LAT : Lowest Astronomical Tide
MLWS: Mean Low Water Springs
MLWN: Mean Low Water Neaps
MHWN: Mean High Water Neaps
MHWS: Mean High Water Springs
HAT : Highest Astronomical Tide

MLLW: Mean Lower Low Water
MLW : Mean Low Water
MHLW: Mean Higher Low Water
MSL : Mean Sea Level
MLHW: Mean Lower High Water
MHW : Mean High Water
MHHW: Mean Higher High Water

Data Source;

1) Tidal Observation Records 1990, DSM
2) Tide Tables 1992, RMN

Table 1.3-5(1/2) SEDIMENT TRANSPORT CAPACITY

(1)KUANTAN

Discharge	Hydraulic Parameters at Section of 0.00 km					Sediment Transport Rate		
	Area	Breadth	Velocity	Sh.Str.	Fr.Vel.	qB	Qs	
Q	A	B	V	Tauo	U*			
(m3/s)	(m2)	(m)	(m/s)	(100kg/m2)	(cm/s)	(1000m3/s/m)	(m3/s)	(1000m3/yr)
50	1318.9	267.1	0.038	0.07	0.273	0.0000	0.0000	0.0
100	1319.3	267.2	0.076	0.30	0.545	0.0000	0.0000	0.0
200	1320.7	267.7	0.151	1.19	1.089	0.0000	0.0000	0.0
500	1330.0	270.6	0.376	7.32	2.706	0.0058	0.0016	49.7
1000	1360.5	280.3	0.735	28.10	5.301	0.0858	0.0240	758.0
2000	1454.0	309.9	1.376	99.60	9.980	1.0773	0.3339	10528.5

Mean Grain Size dm = 0.02 (cm)
Falling Velocity wo= 3.95 (cm/s)
Critical Fr. Velocity U*c = 1.48 (cm/s)

(2)KERTEH

Discharge	Hydraulic Parameters at Section of 0.00 km					Sediment Transport Rate		
	Area	Breadth	Velocity	Sh.Str.	Fr.Vel.	qB	Qs	
Q	A	B	V	Tauo	U*			
(m3/s)	(m2)	(m)	(m/s)	(100kg/m2)	(cm/s)	(1000m3/s/m)	(m3/s)	(1000m3/yr)
5	139.5	120.8	0.036	0.11	0.329	0.0000	0.0000	0.0
10	139.6	120.8	0.072	0.43	0.659	0.0000	0.0000	0.0
20	139.7	120.8	0.143	1.73	1.316	0.0000	0.0000	0.0
50	140.6	121.0	0.356	10.66	3.265	0.0078	0.0009	29.8
100	143.7	121.6	0.696	40.61	6.372	0.1132	0.0138	434.2
200	153.6	123.5	1.302	139.64	11.817	1.3393	0.1654	5216.1

Mean Grain Size dm = 0.05 (cm)
Falling Velocity wo= 7.28 (cm/s)
Critical Fr. Velocity U*c = 1.73 (cm/s)

(3)MARANG

Discharge	Hydraulic Parameters at Section of 0.00 km					Sediment Transport Rate		
	Area	Breadth	Velocity	Sh.Str.	Fr.Vel.	qB	Qs	
Q	A	B	V	Tauo	U*			
(m3/s)	(m2)	(m)	(m/s)	(100kg/m2)	(cm/s)	(1000m3/s/m)	(m3/s)	(1000m3/yr)
5	254.2	204.3	0.020	0.03	0.178	0.0000	0.0000	0.0
10	254.2	204.3	0.039	0.13	0.357	0.0000	0.0000	0.0
20	254.2	204.3	0.079	0.51	0.713	0.0000	0.0000	0.0
50	254.6	204.3	0.196	3.17	1.780	0.0007	0.0001	4.4
100	255.9	204.5	0.391	12.53	3.540	0.0108	0.0022	69.6
200	260.5	205.2	0.768	48.12	6.937	0.1591	0.0326	1029.2

Mean Grain Size dm = 0.05 (cm)
Falling Velocity wo= 7.28 (cm/s)
Critical Fr. Velocity U*c = 1.73 (cm/s)

Table 1.3-5(2/2) SEDIMENT TRANSPORT CAPACITY

(4)TERENGGANU

Discharge Q (m3/s)	Area A (m2)	Breadth B (m)	Velocity V (m/s)	Sh.Str. Tauo (100kg/m2	Fr.Vel. U* (cm/s)	qB (1000m3/s/m)	Qs (m3/s)	Qs (1000m3/yr)
50	1976.6	1121.2	0.056	0.05	0.217	0.0000	0.0000	0.0
100	1978.5	1121.4	0.111	0.19	0.433	0.0000	0.0000	0.0
200	1986.0	1122.2	0.222	0.74	0.862	0.0000	0.0000	0.0
500	2038.9	1127.9	0.551	4.37	2.091	0.0015	0.0017	52.2
1000	2213.1	1146.7	1.081	14.52	3.811	0.0162	0.0186	585.8
2000	2774.0	1207.0	2.026	34.76	5.895	0.0927	0.1119	3529.8

Hydraulic Parameters at Section of 0.00 km; Sediment Transport Rate

Mean Grain Size dm = 0.04 (cm)
Falling Velocity wo= 6.46 (cm/s)
Critical Fr. Velocity U*c = 1.67 (cm/s)

(5)OYA

Discharge Q (m3/s)	Area A (m2)	Breadth B (m)	Velocity V (m/s)	Sh.Str. Tauo (100kg/m2	Fr.Vel. U* (cm/s)	qB (1000m3/s/m)	Qs (m3/s)	Qs (1000m3/yr)
50	1238.9	921.5	0.040	0.12	0.341	0.0000	0.0000	0.0
100	1241.4	922.4	0.081	0.46	0.681	0.0000	0.0000	0.0
200	1251.6	925.9	0.160	1.82	1.350	0.0000	0.0000	0.0
500	1317.8	949.0	0.379	10.24	3.201	0.0114	0.0108	341.2
1000	1521.5	1019.9	0.657	30.48	5.521	0.1009	0.1029	3245.3
2000	2065.4	1209.0	0.968	64.78	8.048	0.4556	0.5508	17370.1

Hydraulic Parameters at Section of 0.00 km; Sediment Transport Rate

Mean Grain Size dm = 0.02 (cm)
Falling Velocity wo= 3.95 (cm/s)
Critical Fr. Velocity U*c = 1.48 (cm/s)

(6)PAPAR

Discharge Q (m3/s)	Area A (m2)	Breadth B (m)	Velocity V (m/s)	Sh.Str. Tauo (100kg/m2)	Fr.Vel. U* (cm/s)	qB (1000m3/s/m)	Qs (m3/s)	Qs (1000m3/yr)
10	482.0	473.4	0.021	0.04	0.188	0.0000	0.0000	0.0
20	483.1	473.5	0.041	0.14	0.374	0.0000	0.0000	0.0
50	491.4	474.1	0.102	0.84	0.919	0.0000	0.0000	0.0
100	517.9	475.8	0.193	3.01	1.734	0.0010	0.0005	14.7
200	596.6	481.2	0.335	8.78	2.963	0.0084	0.0040	127.0
500	859.2	489.8	0.582	24.13	4.912	0.0632	0.0310	976.5

Hydraulic Parameters at Section of 0.00 km; Sediment Transport Rate

Mean Grain Size dm = 0.02 (cm)
Falling Velocity wo= 3.95 (cm/s)
Critical Fr. Velocity U*c = 1.48 (cm/s)

Table 1.3-6(1/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-A)

Marsden Squares : 2652,2653,2654,2655,2656,2662,2663,2664,2665,2666,
2672,2673,2674,2675,2676
Starting Date : 01/01/1949
Ending Date : 31/12/1949
Nos of Data : 17,585
Percent of Calm : 5.2

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
NNW	< 0.75	0.9	0.1	0.0	0.0	0.0	0.0	1.0
(315 - 345)	0.75 - 1.75	0.9	0.4	0.1	0.0	0.0	0.1	1.4
	1.75 - 2.75	0.1	0.2	0.1	0.0	0.0	0.1	0.3
	2.75 - 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	1.9	0.6	0.1	0.0	0.0	0.1	2.7
N	< 0.75	1.0	0.0	0.0	0.0	0.0	0.0	1.0
(345 - 15)	0.75 - 1.75	0.7	0.2	0.0	0.0	0.0	0.0	1.0
	1.75 - 2.75	0.1	0.1	0.0	0.0	0.0	0.0	0.3
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	1.9	0.3	0.0	0.0	0.0	0.0	2.4
NNE	< 0.75	2.4	0.2	0.0	0.0	0.0	0.0	2.7
(15 - 45)	0.75 - 1.75	4.1	1.9	0.5	0.1	0.1	0.2	7.0
	1.75 - 2.75	1.1	2.0	0.9	0.1	0.0	0.0	4.3
	2.75 - 3.75	0.2	0.6	0.5	0.1	0.0	0.0	1.6
	> 3.75	0.0	0.1	0.2	0.0	0.0	0.0	0.5
	TOTAL	7.9	4.9	2.2	0.4	0.2	0.3	16.1
ENE	< 0.75	3.7	0.2	0.1	0.0	0.0	0.0	4.1
(45 - 75)	0.75 - 1.75	5.9	3.2	0.8	0.1	0.1	0.3	10.3
	1.75 - 2.75	1.0	1.9	0.8	0.1	0.0	0.0	4.0
	2.75 - 3.75	0.1	0.3	0.4	0.1	0.0	0.0	1.0
	> 3.75	0.0	0.1	0.1	0.0	0.0	0.0	0.3
	TOTAL	10.7	5.7	2.3	0.3	0.2	0.4	19.7
E	< 0.75	3.4	0.0	0.0	0.0	0.0	0.0	3.6
(75 - 105)	0.75 - 1.75	2.6	0.9	0.2	0.0	0.0	0.0	3.9
	1.75 - 2.75	0.2	0.4	0.2	0.0	0.0	0.0	0.9
	2.75 - 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.2
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	6.2	1.4	0.5	0.1	0.0	0.0	8.7
ESE	< 0.75	2.1	0.1	0.0	0.0	0.0	0.0	2.2
(105 - 135)	0.75 - 1.75	1.1	0.2	0.0	0.0	0.0	0.0	1.4
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	3.2	0.3	0.0	0.0	0.0	0.0	3.8
TOTAL	< 0.75	13.5	0.6	0.1	0.0	0.0	0.0	14.5
(315 - 135)	0.75 - 1.75	15.3	6.8	1.7	0.2	0.3	0.6	25.1
	1.75 - 2.75	2.6	4.6	2.0	0.3	0.1	0.1	9.9
	2.75 - 3.75	0.4	1.1	1.0	0.2	0.0	0.0	3.0
	> 3.75	0.1	0.2	0.3	0.0	0.0	0.0	0.9
	TOTAL	31.9	13.2	5.1	0.9	0.4	0.8	53.4

Table 1.3-6(2/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-B)

Marsden Squares : 2614,2615,2616,2623,2624,2625,2626,2633,2634,
2635,2636,2643,2644,2645,2646
Starting Date : 01/01/1949
Ending Date : 31/12/1983
Nos of Data : 43,458
Percent of Calm : 7.8

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
N	< 0.75	2.4	0.2	0.1	0.0	0.0	0.0	2.6
(345 - 15)	0.75 - 1.75	2.3	0.9	0.2	0.0	0.1	0.1	3.5
	1.75 - 2.75	0.4	0.6	0.3	0.0	0.0	0.0	1.3
	2.75 - 3.75	0.1	0.1	0.1	0.0	0.0	0.0	0.3
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	TOTAL	5.1	1.7	0.6	0.0	0.1	0.1	7.7
NNE	< 0.75	5.5	0.3	0.1	0.1	0.0	0.0	5.9
(15 - 45)	0.75 - 1.75	7.2	3.1	0.7	0.2	0.2	0.2	11.6
	1.75 - 2.75	1.4	2.0	0.9	0.2	0.1	0.0	4.5
	2.75 - 3.75	0.3	0.5	0.4	0.1	0.0	0.0	1.2
	> 3.75	0.1	0.2	0.2	0.1	0.0	0.0	0.4
	TOTAL	14.3	5.9	2.2	0.6	0.2	0.2	23.6
ENE	< 0.75	3.7	0.3	0.1	0.0	0.0	0.0	4.1
(45 - 75)	0.75 - 1.75	3.1	1.3	0.3	0.0	0.1	0.1	4.9
	1.75 - 2.75	0.4	0.5	0.2	0.1	0.0	0.0	1.2
	2.75 - 3.75	0.1	0.1	0.1	0.0	0.0	0.0	0.3
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	TOTAL	7.3	2.1	0.6	0.1	0.1	0.1	10.5
E	< 0.75	2.0	0.1	0.0	0.0	0.0	0.0	2.1
(75 - 105)	0.75 - 1.75	0.8	0.2	0.0	0.0	0.0	0.0	1.1
	1.75 - 2.75	0.1	0.1	0.0	0.0	0.0	0.0	0.1
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.9	0.4	0.0	0.0	0.0	0.0	3.3
ESE	< 0.75	2.0	0.0	0.0	0.0	0.0	0.0	2.1
(105 - 135)	0.75 - 1.75	0.7	0.1	0.0	0.0	0.0	0.0	1.0
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.8	0.2	0.0	0.0	0.0	0.0	3.1
SSE	< 0.75	3.8	0.1	0.0	0.0	0.0	0.0	3.9
(135 - 165)	0.75 - 1.75	2.2	0.5	0.1	0.0	0.0	0.0	2.9
	1.75 - 2.75	0.1	0.0	0.0	0.0	0.0	0.0	0.2
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	6.1	0.6	0.1	0.0	0.0	0.0	7.1
TOTAL	< 0.75	19.4	0.9	0.2	0.1	0.0	0.0	20.7
(15 - 165)	0.75 - 1.75	16.3	6.2	1.3	0.2	0.3	0.4	24.9
	1.75 - 2.75	2.4	3.1	1.4	0.3	0.1	0.0	7.3
	2.75 - 3.75	0.4	0.7	0.5	0.1	0.0	0.0	1.7
	> 3.75	0.1	0.2	0.2	0.1	0.0	0.0	0.6
	TOTAL	38.5	10.9	3.4	0.7	0.4	0.5	55.2

Table 1.3-6(3/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-D)

Marsden Squares : 2630,2631,2640,2738,2739,2748,2749
Starting Date : 01/01/1949
Ending Date : 31/12/1983
Nos of Data : 13,600
Percent of Calm : 16.7

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
SSW	< 0.75	2.8	0.1	0.0	0.0	0.0	0.0	3.0
(195 - 225)	0.75 - 1.75	0.5	0.1	0.0	0.0	0.0	0.0	0.7
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	3.4	0.2	0.0	0.0	0.0	0.0	3.7
WSW	< 0.75	2.6	0.0	0.0	0.0	0.0	0.0	2.7
(225 - 255)	0.75 - 1.75	0.7	0.1	0.0	0.0	0.0	0.0	0.9
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	3.3	0.2	0.0	0.0	0.0	0.0	3.7
W	< 0.75	4.4	0.1	0.0	0.0	0.0	0.0	4.6
(255 - 285)	0.75 - 1.75	1.2	0.2	0.1	0.0	0.0	0.0	1.6
	1.75 - 2.75	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	5.6	0.4	0.2	0.1	0.0	0.0	6.4
WNW	< 0.75	6.6	0.3	0.1	0.1	0.0	0.1	7.2
(285 - 315)	0.75 - 1.75	3.9	0.7	0.1	0.0	0.1	0.1	5.1
	1.75 - 2.75	0.2	0.1	0.0	0.0	0.0	0.0	0.4
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	TOTAL	11.0	1.2	0.2	0.1	0.1	0.2	12.9
NNW	< 0.75	7.2	0.3	0.1	0.0	0.0	0.0	7.7
(315 - 345)	0.75 - 1.75	4.2	1.1	0.2	0.0	0.0	0.1	6.0
	1.75 - 2.75	0.4	0.2	0.0	0.0	0.0	0.0	0.7
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	11.8	1.7	0.4	0.1	0.1	0.3	14.5
TOTAL	< 0.75	23.6	0.8	0.2	0.1	0.0	0.1	25.1
(195 - 345)	0.75 - 1.75	10.6	2.3	0.4	0.0	0.1	0.3	14.3
	1.75 - 2.75	0.7	0.3	0.0	0.0	0.0	0.0	1.3
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	TOTAL	35.1	3.8	0.8	0.3	0.3	0.6	41.1

Table 1.3-6(4/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-E)

Marsden Squares : 2650,2660,2757,2758,2759,2767,2768,2769
Starting Date : 01/01/1949
Ending Date : 31/12/1983
Nos of Data : 11,235
Percent of Calm : 14.0

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
S	< 0.75	2.2	0.1	0.0	0.0	0.0	0.0	2.2
(165 - 195)	0.75 - 1.75	0.5	0.2	0.0	0.0	0.0	0.0	0.9
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.7	0.3	0.1	0.1	0.0	0.0	3.2
SSW	< 0.75	2.0	0.0	0.1	0.0	0.0	0.0	2.2
(195 - 225)	0.75 - 1.75	0.6	0.2	0.0	0.1	0.0	0.0	0.9
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.7	0.3	0.1	0.1	0.0	0.1	3.4
WSW	< 0.75	2.4	0.0	0.0	0.0	0.0	0.0	2.5
(225 - 255)	0.75 - 1.75	1.1	0.2	0.1	0.1	0.0	0.0	1.6
	1.75 - 2.75	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	3.6	0.4	0.2	0.1	0.1	0.1	4.5
W	< 0.75	4.2	0.1	0.0	0.0	0.0	0.1	4.6
(255 - 285)	0.75 - 1.75	2.7	0.9	0.3	0.0	0.0	0.0	4.0
	1.75 - 2.75	0.2	0.2	0.1	0.0	0.0	0.0	0.6
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	7.2	1.4	0.5	0.0	0.0	0.1	9.3
WNW	< 0.75	5.8	0.4	0.1	0.0	0.0	0.0	6.4
(285 - 315)	0.75 - 1.75	5.1	2.0	0.4	0.1	0.0	0.1	7.9
	1.75 - 2.75	0.5	0.6	0.2	0.0	0.0	0.0	1.3
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	11.4	3.0	0.7	0.3	0.2	0.2	15.8
NNW	< 0.75	4.9	0.2	0.1	0.0	0.0	0.1	5.4
(315 - 345)	0.75 - 1.75	2.8	0.9	0.3	0.0	0.0	0.0	4.2
	1.75 - 2.75	0.1	0.2	0.0	0.0	0.0	0.0	0.4
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	8.0	1.4	0.4	0.0	0.1	0.1	10.1
TOTAL	< 0.75	21.5	0.9	0.3	0.0	0.1	0.3	23.3
(195 - 345)	0.75 - 1.75	12.8	4.5	1.1	0.4	0.1	0.2	19.6
	1.75 - 2.75	0.9	1.2	0.4	0.0	0.0	0.0	2.9
	2.75 - 3.75	0.0	0.1	0.1	0.0	0.0	0.0	0.3
	> 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	TOTAL	35.5	6.9	2.1	0.6	0.6	0.7	46.3

Table 1.3-6(5/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-F)

Marsden Squares : 2510,2511,2520,2521,2530,2531,2532,2540,2541,
2542,2629,2639,2649
Starting Date : 01/01/1949
Ending Date : 31/12/1983
Nos of Data : 9,414
Percent of Calm : 9.1

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
WNW	< 0.75	1.5	0.2	0.0	0.0	0.0	0.0	1.7
(285 - 315)	0.75 - 1.75	1.1	0.5	0.1	0.0	0.0	0.0	1.7
	1.75 - 2.75	0.2	0.2	0.1	0.0	0.0	0.0	0.5
	2.75 - 3.75	0.0	0.0	0.1	0.1	0.0	0.0	0.2
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.8	0.8	0.3	0.1	0.0	0.0	4.1
NNW	< 0.75	1.4	0.1	0.0	0.0	0.0	0.0	1.5
(315 - 345)	0.75 - 1.75	1.2	0.9	0.2	0.0	0.1	0.0	2.3
	1.75 - 2.75	0.2	0.4	0.2	0.2	0.0	0.0	0.9
	2.75 - 3.75	0.0	0.1	0.1	0.0	0.0	0.0	0.2
	> 3.75	0.0	0.0	0.1	0.0	0.0	0.0	0.1
	TOTAL	2.7	1.4	0.5	0.3	0.1	0.1	5.1
N	< 0.75	2.1	0.2	0.0	0.1	0.0	0.0	2.5
(345 - 15)	0.75 - 1.75	2.4	2.4	0.5	0.2	0.1	0.1	5.6
	1.75 - 2.75	0.7	1.4	1.0	0.2	0.0	0.0	3.3
	2.75 - 3.75	0.2	0.3	0.4	0.2	0.1	0.0	1.1
	> 3.75	0.0	0.1	0.1	0.1	0.1	0.0	0.5
	TOTAL	5.4	4.3	2.1	0.7	0.3	0.2	13.1
NNE	< 0.75	4.6	0.3	0.1	0.1	0.0	0.0	5.2
(15 - 45)	0.75 - 1.75	5.5	3.1	0.7	0.2	0.2	0.1	9.9
	1.75 - 2.75	1.2	2.0	0.8	0.2	0.1	0.1	4.2
	2.75 - 3.75	0.1	0.6	0.3	0.2	0.0	0.0	1.3
	> 3.75	0.1	0.1	0.2	0.1	0.0	0.0	0.4
	TOTAL	11.4	6.2	2.3	0.6	0.3	0.2	21.0
ENE	< 0.75	3.8	0.2	0.1	0.0	0.0	0.1	4.1
(45 - 75)	0.75 - 1.75	3.1	1.3	0.1	0.1	0.1	0.0	4.7
	1.75 - 2.75	0.5	0.7	0.3	0.0	0.0	0.0	1.6
	2.75 - 3.75	0.1	0.1	0.1	0.0	0.0	0.0	0.3
	> 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	TOTAL	7.5	2.5	0.6	0.1	0.1	0.1	10.9
TOTAL	< 0.75	13.3	1.0	0.2	0.1	0.0	0.1	15.0
(285 - 75)	0.75 - 1.75	13.2	8.2	1.5	0.4	0.4	0.2	24.2
	1.75 - 2.75	2.8	4.6	2.4	0.5	0.1	0.1	10.5
	2.75 - 3.75	0.4	1.0	0.9	0.4	0.1	0.0	3.1
	> 3.75	0.1	0.2	0.3	0.2	0.1	0.0	1.2
	TOTAL	29.8	15.1	5.8	1.8	0.7	0.5	54.2

Table 1.3-6(6/6) WAVE STATISTICS BY APPROACHING DIRECTION (AREA-H)

Marsden Squares : 2554,2555,2556,2564,2565,2566,2574,2575,2576
Starting Date : 01/01/1949
Ending Date : 31/12/1983
Nos of Data : 7,914
Percent of Calm : 7.4

Wave Direction	Wave Height (m)	Frequency (%) by Wave Period (sec) 5-6	7-8	9-10	11-12	13-14	>14	Total
W	< 0.75	2.1	0.1	0.0	0.0	0.0	0.0	2.4
(255 - 285)	0.75 - 1.75	2.2	1.0	0.2	0.0	0.0	0.1	3.5
	1.75 - 2.75	0.3	0.4	0.2	0.0	0.0	0.0	1.1
	2.75 - 3.75	0.0	0.2	0.1	0.0	0.0	0.0	0.4
	> 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	TOTAL	4.7	1.8	0.7	0.1	0.0	0.1	7.6
WNW	< 0.75	1.1	0.2	0.0	0.0	0.0	0.0	1.3
(285 - 315)	0.75 - 1.75	1.1	0.6	0.1	0.0	0.0	0.0	1.9
	1.75 - 2.75	0.1	0.3	0.1	0.0	0.0	0.0	0.6
	2.75 - 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	TOTAL	2.4	1.1	0.3	0.0	0.1	0.0	4.0
NNW	< 0.75	1.1	0.1	0.0	0.0	0.0	0.0	1.2
(315 - 345)	0.75 - 1.75	0.9	0.5	0.2	0.0	0.0	0.0	1.7
	1.75 - 2.75	0.1	0.4	0.3	0.0	0.0	0.0	0.8
	2.75 - 3.75	0.1	0.1	0.1	0.0	0.0	0.0	0.3
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.2	1.2	0.5	0.1	0.0	0.0	4.2
N	< 0.75	1.8	0.1	0.0	0.0	0.0	0.0	2.0
(345 - 15)	0.75 - 1.75	0.8	0.2	0.2	0.1	0.1	0.0	1.4
	1.75 - 2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	2.75 - 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	> 3.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	2.7	0.4	0.3	0.1	0.1	0.0	3.6
TOTAL	< 0.75	6.1	0.5	0.1	0.0	0.0	0.0	6.9
(255 - 15)	0.75 - 1.75	5.1	2.3	0.7	0.2	0.1	0.1	8.5
	1.75 - 2.75	0.6	1.1	0.7	0.1	0.0	0.0	2.6
	2.75 - 3.75	0.1	0.4	0.2	0.0	0.0	0.0	0.9
	> 3.75	0.0	0.1	0.0	0.0	0.0	0.0	0.2
	TOTAL	12.0	4.5	1.8	0.4	0.2	0.2	19.4

Table 1.3-7(1/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (PERLIS)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
180	6.0	194.8	0.901	0.955	0.860	200.9	0.853	0.981	0.837	205.7	0.840	1.024	0.860	210.7	0.836	1.104	0.923	215.2	0.829	1.188	0.985
	8.0	203.0	0.824	1.068	0.880	207.7	0.811	1.112	0.902	211.1	0.807	1.177	0.950	215.0	0.800	1.283	1.026	218.0	0.794	1.370	1.088
	10.0	210.7	0.735	1.198	0.881	214.3	0.736	1.253	0.922	215.7	0.735	1.330	0.978	218.8	0.730	1.462	1.067	221.0	0.727	1.556	1.131
210	6.0	221.7	0.877	0.947	0.831	223.6	0.859	0.973	0.836	225.3	0.854	1.019	0.870	225.4	0.855	1.097	0.938	227.4	0.856	1.175	1.006
	8.0	221.9	0.821	1.070	0.878	222.5	0.800	1.112	0.890	222.2	0.790	1.174	0.927	223.9	0.780	1.282	1.000	225.8	0.774	1.377	1.066
	10.0	221.0	0.797	1.208	0.963	219.3	0.778	1.264	0.983	218.3	0.764	1.348	1.030	220.2	0.753	1.476	1.111	221.8	0.747	1.558	1.164
240	6.0	235.2	0.538	0.994	0.535	236.2	0.525	1.021	0.536	238.0	0.514	1.064	0.547	241.3	0.500	1.148	0.574	243.2	0.489	1.318	0.645
	8.0	235.3	0.772	1.110	0.857	238.1	0.760	1.158	0.880	241.0	0.747	1.227	0.917	241.8	0.736	1.334	0.982	242.2	0.730	1.438	1.050
	10.0	232.5	0.751	1.207	0.906	235.9	0.736	1.266	0.932	238.3	0.725	1.343	0.974	241.8	0.713	1.476	1.052	243.4	0.706	1.577	1.113

Table 1.3-7(2/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KEDAH)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
180	6.0	201.5	0.257	0.976	0.251	204.0	0.254	1.005	0.255	206.3	0.251	1.043	0.262	211.9	0.248	1.127	0.279	230.3	0.240	1.292	0.310
	8.0	213.0	0.730	1.102	0.804	214.3	0.730	1.141	0.833	215.9	0.731	1.214	0.887	217.6	0.731	1.313	0.960	226.0	0.728	1.427	1.039
	10.0	213.6	0.717	1.211	0.868	215.9	0.713	1.277	0.911	218.4	0.709	1.351	0.958	222.2	0.704	1.493	1.051	224.1	0.701	1.588	1.113
210	6.0	219.3	1.026	0.954	0.979	219.9	1.027	0.978	1.004	220.8	1.029	1.026	1.056	221.6	1.030	1.099	1.132	0.0	0.000	0.000	0.000
	8.0	225.7	1.145	1.088	1.245	227.7	1.153	1.125	1.296	229.7	1.162	1.197	1.390	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
	10.0	236.9	0.914	1.212	1.108	239.7	0.909	1.273	1.157	241.1	0.907	1.348	1.223	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
240	6.0	240.9	0.976	0.949	0.926	241.4	0.974	0.971	0.945	242.4	0.972	1.013	0.984	244.2	0.970	1.088	1.055	245.4	0.969	1.148	1.112
	8.0	248.6	0.842	1.061	0.892	248.4	0.838	1.110	0.930	247.5	0.835	1.173	0.979	245.5	0.831	1.279	1.062	243.9	0.829	1.356	1.123
	10.0	246.5	0.828	1.216	1.007	245.7	0.826	1.254	1.036	244.6	0.823	1.332	1.096	243.5	0.820	1.466	1.202	243.5	0.820	1.466	1.202
270	6.0	264.7	0.963	0.947	0.912	264.3	0.964	0.971	0.936	264.0	0.965	1.019	0.983	264.0	0.966	1.089	1.052	264.2	0.967	1.149	1.111
	8.0	258.7	0.851	1.069	0.910	258.9	0.850	1.108	0.942	259.3	0.850	1.180	1.003	260.0	0.851	1.277	1.087	260.6	0.852	1.349	1.149
	10.0	258.9	0.808	1.201	0.970	259.4	0.805	1.269	1.022	260.4	0.804	1.347	1.083	262.6	0.803	1.472	1.182	262.6	0.803	1.472	1.182

Table 1.3-7(3/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (TG.PIANDANG)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
210	6.0	242.0	0.629	0.948	0.596	243.8	0.624	0.968	0.604	247.2	0.616	1.015	0.625	252.0	0.603	1.087	0.655	263.5	0.582	1.261	0.734
	8.0	249.0	0.517	1.032	0.534	250.5	0.514	1.070	0.550	252.5	0.511	1.131	0.578	256.0	0.508	1.233	0.626	262.1	0.505	1.436	0.725
	10.0	250.8	0.705	1.033	0.728	251.5	0.699	1.074	0.751	252.9	0.692	1.132	0.783	254.4	0.680	1.235	0.840	260.8	0.657	1.455	0.956
240	6.0	250.1	0.611	1.033	0.631	249.4	0.607	1.072	0.650	247.8	0.602	1.132	0.681	247.3	0.594	1.234	0.733	241.5	0.581	1.446	0.840
	8.0	254.8	0.756	1.152	0.871	252.6	0.753	1.217	0.916	250.7	0.751	1.297	0.974	250.7	0.751	1.412	1.060	247.4	0.751	1.650	1.239
	10.0	257.1	0.761	1.173	0.893	259.1	0.756	1.218	0.921	261.5	0.749	1.300	0.974	265.0	0.741	1.420	1.052	270.0	0.716	1.669	1.195
270	6.0	265.3	0.759	1.163	0.882	264.0	0.755	1.218	0.919	261.3	0.750	1.299	0.974	258.0	0.746	1.416	1.056	249.6	0.734	1.660	1.217
	8.0	264.3	0.889	0.948	0.843	263.1	0.888	0.965	0.857	263.6	0.888	1.006	0.893	266.6	0.827	1.083	0.896	271.2	0.826	1.262	1.042
	10.0	270.1	0.867	1.033	0.896	267.2	0.865	1.074	0.929	259.8	0.862	1.136	0.979	259.8	0.862	1.136	0.979	259.8	0.797	1.449	1.155
300	6.0	281.3	0.879	1.166	1.025	276.6	0.876	1.223	1.071	277.1	0.873	1.297	1.132	277.9	0.870	1.423	1.238	284.1	0.866	1.662	1.439
	8.0	298.7	0.883	0.950	0.839	294.2	0.880	0.969	0.853	286.7	0.876	1.013	0.887	276.7	0.873	1.082	0.945	261.7	0.867	1.274	1.105
	10.0	303.6	0.850	1.059	0.900	302.2	0.848	1.090	0.924	298.0	0.845	1.154	0.975	290.3	0.842	1.267	1.067	276.0	0.838	1.504	1.260

Table 1.3-7(4/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (BERUAS)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
240	6.0	250.0	0.844	0.942	0.795	252.0	0.836	0.971	0.812	254.6	0.830	1.008	0.837	256.8	0.826	1.043	0.862	252.3	0.793	1.250	0.991
	8.0	253.0	0.802	1.029	0.825	254.5	0.795	1.065	0.847	257.4	0.788	1.133	0.893	258.9	0.785	1.168	0.917	260.2	0.773	1.433	1.108
	10.0	253.2	0.837	1.147	0.960	255.0	0.831	1.201	0.998	258.0	0.825	1.282	1.058	259.0	0.700	1.343	0.940	261.3	0.690	1.470	1.014
270	6.0	270.3	0.858	0.943	0.809	234.3	0.853	0.969	0.827	271.0	0.849	1.015	0.862	271.5	0.848	1.038	0.880	272.5	0.830	1.223	1.015
	8.0	268.6	0.803	1.035	0.831	268.9	0.797	1.078	0.859	270.0	0.793	1.138	0.902	270.8	0.792	1.171	0.927	271.0	0.780	1.439	1.122
	10.0	271.3	0.694	1.161	0.806	271.3	0.686	1.222	0.838	272.2	0.681	1.297	0.883	273.0	0.679	1.349	0.916	274.2	0.661	1.500	0.992
300	6.0	274.5	0.817	0.944	0.771	268.6	0.795	0.971	0.772	249.0	0.712	1.011	0.720	251.1	0.628	1.086	0.682	252.0	0.605	1.235	0.747
	8.0	280.8	0.649	1.031	0.669	279.8	0.641	1.076	0.690	279.4	0.638	1.130	0.721	279.7	0.635	1.218	0.773	280.1	0.622	1.399	0.870
	10.0	261.8	0.469	1.163	0.545	258.1	0.453	1.216	0.551	256.7	0.443	1.296	0.574	256.3	0.433	1.417	0.614	256.9	0.420	1.498	0.629

Table 1.3-7(5/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KUANTAN)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
30	6.0	71.8	0.586	0.969	0.568	79.8	0.544	0.997	0.542	83.0	0.512	1.036	0.530	96.9	0.396	1.118	0.442	107.4	0.338	1.302	0.440
	8.0	73.5	0.533	1.088	0.580	80.7	0.504	1.127	0.568	86.7	0.468	1.193	0.558	98.6	0.409	1.300	0.532	102.3	0.391	1.521	0.595
	10.0	72.9	0.712	1.209	0.861	80.3	0.672	1.255	0.843	86.3	0.619	1.340	0.830	100.1	0.513	1.469	0.754	102.5	0.477	1.730	0.824
60	6.0	77.9	0.702	0.957	0.671	83.7	0.663	0.982	0.651	88.1	0.612	1.024	0.627	100.6	0.558	1.105	0.617	103.4	0.486	1.280	0.622
	8.0	85.0	0.736	1.085	0.798	91.7	0.693	1.134	0.786	96.7	0.624	1.200	0.749	97.3	0.580	1.295	0.751	87.7	0.680	1.507	1.024
	10.0	85.3	0.490	1.210	0.592	92.2	0.461	1.274	0.587	97.2	0.417	1.356	0.565	98.2	0.387	1.470	0.569	84.9	0.280	1.760	0.493
90	6.0	92.1	0.739	0.979	0.723	94.4	0.731	1.001	0.732	98.7	0.692	1.047	0.724	101.2	0.663	1.125	0.747	93.1	0.453	1.328	0.602
	8.0	88.5	0.763	1.106	0.844	93.4	0.759	1.160	0.880	94.8	0.767	1.223	0.938	107.5	0.786	1.321	1.038	112.3	0.806	1.588	1.279
	10.0	81.4	0.707	1.206	0.852	87.1	0.702	1.261	0.885	92.3	0.688	1.350	0.929	97.0	0.627	1.479	0.928	107.5	0.588	1.744	1.026
120	6.0	121.9	0.733	0.956	0.701	123.7	0.732	0.982	0.719	124.5	0.727	1.032	0.751	122.3	0.697	1.105	0.770	108.9	0.662	1.284	0.850
	8.0	122.0	0.476	1.088	0.517	124.0	0.474	1.133	0.537	124.8	0.471	1.209	0.570	122.5	0.446	1.308	0.583	108.8	0.420	1.539	0.646
	10.0	103.6	0.432	1.221	0.528	105.2	0.430	1.273	0.547	107.4	0.427	1.345	0.575	113.5	0.405	1.469	0.594	103.4	0.390	1.727	0.673
150	6.0	123.2	0.494	1.008	0.498	123.4	0.494	1.021	0.504	124.5	0.491	1.076	0.528	123.9	0.438	1.155	0.506	112.3	0.410	1.322	0.542
	8.0	120.1	0.374	1.102	0.412	122.3	0.373	1.149	0.429	123.8	0.371	1.227	0.456	126.4	0.358	1.329	0.476	111.2	0.339	1.574	0.533
	10.0	118.2	0.364	1.187	0.432	120.7	0.364	1.245	0.453	122.4	0.363	1.340	0.486	121.0	0.352	1.469	0.518	121.3	0.343	1.745	0.598

Table 1.3-7(6/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KERTEH)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
30	6.0	65.8	0.636	0.942	0.599	67.7	0.600	0.962	0.577	71.2	0.532	1.006	0.535	80.1	0.432	1.084	0.468	99.8	0.377	1.242	0.469
	8.0	69.9	0.698	1.010	0.706	73.0	0.641	1.051	0.674	79.6	0.553	1.118	0.618	90.0	0.459	1.211	0.556	114.6	0.352	1.416	0.499
	10.0	76.3	0.600	1.114	0.668	83.9	0.538	1.160	0.624	87.4	0.491	1.244	0.611	92.9	0.419	1.357	0.569	105.9	0.361	1.605	0.580
60	6.0	75.7	0.871	0.948	0.825	76.9	0.846	0.969	0.819	79.0	0.777	1.016	0.790	87.2	0.680	1.086	0.738	99.2	0.476	1.271	0.605
	8.0	79.0	0.836	1.017	0.850	81.1	0.813	1.061	0.863	85.6	0.788	1.121	0.883	92.4	0.741	1.222	0.905	95.7	0.734	1.431	1.051
	10.0	87.1	1.016	1.148	1.166	87.6	1.062	1.206	1.280	93.2	1.105	1.287	1.423	96.8	1.146	1.408	1.614	116.3	1.024	1.651	1.691
90	6.0	94.9	0.944	0.946	0.893	93.9	0.921	0.967	0.890	96.7	0.877	1.009	0.885	103.6	0.831	1.086	0.902	115.3	0.745	1.258	0.938
	8.0	94.7	0.873	1.039	0.907	93.6	0.845	1.072	0.905	96.8	0.796	1.133	0.902	103.9	0.744	1.234	0.918	116.0	0.651	1.450	0.944
	10.0	94.3	0.801	1.175	0.941	93.1	0.774	1.215	0.940	97.3	0.732	1.293	0.946	105.9	0.677	1.432	0.970	116.6	0.595	1.675	0.997
120	6.0	118.7	0.968	0.946	0.916	120.0	0.973	0.973	0.947	119.0	0.998	1.018	1.015	119.0	1.029	1.091	1.123	130.4	1.021	1.271	1.298
	8.0	112.8	0.893	1.044	0.933	115.4	0.900	1.090	0.981	117.1	0.931	1.154	1.075	118.0	0.973	1.260	1.226	117.0	1.053	1.458	1.535
	10.0	109.1	1.031	1.182	1.219	110.6	1.042	1.244	1.297	109.4	1.094	1.326	1.450	114.9	1.134	1.452	1.647	119.2	1.187	1.693	2.009
150	6.0	127.5	0.811	0.957	0.776	128.0	0.810	0.978	0.792	128.5	0.801	1.018	0.815	128.6	0.795	1.096	0.871	128.7	0.766	1.271	0.974
	8.0	123.4	0.900	1.074	0.966	122.9	0.897	1.110	0.996	117.5	0.881	1.178	1.038	120.1	0.865	1.286	1.112	122.4	0.828	1.499	1.240
	10.0	113.8	0.716	1.244	0.891	114.5	0.715	1.274	0.911	107.2	0.724	1.347	0.976	107.5	0.729	1.476	1.077	127.6	0.696	1.758	1.223

Table 1.3-7(7/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (MARANG)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
0	6.0	23.3	0.823	0.937	0.771	24.4	0.817	0.968	0.791	23.9	0.817	1.005	0.822	26.2	0.798	1.085	0.866	31.3	0.724	1.249	0.905
	8.0	33.4	0.803	1.047	0.840	33.5	0.797	1.076	0.857	35.8	0.775	1.146	0.888	40.2	0.724	1.244	0.901	41.8	0.820	1.441	1.182
	10.0	34.7	0.805	1.173	0.944	34.7	0.805	1.231	0.991	34.6	0.806	1.307	1.054	42.1	0.548	1.280	0.702	44.5	0.509	1.508	0.767
30	6.0	33.0	0.988	0.941	0.930	33.2	0.986	0.960	0.946	31.9	0.979	1.001	0.980	31.5	0.897	1.085	0.974	33.0	0.883	1.258	1.110
	8.0	37.2	1.022	1.035	1.058	42.3	1.020	1.088	1.110	45.8	1.019	1.148	1.170	42.6	1.029	1.246	1.282	40.0	1.000	1.452	1.453
	10.0	39.1	1.017	1.175	1.195	38.6	1.021	1.237	1.263	36.8	1.027	1.311	1.346	44.7	1.027	1.437	1.476	47.0	1.027	1.764	1.812
60	6.0	61.8	0.995	0.945	0.940	64.2	0.994	0.967	0.961	67.7	0.992	1.002	0.994	71.4	0.945	1.086	1.026	58.3	0.913	1.252	1.144
	8.0	61.6	0.983	1.028	1.010	64.9	0.983	1.082	1.064	68.4	0.982	1.138	1.117	63.7	0.963	1.241	1.195	52.7	0.953	1.472	1.402
	10.0	60.8	0.975	1.155	1.126	60.3	0.975	1.229	1.198	60.4	0.975	1.297	1.265	56.4	0.972	1.420	1.380	55.7	0.970	1.676	1.626
90	6.0	80.5	0.963	0.941	0.907	78.6	0.959	0.968	0.929	78.3	0.957	1.015	0.971	82.8	0.956	1.088	1.039	75.2	0.955	1.255	1.198
	8.0	70.5	0.845	1.041	0.879	69.2	0.840	1.079	0.906	69.4	0.837	1.151	0.963	73.1	0.821	1.236	1.015	67.5	0.811	1.469	1.192
	10.0	69.9	0.862	1.172	1.010	69.5	0.857	1.217	1.043	68.2	0.852	1.302	1.109	65.4	0.838	1.426	1.195	62.9	0.834	1.651	1.376
120	6.0	96.3	0.971	0.942	0.915	92.0	0.971	0.970	0.942	88.8	0.975	1.020	0.994	87.5	0.940	1.091	1.025	67.6	0.870	1.262	1.098
	8.0	84.8	0.762	1.045	0.796	83.6	0.753	1.090	0.821	84.5	0.747	1.153	0.861	83.7	0.675	1.254	0.847	68.6	0.615	1.475	0.907
	10.0	85.5	0.754	1.179	0.889	82.5	0.740	1.244	0.921	81.3	0.733	1.335	0.979	82.5	0.713	1.454	1.036	73.8	0.699	1.724	1.204

Table 1.3-7(8/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (TERENGGANU)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
0	6.0	17.1	0.863	0.951	0.821	18.1	0.864	0.972	0.840	18.5	0.867	1.020	0.885	22.2	0.847	1.096	0.928	31.0	0.818	1.261	1.032
	8.0	30.1	0.817	1.033	0.843	33.9	0.820	1.072	0.879	34.4	0.831	1.137	0.944	35.7	0.852	1.232	1.049	39.9	0.864	1.435	1.240
	10.0	37.0	0.942	1.149	1.082	40.4	0.938	1.196	1.122	42.0	0.938	1.283	1.203	43.2	0.907	1.406	1.276	46.1	0.881	1.665	1.466
30	6.0	40.8	1.009	0.960	0.968	43.0	1.009	0.982	0.991	43.9	1.014	1.028	1.042	42.2	1.024	1.106	1.132	51.9	1.025	1.279	1.311
	8.0	37.8	0.980	1.032	1.011	35.6	0.982	1.070	1.050	39.2	0.988	1.133	1.119	40.9	0.997	1.232	1.229	62.3	0.982	1.445	1.419
	10.0	46.9	1.066	1.147	1.223	47.1	1.072	1.208	1.295	45.0	1.086	1.280	1.391	37.6	1.112	1.403	1.560	43.0	1.165	1.674	1.950
60	6.0	58.1	0.997	0.937	0.935	57.5	0.997	0.964	0.961	58.7	0.996	1.003	0.999	62.8	0.980	1.078	1.056	82.9	0.965	1.243	1.200
	8.0	57.6	0.978	1.042	1.019	57.6	0.977	1.086	1.061	60.9	0.976	1.143	1.116	65.6	0.960	1.244	1.195	84.4	0.953	1.442	1.374
	10.0	57.7	0.951	1.182	1.124	58.0	0.951	1.240	1.179	61.0	0.950	1.310	1.245	66.2	0.935	1.435	1.342	85.2	0.930	1.681	1.563
90	6.0	83.0	1.052	0.943	0.992	82.5	1.056	0.964	1.018	80.9	1.060	1.011	1.072	77.0	1.055	1.082	1.141	79.6	1.068	1.236	1.321
	8.0	78.9	1.107	1.034	1.145	78.9	1.119	1.075	1.203	79.7	1.130	1.116	1.261	75.0	1.210	1.230	1.488	71.0	1.171	1.484	1.737
	10.0	76.5	0.990	1.142	1.130	74.8	0.986	1.198	1.182	72.1	0.993	1.277	1.268	69.8	0.981	1.396	1.370	62.5	0.980	1.637	1.605
120	6.0	93.7	0.915	0.942	0.861	87.1	0.898	0.968	0.869	76.5	0.897	1.011	0.907	71.1	0.941	1.088	1.024	47.6	0.948	1.266	1.200
	8.0	90.0	0.902	1.035	0.933	89.0	0.902	1.069	0.964	86.5	0.901	1.131	1.019	81.4	0.891	1.226	1.092	79.1	0.893	1.416	1.265
	10.0	85.5	0.932	1.155	1.076	84.2	0.934	1.203	1.124	84.1	0.922	1.286	1.185	83.8	0.868	1.405	1.219	74.8	0.846	1.657	1.402

Table 1.3-7(9/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (OYA)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
300	6.0	320.1	0.935	0.949	0.887	324.1	0.929	0.973	0.904	329.8	0.909	1.017	0.925	335.5	0.870	1.096	0.953	349.5	0.832	1.275	1.061
	8.0	328.0	0.997	1.099	1.096	332.5	1.006	1.147	1.154	336.1	0.991	1.213	1.202	339.8	0.990	1.314	1.301	345.5	0.973	1.554	1.512
	10.0	334.7	0.978	1.219	1.192	335.7	0.966	1.272	1.229	335.4	0.964	1.354	1.305	338.1	0.967	1.484	1.435	327.0	1.022	1.753	1.792
330	6.0	339.4	0.988	0.945	0.934	341.9	0.994	0.940	0.935	345.9	0.962	1.013	0.975	356.6	0.907	1.096	0.994	7.0	0.888	1.266	1.125
	8.0	340.6	0.983	1.072	1.054	342.7	0.991	1.116	1.106	348.4	0.972	1.178	1.146	354.4	0.977	1.279	1.250	1.5	0.977	1.489	1.455
	10.0	339.7	0.980	1.192	1.168	342.0	0.989	1.249	1.235	347.5	0.963	1.329	1.280	358.5	0.921	1.450	1.336	4.6	0.910	1.699	1.546
0	6.0	358.2	0.999	0.958	0.957	359.5	0.998	0.983	0.981	359.8	0.996	1.025	1.021	359.5	0.994	1.098	1.091	5.0	0.992	1.271	1.261
	8.0	357.3	0.959	1.090	1.089	358.8	0.998	1.132	1.130	359.6	0.997	1.198	1.195	7.2	0.980	1.297	1.271	5.2	0.973	1.518	1.477
	10.0	357.3	0.999	1.202	1.201	358.9	0.998	1.254	1.251	359.5	0.997	1.335	1.331	7.1	0.981	1.453	1.426	5.1	0.974	1.712	1.668
30	6.0	21.0	0.958	0.952	0.912	20.4	0.963	0.977	0.941	19.2	0.968	1.021	0.988	16.7	0.973	1.098	1.069	3.3	0.958	1.282	1.228
	8.0	11.4	0.890	1.080	0.961	11.0	0.888	1.123	0.997	9.8	0.884	1.189	1.051	5.7	0.877	1.294	1.135	5.9	0.873	1.521	1.328
	10.0	7.2	0.907	1.210	1.097	7.0	0.910	1.261	1.147	6.4	0.912	1.335	1.218	5.6	0.915	1.466	1.342	4.6	0.915	1.711	1.566
60	6.0	36.1	0.797	0.968	0.771	34.2	0.784	0.994	0.779	30.4	0.739	1.037	0.766	29.8	0.715	1.118	0.800	37.4	0.733	1.296	0.950
	8.0	25.5	0.892	1.104	0.985	24.5	0.886	1.150	1.019	21.5	0.873	1.217	1.063	21.6	0.875	1.320	1.155	34.3	0.903	1.549	1.399
	10.0	19.1	1.016	1.211	1.230	18.8	1.012	1.267	1.282	17.8	0.991	1.344	1.332	15.8	0.976	1.469	1.434	4.8	0.959	1.715	1.645

Table 1.3-7(10/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (PAPAR)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
300	6.0	295.5	0.985	0.946	0.932	298.4	0.983	0.971	0.954	300.4	0.986	1.004	0.990	302.6	0.987	1.091	1.077	306.9	0.984	1.304	1.283
	8.0	297.7	1.046	1.058	1.106	297.2	1.080	1.097	1.185	294.9	1.105	1.173	1.297	294.7	1.114	1.271	1.417	296.3	1.109	1.474	1.635
	10.0	296.8	0.995	1.192	1.186	299.7	0.983	1.249	1.228	300.6	0.989	1.310	1.295	299.8	1.004	1.434	1.439	289.6	1.034	1.709	1.766
330	6.0	327.9	0.984	0.947	0.932	329.3	0.984	0.971	0.955	333.6	0.983	1.015	0.998	333.4	0.983	1.091	1.072	331.7	0.982	1.258	1.235
	8.0	324.9	0.919	1.036	0.953	326.6	0.918	1.074	0.986	330.5	0.917	1.153	1.057	337.3	0.916	1.245	1.141	347.5	0.882	1.450	1.279
	10.0	323.6	0.952	1.166	1.110	325.9	0.949	1.221	1.159	333.8	0.946	1.304	1.233	339.2	0.938	1.409	1.322	354.8	0.748	1.668	1.248
0	6.0	349.4	0.876	0.946	0.829	350.8	0.858	0.974	0.836	354.9	0.866	1.018	0.881	359.4	0.871	1.096	0.955	355.9	0.866	1.260	1.091
	8.0	346.0	0.930	1.044	0.971	347.9	0.914	1.091	0.998	351.2	0.917	1.145	1.050	355.7	0.926	1.254	1.161	356.8	0.939	1.491	1.399
	10.0	346.4	0.949	1.180	1.120	348.6	0.929	1.241	1.152	350.5	0.929	1.307	1.213	354.1	0.927	1.435	1.331	356.8	0.909	1.691	1.537

Table 1.3-8 EVALUATION OF BREAKER INDEX

River Mouth	Beach Slope m	Coefficients a	b	Wave Period T (sec)	Breaker Index by Breaker height 5 m	4 m	3 m	2 m	1 m
Perlis	1/1000	0.823	0.788	6	0.776	0.778	0.781	0.783	0.785
				8	0.781	0.782	0.784	0.785	0.786
				10	0.783	0.784	0.785	0.786	0.787
Kedah	1/1000	0.823	0.788	6	0.776	0.778	0.781	0.783	0.785
				8	0.781	0.782	0.784	0.785	0.786
				10	0.783	0.784	0.785	0.786	0.787
Tg.Piandang	1/ 500	1.631	0.795	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Beruas	1/ 500	1.631	0.795	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Kuantan	1/ 500	1.631	0.795	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Kerten	1/ 300	2.685	0.805	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Marang	1/ 100	7.571	0.856	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Terenggan	1/ 100	7.571	0.856	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Oya	1/ 400	2.030	0.799	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794
Papar	1/ 100	7.571	0.856	6	0.772	0.777	0.781	0.786	0.791
				8	0.782	0.785	0.787	0.790	0.793
				10	0.787	0.789	0.790	0.792	0.794

Table 1.3-9 WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES FOR MERSING

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction N	Period (sec)	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks	Direction N	Kr	Ks	K=Kr*Ks
0	6.0	34.8	0.642	0.958	0.615	41.6	0.623	0.984	0.613	47.4	0.607	1.031	0.626	51.4	0.598	1.110	0.663	55.4	0.587	1.277	0.749
	8.0	32.6	0.835	1.099	0.918	36.6	0.826	1.143	0.944	45.4	0.810	1.206	0.977	55.0	0.788	1.318	1.039	58.9	0.775	1.544	1.197
	10.0	38.3	0.658	1.217	0.800	41.6	0.668	1.270	0.849	44.4	0.788	1.353	1.067	46.3	0.707	1.484	1.049	45.2	0.708	1.750	1.239
30	6.0	50.9	0.798	0.946	0.755	54.8	0.786	0.970	0.762	58.4	0.774	1.015	0.786	60.6	0.763	1.091	0.833	62.2	0.750	1.257	0.943
	8.0	51.1	0.638	1.056	0.674	54.7	0.653	1.098	0.717	57.6	0.604	1.159	0.700	60.2	0.600	1.260	0.756	62.1	0.676	1.467	0.991
	10.0	66.1	0.707	1.196	0.845	64.9	0.648	1.252	0.811	64.3	0.520	1.331	0.692	64.4	0.520	1.464	0.761	65.1	0.588	1.685	0.991
60	6.0	68.4	1.051	0.945	0.993	70.6	1.046	0.971	1.016	73.3	1.038	1.016	1.055	74.3	1.025	1.094	1.121	72.5	1.001	1.266	1.267
	8.0	66.8	0.840	1.063	0.893	68.7	0.836	1.107	0.926	72.7	0.830	1.168	0.970	76.4	0.814	1.272	1.035	71.7	0.786	1.490	1.171
	10.0	65.5	0.736	1.203	0.885	65.9	0.733	1.261	0.925	66.3	0.730	1.333	0.973	70.0	0.721	1.467	1.058	68.2	0.701	1.719	1.205
90	6.0	83.8	0.751	0.946	0.710	82.0	0.896	0.970	0.870	80.8	0.889	1.012	0.900	78.9	0.869	1.089	0.946	78.4	0.833	1.258	1.048
	8.0	70.0	0.770	1.040	0.801	68.2	0.700	1.079	0.755	68.4	0.700	1.151	0.806	72.1	0.690	1.236	0.853	66.5	0.660	1.469	0.970
	10.0	60.0	0.730	1.172	0.856	68.5	0.720	1.217	0.876	67.2	0.720	1.302	0.937	64.0	0.701	1.426	1.000	61.3	0.650	1.651	1.073
120	6.0	88.9	0.751	0.942	0.707	87.7	0.743	0.970	0.721	87.8	0.677	1.020	0.691	86.5	0.731	1.091	0.798	83.0	0.694	1.262	0.876
	8.0	83.8	0.734	1.045	0.767	82.6	0.776	1.090	0.846	84.0	0.600	1.153	0.692	81.6	0.665	1.254	0.834	79.0	0.620	1.475	0.915
	10.0	84.5	0.721	1.179	0.850	81.4	0.765	1.244	0.952	79.8	0.630	1.335	0.841	81.2	0.650	1.454	0.945	72.5	0.720	1.724	1.241

Table 1.3-10 BREAKDOWN OF LONGSHORE ENERGY FLUX FACTOR FOR MERSING

Shoreline Orientation = 334 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy	Longshore Transport
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	Flux Factor (J/m/s)	Rate (1000m3/yr)
0	6	0.50	2.4	0.48	0.37	57	7	1.3	0.2
(N)		1.25	2.3	1.16	0.90	55	9	15.8	2.8
		2.25	0.4	1.92	1.50	52	12	12.7	2.3
		3.25	0.1	2.65	2.07	49	15	8.6	1.5
		4.00	0.0	3.19	2.49	47	17	0.0	0.0
	8	0.50	0.2	0.77	0.60	60	4	0.2	0.0
		1.25	0.9	1.70	1.33	56	8	13.8	2.4
		2.25	0.6	2.84	2.21	47	17	68.2	12.1
		3.25	0.1	3.94	3.07	37	27	37.0	6.6
		4.00	0.0	4.74	3.69	34	30	0.0	0.0
	10	0.50	0.1	0.79	0.62	45	19	0.5	0.1
		1.25	0.4	1.72	1.34	46	18	13.7	2.4
		2.25	0.3	3.04	2.37	44	20	45.8	8.1
		3.25	0.1	3.71	2.90	42	22	27.2	4.8
		4.00	0.0	4.27	3.33	41	23	0.0	0.0
Sub-total			7.9			North to South		245.0	43.4
						South to North		0.0	0.0
30	6	0.50	5.5	0.60	0.47	63	1	1.0	0.2
(NNE)		1.25	7.2	1.40	1.10	62	2	21.6	3.8
		2.25	1.4	2.34	1.83	60	4	25.2	4.5
		3.25	0.3	3.24	2.53	58	6	19.1	3.4
		4.00	0.1	3.92	3.06	55	9	13.9	2.5
	8	0.50	0.3	0.64	0.50	63	1	0.1	0.0
		1.25	3.1	1.36	1.06	61	3	9.0	1.6
		2.25	2.0	2.15	1.67	60	4	29.0	5.1
		3.25	0.5	2.93	2.28	58	6	23.4	4.1
		4.00	0.2	3.65	2.85	56	8	21.7	3.8
	10	0.50	0.2	0.64	0.50	65	-1	-0.0	-0.0
		1.25	1.3	1.37	1.07	65	-1	-1.2	-0.2
		2.25	1.2	2.15	1.68	64	0	-1.6	-0.3
		3.25	0.5	2.90	2.26	64	0	-1.0	-0.2
		4.00	0.3	4.20	3.28	65	-1	-6.6	-1.2
Sub-total			24.1			North to South		163.9	29.0
						South to North		-10.5	-1.9
60	6	0.50	3.7	0.81	0.63	72	-8	-9.2	-1.6
(ENE)		1.25	3.1	1.82	1.42	74	-10	-70.4	-12.5
		2.25	0.4	3.04	2.37	73	-9	-30.2	-5.4
		3.25	0.1	4.21	3.28	70	-6	-11.6	-2.1
		4.00	0.0	5.09	3.97	68	-4	0.0	0.0
	8	0.50	0.3	0.75	0.59	71	-7	-0.5	-0.1
		1.25	1.3	1.69	1.32	75	-11	-27.2	-4.8
		2.25	0.5	2.82	2.20	73	-9	-32.0	-5.7
		3.25	0.1	3.87	3.02	69	-5	-7.9	-1.4
		4.00	0.0	4.63	3.61	67	-3	0.0	0.0
	10	0.50	0.1	0.77	0.60	68	-4	-0.1	-0.0
		1.25	0.5	1.73	1.35	70	-6	-5.6	-1.0
		2.25	0.3	2.83	2.21	67	-3	-6.2	-1.1
		3.25	0.1	3.87	3.02	66	-2	-3.0	-0.5
		4.00	0.0	4.61	3.59	66	-2	0.0	0.0
Sub-total			10.5			North to South		0	0
						South to North		-203.9	-36.1
90	6	0.50	2.0	0.67	0.52	78	-14	-5.3	-0.9
(E)		1.25	0.8	1.56	1.22	79	-15	-17.8	-3.1
		2.25	0.1	2.63	2.05	80	-16	-8.9	-1.6
		3.25	0.0	3.66	2.85	82	-18	0.0	0.0
		4.00	0.0	4.22	3.29	82	-18	0.0	0.0
	8	0.50	0.1	0.62	0.48	64	0	-0.0	-0.0
		1.25	0.2	1.43	1.12	69	-5	-1.3	-0.2
		2.25	0.1	2.39	1.87	71	-7	-3.0	-0.5
		3.25	0.0	3.28	2.56	68	-4	0.0	0.0
		4.00	0.0	3.89	3.04	68	-4	0.0	0.0
	10	0.50	0.0	0.69	0.54	60	4	0.0	0.0
		1.25	0.0	1.63	1.27	63	1	0.0	0.0
		2.25	0.0	2.74	2.13	66	-2	0.0	0.0
		3.25	0.0	3.71	2.89	68	-4	0.0	0.0
		4.00	0.0	4.44	3.46	65	-1	0.0	0.0
Sub-total			3.3			North to South		0	0
						South to North		-36.3	-6.4
120	6	0.50	2.0	0.56	0.44	81	-17	-4.0	-0.7
(ESE)		1.25	0.7	1.34	1.04	84	-20	-14.0	-2.5
		2.25	0.0	2.21	1.72	87	-23	0.0	0.0
		3.25	0.0	2.90	2.26	88	-24	0.0	0.0
		4.00	0.0	3.65	2.85	88	-24	0.0	0.0
	8	0.50	0.0	0.59	0.46	78	-14	0.0	0.0
		1.25	0.1	1.39	1.08	80	-16	-1.8	-0.3
		2.25	0.0	2.25	1.76	82	-18	0.0	0.0
		3.25	0.0	2.91	2.27	84	-20	0.0	0.0
		4.00	0.0	4.22	3.29	83	-19	0.0	0.0
	10	0.50	0.0	0.80	0.62	71	-7	0.0	0.0
		1.25	0.0	1.61	1.25	78	-14	0.0	0.0
		2.25	0.0	2.53	1.97	80	-16	0.0	0.0
		3.25	0.0	3.94	3.08	81	-17	0.0	0.0
		4.00	0.0	4.55	3.55	83	-19	0.0	0.0
Sub-total			2.8			North to South		0.0	0.0
						South to North		-19.9	-3.5
Grand-total			48.6			North to South		408.9	72.4
						South to North		-270.6	-47.9

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(1/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (KUANTAN)

Shoreline Orientation = 52 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
30 (NNE)	6	0.50	5.5	0.28	0.22	115	27	2.8	0.5
		1.25	7.2	0.71	0.55	110	32	40.1	7.1
		2.25	1.4	1.27	0.99	105	37	36.9	6.5
		3.25	0.3	1.84	1.44	99	43	20.6	3.6
		4.00	0.1	2.53	1.98	89	53	14.7	2.6
	8	0.50	0.3	0.38	0.30	105	37	0.4	0.1
		1.25	3.1	0.95	0.74	103	39	40.3	7.1
		2.25	2.0	1.58	1.23	100	42	92.9	16.4
		3.25	0.5	2.25	1.76	96	46	56.7	10.0
		4.00	0.2	2.84	2.22	89	53	39.0	6.9
	10	0.50	0.2	0.53	0.41	104	38	0.6	0.1
		1.25	1.3	1.27	0.99	102	40	34.8	6.2
		2.25	1.2	2.24	1.75	97	45	134.6	23.8
		3.25	0.5	3.49	2.72	83	59	150.9	26.7
		4.00	0.3	4.36	3.40	78	64	138.9	24.6
Sub-total			24.1			North to South		804.3	142.4
						South to North		0.0	0.0
60 (ENE)	6	0.50	3.7	0.40	0.31	105	37	5.3	0.9
		1.25	3.1	1.00	0.78	103	39	44.9	7.9
		2.25	0.4	1.78	1.39	101	41	25.0	4.4
		3.25	0.1	2.60	2.03	93	49	16.1	2.9
		4.00	0.0	3.25	2.54	87	55	0.0	0.0
	8	0.50	0.3	0.66	0.51	84	58	1.4	0.3
		1.25	1.3	1.37	1.07	91	51	41.9	7.4
		2.25	0.5	2.16	1.69	97	45	51.5	9.1
		3.25	0.1	3.15	2.45	96	46	26.2	4.6
		4.00	0.0	4.03	3.15	91	51	0.0	0.0
	10	0.50	0.1	0.32	0.25	76	66	0.1	0.0
		1.25	0.5	0.79	0.62	82	60	3.6	0.6
		2.25	0.3	1.57	1.23	93	49	13.8	2.4
		3.25	0.1	2.36	1.84	98	44	12.8	2.3
		4.00	0.0	2.90	2.26	97	45	0.0	0.0
Sub-total			10.5			North to South		242.5	42.9
						South to North		0.0	0.0
90 (E)	6	0.50	2.0	0.39	0.30	88	54	2.6	0.5
		1.25	0.8	0.96	0.75	93	49	10.8	1.9
		2.25	0.1	2.14	1.67	101	41	9.9	1.8
		3.25	0.0	3.02	2.36	99	43	0.0	0.0
		4.00	0.0	3.75	2.92	95	47	0.0	0.0
	8	0.50	0.1	0.82	0.64	113	29	0.8	0.1
		1.25	0.2	1.72	1.34	109	33	10.6	1.9
		2.25	0.1	2.75	2.15	98	44	18.8	3.3
		3.25	0.0	3.72	2.90	94	48	0.0	0.0
		4.00	0.0	4.42	3.45	91	51	0.0	0.0
	10	0.50	0.0	0.66	0.51	111	31	0.0	0.0
		1.25	0.0	1.53	1.19	102	40	0.0	0.0
		2.25	0.0	2.68	2.09	94	48	0.0	0.0
		3.25	0.0	3.73	2.91	89	53	0.0	0.0
		4.00	0.0	4.45	3.47	85	57	0.0	0.0
Sub-total			3.3			North to South		53.5	9.5
						South to North		0.0	0.0
120 (ESE)	6	0.50	2.0	0.54	0.43	103	39	6.4	1.1
		1.25	0.7	1.30	1.01	113	29	17.1	3.0
		2.25	0.0	2.21	1.72	123	19	0.0	0.0
		3.25	0.0	3.11	2.42	124	18	0.0	0.0
		4.00	0.0	3.72	2.90	124	18	0.0	0.0
	8	0.50	0.0	0.41	0.32	101	41	0.0	0.0
		1.25	0.1	1.03	0.80	109	33	1.5	0.3
		2.25	0.0	1.71	1.33	119	23	0.0	0.0
		3.25	0.0	2.40	1.87	123	19	0.0	0.0
		4.00	0.0	2.93	2.28	125	17	0.0	0.0
	10	0.50	0.0	0.43	0.34	98	44	0.0	0.0
		1.25	0.0	1.06	0.83	104	38	0.0	0.0
		2.25	0.0	1.74	1.36	111	31	0.0	0.0
		3.25	0.0	2.43	1.90	111	31	0.0	0.0
		4.00	0.0	2.95	2.30	108	34	0.0	0.0
Sub-total			2.8			North to South		25.0	4.4
						South to North		0.0	0.0
150 (SSE)	6	0.50	3.8	0.35	0.27	105	37	3.9	0.7
		1.25	2.2	0.87	0.68	111	31	20.5	3.6
		2.25	0.1	1.49	1.16	118	24	3.0	0.5
		3.25	0.0	2.12	1.66	124	18	0.0	0.0
		4.00	0.0	2.68	2.09	124	18	0.0	0.0
	8	0.50	0.1	0.34	0.27	101	41	0.1	0.0
		1.25	0.5	0.85	0.67	109	33	4.6	0.8
		2.25	0.0	1.43	1.12	118	24	0.0	0.0
		3.25	0.0	1.98	1.55	126	16	0.0	0.0
		4.00	0.0	2.39	1.86	125	17	0.0	0.0
	10	0.50	0.0	0.38	0.30	121	21	0.0	0.0
		1.25	0.1	0.96	0.75	121	21	0.9	0.2
		2.25	0.0	1.55	1.21	121	21	0.0	0.0
		3.25	0.0	2.13	1.66	121	21	0.0	0.0
		4.00	0.0	2.55	1.99	122	20	0.0	0.0
Sub-total			6.8			North to South		33.0	5.8
						South to North		0.0	0.0
Grand-total			47.5			North to South		1,158.2	205.0
						South to North		0.0	0.0

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(2/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (KERTEH)

Shoreline Orientation = 37 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
30 (NNE)	6	0.50	5.5	0.30	0.23	114	13	1.8	0.3
		1.25	7.2	0.75	0.59	105	22	37.0	6.5
		2.25	1.4	1.35	1.05	93	34	41.2	7.3
		3.25	0.3	1.95	1.52	81	46	23.8	4.2
		4.00	0.1	2.64	2.06	74	53	16.3	2.9
	8	0.50	0.3	0.32	0.25	131	-4	-0.0	-0.0
		1.25	3.1	0.80	0.62	120	7	6.8	1.2
		2.25	2.0	1.55	1.21	101	26	70.5	12.5
		3.25	0.5	2.45	1.91	85	42	69.8	12.4
		4.00	0.2	3.25	2.54	78	49	56.4	10.0
	10	0.50	0.2	0.37	0.29	114	13	0.1	0.0
		1.25	1.3	0.93	0.72	107	20	10.5	1.9
		2.25	1.2	1.65	1.28	98	29	53.5	9.5
		3.25	0.5	2.47	1.92	90	37	68.4	12.1
		4.00	0.3	3.15	2.45	87	40	77.6	13.7
Sub-total			24.1			North to South		533.8	94.5
						South to North		-0.0	-0.0
60 (ENE)	6	0.50	3.7	0.39	0.30	107	20	3.4	0.6
		1.25	3.1	0.97	0.76	100	27	35.0	6.2
		2.25	0.4	2.16	1.69	86	41	40.6	7.2
		3.25	0.1	3.34	2.60	78	49	30.2	5.3
		4.00	0.0	4.22	3.29	69	58	0.0	0.0
	8	0.50	0.3	0.67	0.53	97	30	1.5	0.3
		1.25	1.3	1.52	1.18	94	33	50.3	8.9
		2.25	0.5	2.57	2.00	89	38	76.9	13.6
		3.25	0.1	3.62	2.83	83	44	37.3	6.6
		4.00	0.0	4.40	3.43	80	47	0.0	0.0
	10	0.50	0.1	1.08	0.84	115	12	0.7	0.1
		1.25	0.5	2.42	1.89	95	32	60.7	10.7
		2.25	0.3	3.76	2.94	89	38	119.5	21.2
		3.25	0.1	4.90	3.82	87	40	77.9	13.8
		4.00	0.0	5.72	4.46	87	40	0.0	0.0
Sub-total			10.5			North to South		534.0	94.5
						South to North		0.0	0.0
90 (E)	6	0.50	2.0	0.60	0.47	120	7	2.0	0.4
		1.25	0.8	1.47	1.14	110	17	17.6	3.1
		2.25	0.1	2.57	2.00	100	27	12.9	2.3
		3.25	0.0	3.70	2.89	95	32	0.0	0.0
		4.00	0.0	4.58	3.57	94	33	0.0	0.0
	8	0.50	0.1	0.61	0.47	121	6	0.1	0.0
		1.25	0.2	1.49	1.16	110	17	4.5	0.8
		2.25	0.1	2.62	2.04	100	27	13.5	2.4
		3.25	0.0	3.77	2.94	94	33	0.0	0.0
		4.00	0.0	4.65	3.63	94	33	0.0	0.0
	10	0.50	0.0	0.64	0.50	120	7	0.0	0.0
		1.25	0.0	1.57	1.22	111	16	0.0	0.0
		2.25	0.0	2.74	2.14	100	27	0.0	0.0
		3.25	0.0	3.92	3.06	93	34	0.0	0.0
		4.00	0.0	4.83	3.77	94	33	0.0	0.0
Sub-total			3.3			North to South		50.6	9.0
						South to North		0.0	0.0
120 (ESE)	6	0.50	2.0	0.83	0.65	132	-5	-3.5	-0.6
		1.25	0.7	1.82	1.42	121	6	9.7	1.7
		2.25	0.0	2.94	2.29	119	8	0.0	0.0
		3.25	0.0	3.95	3.08	120	7	0.0	0.0
		4.00	0.0	4.73	3.69	119	8	0.0	0.0
	8	0.50	0.0	0.98	0.77	117	10	0.0	0.0
		1.25	0.1	1.97	1.54	118	9	2.5	0.4
		2.25	0.0	3.07	2.40	117	10	0.0	0.0
		3.25	0.0	4.07	3.17	115	12	0.0	0.0
		4.00	0.0	4.82	3.76	113	14	0.0	0.0
	10	0.50	0.0	1.20	0.94	118	9	0.0	0.0
		1.25	0.0	2.45	1.91	112	15	0.0	0.0
		2.25	0.0	3.80	2.97	110	17	0.0	0.0
		3.25	0.0	5.06	3.95	109	18	0.0	0.0
		4.00	0.0	6.01	4.69	108	19	0.0	0.0
Sub-total			2.8			North to South		12.3	2.2
						South to North		-3.5	-0.6
150 (SSE)	6	0.50	3.8	0.62	0.49	129	-2	-1.1	-0.2
		1.25	2.2	1.45	1.13	129	-2	-4.8	-0.9
		2.25	0.1	2.43	1.89	129	-2	-0.7	-0.1
		3.25	0.0	3.35	2.62	128	-1	0.0	0.0
		4.00	0.0	4.06	3.16	128	-1	0.0	0.0
	8	0.50	0.1	0.80	0.62	123	4	0.1	0.0
		1.25	0.5	1.80	1.41	121	6	7.3	1.3
		2.25	0.0	2.99	2.34	118	9	0.0	0.0
		3.25	0.0	4.13	3.22	123	4	0.0	0.0
		4.00	0.0	4.96	3.87	123	4	0.0	0.0
	10	0.50	0.0	0.78	0.61	132	-5	0.0	0.0
		1.25	0.1	1.75	1.37	112	15	3.0	0.5
		2.25	0.0	2.84	2.22	107	20	0.0	0.0
		3.25	0.0	3.83	2.99	113	14	0.0	0.0
		4.00	0.0	4.60	3.59	114	13	0.0	0.0
Sub-total			6.8			North to South		10.4	1.8
						South to North		-6.7	-1.2
Grand-total			47.5			North to South		1,141.1	202.0
						South to North		-10.1	-1.8

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(3/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (MARANG)

Shoreline Orientation = 325 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
0 (N)	6	0.50	1.0	0.58	0.45	33	22	2.6	0.5
		1.25	0.7	1.41	1.10	29	26	19.4	3.4
		2.25	0.1	2.43	1.89	25	30	11.8	2.1
		3.25	0.0	3.37	2.63	24	31	0.0	0.0
		4.00	0.0	4.05	3.16	24	31	0.0	0.0
	8	0.50	0.0	0.76	0.59	42	13	0.0	0.0
		1.25	0.2	1.55	1.21	41	14	4.2	0.7
		2.25	0.1	2.57	2.01	38	17	9.0	1.6
		3.25	0.0	3.61	2.82	34	21	0.0	0.0
		4.00	0.0	4.36	3.40	33	22	0.0	0.0
	10	0.50	0.0	0.49	0.38	46	9	0.0	0.0
		1.25	0.0	1.19	0.93	44	11	0.0	0.0
		2.25	0.0	3.03	2.36	35	20	0.0	0.0
		3.25	0.0	4.10	3.20	35	20	0.0	0.0
		4.00	0.0	4.87	3.80	35	20	0.0	0.0
Sub-total			2.1			North to South		47.2	8.3
						South to North		0.0	0.0
30 (NNE)	6	0.50	2.4	0.71	0.55	33	22	10.5	1.9
		1.25	4.1	1.61	1.25	32	23	144.0	25.5
		2.25	1.1	2.82	2.20	32	23	159.4	28.2
		3.25	0.2	3.95	3.08	33	22	64.0	11.3
		4.00	0.0	5.05	3.94	33	22	0.0	0.0
	8	0.50	0.2	0.93	0.73	40	15	1.3	0.2
		1.25	1.9	2.04	1.59	43	12	70.3	12.5
		2.25	2.0	3.31	2.58	45	10	208.0	36.8
		3.25	0.6	4.50	3.51	40	15	195.1	34.5
		4.00	0.1	5.36	4.18	35	20	62.7	11.1
	10	0.50	0.0	1.11	0.87	47	8	0.0	0.0
		1.25	0.9	2.28	1.78	42	13	44.8	7.9
		2.25	1.0	3.70	2.89	38	17	218.9	38.7
		3.25	0.6	4.98	3.89	39	16	261.7	46.3
		4.00	0.2	5.93	4.62	40	15	131.2	23.2
Sub-total			15.3			North to South		1,571.9	278.2
						South to North		0.0	0.0
60 (ENE)	6	0.50	3.7	0.73	0.57	55	0	0.2	0.0
		1.25	5.9	1.68	1.31	67	-12	-132.3	-23.4
		2.25	1.0	2.87	2.24	68	-13	-92.7	-16.4
		3.25	0.1	4.00	3.12	64	-9	-15.2	-2.7
		4.00	0.0	4.84	3.77	62	-7	0.0	0.0
	8	0.50	0.2	0.90	0.70	52	3	0.3	0.0
		1.25	3.2	1.93	1.50	63	-8	-67.0	-11.9
		2.25	1.9	3.19	2.48	68	-13	-221.4	-39.2
		3.25	0.3	4.34	3.39	64	-9	-53.0	-9.4
		4.00	0.1	5.15	4.02	61	-6	-19.0	-3.4
	10	0.50	0.1	1.03	0.80	56	-1	-0.0	-0.0
		1.25	1.3	2.17	1.69	57	-2	-9.8	-1.7
		2.25	0.9	3.53	2.75	60	-5	-58.1	-10.3
		3.25	0.5	4.75	3.71	61	-6	-72.1	-12.8
		4.00	0.1	5.62	4.39	61	-6	-23.7	-4.2
Sub-total			19.3			North to South		0.5	0.1
						South to North		-764.3	-135.3
90 (E)	6	0.50	3.4	0.77	0.60	73	-18	-15.8	-2.8
		1.25	2.6	1.70	1.33	81	-26	-114.8	-20.3
		2.25	0.2	2.82	2.20	79	-24	-29.8	-5.3
		3.25	0.0	3.88	3.03	79	-24	0.0	0.0
		4.00	0.0	4.68	3.65	80	-25	0.0	0.0
	8	0.50	0.0	0.76	0.60	66	-11	0.0	0.0
		1.25	0.9	1.68	1.31	71	-16	-26.3	-4.7
		2.25	0.4	2.80	2.18	70	-15	-39.6	-7.0
		3.25	0.1	3.81	2.97	69	-14	-20.2	-3.6
		4.00	0.0	4.56	3.56	70	-15	0.0	0.0
	10	0.50	0.0	0.88	0.69	63	-8	0.0	0.0
		1.25	0.2	1.93	1.50	65	-10	-5.4	-1.0
		2.25	0.2	3.16	2.46	68	-13	-24.0	-4.2
		3.25	0.0	4.30	3.35	70	-15	0.0	0.0
		4.00	0.0	5.16	4.03	70	-15	0.0	0.0
Sub-total			8.0			North to South		0.0	0.0
						South to North		-275.8	-48.8
120 (ESE)	6	0.50	2.1	0.70	0.55	62	-7	-3.0	-0.5
		1.25	1.1	1.66	1.30	81	-26	-46.1	-8.2
		2.25	0.0	2.88	2.24	89	-34	0.0	0.0
		3.25	0.0	3.93	3.07	92	-37	0.0	0.0
		4.00	0.0	4.72	3.68	95	-40	0.0	0.0
	8	0.50	0.1	0.58	0.45	62	-7	-0.1	-0.0
		1.25	0.2	1.40	1.09	75	-20	-4.4	-0.8
		2.25	0.0	2.47	1.92	84	-29	0.0	0.0
		3.25	0.0	3.49	2.72	84	-29	0.0	0.0
		4.00	0.0	4.18	3.26	84	-29	0.0	0.0
	10	0.50	0.0	0.77	0.60	72	-17	0.0	0.0
		1.25	0.0	1.70	1.33	80	-25	0.0	0.0
		2.25	0.0	2.84	2.22	82	-27	0.0	0.0
		3.25	0.0	3.86	3.01	82	-27	0.0	0.0
		4.00	0.0	4.61	3.60	84	-29	0.0	0.0
Sub-total			3.5			North to South		0.0	0.0
						South to North		-53.5	-9.5
Grand-total			48.2			North to South		1,619.6	286.7
						South to North		-1,093.6	-193.6

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(4/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (TERENGGANU)

Shoreline Orientation = 325 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
0 (N)	6	0.50	1.0	0.66	0.52	34	21	3.6	0.6
		1.25	0.7	1.53	1.20	26	29	25.7	4.5
		2.25	0.1	2.59	2.02	20	35	15.2	2.7
		3.25	0.0	3.57	2.78	18	37	0.0	0.0
		4.00	0.0	4.28	3.34	18	37	0.0	0.0
	8	0.50	0.0	0.79	0.62	41	14	0.0	0.0
		1.25	0.2	1.72	1.34	37	18	6.9	1.2
		2.25	0.1	2.77	2.16	35	20	12.4	2.2
		3.25	0.0	3.72	2.90	34	21	0.0	0.0
		4.00	0.0	4.42	3.45	32	23	0.0	0.0
	10	0.50	0.0	0.94	0.73	46	9	0.0	0.0
		1.25	0.0	2.04	1.59	43	12	0.0	0.0
		2.25	0.0	3.36	2.62	41	14	0.0	0.0
		3.25	0.0	4.57	3.56	38	17	0.0	0.0
		4.00	0.0	5.48	4.28	35	20	0.0	0.0
Sub-total			2.1			North to South		63.8	11.3
						South to North		0.0	0.0
30 (NNE)	6	0.50	2.4	0.84	0.66	53	2	1.2	0.2
		1.25	4.1	1.84	1.43	44	11	106.9	18.9
		2.25	1.1	3.01	2.34	44	11	97.5	17.3
		3.25	0.2	4.12	3.21	43	12	42.7	7.6
		4.00	0.0	5.02	3.92	47	8	0.0	0.0
	8	0.50	0.2	0.91	0.71	64	-9	-0.7	-0.1
		1.25	1.9	1.97	1.54	41	14	70.5	12.5
		2.25	2.0	3.18	2.48	39	16	292.4	51.7
		3.25	0.6	4.31	3.37	36	19	210.4	37.2
		4.00	0.1	5.16	4.03	38	17	50.1	8.9
	10	0.50	0.0	1.17	0.91	42	13	0.0	0.0
		1.25	0.9	2.37	1.85	40	15	56.9	10.1
		2.25	1.0	3.78	2.95	47	8	119.1	21.1
		3.25	0.6	5.08	3.96	47	8	146.2	25.9
		4.00	0.2	6.04	4.71	47	8	77.6	13.7
Sub-total			15.3			North to South		1,271.4	225.0
						South to North		-0.7	-0.1
60 (ENE)	6	0.50	3.7	0.77	0.60	88	-33	-26.0	-4.6
		1.25	5.9	1.73	1.35	68	-13	-154.6	-27.4
		2.25	1.0	2.89	2.26	59	-4	-30.8	-5.4
		3.25	0.1	4.00	3.12	58	-3	-4.2	-0.7
		4.00	0.0	4.81	3.75	58	-3	0.0	0.0
	8	0.50	0.2	0.88	0.69	87	-32	-1.9	-0.3
		1.25	3.2	1.92	1.50	67	-12	-100.0	-17.7
		2.25	1.9	3.18	2.48	60	-5	-93.7	-16.6
		3.25	0.3	4.35	3.39	58	-3	-15.9	-2.8
		4.00	0.1	5.19	4.05	58	-3	-8.3	-1.5
	10	0.50	0.1	1.00	0.78	85	-30	-1.3	-0.2
		1.25	1.3	2.12	1.65	66	-11	-45.9	-8.1
		2.25	0.9	3.48	2.72	60	-5	-48.2	-8.5
		3.25	0.5	4.73	3.69	58	-3	-35.3	-6.2
		4.00	0.1	5.65	4.40	58	-3	-10.1	-1.8
Sub-total			19.3			North to South		0.0	0.0
						South to North		-576.4	-102.0
90 (E)	6	0.50	3.4	0.85	0.66	80	-25	-25.7	-4.5
		1.25	2.6	1.85	1.44	77	-22	-127.2	-22.5
		2.25	0.2	3.08	2.40	81	-26	-39.1	-6.9
		3.25	0.0	4.21	3.29	83	-28	0.0	0.0
		4.00	0.0	5.08	3.96	83	-28	0.0	0.0
	8	0.50	0.0	1.08	0.85	71	-16	0.0	0.0
		1.25	0.9	2.25	1.75	76	-21	-68.8	-12.2
		2.25	0.4	3.53	2.76	79	-24	-105.2	-18.6
		3.25	0.1	4.81	3.75	79	-24	-56.1	-9.9
		4.00	0.0	5.73	4.47	79	-24	0.0	0.0
	10	0.50	0.0	1.02	0.80	63	-8	0.0	0.0
		1.25	0.2	2.16	1.68	70	-15	-10.3	-1.8
		2.25	0.2	3.51	2.74	73	-18	-41.4	-7.3
		3.25	0.0	4.75	3.71	76	-21	0.0	0.0
		4.00	0.0	5.68	4.43	78	-23	0.0	0.0
Sub-total			8.0			North to South		0.0	0.0
						South to North		-473.7	-83.8
120 (ESE)	6	0.50	2.1	0.77	0.60	42	13	7.1	1.2
		1.25	1.1	1.69	1.32	64	-9	-18.2	-3.2
		2.25	0.0	2.69	2.10	75	-20	0.0	0.0
		3.25	0.0	3.66	2.86	84	-29	0.0	0.0
		4.00	0.0	4.44	3.46	90	-35	0.0	0.0
	8	0.50	0.1	0.81	0.63	79	-24	-0.7	-0.1
		1.25	0.2	1.78	1.39	81	-26	-9.9	-1.8
		2.25	0.0	2.95	2.30	86	-31	0.0	0.0
		3.25	0.0	4.01	3.13	89	-34	0.0	0.0
		4.00	0.0	4.81	3.75	90	-35	0.0	0.0
	10	0.50	0.0	0.90	0.70	74	-19	0.0	0.0
		1.25	0.0	1.96	1.53	83	-28	0.0	0.0
		2.25	0.0	3.34	2.61	84	-29	0.0	0.0
		3.25	0.0	4.56	3.56	85	-30	0.0	0.0
		4.00	0.0	5.44	4.25	86	-31	0.0	0.0
Sub-total			3.5			North to South		7.1	1.2
						South to North		-28.8	-5.1
Grand-total			48.2			North to South		1,342.2	237.6
						South to North		-1,079.6	-191.1

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(5/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (OYA)

Shoreline Orientation = 272 N

Ocean Wave Characteristics Direction N	Period (sec)	Height (m)	Percent (%)	Breaking Wave Characteristics Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	Longshore Energy Flux Factor (J/m/s)	Longshore Transport Rate (1000m3/yr)
300 (WNW)	6	0.50	1.5	0.68	0.53	354	8	2.4	0.4
		1.25	1.1	1.57	1.23	342	20	33.3	5.9
		2.25	0.2	2.69	2.10	332	30	30.8	5.5
		3.25	0.0	3.78	2.95	325	37	0.0	0.0
		4.00	0.0	4.58	3.57	322	40	0.0	0.0
	8	0.50	0.2	0.97	0.76	346	16	1.5	0.3
		1.25	0.5	2.07	1.61	340	22	32.4	5.7
		2.25	0.2	3.40	2.65	335	27	52.0	9.2
		3.25	0.0	4.64	3.62	330	32	0.0	0.0
		4.00	0.0	5.52	4.30	326	36	0.0	0.0
	10	0.50	0.0	1.10	0.86	328	34	0.0	0.0
		1.25	0.1	2.23	1.74	337	25	8.4	1.5
		2.25	0.1	3.61	2.82	336	26	29.5	5.2
		3.25	0.2	4.97	3.88	335	27	134.1	23.7
		4.00	0.0	6.00	4.68	334	28	0.0	0.0
	Sub-total		4.1			West to East		324.4	57.4
						East to West		0.0	0.0
330 (NNW)	6	0.50	1.4	0.72	0.56	10	-8	-2.5	-0.4
		1.25	1.2	1.64	1.28	0	2	3.5	0.6
		2.25	0.2	2.82	2.20	348	14	18.9	3.4
		3.25	0.0	3.91	3.05	342	20	0.0	0.0
		4.00	0.0	4.92	3.84	325	37	0.0	0.0
	8	0.50	0.1	0.93	0.73	2	0	-0.0	-0.0
		1.25	0.9	2.00	1.56	354	8	20.1	3.6
		2.25	0.4	3.27	2.55	347	15	58.1	10.3
		3.25	0.1	4.49	3.50	342	20	41.5	7.3
		4.00	0.0	5.34	4.16	340	22	0.0	0.0
	10	0.50	0.0	0.99	0.77	5	-3	0.0	0.0
		1.25	0.3	2.12	1.66	357	5	5.0	0.9
		2.25	0.4	3.60	2.81	344	18	85.9	15.2
		3.25	0.1	4.89	3.81	340	22	55.0	9.7
		4.00	0.1	5.81	4.53	338	24	91.1	16.1
	Sub-total		5.2			West to East		379.1	67.1
						East to West		-2.5	-0.4
0 (N)	6	0.50	2.1	0.81	0.63	6	-4	-2.6	-0.5
		1.25	2.4	1.78	1.39	1	1	6.8	1.2
		2.25	0.7	2.95	2.30	360	2	12.3	2.2
		3.25	0.2	4.08	3.18	359	3	9.0	1.6
		4.00	0.0	4.92	3.84	358	4	0.0	0.0
	8	0.50	0.2	0.95	0.74	5	-3	-0.3	-0.0
		1.25	2.4	2.03	1.58	7	-5	-36.5	-6.5
		2.25	1.4	3.36	2.62	359	3	40.5	7.2
		3.25	0.3	4.60	3.59	358	4	28.9	5.1
		4.00	0.1	5.51	4.30	356	6	20.4	3.6
	10	0.50	0.1	1.05	0.82	5	-3	-0.2	-0.0
		1.25	0.9	2.23	1.74	5	-3	-11.7	-2.1
		2.25	1.2	3.67	2.86	359	3	46.7	8.3
		3.25	0.7	5.00	3.90	357	5	95.7	16.9
		4.00	0.3	6.00	4.68	356	6	86.1	15.2
	Sub-total		13.0			West to East		346.4	61.3
						East to West		-51.2	-9.1
30 (NNE)	6	0.50	4.6	0.79	0.61	0	2	2.0	0.4
		1.25	5.5	1.75	1.36	13	-11	-126.8	-22.4
		2.25	1.2	2.87	2.24	19	-17	-139.0	-24.6
		3.25	0.1	3.93	3.07	20	-18	-27.3	-4.8
		4.00	0.1	4.71	3.68	21	-19	-44.1	-7.8
	8	0.50	0.3	0.85	0.66	6	-4	-0.4	-0.1
		1.25	3.1	1.84	1.44	6	-4	-27.5	-4.9
		2.25	2.0	3.03	2.36	10	-8	-128.1	-22.7
		3.25	0.6	4.13	3.22	11	-9	-96.5	-17.1
		4.00	0.1	4.94	3.85	11	-9	-26.1	-4.6
	10	0.50	0.2	1.00	0.78	5	-3	-0.3	-0.0
		1.25	1.2	2.12	1.65	6	-4	-15.0	-2.7
		2.25	1.2	3.41	2.66	7	-5	-62.2	-11.0
		3.25	0.5	4.63	3.61	7	-5	-61.1	-10.8
		4.00	0.3	5.53	4.31	7	-5	-58.8	-10.4
	Sub-total		21.0			West to East		2.0	0.4
						East to West		-813.1	-143.9
60 (ENE)	6	0.50	3.8	0.61	0.48	40	-38	-16.0	-2.8
		1.25	3.1	1.38	1.08	35	-33	-93.9	-16.6
		2.25	0.5	2.27	1.77	30	-28	-48.1	-8.5
		3.25	0.1	3.21	2.50	31	-29	-23.4	-4.1
		4.00	0.0	4.00	3.12	34	-32	0.0	0.0
	8	0.50	0.2	0.90	0.70	36	-34	-2.1	-0.4
		1.25	1.3	1.87	1.46	23	-21	-62.9	-11.1
		2.25	0.7	3.06	2.38	22	-20	-108.1	-19.1
		3.25	0.1	4.21	3.28	25	-23	-38.7	-6.9
		4.00	0.1	5.04	3.93	26	-24	-62.5	-11.1
	10	0.50	0.1	1.04	0.81	5	-3	-0.2	-0.0
		1.25	0.3	2.24	1.75	16	-14	-16.1	-2.9
		2.25	0.3	3.73	2.91	19	-17	-65.7	-11.6
		3.25	0.1	5.11	3.98	19	-17	-49.5	-8.8
		4.00	0.0	6.13	4.78	19	-17	0.0	0.0
	Sub-total		10.7			West to East		0.0	0.0
						East to West		-587.3	-103.9
Grand-total			54.0			West to East		1,051.8	186.2
						East to West		-1,454.1	-257.4

Note <1 : Angle between wave crest and shoreline

Table 1.3-11(6/6) BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION (PAPAR)

Shoreline Orientation = 220 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Period (sec)	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
300 (WNW)	6	0.50	1.1	0.82	0.64	308	2	0.8	0.1
		1.25	1.1	1.76	1.38	304	6	15.0	2.7
		2.25	0.1	2.88	2.24	301	9	6.7	1.2
		3.25	0.0	3.98	3.10	298	12	0.0	0.0
		4.00	0.0	4.80	3.74	296	14	0.0	0.0
	8	0.50	0.2	1.04	0.81	296	14	1.5	0.3
		1.25	0.6	2.21	1.72	295	15	33.0	5.8
		2.25	0.3	3.54	2.76	296	14	49.1	8.7
		3.25	0.0	4.69	3.66	298	12	0.0	0.0
		4.00	0.0	5.53	4.31	298	12	0.0	0.0
	10	0.50	0.0	1.09	0.85	290	20	0.0	0.0
		1.25	0.1	2.23	1.74	300	10	3.8	0.7
		2.25	0.1	3.60	2.81	300	10	12.6	2.2
		3.25	0.0	4.95	3.86	297	13	0.0	0.0
		4.00	0.0	5.95	4.64	294	16	0.0	0.0
Sub-total			3.6			West to East		122.6	21.7
						East to West		-0.0	0.0
330 (NNW)	6	0.50	1.1	0.79	0.62	331	-21	-6.2	-1.1
		1.25	0.9	1.75	1.37	333	-23	-39.2	-6.9
		2.25	0.1	2.89	2.26	334	-24	-15.6	-2.8
		3.25	0.1	3.98	3.11	329	-19	-29.6	-5.2
		4.00	0.0	4.86	3.79	334	-24	0.0	0.0
	8	0.50	0.1	0.82	0.64	349	-39	-0.9	-0.2
		1.25	0.5	1.84	1.44	339	-29	-29.2	-5.2
		2.25	0.4	3.04	2.37	330	-20	-62.6	-11.1
		3.25	0.1	4.09	3.19	326	-16	-27.4	-4.9
		4.00	0.0	4.90	3.82	325	-15	0.0	0.0
	10	0.50	0.0	0.80	0.62	358	-48	0.0	0.0
		1.25	0.2	2.10	1.64	339	-29	-16.0	-2.8
		2.25	0.3	3.44	2.69	330	-20	-64.2	-11.4
		3.25	0.1	4.68	3.65	324	-14	-34.0	-6.0
		4.00	0.0	5.59	4.36	322	-12	0.0	0.0
Sub-total			3.9			West to East		0.0	0.0
						East to West		-325.0	-57.5
0 (N)	6	0.50	1.8	0.70	0.55	355	-45	-11.0	-1.9
		1.25	0.8	1.58	1.23	358	-48	-37.5	-6.6
		2.25	0.0	2.60	2.03	357	-47	0.0	0.0
		3.25	0.0	3.55	2.77	353	-43	0.0	0.0
		4.00	0.0	4.27	3.33	350	-40	0.0	0.0
	8	0.50	0.1	0.90	0.70	357	-47	-1.1	-0.2
		1.25	0.2	1.88	1.47	356	-46	-14.5	-2.6
		2.25	0.0	3.02	2.36	351	-41	0.0	0.0
		3.25	0.1	4.14	3.23	348	-38	-50.3	-8.9
		4.00	0.0	4.98	3.89	346	-36	0.0	0.0
	10	0.50	0.0	0.99	0.77	357	-47	0.0	0.0
		1.25	0.4	2.10	1.64	354	-44	-38.3	-6.8
		2.25	0.0	3.41	2.66	350	-40	0.0	0.0
		3.25	0.0	4.70	3.67	347	-37	0.0	0.0
		4.00	0.0	5.67	4.42	345	-35	0.0	0.0
Sub-total			3.4			West to East		0.0	0.0
						East to West		-152.7	-27.0
Grand-total			10.9			West to East		122.6	21.7
						East to West		-477.7	-84.6

Note <1 : Angle between wave crest and shoreline

Table 1.4-1 NUMBER OF WAVES BY DIRECTION.PERIOD AND HEIGHT
FOR PERIOD FROM OCT.26 - NOV.23. 1992

Direction: D	Period: T (sec)	Wave Height 0.0<= <0.5	0.5<= <1.0	1.0<= <1.5	1.5<= <2.0	2.0<= <2.5	2.5<= <3.0	Total
345<= D <15	5<= T <7	0	4	1	0	0	0	5
(N)	7<= T <9	2	16	5	0	0	0	23
15<= D <45	5<= T <7	3	44	20	4	0	0	71
(NNE)	7<= T <9	14	29	35	10	15	1	104
	9<= T	0	8	1	0	0	0	9
45<= D <75	5<= T <7	3	12	17	0	0	0	32
(ENE)	7<= T <9	2	16	55	15	11	1	100
	9<= T	0	1	3	0	0	0	4
Total		24	130	137	29	26	2	348

Table 1.4-2 BREAKDOWN OF LONGSHORE TRANSPORT RATE CALCULATION USING LEO DATA (MARANG)

Shoreline Orientation = 330 N

Ocean Wave Characteristics				Breaking Wave Characteristics				Longshore Energy Flux Factor	Longshore Transport Rate
Direction N	Perio (sec	Height (m)	Percent (%)	Depth (m)	Height (m)	Direction N	Angle<1 (deg.)	(J/m/s)	(1000m3/yr)
0 (N)	6	0.75	1.15	0.87	0.68	32	28	280	4.1
		1.25	0.29	1.41	1.10	29	31	996	3.7
		1.75	0.00	1.94	1.52	26	34	2,317	0.0
		2.25	0.00	2.43	1.89	25	35	4,109	0.0
		2.75	0.00	2.91	2.27	24	36	6,527	0.0
	8	0.75	4.60	1.08	0.85	42	18	348	20.7
		1.25	1.44	1.55	1.21	41	19	883	16.4
		1.75	0.00	2.02	1.58	40	20	1,776	0.0
		2.25	0.00	2.57	2.01	38	22	3,566	0.0
		2.75	0.00	3.11	2.43	36	24	6,155	0.0
	10	0.75	0.00	0.74	0.58	45	15	111	0.0
		1.25	0.00	1.19	0.93	44	16	393	0.0
		1.75	0.00	1.61	1.25	43	17	873	0.0
		2.25	0.00	3.03	2.36	35	25	5,911	0.0
		2.75	0.00	3.57	2.78	35	25	8,883	0.0
Sub-total			7.48					North to South	45.0
								South to North	0.0
30 (NNE)	6	0.75	12.64	1.05	0.82	33	27	440	71.7
		1.25	5.75	1.61	1.25	32	28	1,294	96.0
		1.75	1.15	2.19	1.71	32	28	2,827	41.9
		2.25	0.00	2.82	2.20	32	28	5,325	0.0
		2.75	0.00	3.46	2.70	32	28	8,804	0.0
	8	0.75	8.33	1.31	1.02	41	19	585	62.9
		1.25	10.06	2.04	1.59	43	17	1,614	209.4
		1.75	2.87	2.68	2.09	45	15	2,841	105.2
		2.25	4.31	3.31	2.58	45	15	4,816	267.7
		2.75	0.29	3.92	3.06	43	17	8,304	31.1
	10	0.75	2.30	1.51	1.18	46	14	634	18.8
		1.25	0.29	2.28	1.78	42	18	2,157	8.1
		1.75	0.00	3.02	2.35	37	23	5,449	0.0
		2.25	0.00	3.70	2.89	38	22	8,698	0.0
		2.75	0.00	4.35	3.39	39	21	12,719	0.0
Sub-total			47.99					North to South	912.8
								South to North	0.0
60 (ENE)	6	0.75	3.45	1.08	0.84	59	1	14	0.6
		1.25	4.89	1.68	1.31	67	353	(430)	(27.1)
		1.75	0.00	2.28	1.77	70	350	(1,320)	0.0
		2.25	0.00	2.87	2.24	68	352	(1,875)	0.0
		2.75	0.00	3.44	2.69	66	354	(2,238)	0.0
	8	0.75	4.60	1.26	0.98	56	4	130	7.7
		1.25	15.80	1.93	1.50	63	357	(248)	(50.6)
		1.75	4.31	2.56	2.00	66	354	(1,104)	(61.4)
		2.25	3.16	3.19	2.48	68	352	(2,311)	(94.2)
		2.75	0.29	3.78	2.95	66	354	(2,608)	(9.8)
	10	0.75	0.29	1.42	1.10	56	4	158	0.6
		1.25	0.86	2.17	1.69	57	3	334	3.7
		1.75	0.00	2.86	2.23	60	0	44	0.0
		2.25	0.00	3.53	2.75	60	360	(124)	0.0
		2.75	0.00	4.17	3.25	60	360	(218)	0.0
Sub-total			37.65					North to South	12.6
								South to North	(243.1)
90 (E)	6	0.75	0.00	1.12	0.87	76	344	(335)	0.0
		1.25	0.00	1.70	1.33	81	339	(1,192)	0.0
		1.75	0.00	2.27	1.77	82	338	(2,546)	0.0
		2.25	0.00	2.82	2.20	79	341	(3,952)	0.0
		2.75	0.00	3.36	2.62	78	342	(5,904)	0.0
	8	0.75	0.00	1.11	0.86	68	352	(173)	0.0
		1.25	0.00	1.68	1.31	71	349	(665)	0.0
		1.75	0.00	2.24	1.75	72	348	(1,481)	0.0
		2.25	0.00	2.80	2.18	70	350	(2,176)	0.0
		2.75	0.00	3.32	2.59	69	351	(3,067)	0.0
	10	0.75	0.00	1.25	0.97	64	356	(101)	0.0
		1.25	0.00	1.93	1.50	65	355	(448)	0.0
		1.75	0.00	2.55	1.99	67	353	(1,200)	0.0
		2.25	0.00	3.16	2.46	68	352	(2,459)	0.0
		2.75	0.00	3.73	2.91	69	351	(4,034)	0.0
Sub-total			0.00					North to South	0.0
								South to North	0.0
120 (ESE)	6	0.75	0.00	1.05	0.82	69	351	(158)	0.0
		1.25	0.00	1.66	1.30	81	339	(1,134)	0.0
		1.75	0.00	2.27	1.77	88	332	(3,075)	0.0
		2.25	0.00	2.88	2.24	89	331	(5,628)	0.0
		2.75	0.00	3.41	2.66	90	330	(8,912)	0.0
	8	0.75	0.00	0.87	0.68	67	353	(78)	0.0
		1.25	0.00	1.40	1.09	75	345	(537)	0.0
		1.75	0.00	1.91	1.49	82	338	(1,679)	0.0
		2.25	0.00	2.47	1.92	84	336	(3,392)	0.0
		2.75	0.00	3.03	2.36	84	336	(5,745)	0.0
	10	0.75	0.00	1.12	0.87	75	345	(313)	0.0
		1.25	0.00	1.70	1.33	80	340	(1,155)	0.0
		1.75	0.00	2.28	1.78	82	338	(2,607)	0.0
		2.25	0.00	2.84	2.22	82	338	(4,427)	0.0
		2.75	0.00	3.36	2.62	82	338	(6,795)	0.0
Sub-total			0.00					North to South	0.0
								South to North	0.0
Grand-total			93.12					North to South	970.4
								South to North	(243.1)

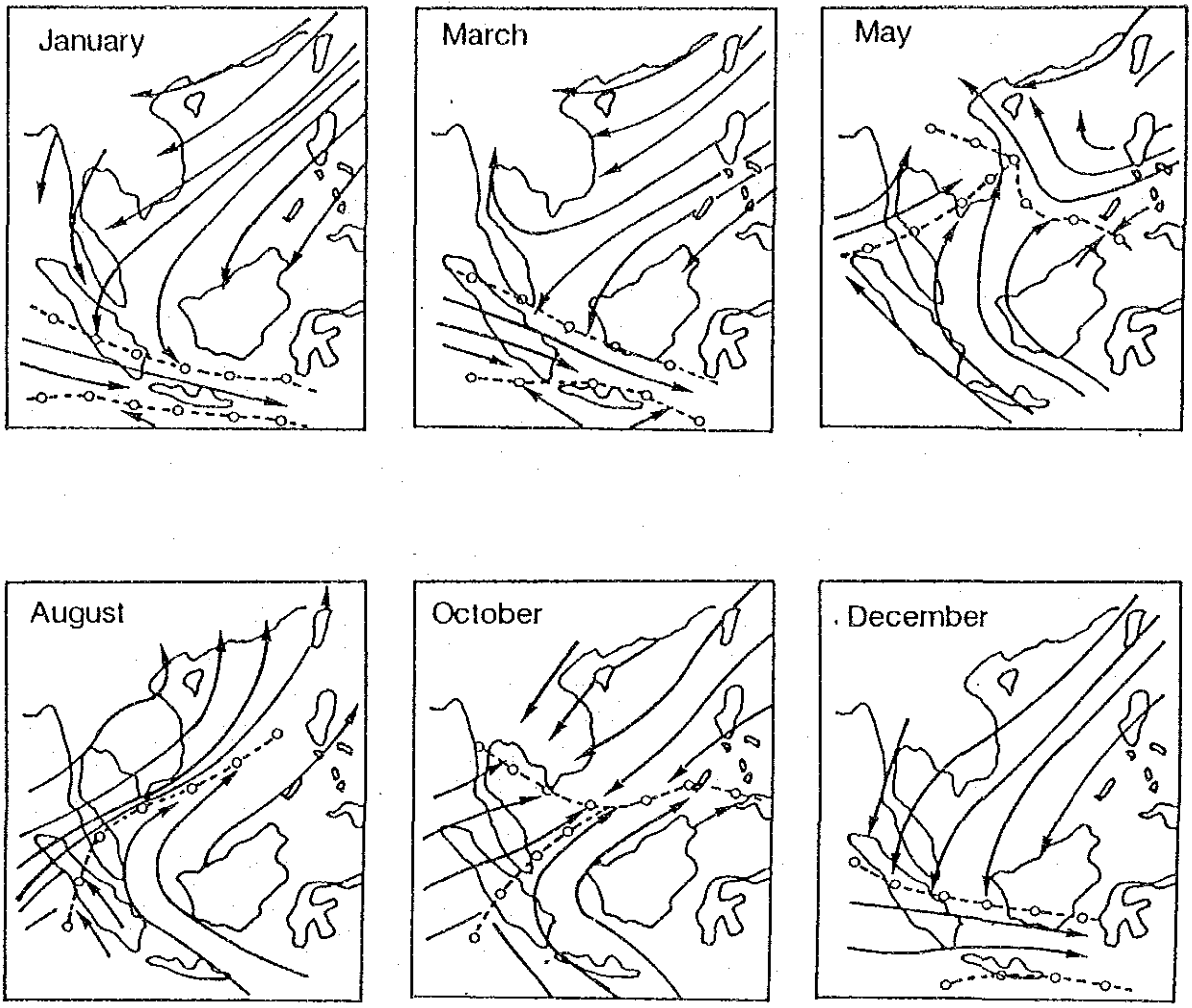
Note <1 : Angle between wave crest and shoreline

Table 1.4-3 ESTIMATION OF LONGSHORE ENERGY FLUX BY USING LEO DATA (PANTAI MARANG STATION)

No.	Date	Time	Wave Period T (sec)	Breaker Height Hsb (m)	Surf-zone Width W (m)	Current Speed VLEO (m/min)	Distance to Dye Patch X (m)	Current Direct-tion	Dimensionless Longshore Current (V/VO)LH	Longshore Energy Flux Factor Pls (J/m/s)
1	01-Apr-93	1830	8.9	0.2	9	3	7	-1	0.295	-3.9
2	04-Apr-93	1800	10.2	0.5	8	6	8	-1	0.200	-25.6
3	05-Apr-93	1800	11.2	0.5	10	7	8	-1	0.287	-26.0
4	07-Apr-93	1800	9.9	0.3	8	6	7	-1	0.258	-11.9
5	08-Apr-93	1800	11.6	0.5	8	7	8	-1	0.200	-29.8
6	09-Apr-93	1800	12.0	0.4	7	6	7	-1	0.200	-17.9
7	11-Apr-93	1800	11.8	0.1	9	4	7	-1	0.295	-2.6
8	13-Apr-93	1830	8.8	0.4	8	6	8	-1	0.200	-20.5
9	14-Apr-93	1800	9.8	0.3	9	5	8	-1	0.253	-11.4
10	15-Apr-88	1800	11.0	0.3	9	4	7	-1	0.295	-7.8
11	16-Apr-93	1830	9.0	0.3	8	9	7	-1	0.258	-17.8
12	17-Apr-93	1800	7.8	0.5	10	6	8	-1	0.287	-22.2
13	18-Apr-93	1830	9.4	0.3	9	5	8	-1	0.253	-11.4
14	20-Apr-93	1830	8.2	0.4	10	7	8	-1	0.287	-20.8
15	21-Apr-93	1830	8.8	0.4	10	7	8	-1	0.287	-20.8
16	22-Apr-93	1800	11.1	0.3	9	5	8	-1	0.253	-11.4
17	23-Apr-93	1800	7.8	0.5	9	6	8	-1	0.253	-22.8
18	24-Apr-93	1800	8.2	0.2	8	6	8	-1	0.200	-10.2
19	25-Apr-93	1830	11.3	0.3	8	5	7	-1	0.258	-9.9
20	26-Apr-93	1830	11.1	0.2	9	6	8	-1	0.253	-9.1
21	27-Apr-93	1800	9.4	0.4	7	5	7	-1	0.200	-14.9
22	28-Apr-93	1800	9.4	0.4	8	5	8	-1	0.200	-17.1
23	30-Apr-93	1800	10.2	0.2	9	6	8	-1	0.253	-9.1
24	09-May-93	1730	9.9	0.4	7	5	7	-1	0.200	-14.9
25	12-May-93	1730	7.9	0.5	8	2	8	-1	0.200	-8.5
26	16-May-93	1730	9.9	0.4	9	3	8	-1	0.253	-9.1
27	17-May-93	1730	9.8	0.3	9	2	9	-1	0.200	-5.8
28	19-May-93	1730	11.4	0.5	10	4	9	-1	0.248	-17.2
29	20-May-93	1730	9.8	0.6	9	3	8	-1	0.253	-13.7
30	21-May-93	1730	11.2	0.3	9	4	8	-1	0.253	-9.1
31	22-May-93	1730	9.6	0.5	8	5	7	-1	0.258	-16.5
32	23-May-93	1730	8.5	0.6	10	3	8	-1	0.287	-13.3
33	25-May-93	1730	9.1	0.4	10	2	8	-1	0.287	-5.9
34	26-May-93	1730	10.0	0.5	10	3	8	-1	0.287	-11.1
35	27-May-93	1730	8.1	0.6	8	4	6	-1	0.304	-13.5
36	28-May-93	1730	8.3	0.7	9	9	8	-1	0.253	-47.9
37	29-May-93	1730	11.5	0.4	11	5	8	-1	0.311	-15.1
38	30-Sep-88	1730	8.8	0.6	9	5	7	-1	0.295	-19.5
39	06-Jun-93	1027	7.1	0.2	8	4	6	-1	0.304	-4.5
40	07-Jun-93	1109	5.9	0.2	8	4	8	-1	0.200	-6.8
41	08-Jun-93	1147	6.2	0.3	10	5	9	-1	0.248	-12.9
42	09-Jun-93	1221	6.4	0.2	9	5	8	-1	0.253	-7.6
43	10-Jun-93	1252	6.4	0.2	10	4	8	-1	0.287	-5.9
44	13-Jun-93	1346	6.4	0.3	10	3	8	-1	0.287	-6.7
45	14-Jun-93	1403	6.0	0.3	9	5	7	-1	0.295	-9.8
46	15-Jun-93	706	6.9	0.2	9	5	9	-1	0.200	-9.6
47	21-Jun-93	1819	6.0	0.3	9	5	8	-1	0.253	-11.4
48	22-Jun-93	1054	6.8	0.2	9	5	8	-1	0.253	-7.6
49	23-Jun-93	1130	6.9	0.3	9	6	8	-1	0.253	-13.7
50	25-Jun-93	300	7.4	0.3	10	6	9	-1	0.248	-15.5
51	26-Jun-93	1302	5.7	0.3	11	6	9	-1	0.281	-15.0
52	28-Jun-93	1344	7.0	0.3	10	5	8	-1	0.287	-11.1
53	29-Jun-93	1355	5.8	0.3	10	6	9	-1	0.248	-15.5
54	08-Jul-93	1146	8.0	0.2	8	4	8	-1	0.200	-6.8
55	09-Jul-93	1206	6.8	0.4	9	6	9	-1	0.200	-23.0
56	20-Jul-93	957	5.1	0.4	9	8	9	-1	0.200	-30.7
57	21-Jul-93	1035	7.0	0.2	7	6	7	-1	0.200	-9.0
58	08-Oct-93	815	6.6	0.5	10	8	10	-1	0.200	-42.6
	Average		8.6	0.4	8.9	5.1	7.9		0.250	-14.5

Current Direction 1 : Observer's left to right
0 : No longshore movement
-1 : Observer's right to left

FIGURES

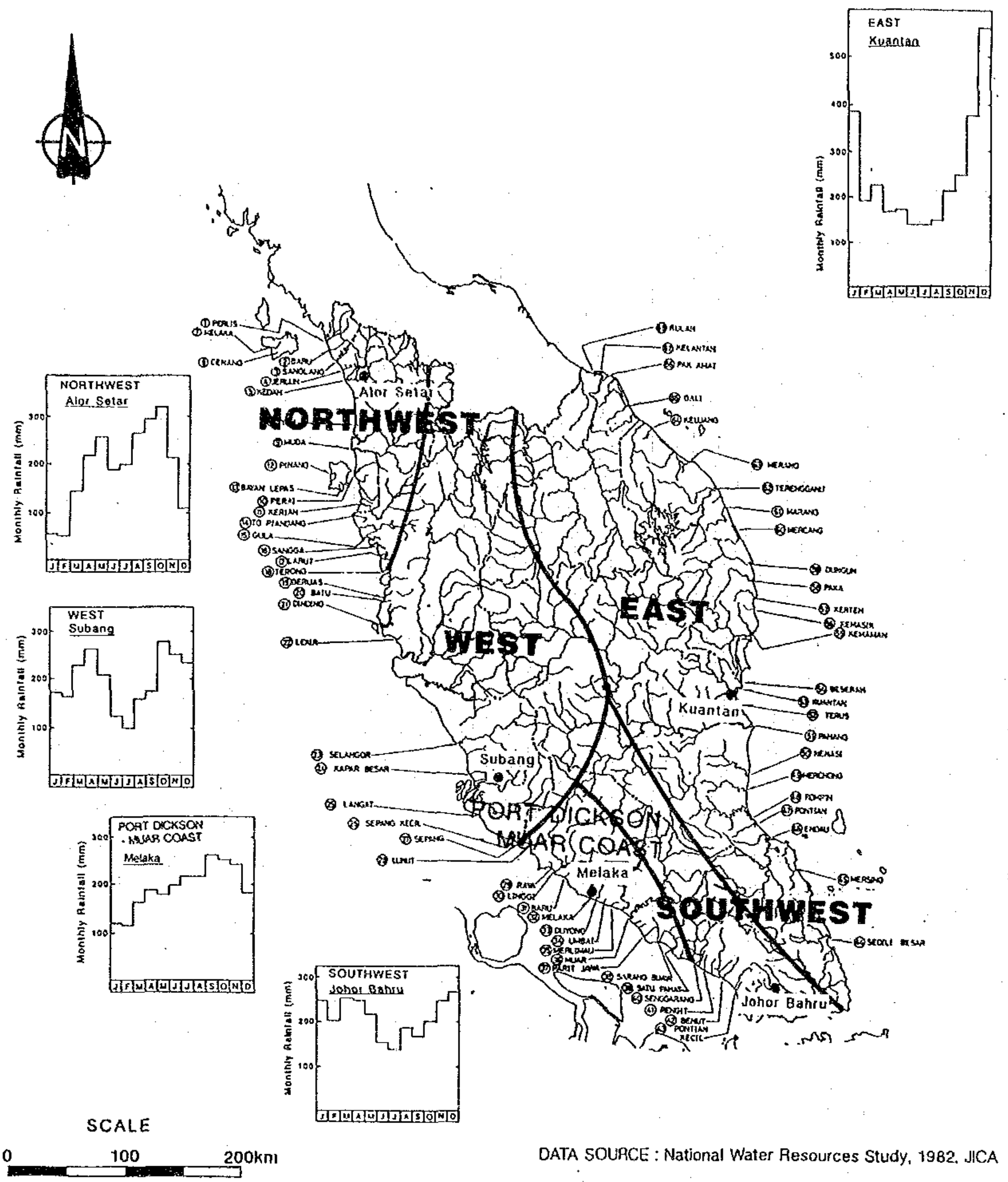


LEGEND

- Wind movement
- Wind boundary

DATA SOURCE : National Water Resources Study, 1982, JICA

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	WIND FLOW PATTERN IN SOUTHEAST ASIA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 1.2-1



DATA SOURCE : National Water Resources Study, 1982, JICA

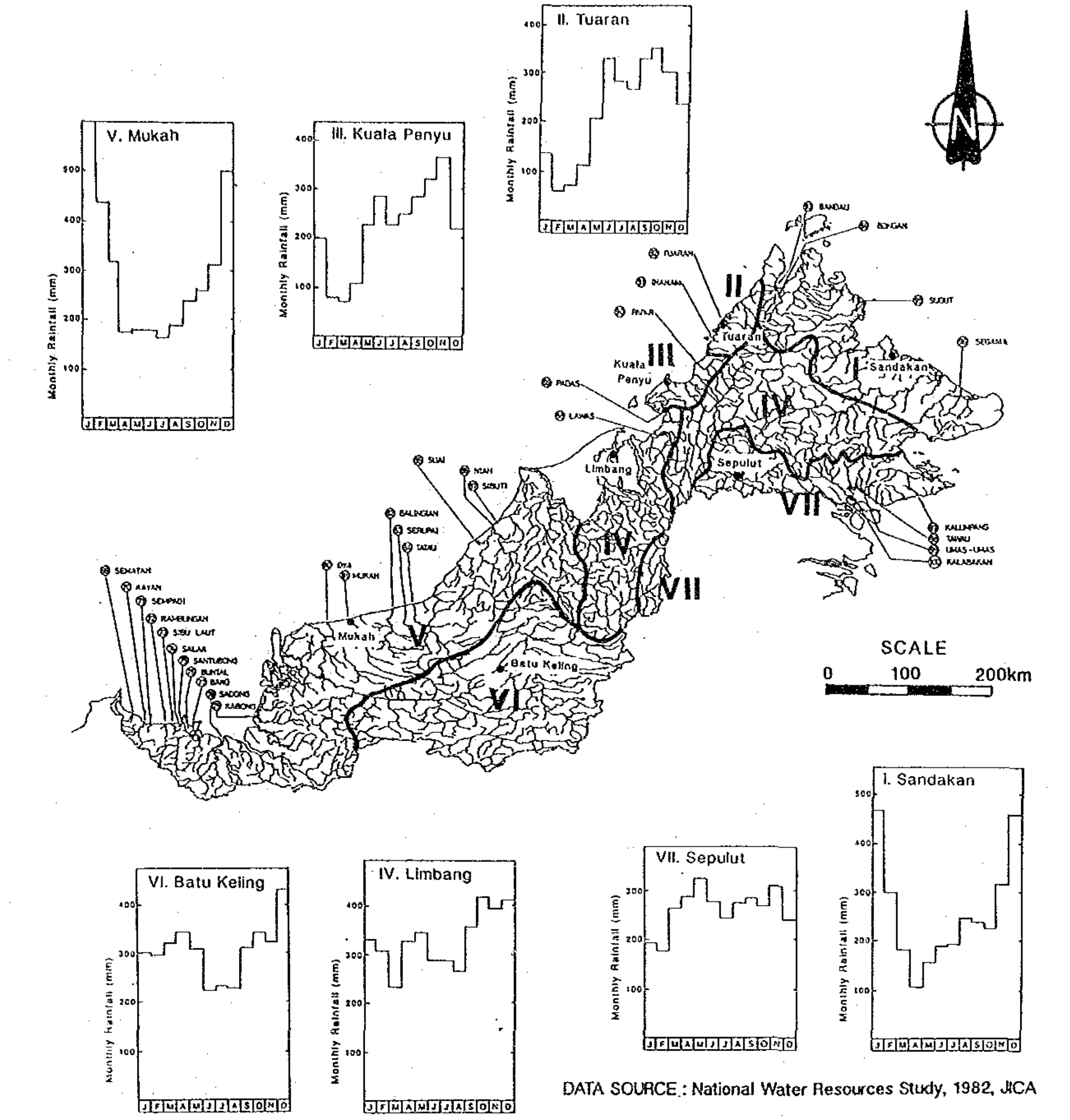
No.	Region	Rainfall Pattern
1	Northwest	This region has two rainfall peaks during the two intermonsoon seasons and low rainfall during the northeast monsoon.
2	West	This region has two rainfall peaks during the two intermonsoon seasons and low rainfall during the southwest monsoon.
3	Port Dickson - Muar Coast	This region has a build-up of rainfall during the southwest monsoon and the second intermonsoon season.
4	Southwest	This region has a rather even rainfall distribution throughout a year.
5	East	Heavy rainfall concentrates during the northwest monsoon season between November and February.

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

RAINFALL REGIONS (PENINSULAR MALAYSIA)

Fig. 1.2-2 (1/2)



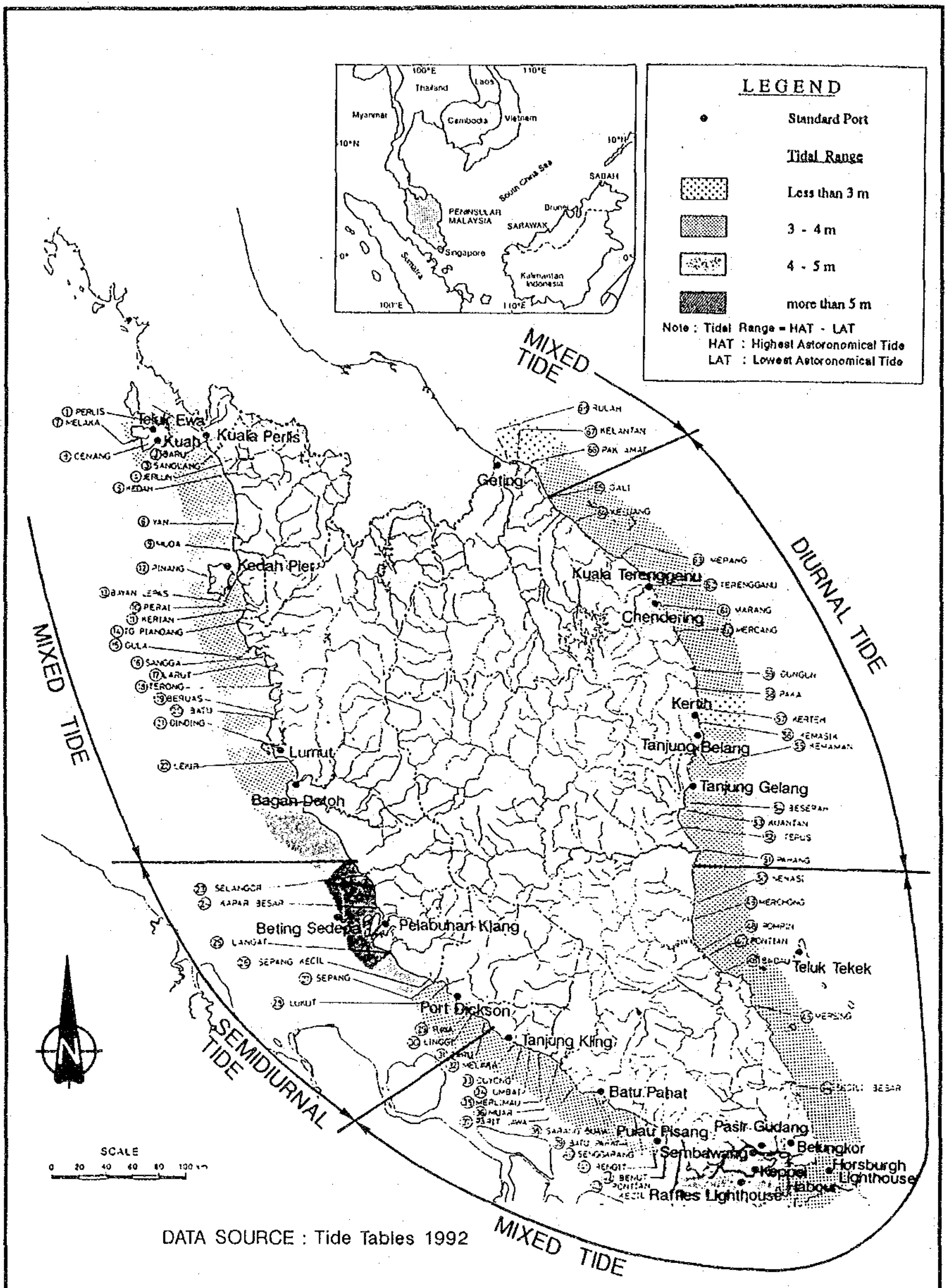
Region	Rainfall Pattern
I	High rainfall concentrates between November and February due to the northeast monsoon.
II	Two rainfall peaks appear in May and October. The heights of the two peaks are almost same.
III	Two rainfall peaks appear in May and October but that of October is bigger.
IV	High rainfall concentrates between September and October, followed by comparatively high rainfall months of November and December.
V	A high rainfall peak appears between November and February. In the other months rainfall distributes evenly.
VI	This type has an even distribution of rainfall throughout a year.
VII	Comparatively heavy rainfall is experienced in the southeast monsoon season.

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

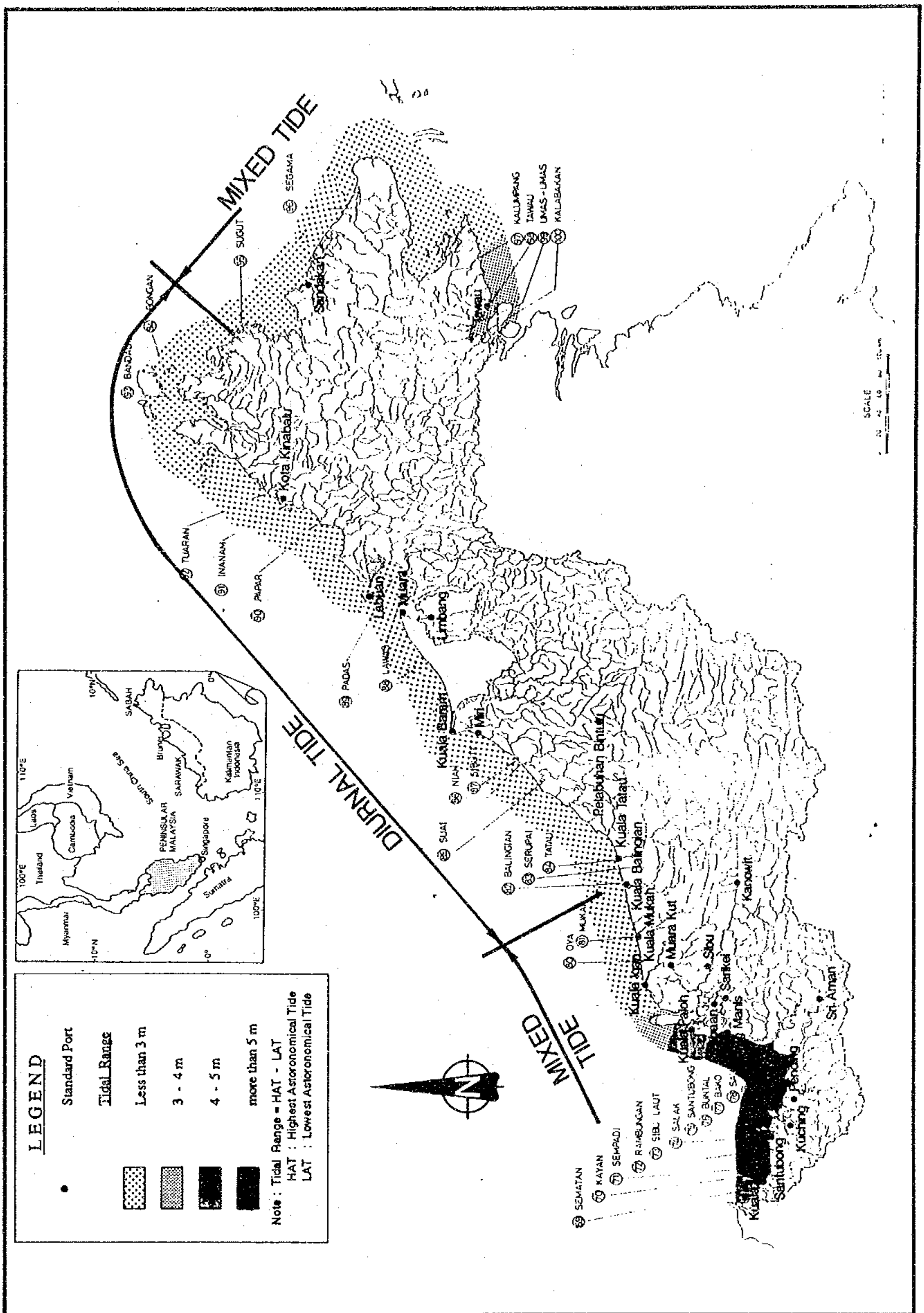
JAPAN INTERNATIONAL COOPERATION AGENCY

RAINFALL REGIONS (SABAH AND SARAWAK)

Fig. 1.2-2 (2/2)



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TIDES IN MALAYSIA (PENINSULAR MALAYSIA)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 1.2-3 (1/2)

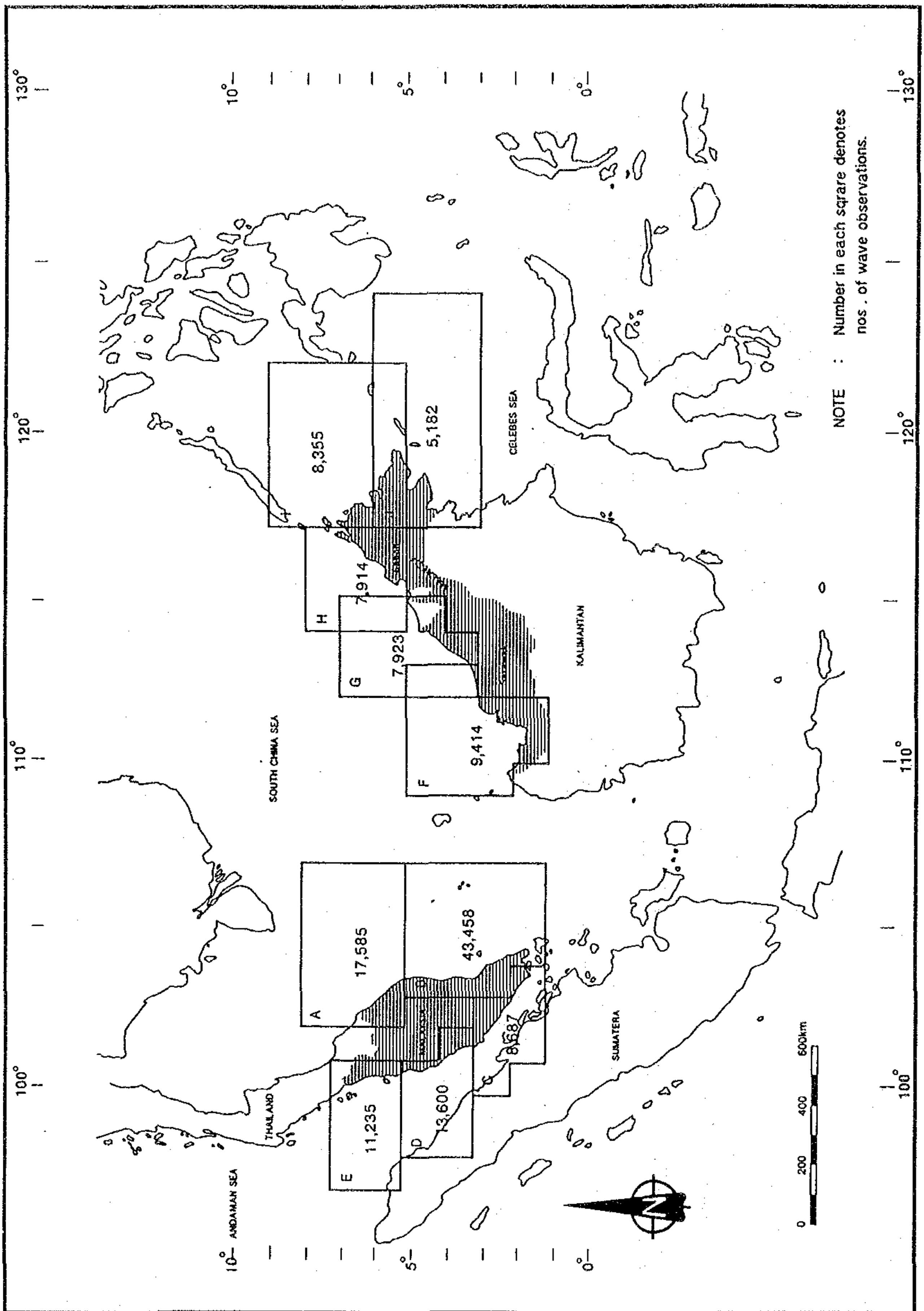


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

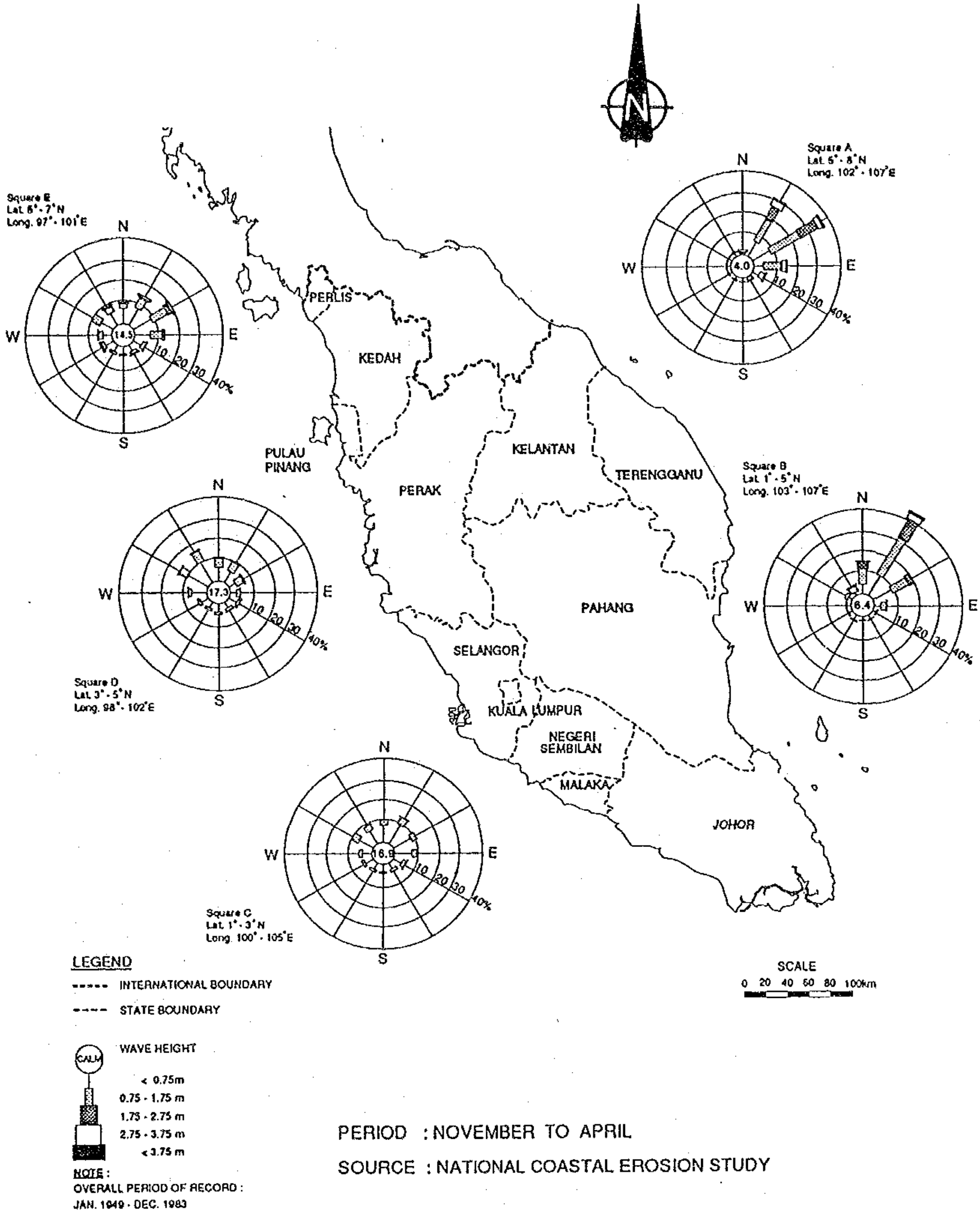
JAPAN INTERNATIONAL COOPERATION AGENCY

TIDES IN MALAYSIA (SABAH AND SARAWAK)

Fig. 1.2-3 (2/2)



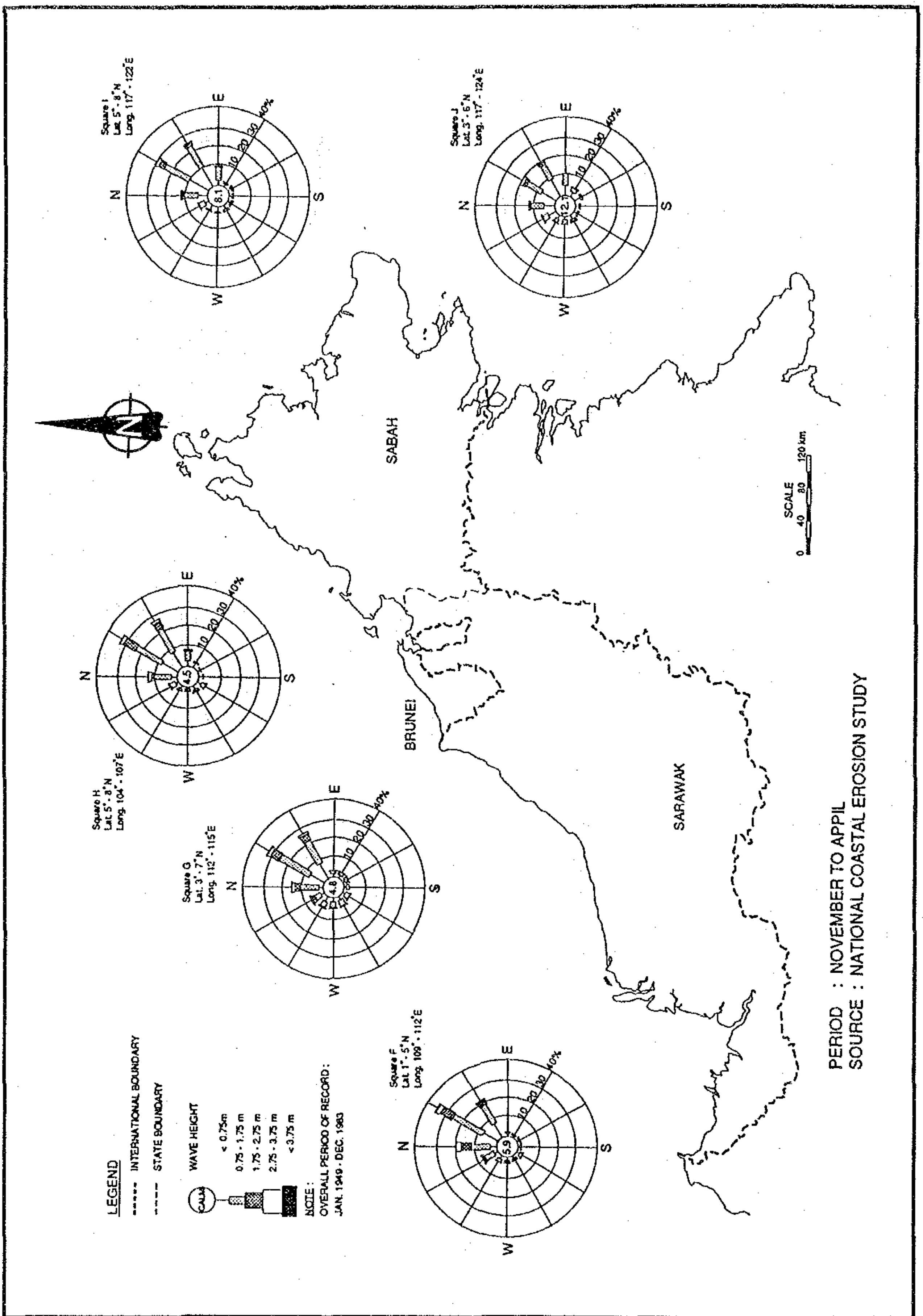
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TEN SEA AREAS FOR STATISTICAL ANALYSIS OF DEEPWATER WAVES	Fig. 1.2-4
JAPAN INTERNATIONAL COOPERATION AGENCY		



PERIOD : NOVEMBER TO APRIL

SOURCE : NATIONAL COASTAL EROSION STUDY

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	WAVE ROSES DURING NORTHEAST MONSOON (PENINSULAR MALAYSIA) Fig. 1.2-5 (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	WAVE ROSES DURING NORTHEAST MONSOON (SABAH AND SARAWAK) Fig. 1.2-5 (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	