The Marine Department conducted sounding survey from March 7 to 10, 1991 both in the inner and outer channel and this is studied in comparison with the results of the sounding survey conducted during the second field survey in 1992. As shown in Fig. 2.2-13, the bottom of the channel at just the mouth (0.0 km) is deep at about 2.0 m from March 1991 to December 1992. From this point to the upstream stretches, the difference of the bottom elevation becomes smaller and at 1.2 km point, it becomes 0.68 m.

The Marine Department started dredging of the outer channel in the beginning of July 1992, and by December 1992, the time when the Team conducted the bathymetric survey, dredging for the stretch of 1 km from the river mouth was completed. The design channel elevation is CD (Chart Datum) -3 m and this corresponds to LSD -4.9 m in this area, as informed.

Fig. 2.2-13 shows that the dredged sections have been silted to the elevations of LSD -3.7 m at 0.0 km section to LSD -3.3 m at -1.0 km section. This siltation in the dredged sections of the outer channel is presumed to be due to the muddy bed material movement from the inner channel as illustrated in Fig. 2.2-13. This means that if the outer channel is dredged, the inner channel will be maintained in levels to the outer channel by the action of river discharge and tidal flow.

Fig. 2.2-14 compares the cross sections of the inner channel in 1990 and 1992, and the present width of the inner channel is approximately 100 m. Comparison of cross sections in the outer channel in 1990 and 1992 is presented in Fig. 2.2-15. As shown in the illustration, the possible minimum elevation without dredging will be around LSD -1.5 m.

2.3 Tanjung Piandang River Mouth

The Tg. Piandang River Mouth is selected as the representative river mouth in Group 5, where river mouth formation is emphasized with the straight coast and the external force of low waves and small tidal prisms (see Table 2.2-1).

Topography

The Tg. Piandang River Mouth is located in the northernmost part of Perak State in the west coast of Peninsular Malaysia. The river mouth faces the open sea of the Strait of Malacca, except to the NNW where Pulau Pinang is located 20 km from the river mouth as shown in Fig. 2.2-16.

The river mouth is located at the tip of an alluvial fan which is formed by numerous channels flowing out from the Inas mountains located west of the central mountain ridges of the Peninsula. The Kerian River flows northwestward in the northern end of the fan and the Tg. Piandang River flows generally westward in the center of the fan. This alluvial fan is presently used for paddy cultivation under Kerian Sg. Manik IADP and the Tg. Piandang River presently functions as a drainage channel under the said project with a drainage area of 9 km^2 and a channel length of 10 km. The area is protected from saltwater intrusion by tidal bunds constructed inland, and these bunds usually divide the cultivation area and mangrove forests.

External Force

Waves generated in the Strait of Malacca and the Andaman Sea by the wind predominantly from the direction between west and northwest are partly sheltered by Pinang Island located 20 km to the northwest of the river mouth. These waves are attenuated by breaking, with bottom friction as they move into the shallow water area near the shore.

The tidal difference between high and low spring tides is about 2 m, and the tidal current is to SSE during rising tide and to NNW during ebbing tide with a maximum current velocity of approximately 30 cm/s in accordance with the data obtained by the JICA Study Team's wave/current gauge. The tidal intrusion volume of the Tanjung Piandang River Mouth is small because the tidal gate provided at 2.7 km upstream is usually closed to prevent intrusion of saltwater.

Offshore Geomorphology

Fig. 2.2-17 is the navigation chart of this area and Fig. 2.2-18 shows the isobaths developed through the sounding survey conducted during the second field survey in 1992. As shown in the illustrations, isobaths in the area present gentle lines with not many transformations, except in the near shore areas.

General seabed gradients are gentler in the northern part and are comparatively steeper in the south because of the presence of the Great Kra Flat which extends north of the mouth to Pulau Pinang. The seabed profile from the river mouth offshore developed from the navigation chart is shown in Fig. 2.2-5, and the same prepared through sounding survey during the second field work is presented in Fig. 2.2-19.

As shown in the illustrations, seabed profiles are gentle at about 1/400 for the stretch from the shoreline to about 3 km offshore. The gradient of the seabed from the river mouth 2 km offshore is gentle at around 1/1,400, and this gradually steepens to 1/180 at 4 km offshore presenting a generally convex profile.

Seabed geomorphology in this area seems to be formed by tidal current in the Strait of Malacca and, accordingly, the NNW-SSE alignment is predominant.

Bed Material

Bed materials were sampled at 52 locations from 2.7 km upstream from the river mouth to 2 km offshore for the Feasibility Study. Gradation analysis and specific gravity testing were conducted for these samples. Median diameters d50 of the samples are in the range of 0.05-0.001 mm, and predominant are medium to coarse silt with d50 of 0.015-0.025. Detailed analysis for aerial distribution of particle size will be conducted during the feasibility study, and a typical gradation curve is presented in Fig. 2.2-7.

As shown in the illustration, the material is clayey silt with the ratio of clay (< 0.002 mm), silt (0.002 to 0.063 mm) and sand (0.063 to 2.0 mm) at 23%, 71% and 6%, respectively. These are the typical materials in muddy coasts.

There is no distinct difference between materials in and out of the mouth and, accordingly, materials of the inner channel are presumed to be of marine origin.

Coastal Change in Neighboring Areas

Coastlines interpreted from aerial photographs of this area for the year 1966, 1974, 1981 and 1986 are presented in Fig. 2.2-20. Shoreline retreat is severe in the northern shore in the 3 km stretch from the mouth at the rate of 300 m for 8 years from 1966-74, 250 m for 7 years from 1974-81 and 250 m for 5 years from 1981-86. On the other hand, in the stretch from 3 km to 4.6 km to the north of the mouth, shoreline accretion of 200 m for 8 years from 1966-74 is found. No distinct change is observed in this stretch from 1974-81.

At the mouth of the river, both banks are retreating due to the demise of mangrove forest, widening the channel by 70 m in average for 8 years from 1966-74. The southern shorelines, to the contrary, have a lot of variations. The aerial photographs taken in 1974 show that shallow mud flats have developed up to 300-400 m offshore from the coastline in 1966 and newly sprouting mangroves scattered in the mud flat can be seen, although some areas along the shore have partly retreated.

The photographs taken in 1981 show a dense mangrove forest extending up to 200-300 m from the shoreline in 1966, and a drainage channel extends southward parallel to the shore. This mangrove forest, however, disappeared by 1986 and the shoreline in 1986 has rather retreated from that in 1966 by 100 m. Although the cause of this mangrove accretion and retreat is not clear at this stage, it is most probably due to the change of ecosystem through obstruction of fresh water supply by bund construction.

River Mouth Configuration

The longitudinal profile of the Tg. Piandang River presents down slope from the upstream gate to the mouth and this fact characterizes the Tg. Piandang River Mouth. In the other rivers, inner channels are maintained relatively deeper and the shallowest part is usually off the mouth. This is because the Tg. Piandang River is originally one of the channels radiately flowing in the alluvial fan with a relatively steep gradient. In

addition, it has only a small catchment area and hence, discharge is not much and release of water from the gate is limited only during the flood season.

A comparison of inner cross sections surveyed in 1988 and 1992 is shown in Fig. 2.2-21. Bottom elevations are slightly lower in 1992, but it can be generally said that there are no distinct changes. As discussed above, both banks are retreating in the stretch from the river mouth to 800 m upstream. The width of the river in this stretch was about 150 m in 1988, but it was 200-250 m in 1992. The sections with retreated mangrove have been scoured by about 1 m on average.

2.4 Beruas River Mouth

The Beruas River Mouth is selected as the representative river mouth in Group 7, where river mouth formation is emphasized with the external force by low waves and large tidal prisms for the river mouth forming an estuary (refer to Table 2.2-1).

Topography

The Beruas River Mouth is located in the approximate center of the coastline of Perak State in the west coast of Peninsular Malaysia. To the east of the river mouth, the Bintang-Imas mountains stretch from north to south and end at Beruas Town. The Beruas River collect water in the southern slope of this mountain with a catchment area of 240 km^2 and the river length of 45 km.

To the north of the river mouth, there is a shore of submergence where the river mouths of Sangga, Larut and Terong are located and there exists Tg. Batu 2 km to the south as shown in Fig. 2.2-22. A vast mangrove forest exists in this area and the Beruas River Mouth is located at the southern tip. In the hinterland of this area, numerous NNE-SSW beach ridge developments connecting Segari Hill located to the south of the mouth and northeastern mountains prove that accretion of the shoreline has taken a long time, as shown in Fig. 2.2-23. An old river trace runs parallel 600 km east of the present river course of the south flowing stretch.

The Beruas River flows in mangrove forests about 7.0 km to the mouth. The left bank is developed as a fishing village for the stretch of 2.0 km from the mouth, while the right bank is reserved as a natural mangrove forest.

External Force

Waves generated in the Strait of Malacca and the Andaman Sea by the wind predominantly from the direction between west and northwest are attenuated by breaking, with bottom friction as they move into the shallow water area near the shore.

The tidal difference between high and low spring tides is about 2.3 m, and the predominant surface ocean current is from southeast to northwest with a current velocity of about 0.3 m/s.

Tidal currents in the river as a result of rising and ebbing tide and the river discharge are abundant. These are the main factors forming the estuary. The Beruas River Mouth has a tidal intrusion stretch of about 7 km with an average river width of about 50 m in this stretch and, accordingly, the tidal prism of the Beruas River Mouth is relatively large.

Offshore Geomorphology

As shown in Fig. 2.2-24, a navigation chart of this area, the area of the shore of submergence to the north of the river mouth where the Sangga, Larut and Terong river mouths are located presents shallow and intricate estuaries and channels, and vast mud flats.

The shallow sea with a depth of 5 m from the chart datum extends up to 15 km offshore in this area, but this 5 m contour comes close to the shore at Tg. Batu. The chart implies a N-S current in the Strait of Malacca, but the effect of this current might be small at the Beruas River Mouth because of the presence of Tg. Batu.

Fig. 2.2-25 shows isobaths developed through the sounding survey conducted during the second field survey in 1992. The profiles are shown in Fig. 2.2-26. As shown in the illustration, bottom elevations in the center of the channel are higher than those in the off channels in the stretch from the mouth to 800 m offshore. The bottom of the

channel in this part is flat at about LSD -1.2 m, and from this point the seabed has a gradient of 1/450 to the elevation of LSD -5 m. In the off channel part, seabed profile is about 1/600 from the shore.

Bed Material

A gradation curve of seabed materials sampled in the outer channel at the mouth is presented in Fig. 2.2-6. As shown in the illustration, the material is silt with the ratio of clay (<0.002 mm), silt (0.002 to 0.063 mm) and sand (0.063 to 2.0 mm) at 10%, 63% and 27%, respectively. The material is slightly sandy when compared to the northern river mouth of Perlis, Kedah and Tg. Piandang, with the median diameter d50 at 0.033 m and the mean particle diameter dm at 0.158.

Coastal Change in Neighboring Areas

Coastlines interpreted from aerial photographs of this area for the year 1966, 1974 and 1981 are presented in Fig. 2.2-23.

Shoreline retreat is 50 m for the period of 15 years from 1966-81 in the northern shore and this corresponds to 3 m annually. In the southern shore, the shoreline has retreated by about 50 m for the period of 7 years from 1974-81 near Sg. Batu. However, the rate of shoreline retreat in this area is comparatively smaller than those in Perlis, Kedah and Tg. Piandang. The location of river banks in the inner channel is stable and no change was observed for the last 15 years.

River Mouth Configuration

The river mouth configuration is characterized with a gradually narrowed river width toward upstream sections in the tidal prism stretch. The Beruas River Mouth was dredged in 1990 and the detailed discussions on siltation rate after the dredging is made in Subsection 6.5.1. A summary of the discussions is given as follows:

The bottom of the inner channel is silted by about 40 cm for 30 months after dredging in June 1990, but this rate is rather small when compared to those in the outer channels. If outer channels are maintained deeper, inner channels will also be maintained deeper.

Outer channels are very easily silted, and if dredging is not conducted, the shallowest part will be about LSD -1.4 m as shown in Fig. 2.2-26.

2.5 Kuantan River Mouth

The Kuantan River Mouth is selected as the representative river mouth in Group 2, where the river mouth is formed on the straight coastline by the external force of high and oblique waves and large tidal prisms (refer to Table 2.2-1). The high and oblique wave generates a littoral current which carries drifting sand. Incidentally, the Kuantan River Mouth is located adjacent to a headland which has a sheltering effect to the wave action. Since most of the river mouths in this group, six river mouth out of ten, are located adjacent to the headland, the existence of the headland will be considered to examine the river mouth condition in this group.

Topography

The Kuantan River Mouth is situated almost in the center of the eastern coastline of Peninsular Malaysia and at the same time in the northern tip of Pahang State. The catchment area is 1,710 km² and the river length is 80 km.

The catchment area is surrounded to the northwest, west and south by the Pahang river basin which has one of the largest catchment areas in Malaysia (29,300 km^2), and the Pahang River Mouth is situated 35 km south of the Kuantan River Mouth as shown in Fig. 2.2-27. The Kuantan River Mouth is accordingly located in the northern end of the alluvial plain formed by the Pahang River.

Two hills, Bt. Tg. Tembeling Hill, 337 m high protruding into the sea, and Bt. Galing Hill, 973 m high located more landward approximately 650 m WNW of Tg. Tembeling are prominent landmarks in the area. Areas except these hills are low, flat lands. Tg. Tembeling shelters the river mouth from N-NE winds predominant in the area.

Aerial photographs and 1/50,000 topographical maps present numerous beach ridge developments from the east to the south of the mouth as shown in Fig. 2.2-28. These ridge developments run parallel to the present shoreline with gentle curves, and these areas remain mainly as non-used sandy grassland. This indicate that the shoreline has

been stable for a long time and the location of the mouth, just west of Tg. Tembeling, seems to be in the balanced condition.

The left bank of the river mouth is developed as Kuantan City, but a vast swampy terrain extends in the remaining areas including the right bank of the mouth, and 5 km from the river mouth and the upstream.

External Force

Since the Kuantan River Mouth is protected to the east by the protruding Tg. Tembeling and to the south by the protruding coast of the outlet of the Pahang River, only incident waves from between the northeast and southeast are expected. Accordingly, oblique waves from the northeast direction predominant during the Northeast Monsoon season are the major forces forming the river mouth configuration.

The tidal difference between mean higher high water and mean lower low water is 2.7 m, while ocean current is less than 0.5 m/s. As noticed that the Kuantan River has a tidal influence stretch of about 25 km and the width is about 130 m on average in this stretch, the tidal prism of the Kuantan River Mouth is quite large.

Offshore Geomorphology

As shown in Fig. 2.2-29, a navigation chart of this area, offshore geomorphology in the river mouth area is strongly affected by Tg. Tembeling. Fig. 2.2-30 shows isobaths developed through the sounding survey conducted during the second field survey in 1992. The profiles are shown in Fig. 2.2-31.

As shown in these illustrations, a shallow shore zone extends up to 2 km from the shore near the mouth. The profile of the outer channel shows bottom elevations of about LSD -2 to LSD -3 m for the stretch of 0.7-2.2 km from the mouth. All outer channel profiles of different years show M-shaped form with the shallowest bed of about LSD -2 m at 0.8 km and 2.2 km, and the bed between these points show a concave profile with the lowest bed elevation of about LSD -3 m. The offshore shallow zone is presumably formed by wave action, namely, by littoral sand drift, and the near shore shallow zone is by river discharge. The sea bed gradient from this shallow zone offshore is about 1/1,100.

Bed Material

A gradation curve of seabed materials sampled in the outer channel at the mouth is presented in Fig. 2.2-32. Curves for the other representative river mouths in the sandy coast, namely in the east coast of the Peninsula and in Sabah and Sarawak, are also illustrated in the figure.

As shown in the illustration, the material is 100% sand (defined as 0.063 to 2.0 mm) with the median diameter d50 of 0.20 mm and the mean grain diameter of 0.19 mm. In the case of sand material, the graded condition is evaluated with the uniformity coefficient *Uc* (= d60/d10) and the curvature coefficient *Uc'* [= $(d30)^2$ / (d10 x d60)]. These values are calculated at *Uc* = 1.7 and *Uc'* = 1.01; sand with *Uc* of less than 10 is called uniform diameter sand, and the gradation curve shows a very uniform gradient. The material was sampled near the shoreline and finer material was washed away.

According to the soil investigation result in Kuantan Port located at the northern part about 25 km away from the Kuantan River Mouth, the surface sand layer is about 6 m thick on an average, underlain by a deep, medium stiff clay containing some dense sand lenses of irregular pattern and distribution.

Coastal Change in Neighboring Areas

Aerial photographs are available for 1966 and 1974 and the coastline is interpreted from these photographs as shown in Fig. 2.2-28. As shown in the illustration, no change of coastline was observed from the photographs and it can be said that the shoreline in this area is in a quite stable condition.

River Mouth Configuration

The inner and outer channel near the mouth is stable when the sections in different years are compared, as shown in Fig. 2.2-33. The inner channel is maintained deep at LSD -8 m at the mouth, LSD -12 m at just upstream of the mouth, LSD -12.9 m and LSD -11.6 m at +400 m and +600 m, respectively. These depths are maintained presumably throughout the year by a relatively higher river discharge with a large volume of tidal prism.

On the other hand, the outer channel is relatively shallow as discussed before and the shallow zone with seabed elevations of about LSD -2 to LSD -3 m extends for the stretch from -700 m to -2,300 m from the mouth. The transition section has a gradient of 1/140 ascending offshore.

Fig. 2.2-34 show isobaths of the outer area of the river mouth in 1989 and 1992. As shown in the illustration, the outer channel naturally formed in this area seems to be generally stable but presents minor changes. This is presumably a result of balance of external forces, namely, wave strength and direction and resulting littoral drifting sand volume, and the river discharge. There is not much change in elevations of the shallowest portion.

These conditions are summarized as follows:

(1) The location of the mouth is fixed.

(2) The inner channel is naturally maintained deep.

(3) A shallow shore zone extends at the stretch from -0.6 km to -2.6 km with elevations from LSD -2 to LSD 13 m.

(4) The outer channel is shifting year by year.

(5) The width of the naturally maintained outer channel is about 200 to 300 m.

The river mouth configuration under these conditions is normally characterized with the development of sand spit from one side of the river bank which tends to shift the river mouth depending on force balance between wave and river flow discharge.

However, the existence of headland and/or island which shelter the wave action sometimes prevents such development of sand spit, but reversely promote the development of wide shallow shore around the river mouth, and the channel in this shallow shore sometimes shifts the course due to the littoral current. Thus, the river mouth configuration has changed.

2.6 Kerteh River Mouth

The Kerteh River Mouth is selected as the representative river mouth in Group 3, where the river mouth is formed on the straight coast by the external force of high and oblique waves and small tidal prism (refer to Table 2.2-1). Incidentally, the Kerteh River Mouth is located adjacent to a headland which has a sheltering effect to the wave action. Since two out of three river mouths included in Group 3 have a headland or an island, the effect of the existence of a headland or an island was considered to examine the river mouth condition in this group.

Topography

The Kerteh River Mouth is located at just the center of the two large basin river mouths of Terengganu and Pahang in the east coast of the Peninsula. In a large scale view, neighboring shorelines from Dungun to the north to Kemaman to the south lay generally N-S and concave lines are developed with the presence of headlands as shown in Fig. 2.2-35. A headland, Bt. Labuhan, 352 m high is situated to the northeast of the Kerteh River Mouth.

The Kerteh River originates in hilly areas 10-20 km inland from the shoreline and flows in heavily meandered channels in low, wet lands extending along the shore. The catchment area is 240 km^2 and the total channel length is 40 km.

A series of hills extending NNW-SSE from Bt. Mempusi, 336 m high, is located 5 km to the west of the river mouth. Low wetland of mangrove forests extend along the heavily meandering river channels to the north of the mouth.

To the south of the river mouth, the topography is low and flat and there are distinct beach ridge developments parallel to the coastline extending about 4.0 km with a width of about 2.5 to 3 km from the coast, as shown in Fig. 2.2-36. This shows accretion of the area has taken a long time. These areas are residential or non-used. Beach ridge development is also found in the left bank of the mouth for the stretch of about 200 m.

External Force

The Kerteh River Mouth is exposed to the South China Sea and subject to extreme wave conditions, especially during the Northeast Monsoon season which causes waves obliquely rushing to the river mouth. The influence of the Southwest Monsoon on the wave environment, however, is not as significant since the winds blow seaward.

The tidal difference between mean higher high water and mean lower low water is 2.7 m and surface ocean current is about 0.3 m/s from northwest to southeast in December and from southeast to northwest in June. The tidal prism of the Kerteh River Mouth is relatively small with a tidal intrusion stretch of about 5 km of and the river width of about 30 m on average.

Offshore Geomorphology

Ten fathoms line (18.3 m deep line from Chart Datum) runs straight in a N-S direction and this line is not affected by coastal topography as shown in Fig. 2.2-37. Isobaths developed from the sounding survey during the second field survey are shown in Fig. 2.2-38. A shallow zone with seabed elevations of less than LSD -5 m extends to a direction of N30°W from Tg. Labohan and the area in 250 to 500 m from the mouth has elevations of less than LSD -1.2 m.

The seabed gradient of 1,000 km left and right of the mouth show a quite different formation as shown in Fig. 2.2-39. The profile in the left bank of the mouth, namely the northern stretch from the tip of the headland, shows steep gradients of about 1/20 from the shore to the elevation of LSD -5 m for a length of 100 m, and from that point offshore the gradient is 1/100 to LSD -12 m.

On the other hand, in the right of the mouth, LSD -5 m seabed is in a distance of 1.5 km from the shore with a gradient of about 1/300, and from that point offshore, the gradient is about 1/175.

Bed Material

A gradation curve of seabed materials sampled in the outer channel at the mouth is presented in Fig. 2.2-22. As shown in the illustration, the material is much coarser than materials in the other representative river mouths in the sandy coast, consisting of 39% of sand (defined as 0.063 to 2.0 mm) and 61% of gravel (2.0 to 75 mm). The median diameter d50 and the mean grain diameter dm are 2.36 mm and 2.46 mm, respectively, and the uniformity coefficient Uc (= d60/d10) is 4.4.

In accordance with the field investigation, the sand in this area is of granite origin and it is probably the same material as the sand found in the Terengganu River basin. This coarse material is widely found in the river mouth area implying that the area is in the erosion tendency.

Change in Coastal Geomorphology and River Mouth Area

The river mouth area is in very unstable condition as shown in Fig. 2.2-40 which compares the river mouth formation in 1966, 1974 and 1983. The meandering river course flowing in the low, wet land is stable at least after 1966 and only the river mouth is unstable.

Overall drifting sand system is from north to south as shown in the form of pocket beach located to the north of the river mouth between Tg. Batu Laut and Tg. Paha. The supply source is presumably the basins of the Terengganu and Dungun rivers; the drifting sand which move westward after passing Tg. Labuhan accordingly flows southward after passing the Kerteh River Mouth.

The development of sand bar extending to SSW from the mouth is distinguished, and the tip of the bar reached to 2.5 km from the mouth in the farthest condition. The historical location of the tip of the bar from the mouth is 1,000 m, 1,600 m and 2,000 m in 1966, 1974 and 1983, respectively. Annual growth rates of the bar are 75 m for the 8 years from 1966 to 1974 and 45 m for the 9 years from 1974 to 1983, and the flush of the bar is probably used to be once in several tens of years.

The river mouth is artificially fixed at present by the construction of the right bank bund. The river presently flows straight to the sea and no effect of the artificial works has been found. The old river course is maintained as a lagoon, but it is presently closed completely by the bund.

As to the inner channel, it is maintained comparatively deeper as shown in Fig. 2.2-39. The riverbed is LSD -7.5 m at 2.1 km point from the mouth and it gradually goes up towards the mouth with some local irregularity. The sand at the bottom of the mouth is probably of marine origin carried by tidal intrusion and, accordingly, in case the outer channel is maintained deeper, the inner channel will be maintained deeper.

The difference with the Kuantan River Mouth, the other representative river mouth which has a similar topographical and external force condition with the existence of a headland to the east of the river mouth but where no distinguished sand bar formation is found, is probably because the tidal prism is very small in the Kerteh River Mouth. If the tidal prism is maintained larger, the river mouth itself will be maintained deeper.

2.7 Marang River Mouth

The Marang River Mouth is selected as the representative river mouth in Group 1, where the river mouth is formed on the straight coast by the external force of high and straight waves and large tidal prisms (refer to Table 2.2-1).

Topography

The Marang River has a catchment area of 460 km^2 and a total channel length of 50 km, and its mouth is located 15 km SSE from the Terengganu River Mouth in Terengganu State.

The shoreline of the area for a stretch of 70 km from the Terengganu River Mouth to the Dungun River Mouth consists of a continuous sandy beach with a straight coastline and is generally aligned in a N35°W direction as shown in Fig. 2.2-41. This is because there are no hills along the shoreline in this area, unlike the stretch to the south of Dungun where the shoreline morphology is distinctly affected by hills as headlands.

Although an island, Kapas Island, is located 5 km offshore from the mouth, the topography in the area is not affected by this. In the areas from Dungun to the north up to Merang passing Terengganu, low wet lands extend from the shoreline to 20-30 km inland and 400-600 m high hills sparsely scatter. The Marang River originates in 600 m high hills but most of the channel runs in a low flat land and this implies a low sediment production in the catchment.

External Force

Although the river mouth is partly sheltered by Kapas Island, it is exposed to the South China Sea, subject to extreme wave conditions especially during the Northeast Monsoon season which cause waves rushing straight to the river mouth. On the other hand, the influence of the Southwest Monsoon on the wave environment is not as significant since the winds blow seaward.

The tidal difference between mean higher high water and mean lower low water is 2.1 m and surface ocean current is about 0.3 m/s in December from northwest to southeast. The tidal prism of the Marang River Mouth is large with a 20 km of the tidal intrusion stretch and the river width of about 80 m.

Offshore Geomorphology

As shown in Fig. 2.2-42, a navigation chart of this area, although a shallow zone extends from the river mouth to Kapas Island, the seabed formation in this area has generally less irregularity. The seabed gradient in this area is steep at about 1/100 to 1/150.

Fig. 2.2-43 shows isobaths developed through the sounding survey conducted during the second field survey in 1992. The profiles are shown in Fig. 2.2-44. A very shallow zone exists at the river mouth but the stretch of the shallow zone with elevations above LSD -5 m is very short at about 1.4 km.

Bed Material

Bed materials were sampled at 50 locations from 1.1 km upstream from the river mouth to 500 m offshore for the Feasibility Study. Gradation analysis and specific gravity testing were conducted for these samples.

Median diameter d50 of the samples is in the range of 0.013-1.2 mm, and the predominant is sand. An average composition of fines (below 0.063 mm), sand (0.063-2.0 mm) and gravel (2.0-60 mm) is 6.0, 91.8, and 2.2%, respectively. Detailed analysis for aerial distribution of particle size was conducted during the feasibility study, and a typical gradation curve is presented in Fig. 2.2-32.

As shown in the illustration, it is composed of very uniform material with the uniformity coefficient *Uc* (= d60/d10) of 1.7 and this implies the coast receives strong wave current.

Change in Neighboring Coasts and River Mouth

The shoreline in the stretch from Terengganu to Dungun seems generally stable. As shown in the aerial photograph interpretation for the year 1966, 1974 and 1980 (see Fig. 2.2-45), the course of the inner channel is not stable and has moved from right to left, or vice versa. Recently, however, the course of the inner channel seems to be stable and the main channel is almost steady in the left side.

Contour maps in the inner channel for the year 1979 and 1983 are compared in Fig. 2.2-46. As shown in the illustration, the main course is in the left side where the riverbed is stable with rock outcrops.

The inner channel was dredged in October-December 1980 for a volume of 231,000 m^3. Although a detailed information is not available, dredging was aligned straight from the bridge to the mouth. The contour map in 1983 shows no trace of the dredged channel and it seems to have silted up completely.

The bed material for the stretch downstream of the bridge is presumably of marine origin carried by tidal intrusion. Since the river mouth area presents a widened shape,

the effect of river discharge is relatively small in this place compared to wave and tidal action.

The river mouth configuration formed under these conditions is characterized with the development at the river mouth of a sand spit from both banks, sometimes one side, at the river mouth and sand dunes are seen in the inner channel. Sediment transported from the river basin is deposited at the shore side around the river mouth resulting in a shallow shore and sediment is pushed back toward the inner channel when the wave and tidal current are so strong, and deposited there.

2.8 Terengganu River Mouth

The Terengganu River Mouth is selected as the representative river mouth in Group 8, whose river mouths are formed in the protruding coast by the external force of high and straight waves and large tidal prisms (refer to Table 2.2-1).

Topography

The Terengganu River Mouth has a catchment area of 4,650 km^2 and a total channel length of 180 km. The river mouth is located on a protruding coastline at the center of the coastline of Terengganu State in the east coast of the Peninsula. Shoreline of this area consists of a continuous sandy beach; straight coastline of N35°W to the south of the mouth and coastline generally aligned in N45°W to Sg. Merang to the north with N30°W 5 km coast just north of the mouth.

The downstream stretch of the Terengganu River flows about 50 km along the channel in low, flat lands. There are distinct beach ridge developments parallel to the coastline and extend several kilometers inland to the north of the river mouth and this implies coastal accretion in a long time. (Refer to Fig. 2.2-41.)

External Force

The Terengganu River Mouth is exposed to the South China Sea and subject to extreme wave conditions especially during the North-East Monsoon season which

causes waves rushing straight to the river mouth. The influence of the Southwest Monsoon on the wave environment is not as significant since the winds blow seaward.

It is reported that the Terengganu River Mouth also experiences long periods of swell generated by typhoons in the South China Sea.

The tidal difference between mean higher high water and mean lower low water is 2.1 m and surface ocean current is about 0.3 m/s in December from northwest to southeast. The tidal prism of the Terengganu River Mouth is quite large with a tidal intrusion stretch of about 22 km and the river width of about 200 m.

River Mouth and Offshore Geomorphology

As shown in the navigation chart of this area (see Fig. 2.2-47), the isobaths in a wide area to the south of the river mouth generally run parallel to the shoreline. To the north of the mouth, to the contrary, the gradient becomes gentler due to the effect of Pulau Redang.

Fig. 2.2-48 show isobaths just outside of the river mouth. The mouth is very deep because the width is narrowed by the left bank sand bar, and the deepest point bed is below LSD -9 m. The bed suddenly becomes shallow and the deepest elevation at a distance of 400 m from the mouth is LSD -3 m as shown in Fig. 2.2-49. Outside of the mouth, a river mouth terrace where bed configuration is unstable is formed for the stretch of 2 km in longshore direction and 1.3 km in offshore direction. The isobaths shown in Fig. 2.2-48 and other bathymetric survey results indicate that the outer channel is directed to the east.

Transitions of coastline at the Terengganu River Mouth for the years 1937 and 1972 are shown in Fig. 2.2-50. Coastline change around the river mouth is a combination of retreat and accretion; however, as far as sand spit is concerned, it has eroded in the shore side while it tends to develop in the inner channel.

Bed Material

The bed materials at the Terengganu River Mouth are of the marine alluvial origin consisting of alluvium gravel, sand, silt and clay, and sand is the most common material

around the river mouth. According to the previous survey results, beach and near shore materials consist predominantly of fine sand with coarser sand found on the beach surface with a mean diameter of 0.2 mm, and the sand spit consists of sand with a mean diameter of 0.7 mm.

The gradation curve of the material sampled on the beach surface is shown in Fig. 2.2-32. As shown in the illustration, the material is composed of uniform sand with a median diameter d50 of 0.34 mm and a uniformity coefficient Uc of 1.9.

Coastal Change in the River Mouth Area

Coastal change in the river mouth area is surveyed in detail by the "Coastal Protection Works at Seberang Takir, Terengganu" and the results are summarized below.

Erosion is severe in the shoreline area on the left side of the mouth, and the left side sand bar is increasing in length and at the same time decreasing in the width. The riverside of the sandbar is in accretion.

The right bank of the mouth is also in a tendency of erosion; however, it became stable after the construction of revetment. The condition of the revetment is not good, however, and back-filling material has blown off in some portions.

The drifting sand is to the north in the left bank shore of the mouth and to the north in the right bank of the mouth. Overall drifting sand is predominantly to the south.

As discussed under topography, the shoreline is in accretion for a long time, but after the completion of the Kenyir Dam, sediment supply from the river basin seems to have decreased. The shore will move to the newly balanced condition.

The inner channel is maintained by dredging at about LSD -6 m. The main flow is in the right bank. The shallowest river bed elevation in case of no dredging will be around LSD -1 m.

2.9 Oya River Mouth

The Oya River Mouth is selected as the representative river mouth in Group 6, where river mouth formation is emphasized with the external force by high and oblique waves and large tidal prisms for the river mouth forming an estuary (refer to Table 2.2-1).

Topography

The Oya River has a catchment area of 1,820 km^2 and a total length of 150 km. The river mouth is located approximately at the center of the coastline of Sarawak State and to the north of Sibu City. The river originates in 600 m class hills, but it heavily meanders in low wetland for more than half of the stretch. This low wetland is very large, formed by the Rajang and other rivers. The total shoreline of this low land amounts to about 500 km with an area of approximately 17,000 km^2 (see Fig. 2.2-51).

The part west of Sibu presents a shoreline of submergence with its characteristics of shallow estuaries, complicated coastline, solitary islands and channels. The coastline where the Oya River Mouth is located, however, is almost straight with a length of 150 km extending E-W.

External Force

The Oya River Mouth is exposed to the South China Sea and subject to extreme wave conditions especially during the Northeast Monsoon season which causes wave rushing obliquely to the river mouth. The influence of the Southwest Monsoon on the wave environment is, however, not as significant since the winds blow seaward.

The tidal difference between high and low spring tides is 1.4 m and surface ocean current is about 0.2 m/s from northeast to southwest in December and 0.3 m/s from the same direction in June. The tidal prism of the Oya River Mouth is quite large with 25 km of tidal intrusion stretch and river width of about 150 m.

Offshore Topography and River Mouth Condition

As shown in the navigation chart of this area (see Fig. 2.2-52), isobaths in this area generally run parallel to the coast. A shallow shore zone below 2 m from the chart

datum extends about 500 m from the river mouth, then the seabed deepens gradually with a gradient of about 1/500.

Fig. 2.2-53 show seabed contour lines developed through the sounding survey conducted during the second field work. As shown in the illustration, the seabed from the river mouth to elevations about LSD -3 m presents a protruding terrace formed by river discharge. The channel is maintained in the west side.

These seabed contour lines as well as the topography at the river mouth imply that the overall drifting sand direction is predominantly to the west. This river mouth terrace might be pushed offshore with a relation of force of river discharge and wave, but this will be cleared. The shallowest part of the outer channel in the balanced condition will be at LSD -1.8 m.

Inner channels are maintained relatively deep as shown in Fig. 2.2-54, profile of inner and outer channel bottom by the discharge of the river. Drifting of sand from outer to inner channel was not observed.

Bed Material

The gradation curve of the sample at the shoreline is presented in Fig. 2.2-32. The curve is similar to that in the west coast of the Peninsula. The material is composed of 100% sand with a median diameter d50 at 0.2 mm, and with uniform sand of uniformity coefficient at 1.9.

Coastal Change

The river mouth configuration formed under these conditions is normally characterized with the development of a sand spit from one side bank at the river mouth, which tends to shift the river mouth depending on force balance between the wave and river flow discharge.

The shorelines for the year 1972, 1978 and 1984 were interpreted from the aerial photographs as shown in Fig. 2.2-55. As shown in the illustration, numerous beach ridge developments are found in both banks and implies coastal accretion in a long time range. The illustration also shows that the right bank is generally stable with

slight erosion from 1978 to 1984, probably of some human action, and in the left bank, the sand bar is becoming thinner and the shore is eroded. The shoreline retreated 150 m for 12 years from 1972 to 1984 at the most severe point.

2.10 Papar River Mouth

The Papar River Mouth is selected as the representative river mouth in Group 9, where the river mouth is formed by the external force of high and oblique waves and small tidal prisms on a protruding coastline (refer to Table 2.2-1).

Topography

The Papar River has a catchment area of 770 km^2 and a total length of 70 km. The river mouth is located on a northwest facing coast about 30 km SSW of Kota Kinabalu, the capital of Sabah, in East Malaysia. Northern mountain ridges in Borneo Island run parallel to the coast in SW-NE direction about 30 km inland with Mount Kinabalu in the northeastern end as shown in Fig. 2.2-56.

Only a narrow flat land is developed between the mountain and the coast with an average width of about 5 km near Kota Kinabalu. The coast where the Papar River Mouth is situated presents a gently protruding coast formed by sediments carried from the mountains. A wide low flat land formed by the Padas River extends southwest of the Papar River Mouth.

The river mouth is located at a corner where a flat NNE-SSW coast in the right bank of the mouth suddenly changes to N-S coast. In the northeastern plain, numerous beach ridge developments are found proving coastal accretion in a long time range. The river channel is heavily meandered in the downstream stretch and the mouth is thrust to the west.

External Force

The Papar River Mouth is exposed to the South China Sea and subject to extreme wave conditions especially during the North-East Monsoon season which causes waves rushing obliquely to the river mouth. The influence of the Southwest Monsoon on the wave environment is, however, not so significant since the winds blow seaward.

The tidal difference between mean higher high water and mean lower low water is 1.8 m and surface ocean current is about 0.1 m/s from northeast to southwest in December and 0.3 m/s from the same direction in June. The tidal prism of the Papar River Mouth is relatively small with 6 km of tidal intrusion and an average river width of about 30 m.

Offshore and River Mouth Topography

As shown in the navigation chart of this area (see Fig. 2.2-57), the north facing shore to the east of the river mouth and the west facing shore to the south of the river mouth present different gradients. In the north facing shore, 20 fathoms line is about 25-30 km offshore, while in the west facing shore, it is 50 km offshore. The gradients to this line are 1/750 and 1/1,400, respectively.

The off-the-mouth seabed gradient is steep at about 1/50 in both sides, the offshore seabed contour line show a protruding river mouth terrace formation to the elevations of about LSD -4 m as shown in Fig. 2.2-58. This terrace is considered to be a part of the sand spit developed from east to west. The sand spit is sometimes flushed in relation to the external force balance of river discharge and waves.

The inner channel is maintained deep generally below LSD -3 m as shown in the riverbed profile in Fig. 2.2-59.

Bed Material

The shoreline material is composed of very uniform sand similar to that in the other sandy representative river mouths. The median diameter d50 is 0.2 mm and the material is composed of 100% sand (0.062-2.0 mm), with the uniformity coefficient at 1.9.

Shoreline Change in the River Mouth Area

Fig. 2.2-60 compares the shorelines in 1972 and in 1986. The sand spit extends 2 km from the present river mouth location to WSW with a width of about 150 m. The river flows WSW-ward along the sand spit.

In 1986, the sand spit has been cut and the river flows almost straight from the inner channel to the direction of WNW. At the river mouth, terrace exists. In accordance with the aerial observation conducted during the First Field Survey in February 1998 after the monsoon season, there are traces of sand spit offshore in the left bank.

The offshore geomorphology surveyed as shown in Fig. 2.2-58 is of December 1992 and it is in the end of the dry season. Much rainfall in this area is from August to November and the last part of the rainfall season is in the monsoon season when waves are high.

Accordingly, the sand spit presumably develops to the west in the year when river discharge is not so large, and it is flushed to form terrace in the year when river discharge is dominant.

The outer channel's shallowest elevation in the natural condition is considered at LSD -1.1 m from the survey results.

3. GEOMORPHOLOGY OF FEASIBILITY STUDY RIVER MOUTH

3.1 Tanjung Piandang River Mouth

The Tanjung Piandang River Mouth, which has a catchment area of 9 km^2 and a channel length of 10 km, is located on a relatively straight coastline with a shallow shore zone having a very gentle gradient of 1/1500. Over the long term period of 25 years or more, the south coast had undergone shoreline changes at the average rate of 10 m/year as determined in the Master Plan Study. Siltation is caused by tidal current in the Strait of Malacca and the predominant direction is from NNW to SSE. The survey data of the present JICA Study Team presents less profile changes during the two survey periods. By comparing the data of the two bathymetric surveys

conducted, short term profile changes were observed, as described below. (Refer to Fig. 2.3-1 to 2.3-3.)

(1) Inside of the River Mouth

The waterline has not changed much, except at a few locations where deposits caused by intidal flow were found at the entrance of the stream and at the narrow part of the main channel.

(2) Around the River Mouth

Both sides of the shoreline had erosion, especially the southern beach which had receded by 1 to 2 m. Siltation was observed not only on the river mouth area but on quite a large area from a depth of 0.0 m to -3.0 m. Movement is from south to north, caused by alongshore current. The bottom slope of Tanjung Piandang River Mouth is gentle and some 20 to 50 cm of deposit at each survey line was observed.

3.2 Marang River Mouth

The Marang River has a catchment area of 460 km^2 and a total channel length of 50 km. Its mouth is located 15 km SSE from the Terengganu River Mouth in Terengganu State. Based on the long term profile changes, the shoreline of the stretch of 70 km from the Terengganu River Mouth to the Dungun River Mouth consists of a continuous sandy beach with a straight coastline and is generally aligned in a N35W direction.

The dominant wave direction around this area is from ENE to NNE and the angle between orientation of shoreline and wave direction (assumed NE) is about 80°. In general, the equilibrium shoreline is perpendicular to the wave direction without evaluating the characteristics of topography and/or sand supply and demand are in equal volume at a certain wide area.

The shoreline from Dungun in the north up to Merang passing through Terengganu may likely be in equilibrium, because the angle of the orientation of shoreline and wave

direction is nearly 90° and the balance of sand movement from upstream to downstream with alongshore current is maintained at the same bottom profile.

As for the short term profile changes, they are reflected from the two bathymetric survey data, as summarized below. (Refer to Fig. 2.3-4 and 2.3-5.)

(1) Inside of the River Mouth

The two bathymetric survey results show that some sediment have been transported from the upper stream. The cross section at each survey line shows that sediment was not deposited at the navigation channel but in other shallow areas, and the channel can be maintained because of the constant flow capacity. The deepest point of the cross section may shift to another place, but it will keep an almost the same profile.

(2) Around the River Mouth

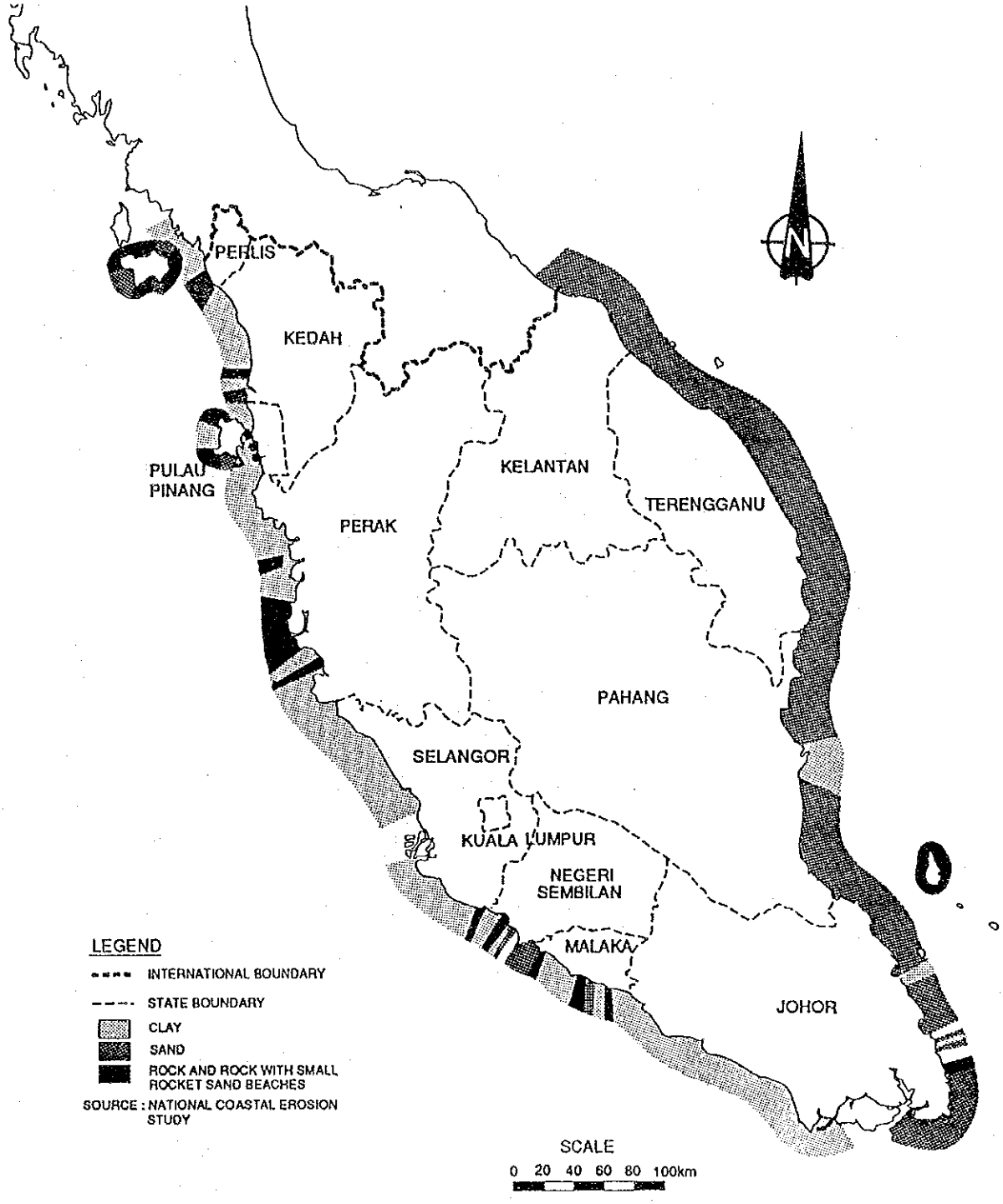
The survey observation data cover only six months from the beginning of the northeast monsoon season; hence, it might be hard to know the annual beach profile changes. However, high waves concentrate on this season and, generally, it is a good period to observe changes in topography. Comparison of the survey data shows that the limit of sediment movement could be between LSD -4 m and LSD -5 m and the beach profile further from the river mouth shows a lesser change. There are some sediment deposited near the river mouth transported from the upper stream of Marang River and by alongshore current, especially those transported from the river and pushed back by wave forces. Therefore, sand accretion in front of the river mouth is developing based on storm wave attack.

TABLES

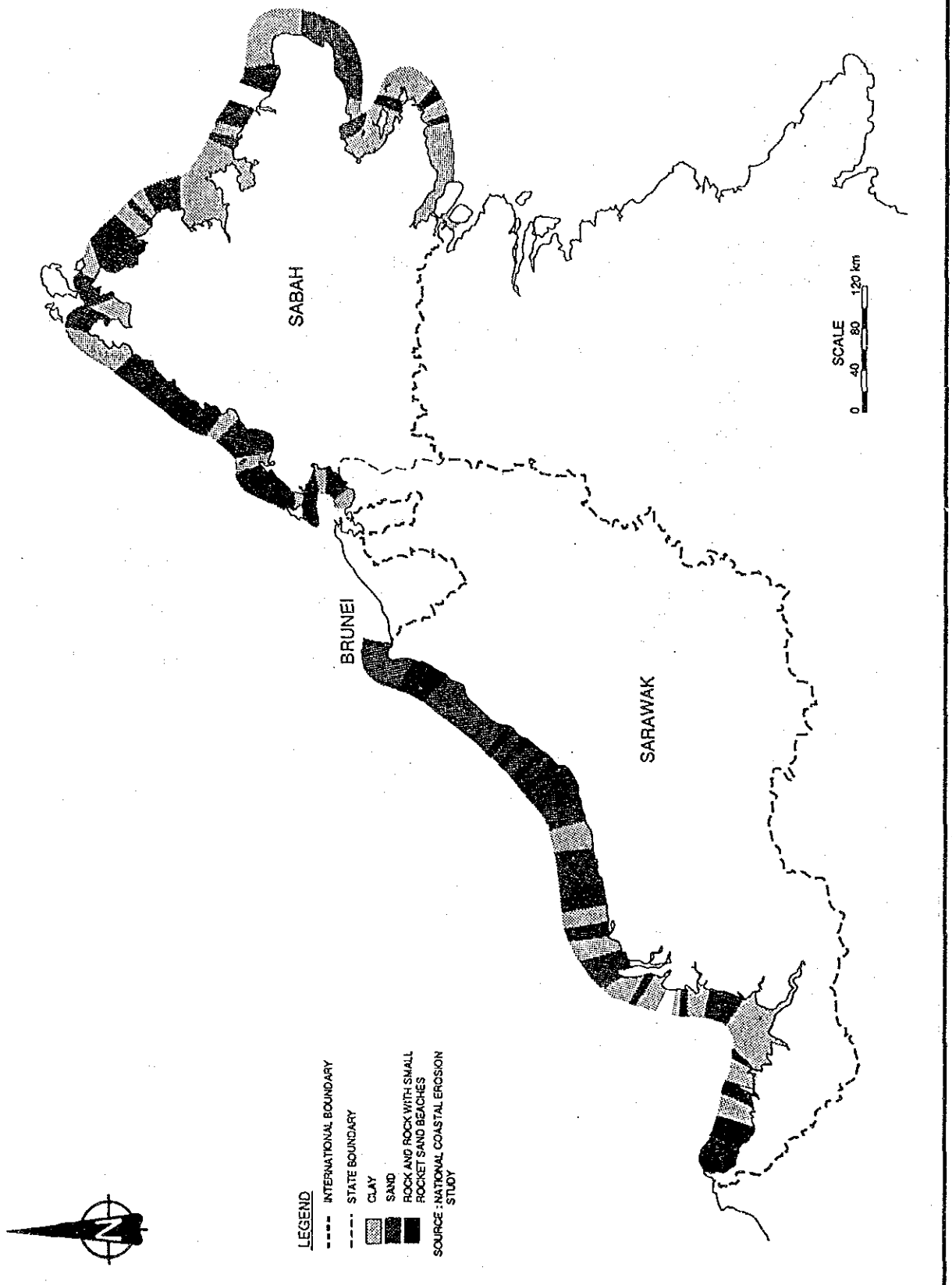
Table 2.1-1 REPRESENTATIVE RIVER MOUTH OF EACH GROUP

Serial	River Mouth	Group No.	Coastal Geomorphology	External Force		Catchment Area (km2)	River Length (km)	Stretch of Tidal Influence (Km)	Average River Width (m)
				Wave	Tidal Prism				
1.	Perlis	4	Straight	Low	Large	600	45	20	60
5.	Kedah	10	Protruding	Low	Large	3060	110	12	200
14.	Tg. Piandang	5	Straight	Low	Small	9	10	1	25
19.	Beruas	7	Estuary	Low	Large	240	45	7	50
53.	Kuantan	2	Straight	High & Oblique	Large	1710	80	25	130
57.	Kerteh	3	Straight	High & Oblique	Small	240	40	5	30
61.	Marang	1	Straight	High & Straight	Large	460	50	20	80
62.	Terengganu	8	Protruding	High & Straight	Large	4650	180	22	200
80.	Oya	6	Estuary	High & Oblique	Large	1820	150	25	150
90.	Papar	9	Protruding	High & Oblique	Small	770	70	6	30

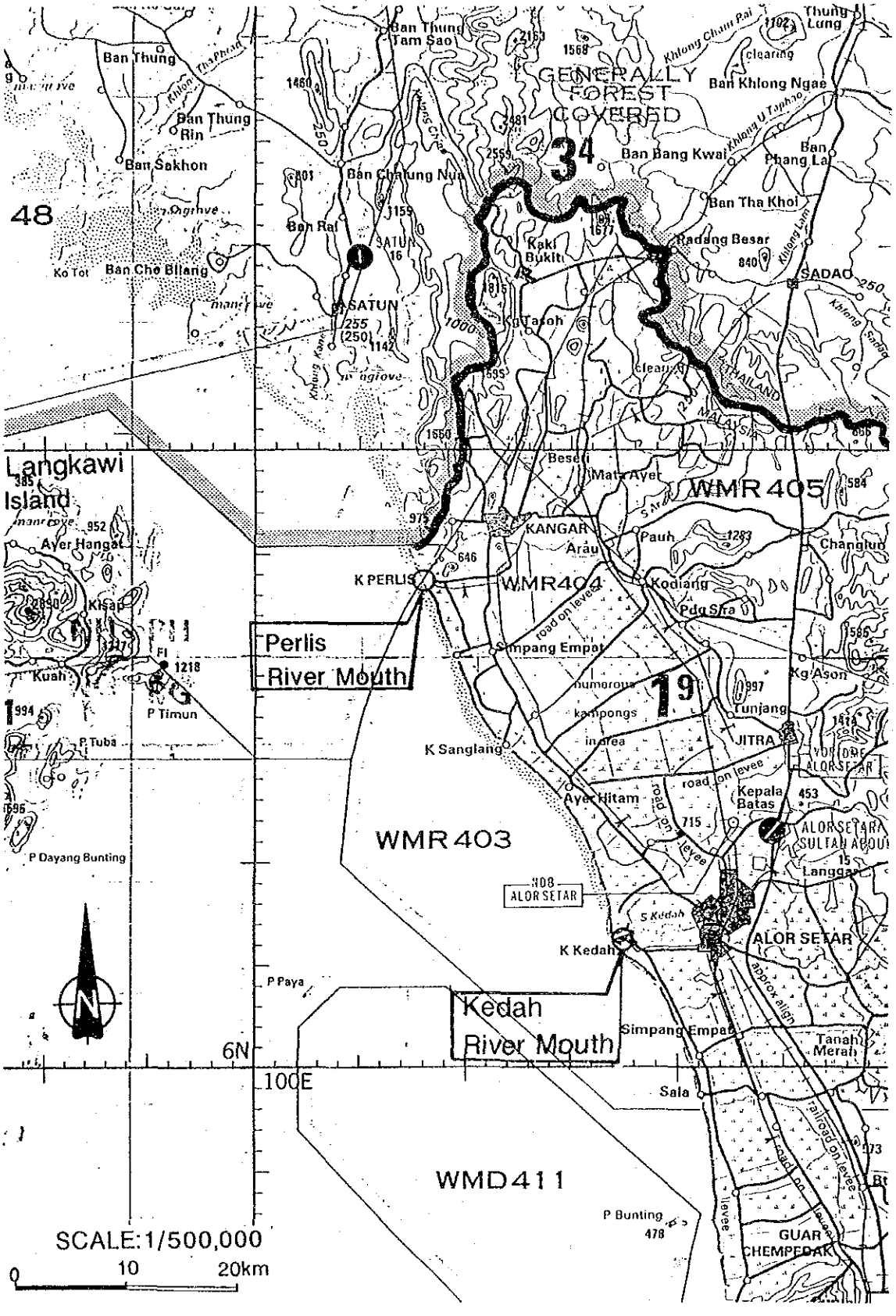
FIGURES



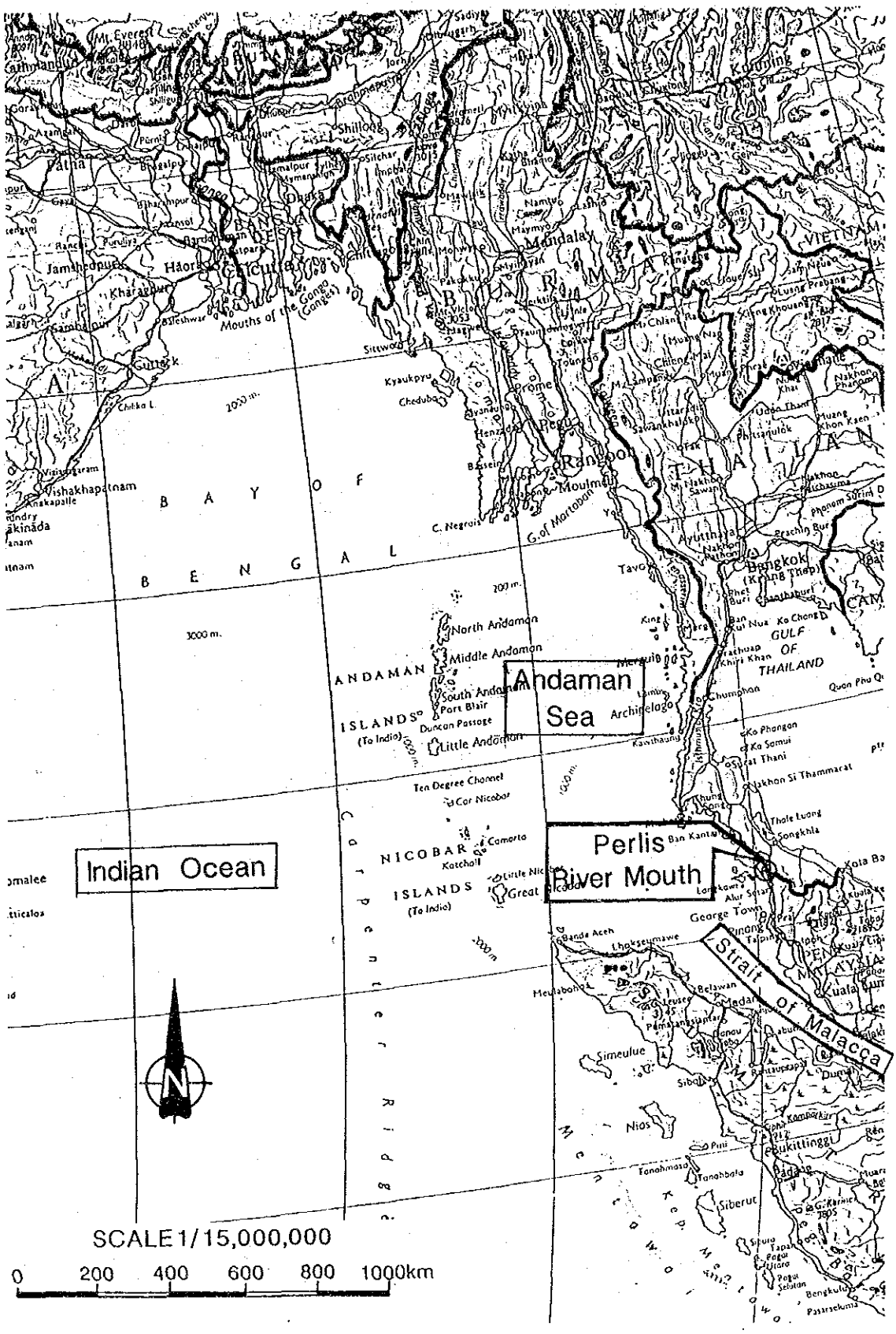
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION OF SHORELINE MATERIAL (PENINSULAR MALAYSIA) Fig.2.1-1(1/2)



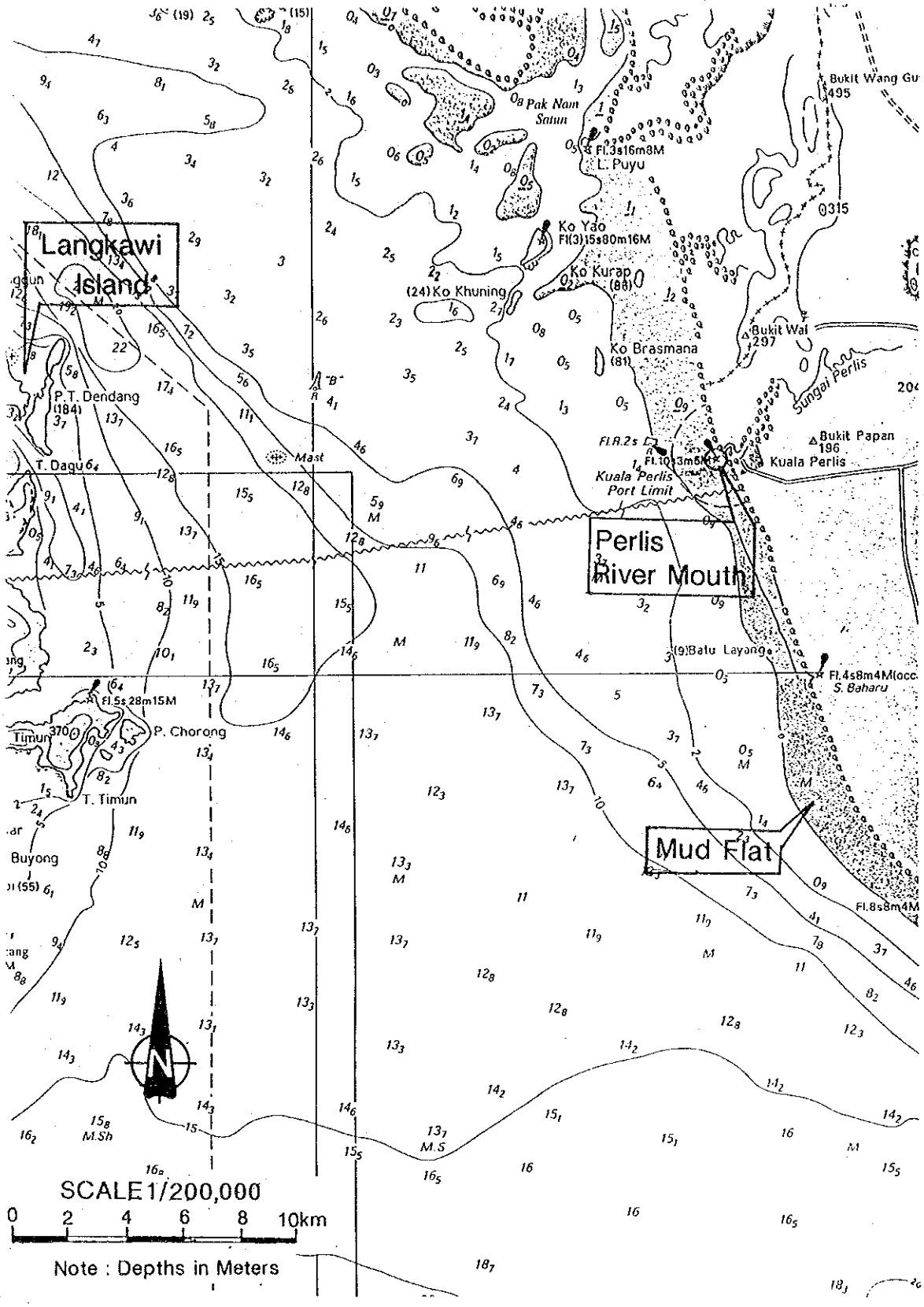
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	DISTRIBUTION OF SHORELINE MATERIAL (SABAH AND SARAWAK)
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.1-1(2/2)



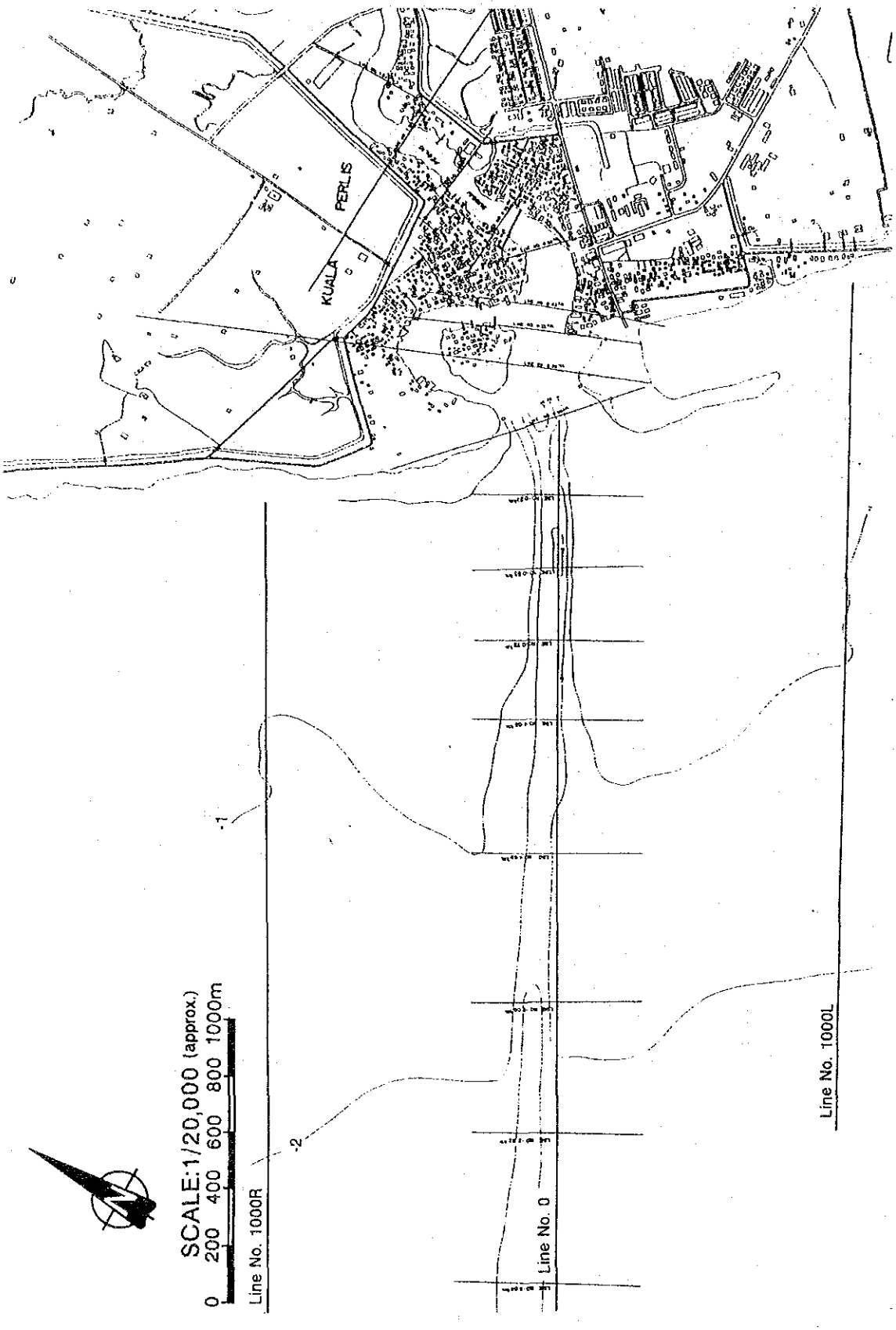
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TOPOGRAPHICAL MAP AROUND PERLIS AND KEDAH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-1



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	LOCATION OF ANDAMAN SEA AND PERLIS RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-2

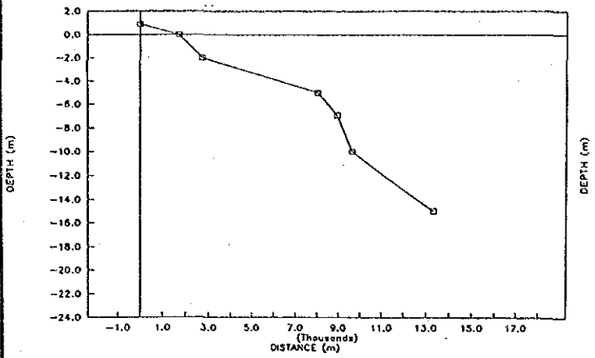


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN PERLIS RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-3

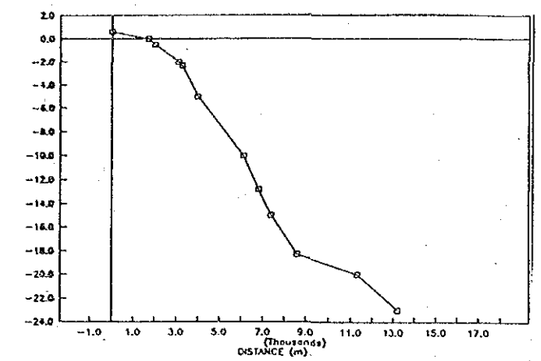


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	DEPTH CHART OF PERLIS RIVER MOUTH SURVEYED IN 1992 Fig.2.2-4

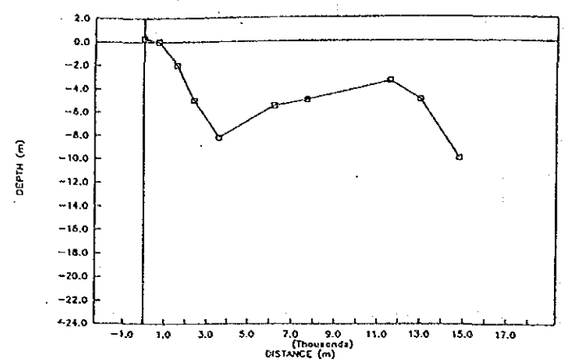
PERLIS



KEDAH



TANJUNG PIANDANG



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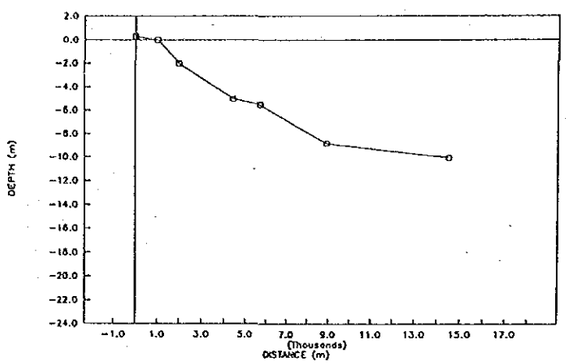
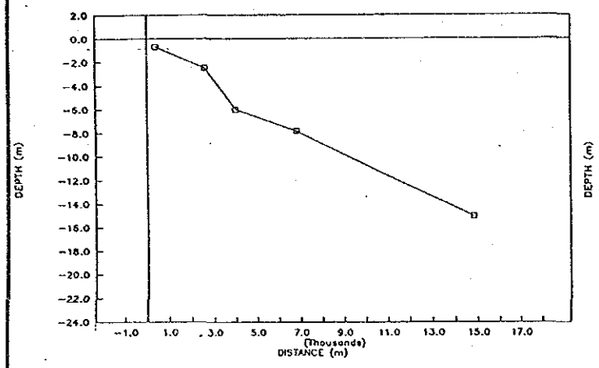
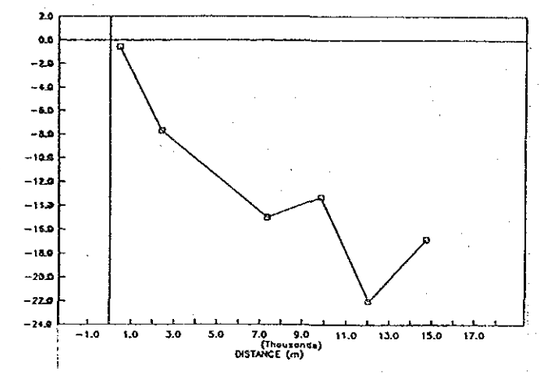


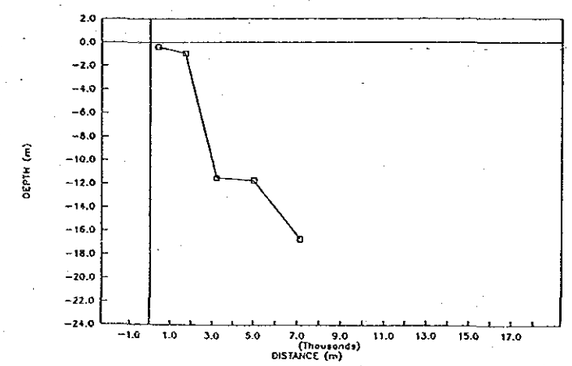
KUANTAN



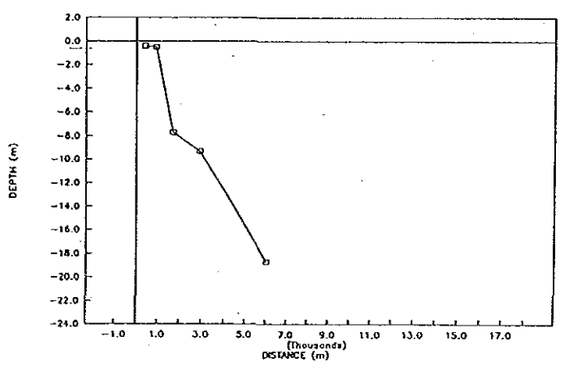
KERTEH



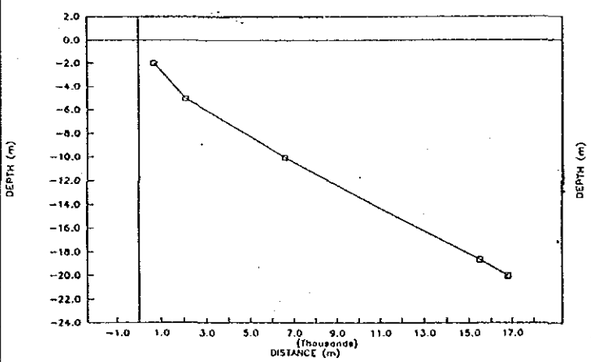
MARANG



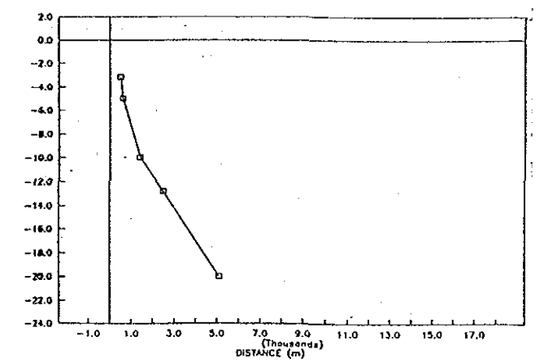
TERENGGANU



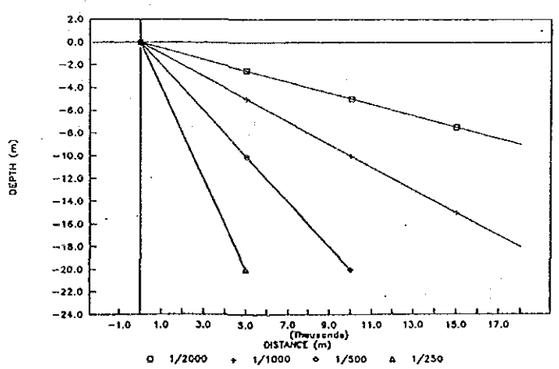
OYA



PAPAR

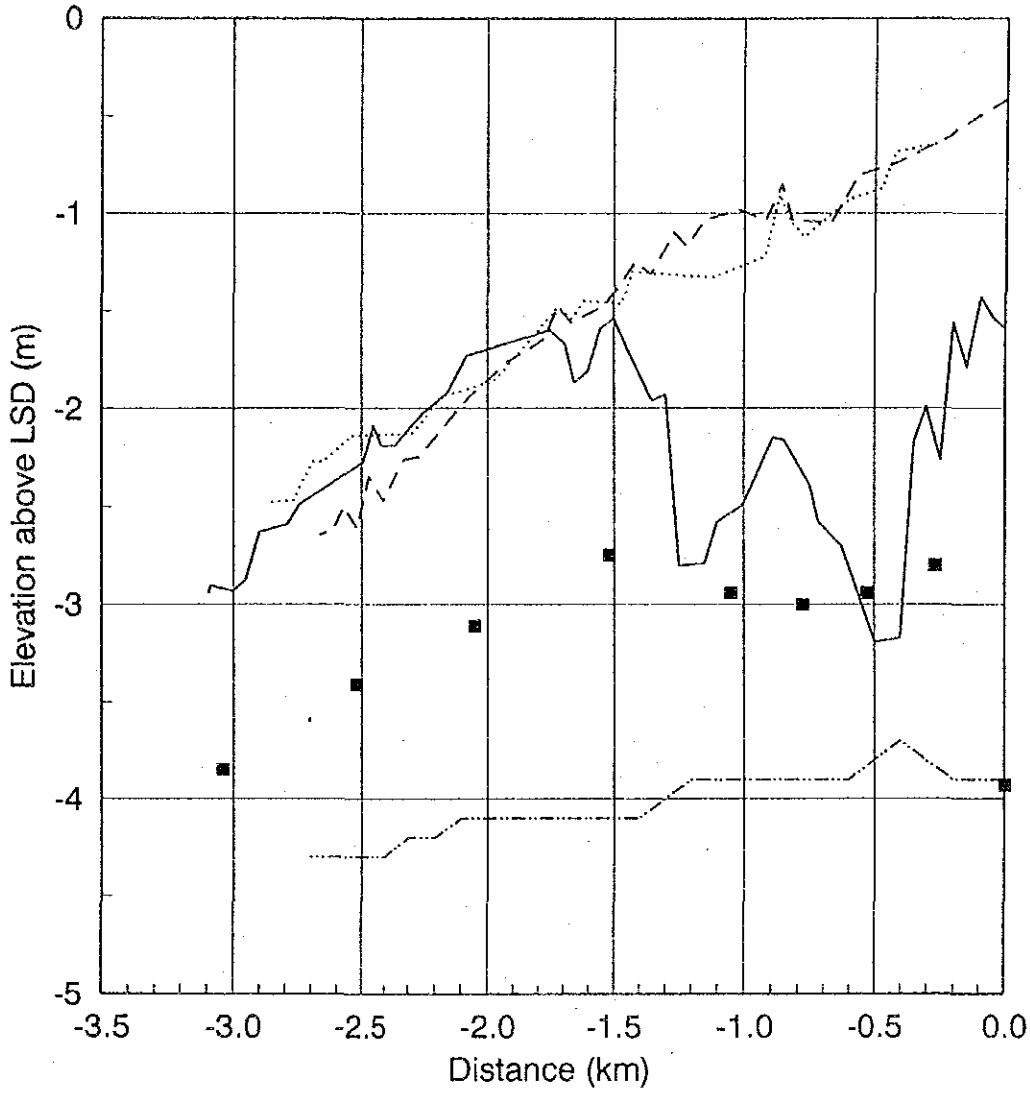


LEGEND

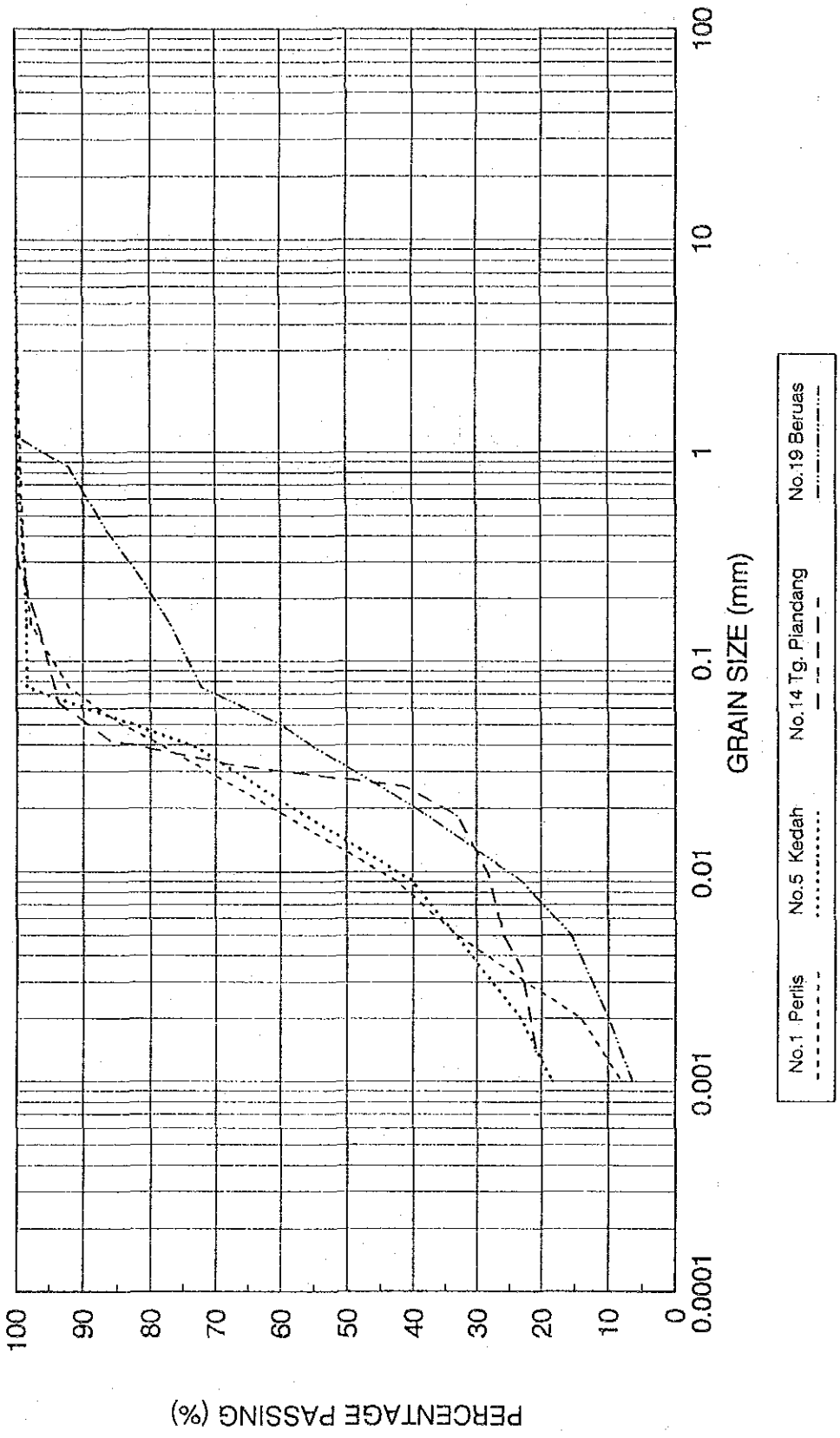


Note : Datum is Chart Datum

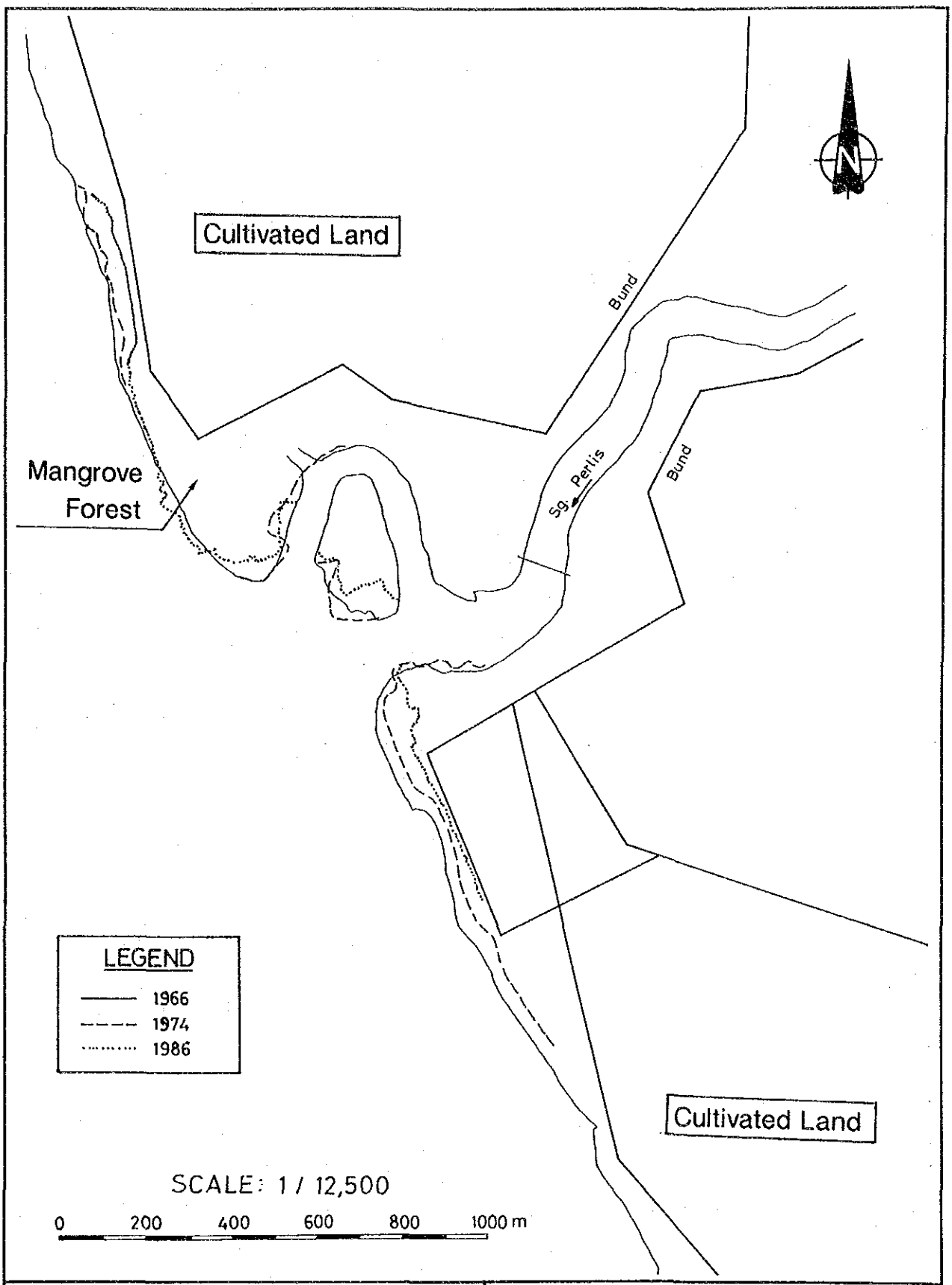
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	SHORE PROFILE AT REPRESENTATIVE RIVER MOUTH Fig.2.2-5



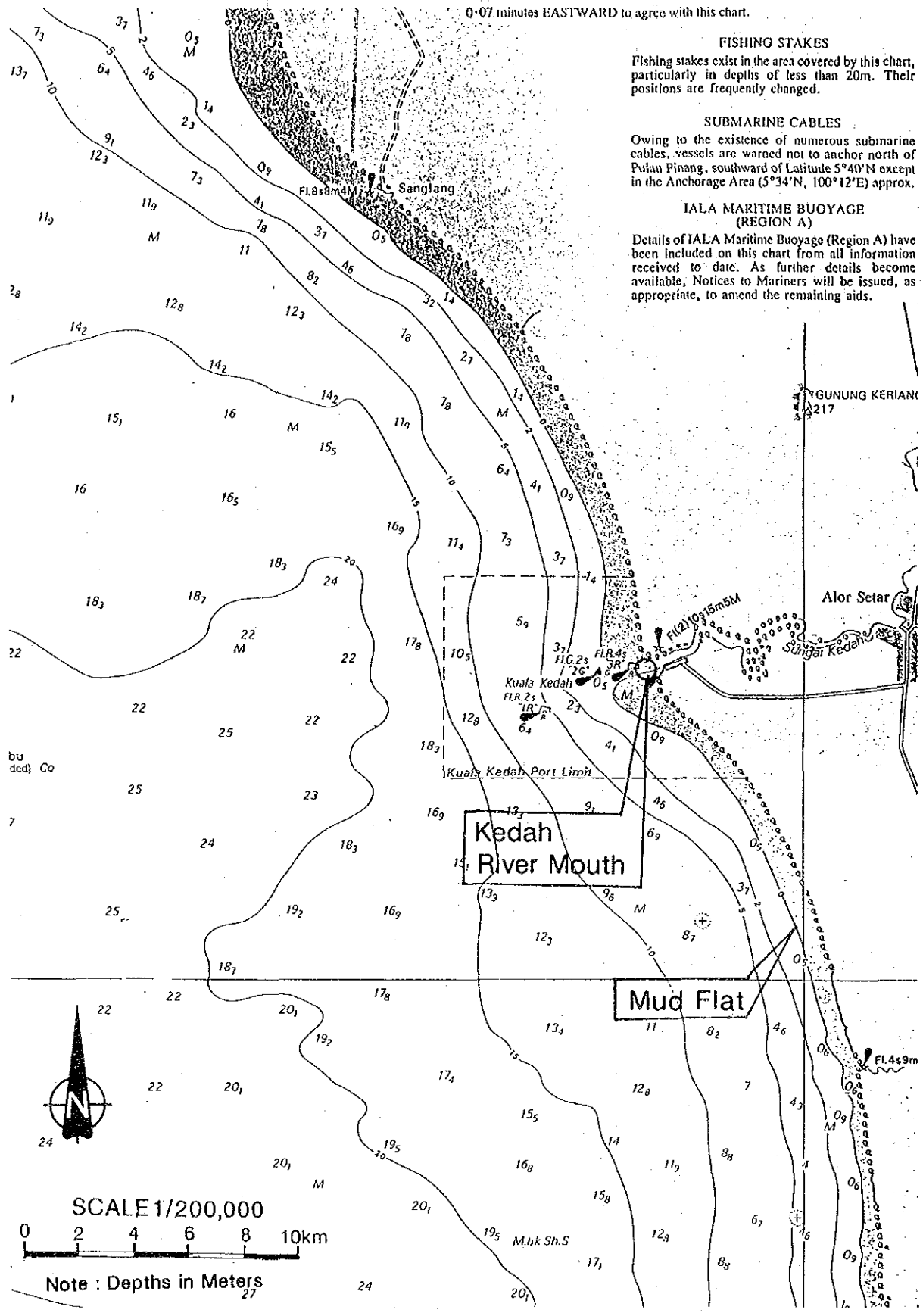
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	OUTER CHANNEL PROFILE AT PERLIS RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-6



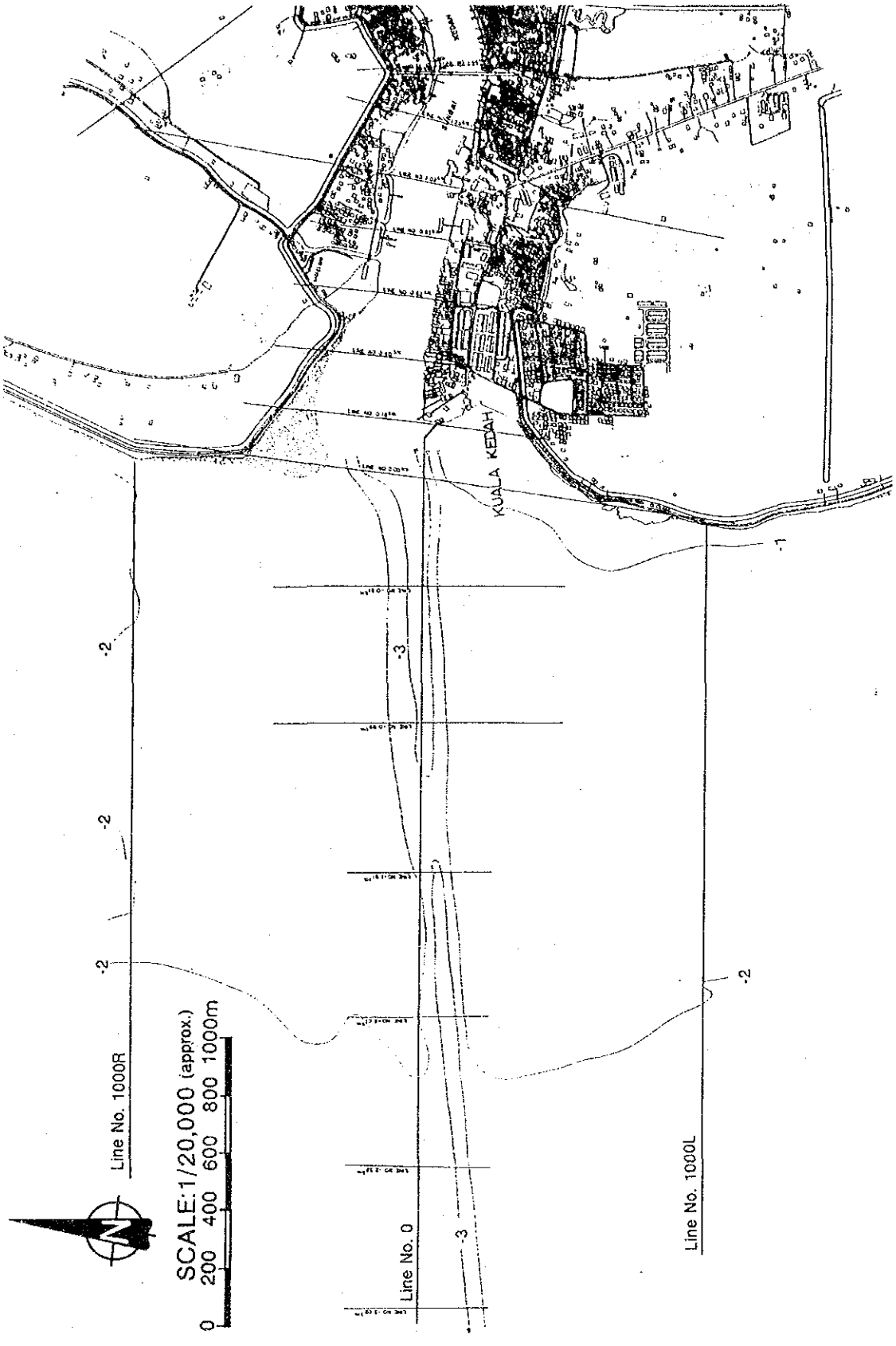
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	GRADATION CURVE OF BED MATERIAL FOR REPRESENTATIVE RIVER MOUTH IN MUDDY COAST Fig.2.2-7



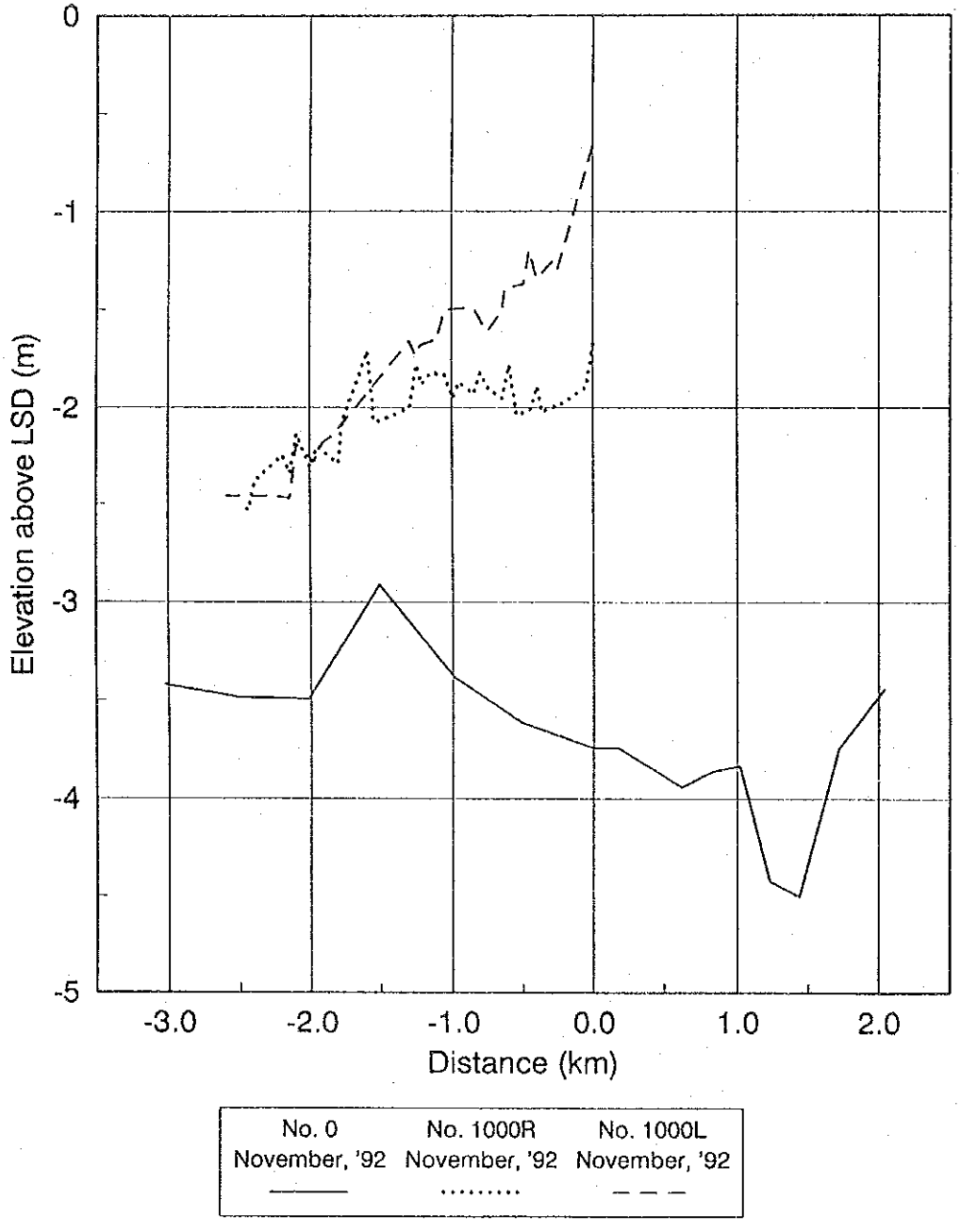
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSITION OF COASTLINE AT PERLIS RIVER MOUTH Fig. 2.2-8



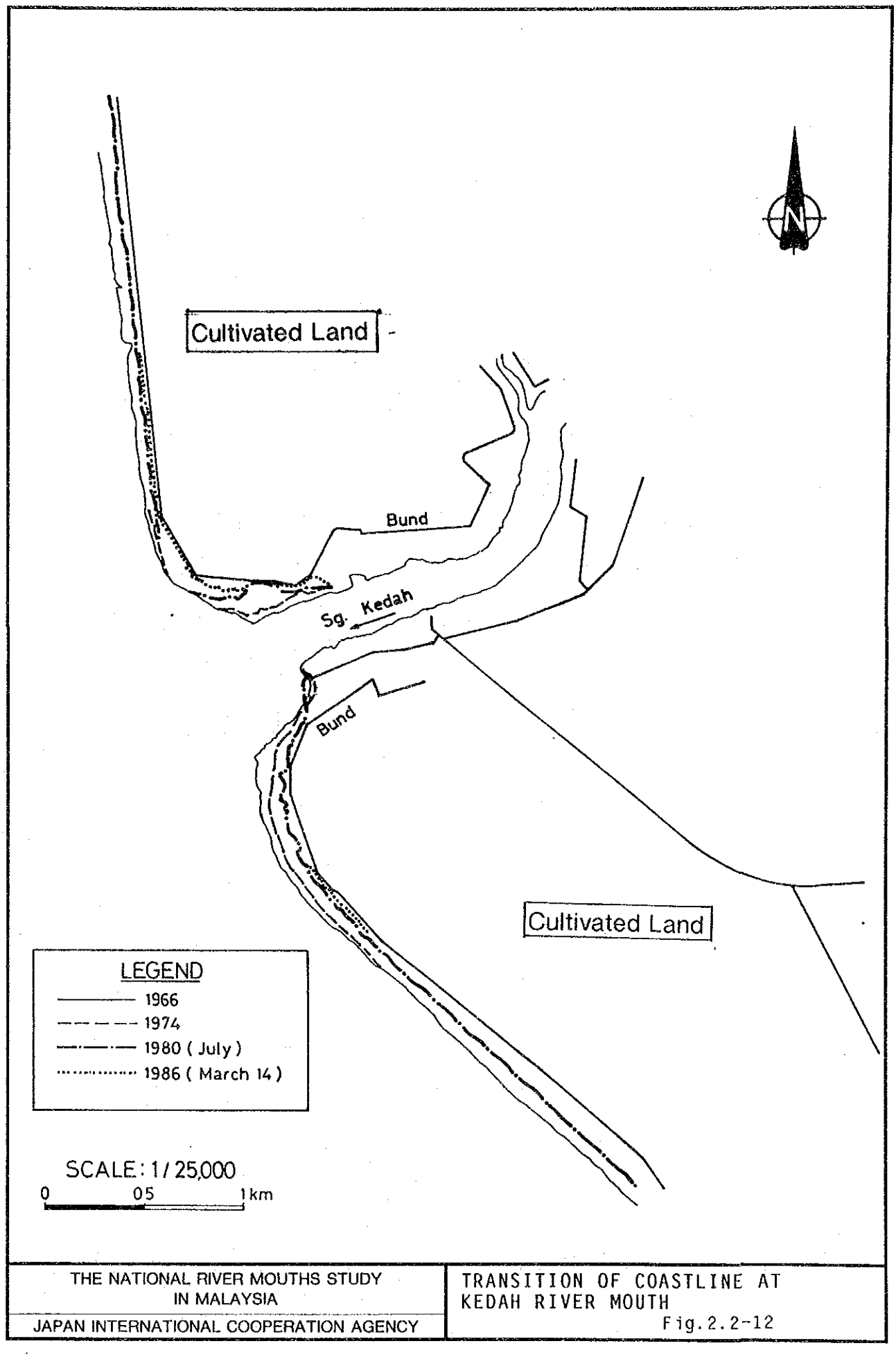
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN KEDAH RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-9



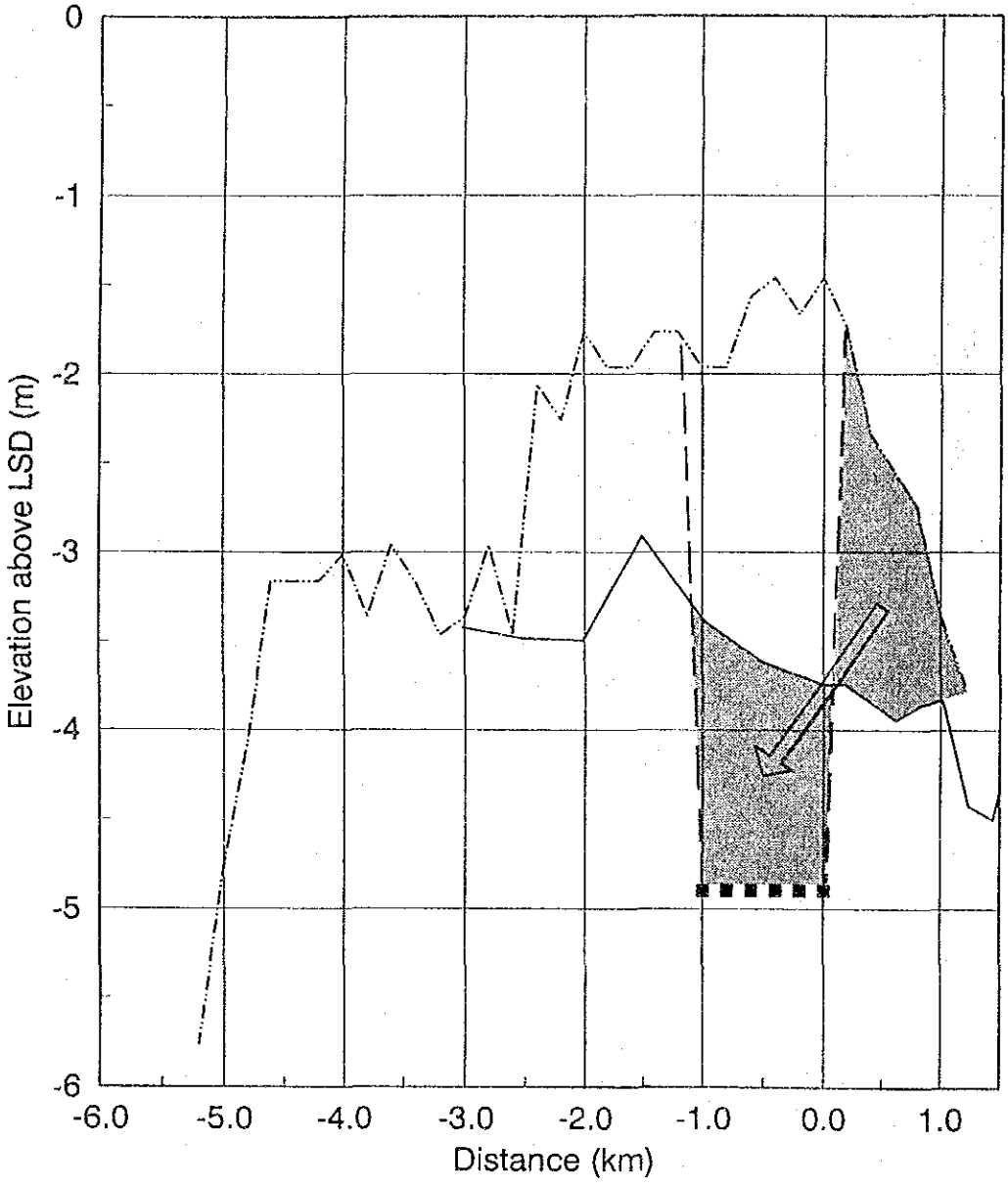
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	DEPTH CHART OF KEDAH RIVER MOUTH SURVEYED IN 1992
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-10



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	INNER AND OUTER CHANNEL PROFILE OF KEDAH RIVER MOUTH Fig.2.2-11

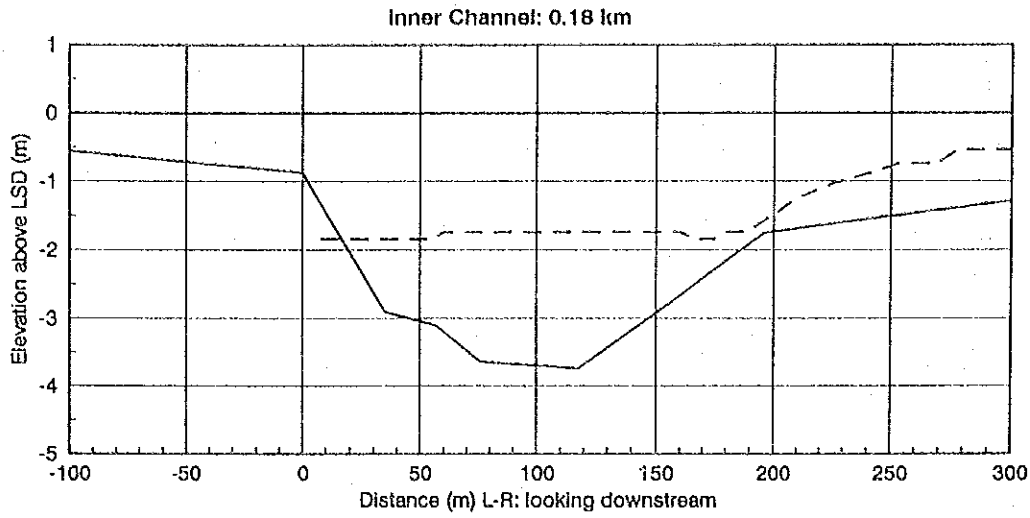


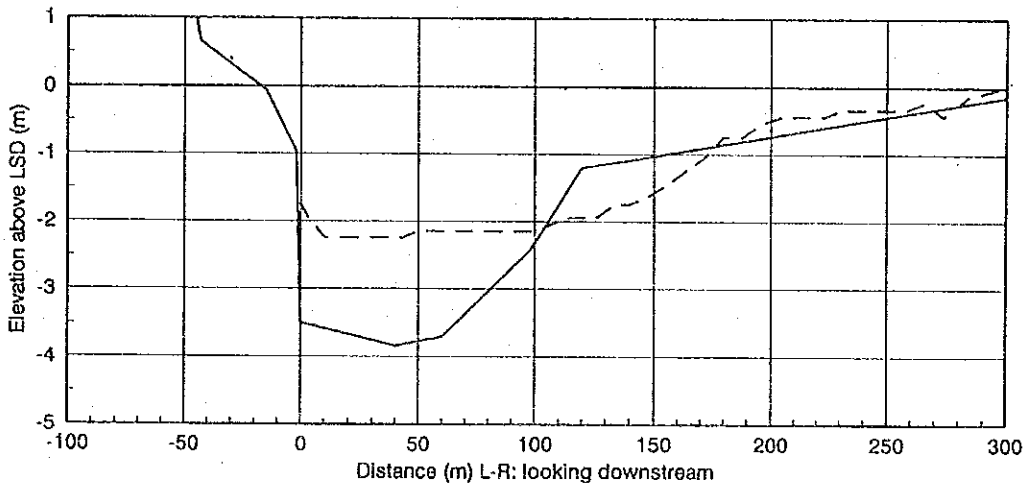
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TRANSITION OF COASTLINE AT KEDAH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-12

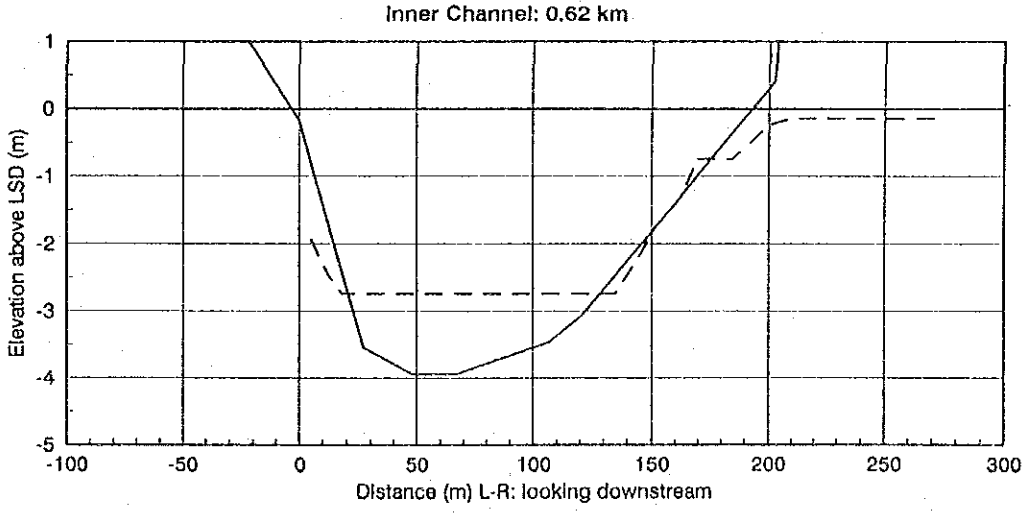


Note :
: Movement of inner channel bottom deposits after dredging of outer channel in September '92 .

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CHANGE OF INNER AND OUTER CHANNEL PROFILE OF KEDAH RIVER MOUTH Fig.2.2-13
JAPAN INTERNATIONAL COOPERATION AGENCY	

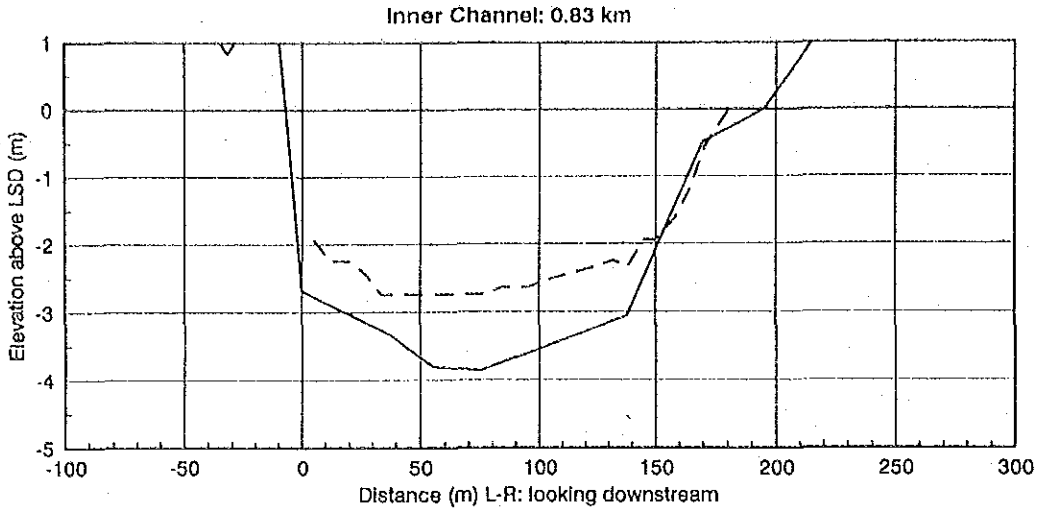


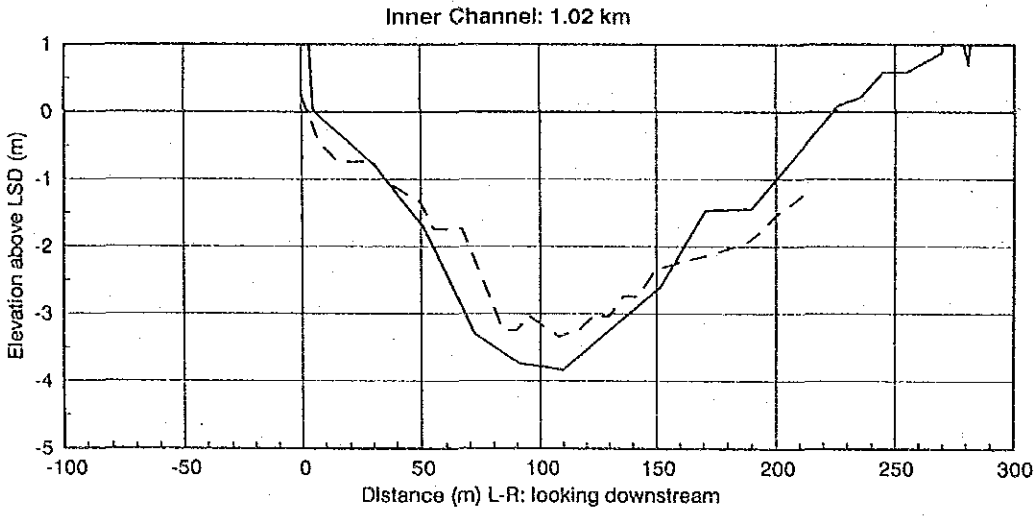


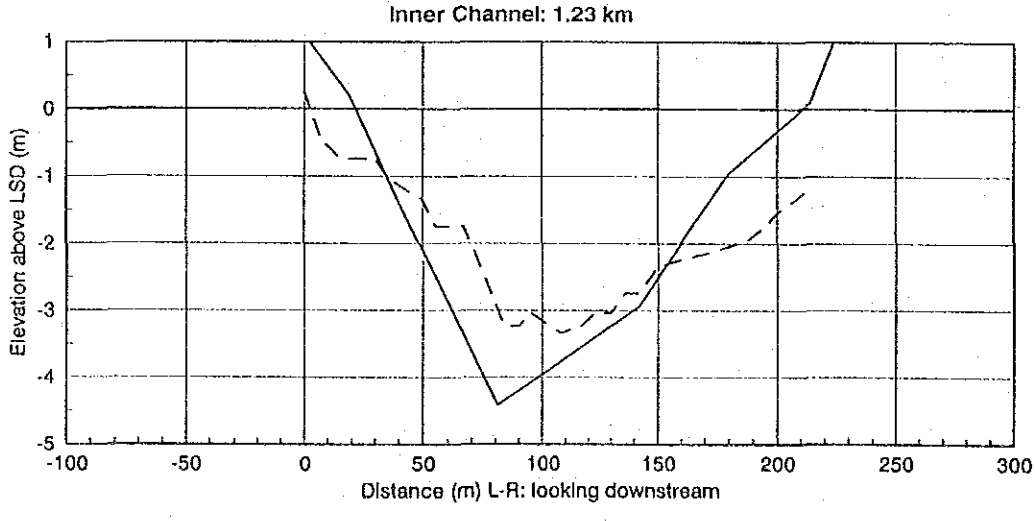


November, '92 June 15-24, '90

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CHANGE OF INNER CHANNEL CROSS SECTIONS OF KEDAH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-14(1/2)

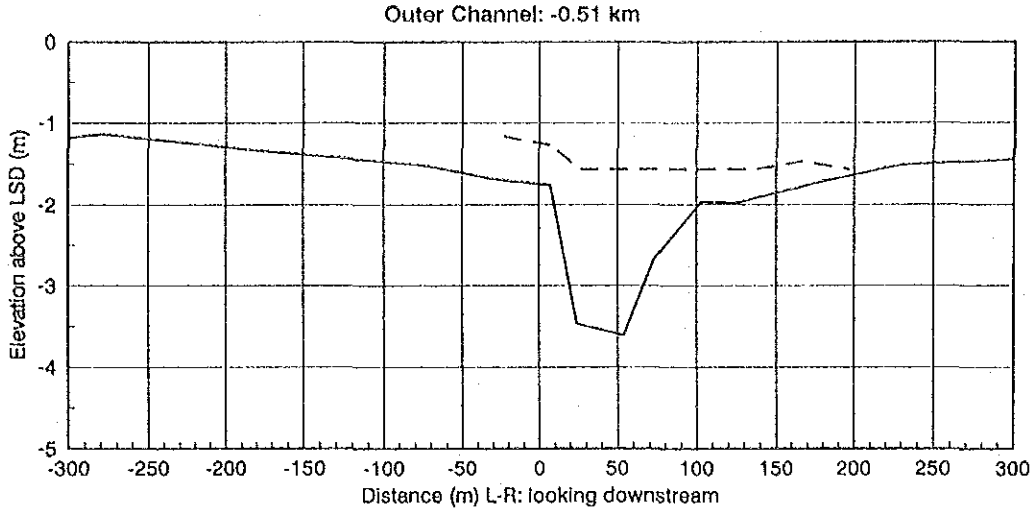


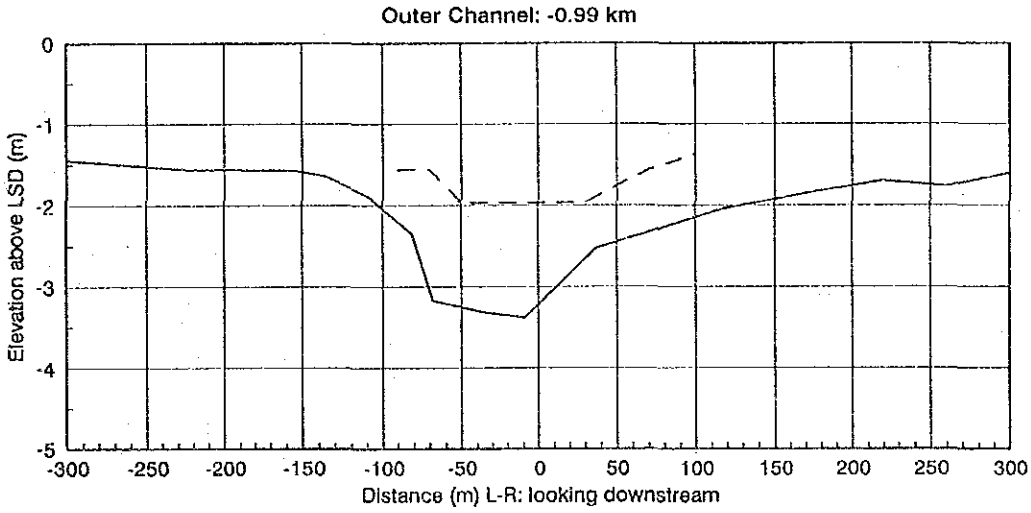


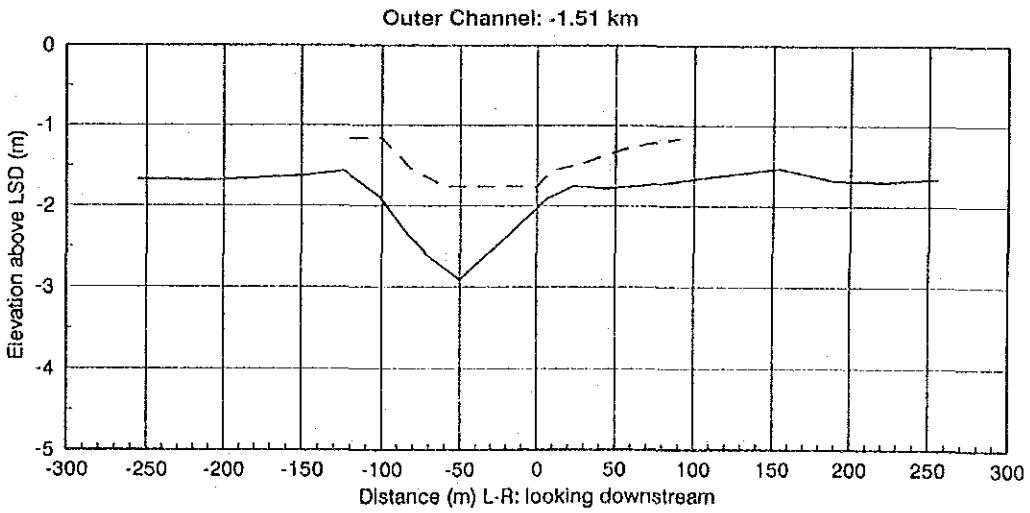


November, '92 June 15-24, '90

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CHANGE OF INNER CHANNEL CROSS SECTIONS OF KEDAH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-14(2/2)

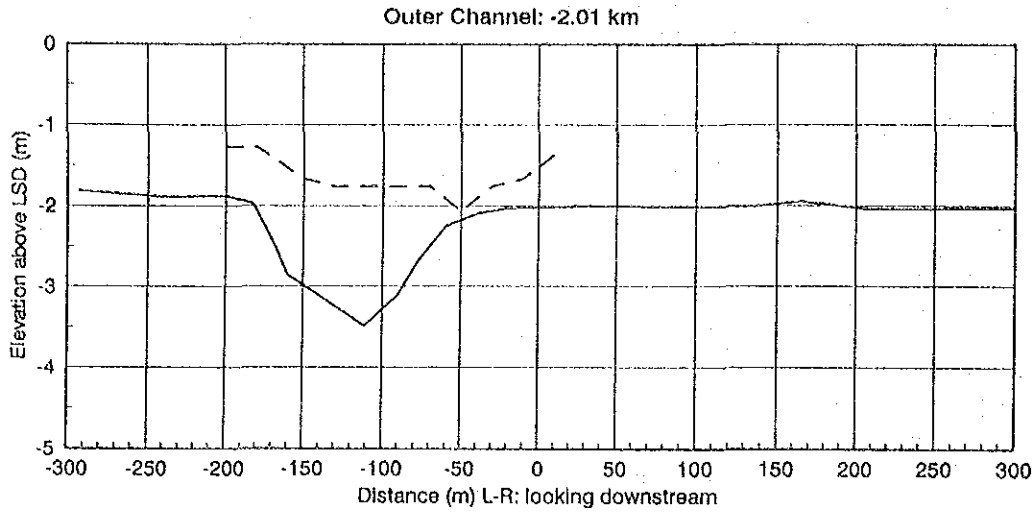


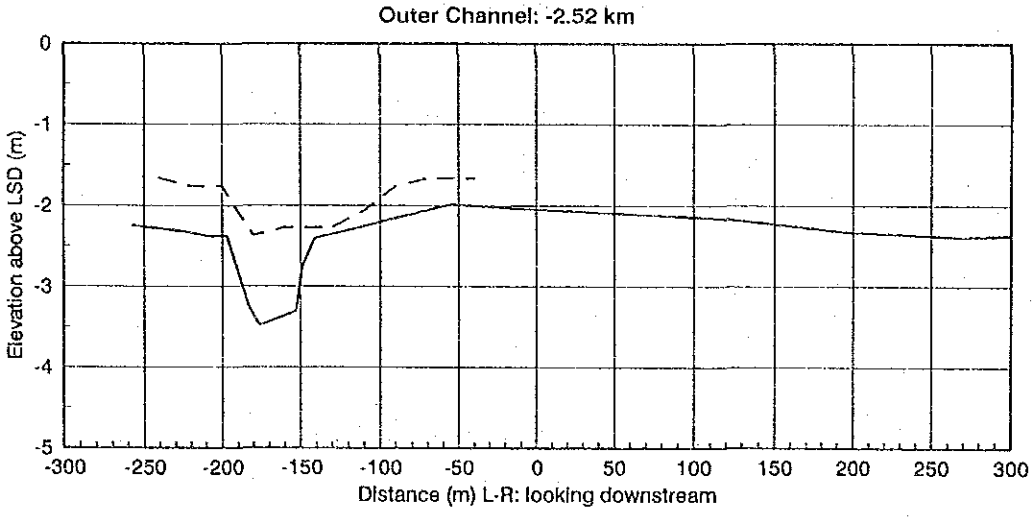


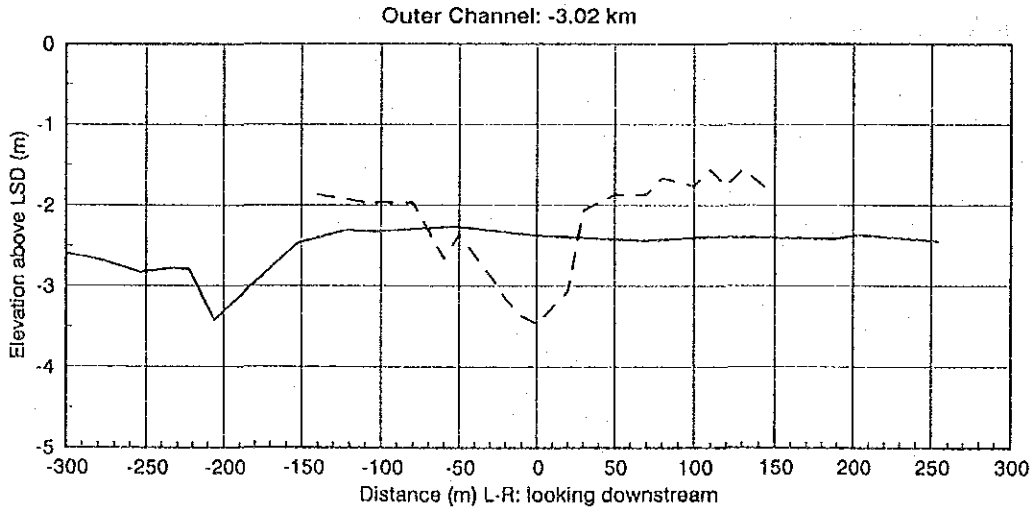


November, '92 March 7-10, '92

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF OUTER CHANNEL CROSS SECTIONS OF KEDAH RIVER MOUTH Fig.2.2-15(1/2)

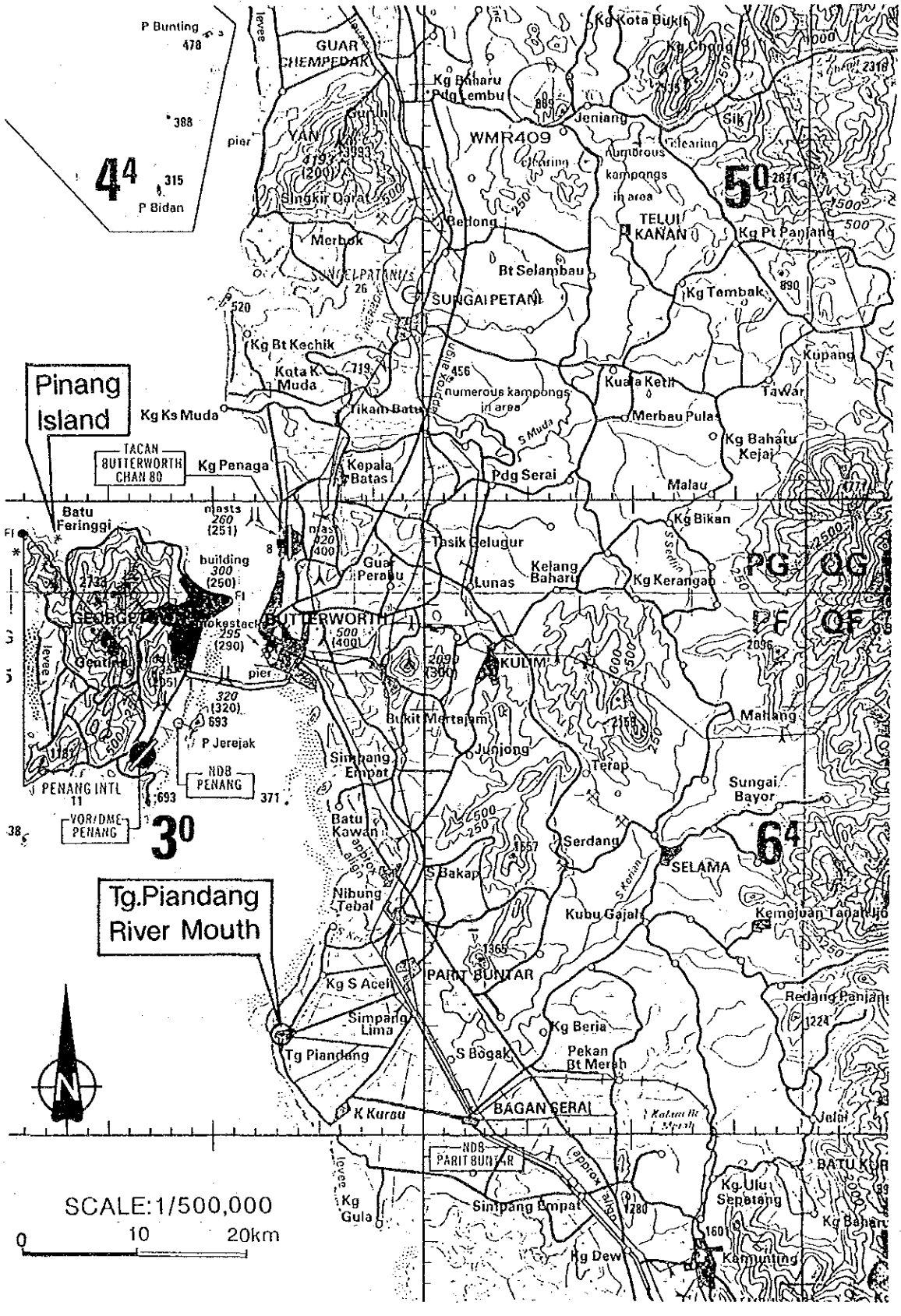




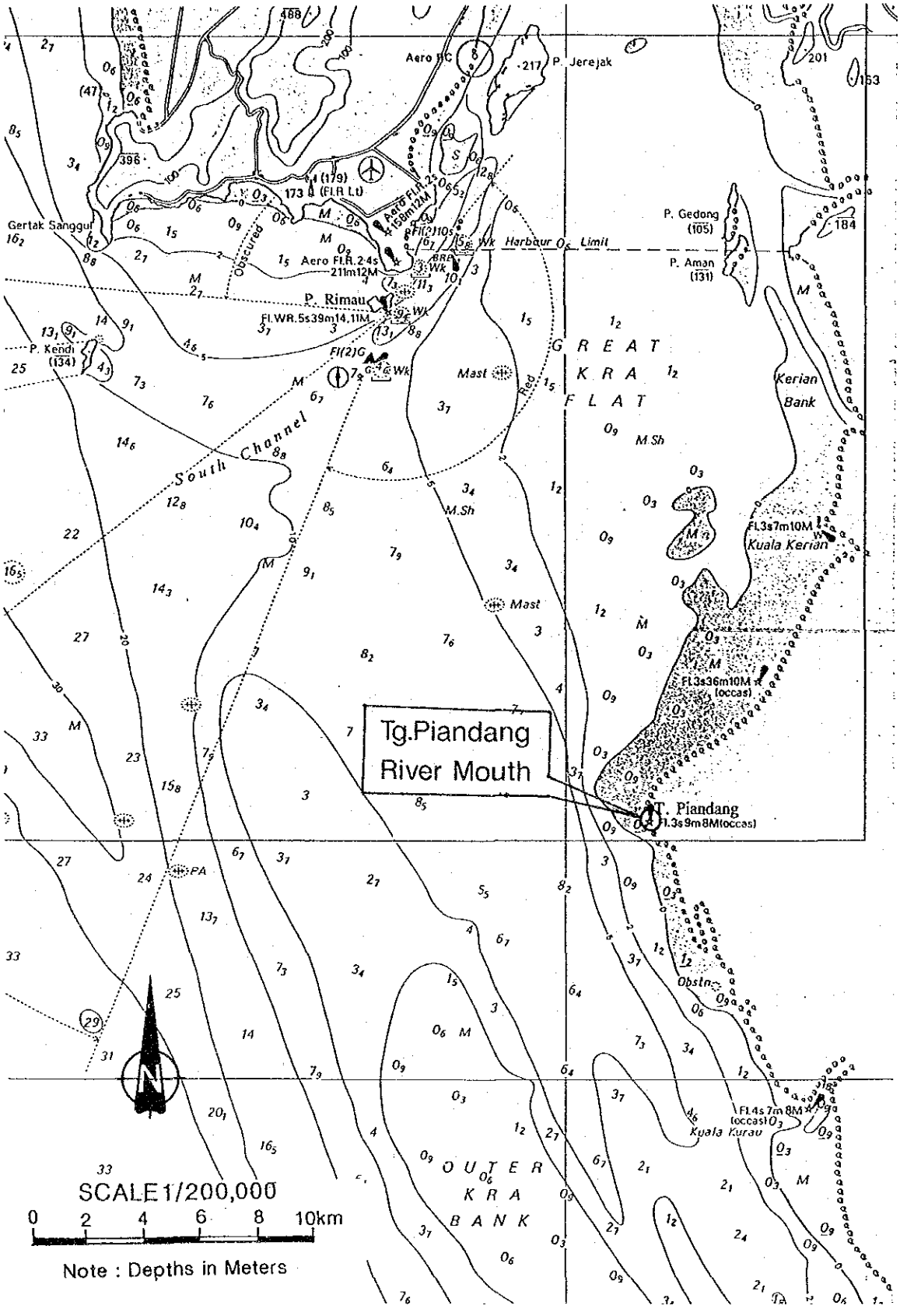


November, '92 March 7-10, '92

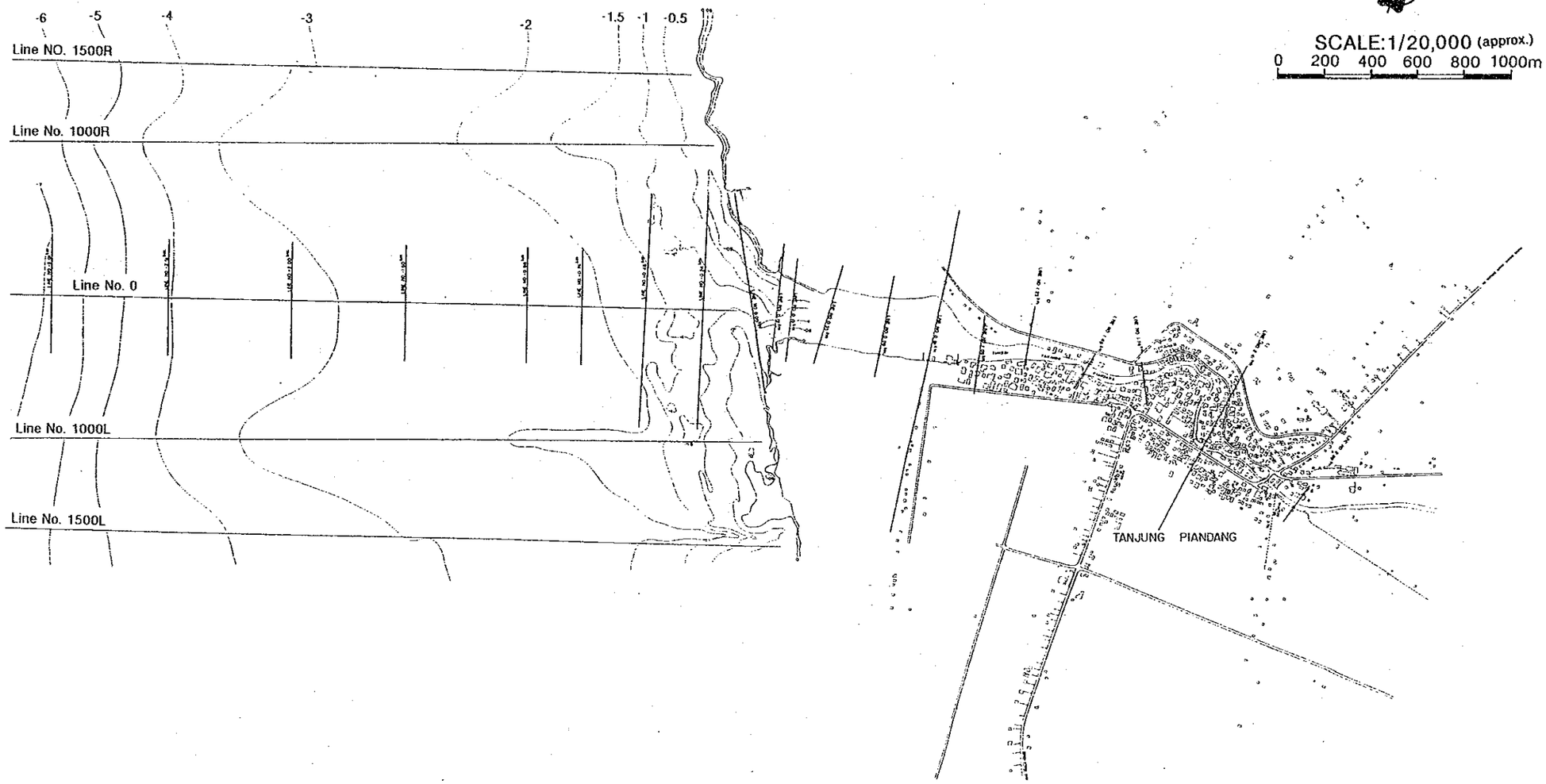
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF OUTER CHANNEL CROSS SECTIONS OF KEDAH RIVER MOUTH Fig.2.2-15(2/2)



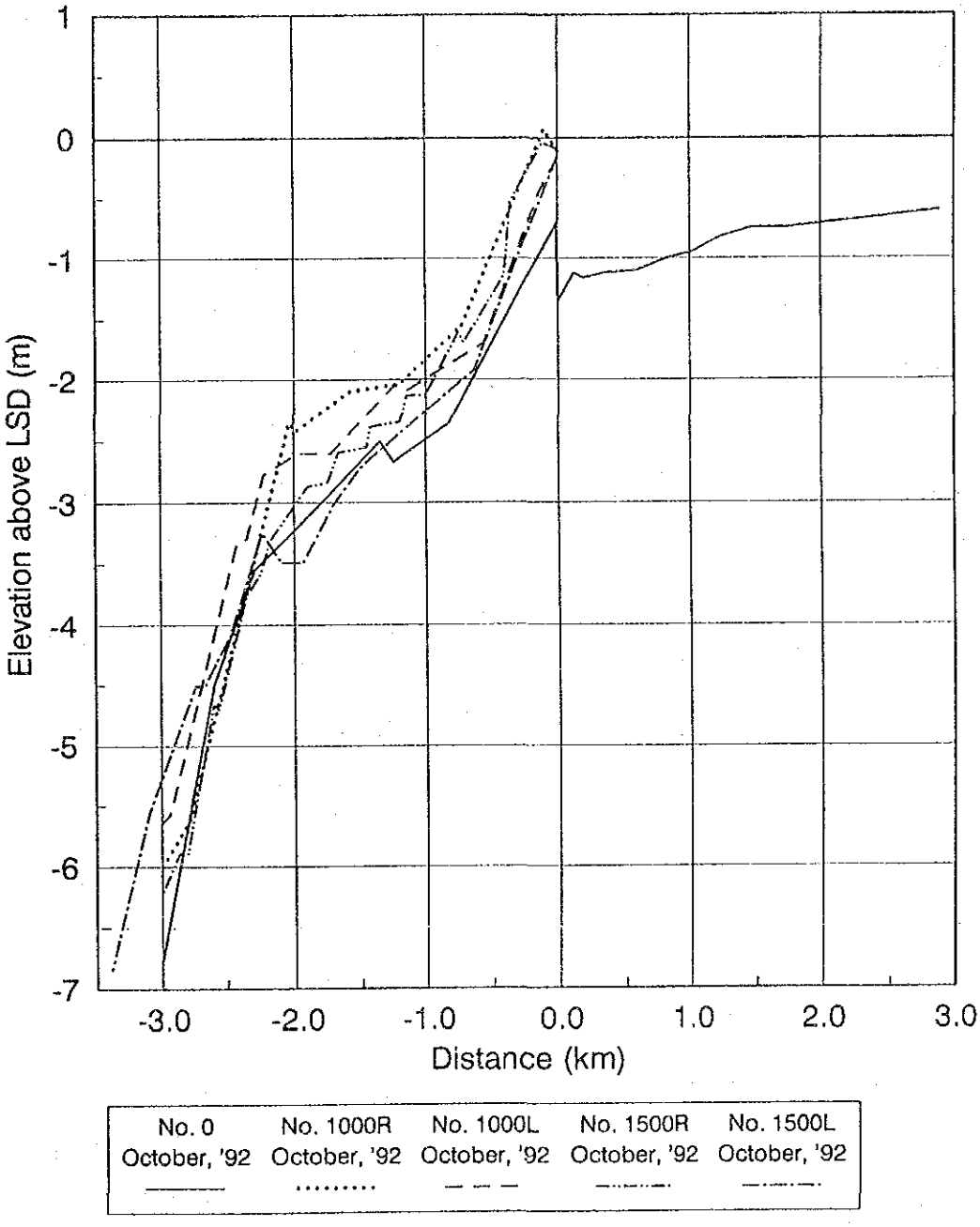
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TOPOGRAPHICAL MAP AROUND TG. PIANDANG RIVER MOUTH Fig.2.2-16



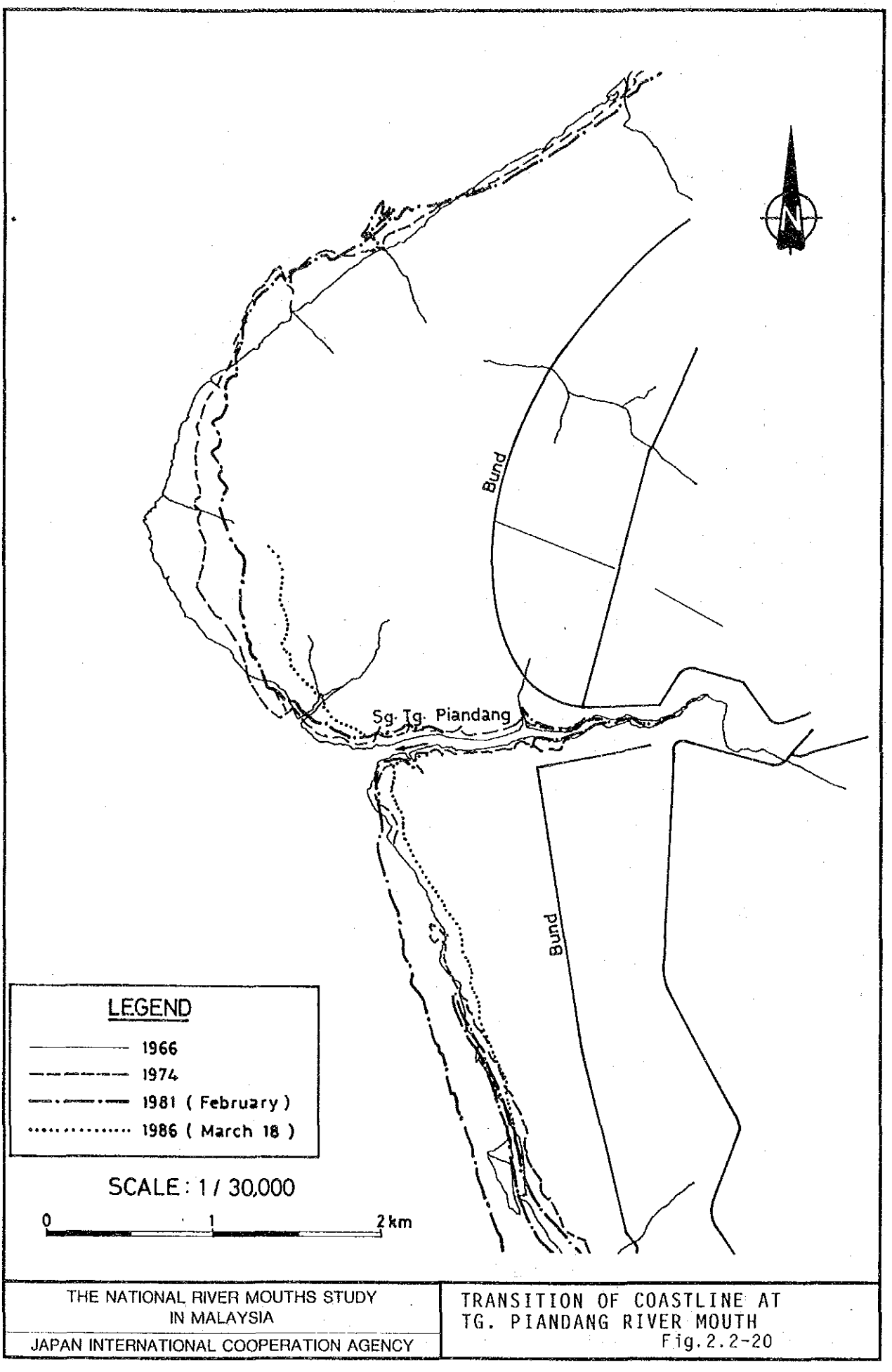
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	NAVIGATION CHART IN TG. PIANDANG RIVER MOUTH AREA Fig.2.2-17



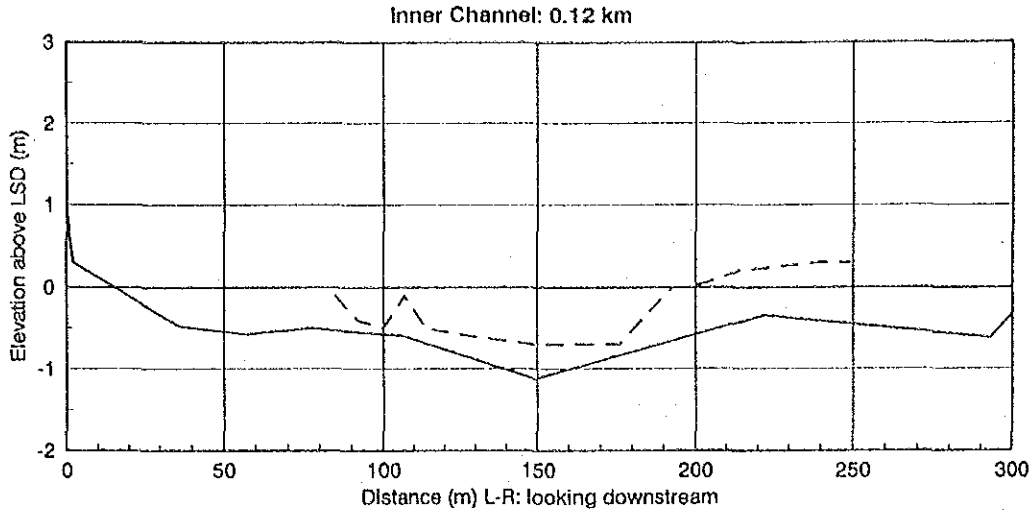
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	DEPTH CHART OF TG. PIANDANG RIVER MOUTH SURVEYED IN 1992 Fig.2.2-18

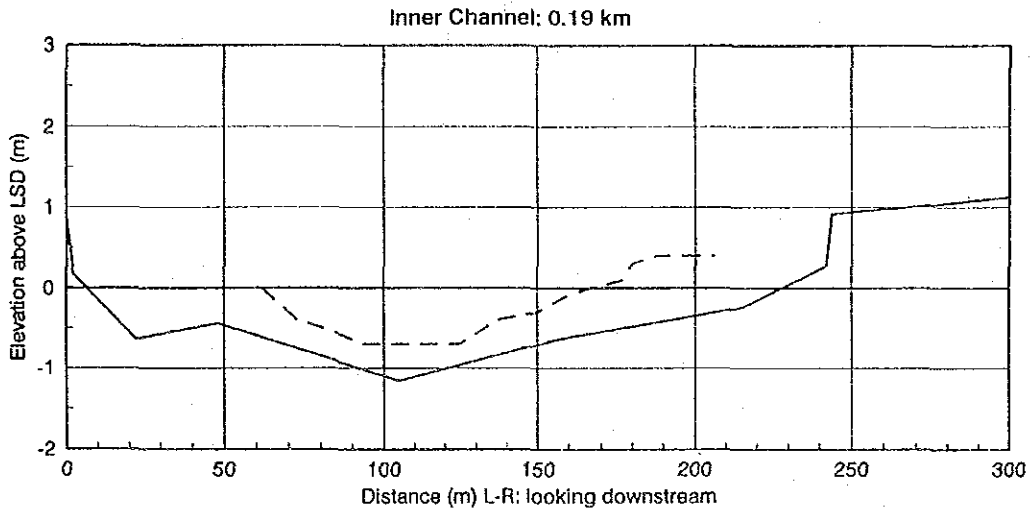


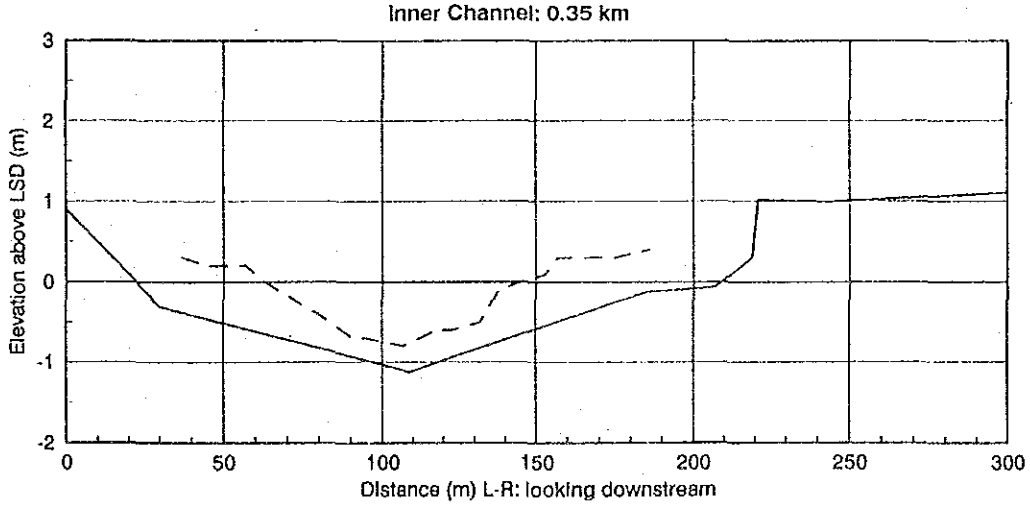
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	INNER AND OUTER CHANNEL PROFILE OF TG. PIANDANG RIVER MOUTH Fig.2.2-19



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSITION OF COASTLINE AT TG. PIANDANG RIVER MOUTH Fig.2.2-20

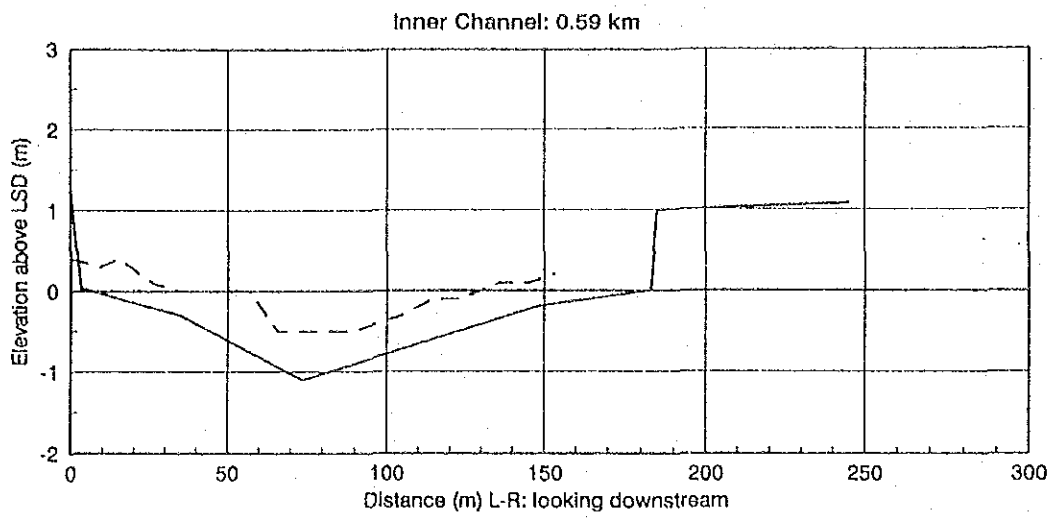


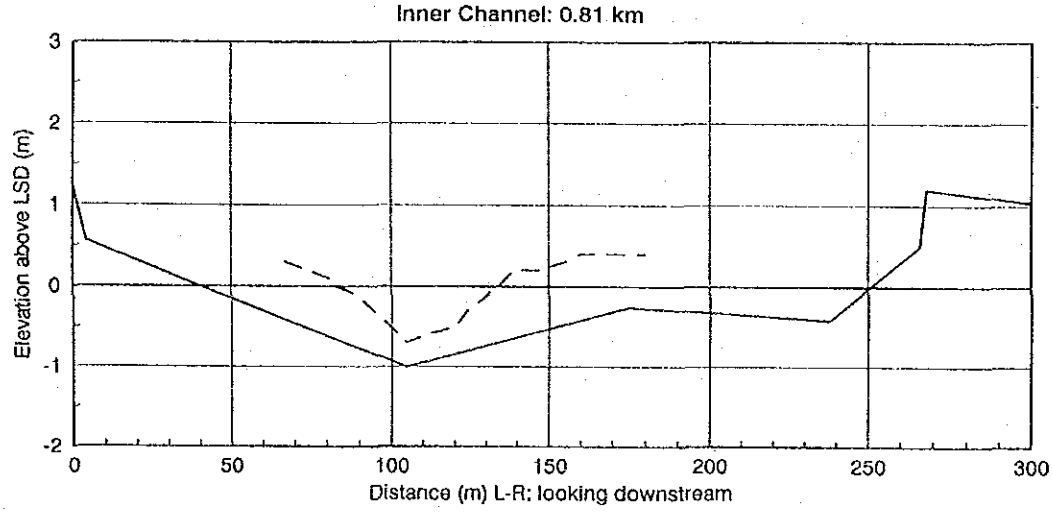


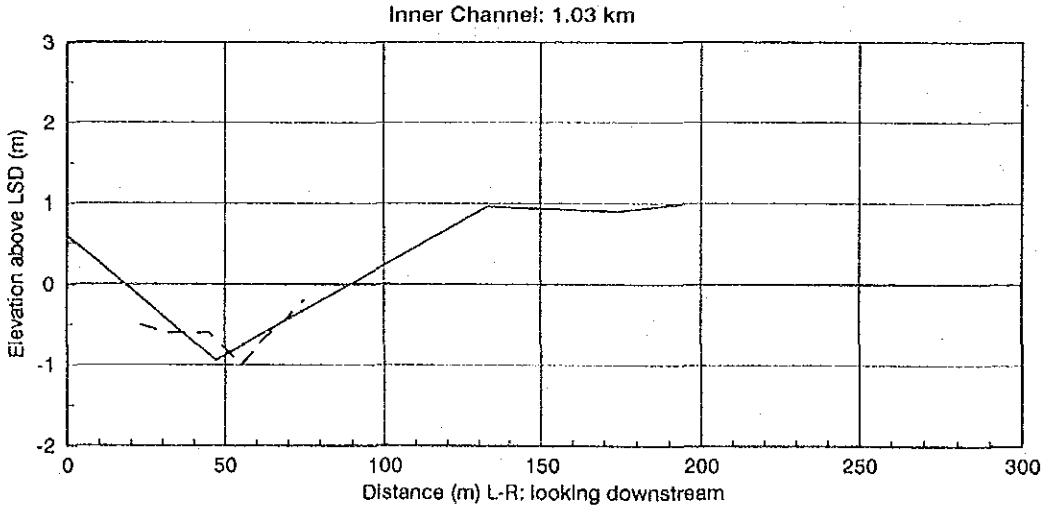


October, '92 June18-July9, '88

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF INNER CHANNEL CROSS SECTIONS OF TG. PIANDANG RIVER MOUTH Fig.2.2-21(1/2)

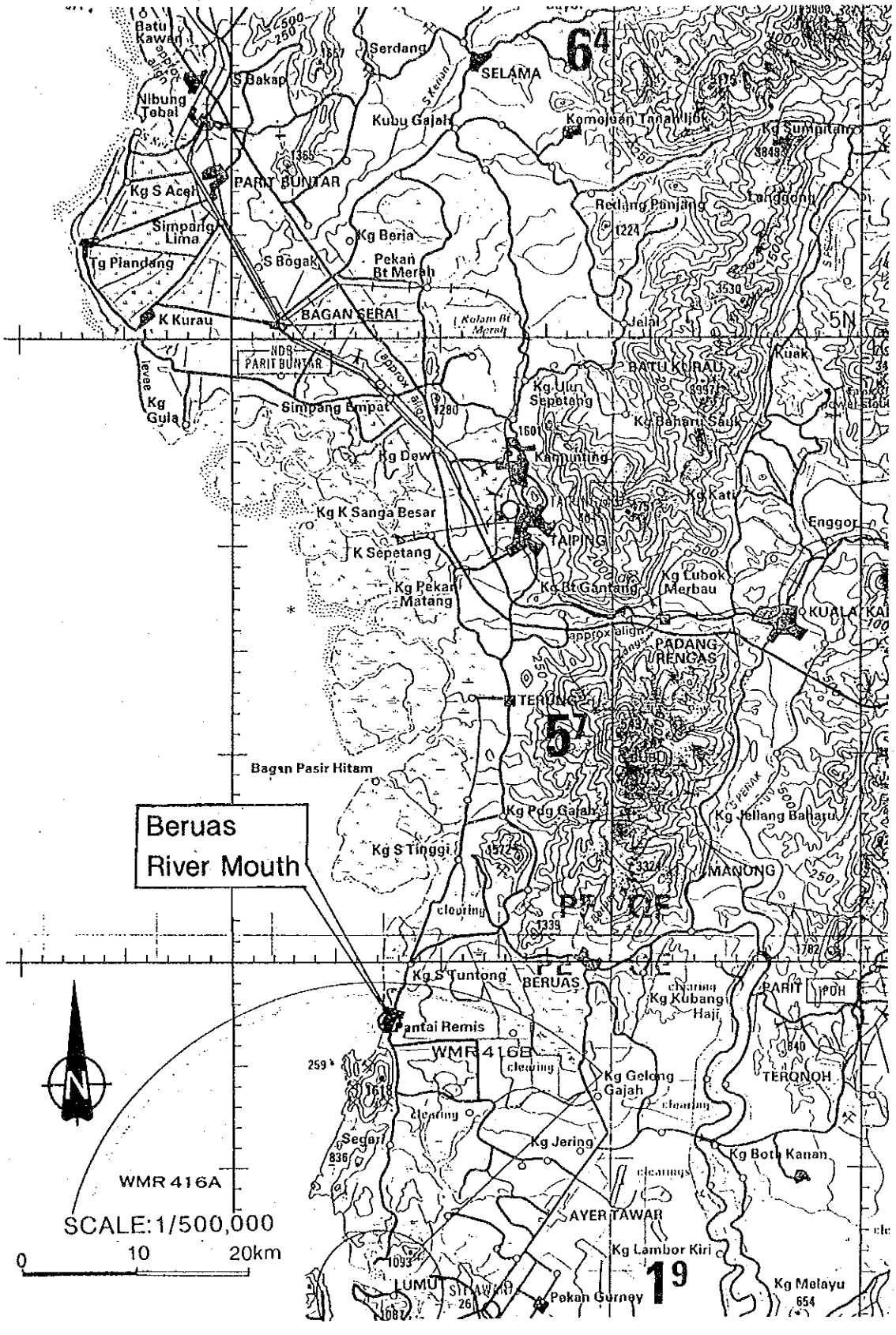




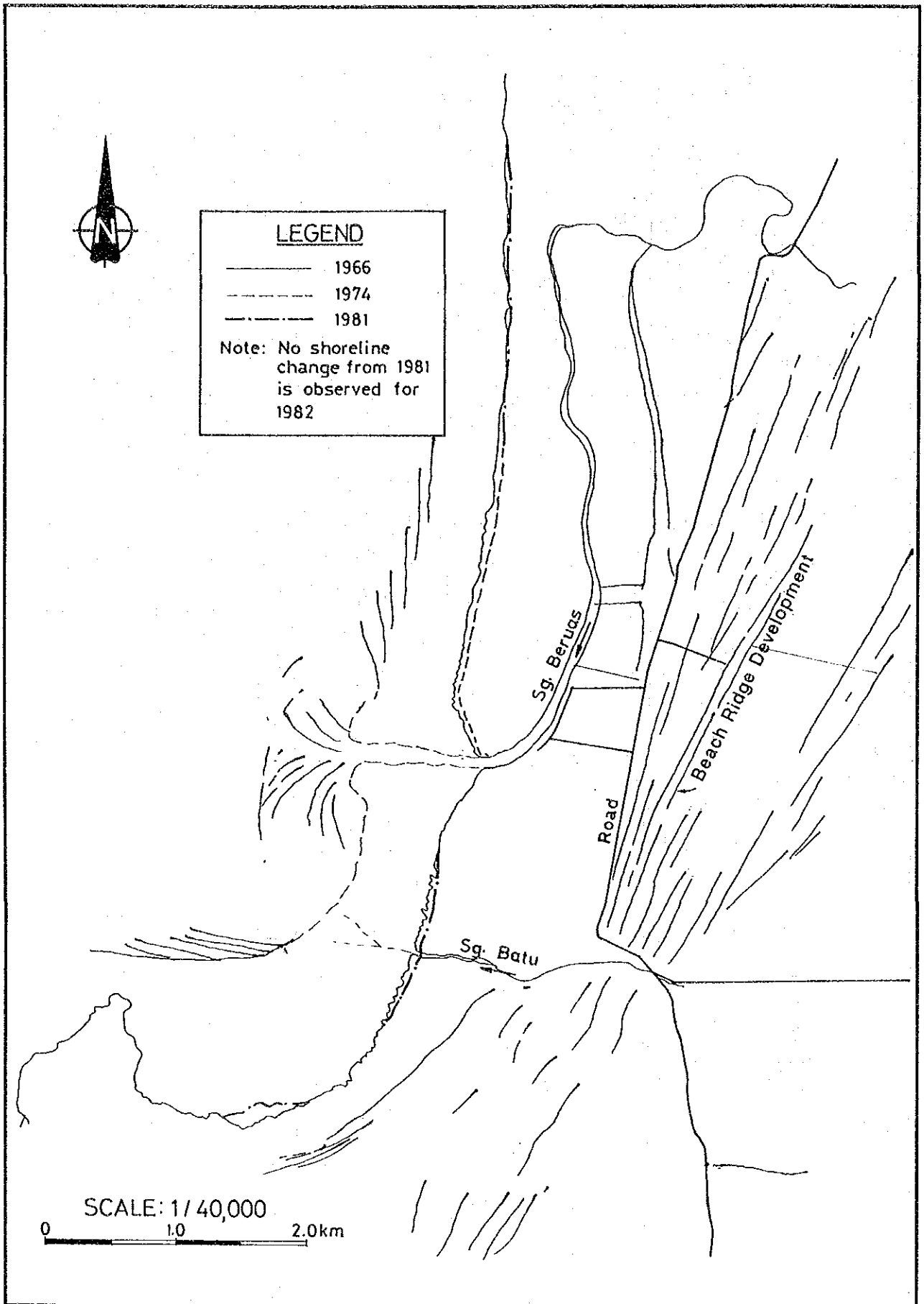


October, '92 June16-July9, '88

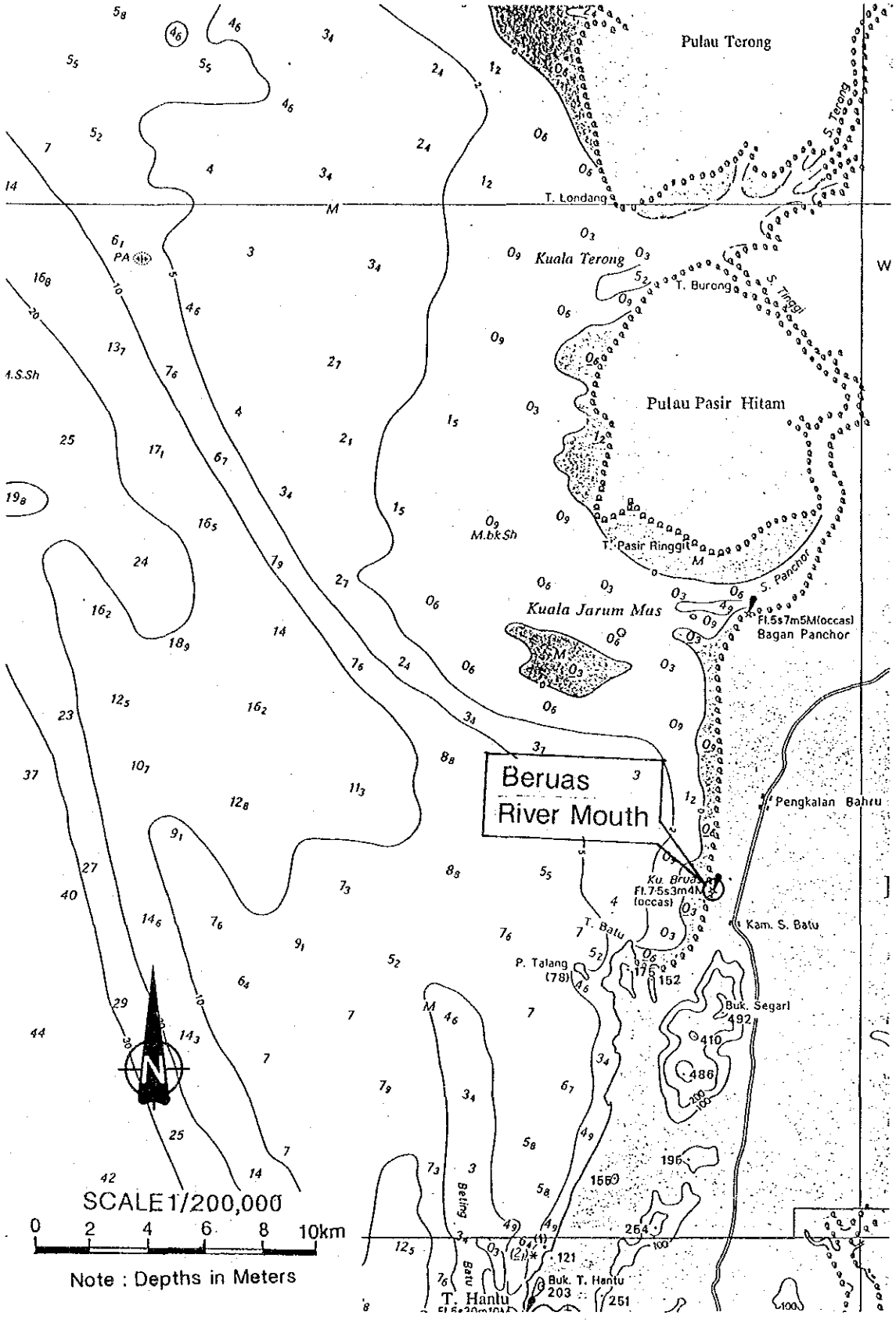
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF INNER CHANNEL CROSS SECTIONS OF TG. PIANDANG RIVER MOUTH Fig.2.2-21(2/2)



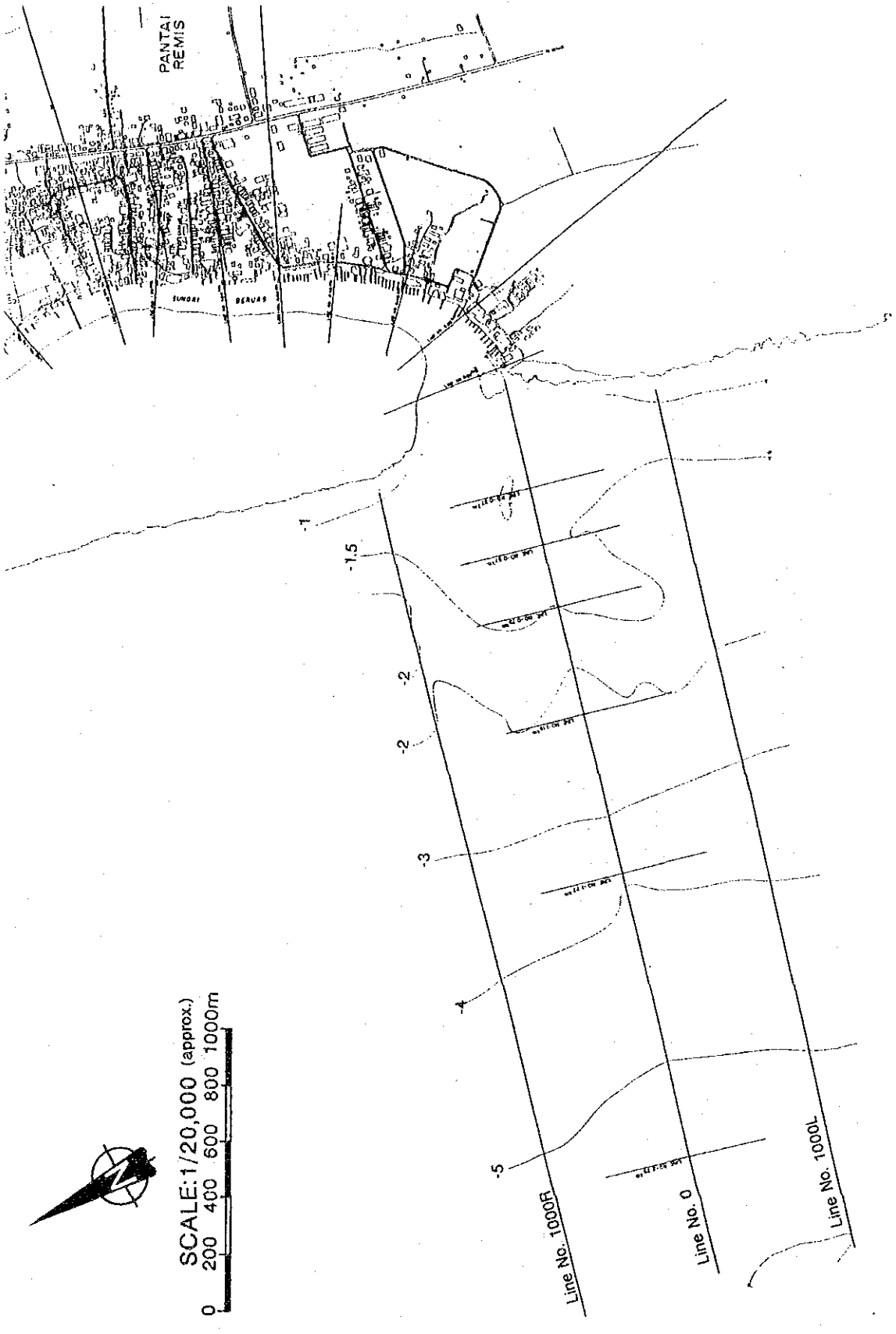
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TOPOGRAPHICAL MAP AROUND BERUAS RIVER MOUTH Fig.2.2-22



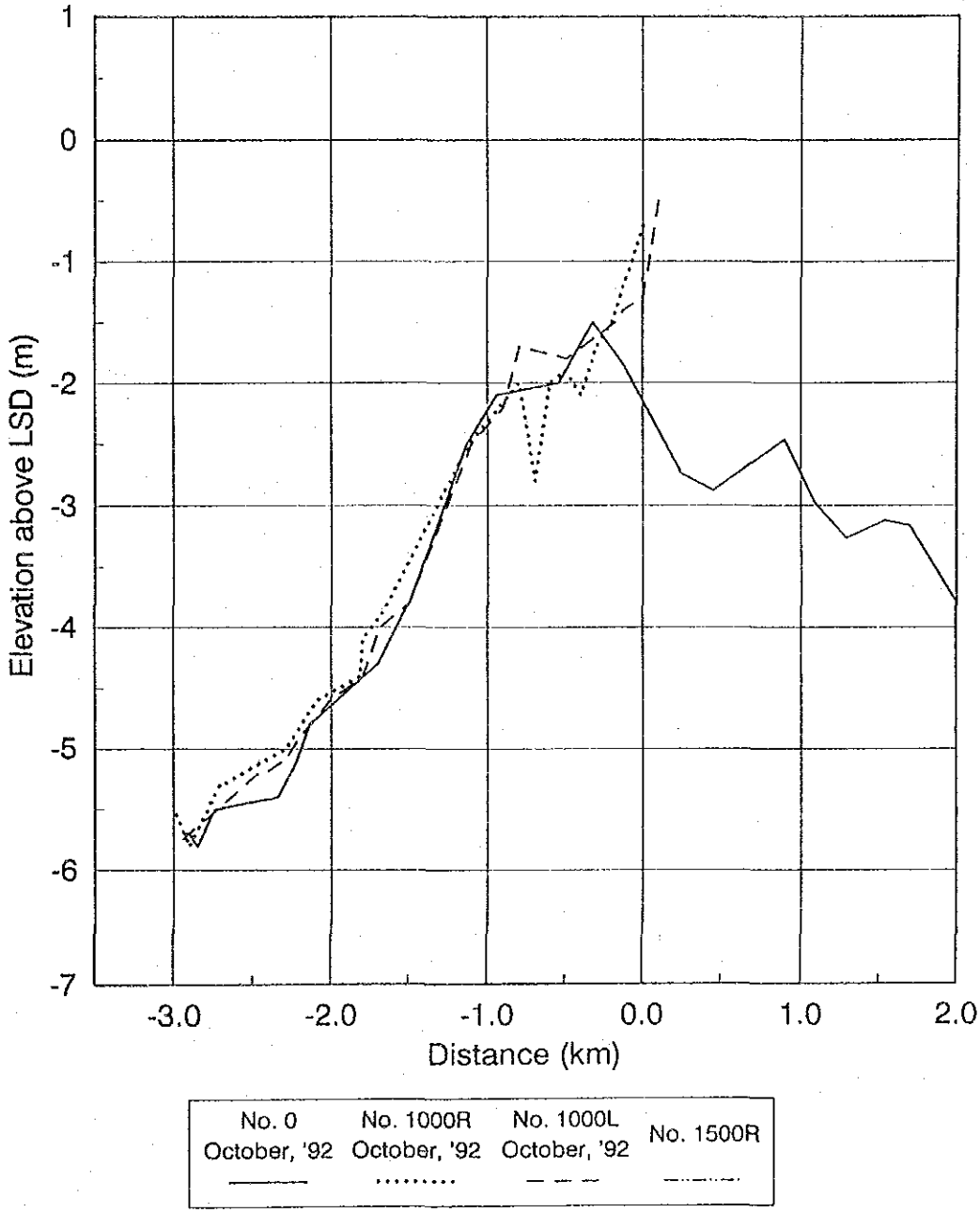
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	AERIAL PHOTOGRAPH INTERPRETATION FOR BERUAS RIVER MOUTH Fig.2.2-23



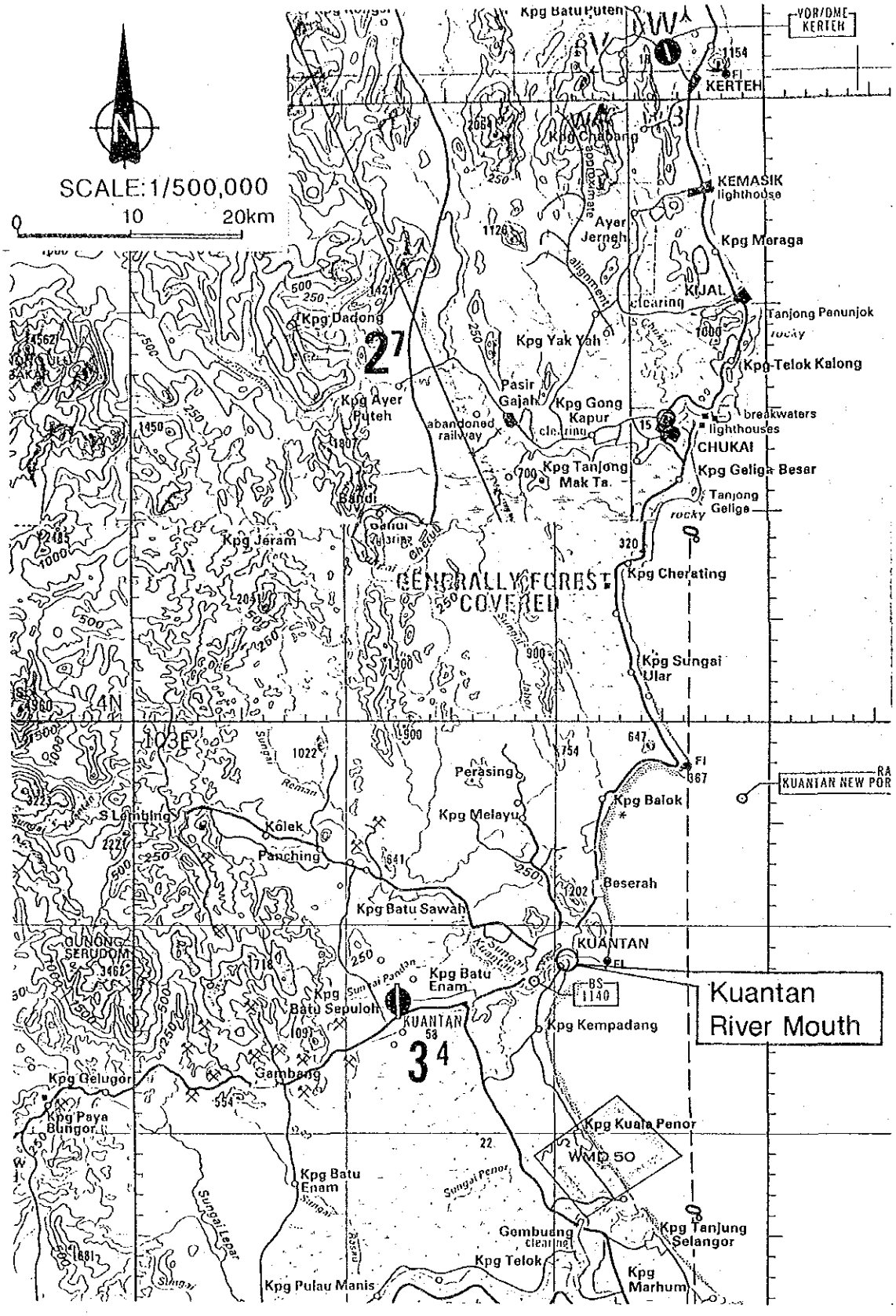
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN BERUAS RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-24



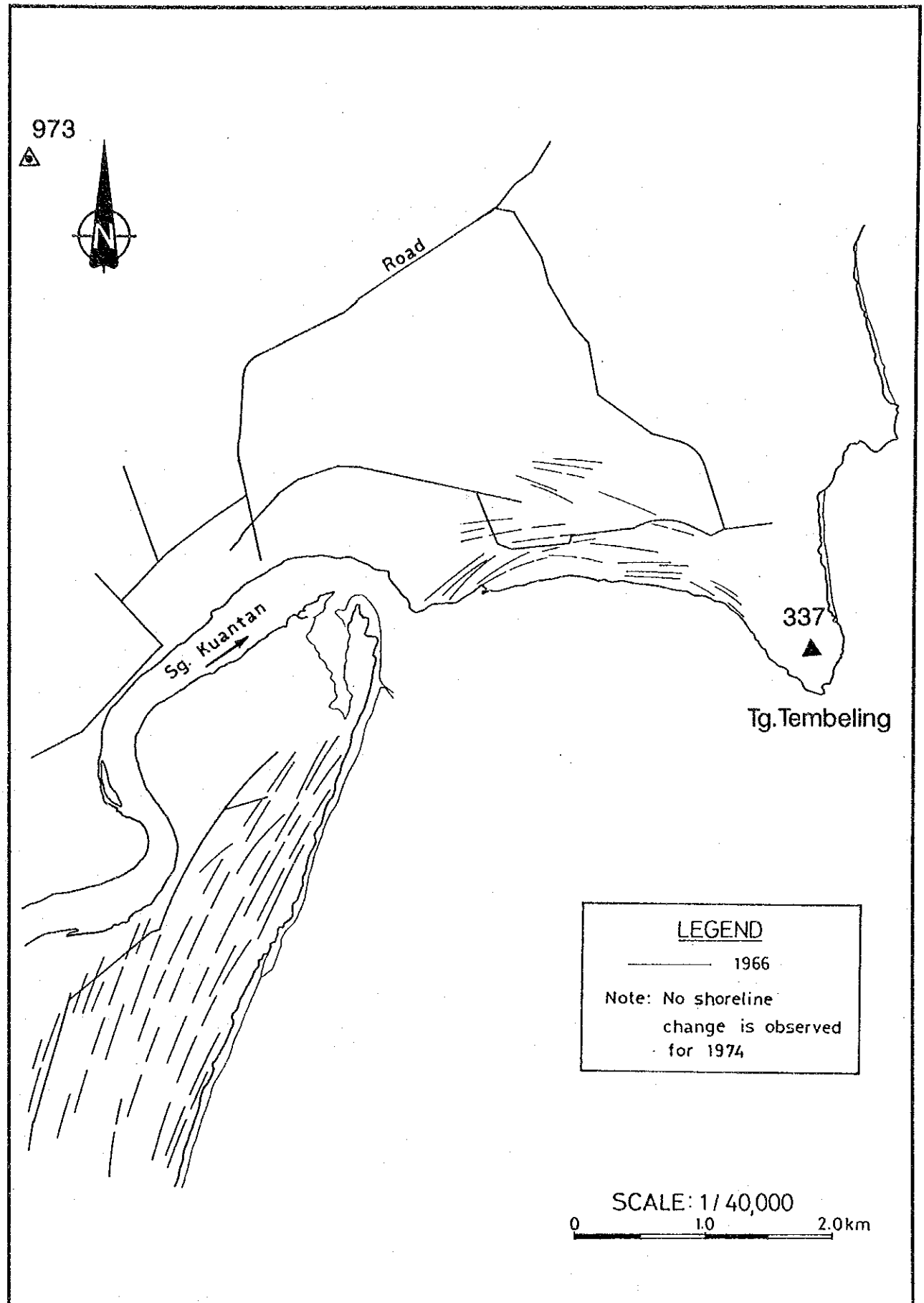
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	DEPTH CHART OF BERUAS RIVER MOUTH SURVEYED IN 1992
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-25



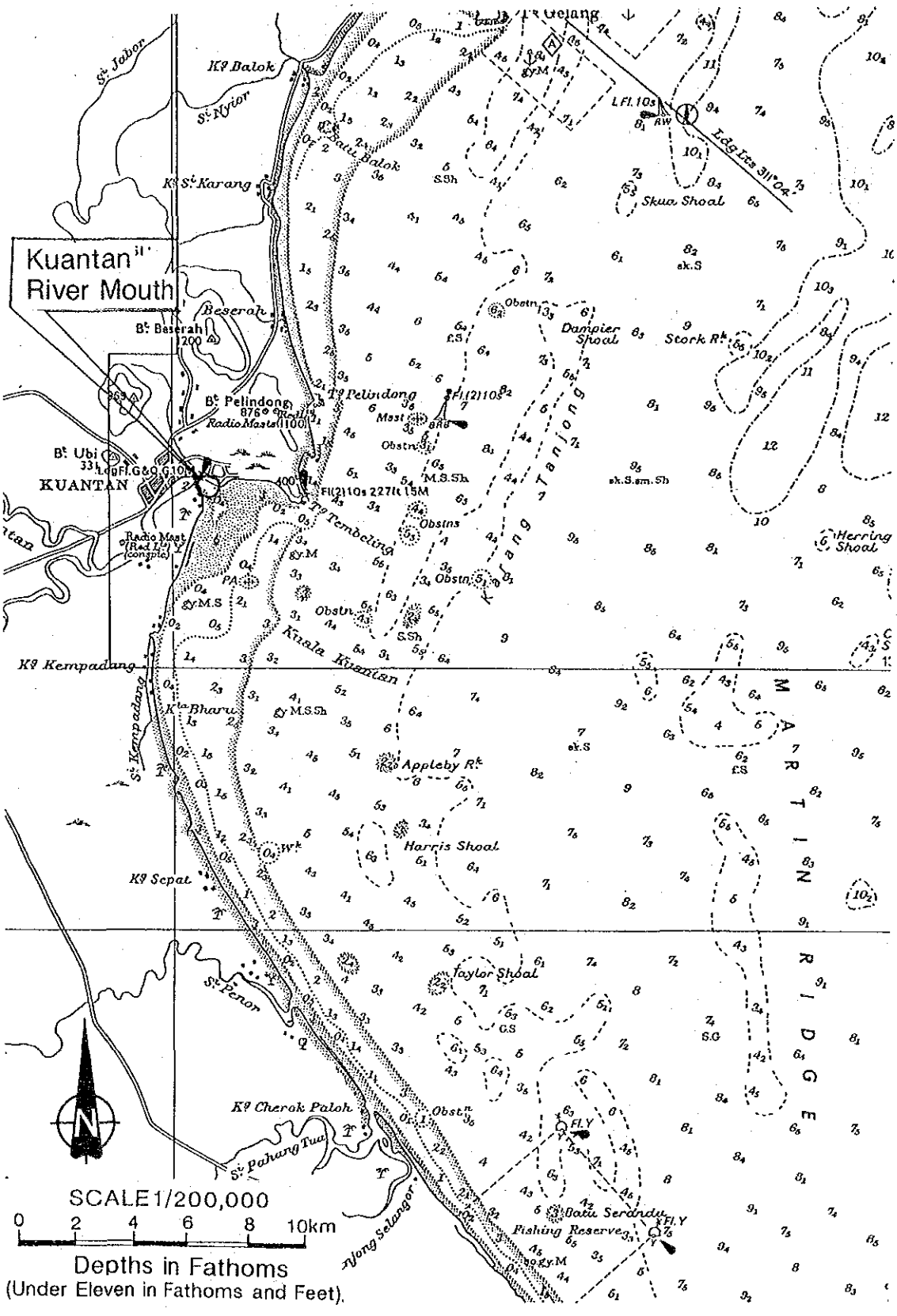
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INNER AND OUTER CHANNEL PROFILE OF BERUAS RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-26



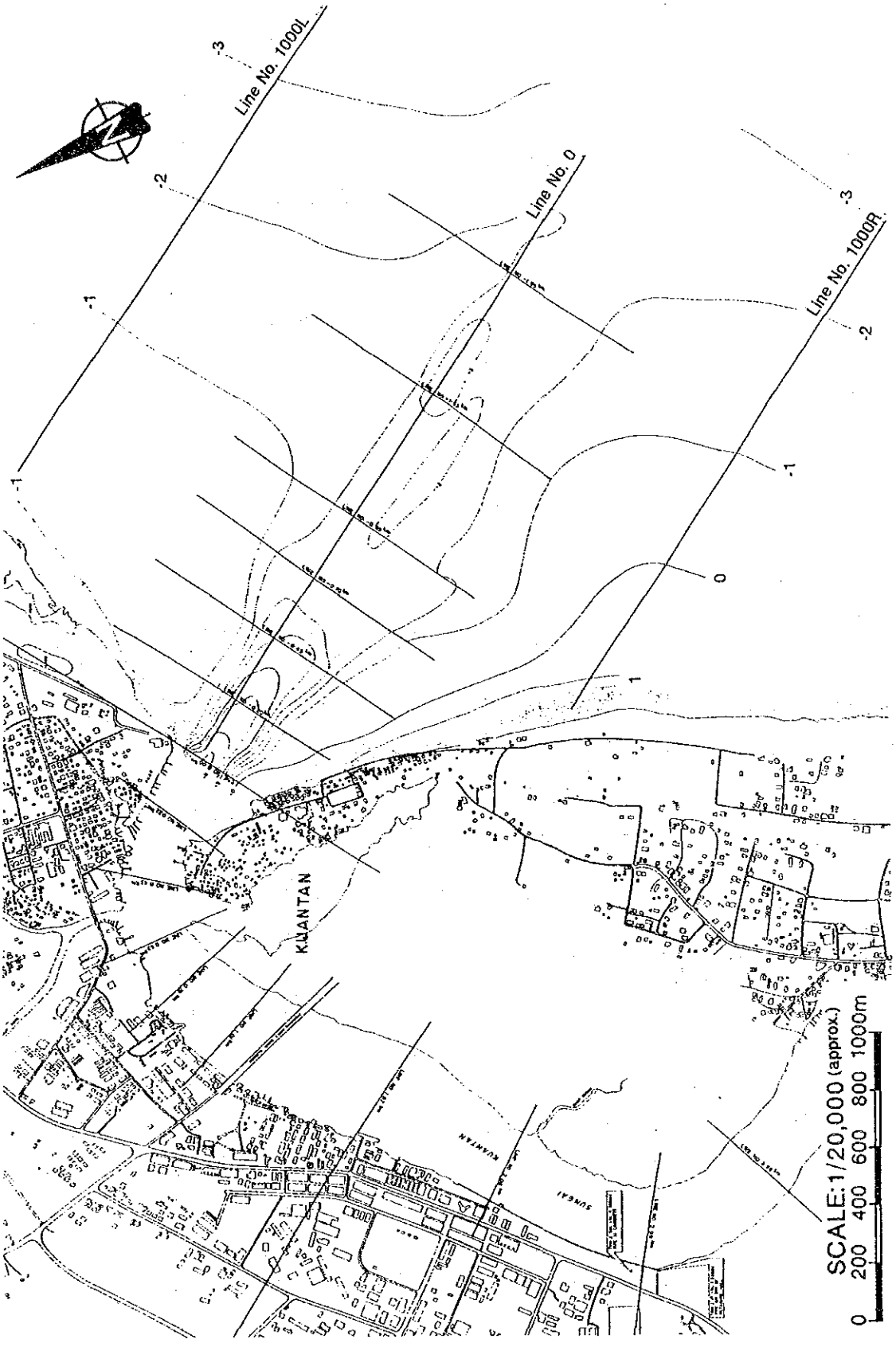
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TOPOGRAPHICAL MAP AROUND KUANTAN RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-27



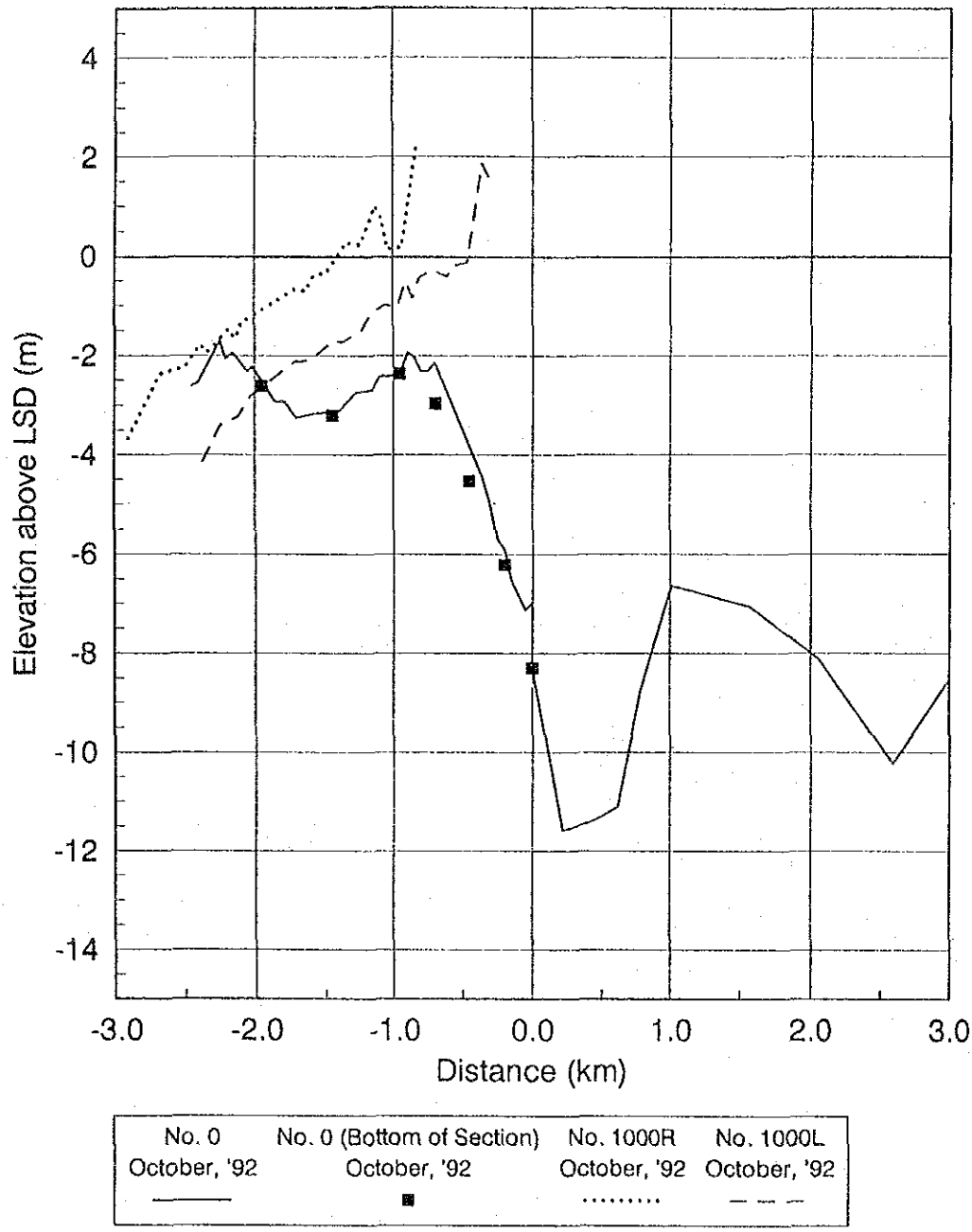
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	AERIAL PHOTOGRAPH INTERPRETATION FOR KUANTAN RIVER MOUTH Fig. 2.2-28



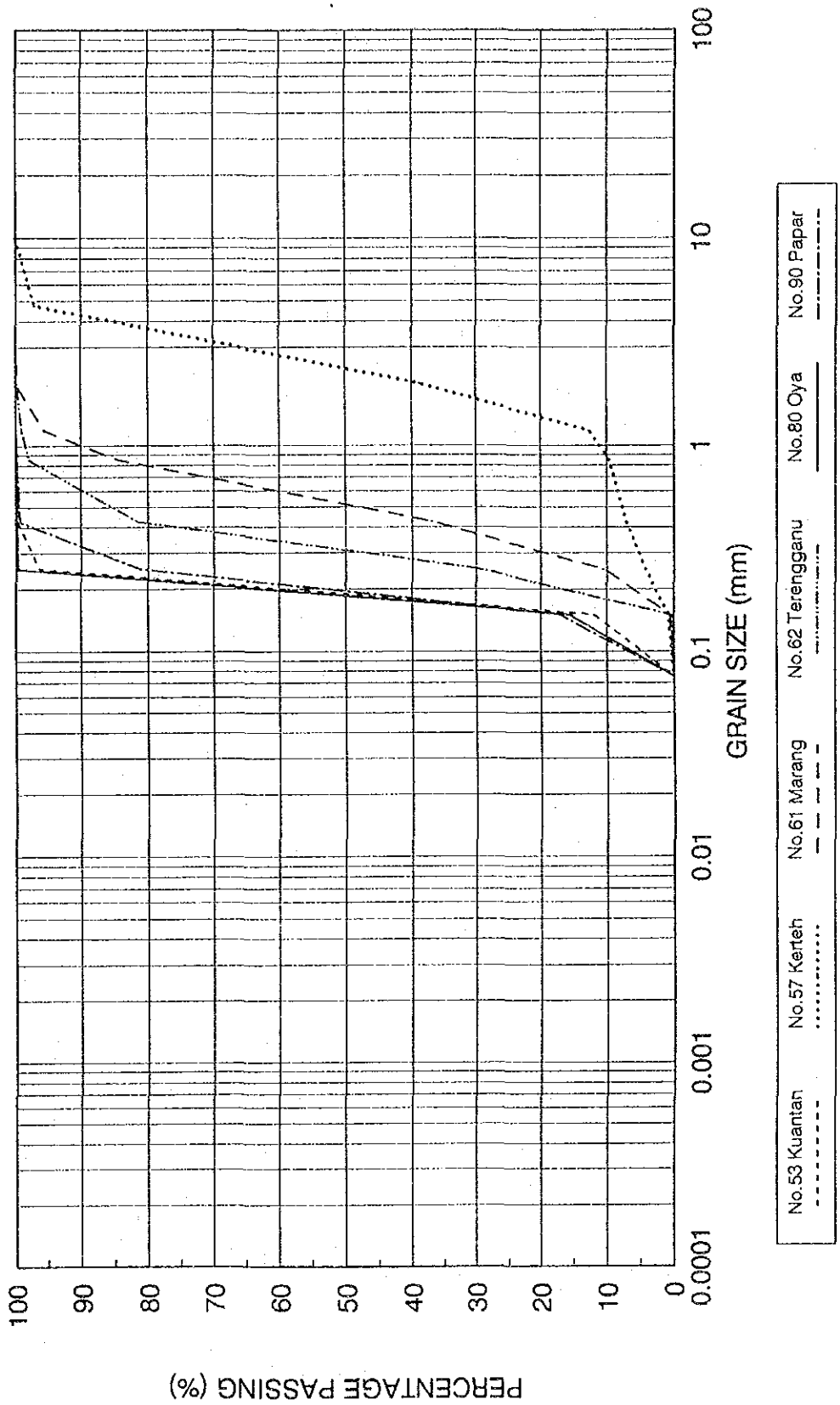
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN KUANTAN RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-29



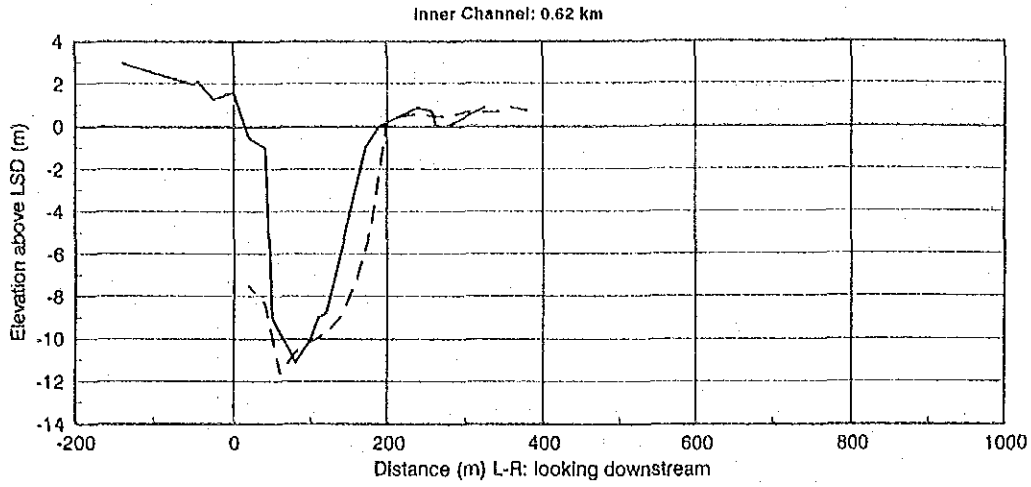
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	DEPTH CHART OF KUANTAN RIVER MOUTH SURVEYED IN 1992 Fig.2.2-30

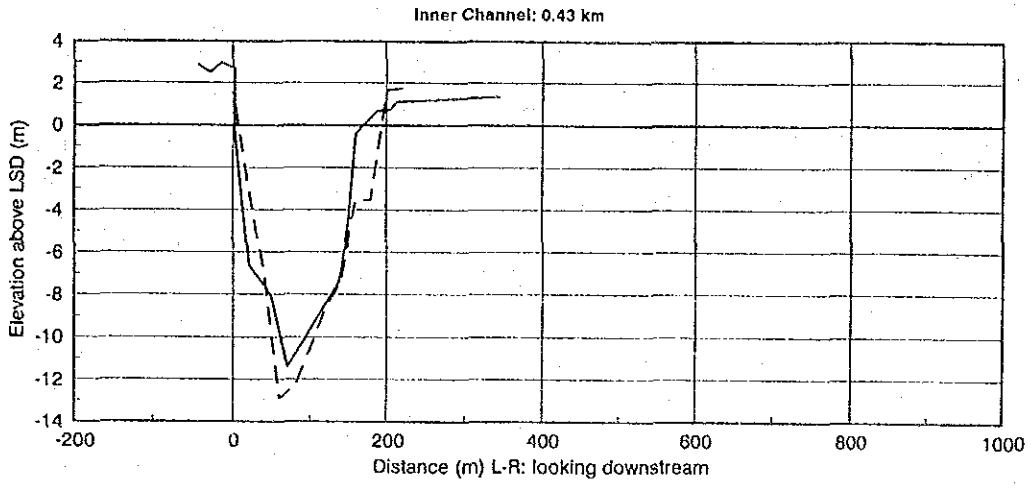


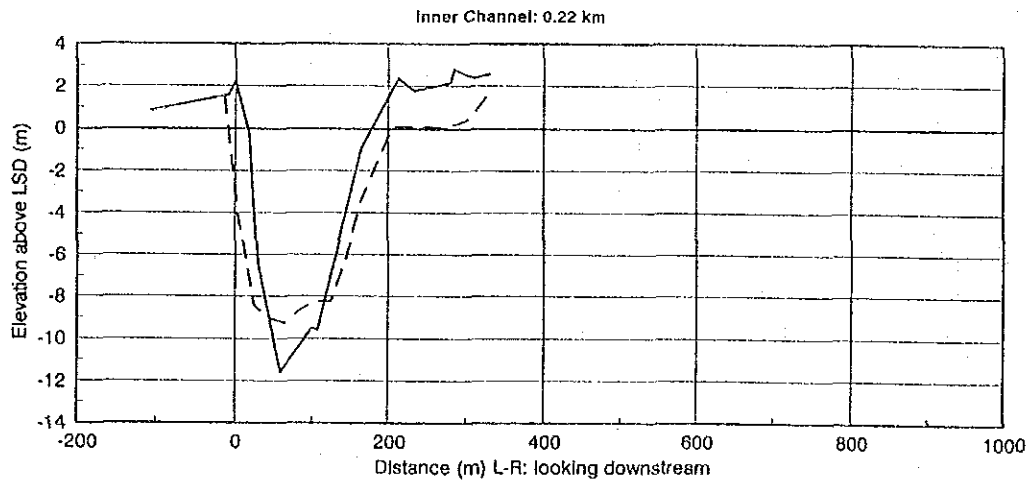
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INNER AND OUTER CHANNEL PROFILE OF KUANTAN RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-31

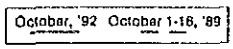


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	GRADATION CURVE OF BED MATERIAL FOR REPRESENTATIVE RIVER MOUTH IN SANDY COAST Fig.2.2-32

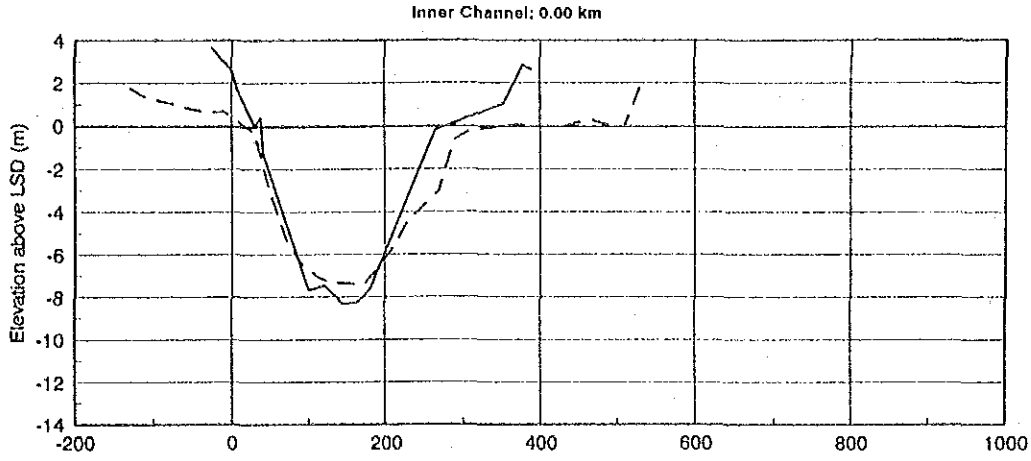


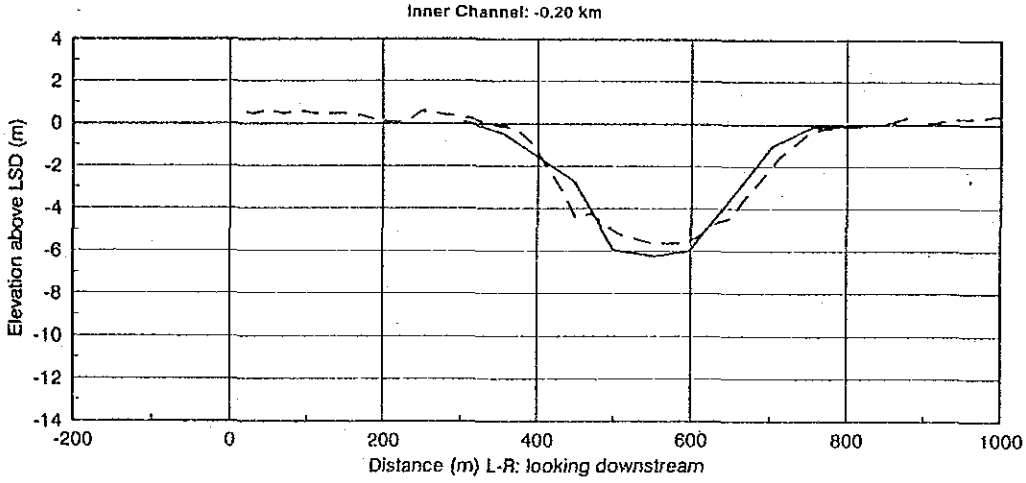


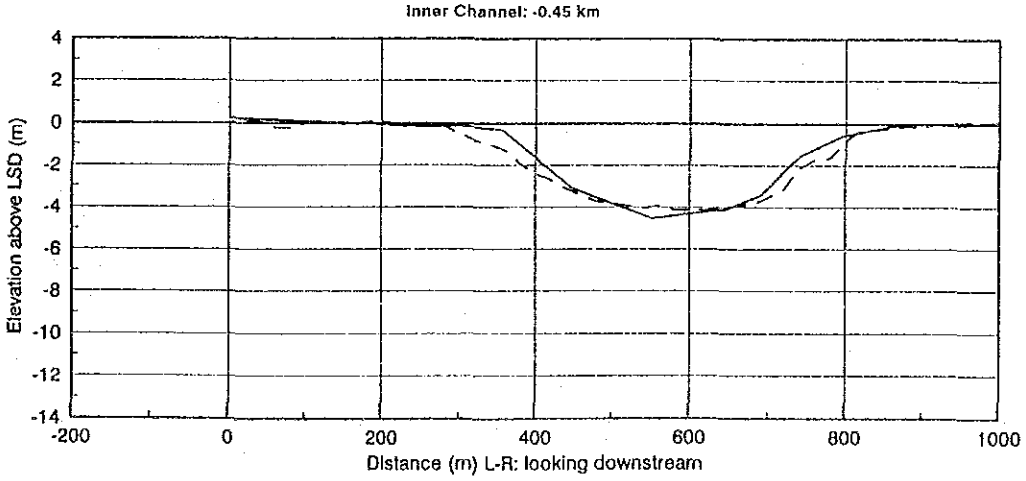




THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CHANGE OF INNER AND OUTER CHANNEL CROSS SECTIONS OF KUANTAN RIVER MOUTH Fig.2.2-33(1/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

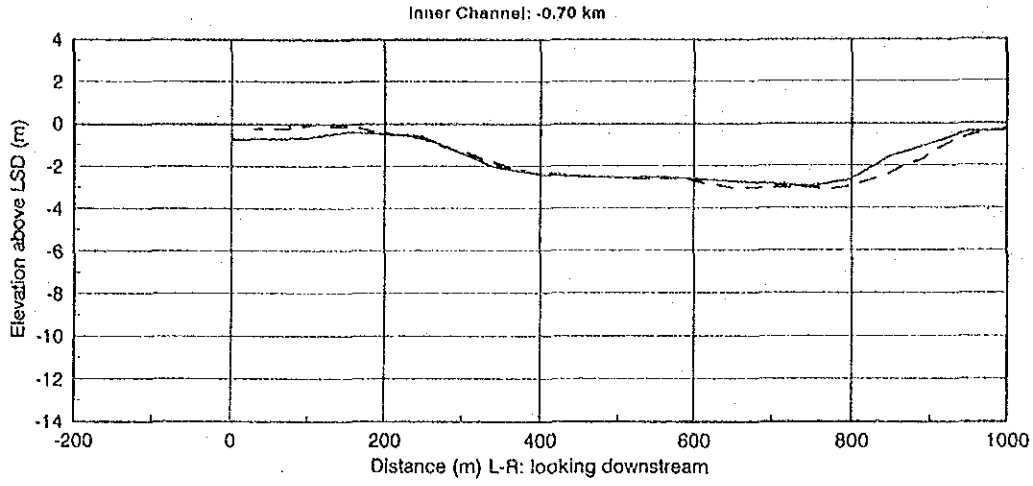


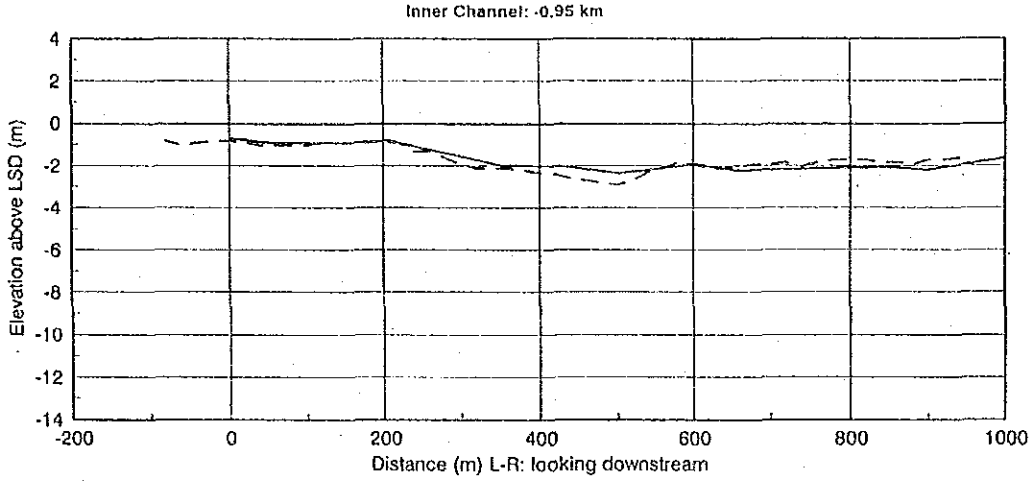


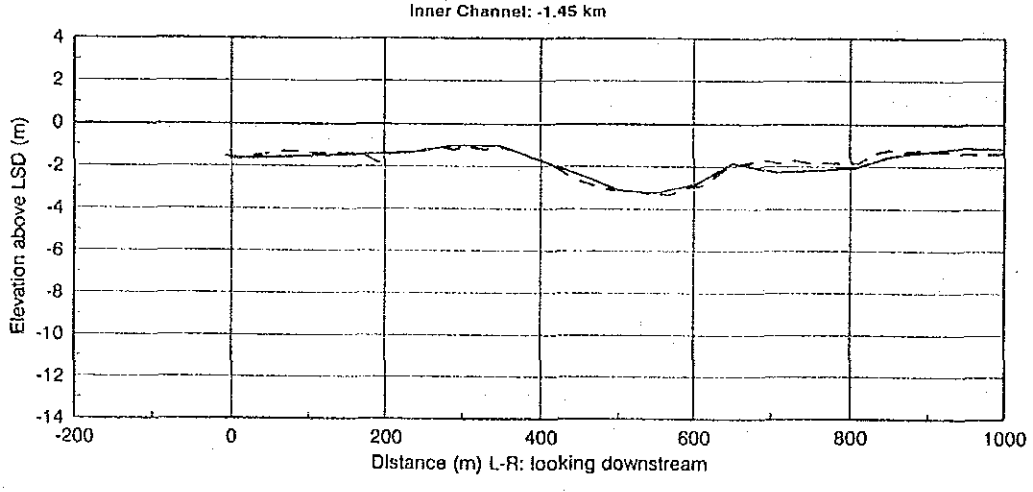


October, '92 October 1-16, '89

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF INNER AND OUTER CHANNEL CROSS SECTIONS OF KUANTAN RIVER MOUTH Fig.2.2-33(2/3)



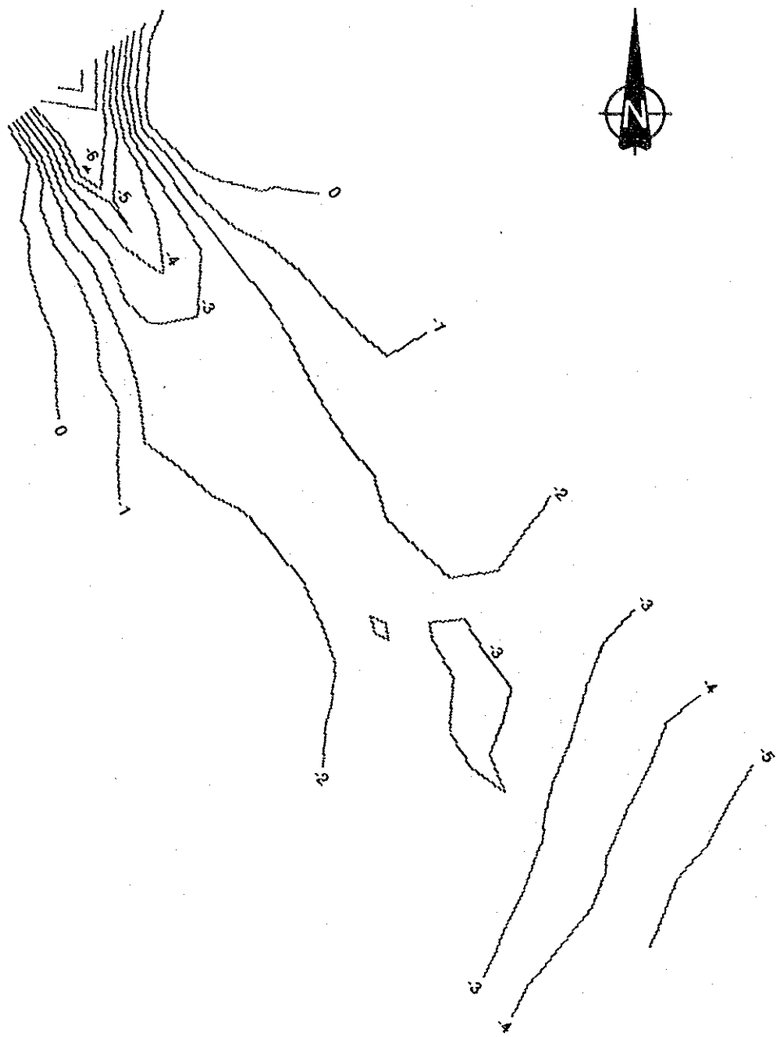




October, '92 October 1-18, '89

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CHANGE OF INNER AND OUTER CHANNEL CROSS SECTIONS OF KUANTAN RIVER MOUTH Fig.2.2-33(3/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

October 1992



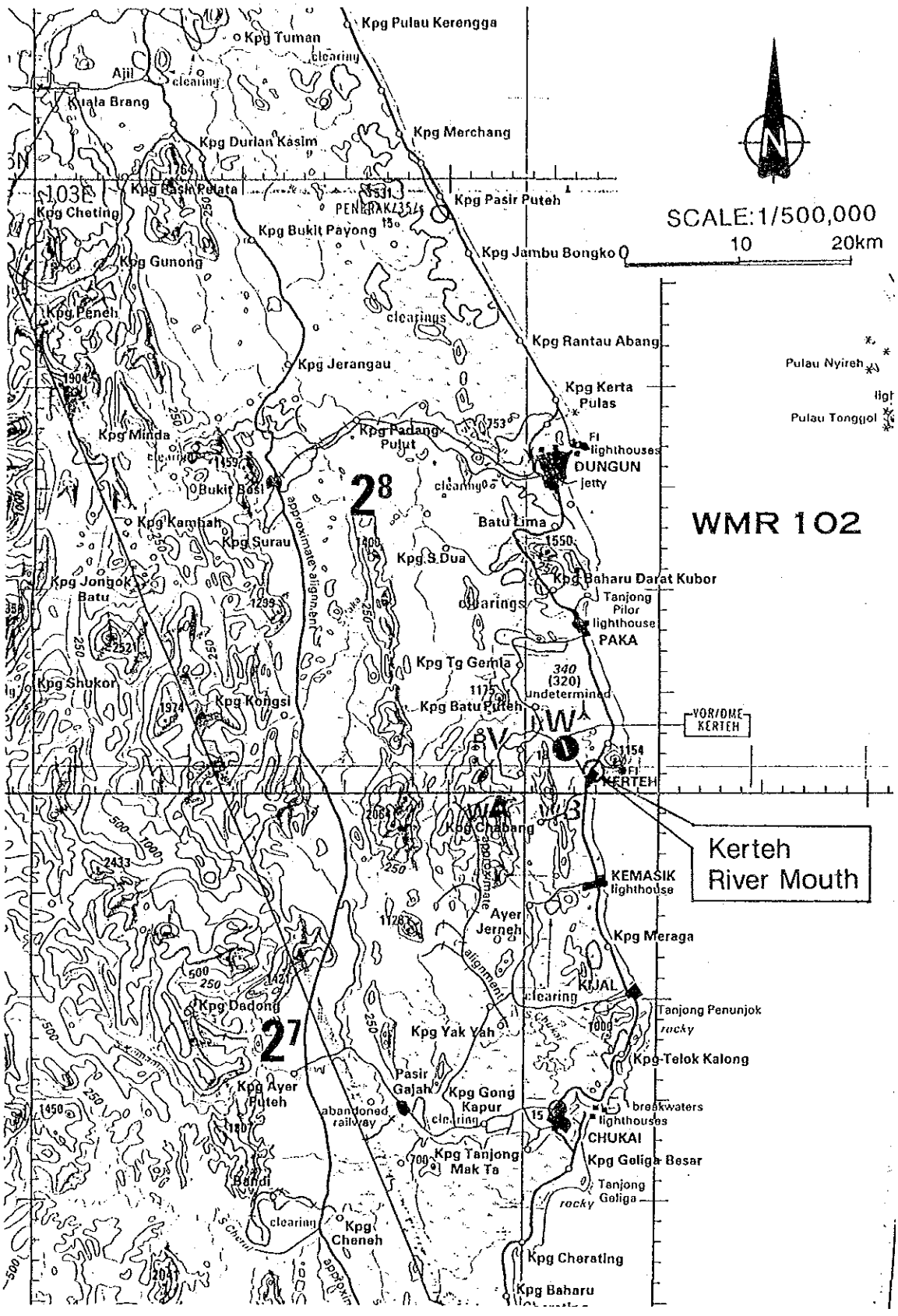
October 1989

SCALE : 1/20,000

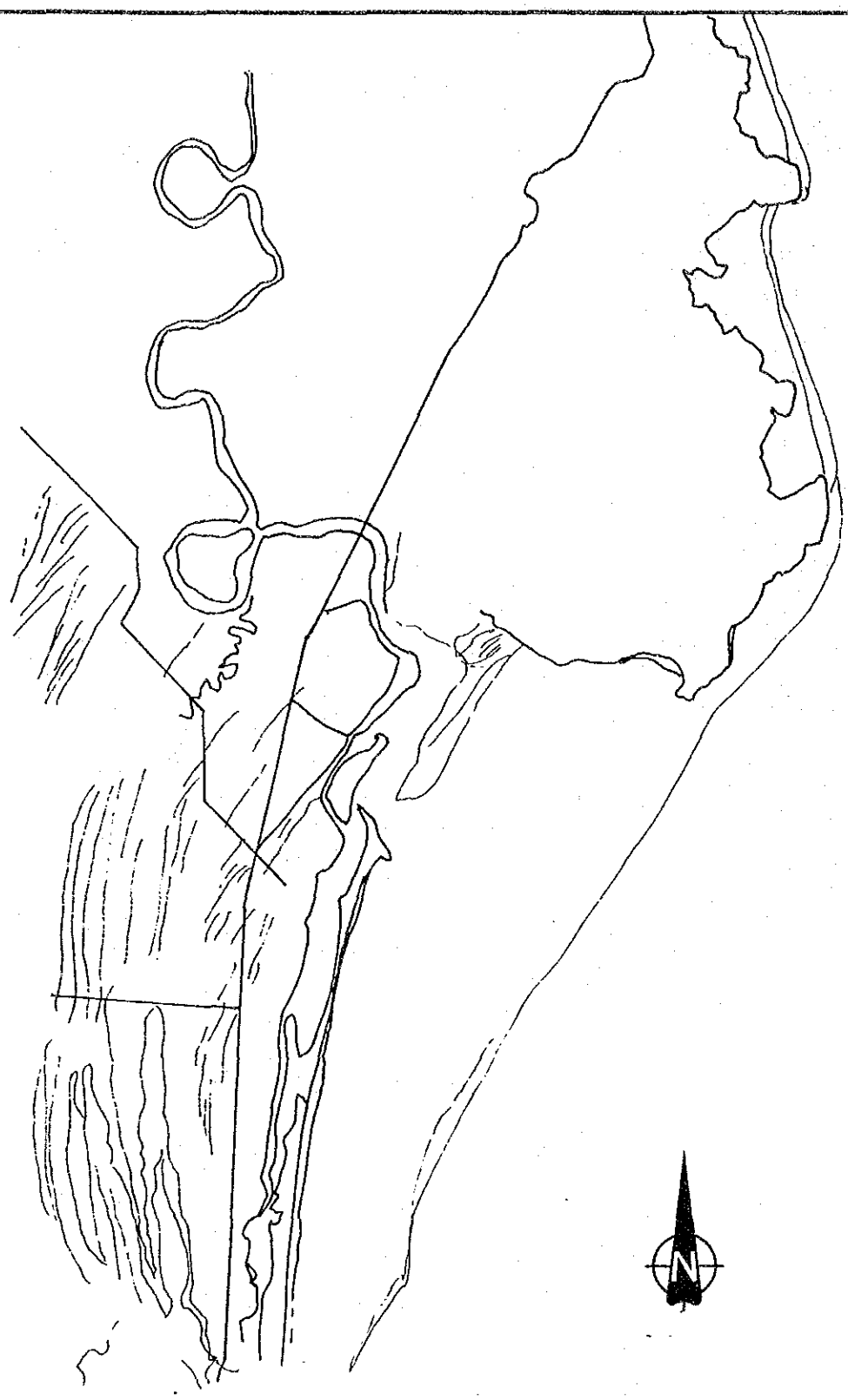
0 200 400 600 800 m

Note : contours are elevations above LSD

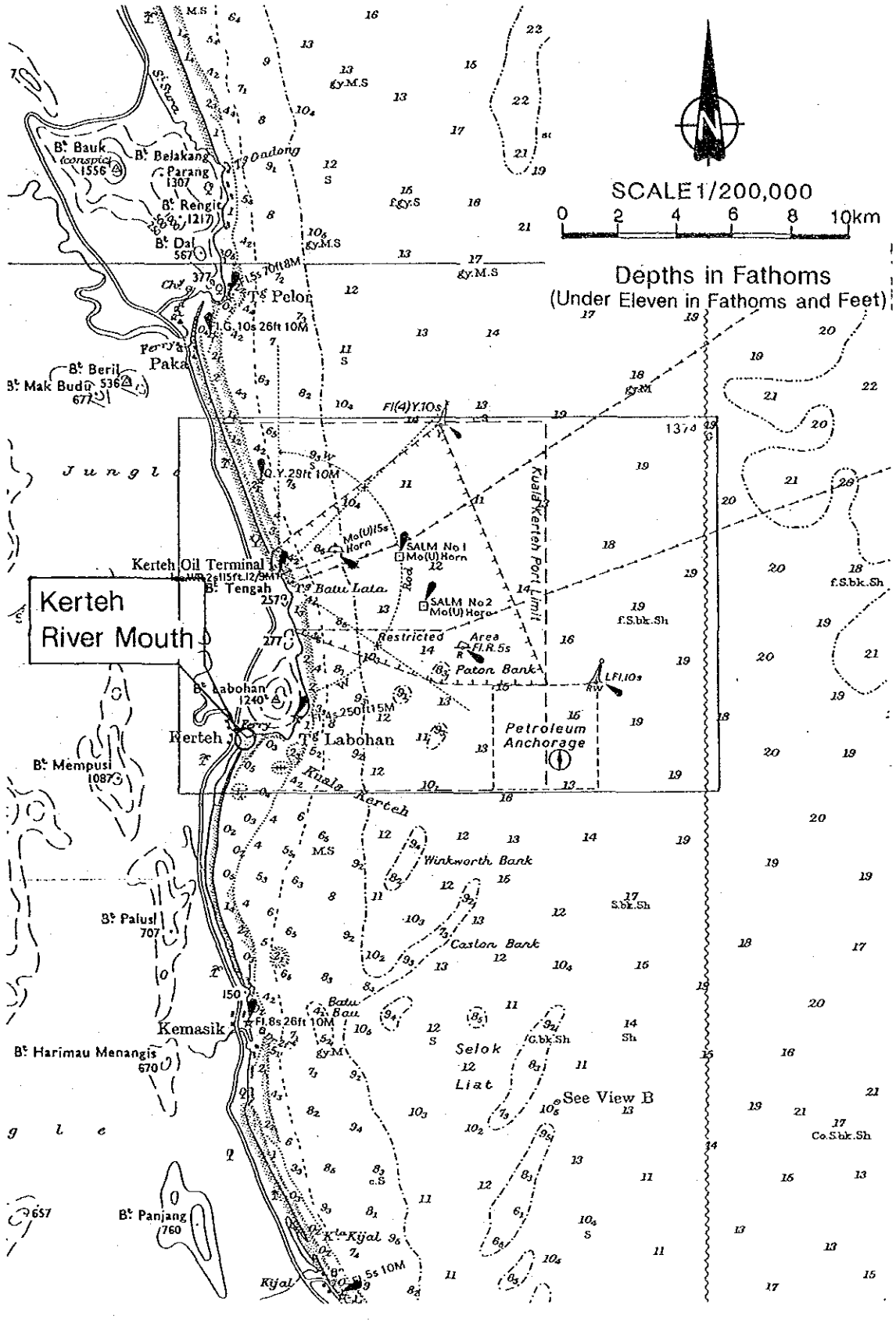
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	COMPARISON OF SEABED CONTOURS FOR KUANTAN RIVER MOUTH Fig.2.2-34



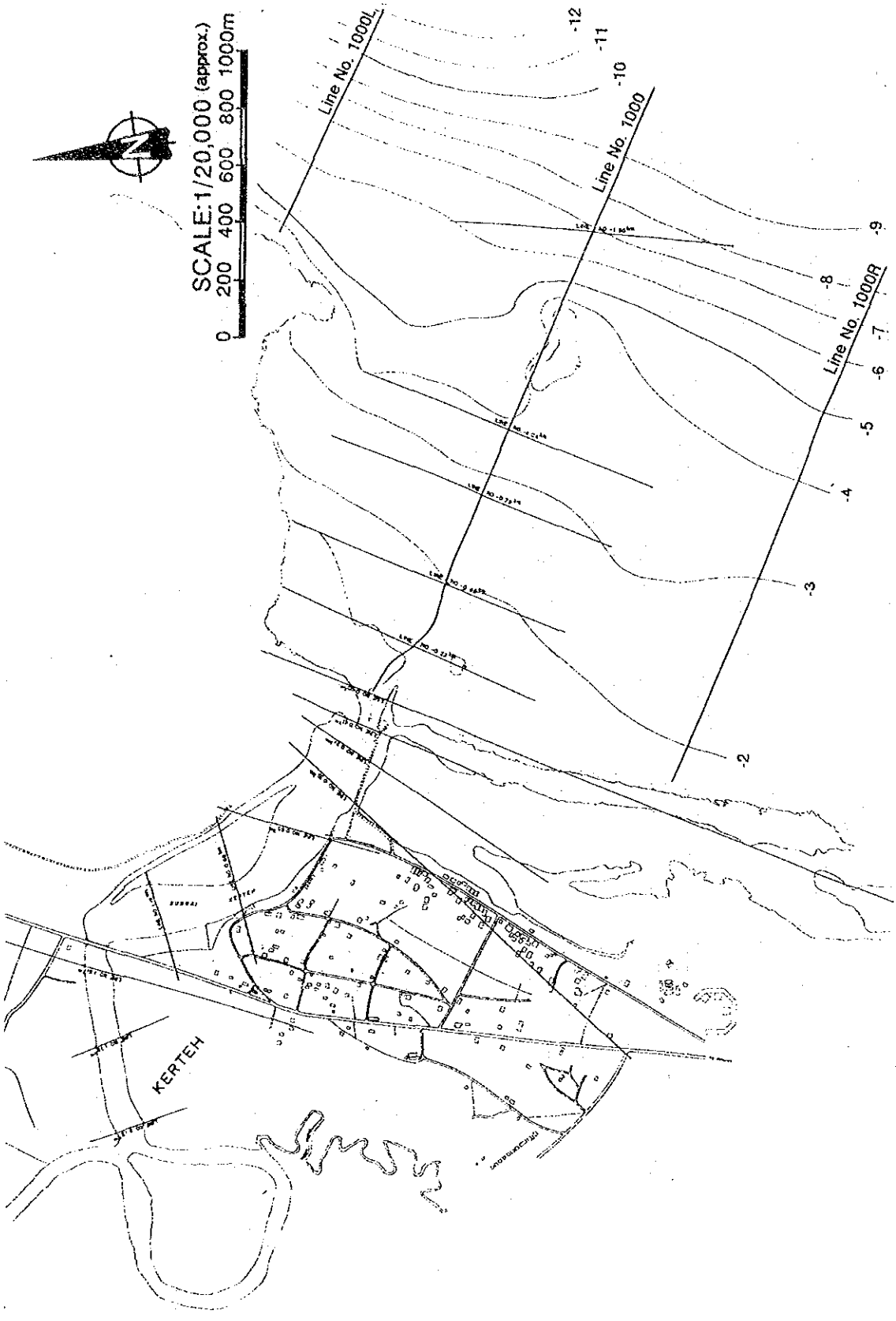
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TOPOGRAPHICAL MAP AROUND KERTEH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-35



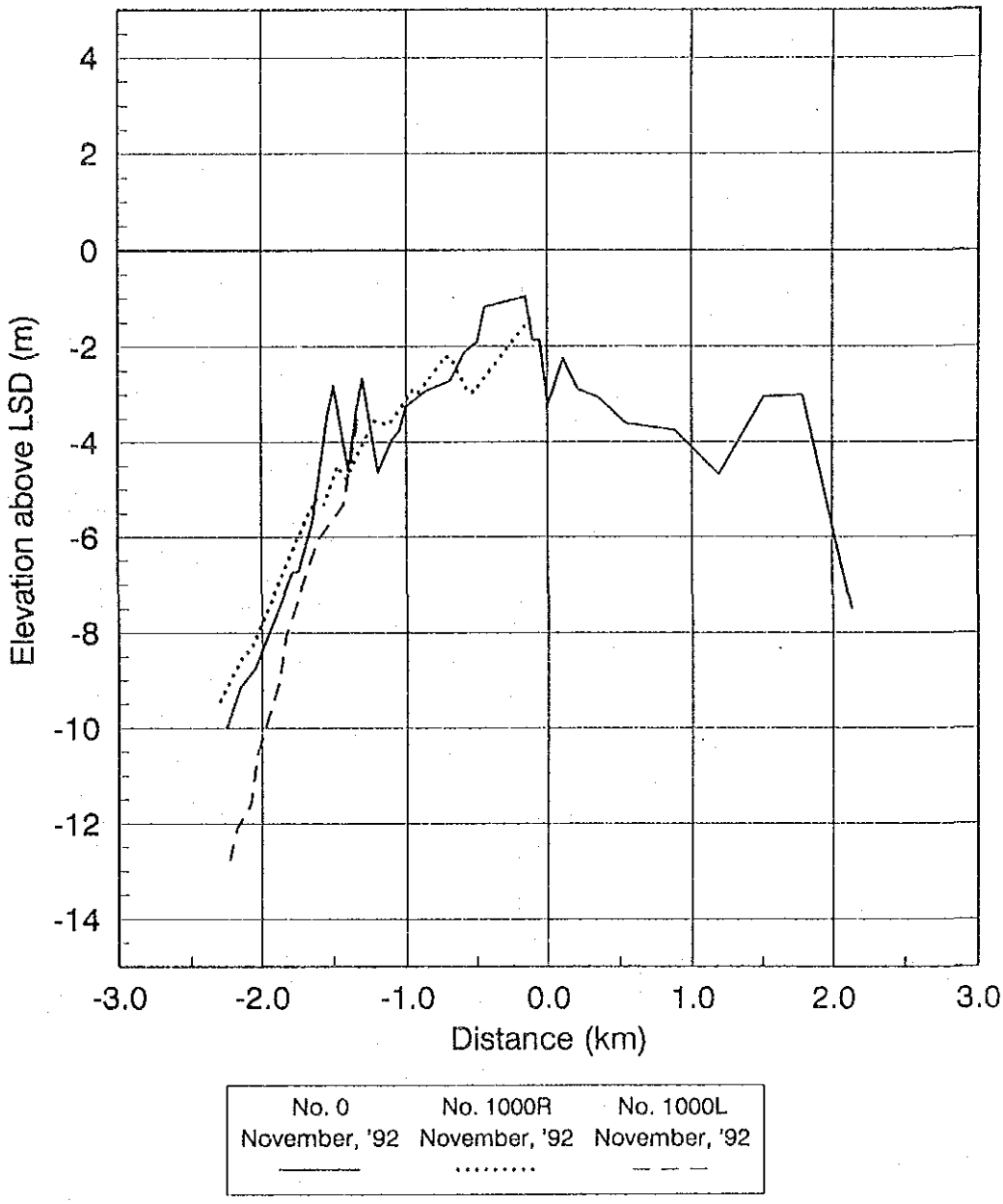
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	AERIAL PHOTOGRAPH INTERPRETATION FOR KERTEH RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-36



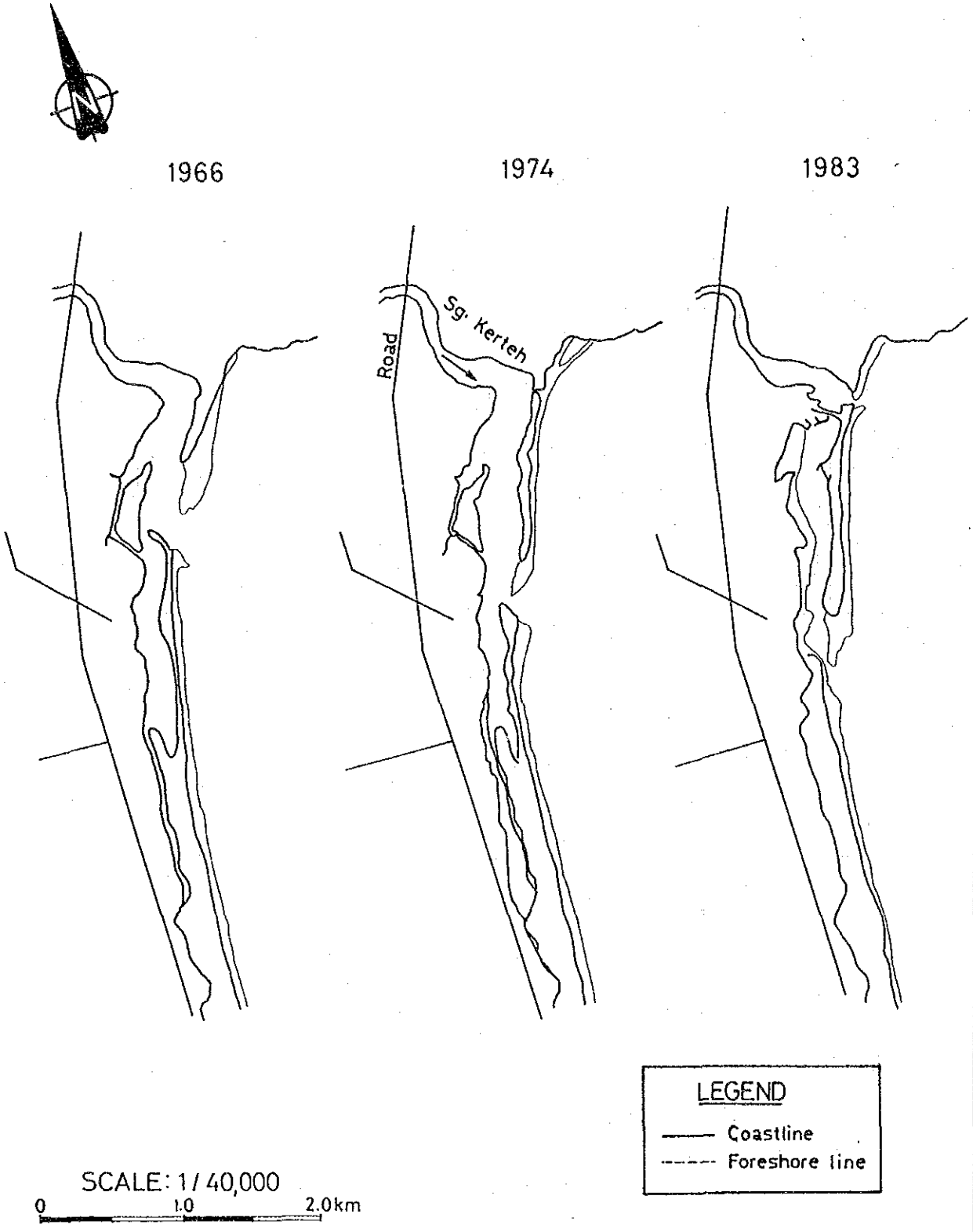
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN KERTEH RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-37



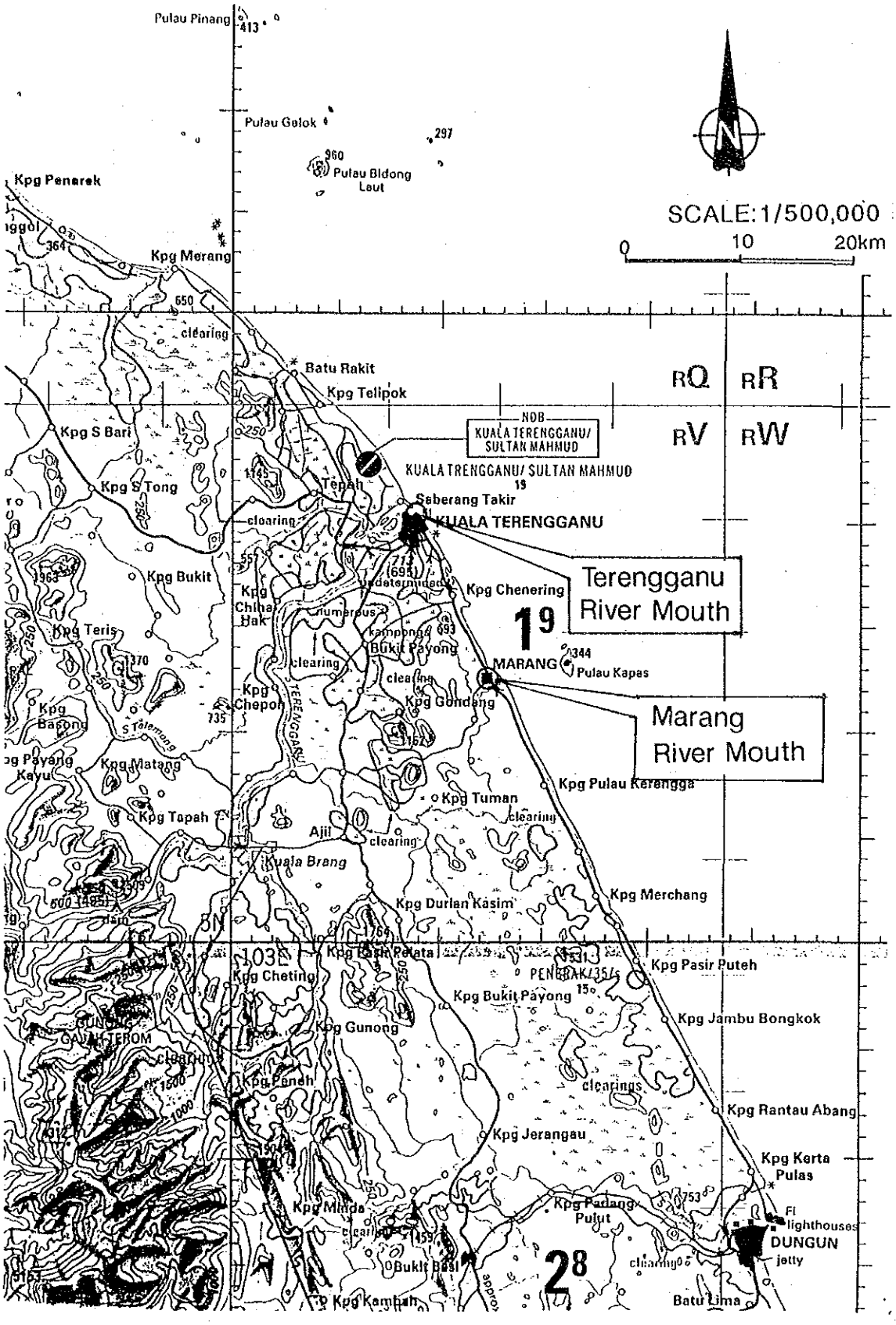
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	DEPTH CHART OF KERTEH RIVER MOUTH SURVEYED IN 1992 Fig. 2.2-38



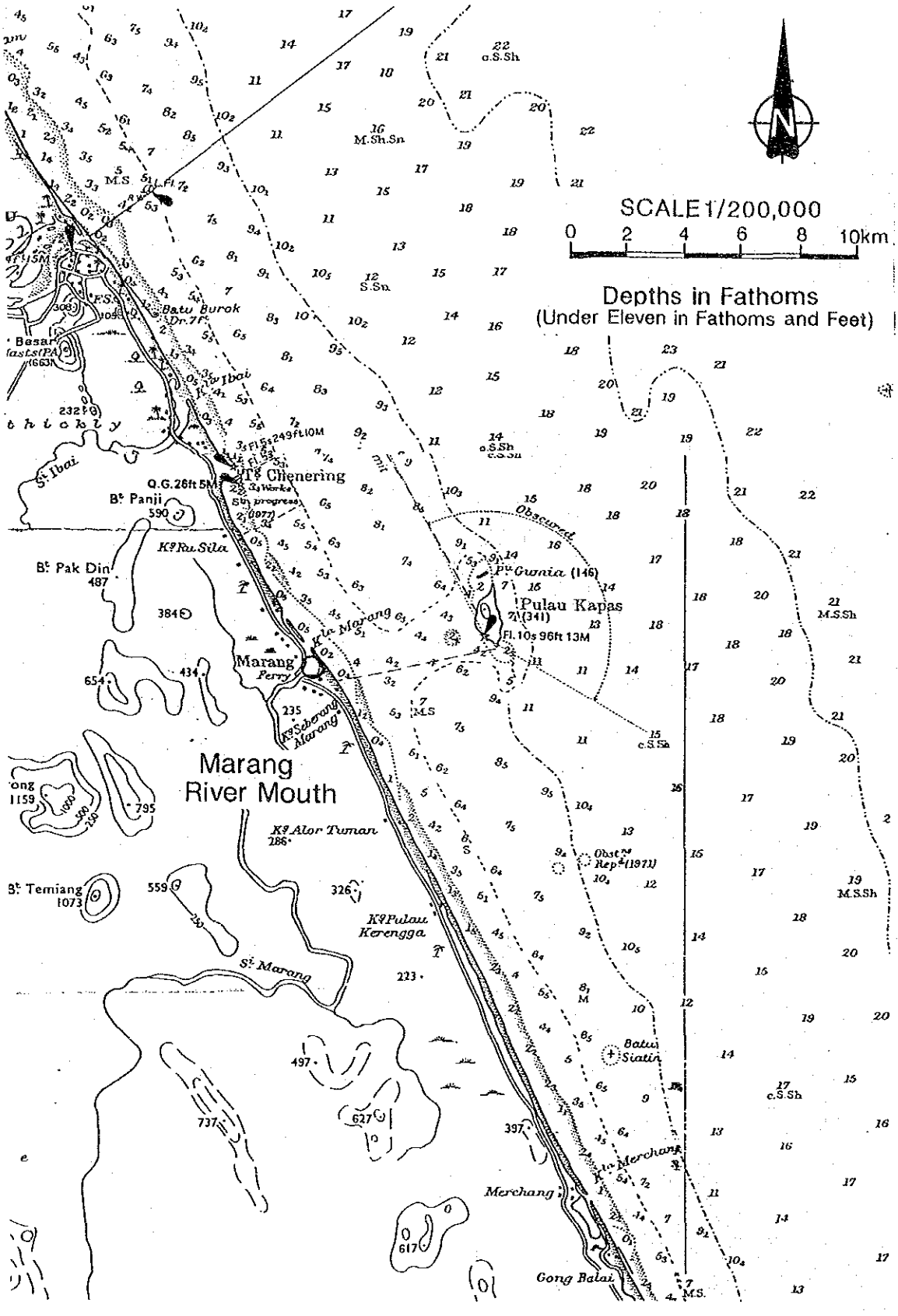
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	INNER AND OUTER CHANNEL PROFILE OF KERTEH RIVER MOUTH Fig.2.2-39



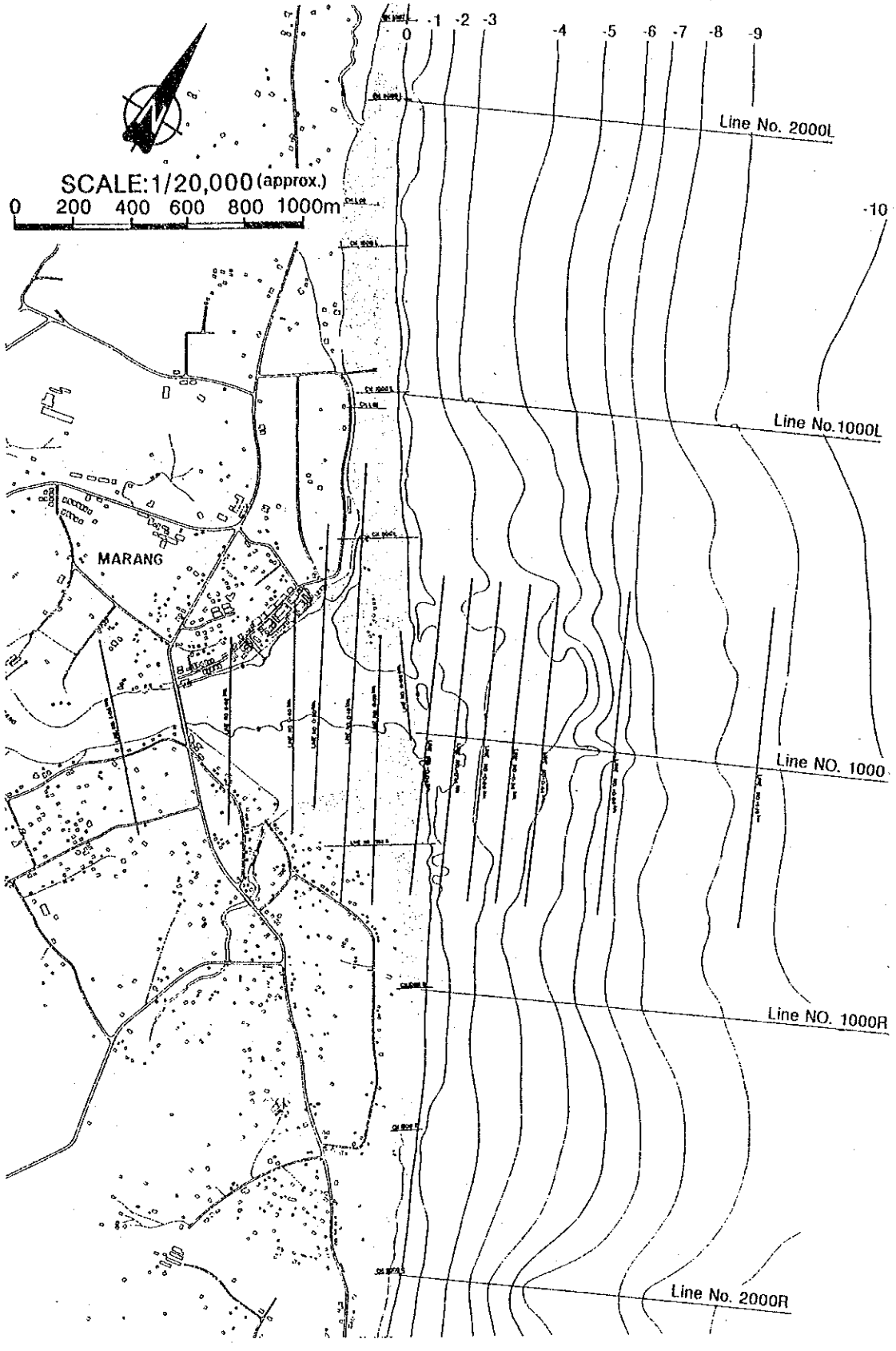
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSITION OF COASTLINE AT KERTEH RIVER MOUTH Fig. 2.2-40



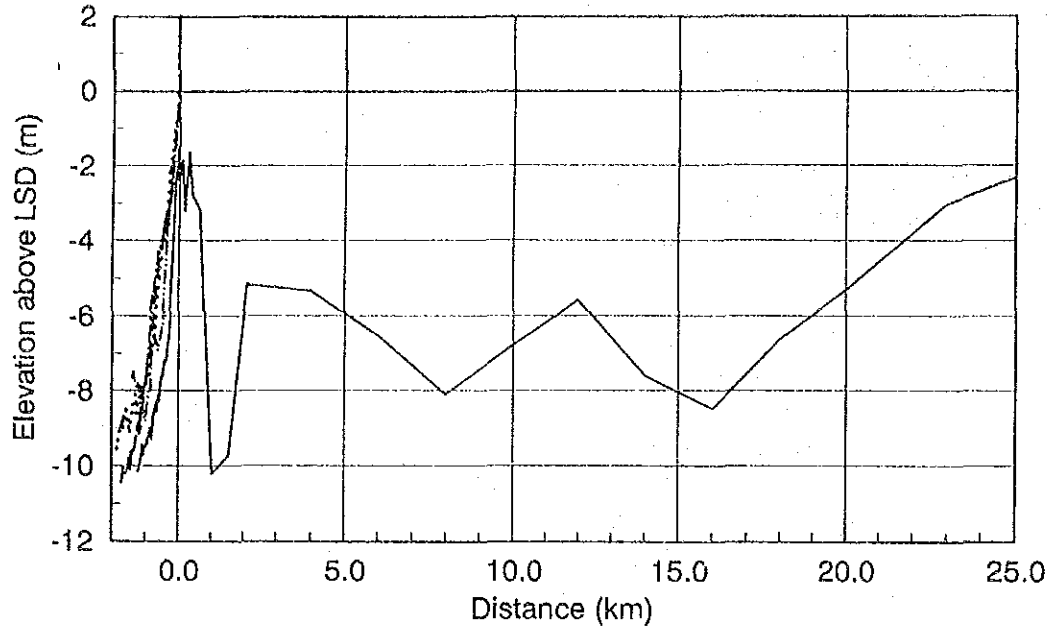
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	TOPOGRAPHICAL MAP AROUND MARANG AND TERENGGANU RIVER MOUTH Fig.2.2-41

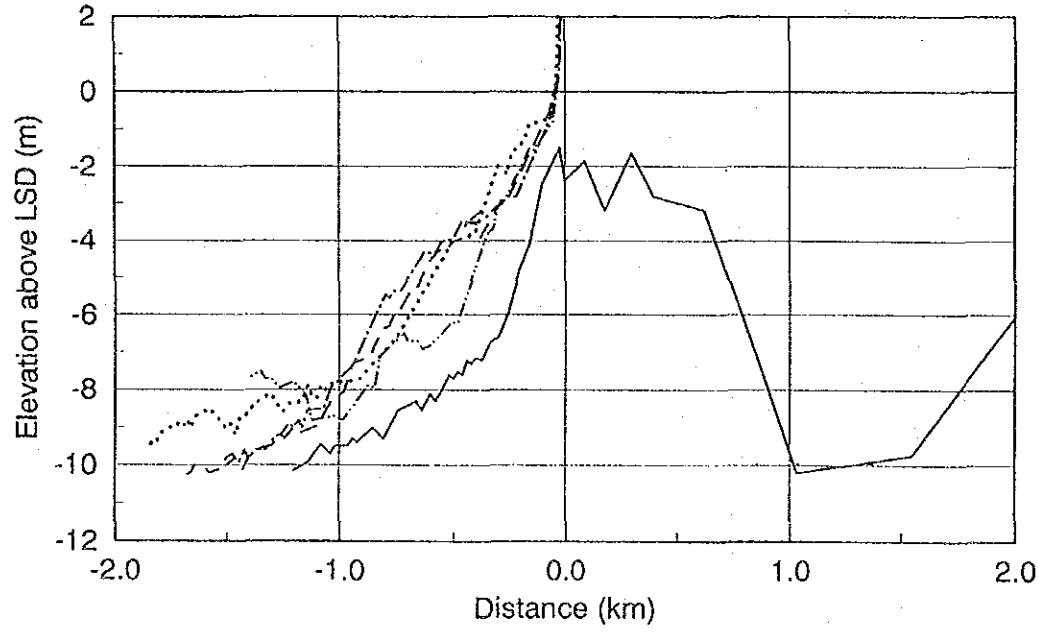


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	NAVIGATION CHART IN MARANG RIVER MOUTH AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-42



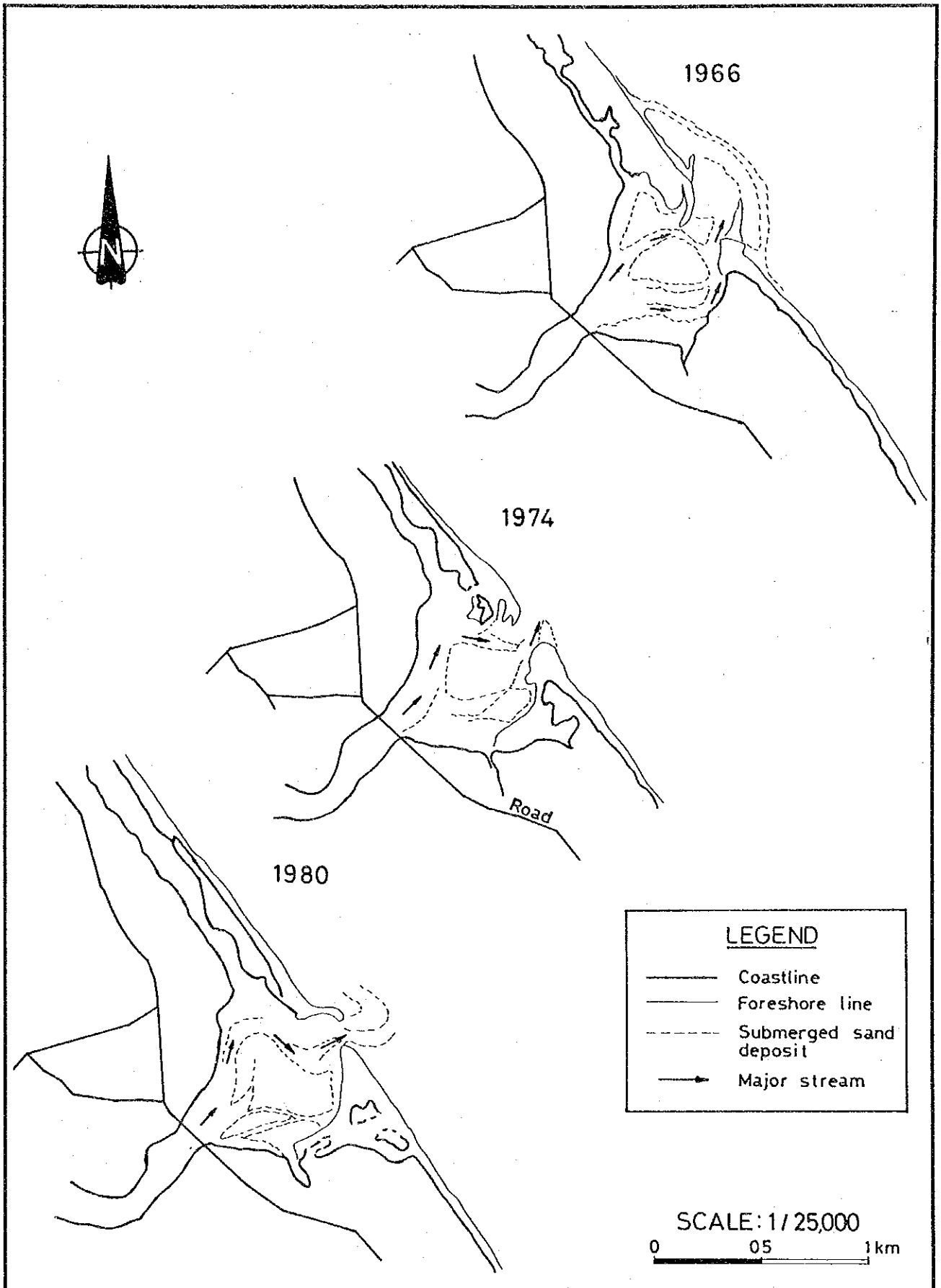
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	DEPTH CHART OF MARANG RIVER MOUTH SURVEYED IN 1992
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.2.2-43





No. 0	No. 1000R	No. 1000L	No. 2000R	No. 2000L
October, '92	October, '92	October, '92	October, '92	October, '92

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	INNER AND OUTER CHANNEL PROFILE OF MARANG RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-44



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	TRANSITION OF COASTLINE AT MARANG RIVER MOUTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.2-45