KINGDOM OF THAILAND

FEASIBILITY REPORT ON SONGKHLA PORT PROJECT

MARCH 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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FOREWORD

In compliance with the request of the Royal Thai Government, the Government of Japan undertook to conduct a survey for construction project of Songkhla port and entrusted the Overseas Technical Cooperation Agency with its execution.

Noting the significance of Songkhla port construction project for economic and regional development of Thailand, the Agency has sent three survey missions to Thailand over the past years. The present feasibility survey was conducted at the strong request of the Royal Thai Government with due consideration given to the recent changes in economic situation and the future economic development.

With the same untiring cooperation of the competent Thai authorities as offered to the past survey missions, the feasibility survey was carried out smoothly as originally planned. It will give me a great pleasure if this report, which contains the outcome of the survey, tends to expedite improvement and expansion of Songkhla port and to promote the friendly relations and economic ties between two countries.

I avail myself of this opportunity to express my deep gratitude to authorities of the Royal Thai Government and other persons concerned for the kind and willing cooperation offered to the mission throughout the survey period.

March 1973

K. Tatsuke

Keiichi Tatsuke
Director-General
Overseas Technical Cooperation Agency

INTRODUCTION

The present feasibility survey was conducted for the purpose of working out a phased master plan for construction of modern port facilities at Songkhla port, Southern Thailand, with due account taken of the recent changes in Thai economy and the country's future development.

The survey mission left Tokyo about mid-August 1971 for Thailand where it was divided into the Planning Group and the Surveying Group. The former spent about four weeks and the latter about fifteen weeks for their respective survey activities.

After its return to Japan, the mission engaged in the compilation and analysis of data collected in Thailand and further conducted experiments and analyses on soil specimens sampled during the survey. The construction plan, preliminary design of structures, cost estimation, and economic evaluation of the project which are contained in this report are all based on the results of these studies and experiments.

The formation of the mission was as follows.

Planning Group:

Leader	KUBOSHIMA Nobuhiro Director; District Port Construction Bureau the 2nd, Ministry of Transport
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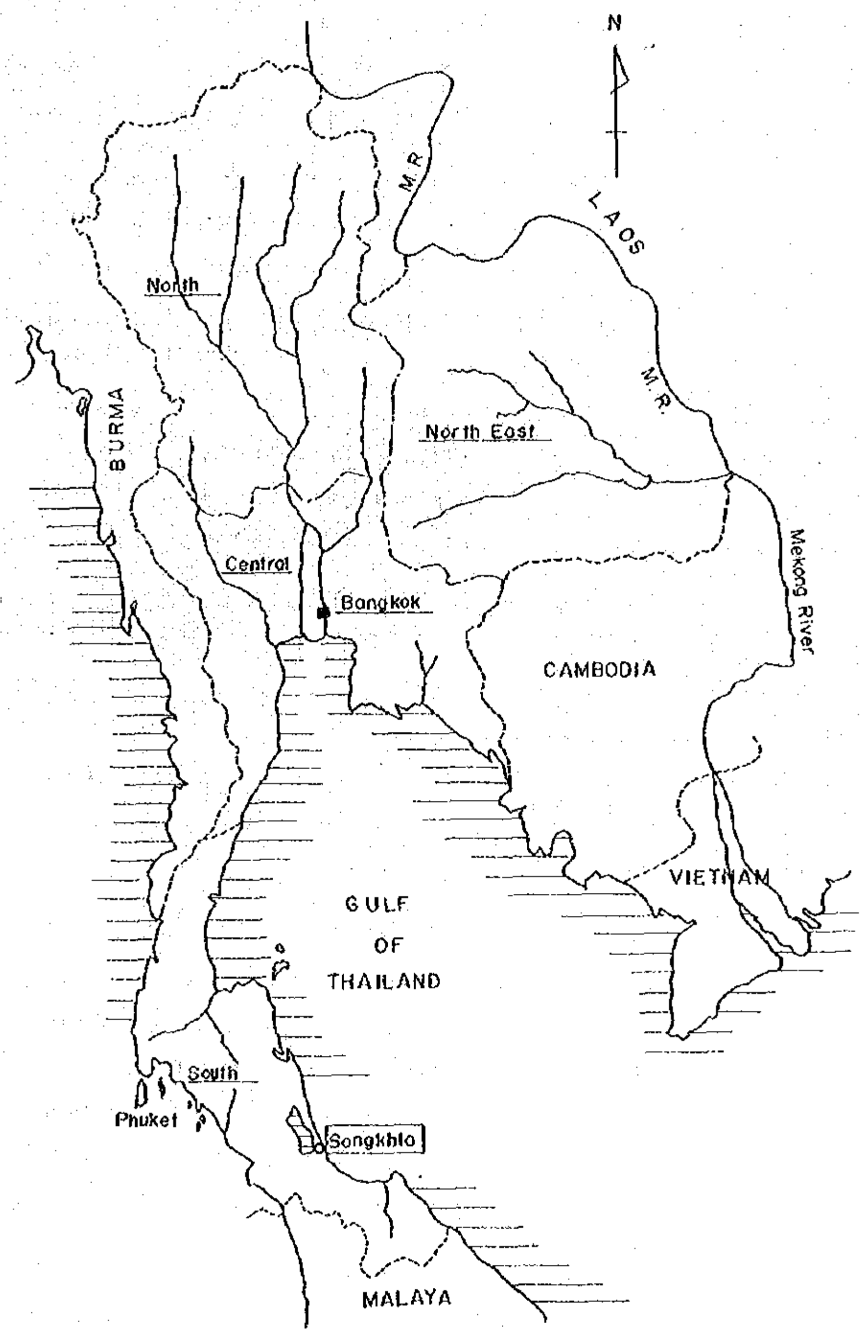
LOCATION


N
M.R.
LAOS
North
BURMA
M.R.
North East
Central
Bangkok
Mekong River
CAMBODIA
VIETNAM
GULF
OF
THAILAND
South
Phuket
Songkhla
MALAYA

CONTENTS

I SUMMARY

I SUMMARY

1. Thailand has pursued a smooth course economic development in Southeast Asia. Her socio-economic activities, however, are concentrated in the central part around Bangkok, while Southern Thailand still remains in the initial stage of development.

Southern Thailand abounds in primary products such as natural rubber and tin, and offers a promising prospect for future development. Hat Yai and offers a promising prospect for future development. Hat Yai and Songkhla are the centres of this area, and Songkhla port is the gateway of these two cities to the outside world. At present, however, Songkhla port lacks facilities for mooring large vessels, so that natural rubber, the major commodity exported from this port, is loaded by the lighter service. This means that Thailand's natural rubber is made so much weaker in international competitive power and the port does not function as it should for regional development.

2. At present, two Changwats, i.e., Songkhla and Phattalung, are the major areas embraced in the hinterland of the port's foreign trade. With the improvement and expansion of its facilities, however, the port will have a wider hinterland area covering additional Changwats such as Nakon Si Thammarat, Trang, Pattani, Satun, Yara and Narathiwat. Further, it is likely that Changwat Surat Thani will join to the hinterland.

Phuket port is known as another important foreign trade port in Southern Thailand besides Songkla port. These two are the representative ports in this part of the country and located on the east and west coast respectively. Viewed from their functions and topographic conditions, the two ports are entirely independent of each other, so that the improvement effected to one of them can hardly affect the improvement plan of the other. Improvement of the both ports is indispensable for balanced development of the entire Southern Thailand.

As for domestic trade, Songkhla and Phattalung will remain as the main Changwats in the hinterland of Songkhla port because small vessels are the major means of domestic cargo traffic.

3. The volume of cargoes handled at Songkhla port recorded 344 thousand tons in 1970. This does not include the large volume of latent cargoes which were transported by other transport means or via other routes due to the port's poor facilities. Such latent cargoes exist in the port's own influence zone, and their volume is expected to increase with the economic progress of Southern Thailand.

It is estimated that the latent cargo volume of Songkhla port will reach 820 thousand tons in 1975, 1,060 thousand tons in 1980 and 1,850 thousand tons in 1990. An important fact to be noted here is that the consignors cannot be encouraged to ship the voluminous latent cargoes through Songkhla port merely by the improvement of its wharves and other facilities.

To turn the latent cargoes actualized, it is imperative that the improvement of transport facilities should be coupled by that of the commodity collecting and distributing mechanism. It will require quite a long time to materialize such functional improvements, but it deserves attention that by effecting such improvements, the port's cargo handling volume (in its plan) is estimated to increase to 553 thousand tons in 1975 and further to 930 thousand tons in 1980. It is believed that full coverage of all the latent cargo volume of 1,850 thousand tons (estimate) will be attained in 1990.

4. Except in the vicinity of the lake outlet, the coastal area near the port is composed of fine sand, and the sea bottom slope ranges from 1/200 to 1/300. The area around the port presents the climatic features of Asian Monsoon Zone. No wave observation data are available, but the significant wave height and period for structural design estimated from the wind records are 2.2 m and 6 ~ 7 sec, respectively.

On the sea bottom, silty material carried from the lake and measuring less than 50μ in grain size is widely distributed from the tip of the breakwater to Ko-Nu and its neighbourhood. Interposition of soft silt layers is noticed in the soil, and this increases from the beach toward the offing with the aggravating soil condition. For this geological reason, construction of port facilities in the open sea area will incur a large cost and is not therefore advisable.

The critical depth of sand movement, which can bear upon the maintenance of the navigation channel, is estimated to be within the range of 4.0 to 5.0 m. Accordingly, intrusion of sand drift can be checked almost completely by constructing a breakwater to that depth.

Further, if a training dyke is constructed on the lake outlet, the flushing effect of stream will be intensified and it will be technically possible to maintain a depth sufficient for navigation of large vessels.

5. The construction plan of Songhkla port should be mapped out for export expansion of primary products centring on natural rubber and for betterment of livelihood of local inhabitants. It should also be so formulated that the port facilities will exhibit their functions with a minimum of cost and at the earliest date.

With respect to the selection of a construction site that satisfies all these demands, the inner harbour plan is most recommendable because of the above-mentioned technical conditions, possibility of making full use of the existing breakwater and navigation channel, and low construction cost. Under this plan, it is envisaged that a-8.0m quay wall having 5 berths, a-5.5 m quay wall having 4 berths, a 500 m long breakwater, a 1,770 m long training dyke, etc. will be constructed by 1990.

The port construction work will be carried out over two stages, with the First Stage divided into Sub-stage I and Sub-stage II.

Sub-stage I (1974 ~ 1977) will cover the construction of the training dyke (1,000 m), quay wall with a depth of -8 m and having 2 berts, another quay wall with a depth of -5.5 m and having 2 berts, and other related facilities. Capital investment required for construction of these facilities is US$9,380 thousand.

Construction in Sub-stage II (1982 ~ 1985) will cover the training wall (770 m), breakwater (500 m), 2 berths (along the -8.0 m quay wall), 1 berth (along the -5.5 m quay wall), and other related facilities. Capital investment required in this sub-stage is US$8,440 thousand.

In the 2nd Stage (1989 ~ 1990), 1 berth each along the -8.0 m and -5.5 m quay walls will be constructed. Capital investment required in this stage is US$1,900 thousand.

6. Economic evaluation of the project, which calls for the capital investment introduced above, must be made from two different angles.

In other words, the project must be evaluated against the yardstick of national economy and sound port management. In the former approach, the net value that can be brought about to national economy by the port construction should be assessed, while in the latter, the project should be checked to see if it promises sound port management. To be more precise, evaluation should be based on the method of cost-benefit ratio (discount rate: 10%) as well as the method of internal rate of return in the former approach, whereas in the latter, the method of financial rate of return must be employed.

7. The analysis of the net value to national economy shows that the cost-benefit ratio is 1.16 and the internal rate of return 14.9%, indicating that the project is valuable for the development of national economy.

When evaluated by the analysis of port management, however, the project does not present a promising prospect since the financial rate of return turns out to be 5.5% with the present port tariff structure.

Nevertheless, if the prevailling port tariff structure is revised for increased revenues or the government grants subsidy to cover part of the construction cost, the port management can be made both sound and pyable. If, again, the Treasury finances the construction of the outer facilities and harbour facilities costing 44% of the total construction cost, the financial rate of return will rise to 12.8%.

Therefore, if the project is supported by such measures, it can be justified for sound port management.

8. It can be verfied that the improvement of Songkhla port is not only technically feasible but also sound from the viewpoint of national economy and port management.

By investing about US$10 million during the four year period of Sub-stage I, Songkhla port will be transformed into a modern foreign trade port capable of meeting the transport demand expected to arise during about eight years subsequent to 1974.

It is no doubt that the said 10 million dollar investment will foster the competitive power of natural rubber and other primary products on the world market and at the same time contribute largely to the improvement of Thailand's international balance of payments.

II EXISTING STATE OF SOUTHERN THAILAND

II EXISTING STATE OF SOUTHERN THAILAND

A. Socio-economic Condition

9. Southern Thailand occupies about 13.5% and 12.6% respectively of the nation's total area and population.

Table 1 shows the share of Southern Thailand in Thailand's gross domestic product (GDP). As seen in the table, Southern Thailand's share is on the decline and the gap between this area and other parts of the country is likely to be widened in the coming years. The table also indicates that the annual growth rate in Southern Thailand is subject to a large fluctuation just as in other parts of the country excepting the central part, and this suggests that Thai economy is still needful of infrastructural improvement.

10. Table 2 shows the major economic indices in each Changwant of Southern Thailand.

As the table indicates, Changwant Nakhon Si Thamarat has the largest population, but urban population is concentrated in Changwat Songkhla. Changwat Songkhla for surpasses other Changwats in the value of commercial transactions, indicating that it is the centre of economic activities in Southern Thailand.

The table also shows that natural rubber is produced mostly in the southern part of the area, whereas tin is produced chiefly in the northern part.

11. Fig. 1 shows the transport network of Southern Thailand. Nakhon Si Tharmarat port and Songkhla port on the east coast and Kantang port on the west coast are favourably located for connection with the railway line linking Bangkok and Malaysia. For connection with the road network, Phuket port is advantageous for transportation to and from Bangkok, whereas Songkhla port is located favourably for transportation to and from the west coast and Southern Malaysia.

B. Ports in Southern Thailand

12. About 20 ports are found on the coast of Southern Thailand. All these ports are the important gateways for export of the area's major products such as tin and natural rubber as well as for import of daily necessaries, petroleum and petroleum products, construction materials, etc.

Seven of these 20 ports, i.e., Songkhla, Pattani, Narathiwat, Nakhon Si Thamarat, Phuket, Krabi and Kantang, are important for their larger cargo handling volume. In 1969, the seven ports combined handled 84% of total seaborne cargo volume of the area.

13. Table 3 shows the record of cargo handling volume at all Thai port and at the ports in Southern Thailand. As seen in the table, Southern Thailand occupies about 10% and 50% respectively of the nation's total foreign and domestic cargo volumes. About 60% of the cargoes handled

Table 1 - Economic Activities in Southern Thailand

(Million Baht)

		1966	1967	1968	1969	1970	1971	AV. 1967~71
WHOLEKINGDOM	GDP.	89,189.6	94,109.3	102,377.5	112,377.5	119,100.6	126,365.7	
	GR. (%)		5.5	9.0	9.6	6.0	6.1	7.2
	Share	100.0	100.0	100.0	100.0	100.0	100.0	
NORTHEAST	GDP.	16,4 7.7	15,72 .2	16,970.7	18, 5.0	20,06 .0	21,424.0	
	GR. (%)		-4.7	7.	11.5	6.0	6.8	5.5
	Share	12.5	16.7	16.6	16.8	16.8	17.0	
NORTH	GDP.	13,848.7	14,156.5	15,720.7	17,650.2	1 ,026.6	19,180.5	
	GR. (%)		2.5	10.7	8.5	5.7	6.4	6.8
	Share	15.5	15.1	15.3	15.2	15.1	15.2	
SOUTH	GDP.	11,120.2	11,726.5	12,927.0	14,089.3	14,814.5	15,324.8	
	GR. (%)		5.5	10.3	9.1	5.0	3.4	6.7
	Share	12.5	12.5	12.6	12.5	12.4	12.1	
CENTRAL	GDP.	47,723.0	52,49 .1	56,959.1	62,313.0	66,199.5	70,436.3	
	GR. (%)		9.9	8.6	9.4	6.2	6.4	
	Share	53.5	55.7	55.5	55.5	55.7	55.7	

AT CONSTANT 1962 PRICE

Table 2 - Major Economic Indices of Southern Thailand

	Land	Population	Urban Population	Value of Commercial Transactions	Number of Automobiles	Number of Households	Number of Farm House-holds	Rice Produc-tion	Rubber Produc-tion	Tin Produc-tion
	($1,000km^2$)	(1,000 person)	(1,000 person)	(B million)	(1,000)	(1,000)	(1,000)	(1,000t)	(1,000t)	(1,000t)
		1970	1969	1966	1969	1960	1960	1968	1968	(1970)
SOUTH	70.2	4,269	502	3,563	80	617	486	983	237.4	
CHUMPHON	5.7	235	18	117	4	33	27	51	0.3	2.0
RANONG	3.4	59	9	122	2	7	4	5	0.4	8.0
SURAT THANI	12.8	434	46	124	5	60	49	130	15.2	1.6
PHANG-NGA	4.1	135	14	63	3	16	12	16	9.6	3.4
NAKKON SI-TAMARAT	10.2	927	72	337	8	129	108	333	38.4	1.7
PHUKET	0.8	150	36	291	8	12	6	4	4.7	6.5
KRABI	4.6	148	8	27	2	17	16	34	10.0	-
PHATTALUNG	3.3	298	14	74	3	44	40	167	14.8	-
TRANG	4.9	326	40	204	9	43	35	30	27.4	1.9
SATUN	2.7	131	10	31	2	14	11	23	5.3	-
SONGKHLA	6.7	621	106	1,298	13	97	73	133	42.6	1.5
PATTANI	2.0	330	32	146	7	59	46	28	14.0	-
YALA	4.7	199	51	546	6	30	22	9	24.9	0.8
NARATIWAT	4.2	326	37	184	7	56	39	21	29.8	-

at ports in Southern Thailand are primary products such as natural rubber, tin and other mineral products.

The 1965 survey indicates that 67% of the inter-regional export cargoes handled at Southern Thai ports were sent to Bangkok, and 75% of the inter-regional import cargoes also handled at Southern Thai ports came from Bangkok. So far as viewed from the field of marine transportation, this is clear evidence to show that Southern Thailand is closely tied with Bangkok in economic activities.

Table 3 - Cargo Handling Volume at All Thai Ports and at Southern Thai Ports

(1,000 t)

		1960	1965	1970	Remarks
All Thai Ports	Foreign Trade	4,955	10,253	14,826	
	Domestic Trade	902	1,054	2,760	
Southern Thai Ports	Foreign Trade	304	1,115	487	
	Domestic Trade	471	516	2,209	

14. The existing state of Phuket port, Kantang port and Pattani port is as outlined below.

1) Phuket Port

Phuket port has a simple wooden pier for fishing operation as public facilities and a privately operated petroleum berth and tin loading pier. The port handles 100 to 140 thousand tons of cargoes consisting chiefly of tin and natural rubber (export) and petroleum (import). Phuket island is connected with the mainland by a bridge, but railway construction to the port is still in the planning stage. Considering its connection with the existing land transport network, the port's hinterland area is not so large. Viewed from the natural conditions such as topography and marine meteorology, however, the port's location is one of the best in Southern Thailand for construction of a larger and improved port.

2) Kantang Port

Since Kantang port is located about 20 km upstream of the estuary, maintenance of its navigation channel is made extremely difficult. It handles about 70 to 100 thousand tons of cargoes consisting mostly of natural rubber for export. Since the port is quite favourably situated for connection with the land transport network, a drastic measure must be taken against the silting up of its channel.

3) Pattani Port

This port is located about 6 km upstream of the estuary and its navigation channel is small in both depth and width. Its annual cargo handling volume ranges from 100 to 150 thousand tons composed chiefly of export natural rubber and foodstuffs imported from other parts of the country. The port is favourably located for connection with both roads and railways.

15. In Southern Thailand, functions of major ports bear closely on the daily and better life of local inhabitants. Selection of the ports to be improved for future development of this area must be made with due consideration given to such factors as the transport network, urban development, mineral resources, degree of industrial agglomeration, and natural conditions.

Hat Yay, the largest city in Southern Thailand, is located very close to Sangkhla port. Not only that, the port is also close to main roads and railway lines. Its improvement can be justified by reason of the surrounding social, industrial and natural conditions. If a modern port is to be constructed in this area for promotion of foreign trade, Songkhla provides the most advantageous site.

C. Existing State of Songkhla Port

16. An increasingly heavy weight has come to be carried by Songkhla port in recent years in the commodity transportation by virtue of its many favourable conditions.

Table 4 shows the recent record of cargo volumes handled at all Southern Thai ports and at Songkhla port.

Table 4 - Cargo Handling Volume of All Southern Thai Ports and Songkhla Port

(1,000 t)

		1960	1965	1970	Remarks
All Southern Thai Ports	Foreign Trade	304	1,115	487	
	Domestic Trade	471	516	2,209	
Songkhla Port	Foreign Trade	48	70	93	
	Domestic Trade	91	127	254	

The 1965 survey disclosed that within the total domestic trade cargoes handled at Songkhla port, 80% of outgoing cargoes went to Bangkok and 76% of incoming cargoes came also from Bangkok.

17. During 1970, a total of 143 vessels called at Songkhla port for foreign trade and 800 for domestic trade. Table 5 shows the average class of vessels and their average loading weight.

Table 5 - Average Vessel Class and Loading Weight of Vessels Calling at Songkhla Port

		Average Class(RT)	Average Loading Weight (ton)
Foreign Trade	Southeast Asia	200 ~ 400	200 ~ 400
	Areas Other Than Southeast Asia	2,000~2,500	800~1,000
	Ordinary Carriers	100 ~ 150	100 ~ 150
	Tankers	100~150, 1,000~1,500	400~500, 1,000~1,500

18. The existing port facilities are constructed in front of Songkhla city over a distance of about 3.6 km. Table 6 shows the major mooring facilities of the port.

Table 6 - Main Mooring Facilities of Songkhla Port

Name	Depth	Width	Structure	Remarks
Navy Pier	-4.0 m	12.0 m	Concrete pier	Equipped with water supply facilities.
Harbour Dept. Pier	-6.0	84.0	"	"
National Railway Pier	-6.0	50.0	"	Provided with a siding track and an oil pipe (15 cmϕ, 13,000 k /).
Marine Police Pier	-3.5	-	"	
Thai Navigation Co. Pier	-3.0	-	Plank pier with concrete studs	Equipped with a 5 t crane (capacity: 1,000 t/d).
Fishing Pier	-4.0	90.0	Concrete pier	
Fish Market Pier	-2.5	5 piers	Plank pier with concrete studs	Used for landing of fish catch and communication with the islands in the lake.
Sing Tong Co. Pier	-3.0		"	Provided with a transit shed (50 m^2) and open stock yard (1,000 m^2).
Customs Pier	-3.5	30.0	Concrete pier	
Harima Sute Co. Pier	-4.5	10.0	"	Equipped with water supply facilities.
Dockyard	-	-	3 rows x 2 ships	For construction of 30 GT wooden boats.
Dockyard	-	-		For construction of 20 GT wooden boats.

Besides the facilities listed above, the port is equipped with a terminal facility of ferry boats.

19. Since different facilities are disorderly installed on a short waterfront integrated operation and development of the port is made difficult. If Songkhla port is to be improved to play the major role in the development of Southern Thailand, the following measures will have to be enforced.

i) Establishment of an administrative body responsible for the port operation.

ii) Systematic improvement of port facilities for effective utilization of the waterfront line.

iii) Improvement of the cargo collecting and distributing system.

iv) En hanced enforcement of safety measures.

v) Collection and compilation of statistics relating to the port operation.

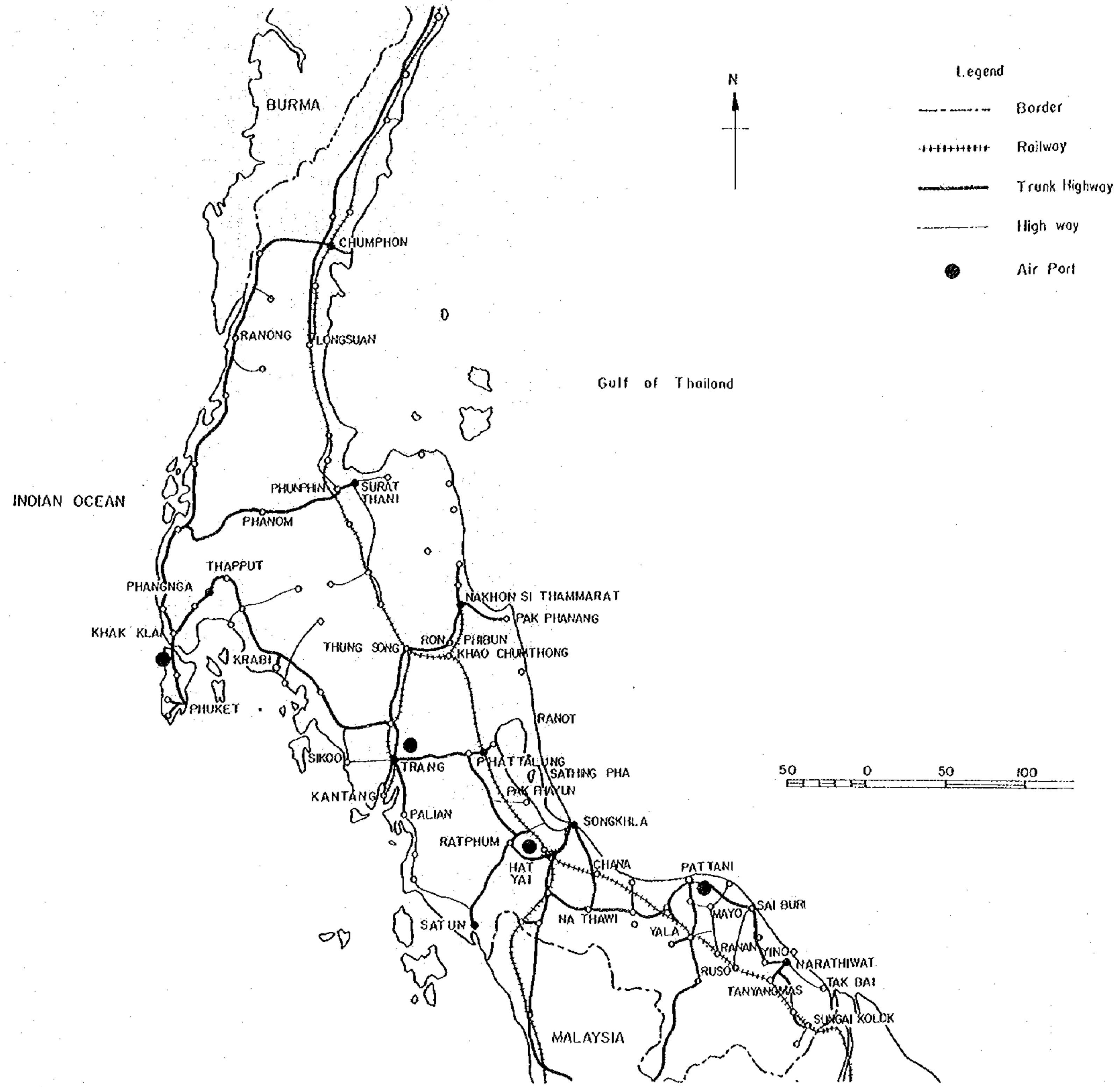


Fig. 1 Traffic Map in Southern Thailand

III ECONOMIC FACTORS DETERMING THE SCALE OF SONGKHLA PORT

III ECONOMIC FACTORS DETERMING THE SCALE OF SONGKHLA PORT

A. Hinterland

20. In making selection between different transport means such as trucks, railways and ships for shipment of cargoes generating in the hinterland of a port, a great diversity of factors must be taken into consideration. In addition to speed, safety and reliability, these factors include the type and volume of cargo, maximum payable rate of transport cost, prevailing freight and cartage, and route. All these factors must be put to a rigid and comprehensive review in order to determine which transport means is to be used.

21. In studying the hinterland of Songkhla port, the following preconditions must be assumed.

i) Origins and destinations of cargo traffic generating in Thailand are all represented by cities.

ii) Since economic activities in Thailand are concentrated in Bangkok and Thonburi, Bangkok is taken as an origin and destination of the domestic cargo traffic.

iii) Rates of transportation charges have shown virtually no changes over the past seven years (See Table 7). This trend is considered to continue in future. Even in case there arises any large fluctuation, the balance between the rates of different transportation charges is assumed to be maintained.

iv) The road and railway network is assumed to be in the state of 1970.

v) The amount of each lot of cargo traffic demand is 100 metric tons (all the weights appearing in the following pages are expressed in metric ton).

Table - 7 Consumer Price Index for Bangkok-Thon Buri by Group (October 1964~September 1965:100)

Weights / Period	All Items	Food	Clothing	Housing	Personal & Medical Care	Trans-portation	Recreation Reading & Education	Tobacco & Alcoholic
	100.0	49.0	9.4	17.8	7.2	6.1	56	49
1964	99.4	99.5	100.9	98.8	99.0	99.8	99.4	100.0
1965	100.3	100.1	99.9	100.6	100.2	100.3	100.1	100.0
1966	104.1	106.6	100.4	102.2	104.0	99.9	101.5	99.9
1967	108.2	114.2	100.4	102.2	107.9	99.0	101.8	99.9
1968	110.5	118.1	100.7	103.0	107.9	102.8	101.9	99.9
1969	112.8	122.8	100.5	104.4	107.9	99.0	101.9	99.9
1970	113.7	123.1	102.4	106.7	108.1	100.1	101.7	100.4

* Financial port, Sept. 2, 1971

22. Since Bangkok is one of the ends of domestic cargo traffic routes, the following four cargo traffic patterns are considered to be existent between Bangkok and the cities in Southern Thailand (See Table 8).

i) Truck transportation over the entire route.

ii) Railway transportation over the entire route.

iii) Marine transportation via Songkhla port.

iv) Marine transportation via neighbouring ports.

Table 8 - Patterns of Domestic Trade Cargo Traffic

i) Truck Transportation

[Transit shed in Bangkok city] — Shipment from transit shed and loading (N_{1D})
→ (Truck) (L_T) — Unloading (N_{2D}) → [Transit shed at the place of destination]

ii) Railway Transportation

[Transit shed in Bangkok city] — Shipment from transit shed and loading
→ (Truck) (L_T) — Transhipment ($N_{3(T-R)}$) → (Railways) — Transhipment ($N_{3(R-T)}$) → (Truck) (L_T) —
Unloading (N_{2D}) → [Transit shed at the place of destination]

iii) Transportation by Coasting Vessels (via Songkhla Port)

[Transit shed in Bangkok city] — Shipment from transit shed and loading (N_{1D})
→ (Truck) (L_T) — Transhipment ($N_{3(S-T)}$) → [Bangkok port] (N_P) → (Coasting vessel) (L_S) —
→ [Songkhla port] (N_P) — Transhipment ($N_{3(T-S)}$) → (Truck) (L_P) — Unloading (N_{2D})
→ [Transit shed at the place of destination]

iv) Transportation by Coasting Vessels (via the Closest Port to the Place of Destination)

[Transit shed in Bangkok city] — Shipment from transit shed and loading (N_{1D})
→ (Truck) (L_T) — Transhipment ($N_{3(T-R)}$) → [Bangkok port] (N_P) → (Coasting vessel) (L_S) —
→ [Closest port to the place of destination] (N_P) — Transhipment ($N_{3(S-T)}$)
→ (Truck) (L_T) — Unloading (N_{2D}) → [Transit shed at the place of destination]

As for the patterns of foreign trade cargo traffic, the preconditions presented under Item 22 must be supplemented by another assumption that import and export cargoes of Thailand are handled at three ports, i. e., Bangkok, Phuket and Songkhla, and that the same freight rate is applied at all the three ports. This additional assumption is required because of the fact that shipping companies try to increase the rotation of ships due to their profit-seeking nature, endeavouring to cut down the ships' stay in the port to a minimum and to decrease the number of calling ports by concentrating cargoes at well consolidated ports through application of a lower freight rate, and this leads to the decrease in the number of foreign trade ports.

On the basis of these assumptions, the following patterns can be considered for foreign trade cargo traffic (See Table 9).

i) Lighter service at Songkhla port, and truck transportation.

ii) Cargo handling on the wharf of Songkhla port, and truck transportation.

iii) Lighter service at Songkhla port, and railway transportation.

iv) Cargo handling on the wharf of Songkhla port, and railway transportation.

v) Cargo handling on the wharf of Bangkok port, and railway transportation.

vi) Lighter service at Phuket port, and truck transportation.

Table 9 - Patterns of Foreign Trade Cargo Traffic

i) Lighter Service at Songkhla Port, and Truck Transportation

[Carrier] —Transhipment (N_{2H} for carrier, N_{1L} for Lighter)→ (Lighter) L_L —Unloading (N_{2L})→ [Songkhla port] N_{PF} —Loading (L_{1T})→ (Truck) L_T —Unloading (N_{2D})→ [Transist shed at the place of destination]

ii) Cargo Handling on the Wharf of Songkhla Port, and Truck Transportation

[Carrier] —Unloading (N_{2H} for carrier)→ [Songkhla port] N_{PF} —Loading (N_{1T})→ (Truck) —Unloading (N_{2D})→ [Transit shed at the place of destination]

iii) Lighter Service at Songkhla Port, and Railway Transportation

[Carrier] —Transhipment (N_{2H} for carrier, N_{1L} for lighter)→ (Lighter) L_L —Unloading (N_{2L})→ [Songkhla port] N_{PF} —Loading (N_{1R})→ (Railway) L_R —Transhipment ($N_{3(R-T)}$)→ (Truck) L_T —Unloading (N_{2D})→ [Transit shed at the place of destination]

iv) Cargo Handling on the Wharf of Songkhla Port, and Railway Transportation

Carrier —Unloading (N_{2H} for carrier)→ Songkhla port (N_{PF}) —Loading (N_{1R})→ (Railway) (L_R) —Transhipment ($N_{3(R-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ Transit shed at the place of destination

v) Cargo Handling on the Wharf of Bangkok Port, and Railway Transportation

Carrier —Unloading (N_{2H} for carrier)→ Bangkok port (N_{PF}) —Loading (N_{1R})→ (Railway) (L_R) —Transhipment ($N_{3(R-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ Transit shed at the place of destination

vi) Lighter Service at Phuket Port, and Truck Transportation

Carrier —Transhipment (N_{2H} for carrier, N_{1L} for lighter)→ (Lighter) (L_L) —Unloading (N_{2L})→ Phuket port (N_{PF}) —Loading (N_{1T})→ (Truck) (L_T) —Unloading (N_{2D})→ Transit shed at the place of destination

24. From the link and node costs shown in Table 10, the transportation cost can be calculated for each of the patterns shown above. For example, in the case of Pattern iii) of domestic cargo traffic, the total transportation cost is the sum of the link and node cost listed below.

Charges for shipment from transit shed and loading on the truck	N_{1D}
Truckage	L_T
Transhipment charges	$N_{3(T-S)}$
Port charges	N_P
Charges for coasting transportation	L_S
Port charges	N_P
Transhipment charges	$N_{3(S-T)}$
Truckage	L_T
Unloading charges	N_{2D}

Table 10 - Link and Node Costs

		Notation	Cost (Baht/ton)	Remarks
Node	N_{1D}	Shipment from transit shed and loading onto truck	12	Obtained through interviews with the forwarding agents in Bangkok city.
	N_{2D}	Unloading from truck	12	
	N_{1T}	Loading onto truck	12	Ditto
	N_{1R}	Loading onto goods wagon	10	Ditto
	N_{2H}	Unloading from carrier (foreign trade cargo)	21	Average of the rates applied to different cargoes at Kantang port.
	$N_{3(T-R)}$	Transhipment from truck to railway	15	Obtained through interviews with the forwarding agents in Bangkok city
	$N_{3(R-T)}$	Transhipment from railway to truck	15	Ditto
	$N_{3(T-S)}$	Transhipment from truck to coasting vessel	10	Obtained through interviews with the forwarding agents in Bangkok city and the shipping agents in Songkhla city.
	$N_{3(S-T)}$	Transhipment from coasting vessel to truck		Ditto
	N_P	Port charges (domestic trade cargo)	5	Obtained through interviews with the shipping agents in Bangkok city; not intended to be applied at a port with well consolidated facilities.
	N_{PF}	Port charges (foreign trade cargo)	39	Obtained through interviews with the shipping agents in Bangkok city on cargo handling and landing charges collected at Bangkok port. The rate shown increases to about 115 Bhat/ton if customs fee, wharfage, etc. are added.
Link	L_T	Truckage	0.3 B/kg	Obtained through interviews with the trucking agents sampled from all trucking agents in the country. ETO's standard rate is not employed.
	L_R	Railway transportation charges		Arithmetic mean of SRT's freight tariffs for Classes 2,4,5 and 8.
	L_S	Charges for coasting transportation	83	Average of the rates applied to different cargoes at Songkhla port; obtained through interviews with the shipping agents in Songkhla city.
	L_L	Lighter's charge (including the terminal charge for L L_{1L} and L_{2L}	35	Obtained by interviews with the forwarding agents in Songkhla city and with the consignors shipping cargoes via Songkhla port.

25. In the case of domestic cargo traffic, the hinterland area of Songkhla port can be obtained by first calculating the transportation cost by all the four patterns of cargo traffic between major cities in Southern Thailand and Bangkok, and then checking those cities which incur a smaller transportation cost by Pattern iii) than by any of the other three patterns. The calculation indicates that the hinterland embracing such cities covers Changwats of Phattalung, Satun and Songkhla. Of these Changwats, Satun has its own port, i.e., Satun port. Partly for this reason and partly for the rather daring assumptions presented above, Changwat Satun is excluded from the hinterland of Songkhla port shown in Fig. 2.

Table 11 - Comparison of Transportation Costs (Domestic Trade)

Unit: Baht/ton

Pattern of Transportation / City	i) Truck Transportation (from Bangkok)	ii) Railway Transportation (from Songkhla)	iii) Transportation by coasting vessels (via Songkhla by truck)	iv) Transportation by Coasting Vessels (via Closest Port to the Place of Destination) (via)	
Chumphon	174	157	399	Chumphone	157
Phangnga	294	251	273		-
Phuket	298	254	301		-
Krabi	355	231	249		-
Trang	361	198	206	Songkhla	206
Phattalung	380	200	190	Songkhla	190
Hat Yai	411	209	157	Songkhla	157
Pattani	454	218	188	Pattani	157
Yala	456	221	189	Pattani	159
Betong		249	227	Pattani	159
Narathiwat	484	227	218	Narathiwat	157
	369	228	214	Songkhla	214

26. The hinterland of foreign trade cargo traffic can be obtained in much the same way as explained above, i.e., by comparison of transportation costs. Table 12 shows transportation costs obtained by calculation and Fig. 3 illustrates the hinterland area prepared from Table 12.

27. It is considered that Songkhla port's foreign trade covers the same hinterland area as delineated by its domestic trade, i.e., changwats of Songkhla and Phattalung. In Southern Thailand, each economic centre has a port nearby, and all such ports are just about on the same level of development and none has well consolidated facilities and operation system required to cover a large hinterland area. It can therefore be reasoned that the same hinterland area is covered by both foreign trade and domestic trade of each port in this area.

Table 12 - Comparison of Transportation Costs (Foreign Trade)

Unit: Bhat/ton

Pattern of Transportation / City	i) Lighter Service at Songkhla Port and Truck Transportation	ii) Cargohandling on the Wharf at Songkhla Port and Truck Transportation	iii) Lighter Service at Songkhla Port and Railway Transportation	iv) Cargohandling on the Wharf of Songkhla Port and Railway Transportation	v) Cargohandling on the Wharf at Bangkok Port and Railway Transportation	vi) Lighter Service at Phuket Port and Truck Transportation
Chumphon	371	336	226	191	190	248
Ranong	334	299	254	219	218	212
Suratthani	329	294	204	169	205	206
Krabi	221	186	230	195	264	176
Trang	178	143	197	162	231	214
Kantang	186	151	200	165	233	222
Nakhon Si Thammarat	214	179	189	154	229	233
Phattalung	162	127	170	135	233	233
Theng Song	200	165	187	152	223	
Yala	162	127	174	139	254	
Narathiwat	190	155	181	146	260	

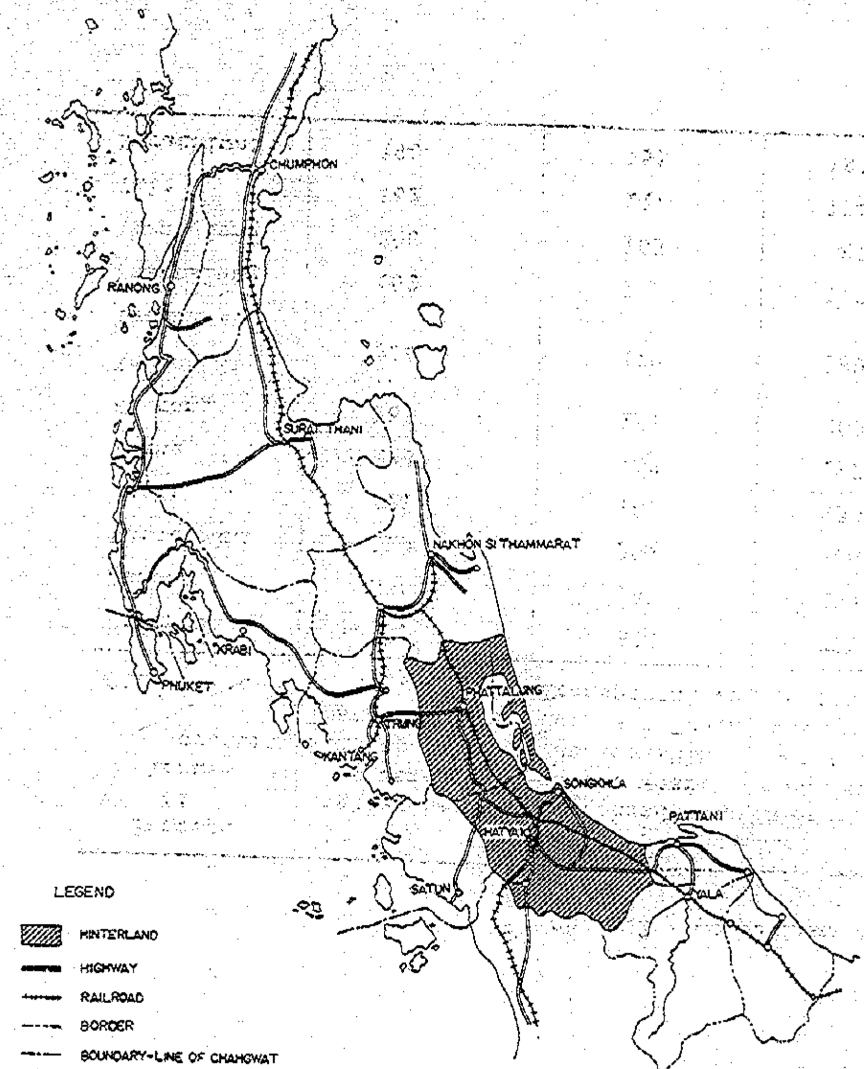


Fig. 2 Hinterland of Domestic Trade

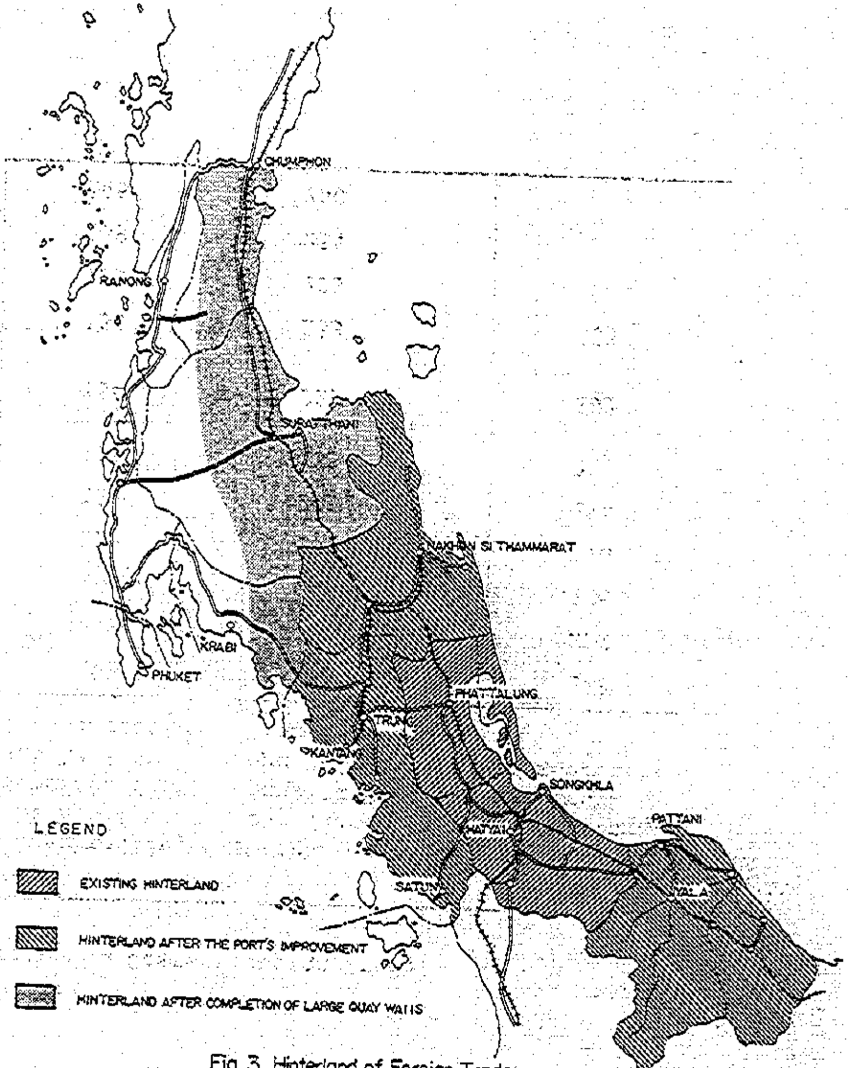


Fig. 3 Hinterland of Foreign Trade

28. For economic reasons described already, foreign trade ports are limited to a small number of well consolidated ports. In particular, those called at by regular liners are selected rigidly. Whether a port can serve for foreign trade cargo traffic depends largely on the intensity of economic activities (intensity of urban activities) in its hinterland. This is because if the economy in an area is active, it naturally calls for trade with foreign countries, and promotion of foreign trade makes the economy in that area further animated.

29. A foreign trade port does not come into existence of itself. It is something to be intentionally developed under the development policy for an entire nation or a certain specific region with account taken of the intensity of its economic activities.

Considering her economic and geographic conditions, Thailand should foster the development of at least three foreign trade ports. One of such ports should cover the extensive area lying north of Bangkok, and the other two should embrace the east coast side (Gulf of Thailand side) and the west coast side (Indian Ocean side) of Southern Thailand.

30. Bangkok and surrounding northern area is covered by the existing Bangkok port (it is likely that Sattahip port will have the functions similar to those now performed by Bangkok port). In selecting a port that represent the whole Southern Thailand, consideration should be given to a number of factors such as the distribution of cities and industries, development of transport network, and so forth. At present, the east coast side of this area is represented by Songkhla port and the west coast side by Phuket port.

31. If Songkha port and Phuket port are taken as the only foreign trade ports of Southern Thailand, the hinterland area of the former's foreign trade becomes quite large by comparison of the transport cost shown in Table 12.

To be more precise, its hinterland, now covering Changwats of Songkhla and Phattalung, will additionally embrace Nakhon Si Thammarat, Trang, Satun, Pattani, Yala, and Narathiwat (Surathani is to be considered for inclusion in the common hinterland of the three ports, i. e., Bangkok, Songkhla and Phuket).

32. When Songkhla port is improved to the extent that large vessels can be moored for cargo handling on its quay walls, its hinterland will embrace part of three additional changwats, i. e., Chumphon, Surathani and Krabi. However, since Chumphon and Krabi have no major cities in the areas to be included in the port's hinterland, they should be excluded (by reason of the precondition that origins and destinations of all cargo traffic should be represented by cities). Conversely, all the major cities of Changwat Surathani are found in the area which will be included in the port's hinterland, so that this area is to be embraced in the hinterland. Hence, a total of nine changwats including Songkhla will be embraced in the hinterland of Songkhla port after its improvement.

B. Latent Cargo Volume of Songkhla Port

33. The latent cargo volume referred to here is the maximum volume of cargoes which will be handled at Songkhla port when the economic growth has made a smooth progress and distribution mechanism has been improved satisfactorily in the above-delineated hinterland of the port.

The latent cargo volume is estimated by the macroscopic as well as microscopic methods. In the former method, the total cargo handling volume of all Thai ports is estimated in order to obtain the cargo volume generating in Southern Thailand from its ratio to the nation's total. The value obtained by this method is employed in checking the results of microscopic estimation. In the microscopic method, the cargo volume within the hinterland of Songkhla port is estimated by the kind of major commodities.

34. The growth rates shown in Table 13 are used as the basic economic indices for estimating latent cargo volume. The indices for 1975 are the growth rates envisaged by the Third Economic Development Plan (1972 ~ 1976), and those for the period from 1977 to 1990 are the values given by National Economic Development Board (N. E. D. B.) of Thailand.

Table 13 - Major Economic Indices

Economic Indices	Year	Average Annual Growth Rate	Remarks
G.D.P.	1971 ~ 1976	6.0	The 3rd Five Year Economic Development Plan
	1977 ~ 1990	7.0	N.E.D.B.
Population	1971 ~ 1976	2.5	The 3rd Five Year Economic Development Plan
	1977 ~ 1990	2.5	N.E.D.B.
Rubber	1971 ~ 1976	3.0	The 3rd Five Year Economic Development Plan
	1977 ~ 1990	3.0	N.E.D.B.

35. The macroscopic estimation is made as described below.

i) The total cargo handling volume of all Thai ports is estimated for future from its assumptive annual growth rate.

ii) The ratio of cargo handling volume in Southern Thailand to the nation's total volume thus obtained is assumed for estimation of the cargo volume generating in Southern Thailand. In this case, the estimate of mineral products is made separately because their volume is subject to large annual fluctuation.

Table 14 shows the results of macroscopic estimation.

Table 14 - Macroscopic Estimation of Port Cargoes Generating in Southern Thailand

Unit: 1,000t

Year			Southern Thailand (ex. mineral products)		Southern Thailand (incl. mineral products)	Remarks
	Cargo Volume	Average Annual Growth Rate(%)	Cargo Volume	Share of Southern(%) Thailand	Cargo Volume	
1959	5,144		801	15.6	801	1) Approximation to the growth rate of G.D.P
1964	9,351	(64/59) 13	832	8.9	832	
1969	14,930	(69/64) 10	1,116	7.5	2,402	2) Inference drawn from the past trends.
1975	25,200	1)	1,890	7.5 2)	2,290 3)	
1980	49,100	(80/69) 9.0	2,730	7.0	3,130	3) 400,000 tons taken for mineral products.
1990	85,500	(90/80) 8.0	5,140	6.0	5,540	

36. The microscopic estimation is made as described below.

i) The cargo handling volume of Southern Thai ports is estimated for major items from:

a) Future trend based on its past record, or

b) Its correlation with the relevant economic indices. (See Table 15)

ii) The cargo handling volume thus obtained is distributed to each changwat by the economic indices pertaining to respective commodity items.

iii) Cargo volumes generating in changwats within the hinterland of Songkhla port are summed up. The sum total thus obtained is the latent cargo volume of Songkhla port.

iv) The following corrections are effected for natural rubber, cement and petroleum.

Natural rubber:

Natural rubber is the most important export commodity of Southern Thailand and the greater part of its production is supplied to the world market. Major rubber importing countries are shown in Table 16. Which port in Southern Thailand will be used for export of natural rubber is determined primarily by the cost of transportation from the producing area to the consuming area. If selection is made solely by the domestic transport cost, then Songkhla port will handle all of export natural rubber produced in its hinterland area. In actuality, however, the rubber exporting country is determined by whether the importing country is nearer to the east coast or west coast of Malaysian peninsula. Hence, natural rubber produced in the Songkhla's hinterland could be shipped from Kantang or Phuket depending on the location of the importing country. and converse cases could happen.

Table 15 - Method of Microscopic Estimation of Sea-borne Cargoes

- Caroges
  - Foreign Trade
    - Exports
      - Foods
        - Fish .... (Export volume in 1965) x (13.5%/yr for 65 - 75; 10%/yr for 75 - 90)
        - Fruits ..... Export volume in 1965 (export value/unit price) x (10%/yr for 65 - 90) x (share of Southern Thailand)
        - Oxen and cows ... Export volume in 1965 (export value/unit price) x (5%/yr for 65 - 90) x (share of Southern Thailand)
      - Minerals
        - Tin-metals .. (Export volume in 1970) x (2.9%/yr for 70 - 90) x (share of Southern Thailand)
        - Manganese .. (Export volume in 1970) x (4.6%/yr for 70 - 90) x (share of Southern Thailand)
        - Gypsum ..... (Export volume in 1970) x (1.0%/yr for 70 - 90) x (share of Southern Thailand)
        - Lignite .... Ditto
      - Rubber .... Planned export volume in 1975 (5 Year Economic Development Plan) x (5%/yr for 75 - 90) x (share of Southern Thailand)
      - Wood .... Planned export volume in 1975 (export value/unit price; 5 Year Economic Development Plan) x (3.4%/yr for 75 - 90) x (share of Southern Thailand)
    - Imports
      - Construction Material - Steel .... {Nation's total demand for steel materials (correlation with the construction investment)} x (share to construction work) x (share of Southern Thailand)
      - Chemicals
        - Oil .... {Nation's total demand for petroluem (correlation with GNP)} x share of Southern Thailand (number of motor vehicles) x (import rate)
        - Fertilizers ..... (Fertilizer consumption per unit area) x (farmland area) x (import rate)
  - Domestic Trade
    - Exports
      - Foods
        - Fish .... (Shipment volume in 1965) x(10%/yr for 65 - 90)
        - Fruits ..... (Shipment volume in 1965) x (growth rate of GNP)
      - Minerals
        - Silica ..... Planned shipment volume in 1965 (5 Year Economic Development Plan) x (3%/yr for 75 - 90)
        - Lignite .... Shipment volume in 1970 (1%.yr for 70 - 90) x (share of Southern Thailand)
        - Gpysum ..... Shipment volume in 1970 (1%/yr for 70 - 90) x (share of Southern Thailand)
        - Manganese .... Shipment volume in 1970 (4.6%/yr for 70 - 90) x (share of Southern Thailand)
      - Wood .... (Shipment volume in 1965) x growth rate of forest industry (6.5%/yr for 65 -70; 3.4%/yr for 70 - 90)
    - Imports
      - Foods
        - Rice .... (Shipment volume in 1965) x (population growth rate in Southern Thailand)
        - Sugar ...... (Shipment volume in 1965) x (growth rate of per capita consumption) x (population growth rate)
        - Drinks ..... Ditto
        - Fish......... (Shipment volume in 1965) x (10%/yr for 65 - 90)
        - Fruits........ (Shipment volume in 1965) x (growth rate of G.N.P.)
        - Oxen & Cows ..... Ditto
      - Livings — Clothes, drugs, household supplies, etc. .... (Volume received in 1965) x (growth rate of GNP)
      - Construction Materials
        - Steel ...... {Nation's total demand for steel materials (correlation with construction investment)} x (share to construction work) x (share of Southern Thailand) x (rate of domestic trade)
        - Cement ..... {Nation's total demand for cement (correlation with construction investment)} x share of Southern Thailand (all for domestic trade)
        - Wood .... (Volume received in 1965) x (Growth rate of construction investment)
      - Chemicals
        - Oil .... {Nation's total demand for petroleum (correlation with GNP)} x (share of Southern Thailand) x (rate of domestic trade)
        - Fertilizers ..... (Fertilizer consumption per unit area) x (farmland area) x (rate of domestic trade)

In certain limited cases, natural rubber consigned to Japanese buyers is shipped from Phuket port, whereas Songkhla port occasionally handles rubber for shipment to European market. Generally speaking, however, Songkhla and other ports on the east coast handle the natural rubber for shipment to countries like Japan which are closer to the east coast of Malaysian peninsular, and Phuket and other ports on the west coast export rubber consigned to European market.

Rubber is also exported via Malaysia and Singapore. Final importing countries of such rubber are not clearly known, but it is believed that the natural rubber is reexported from these two countries in the same manner as described above.

In Table 16, importing countries numbered 1 to 4 are grouped as being closer to the east coast and those numbered 5 to 24 are grouped as being closer to the west coast. The former group of countries occupies about 70% of the total rubber export value. It can be said that about 70% of total natural rubber production of Southern Thailand is exported to the countries located on the east side of Malaysian peninsula, though this percentage is naturally subject to some minor fluctuation. Therefore, if Songkhla port is improved as the only foreign trade port on the east coast, it will be handling about 70% of all export of the natural rubber.

Since the distribution mechanism of natural rubber is complicated, the concept of hinterland is disregarded for simplicity of estimation and Songkhla port is assumed to handle about 70% of total rubber production. A trial calculation shows that the total rubber export volume from Southern Thailand will amount to 521 thousand tons in 1990, of which 467 thousand tons is estimated to be produced in the hinterland of Songkhla port and exported from Songkhla port. For the abovementioned reason, however, Songkhla port's rubber export volume is set at 365 thousand tons which is 70% of the total export volume.

Cement:

Demand for cement in Southern Thailand is expected to pursue a steady upward trend in future. Since cement is produced in the vicinity of Toong Song, it has been transported by overland transport means over many years in the past (See Fig. 4) and there is little probability that the prevailing overland transportation will give place to marine transportation. For this reason, cement is to be excluded from seaborne cargoes.

Petroleum:

Imported petroleum is carried from Singapore by tankers of 100 ~ 600 R/T class and can therefore be supplied, as in the past years, via Southern Thai ports. For this reason, the hinterland of Songkhla port for imported petroleum transportation is considered to coincide with that for domestic cargo traffic.

Table 17 shows the latent cargo volume estimated for Songkhla port.

Table 16 - Importing Countries of Natural Rubber

No.	Country	Export Volume (ton)
1	U.S.A	26,000
2	Japan	143,529
3	Hongkong	410
4	Taiwan	20
5	England	9,005
6	West Germany	7,155
7	France	5,586
8	Denmark	437
9	Belgium	2,020
10	Norway	22
11	Sweden	1,299
12	Netherlands	2,078
13	Italy	24,528
14	Spain	5,530
15	Czechoslovakia	885
16	Yugoslavia	7,737
17	Greece	885
18	Portugal	1,123
19	Turkey	2,908
20	Angola	183
21	Israel	5
22	Morocco	30
23	Poland	508
24	Finland	508
25	Malaysia	19,493
26	Singapore	17,279
	Total	279,163

Note: Nos. 1 ~ 4 Countries closer to the east coast.
Nos. 5 ~ 25 Countries closer to the west coast.
Nos. 25 & 26 For reexport to countries on either side of Malay peninsula.

Table 17 Latent cargo volume of Songkhla Port

Unit; (1,000 ton)

	1965			1975			1980			1990		
	Foreign	domestic	total	foreign	domestic	total	foreign	domestic	total	foreign	domestic	total
food stuffs	1	56	57	23	135	158	36	180	216	87	339	426
daily necessities		4	4									
construction material		40	40	48	17	65	79	28	107	187	64	251
petroleum	2	6	8	73	74	147	80	117	197	120	271	391
fertilizers		4	4	19	1	20	21	2	23	31	3	34
mineral products	5		5	32	113	145	36	131	167	46	175	221
natural rubber	56	3	59	236		236	273		273	365		365
timber		4	4	9	38	47	25	49	74	78	81	159
others		37	37									
total	65	155	220	440	378	818	550	507	1057	914	933	1847

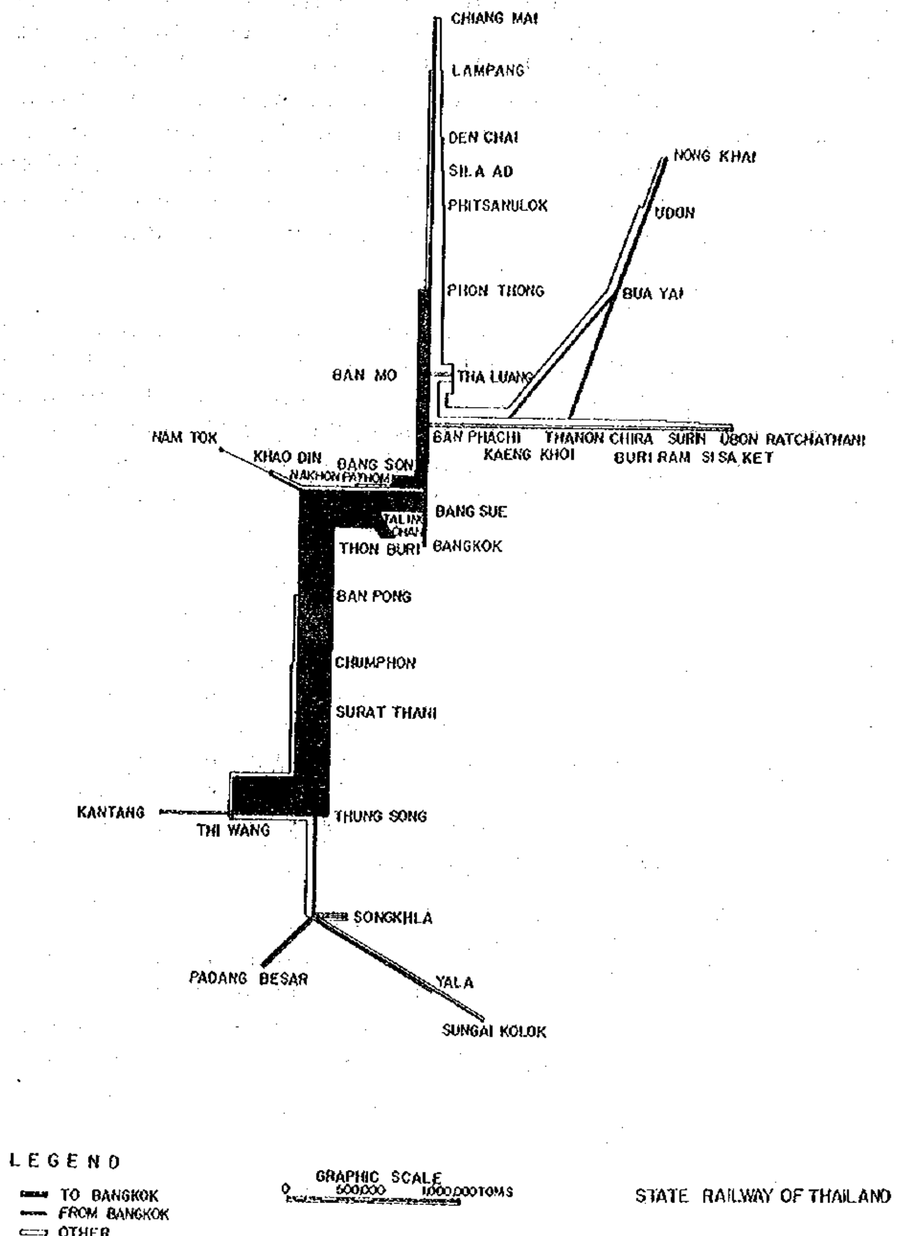


Fig 4 Route of Cement Transportation

C. Planned Cargo Handling Volume of Songkhla Port

37. The volume of cargoes handled at a port is affected by the complex interaction of various factors such as the port facilities, cargo collecting and distributing mechanism, cargo handling system, tariff and port charges. Unless these conditions are favourable, mere existence of a huge latent cargo volume within a port's hinterland does not promise to augment the cargo volume to be actually handled at that port (planned cargo handling volume).

Considering the rather poor functions now performed by Songkhla port, probability is high that a substantially long time will be required before the whole latent cargo volume in its hinterland comes to be actually handled by the improvement of port facilities and cargo collecting and distributing mechanism. Time required for the planned cargo handling volume to reach the level of the latent cargo volume will vary by the type of trade. In the aspect of foreign trade, Songkhla port covers an extensive hinterland area but no appreciable improvement has yet been made to the collecting and distributing mechanism in its hinterland. To cover the whole of latent foreign trade cargoes, therefore, continued improvement efforts will have to be made at least for the coming ten years or so. In the aspect of domestic trade, however, a shorter period of about five years will be required since the port has been handling cargoes over the past years and its hinterland is rather small. About petroleum and petroleum products, the same period as for the domestic trade will be required, too.

38. From the discussion advanced above, the year when the planned cargo handling volume catches up with the latent cargo volume is set at 1985 for foreign trade and at 1980 for domestic trade and petroleum. Up to these target years, the cargo handling volume of Songkhla port is assumed to increase at a same annual growth rate from the volume recorded in 1970. The relationship between the latent cargo volume and the planned cargo handling volume is illustrated in Fig. 5.

D. Relations with Other Thai Ports

39. Songkhla port is situated on the east coast of Southern Thailand whereas Phuket port is on the west coast, and these two are the major ports of Southern Thailand. Since it is imperative to attain the maximum effect from the limited fund availability, care must be taken in planning the improvement of the two ports in order to avoid any needless duplication of capital input. Studies made below are therefore intended to clarify how Phuket port will be influenced by the improvement of Songkhla port.

As described in Item A(Hinterland of Songkhla Port), the hinterland of Songkhla port is limited to changwats of Songkhla and Phattalung insofar as domestic trade is concerned, and Phuket port can be likewise considered to have a small hinterland area. It is evident that there will arise no competition between the two ports with respect to hinterland, and this holds true with petroleum.

40. However, when the competition in the field of foreign trade is put to an analysis, the following questions are brought to fore.

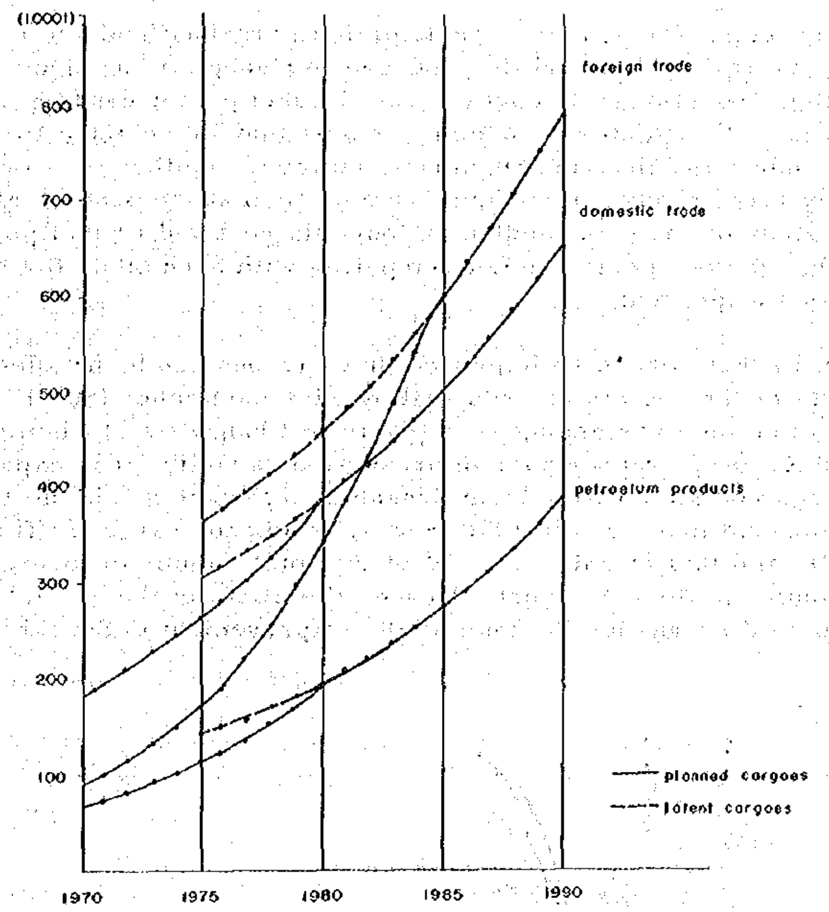


Fig. 5 Volume of Latent Cargoes and Planned Cargoes

i) Whether the two ports are currently competing with each other for foreign trade cargoes.

ii) Whether the two hinterland areas will overlap with each other when both ports are improved to the extent that cargo handling service on the wharf can take place of the prevailing lighter service.

iii) What will be the items and volume of cargoes generating in the overlapped area, if overlapping ever develops.

iv) How Items ii) and iii) above will be affected by the improvement of the two ports and construction of a railway line linking Phuket port and Surathani.

41. Assuming that the existing Songkhla port and Phuket port are the only foreign trade ports of Southern Thailand, a study is made below on their hinterland area by comparing the costs incurred by Transportation Patterns i), iii) and iv).

As described in Section 31, Songkhla port embraces Songkhla and seven other changwats, whereas Phuket port's hinterland includes Phuket, Krabi and Ranong. Changwat Surathani is the area where the two ports compete with each other.

42. Therefore, if foreign trade ports of Southern Thailand are thus limited in number, natural rubber and tin produced in Changwat Surathani will be shipped either from Songkhla port or from Phuket port depending on the destination and other factors. Whichever port may be selected for export of natural rubber and tin from Surathani, however, neither port is required to effect any large change to its improvement plan at the present stage. Item-wise study of cargoes handled at Songkhla port and Phuket port also indicates that the two ports are not competing with each other for foreign trade cargoes at present.

43. When Phuket port is so improved that cargoes can be handled on its wharf, parts of the two hinterlands will overlap each other (See Fig. 6). However, since the overlapping area (parts of Changwats of Chumphon, Ranong and Krabi) is rather poor in productive capacity, it is expected that the cargo volume shifting from Songkhla to Phuket will be no larger than about 18 thousand tons even in 1990 (See Appendix for cargo traffic generation in 1980), and this is only about 3% of the total volume of foreign trade cargoes handled at Songkhla port. Hence, the effect of the hinterland overlapping can be disregarded in planning the improvement of Songkhla port.

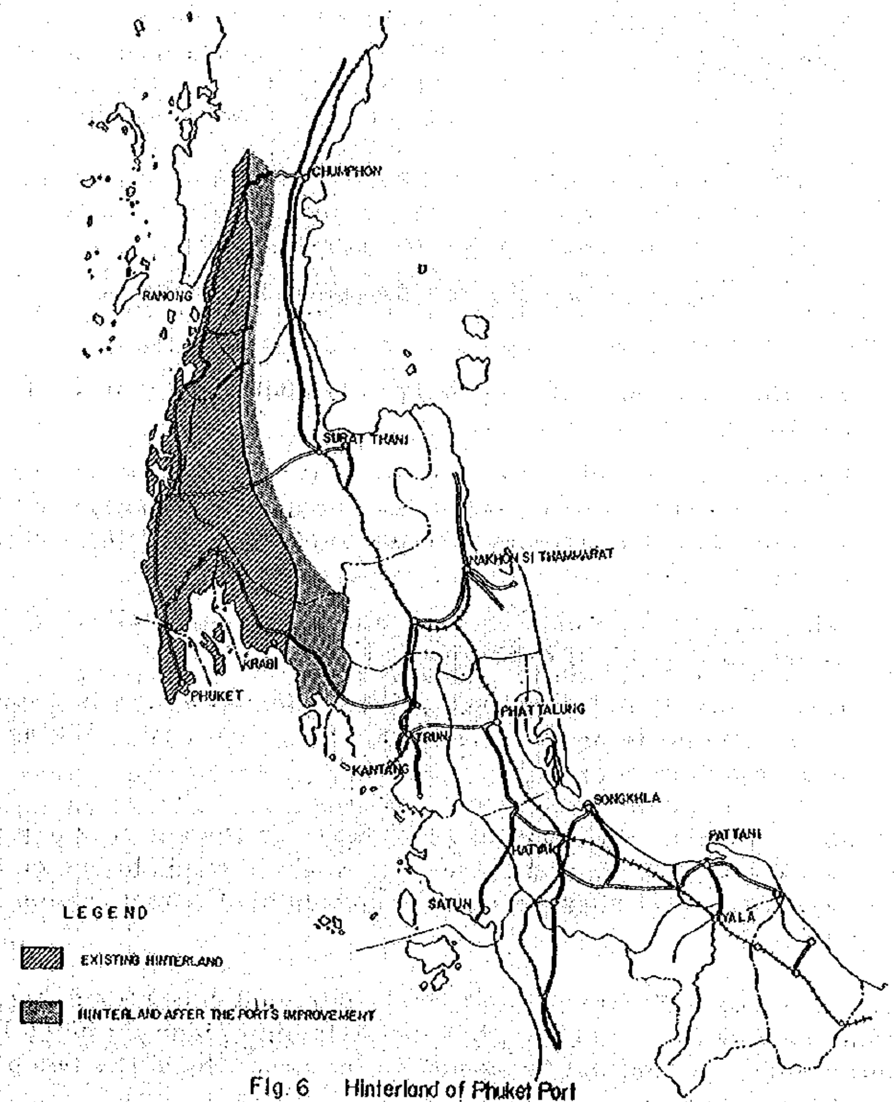


Fig. 6 Hinterland of Phuket Port

When a new railway line is constructed, Changwat Surathani will be included in Phuket port's hinterland. But the resultant shift of cargoes from Songkhla to Phuket will be limited to only 65 thousand tons which is small enough to be disregarded in drafting Songkhla's improvement plan.

Accordingly, it can be said that the two ports are independent of each other and exercise little influence on each other.

44. The relationship between Kantang port and Songkhla port in foreign trade is reviewed below on the basis of the commodities handled.

The two ports are competing for export of natural rubber. Judging from the present distribution of natural rubber producing areas, the hinterland of Songkhla must be considered to be overlapping that of Kantang with respect to natural rubber.

Insofar as export rubber is concerned, the two ports are closely related and competing with each other, so that the improvement of one port must be planned with due account taken of the functions of the other as stated in Volume 1 of Kantang Harbour Study.

However, the competition between the two ports will be mitigated as stated in Section 36 when Songkhla port is developed into a fullfledged foreign trade port.

Table 18 - Cargo Handling Volume of Kantang Port

	Export		Inport	
1969		61,723		1,990
1970		60,758		10,782
1971		67,273		21,183
	Rubber	60,844	Petrol	19,850
	Cement	20,033	Fertilizer	798
	Fish Meal	10,090	Oil	289
	Livestock	5,020	Mining Spare Parts	212
	Sundries	1,274	Others	34
	Others	12		

45. The study made below relates to the relationship of Songkhla with Bangkok port and Sattahip port. For the purpose of this study, the relations between the latter two ports must be made clear.

Sattahip port is a naval port and supplements the function of Bangkok port. The two ports have their hinterland areas overlapped in greater part. Since Bangkok port is a river port constructed on the bank of the Chao Phraya river, its navigation channel cannot be maintained deep enough to allow entry of large carriers for export of bulk cargoes like maize. A deep sea port is required for shipment of bulk cargoes, and this function is exhibited by Sattahip port. Hence, the two ports perform essentially the same functions.

46. Considered from the viewpoint of hinterland, Songkhla port functions independently of these two ports with respect to export cargoes. As regards import cargoes, however, Bangkok port (Sattahip port) covers the entire country. When Songkhla port is improved and handles part of commodities imported into Southern Thailand, the hinterland of Bangkok port (Sattahip port) will become smaller. However, this will in no way affect the improvement plan of Bangkok port (Sattahip port) because the import cargo volume to be handled at Songkhla will be extremely small relative to that of Bangkok port.

47. Conversely, improvement of Bangkok port (Sattahip port) will not save the need for improving Songkhla port because the large consumer demand in Southern Thailand will make the transhipment from Bangkok more costly than direct import through Songkhla.

IV NATURAL CONDITIONS IN THE NEIGHBOURHOOD OF SONGKHLA PORT

IV NATURAL CONDITIONS IN THE NEIGHBOURHOOD OF SONGKHLA PORT

A. Topography

48. The port of Songkhla is situated on the right side band of the channel leading from Lake Songkhla to outer sea, and is provided with facilities allowing entry of 2,000 DW class vessels. Lake Songkhla, combined with Lake Sap and Lake Luang, covers a water surface area of 1,000 km^2, and flat damp land extends within 20 km from the shore of these lakes. (See the topographic lake map shown in Appendix).

From the point about 70 km to the southwest of the port, a mountain range stretches through Malay peninsula. With the exception of the lake outlet, the bottom material near the port is composed of fine sand and the grain size extremely small in places where the water depth exceeds -3.0 m. As can be imagined from this fact, the sea bottom has a mild gradient ranging from 1/200 to 1/300. On the left side bank of the lake channel is found a hill of aqueous rocks called Khao Daeng. The channel course is therefore fixed, and its depth is also maintained by the slope current created by the water level difference between the lake and outer sea. Sand bars are widely distributed in the front part of the lake facing the sea.

B. Climate

49. The area around Songkhla port presents the climatic features of Asian Monsoon Zone. However, with NE monsoon intercepted by Indo-China peninsula and SW monsoon by the mountain range stretching in the back, wind produces a relatively moderate effect. NE monsoon blows mostly from east and its average velocity is 6 ~ 8 m/sec. SW monsoon blows from south-west and its average velocity is about 3 m/sec.

Table 19 - Wind at Songkhla Port and Vicinities

Period: 1951~1965
Source: Songkhla Metrological

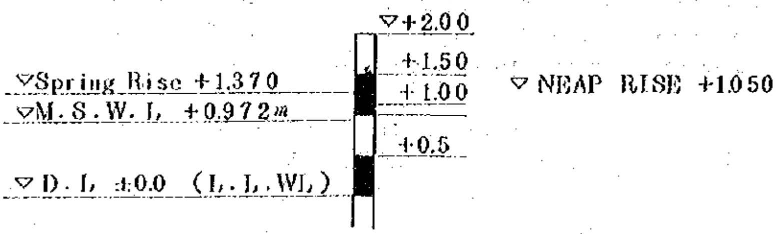
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Wind	E	E	E	E	SW	SW	SW	SW	SW	SW	E	E
Mean Wind Speed (m/s)	7.6	6.6	5.2	3.7	2.9	3.1	3.1	3.5	3.4	3.1	4.1	6.0
Max(Instantaneous Wind Speed	NE 20.6	E 22	E 20	E 25.7	N 33.4	W 36	W 25.7	NW 26.8	NW 20.6	NE 24.2	E 36.0	23.6

Railfall varies largely by season, with its monthly value ranging from 40 to 600 mm. Average annual rainfall is about 2,000 mm, and the greater part of this rainfall is recorded in the October ~ December period. In the monsoon season lasting from October to January, the number of monthly rainy days averages 20, and this has a hampering effect on the port construction work.

C. Marine Meteorology

50. Gulf of Thailand is generally shallow and diurnal tide is well developed. In the vicinity of Songkhla port, however, semi-diurnal tide is rather prominent and the tide curves indicate the existence of diurnal inequality.

The tidal range obtained by harmonic analysis of the tidal level data of Thai Navy (recorded at Ko Nu over a period of 10 years) is as shown below.



The tidal levels shown above are those observed at Ko Nu in the outer harbour area. The tidal range is smaller than shown above in the inner harbour area.

Record of wave observation is completely lacking. The wave height in the neighbourhood of the port obtained by visual observation by the Hydrographic Department of Thai Navy is 2.0 m. The wave height and period for structural design, estimated by the team from the wind record, are as follows.

$H_{1/3}$ = 2.2 m Wind Direction: ENE ~ E

$T_{1/3}$ = 6 ~ 7 sec

Of these values, the wave height is considered justifiable, but the wave period appears somewhat shorter than the actual value. It is therefore strongly urged that year-round wave observation be conducted at a point where the water depth is approximately -10m.

In the offshore area of the port, the tidal current flows in NW direction at flood tide and in SE direction at ebb tide. The current velocity is considered to rise to about 1 knot in the NE monsoon season due to the effect of drift current.

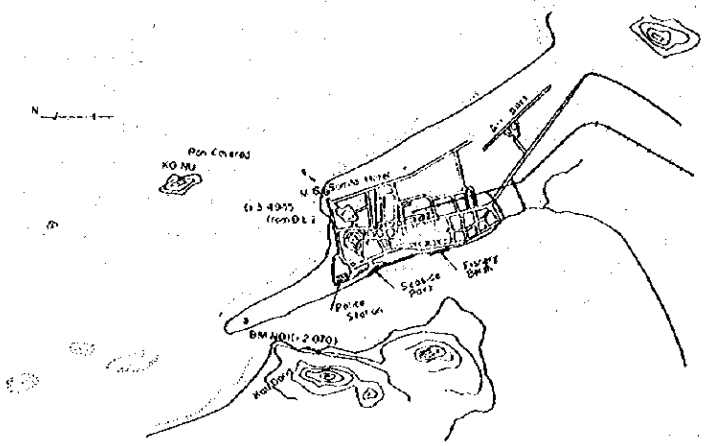
During the present survey, tidal level and magnitude were surveyed simultaneously on the west side of channel entrance, at an innermost point of the inner harbour (National Railway Pier) and at Ko Yo. The following bench marks were used in this survey.

Ms (Main Bench ...... Located close to the shore in front of Samila Hotel)

Bm No. 1

The elevations and locations of these two bench marks are as shown in Fig. 7 below.

Fig. 7 - Elevations and Locations of Bench Marks



h = 2. 5225 m (from M. S. W. L. , Thai Army, Feb. 1926)

N = 797. 530^{988} (= 7°12')
E = 676. 575^{586} (= 100°35')

where, M. S. W. L. ~ 0. 972 m D. L.

therefore, Ms. h = 2. 5225 + 0. 972 = 3. 4945 m (from D. L.)

D. Hydraulics of Lake Outlet

51. The team also surveyed the current at the harbour entrance on October 1, 2, 3, 9, 10 and 11, 1971 at three places, i. e. , harbour entrance, National Railway Pier, and front of Harbour Department Pier. Equipment of Suiken and Ecman c/m type were employed for observation of the inflowing and outflowing time of spring and neap tides.

Table 20 - Maximum Velocity of Surface Current

Survey Point	V_{max}		Survey Conditions		
			Depth	Width	Average Cross-sectional Area
Point A at Harbour Entrance	1.1 m/s	(2.1 kt)	-8.00	350m	2,900m^2
Point B in Front of Harbour Dept. Pier	0.75 m/s	(1.44 kt)	-8.00	1,100	
Point C on State Railway Pier	0.65 m/s	(1.25 kt)	-	1,400	

It is considered that drift sand moves from SE to NW in the NE monsoon season. From the wave data and the grain size analysis of bed material (which was conducted on specimens sampled at intervals of 1. 0 m on Survey Lines A, B, C, D and E established near the coast), the critical water depth of bed material movement is estimated to be within the range of -3.5 m to -4.5 m. The channel between the lake and outer sea forms a density current of intensified mixing type and its bed is exposed to a large current velocity that produces flushing effect. Since the grain size of bed material is small both in the lake outlet channel and in the navigation channel, it is believed that a water depth can be maintained at -8 m with a tractive force of about 15 dyne/cm^2. Curves in the channel serve to maintain the water depth because the tractive force generally increases in the downstream section. At ebb tide, however, scouring occurs on the left bank side, and this should be prevented by a suitable countermeasure.

E. Soil

52. Outline of Soil Survey

The soil survey was conducted by both disturbed and undistrubed sampling in the inner harbour, lake outlet and outer harbour near Ko Nu. Soil specimens were collected at the 14 points shown in Fig. 8.

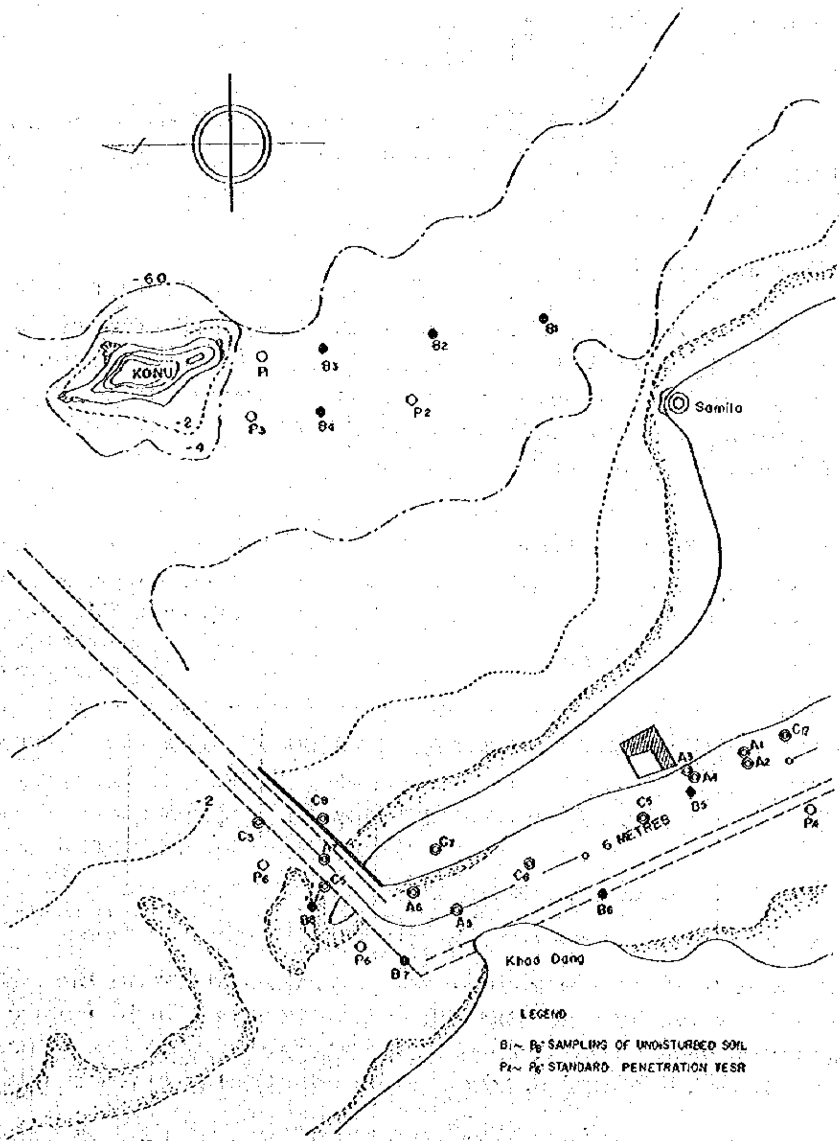


Fig 8 Location of drill Holes Completed

The soil test covered the standard penetration test conducted at the sampling points and the laboratory test required for disturbed sampling. In addition, the data collected by the first and second teams and by the Thai government were put to an analysis.

53. The soil nature in the vicinity of Songkhla port is as outlined below.

1) Inner Harbour

Sediment transported from Lake Songkhla is distributed widely in the vicinity of the port from the head of the existing breakwater to the neighbourhood of Ko Nu. From Laem Sai to the inner harbour area, a medium fine sand layer having a thickness of 4 to 6 m is found extending from the sea bottom to a depth of about -11 m. This layer is underlain by a consolidated lateritic clay which presents brownish colour and extends downwards to a depth of about -37 m. These layers in the inner harbour area are generally stratified horizontally (See Bor. No. B5 shown in Appendix).

2) Lake Outlet

The surface layer in and around the curved section of the lake outlet channel approximately 500 m far from Khao Daeng is composed of coarse sand grains and ranges from 8 to 10 m in thickness. This coarse sand layer gives place to a stiff consolidated clayey layer from a depth of about -15 m.

Lens-shaped interposition of a soft silty layer having a thickness of about 8 ~ 10 m is noted increasingly in the fine sand layer from the root of the existing breakwater towards the offing.

Deeper than -11 m, soil is composed of compact fine sand (See Boring No. B_7, P_5, B_8 and P_6 shown in Appendix).

3) Outer Harbour

In the outer harbour area, the surface layer is underlain by an extremely soft silt layer having a thickness of about 5.0 m. At a depth of -11 to -12 m, however, this silt layer gives place to a consolidated clayey formation.

Though the borehole was dug to a depth of -26 m, it did not reach the bed rock.

54. Following are the results of the soil test.

1) Test Method

The unconfined compression test was conducted at Songkhla immediately after sampling.

The physical and mechanical tests were conducted on the specimens brought back to Japan. All the following tests in Japan were made according to the relevant JIS which conforms to the international standard for soil test.

Undisturbed specimens (clayey soil):

Physical tests - Specific gravity test of soil particles, natural moisture test, mechanical analysis, test of weight per unit volume, liquid limit test, and plastic limit test.

Mechanical tests - Consolidation test and direct shear test.

Disturbed specimens (sandy soil):

Physical tests - Specific gravity test of soil particles and mechanical analysis.

Table 21 - Test Items and Test Methods

	Test Items	Test Method	Remarks
Physical	Specific gravity test of Soil Partides	JIS A1202	
	Natural Moisture Ratio Test	JIS A1203	
	Mechanical Analysis	JIS A1204	
	Liquid limit Test	JIS A1205	
	Plastic Limit Test	JIS A1206	
	Weight of Unit Volume	JIS A1209	
Mechanical	Unconfined Compression Test	JIS A 1216	
	Direct Shear Test		
	Consolidation Test	JIS A1217	

2) Soil Texture

The soil texture described below is that of the silt layer extending around the depth of the foundation of port structures in the lake outlet and outer harbour area only.

The consolidated layer in the innher harbour area has a large N-value. Undisturbed specimens were not therefore sampled in this area.

i) Lake Outlet (Br. No. B_8)

Depth		:	-4.60 ~ -11.0 m, clay.	
Specific gravity of soil particles (G_s)		:	2.72 ~ 2.78	
Natural moisture content (W)		:	48 ~ 66%	
Classification -	S	:	1 ~ 6%	clay
	M	:	29~37%	
	C	:	60~70%	
Consistency -	W_L	:	80%	
	W_P	:	22%	
	L_P	:	58%	

Weight of unit volume ($_t$) : 1.62~1.73 t/m^3

Void ratio (e) : 1.8~1.87

Compression index (C_c) : 1.1~1.2

Coefficient of consolidation (C_v) : (1.2~2.7) x $10^{-2}cm^2$/min.

Modulus of volume (M_v) : 0.056 cm^3/kg

The unconfined compression strength of this clayey layer is as shown below.

q_u = 0.453 - 0.765 kg/cm^2

The increase of this strength by depth can be expressed as follows.

q_u = 0.4 kg/cm^2 + 0.06Z (Base: -5.0m)

ii) Outer Harbour

Depth		:	-6.00 ~ -11.00 m, clay	
G_s		:	2.76	
W		:	80%	
Classification -	M	:	34 ~ 28%	) clay
	C	:	66 ~ 72%	
Consistency -	W_L	:	90%	
	Wp	:	21%	
	Lp	:	69%	
$_t$		:	1.53 t/m^3	
e		:	2.3 ~ 2.42	
Cc		:	1.2 ~ 1.6	
Mv		:	0.098 ~ 0.142 cm^3/kg	
Cv		:	(1.2 ~ 2.1) x 10^{-2} cm^2/min.	
P_o		:	1.24 ~ 1.63 kg/cm^2	

The unconfined compression strength of this clayey layer is as shown below.

q_u = 0.166 ~ 0.334 kg/cm^2

The increase of this strength by depth can be expressed as follows.

q_u = 0.1 kg/cm^2 + 0.05Z (Base: -6.0 m)

V SONGKHLA PORT CONSTRUCTION PROJECT

V SONGKHLA PORT CONSTRUCTION PROJECT

A. Fundamental Approach to the Project

55. In Southern Thailand, development efforts should be directed towards fostering primary industries in the immediate future. Development of secondary industries can be expected when the basis for their growth has been provided by the development of primary industries. Natural rubber is the major primary product in Southern Thailand. Economy is heavily dependent on natural rubber production particularly in Songkhla's hinterland area. At present, however, the port lacks deepwater wharves for large vessels and its export cargoes are all handled by the inefficient lighters. This is largely hampering expansion of natural rubber export from Southern Thailand.

Stable supply of cheap commodities is indispensable for further expansion of consumer economy in and around Hat Yai. Commodities consumed in this area are now supplied from Bangkok except for a small fraction that comes from Malaysia. It leaves no doubt that marine transportation incurs the least cost on cargoes shipped from Bangkok, but the facilities currently available at Songkhla port are not sufficient for handling such sea-borne cargoes. It is to be added that direct import through Songkhla port will incur less cost than the prevailing marine transportation from Bangkok.

56. The Songkhla port construction project must be a scheme that promises expanded export and better and stabilized livelihood for the people. Hence, the fundamental approach to the project should be as outlined below.

i) The port facilities should be expanded to allow for entry of large ocean-going vessels at any time. Further, improvement should be so made that the port will be able to perform its functions in an efficient and safe manner.

ii) The project should be so planned that it will produce benefits at the earliest date with a minimum of capital input. For this purpose, the construction work should be carried out in a concentric and systematic manner, minimizing the construction of such facilities as breakwaters and training dykes which do not directly serve for yielding income.

iii) The project should be so implemented that the existing and new facilities will be used in an efficient as well as integrated manner particularly in the initial stage of construction.

iv) There should be left room for future expansion of the port.

v) The project should be planned to preserve the recreation zones near the port.

vi) Petroleum products will be handled entirely by the National Railway as at present. If new port facilities are to be constructed in the outer harbour area as proposed by T. C. I., mooring facilities for tankers should also be provided. This is because the maintenance dredging of the existing navigation channel can never be dispensed with for mooring tankers at the existing National Railway's pier, and this incurs a large cost.

57. In planning the project, due consideration should also be given to the future renovation of marine transportation, particularly the expanding container transportation.

Advent of container transportation was occasioned by economic as well as social factors. The economic factors are the desires for quick cargo handling work and efficient rotation of vessels, and the social factor is the acute labour shortage in the advanced countries. Unlike the conventional carriers, therefore, container ships will call at a limited small number of ports.

58. Considering the quality and volume of cargoes it handles, Bangkok port (including Sattahip port) is the only port conceivable in Thailand for handling containerized cargoes, but its container ship service will be limited, for some time to come, to the feeder service from Hongkong. Effect of container ship service on Songkhla port will be negligible because the port handles a small volume of cargoes and there are few cargoes suited for containerization. Containerized shipping operation at Songkhla port is also a remote possibility for the same reason.

59. It is to be studied how Songkhla port will be affected by the possible calling of container ships at Bangkok port (Sattahip port). Will it occur that Songkhla's export cargoes come to be eventually transported by small vessels to Bangkok for shipment as containerized cargoes?

It is expected that Songkhla's main foreign trade cargoes will be limited to natural rubber and construction materials for some time in future. From the global trend of container transportation, it can be said that these cargoes are not suited for containerization. Container shipping service at Bangkok port (Sattahip port) will not therefore have any marked effect on the character, scale or facilities of Songkhla port.

B. Determination of Port Scale

60. The scale of a port is usually indicated by the planned cargo handling volume, class of the largest vessels expected to call at it, and number of berths.

The planned cargo handling volume of Songkhla port is shown in Table 22. The total volume of cargoes handled at the port, which stood at about 340,000 tons in 1970, is estimated to increase to 1,000,000 tons in 1981. The percentage of the foreign trade cargo volume in the total cargo handling volume of the port is expected to rise from 26% (recorded in 1970) to 37% in 1980 and further to 43% in 1990. Hence, Songkhla port will grow into the second largest foreign trade port of Thailand in the coming two decades.

61. Class determination of the vessels calling at Songkhla port is made in the following way. The class of foreign trade cargo carriers is determined on the basis of their class distribution recorded at both Bangkok and Songkhla (See Table 23), whereas that of domestic trade cargo carriers is determined using their class distribution data recorded at Songkhla port alone. The class distribution of foreign trade cargo carriers that have entered Songkhla port in the past shows that 96% of all vessels are smaller than 5,000 G/T.

Vessels entering Bangkok port are larger in average size than those calling at Songkhla, but about 90% of them have a draught of less than 7.32 m. Considering the kinds and volume of cargoes which will be handled at Songkhla port, entry of extremely large vessels will not be required and therefore, 7,000 D/W is taken as the maximum size of foreign trade carriers to be accommodated at the port.

The class distribution of domestic cargo carriers indicates that vessels of 100 to 300 R/T constitute the majority. 2,000 D/W is taken as the maximum size of domestic cargo carriers in anticipation of some expansion of their size in future. From the same viewpoint, 2,000 D/W is taken as the maximum size of tankers.

62. The required number of berths can be obtained by the application of the following equation. The number of berths for handling foreign trade cargoes should be checked by the Queuing theory.

$$V = \frac{365 \times \alpha}{t_b} \varepsilon$$

$$t_b = \frac{\varepsilon}{\mu} t_o$$

where, V : Cargo handling volume per berth (ton/berth)

α : Quay wall occupancy rate

ε : Cargo weight per ship (ton)

t_b : Average number of staying days in the port per ship

μ : Average daily cargo handling volume (ton)

t_o : Number of days required for preparation for entering and sailing.

Studies indicate that the port should be provided, by 1990, with 5 berths for foreign trade cargoes (in terms of -8.0 quay wall) and 4 berths for domestic trade cargoes (in terms of -5.5 m quay wall). The present capacity of the domestic trade quay wall, as estimated from the past cargo handling record, is about 200,000 tons.

Table 22 Planned cargo handling volume of Songkhla port

Unit; 1,000 ton

Year	foreign trade	domestic trade	petroleum Products (foreign & domestic)	total
1970	91	187	66	344
75	170	269	114	553
76	202	289	123	614
77	230	312	142	684
78	263	335	158	756
79	299	362	177	838
80	343	390	197	930
81	391	411	211	1,013
82	447	433	226	1,106
83	510	456	242	1,208
84	563	480	259	1,302
85	604	506	278	1,388
86	638	533	297	1,468
87	674	562	319	1,555
88	712	592	337	1,641
89	751	623	365	1,739
90	794	662	391	1,847

Table 23 - Class of Vessels Calling at Ports of Songkhal and Bangkok

Vessels Calling at Songkhla Port (1970)

(foreign trade)

Class	(A) consigned Southeast Asia		(B) Except Southeast Asia		(A) + (B)	
	Number	%	Number	%	Number	%
0 ~ 200 R/T	63	38.9			63	24.2
201 ~ 400	45	27.8			45	17.3
401 ~ 600	24	14.8			24	9.2
601 ~ 800	24	14.8			24	9.2
801 ~ 1,000	4	2.5			4	1.5
1,001 ~ 1,500	2	1.2	2	2.0	4	1.5
1,501 ~ 2,000			35	35.7	35	13.5
2,001 ~ 2,500			24	24.5	24	9.2
2,501 ~ 3,000			12	12.2	12	4.6
3,001 ~ 4,000			14	14.3	14	5.4
4,001 ~ 5,000			2	2.0	2	0.8
5,001 ~ 6,000			9	9.2	9	3.5
6,001 ~						
Total	162	100.0	98	100.0	260	100.0

(domestic trade)

class	freight vessel		tanker		total	
	Number	%	Number	%	Number	%
0 ~ 50 R/T	57	7.0	11	9.2	68	7.3
51 ~ 100	208	25.6			208	22.4
101 ~ 150	235	28.9	42	35.0	277	29.7
201 ~ 300	173	21.3	4	3.3	177	19.0
301 ~ 400	6	0.7			6	0.6
401 ~ 500	30	3.7			30	3.2
501 ~ 600			39	32.5	39	4.2
601 ~ 700	1	0.1			1	0.1
801 ~ 900	1	0.1			1	0.1
701 ~ 1,000	1	0.1	2	1.7	3	0.3
1,001 ~ 1,500			22	18.3	22	2.4
1,501 ~						
Total	814	100.0	120	100.0	934	100.0

Vessels Calling at Bangkok Port

Class of vessels calling at Bangkok Port

Class	1967		1968		1969		1970	
	Number	%	Number	%	Number	%	Number	%
0 ~ 1,000 G/T	86	9.7	95	8.3	117	9.8	89	7.4
1,001 ~ 2,000	148	16.7	160	14.0	143	11.9	217	18.1
2,001 ~ 3,000	236	26.6	260	22.7	207	17.3	199	16.4
3,001 ~ 4,000	194	21.8	217	19.0	263	21.9	269	22.4
4,001 ~ 5,000	168	18.9	169	14.8	186	15.5	153	12.8
5,001 ~ 6,000	65	7.3	149	13.0	162	13.5	140	11.7
6,001 ~ 7,000	30	3.4	50	4.4	52	4.3	49	4.1
7,001 ~ 8,000	25	2.8	40	3.5	27	2.7	27	2.3
8,001 ~ 9,000	1	0.1	3	0.3	13	1.1	13	1.1
9,001 ~								
Total	953	100.0	1,143	100.0	1,172	100.0	1,156	100.0

C. Selection of Construction Site

63. The construction site of Songkhla port should conform to the fundamental concept of the project and at the same time be able to accommodate the required port facilities. The following are the major conditions to be considered in selecting the site.

i) The site should be suited for construction of the facilities allowing entry of 7,000 D/W class ocean-going vessels for the present and of 10,000 D/W class vessels in future.

ii) The site should provide room for future expansion of the port.

iii) The site should assure that the port operation will be substantially improved within a short period and at a minimum of capital input.

iv) The construction and maintenance cost should be low.

v) The site should permit the construction work to be executed smoothly even in the NE monsoon season when marine meteorology is in a detrimental condition.

From the study of these conditions, the following three plans can be proposed.

64. Inner Harbour Plan

This plan takes advantage of the topographic condition of the inner harbour area for protection of port facilities against waves and aims at integrated operation of the existing and new facilities. Under this plan, the existing breakwater will be extended in prevention of drift sand intrusion and a new training dyke will be constructed in order to maintain the navigation channel at the required depth by the flushing effect which will be produced by the current from Lake Songkhla (See Fig. 9). The training dyke and the navigation channel running along it will be so arranged that the radius of curvature at the curved section will not impair smooth maneuvering of large vessels. This plan is advantageous in that it will demand a small construction cost, allow the use of the existing breakwater and navigation channel during construction, and provide room for expansion that may be required in future by the increase of cargo volume. Furthermore, since port facilities will be built in the inner harbour area under this plan, changes in marine meteorology can be virtually disregarded.

65. Lake Outlet Plan

This plan envisages construction of facilities for foreign trade in the area extending from the lake outlet, with the inner harbour area intended to be used exclusively for domestic trade. As shown in Fig. 10, the existing breakwater will be extended and a new training dyke will be constructed under this plan, so that flushing effect will be produced as in the Inner Harbour Plan. The plan will cause no hindrance to the entry of large vessels and also offer room for future expansion. Its demerit is that the construction cost is somewhat higher than the Inner Harbour Plan and a new navigation channel must be dredged. Another demerit of this plan is that since the facilities for foreign trade will be built in the outer sea area, prudent care must be exerted in the construction work.

66. Outer Sea Area Plan

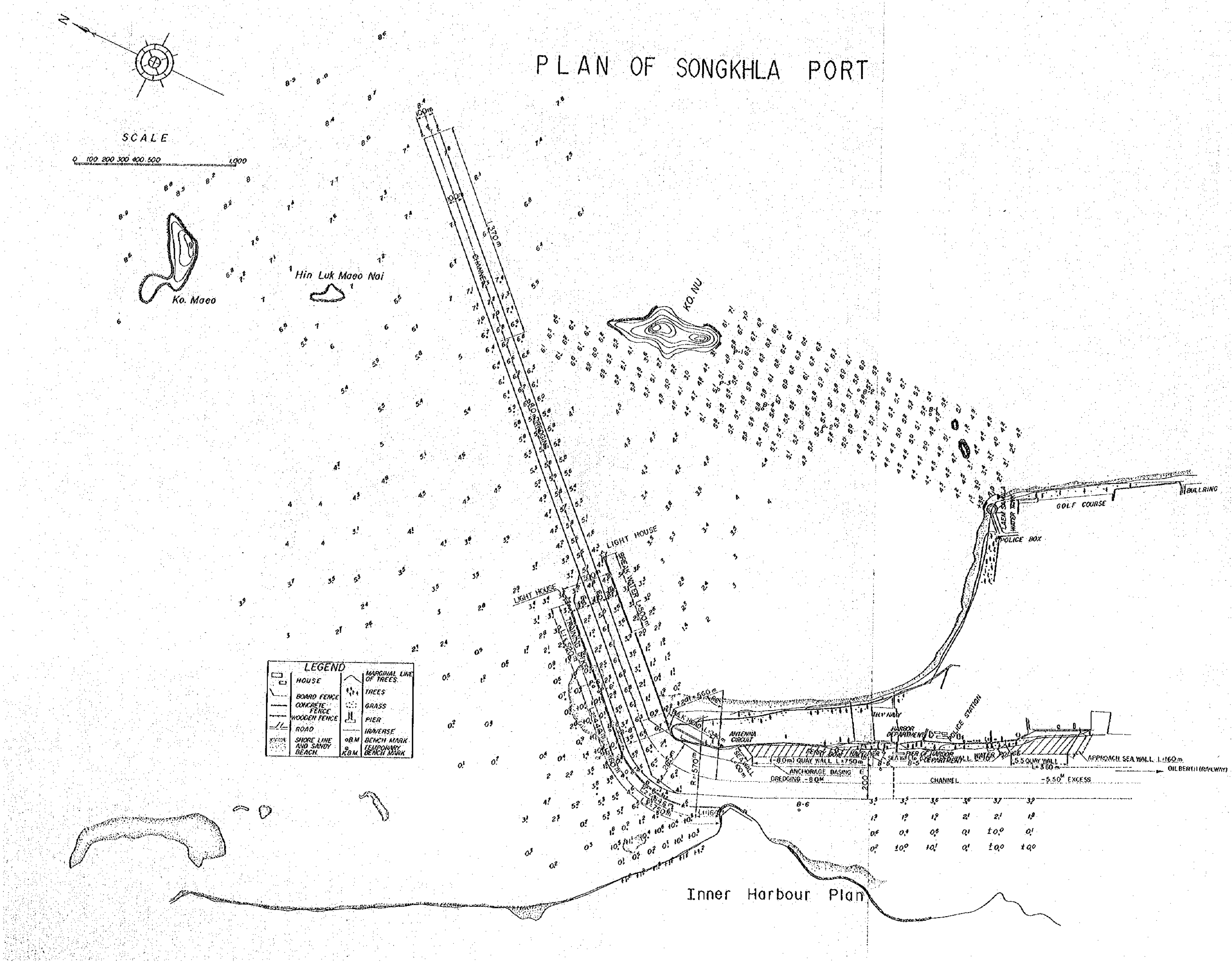
This plan is intended for construction of a new port in the outer sea area completely severed from the existing facilities. As shown in Fig. 11, mooring facilities will be constructed in the area surrounded by two breakwaters, one extending from the coastline to Ko Nu to intercept waves in the NE monsoon season and the other intercepting waves from N-NE direction. This plan is advantageous in that it will secure a large basin and permit free approach to future expansion plans. However, since the mooring facilities cannot be put in use before completion of the both breakwaters, the initial capital input required under this plan is much larger relative to the other plans. Further, the overall construction cost is made much higher than is required by the other plans by reason of the soft soil condition of the breakwater construction sites, and construction work calls for special attention since it will be carried out in the outer sea area.

67. From the comparative study of the three plans, the team recommends that the Inner Harbour Plan be adopted.

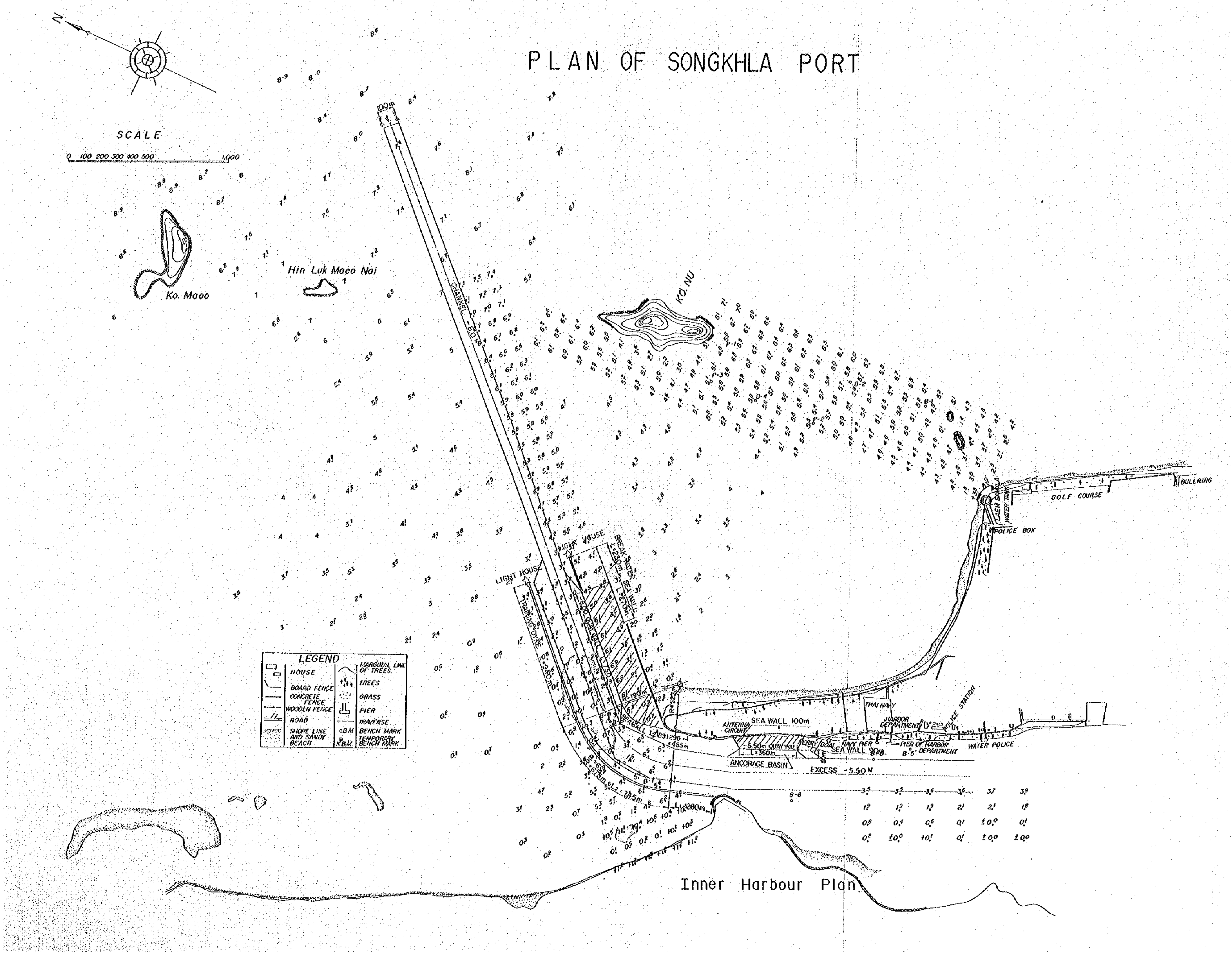
Table 24 Comparison of Proposed Construction Sites

Item	Inner Harbour Plan	Lake Outlet Area Plan	Outer Sea Area Plan	Remarks
Total capital requirement (in US$1,000)	19,720	22,980	33,960	
Capital requirement in Sub-stage I (in US$1,000)	9,380	10,620	18,100	Capital investment required in the period from 1974 to 1977 for putting in service two berts each at -8.0 m quay wall and at -5.5 m quay wall.
Utilization of existing facilities	Effective utilization of the existing breakwater, navigation channel, and wharf for domestic trade cargoes in the inner harbour area can be assured.	Effective utilization of the existing breakwater and wharf for domestic trade cargoes in the inner harbour area can be assured, but a new navigation channel must be created.	Utilization of the existing facilities is not feasible.	
Room for future expansion	Room for expansion of facilities in the inner harbour area after 1990 is smaller relative to the other two plans.	The port can be expanded by extending the breakwaters and training dike.	Room for expansion is larger than Plans A and B.	
Preservation of recreation zones	Recreation zones can be maintained in the existing state.	Same as Plan A.	The greater part of recreation zones cannot be preserved.	
Execution of consturction work	Construction work will be less affected by the changes in marine meteorology than in the case of Plans B and C.	A new navigation channel must be created before -8.0 m quay is put in use.	Construction work will be affected by the changes in marine meteorology to a greater extent than in the case of Plans A and B.	
Calmness in port area	Port area can be maintained calm.	Calmness at -8.0 m quay wall will be somewhat poorer than in the case of Plan A.	Calmness will be poorer compared with Plans A and B.	
Maintenance	Maintenance dreding from the end of breakwaters and training wall towards the offing will be required.	Same as Plan A.	Maintenance dredging of the navigation channel will be required from the harbour entrance towards the offing. Siltation is liable to occur at some parts of inner harbour area.	

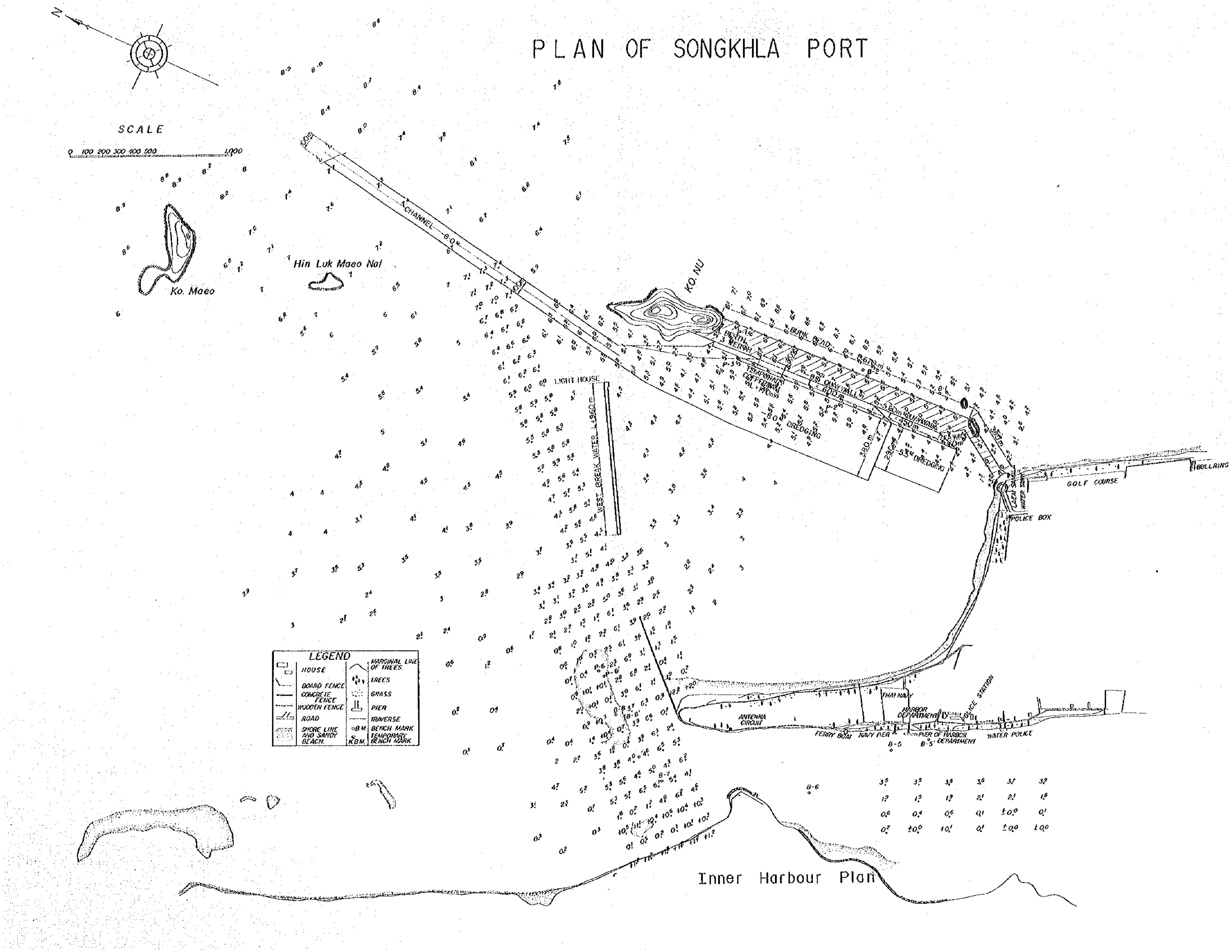
PLAN OF SONGKHLA PORT



PLAN OF SONGKHLA PORT



PLAN OF SONGKHLA PORT



D. Land Facilities Plan

68. Major land facilities required at a port are the cargo handling machinery and equipment, storage facilities including transit sheds and warehouses, harbour department office, welfare facilities for seamen and harbour labourers, and harbour roads.

The description given below relates to storage facilities and harbour road plans.

69. The floor space of a transit shed or warehouse can be obtained from the following equation.

$$W = \frac{V}{n \cdot R} = \alpha \cdot \omega \cdot \ell \cdot b$$

where,
- W : Capacity of storage facility (t).
- V : Cargo volume (t)
- n : Number of warehouses
- R : Rotation ratio (20 rotations/year for transit sheds and 10 rotations/year for warehouses).
- α : Coefficient (0.5 - 0.7)
- ω : Storage capacity per unit area (t/m^2)
- ℓ, b : Frontage and depth of storage facility

Assuming, for example, that four transit sheds are to be built on the -8.0 m wharf, the optimum plot area is 130 m x 35 m per shed. Assuming again that one shed is to be constructed on the -5.5 m wharf, it would have a plot area of 100 m x 35 m (See Figs. 12 and 13).

70. The number of vehicles partaking in the port operation can be obtained by the application of the following equation.

$$T = V \times \frac{\alpha}{\omega} \times \frac{\beta}{12} \times \frac{\gamma}{32} \times \frac{(1+\delta)}{} \times$$

where,
- T : Generated traffic volume (vehicles/hour)
- V : Cargo volume (t)
- α : Ratio of cargo volume carried by vehicles
- β : Monthly fluctuation rate
- γ : Daily fluctuation rate
- ω : Actual loading ratio of vehicles (t/vehicle)
- ε : Actual vehicle ratio
- δ : Related vehicle ratio
- γ : Hourly fluctuation rate

Traffic volume will reach about 500 vehicles/hour in 1980, but this will not produce any adverse effect on the traffic in the city area except in

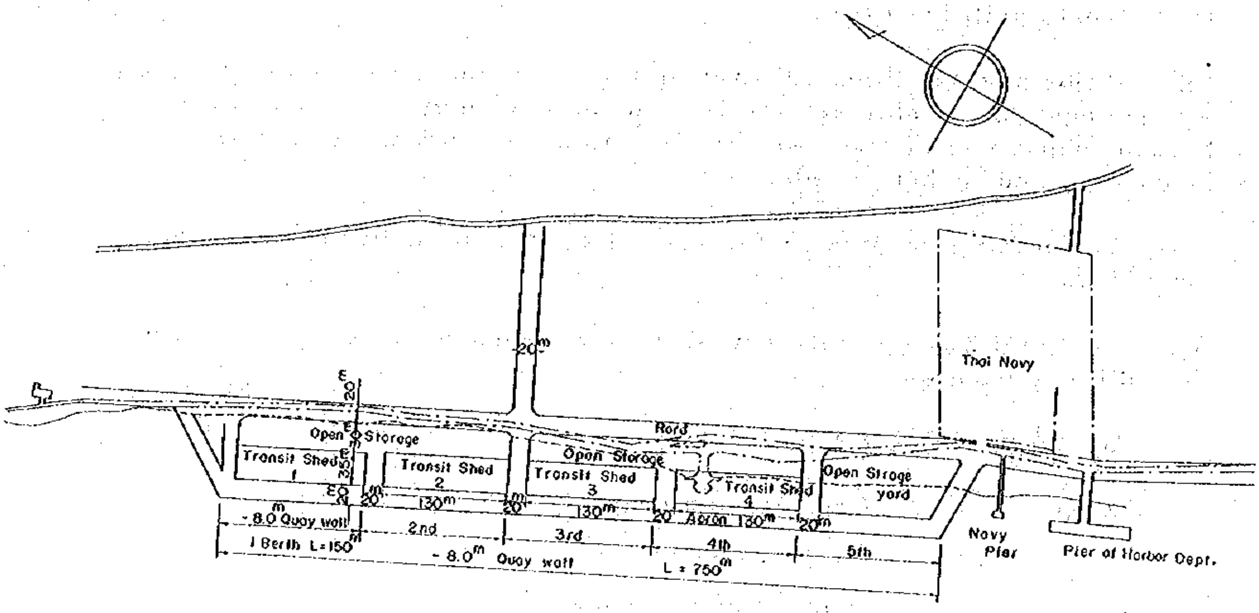


Fig 12 Layout of Wharves for Foreign Trade

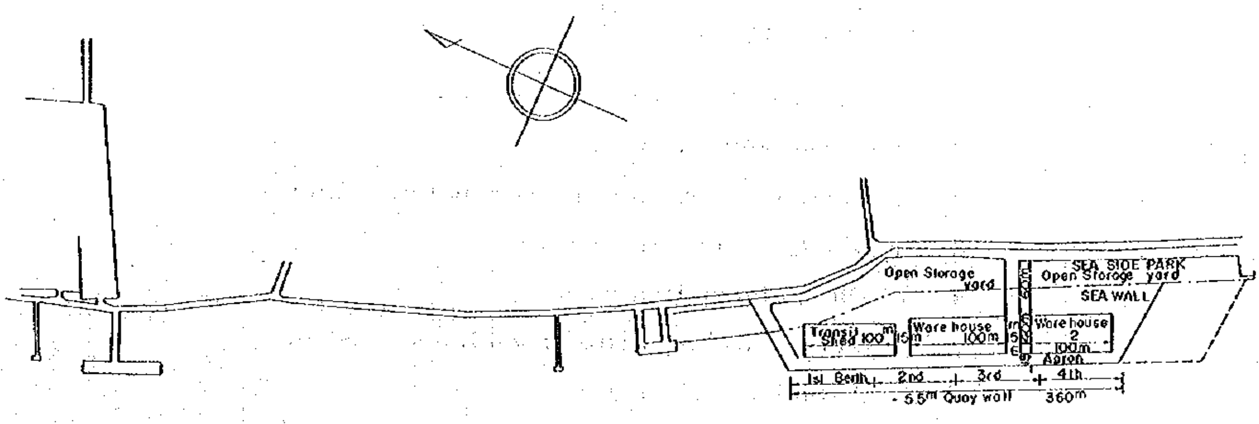


Fig 13 Layout of Wharves for Domestic Trade

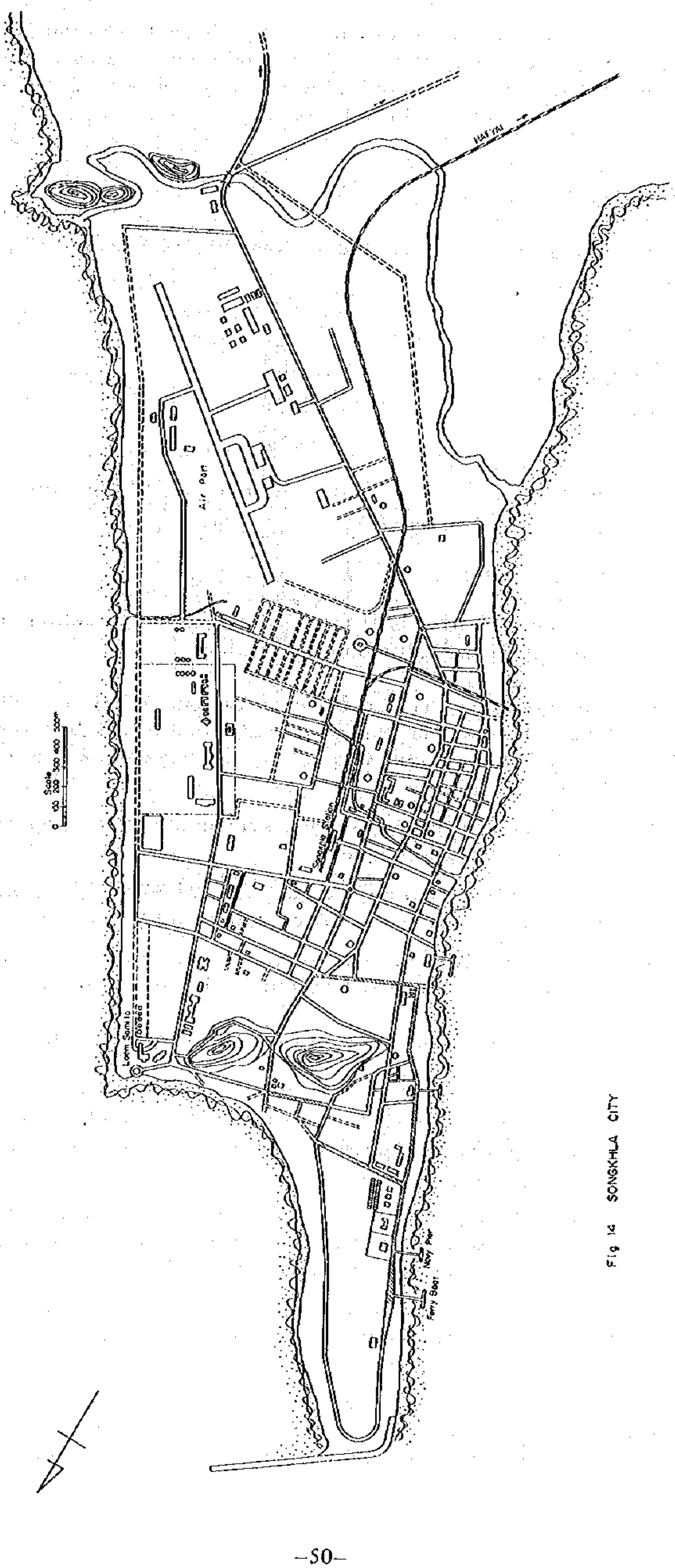


Fig 14 SONGKHLA CITY

the sea-bathing season even if no improvement is effected to the existing road network. It is advisable, however, that vehicles related to the port operation be guided to take the routes shown in Fig. 14 without running on congested and narrow streets in the city area.

E. Construction Programme

71. Major facilities to be constructed at Songkhla port by 1990 are as listed below.

-8.0 m quay wall	5 berths
-5.5 m quay wall	4 berths
Breakwater	500 m long
Training dyke	1,770 m long
Navigation channel	-8.0 m deep and 100 m wide
Transit shed	2
Warehouse	3

72. The above-listed facilities will be constructed in the selected inner harbour area according to the following principles.

i) Construction should be carried out over two stages, i.e., 1st Stage and 2nd Stage. The 1st Stage should be divided into Sub-stage I (1974 to 1977) and Sub-stage II (1982 to 1985), whereas the 2nd Stage is to run from 1989 to 1990.

ii) Facilities for handling foreign trade cargoes should be separated from those for domestic cargo cargoes.

iii) Facilities for handling domestic trade cargoes should be constructed at places where the existing facilities can be fully made use of.

iv) Efforts should be made so as not to cause immediate functional decline of the various existing facilities including the ferry boat terminal.

73. The following points should be taken into account in implementing the construction programme.

i) The breakwater should reach the position with a depth of -4.5 m, the critical water depth of bed material movement from east, so that it will serve as a groyne as well.

ii) Construction of the training dyke should be proceeded with according to the progress of the breakwater construction so that the navigation channel will be free from the intrusion of northeasterly waves.

iii) Dredging of the navigation channel should be so carried out as will meet the minimum requirement and proceeded with in parallel with the commissioning of the -8.0 m quay wall.

iv) Construction of the training dyke and breakwater should be carried out in parallel with the channel dredging work in order to prevent silting up of the channel and to produce flushing effect in the lake channel.

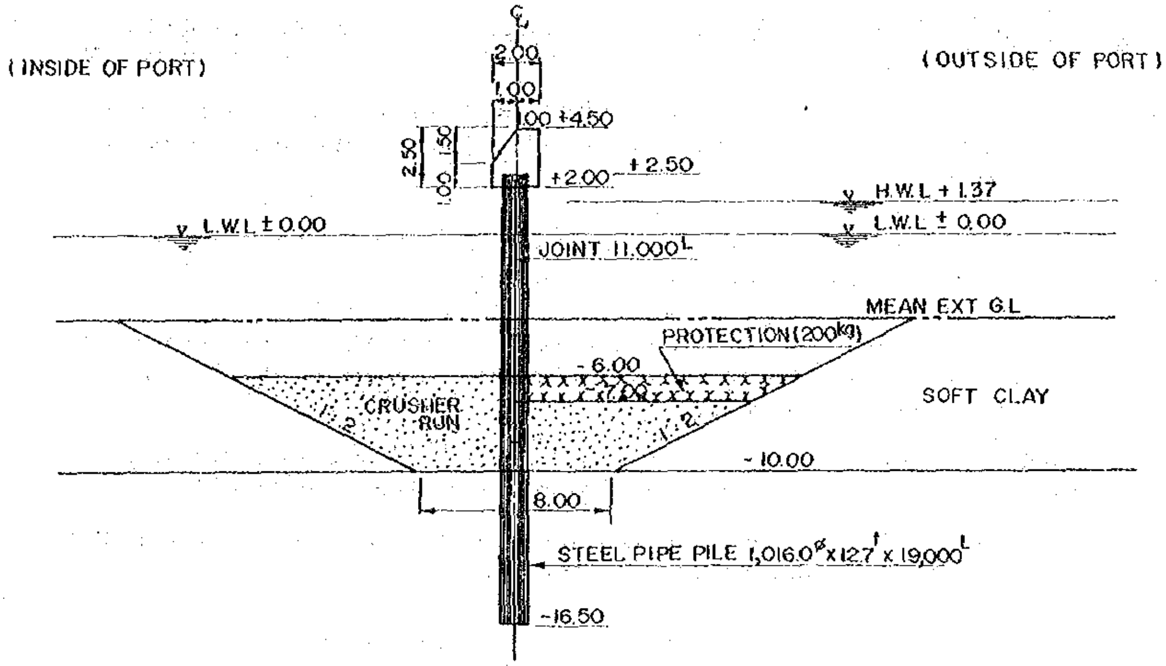


Fig 15 SECTION OF BREAKWATER

(Inner Harbour Plan) UNIT ; m

v) The direction of the navigation channel should be so determined that vessels will not be subjected to wind force on the broadside. Room for future expansion of the channel should also be secured.

vi) One of the berths of the quay wall for foreign trade should have the structure which can function for a depth of -9 m to cope with the possible future need for berthing vessels of large tonnage.

vii) The construction of land facilities should be carried out in parallel with that of berthing facilities.

viii) The construction site of the quay wall for domestic trade has a depth of -5.0 to -6.0 m. A unified depth of -5.5 m should be adopted for all berths.

74. The following points should be taken into account in designing the port facilities because of the port's site conditions.

i) Structures should be of a simple construction using steel sheet piles or steel pipe piles for the sake of economy as well as efficient and reliable construction work.

ii) Structures should be of the type or types which call for a minimum degree of underwater work because of the turbidity of water.

iii) Efforts should be made for maximum use of locally available construction materials, machines and equipment.

75. The following are the design criteria of major structures.

1) Tidal Level

H.W.L	+1.37 m
L.W.L	±0.00 m

2) Waves in Front of Breakwater

Wave Direction	E
Wave Height	$H_{1/3}$ = 2.20 m
Wave Period	$T_{1/3}$ = 6.0 sec
Wave Length	L = 56.2 m

3) Earthquake

Not considered

4) Crown Height

o Mooring Facilities +3.50 m (From C.D.L)

o Outer Facilities

East Breakwater +4.50 m

Training Dyke +4.00 m

o Reclamanation Site

+3.80 m

5) Vessel Type and Water Depth

Type of Vessels	Tonnage of Vessels	Planned Depth	Planned Length
Cargo Boat	2,000 D/W	-5.50 m	90 m
	7,000 D/W	-8.00 m	150 m
	10,000 D/W	-9.00 m	165 m

6) Approaching Speed of Vessels (Cargo Boats)

V = 0.12 m/s (10,000 D/W class or larger)

V = 0.15 m/s (7,000 D/W class)

V = 0.20 m/s (2,000 D/W class)

7) Corrosion Prevention

Corrosion allowance of 10 ~ 20 mm	Berths with a planned depth of less than -5.5 m
Electric corrosion prevention (anode current) and corrosion allowance (10 ~ 20 mm)	Berths with a planned depth of larger than -8.0 m

8) Typical Cross-section

The typical cross-section of major structures are shown in Fig. 15~19.

76. Construction of major structures will be executed as described below.

1) Foot Protection and Back-filling

Stones weighing 500 to 30 kg each will be used for foot protection of the breakwater and training dyke and backfilling of the wharf. These stones will be collected in the surburbs of Songkhla city and carried by boat to the construction site. The approximate quantity of stones is as shown in Table 25 below.

Table 25 - Required Quantity of Stones

Structure	Quantity of Stone	Remarks
Breakwater groin	6,100 m^3	200 kg/pce
Training Dyke	39,000 m^3	100 kg/pce
"	65,000 m^3	500 kg/pce
Quay Wall	-8.0m 53,000 -5.5m	5 Berth 50~30 kg/ 4 Berth
Total	Aprox. 172,000 m^3	

2) Dredging

Approximately 1.6 million m^3 of earth is expected to be excavated by dredging the navigation channel and basin. Since the dredging work is planned to be carried out in parallel with the construction of the -8.0 m quay wall, the channel will be dredged to have a depth of -8.0 m and a width of 70 m in the three year period from 1974 to 1976. The channel width will be expanded to 100 m in 1983.

A fleet of 2,000 PS class pump dredgers will be required for the planned dredging work.

3) Pile Driving

Steel sheet piles and steel pipe piles will be used for construction of the mooring quay walls (-8.0 m and -5.5 m quay walls), training dyke, breakwater as well as for other transitional part of berths and revetments. The pile driving work is expected to be concentrated in the 1974 ~ 1976 period. All the piles will be driven in the sea area by means of diesel hammers.

4) Concrete Placing

All the materials required for concrete placing such as cement, aggregate, reinforcement bars, moulds, etc. will be procured in Thailand.

5) Pavement Work

Asphalet macadam pavement will be applied to all the aprons and roads.

6) Construction Materials

Table 26 shows the kinds of construction materials to be locally supplied and those to be imported.

Table 26 - Procurement of Construction Materials

Classification of Work	To be supplied locally	To be imported
Breakwater groin Training Dyke	Stone, Construction Machinery concrete, Timber	Steel pipe pile Pile Hammer
Navigation Channel & Anchorage	Timber, Oil	of dredger
Mooring facilities	Stone, Construction Machinery sand, concrete timber	Steel sheet pile Steel pipe pile Tie-rod Rubber Fender Mooring Post Pile Hammer

77. The construction schedule (See Table 27) will be prepared in order that respective facilities will be completed as stated below.

i) In sub-stage I (1974 ~ 1977), facilities required for putting in service two berths each of the -8.0m and -5.5m quay walls should be completed.

Table 27 Inner Harbour Plan Construction Schedule

Classification of Worko	Quantity	1st stage Sub stage I 1974	'75	'76	'77	'78 '79 '80 '81	1st stage Sub stage II '82	'83	'84	'85	'86 '87 '88	2nd stage '89 '90	Remarka
Break Water	500 m						200			300			
Burk head or Sea Wall	340 m				170		170						
Temporary Cofferdam	150 m				80					70			
Approach Sea Wall	170 m	70										100	
Training Dyke	1,770 m	280	220	250	250			330	440				
Dredging	1.593 million m3	0.622	0.373	0.32			0.019	0.221	0.019			0.019	
-8.0 m quay Wall	750 m	150	75	75			150		150			150	
-5.5 m quay Wall	360 m	90			90			90				90	
Sea Wall (Domes)	230		160									70	
Reclamation	794,000 m^3	178,000	44,000	44,000	95,000		88,000	95,000	88,000			162,000	
Land grading	101,300 m^2	22,600	5,400	5,400	11,900		10,800	11,800	10,800			22,600	
Pavement	22,000 m^2		4,300		4,300			2,700	1,600	2,700		4,400	
Transit Shed	5		1	1	1		1	1					
Ware house	2				1				1				

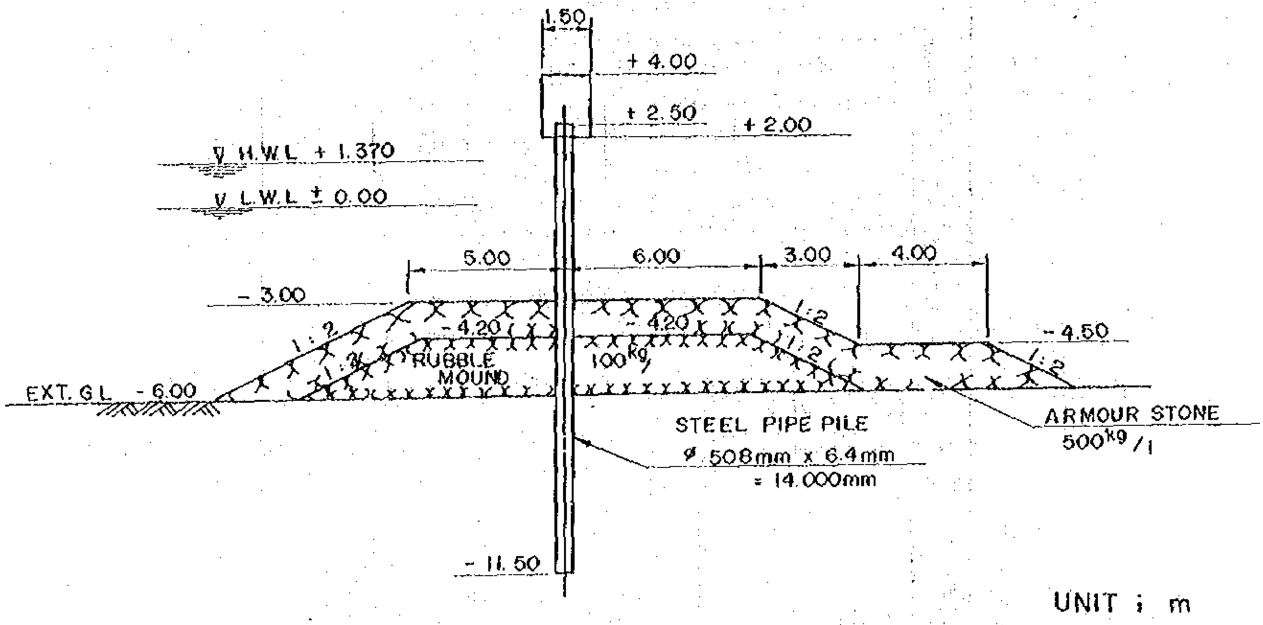


Fig 16 SECTION OF TRAINING DYKE (Part of Curvature)

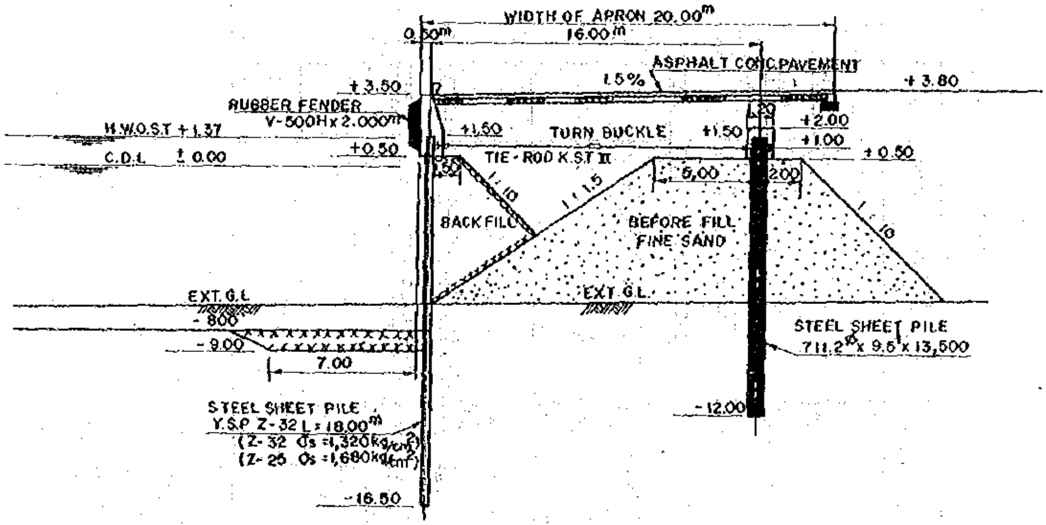


Fig 17 SECTION OF -8.0M QUAY WALL

A PLAN (Inner Harbour Plan) UNIT ; m

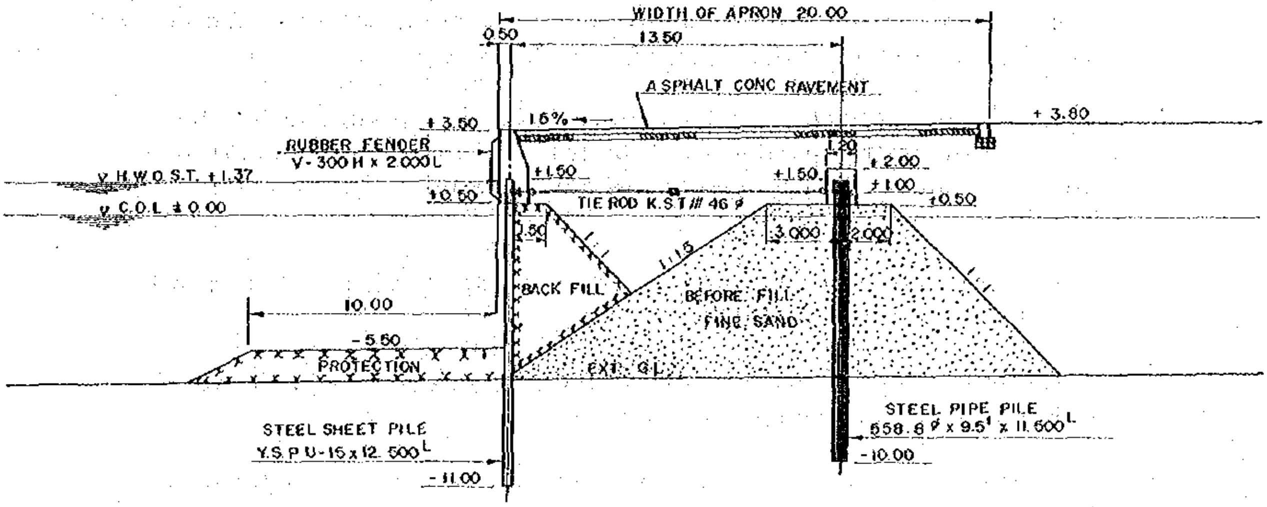


Fig 18 SECTION OF -5.5M QUAY WALL UNIT ; m

Unit ; m A Plan (Inner Horbour Plan)

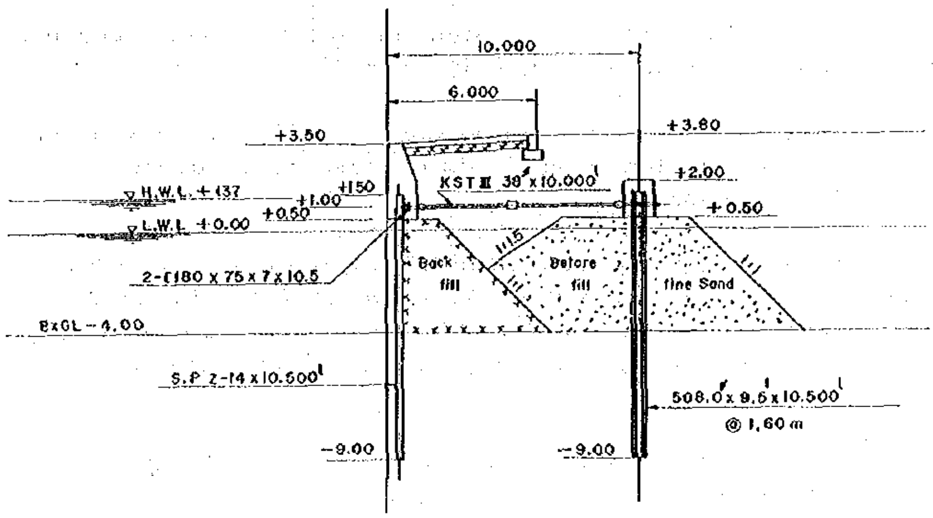


Fig-19 Section of bulkhead

ii) The navigation channel should be put in service when it is dredged to have a depth of -8.0 m and a width of 70 m.

iii) The training dyke should have a length of 1,000 m to prevent silting up of the navigation channel and to obtain flushing effect of the current from the lake (L_2 = 440 + 60 = 500 m, L_3 = 500 m).

iv) In sub-stage II (1982 ~ 1985), construction of two -8.0 m berths, one -5.5 m berth, breakwater (500 m), and training dyke (770 m) should be undertaken to enable the port to exhibit the excepted functions.

v) The main navigation channel should be dredged to expand its width to 100 m by the end of 1983.

78. Calculation of the construction cost and investment amount is worked out on the basis of the following preconditions.

i) Construction materials, machines and equipment not produced in Thailand will be imported from Japan.

ii) Cost for fishermen's compensation, site acquisition and removal to other places is disregarded.

iii) Rise in the cost of labour, materials, machines and equipment during construction is also disregarded (Calculation is worked out with 1974 taken as base year).

iv) Interest on construction cost is calculated only for the foreign currency portion at an annual interest rate of 7.5%.

As shown in Tables 28 and 29, the capital input required for the project completion in 1990, when calculated on the basis of these preconditions, turns out to be US$19,720 thousand.

The total foreign currency requirement is US$13,900 thousand, which is about 70% of the total investment amount. As shown in Table 30, stage-wise breakdown of construction cost is US$8,680 thousand for Sub-stage I, US$7,790 thousand for Sub-stage II, and US$1,770 thousand for the 2nd Stage.

79. The following study relates to the amount of maintenance dredging required under the three plans.

i) Inner Harbour Plan (Plan A)

It ia assumed that the navigation channel will be silted up to its former depth from an offshore point about 100 m far from the breakwater.

$$V_I = 1,400 \times 100 \times 0.6 + 137 \times 100 \times 2.0 = 358,000 \text{ m}^3/\text{year}$$

Inside the breakwater, however, silting up will hardly occur because of the tractive force created by the extension of the dyke (See Fig. 20).

ii) Lake Outlet Area Plan (Plan B)

Outside the breakwater, the channel will be subjected to the same

Table 28 - Investment for Inner Harbour Plan

(Unit : US$1,000)

Facilities	Unit Cost			Sub-Stage I (1974~1977)				Sub-Stage II (1982~1985)				2nd Stage				Remark
	Local Currency	Foreign Currency	Total	Quantity	Local	Foreign	Total	Quantity	Local	Foreign	Total	Quantity	Local	Foreign	Total	
Break Water	0.88	2.01	2.89					500m	440	1,005	1,445					
Burk head	0.56	0.75	1.31	170m	95.2	127.5	222.7	170m	95.2	127.5	222.7					
Temporary Cof-ferdam	0.81		0.81	80m	64.8		64.8	70m	56.7		56.7					
Approach Sea Wall	1.49	1.34	2.83	70m	104.3	93.8	198.1					100m	149	134	283	
Training Dyke	0.91 0.9	0.94 0.9	1.85 1.8	1,000m	905	920	1,825	770m	700.7	723.8	1,424.5					
Dredging	207	311	518	million 1,315m³	272.21	408.97	681.18	million 0.259m³	53.6	80.5	134.1	million 0.019m³	3.9	5.9	98	
-8.0 m quay	1.42 1.71	2.34 2.34	3.76 4.05	300m	469.5	702	1,171.5	300m	426	702	1,128	150m	213	351	564	
-5.5 m quay	1.48	1.34	2.82	180m	266.4	241.2	507.6	90m	1,133.2	602120.6	253.8	90m	133.2	120.6	253.8	
Sea Wall (Domes)	0.74	0.99	1.73	160m	118.4	158.4	276.8					70m	51.8	69.3	121.1	
Reclamation	1.94		194	million 0.361m³	70.034		70.034	million 0.271m³	52.574		52.574	million 0.162m³	31.5		31.5	
Land grading	0.000065		0.000065	45,300m²	2.94		2.94	33,400m²	2.17		2.17	22,600m²	1.47		1.47	
Pavement	0.013		0.013	8,600m²	111.8		111.8	7,000m²	91.0		91	4,400m²	57.2		57.2	
Transit Shed	105	152	257	3	315	456	771	2	210	304	514					
Ware house	77	108	185	1	77	108	185	1	77	108	185					
Navigation Aid		8.6	8.1	2		16.2	16.2	2		16.2	16.2	2	16.2		16.2	
Sab-total					2,872.584	3,232.07	6,104.654		2,338.144	3,187.6	8,525.744		657.27	680.8	1,338.07	
Eng Construction Suppervision						1,220.9	1,220.9			1,104	1,104			267	267	
Others*						567.05	567.05			449.98	449.98					
Contingency						789	789			707	707			161	161	
Grand Total (Construction cost)					2,872.584	5,809.02	8,681.6		2,338.144	5,448.58	8,786.724		657.27	1,108.8	1,765.07	
Investment Amount: Construction cost					2,872.584	5,809.02	8,681.6		2,338.144	5,448.58	8,786.724		657.27	1,108.8	1,765.07	
Investment Amount: Interest						697	697			653	653			133	133	
Investment Amount: Total					2,872.584	6,506.02	9,378.6		2,338.144	6,101.58	8,439.724		657.27	1,241.8	1,899.07	

* Others :
- Tug.boat US$ 459.9 thousand
- Office.gate 181.8 "
- Fork lift 75.46 "
- Trailer 75.36 "
- Tractor 46.42 "
- Wheelcrane 68.18 "

* 1) The construction cost does not include the interest and cost of maintenance dredging.
2) The investment amount is the sum total of the construction cost and interest on its foreign currency portion.

Table 29 - Investment for Inner Harbour Plan

(Unit: 1,000 US$)

	Quantity	Final P an (1974~1990)			Remarks
		Local	Foreign	Total	
Breakwater	500m	440	1,005	1,445	
Bulkhead	340m	190.4	255	445.4	
Temporary Cofferdam	150m	121.5		121.5	80m, 70m
Aproach Sea Wall	170m	253.3	227.8	481.1	70m, 100m
Training Dyke	1,770m	1,605.7	1,643.8	3,249.5	
Dredging	1,593,000m3	329.71	495.37	825.08	
-8.0m Quay Wall	750m	1,108.5	1,755	2,863.5	
-5.5m Quay Wall	360m	532.8	482.4	1,015.2	
Aproach Sea Wall (Dam)	230m	170.2	227.7	397.9	160m, 70m
Reclamation	794,000m3	154.1		154.1	
Land grading	101,300m2	6.58		6.58	
Pavement	20,000m2	260		260	
Transit Shed	5	525	760	1,285	
Warehouse	2	154	216	370	
Navigation Aid	6		48.6	48.6	
Sub Total		5,851.79	7,116.67	12,968.46	
Engineering Cost			2,591.9	2,591.9	Cost for Design, Spec & Supervision
Others			1,017.03	1,017.03	Tug boat, Wheel crane, Fork Lift etc.
Contingency			1,657	1,657	
Total (Construction Cost)		5,851.79	12,382.6	18,234.39	
Investment Amount					
Construction Cost		5,851.79	12,382.6	18,234.39	
Interest		* -	1,483	1,483	
Total		5,851.79	13,865.6	19,717.39	

Notes: 1. The construction cost does not include the interest and cost of maintenance dredging.

2. The investment amount is the sum total of the construction cost and interest on its foreign currency portion.

Table 30 - Approximate Annual Construction Cost

- Inner Harbour Plan -

Unit: US$1,000

Year / Kind of Trade	Sub-Stage I				Sub-Stage II					Remarks
	1974	1975	1976	1977	1982	1983	1984	1985	'89 ~ '90	
Foreign	2,196.5	1,772.3	1,524.2	1,403.0	1,837.3	1,449.9	2,108.9	1,344.8	1,217.0	
Domestic	358.0	43.6	711.0	672.6	340.2	371.0	277.9	57.8	548.7	
Total	2,554.5	1,815.9	2,235.2	2,075.6	2,117.5	1,820.9	2,386.8	1,402.6	1,765.7	

silting up as stated above.

$$V_1 = 1,400 \times 100 \times 0.6 + 137 \times 100 \times 2.0 = 358,000 \ m^3/year$$

Inside the breakwater, tractive force will work for virtual elimination of silting up.

iii) Outer Sea Area Plan (Plan C)

The amount of maintenance dredging required in the inner harbour area where the existing mooring facilities are found is as follows.

Approx. 280,000 m^3 (total excavated earth volume during the period from November 1970 to September 1971 as obtained from the sounding map of the Harbour Department)

527,000m^3(Value obtained from the actual working data of dredgers covering the same period)

It follows, therefore, that the average annual amount of maintenance dredging will total 616,000 m^3, of which 500,000 m^3 will be required in the existing port area and 116,000 m^3 ($\fallingdotseq$1930 x 100 x 0.6) in the new navigation channel.

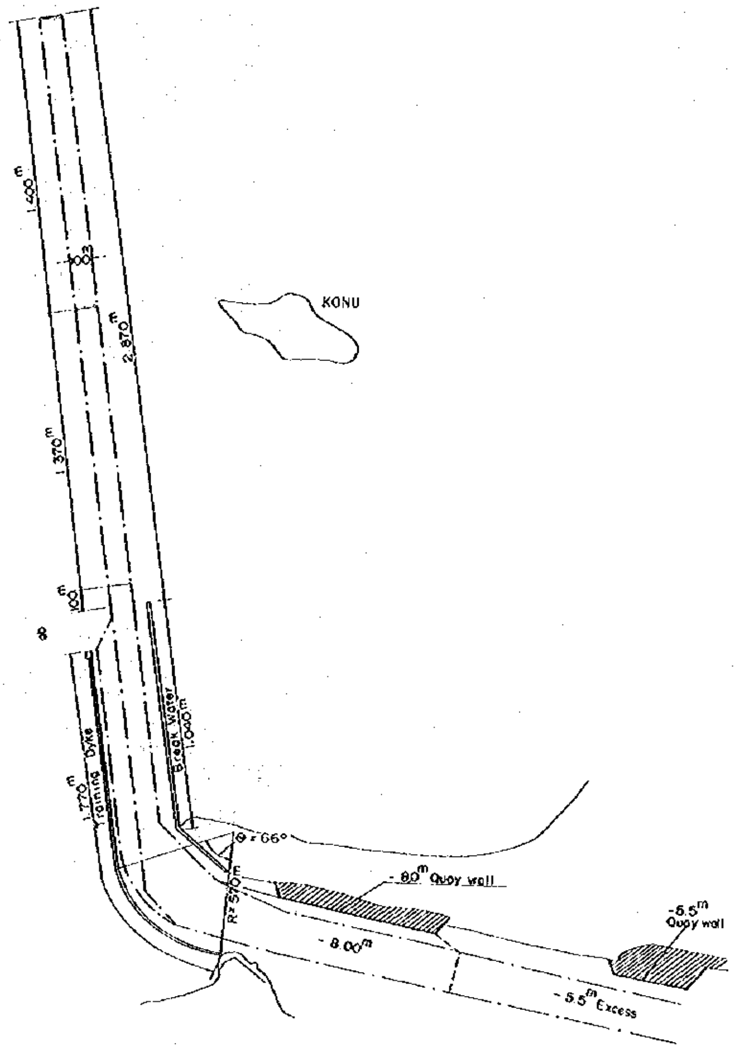


Fig 20 A Plan (Inner Harbour Plan)

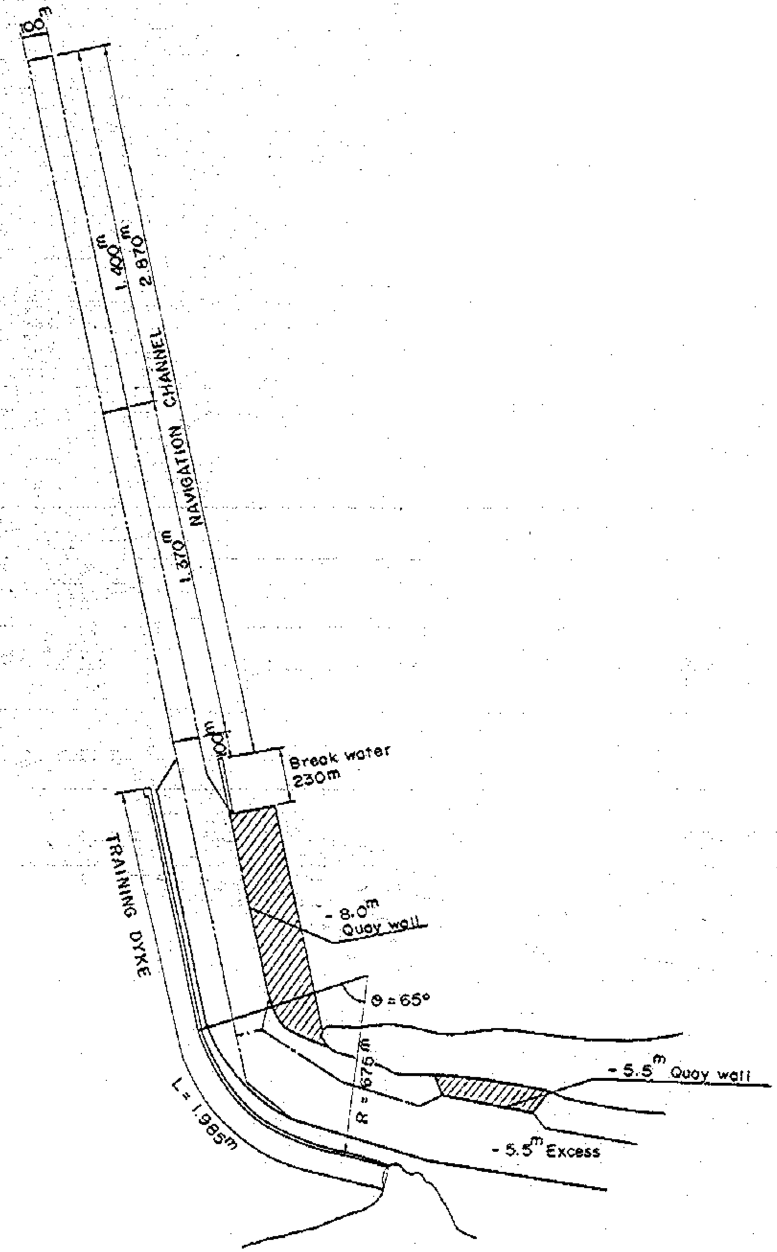


Fig 21 B Plan (Lake Outlet Area Plan)

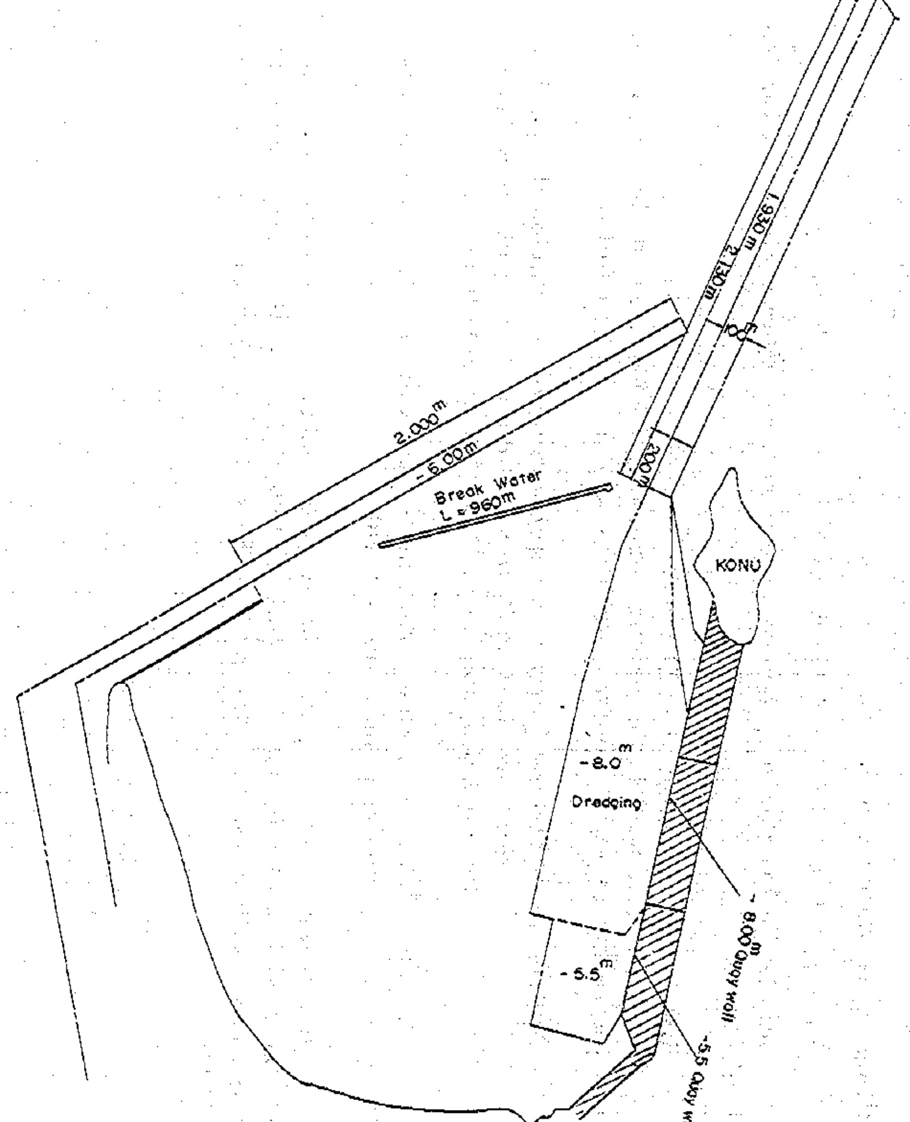


Fig 22 C Plan (Outer Sea Area Plan)

VI ECONOMIC EVALUATION OF THE PROJECT

VI ECONOMIC EVALUATION OF THE PROJECT

A. Method of Economic Evaluation

80. The songkhla port construction project must be evaluated from two different angles. In the first place, the project must be evaluated from the viewpoint of national economy. In other words, it must be analyzed in terms of its value to national economy. In the second place, evaluation must be made against the yards of port management to check if the project assures sound and payable port management. The analysis should be made over a period of 25 years from 1974 to 1999, with the cost-benefit ratio calculation worked out at a discount rate of 10%.

81. Construction of Songkhla port is expected to bring about a diversity of benefits as briefed below.

i) Increased international competitive power of export goods and stable supply of cheap commodities resulting from rationalization of the distribution mechanism.

ii) Industrial development ensued from the construction of large size quay walls.

iii) Increased employment opportunities arising from the port construction and operation.

iv) Income arising from the port management (balance between the revenues for port management and the expenditures for port operation).

Some of these benefits are measurable and some are not. Benefits to be reviewed for the purpose of analysis should therefore be limited to measureable ones such as the saving of transportation cost by rationalization of the distribution system and the net income from port management.

82. In the transport of foreign trade cargoes, the following cost saving can be expected.

i) Saving of the transportation cost by shifting lighter service to cargo handling on the wharf.

ii) Saving of the secondary marine transportation cost from Bangkok by direct import via Songkhla port.

iii) Reduction of the demurrage cost by improvement of the cargo handling method and quicker dispatch of vessels.

Cost saving merits of the basically same nature can also be expected in the transport of domestic trade cargoes.

83. Of the savings of transportation cost listed above, Items i) and ii) are taken for the purpose of the analysis.

The saving of the lighter transportation cost (Item i) varies considerably by the kind and lot of goods and by whether the goods are packed or in bulk, but the average savable amount is 30 Baht/ton. The value of this benefit can be obtained by multiplying the saving rate by the volume of cargoes passing through Songkhla port. Strictly speaking, the distance covered by overland commodity transportation from the port increases in proportion to the saving of the lighter's transportation cost, so that the port's hinterland area is made so much the wider. Accordingly, this benefit should be obtained not by multiplying all the cargo handling volume by 30 Baht/ton, but by applying this saving rate to the cargo volume circulating within the existing hinterland area and half this rate to the cargo volume newly generating by the expansion of the hinterland.

84. The saving of the secondary transportation cost from Bangkok to Songkhla is attainable as explained below.

There has been practically no direct supply of import commodities to Southern Thailand with the exception of petroleum because the ports in this area have no large quay walls and the volume of import cargoes they handle is too small to demand entry of ocean-going vessels. With the improvement of Songkhla port to a well consolidated foreign trade port, however, import commodities which have hitherto been sent to this area from Bangkok by sea or land will be directly imported, cutting down the secondary transportation cost from the capital to Southern Thailand.

Calculation of the secondary cost can be made basically in the same manner as applied for Item i).

i) 87 Baht/ton, the saving rate of marine transportation cost from Bangkok, can be expected for import cargoes supplied to changwants of Songkhla and Phattalung which are in the hinterland of Songkhla port as well as for those going to changwats of Trang and Satun.

ii) Saving of a maximum of 87 Baht/ton to a minimum of 30 Baht/ton can be expected for import cargoes which are distributed within the port's hinterland of foreign trade cargo traffic.

iii) Saving of a maximum of 30 Baht/ton to a minimum of zero is expected for import cargoes to be supplied to Changwat Surathani which will be embraced in the hinterland of the port after its improvement.

85. The revenues and expenditures of Songkhla port are to be obtained on the basis of the port charges collected at Bangkok port because it is probable that the examples set by Port Authority of Thailand will be followed in establishing a Port Authority of Songkhla. Accordingly, using the data shown in Table 31, the revenues and expenditures of the port are set at 115 Baht/ton and 75 Baht/ton respectively for foreign trade cargoes, so that the port's net income turns out to be 40 Baht/ton.

The cargo handling volume shown in Table 31 includes about 1,000 thousand tons handled by lighters in 1968 and 1969. As described in Table 10 and Section 83, the revenues and expenditures of lighter service are 35 Baht/ton and 30 Baht/ton respectively, so that the net income is as small as 2.2 Baht/ton and is to be disregarded.

Table 31 - Net Income of Bangkok Port

Unit: 1,000 Baht

	1968	1969	Remarks
Cargo Handling Volume (A)(1,000t)	2,223	2,226	
REVENUES (B)	274,082	269,333	
Wharf Rate	4,743	4,965	
Channel Dues	14,534	15,975	
Labour Section	48,209	27,758	
Port Operating	174,121	159,451	
Accesarial Service	2,570	2,730	
Rental*	8,208	9,665	Not included in the revenues of Songkhla port.
Passenger & Baggage*	61	72	
Overtime Fees	6,993	7,067	
Others	14,643	21,650	
REVENUES (B_1)	265,813	259,596	Total obtained by deducting asterisked values from (B)
Revenues per Unit Cargo Volume (B_1/A)(Baht/ton)	119.6	116.6	Average for 2 years:118.1
EXPENDITURES (C)	155,804	173,600	
Maintenance	11,295	15,209	
Depreciation	20,847	24,033	
Labour Section	51,443	60,369	
Executive & Administration	39,837	41,794	
Others	32,382	32,195	
Expenditures per Unit Cargo Volume (C/A) (Baht/ton)	70.1	78.0	Average for 2 years:74.1
Net Income (B_1) - (C)	110,009	85,996	
Net Income per Unit Cargo Volume (Baht/ton)	49.5	38.6	Average for 2 years:44.1

Table 32 - Benefit and Cost (Sub-stage I)

Unit: 1,000 Baht

Year	Benefit			Cost		
	Saving of Transportation Cost	Revenues from Port Operation	Total	Construction	Expenditures	Total
1974	0	0	0	53,130	0	53,130
1975	5,400	19,900	25,300	37,770	12,920	50,690
1976	6,420	23,450	29,870	46,490	15,220	61,710
1977	7,490	26,960	34,450	43,180	17,530	60,710
1978	8,640	30,930	39,570	0	20,070	20,070
1979	10,010	35,200	45,210	0	22,840	22,840
1980	11,640	40,400	52,040	0	26,210	26,210
1981	13,560	46,030	59,590	0	29,860	29,860
1982	14,110	47,170	61,280	0	30,580	30,580
1983	"	47,280	61,390	0	30,640	30,640
1984	"	47,400	61,510	0	30,700	30,700
1985	"	47,500	61,610	0	30,750	30,750
1986	"	"	"	0	"	"
1987	"	"	"	0	"	"
1988	"	"	"	0	"	"
1989	"	"	"	0	"	"
1990	"	"	"	0	"	"
1991	"	"	"	0	"	"
1992	"	"	"	0	"	"
1993	"	"	"	0	"	"
1994	"	"	"	0	"	"
1995	"	"	"	0	"	"
1996	"	"	"	0	"	"
1997	"	"	"	0	"	"
1998	"	"	"	0	"	"

Table 33 - Benefit and Cost (1st Stage)

Unit 1,000 Baht

Year	Benefit			Cost		
	Saving of Transportation Cost	Revenues from Port Operation	Total	Construction	Expenditures	Total
1974	0	0	0	(2,554.5) 53,130	0	53,130
1975	5,400	19,900	25,300	(1,815.9) 37,770	12,920	50,690
1976	6,420	23,450	29,870	(2,235.1) 46,490	15,220	61,710
1977	7,490	26,960	34,450	(2,075.9) 43,180	17,530	60,710
1978	8,640	30,930	39,570	0	20,070	20,070
1979	10,010	35,200	45,210	0	22,840	22,840
1980	11,640	40,400	52,040	0	26,210	26,210
1981	13,560	46,030	59,590	0	29,860	29,860
1982	14,110	47,170	61,280	(2,177.5) 45,290	30,580	75,870
1983	18,440	59,530	77,970	(1,820.9) 37,870	38,890	76,760
1984	21,010	66,150	87,160	(2,386.8) 49,650	42,930	92,580
1985	23,490	70,990	94,480	(1,402.7) 29,180	46,070	75,250
1986	24,970	75,040	100,010	0	48,680	48,680
1987	26,550	79,320	105,870	0	51,460	51,460
1988	28,220	83,840	112,060	0	54,380	54,380
1989	29,970	88,490	118,460	0	57,390	57,390
1990	31,870	93,560	125,430	0	60,680	60,680
1991	32,130	94,250	126,380	0	61,130	61,130
1992	"	"	"	0	"	"
1993	"	"	"	0	"	"
1994	"	"	"	0	"	"
1995	"	"	"	0	"	"
1996	"	"	"	0	"	"
1997	"	"	"	0	"	"
1998	"	"	"	0	"	"

Note: Values in parentheses are in U.S. dollars.

With respect to domestic trade cargoes, the revenues and expenditures are calculated to be 5 Baht/ton and 2.5 Baht/ton respectively from the rates of port charges currently effective at Songkhla port, so that the net income turns out to be 2.5 Baht/ton. Petroleum is assumed to be handled by the existing facilities and is therefore excluded from the calculation.

86. The port construction cost is the cost to be used for the purpose of analysis.

87. The benefit and cost calculated by the method described above are shown in Tables 32 and 33.

B. Evaluation Based on National Economy Analysis

88. This evaluation is intended to make clear whether the construction of Songkhla port will contribute to the growth of national economy. For the purpose of this evaluation, the saving of transportation cost and revenues from port operation are taken as benefit while the construction cost and expenditures on port operation taken as cost.

The project analysis for Sub-stage I indicates that the cost-benefit ratio is 1.16 at a discount rate of 10% and the internal rate of return is 14.5%.

Internal rate of return is the profit rate of the unrecovered portion of invested capital and therefore indicates the earning power of unrecovered capital. The said internal rate of return of 14.5% is an evidence to show that the project is sound for Sub-stage I.

89. The project analysis made in the similar way for the 1st Stage produces a cost-benefit ratio of 1.16 and an internal rate of return of 14.9% (See Fig. 23).

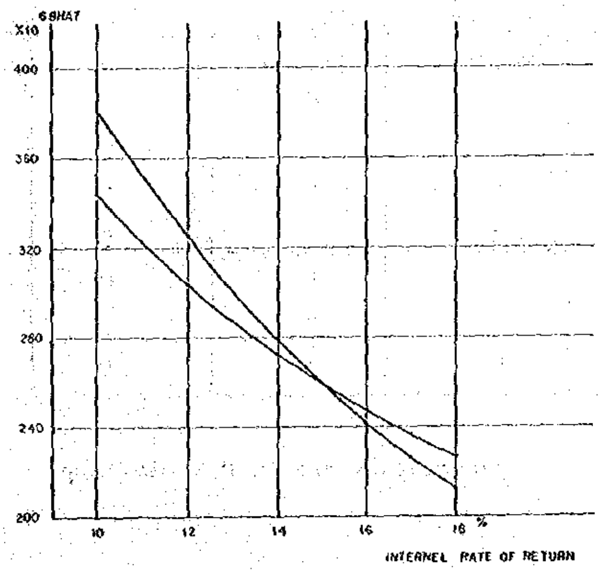


Fig. 23 Internal Rate of Return (1st stage)

Results of these analysis are tabulated in Table 34.

Table 34 - Evaluation Based on National Economy Analysis

	Cost-Benefit Ratio	Internal Rate of Return (%)
Sub-stage I (1974~1977)	1.16	14.5
1st Stage (1974~1985)	1.16	14.9

C. Internal Rate of Return

90. Net income is the only benefit that can be considered in the management analysis of Songkhla port, whereas the port construction cost must be taken as the cost. Analysis made on the basis of these two factors produces a financial rate of return of 5.5%. This value is too low to enable the port to be managed on the self-accounting system.

However, in the case of a project of this type which promises to be beneficial to national economy, the self-supporting accounting system need not be considered a binding condition of management. There are means to provide the basis for sound port management. For example, the government may grant the necessary amount of subsidy to the port authority, raise the port charges, or construct the port facilities for transfer to the port authority.

91. The difficulty in managing Songkhla port on the self-supporting basis arises chiefly from the severity of the surrounding natural conditions. To be more precise, the large capital input required for construction of the breakwaters and training dyke and for dredging of the navigation channel is the major cause of the difficulty.

To offer the possibility of sound management for this project which will have an accelerating effect on the growth of national economy, government subsidy granted to the port authority to cover part of the construction cost will be effective. If construction of the outer and harbour facilities (which incurs 44% of the total construction cost will be effective. If construction of the outer and harbour facilities (which incurs 44% of the total construction cost) is financed by the government, the financial rate of return will rise to 12.8%.

Description given above is summarized in Table 34.

Table 35 - Evaluation Based on Port Management Analysis

	Financial Rate of Return (%)	Remarks
Management by Self-Supporting Accounting System	5.5	
Management with Part of Cost Financed by Government Subsidy	12.8	Subsidy is equivalent to 44% of total construction cost.

The project can be evaluated as promising sound port management if the government supports it with the above-mentioned subsidiary measures.

VII APPENDIX

VII APPENDIX

A. Hydraulic Study on Maintenance of Water Depth of Lake Outlet Channel

1. As stated in the section dealing with the selection of the construction site, maintenance of water depth in the lake outlet area is an indispensable prerequisite to both Plan A (Inner Harbour Plan) and Plan B (Lake Outlet Plan). Hydraulic study made here is intended to look into and elucidate the possibility of maintaining the required water depth.

Hydraulic study intended for the said purpose must be made on two factors responsible for silting up of the navigation channel, i. e., littoral sand drift and sediment load from the lake. To clarify the effect of littoral drift, studies must be made on such elements as the waves, littoral current, grain size distribution of bed material along the coastline, topography, and structures; and to grasp the effect of sediment load, attention should be directed to elements such as the grain size distribution of bed material in the lake and navigation channel, flow characteristics of the channel in the lake outlet, tractive force, and effect produced by the curves in the channel.

2. Waves in the vicinity of Songkhla port have never been observed by a wave detector in the past. Therefore, wave estimation is the only means left for the present study. Data of Thai Navy indicate that the visual observation was conducted aboard a vessel in this area in the NE monsoon season when marine meteorology is in severe condition. The wave height recorded by this observation is 2. 0 m.

As for wind, observation has been carried on over the past years at Songkhla airport. From the data recorded at this airport, those for 1969 were employed for the purpose of the present study, and the winds that have blown from the directions between NE and SE were selected. These winds are observed concentrically in the January - February - March period as well as in the October - November - December period. Waves in these months are assignable to NE monsoon and they cause drift sand to migrate from SE to NW along the coast. Winds recorded to have blown from the directions between W and NE were also selected, and waves caused by them were considered to correspond to those observed in the SW monsoon season. These waves are observed concentrically in the four month period covering June, July, August and September, and they are considered to cause drift sand to migrate from NW to SE.

Due to the lack of the weather map required for fetch determination and the extremely large fetch expected on the east side of the Gulf of Thailand in the NE monsoon season when waves of great significance are generated, an infinite value was assumed for fetch. Accordingly, the wave height, period, etc. were determined by the wind velocity and duration, and S-M-B method was employed for wave estimation.

The wave height and period were obtained by the above-mentioned method for waves generating over 182 days in the NE monsoon season. Figs. A-1 and A-2 show the cumulative frequency distribution prepared by the method of Thomas plotting. The design wave for structural design is given a height and period equivalent to 99. 9% and 99% respectively of the values obtained from these figures.

$H_{1/3} = 2.2$ m

$T_{1/3} = 6 \sim 7$ sec

If structures are to be used for effective and economical control with account taken of the critical water depth of bed material movement, then 95 ~ 99% and 99% respectively of the height and period obtained from Figs. A-1 and A-2 should be taken for the design wave.

$H_{1/3} = 1.2 \sim 1.6$ m

$T_{1/3} = 6 \sim 7$ sec

Figs. A-3 and A-4 show the cumulative frequency distribution of waves generating in the SW monsoon season. For control of drift sand, the design wave should have the following height and period.

$H_{1/3} = 0.5 \sim 0.7$ m

$T_{1/3} = 5$ sec

3. In the offshore area of Songkhla port, the tidal current flows in NW direction at flood tide and in SE direction at ebb tide. It is believed that drift current develops in the NE monsoon season because of the long duration of wind. Since drift current tends to deflect towards the right side of wind direction in the northern hemisphere, the said drift current flows in NW direction. In the NE monsoon season, therefore, drift sand from NW direction prevails by the combined effect of this drift current and waves. The velocity of littoral current is believed to be about 1 knot.

4. As shown in Fig. A-5, five survey lines, A, B, C, D and E, were established along the coast of Songkhla, and bottom material was sampled at intervals of 1 m between D. L. + 1.0 m and D. L. -8.0 m for grain size analysis. Findings of the analysis are as follows.

Between -1.0 m and -2.0 m, the median diameter of bottom material, d_{50}, ranges from 200 to 300 μ, and between -3.0 m and -6.0 m, it ranges from 50 to 100 μ. At places deeper than -7.0 m, d_{50} = 10 - 20μ along all the survey lines, indicating that sediment discharged from the lake is widely distributed and deposited. Figs. A-6 and A-7 show the grain size distribution at each depth along Survey Line D.

When the wave height and period are taken at the values described in the preceding section and the mean grain size of bottom material at 70μ, the critical water depth allowing conspicuous movement of drift sand can be estimated as follows from Fig. A-8.

In the NE monsoon season: 4.0 ~ 5.6 m beneath mean water level.

In the SW monsoon season: 1.2 ~ 1.9 m beneath mean water level.

The above findings indicate that it is advisable, for protecting the navigation channel against silting up through interception of the greater part of sand drift, that the breakwaters be extended to the position where the depth registered 5 m beneath mean sea level, i. e., D. L. -4.0 m, and that

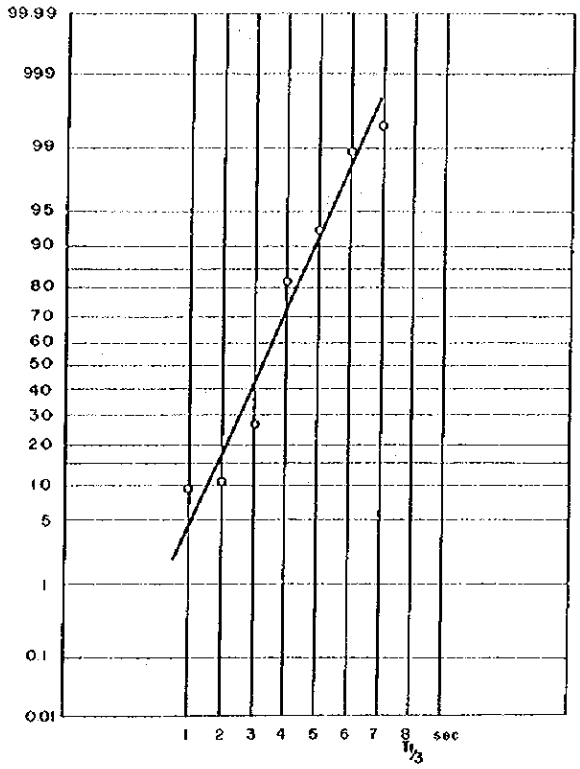


Fig. A-1 NE Monsoon; Cumulative Frequency distribution of Wave Period

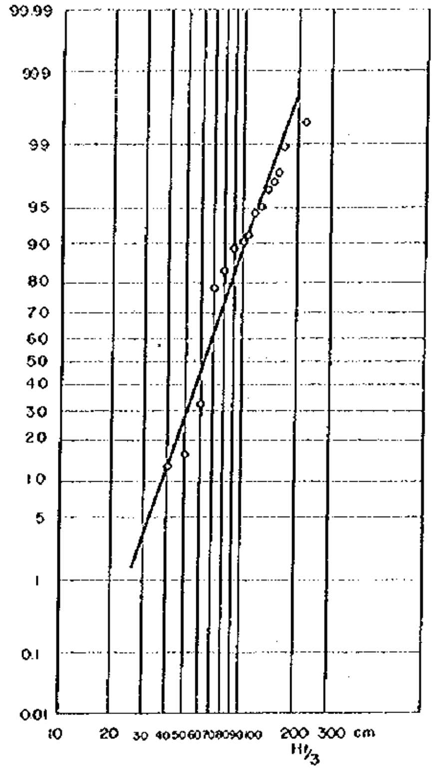


Fig. A-2 NE Monsoon; Cumulative Frequency Distribution of Wave Height

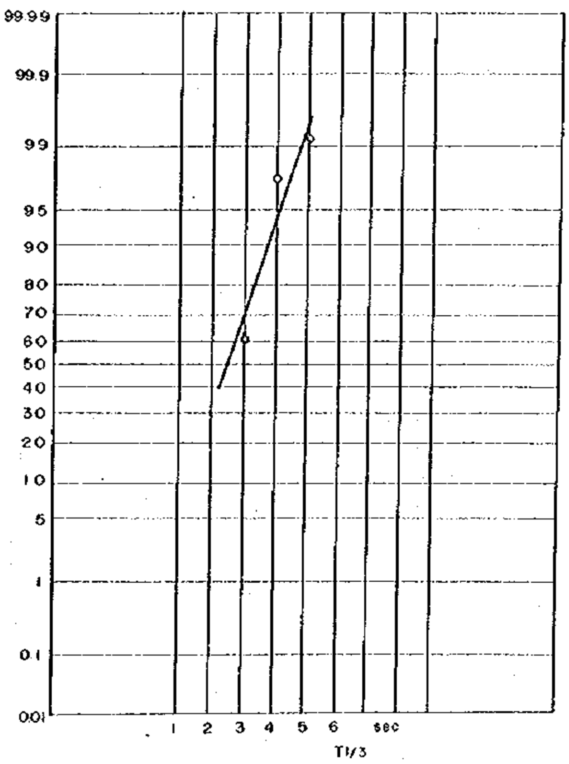


Fig. A-3 SW Monsoon; Cumulative Prequency Distribution of Wave Period

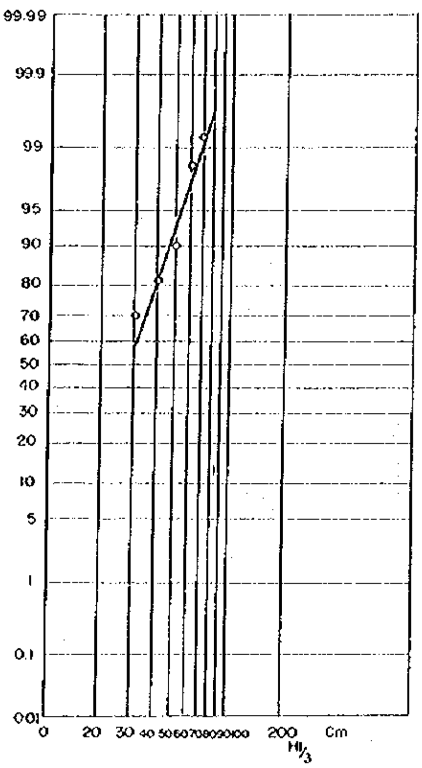


Fig. A-4 SW Monsoon; Cumulative Frequency Distribution of Wave Height

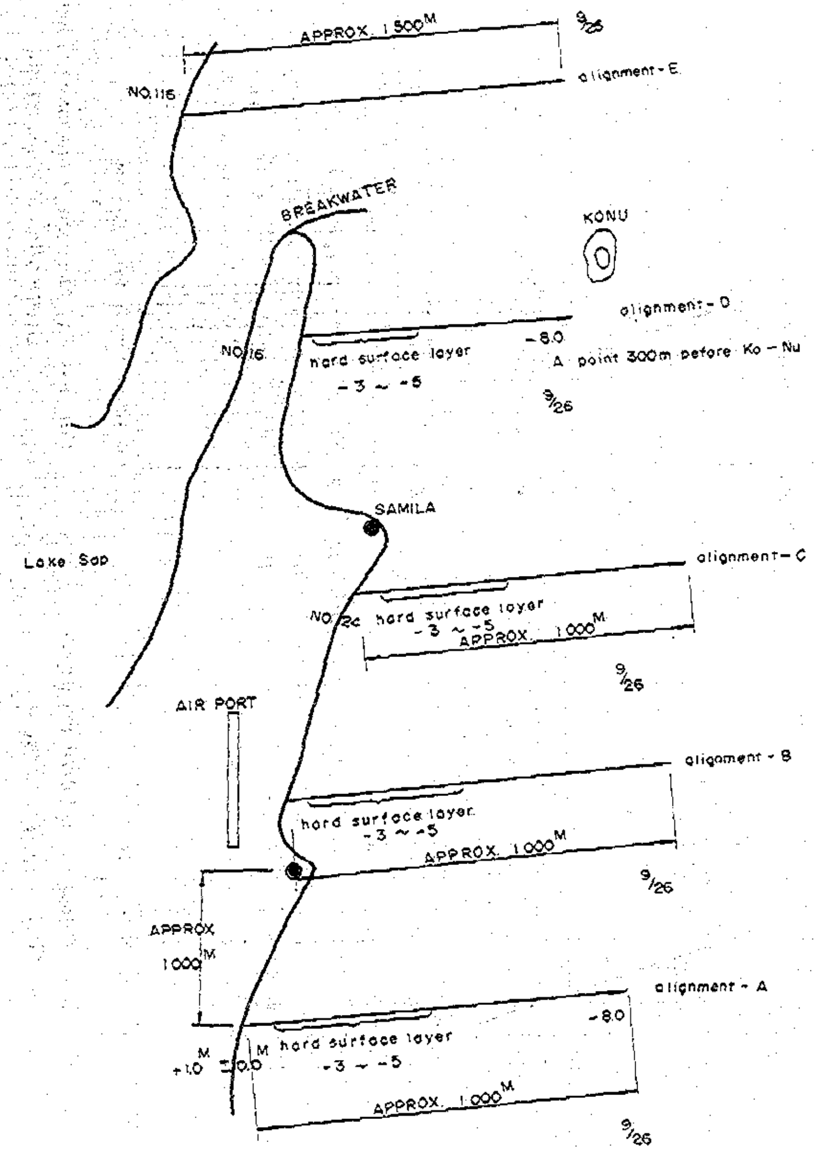


Fig A-5 Bottom Material Sampling Points along the Coast

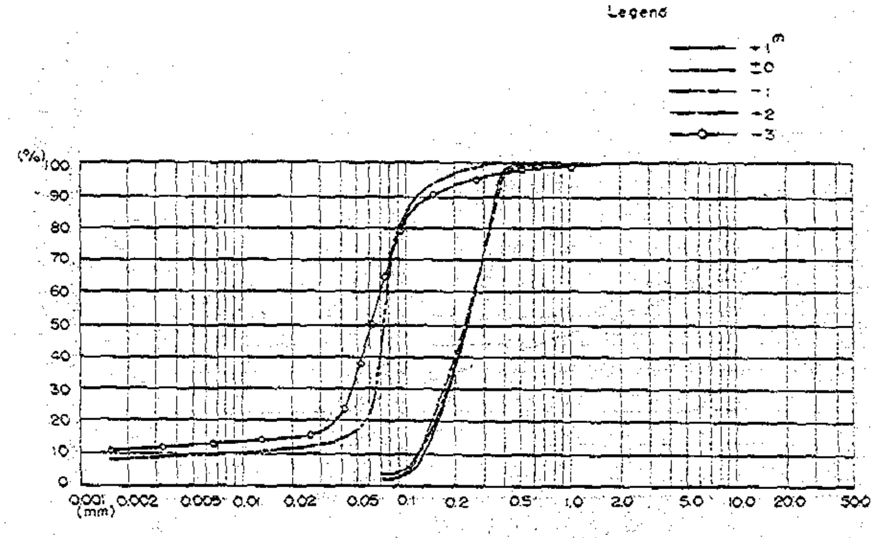


Fig. A-6 Grain Size distribution on Survey Line D

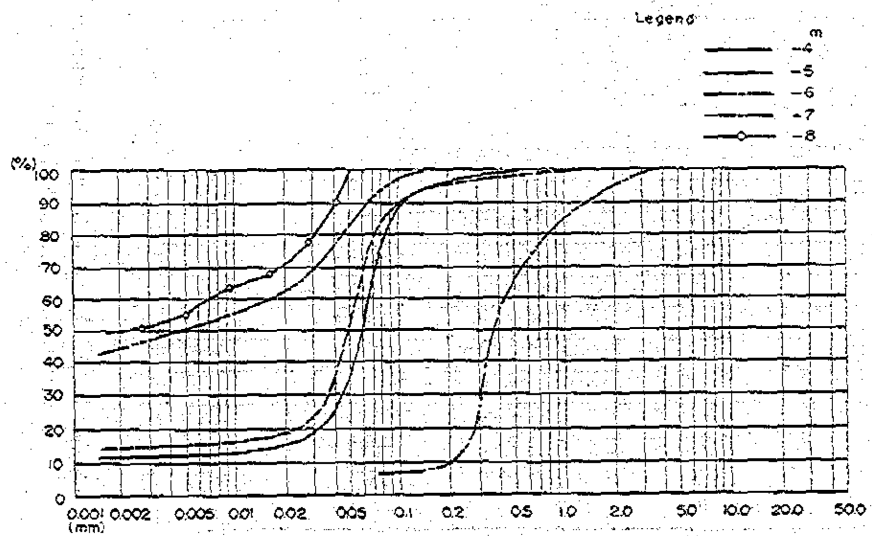


Fig. A-7 Grain Size Distribution on Survey Line D the training dyke be also be extended, in view of the extensive bar in front of the lake outlet, to the position where the depth is D. L. -2. 0 m.

Since the breakwater extension work is not included in Sub-stage I, the amount of maintenance dredging of the navigation channel in Sub-stage I will be larger than in Sub-stage II. The existing breakwater stretches to the vicinity of the place having a depth of D. L. -2. 0 m. At present, considerable siltation is observed over a distance of about 300 m from its head towards the offing.

5. As shown in Fig. A-9, bottom material was sampled from the lake channel towards the lake inside. The grain size analysis of the collected specimens revealed that the mean diameter is extremely small inside the lake, not reaching 30μ, whereas the values in the lake channel are as shown below.

No. 1	d_{50} = 500μ
No. 2	d_{50} = Less than 5μ
No. 3	d_{50} = 100μ
No. 4	d_{50} = 50μ
No. 5	d_{50} = 50μ

The critical tractive force for bed material having a mean diameter of 100μ is calculated below.

Kurihara's formula: $U_c^{*2} = \left\{-76.0 \log_{10}(1.18d) - 37.2\right\} d$

Iwagaki's formula: $U_c^{*2} = 8.41\, d^{11/32}$

$$U_c^{*2} = \frac{\tau_c}{\rho}$$

where, τ_c : Critical tractive force

ρ : Density of water

d : Mean diameter of bed material

Values of τ_c obtained from the above two formulas are as follows.

τ_c : 1. 1 dyne/cm^2

τ_c : 1. 7 dyne/cm^2

Judging from the data of boring work conducted for soil survey, the mean diameter of bed material in the outer sea navigation channel and in the lake channel will be smaller than 100μ except at Station No. 1 of the channel when the channel is dredged to a depth of -8. 0 m. Therefore, τ_c = 1. 5 dyne/cm^2 will suffice.

6. An attempt to maintain the required water depth by the flushing effect proves successful in many cases if the tractive force is larger than ten times the critical value. Since τ_c = 1. 5 dyne/cm^2 as stated above, the required tractive force is -

$$\tau \geqq 10\tau_c \fallingdotseq 15 \text{ dyne/cm}^2$$

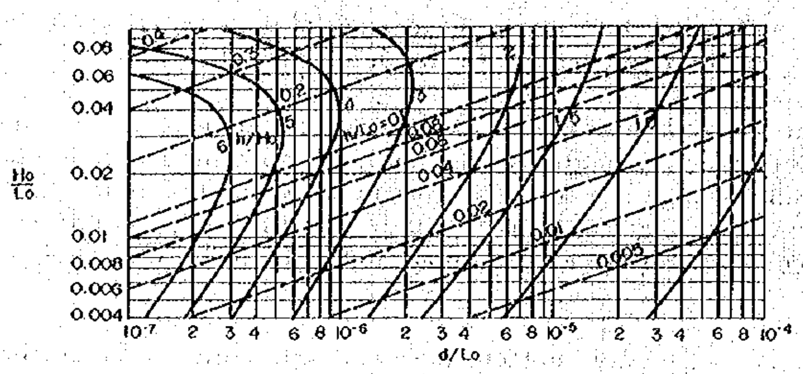


Fig. A-8 Nomograph for Obtaining Critical Depth Showing Conspicuous Movement

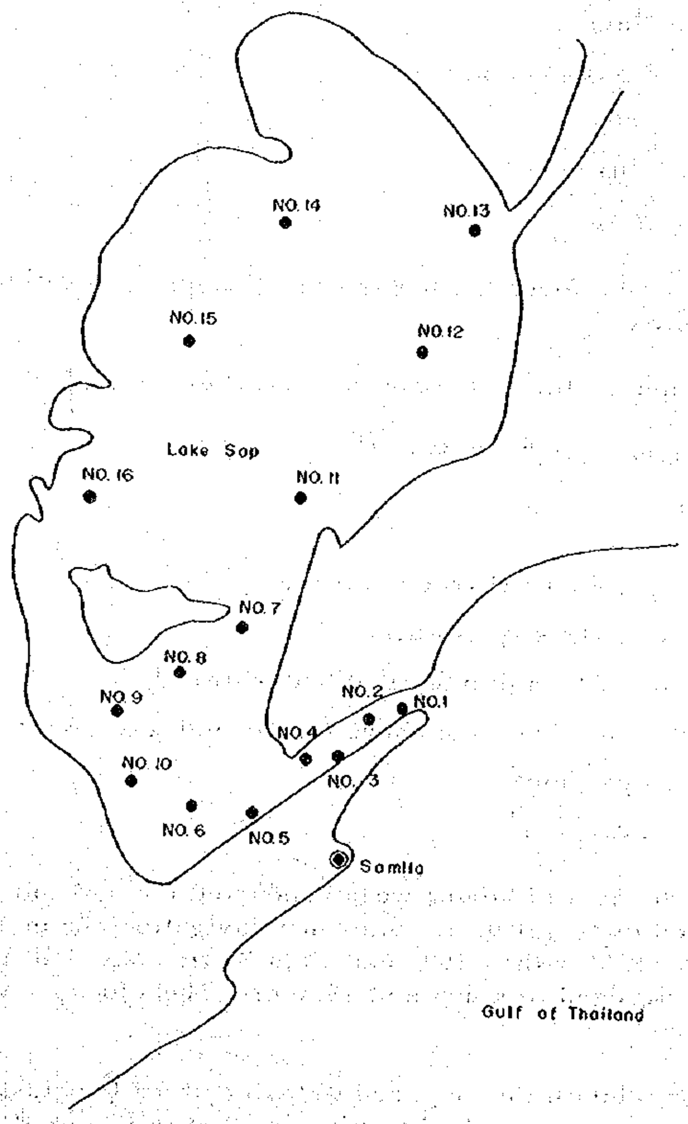


Fig. A-9 Bottom Material Sampling Points at Lake Sap

Tractive force is expressed by the following equation.

$$\tau = \rho \cdot f \cdot |U| \cdot U$$

where, ρ : Density of water

f : Resistance coefficient (non-dimensional)

U : Flow velocity uniform in the vertical direction

The value of f is expressed by the following equation.

$$f = g \cdot n^2 / h^{1/3} \quad \text{(Unit: m-sec)}$$

where, g : Gravitational acceleration

n : Manning's roughness coefficient

h : Water depth

If calculation is to be worked out without regard to curves in the channel, n = 0.020 - 0.025 is taken as in the case of river mouth and h = 9.0m in view of the mean water level. To obtain a tractive force of 15 dyne/cm^2, U is required to have the following value.

U = 70 - 90 cm/sec.

7. The flow observation made at Sations 1 and 3 (See Fig. A-9) disclosed that the specific gravity of water measured at each place is uniform in the vertical direction as shown in Fig. A-10. Further, according to the data of Songkhla Fisheries Experiment Station, the density of water gradually declines towards the inner part of the lake. From these facts, it can be inferred that the lake channel constitutes a density current of strong mixing type which, unlike a two-layered flow, produces a large flow velocity that works on the bottom.

Figs. A-11 and A-12 respectively show the flow velocity measured at spring tide on October 30, 1971 and at neap tide on October 11, 1971 at Station No. 1. Figs. A-13 and A-14 shows the values measured on October 1 and 10 of the same year at Station 3. The values shown in these two figures were measured at a point closer to the right side bank from the centre line of the stream.

Under Plan A, the -8.0 m quay wall will be constructed between Station No. 1 and No. 3. The flow is expected to change by a number of construction works scheduled for Sub-stages I and II such as the dredging of the navigation channel to a depth of -8.0 m, extension of the breakwaters, new construction of a training dyke, etc. However, there will not be any large change in the flow velocity because the increase of flow resistance resulting from the curves in the channel will be balanced with that of water depth due to dredging work by reason of the eventual reformation of the channel section and removal of bars in front of the lake outlet. It is accordingly estimated that a velocity of 70 ~ 90 cm/sec can be maintained from the outer sea navigation channel to the vicinity of the -8.0 m quay wall. It is to be noted, however, that the velocity will not reach this value near the quay wall at neap tide when the velocity at Station No. 3 is small as shown in Fig. A-14. Nevertheless, no siltation will take place because the sediment discharged from the lake is smaller than 50μ in grain size.

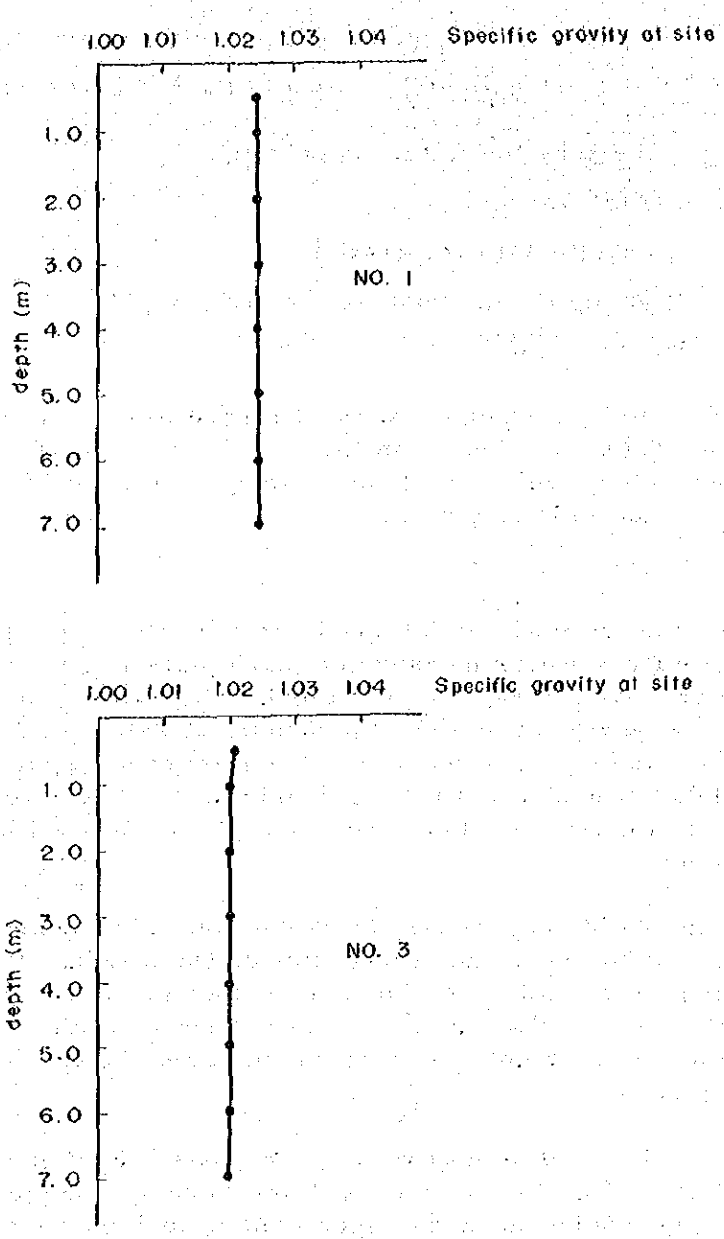


Fig A-10 Specific Gravity Distribution of Seawater in the Vertical Direction

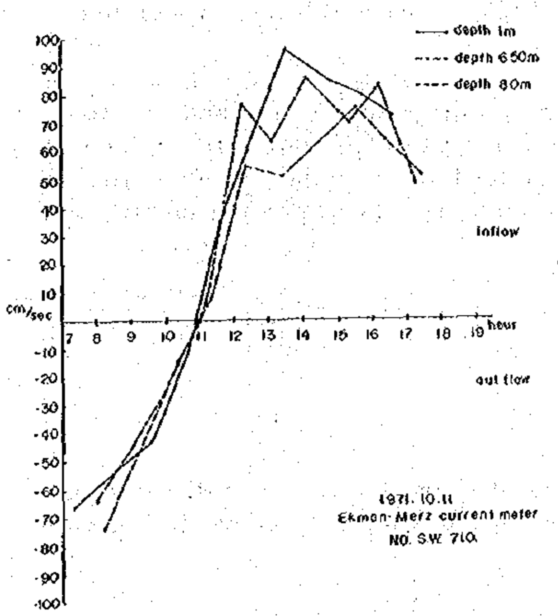


Fig A-12 Flow Velocity at NO. 1 at Neap Tide

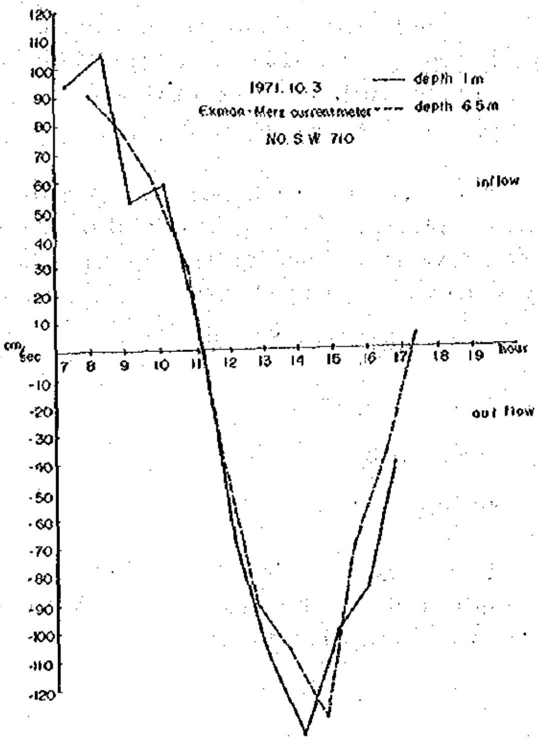


Fig A-11 Flow Velocity at NO. 1 at Spring Tide

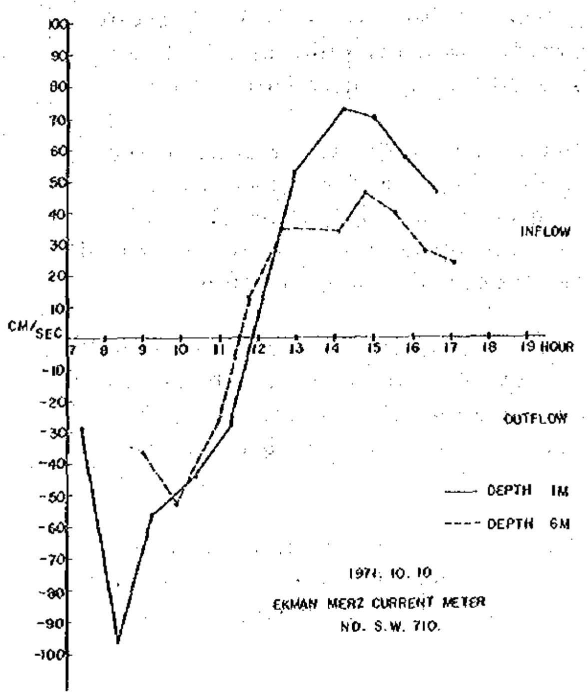


Fig. 14 Flow Velocity at No. 3 at Neap Tide

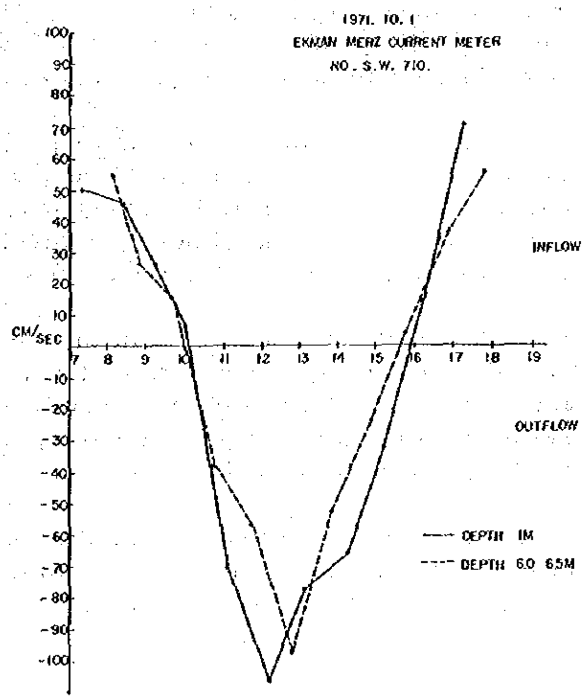


Fig. 13 Flow Velocity at No. 3 at Spring Tide

8. Curves in the channel develop the secondary current which produces a helical flow. This flow is affected by such factors as the angle of curve (θ), radius of curvature of the entire stream (r_c), river width (W), river bed width (b), and water depth (y_o).

A curved flow causes changes in the tractive force imposed on the channel bottom. In Fig. A-15 showing the results of model test, $\bar{\tau}_0$ denotes the tractive force before the curve and τ_0 the local tractive force of the curved flow. The model test was conducted under the following conditions.

$\theta = 60°$

$b/r_c = 0.42$

$W/r_c = 0.6$

$W/y_o = 12$

In the case of Songkhla port, values of these factors will differ from those adopted for the model test as shown below, but they serve to indicate the trend of tractive force.

$\theta = 70°$

$b/r_c = 0.5$

$W/r_c = 0.53$

$W/y_o = 33$

It must be taken into account that in the downstream section, the tractive force increases by more than 50% towards the left side bank from the centre line and by about 2 times just besides the left side bank. Therefore, foot protection of the training dyke should be carefully worked out.

Inflow from the outer sea area, on the other hand, will result in the increase of tractive force on the opposite side of the -8.0 m quay wall. Though this will destroy the dredged side slope of the navigation channel, remedy can be brought about by natural traction since the mean diameter of bottom material is smaller than 50μ as observed at Stations 2 and 4.

9. From the studies made in the foregoing pages, it is considered possible to maintain the navigation channel at a depth of -8.0 m by the flushing effect and drift sand interception that can be expected from the extension of the breakwaters and training dyke having a width of 300 m which is the same as the width of Station No. 1.

It is evident, however, that the offshore navigation channel will be silted up by the sediment load of small diameter from the lake or by littoral drift. Uninterrupted maintenance dredging will therefore be required in this part of the channel.

10. If the breakwater and training dyke are to be newly constructed or extended according to the Inner Harbour Plan, rise of water level in the channel and lake must be taken into consideration. From the current velocity data, it is estimated that the discharge from the lake due to the tidal movement of the outer sea ranges from 1,000 m^3/sec to 1,500 m^3/sec.

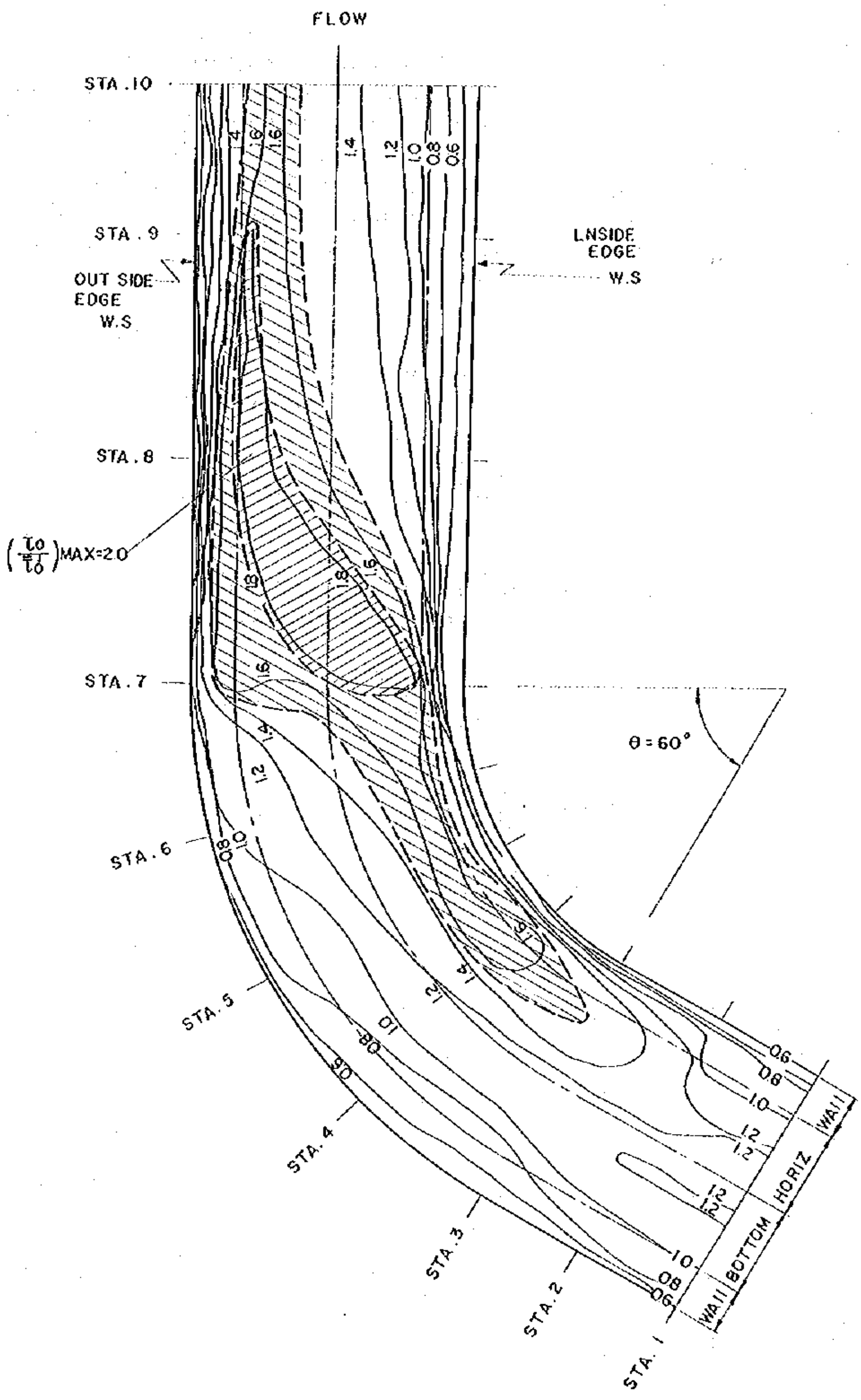


Fig.A-15. Trative Force of Curved Flow

However, this value rises sharply due to the concentrated rainfall in the October - December period each year. The rise of water level should therefore be studied with due regard to this phenomenon.

11. The past record indicates that 1,333 mm of rainfall was recorded in 26 days in November 1969. This is the largest monthly rainfall observed during the period from 1957 to 1970. Since the catchment area of the three lakes, Luang, Sap and Songkhla, is approximately 3,300 km^2, the said rainfall alone will augment the discharge into the Songkhla's channel to an average of about 2,000 m^3/sec. When the discharge caused by the tidal movement is added to this value, the discharge at the harbour entrance will reach 3,000 m^3/sec - 4,000 m^3/sec at time of flooding.

12. The datum level established by Thai Navy (Hydrographic Department) is employed for backwater calculation. This datum level is based on the observation data recorded over a period of ten years at Ko Nu. From the analysis of the data, the following values are made available.

All the calculations made in this report are based on the said datum level.

13. The backwater calculation is worked out by Escoffier-Raytchine-Chatelain method because it is most instrumental in coping with discharge fluctuation.

The water level above the datum line is obtained by the application of the following equation.

$$H_1 - H_2 = \frac{Q^2}{2g}\left(\frac{1}{A_2^2} - \frac{1}{A_1^2}\right) - \frac{1}{2}\left(\frac{n_1^2}{R_1^{4/3} \cdot A_1^2} + \frac{n_2^2}{R_2^{4/3} \cdot A_2^2}\right)$$

where,
- H : Water level above datum level
- Q : Discharge
- g : Gravitational acceleration
- A : Sectional area
- R : Hydraulic mean depth
- n : Manning's roughness coefficient
- ℓ : Distance between Section (1) and Section (2)

Suffixed numbers indicate sections.

Assuming that

$$F_1 = \frac{1}{2gA_1^2} + \frac{n_2^2}{2R_1^{4/3}\ A_1^2}$$

$$F_2 = \frac{1}{2gA_2^2} - \frac{n_2^2}{2R_2^{4/3}\ A_2^2}$$

the equation shown above can be rearranged as follows.

$$H_2 - H_1 = -Q^2 (F_2 - F_1)$$

Since F_1 and F_2 are the functions of H, they can be calculated at each section for preparation of a curve. If the given water level is taken on the curve F_1 of section (1), and a straight line is drawn from that point with a gradient corresponding to $-Q^2$, the value at the intersection on the curve F_2 of section (2) represents the water level of the backwater curve of section (2).

14. A value of +1.37 m at high water spring is taken as the water level of the outer sea. The discharge considered is Q = 3,000 m^3/sec (medium) and Q = 5,000 m^3/sec (maximum). The distance between two sections is taken at 500 m, and the existing lake inlet is indicated by location No. (0) and the entrance of Lake Songkhla by Location No. (8). The head of the breakwater to be extended under the Inner Harbour Plan is indicated by Location No. (-3).

As is clear from the calculations shown in Figs. A-16 and A-17, the backwater levels for Q = 3,000 m^3 sec and Q = 5,000 m^3/sec are shown in Figs. A-18 and A-19 respectively. As indicated in these figures, the port construction under the Inner Harbour Plan will cause the water level to rise 16 cm and 37 cm respectively above the present level at Location No. (8) when Q = 3,000 m^3/sec and Q = 5,000 m^3/sec.

15. The maximum flow velocity at time of flooding is compared between the present and planned channels. By taking the average velocity at mean water level, these are shown as follows.

Q = 3,000 m^3/sec	Present velocity	U = 130 cm/sec
	Inner Harbour Plan	U = 160 cm/sec
Q = 5,000 m^3/sec	Present velocity	U = 210 cm/sec
	Inner Harbour Plan	U = 260 cm/sec

Thus, the flow velocity will rise 30 cm/sec -50 cm/sec as compared with the present value when the port construction is executed under the Inner Harbour Plan.

B. Benefit of Saving of Transportation Cost

1. Saving of transportation cost referred to here is made possible by the improvement of port facilities which results in the change of routes of cargo traffic or in dispensing with the work required prior to the improvement. The transportation cost in this case is not the financial cost which is calculated from the prevailling rates for delineation of the port's hinterland, but it is the economic cost excluding entrepreneurial profit and taxes.

2. The economic cost is obtained by multiplying the financial cost by the conversion rate, k = 0.86, which is applied to truckage in "Thailand Transportation Coordination Study (Wilber Smith/Lyon, 1970)." This rate is applied to transport means other than trucks as well as to the terminal transhipment cost.

The following is the process of calculations worked out in this report.

In the first place, the truckage was classified into running cost and standing cost, and the average transportation cost per truck per unit transported distance was obtained from the various annual expenses required for

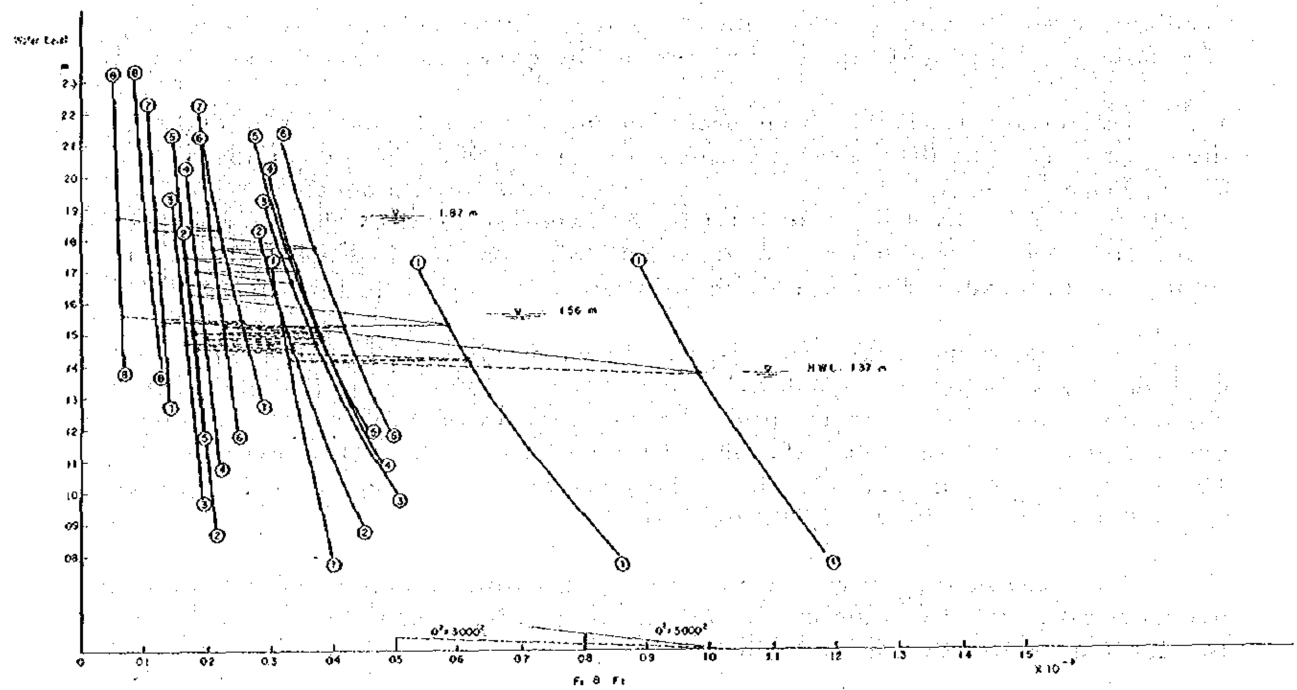


Fig.A-16. Calculation diagram for present channel

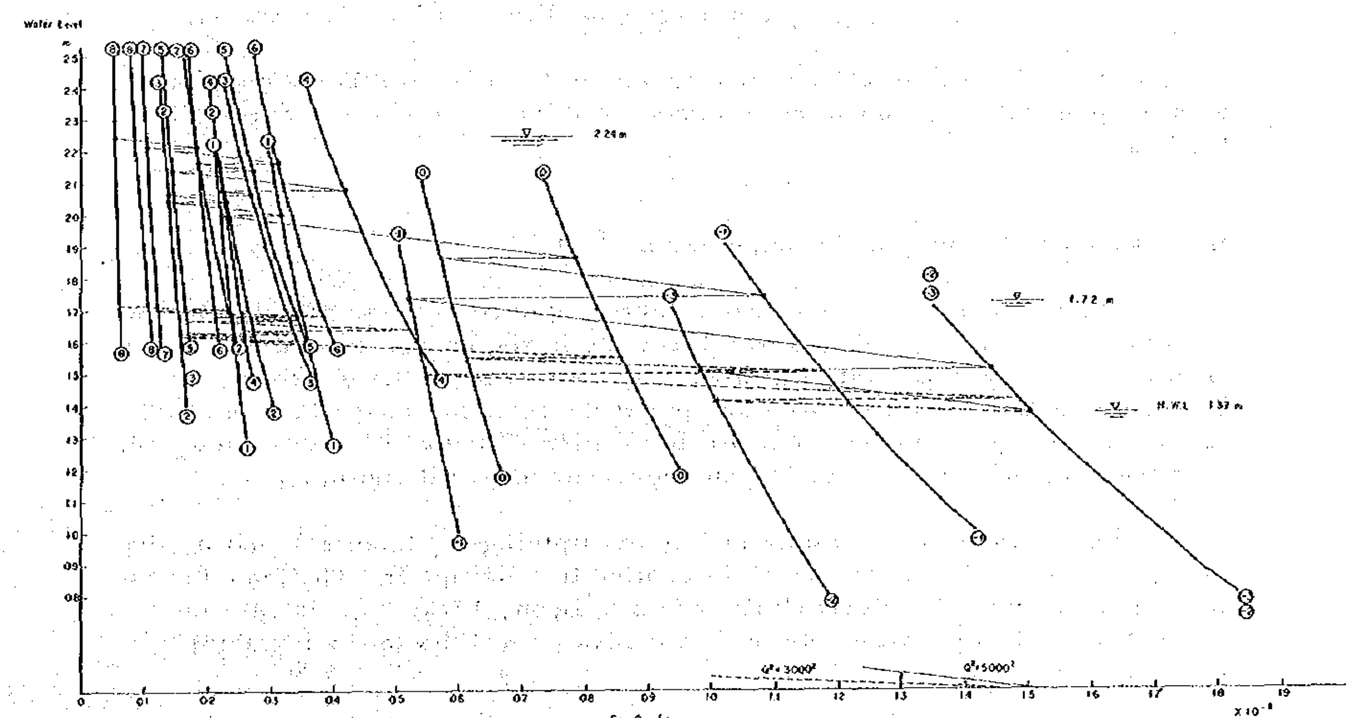


Fig. A-17. Calculation diagram for planned channel

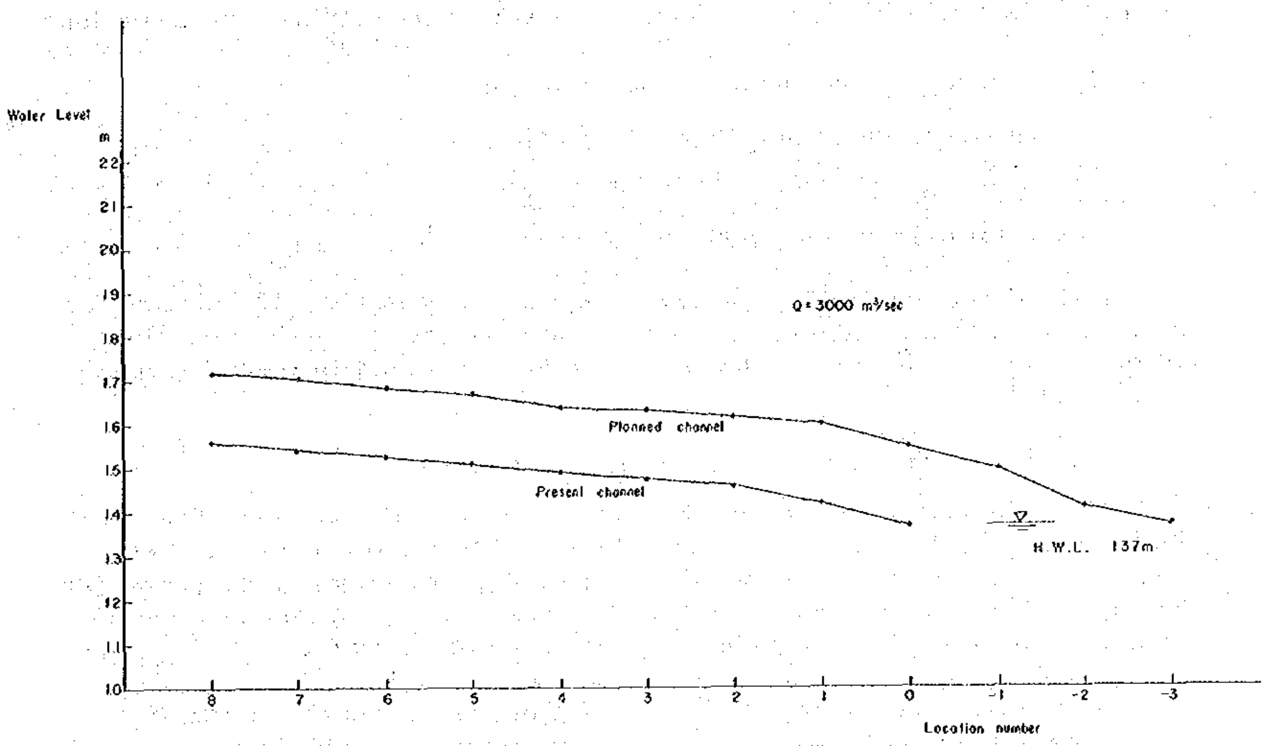


Fig. A-18. Backwater curve

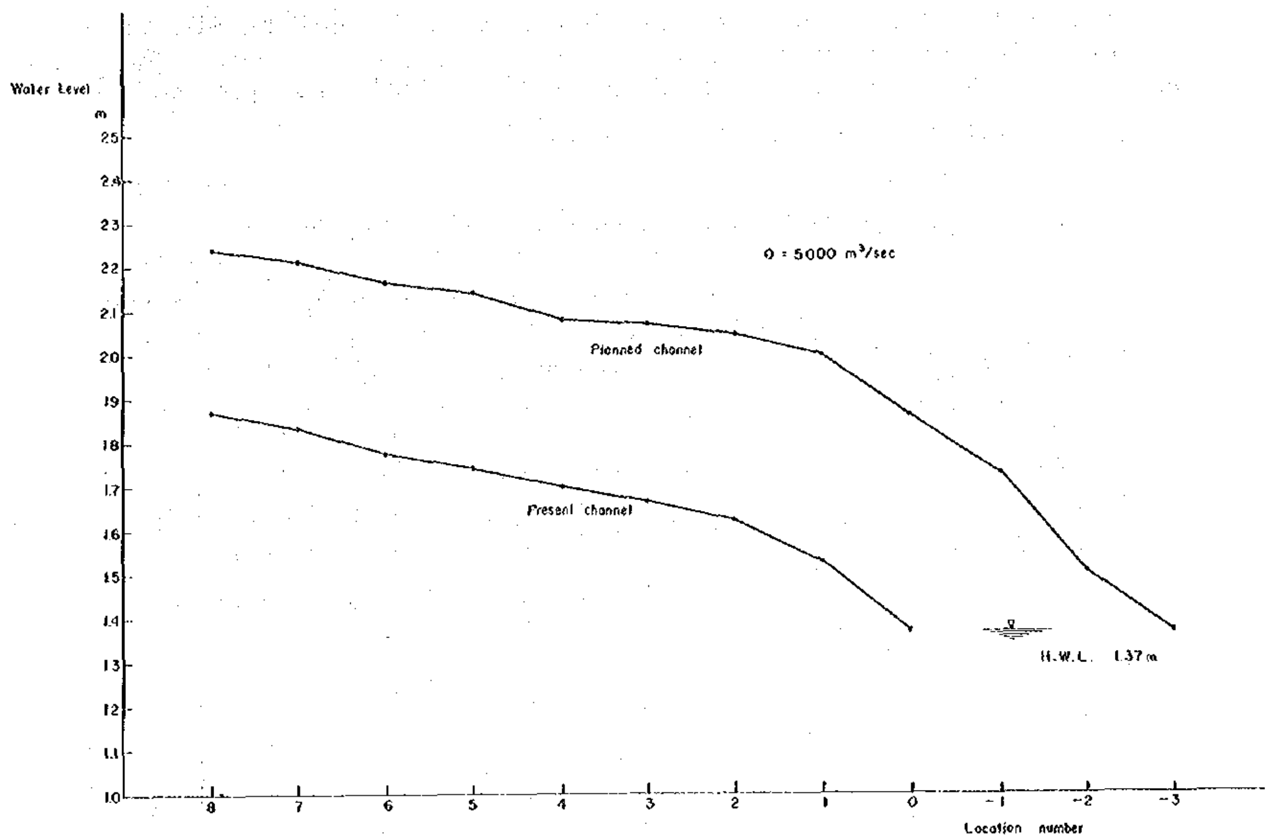


Fig. A-19. Backwater curve

truck transportation. The calculation was based on the following preconditions.

(1) Average truck running speed = 60 km/h

(2) Annual running distance = 80,000 km

(3) Average trip length = 260 km

(4) Ratio of unloaded running distance = 0.38

The calculation disclosed that the financial cost is 152,340 Baht and the economic cost 132,507 Baht per truck per km. Hence, the E/F ratio turns out to be 0.86. Taxes and profit are the major cause of difference between the two costs.

3. Saving of Transportation Cost of Export Cargoes

a) In the hinterland of Songkhla port (changwats of Nakhon Si Thamarat, Phattalung, Songkhla, Satun, Pattani, Yala, and Narathiwat), the planned cargo handling service on the wharf is expected to cut down the transportation cost by 35 Baht/ton as shown in Table 10 of the report, and this cost can be further reduced to 30 Baht/ton by the application of the said E/F ratio of 0.86.

b) Half the above cost, i.e., 15 Baht/ton, is estimated for cargoes generating in Changwat Surathani which is expected to be additionally covered by Songkhla port after its improvement, on the assumption that cargoes will be uniformly distributed in this changwat.

Hence, the calculation of the savable transportation cost for all export cargoes can be worked out by taking weighted average, on the basis of the expected changwat-wise cargo generating volume in 1980 shown in Table B-1.

$30 \times 0.897 + 15 \times 0.103 = 28.5$ Baht/ton

Table B-1 Changwat-wise Cargo Generating Volume in 1980
(Export - Latent Cargo Volume)

Unit: 1,000t

Area	Changwat	Item							Total	%
		Marine Products	Fruits	Beef	Tin	Mn	Gypsum	Natural Rubber		
A	Phattalung		0.9	0.3	-	-	-	26.6	27.8	
	Songkhla	6.0	2.9	1.1	1.4	-	-	76.9	88.3	
	Yala		1.5	0.6	0.8	-	-	45.2	48.1	89.7
	Pattani		1.1	0.4	-	-	-	25.2	26.7	
	Satun		0.4	0.2	-	-	-	9.8	10.4	
	Trang		2.0	0.2	1.8	-	-	49.4	53.4	
	Nakhon Si Thamarat		3.8	0.4	1.6	-	-	69.4	75.2	
	Narathiwat		1.5	0.5	1.5	9.4	-	54.1	67.7	
	Sub Total								396.7	
B	Surathani		2.6	-	-	-	15.4	27.5	45.5	10.3
Total									523.9	100

The cost obtained by the above calculation is assumed to be free from any change during the period of benefit observation.

4. Import Cargoes

Prior to the improvement of Songkhla port, all the cargoes landed at Songkhla are imported from Bangkok port (Overland transportation from Penang port and direct import via Songkhla by lighter service can be disregarded because of the small cargo volume). Hence, the savable transportation cost of import cargoes is the difference between the cost of the present transhipment and railway transportation from Bangkok and the cost of the future on-the-wharf handling at Songkhla port of import cargoes and their railway or truck transportation.

Table B-2 shows the abovementioned patterns of transportation.

Table 2 - Transportation Patterns

(i) Patterns before Improvement of Songkhla Port

a) Transhipment from Bangkok port to Songkhla port

[Carrier] —Unloading (N_{2H} for carrier)→ [Bangkok port] ($N_{PF} + N_P$) —Loading ($N_{3(T-S)}$)→ (coastal vessel) —→ [Songkhla port] (N_P) —Transhipment ($N_{3(S-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the destination]

b) Railway transportation from Bangkok port

See Pattern V shown in Table 9 of the report.

c) Transhipment from Bangkok to the closest port to the destination

[Carrier] —Unloading (N_{2H} for carrier)→ [Bangkok port] ($N_{PF} + N_P$) —Loading ($N_{3(T - S)}$)→ (Coastal vessel) —→ [Closest port to the destination] (N_{PF}) —Transhipment ($N_{3(S - T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the destination]

(ii) Patterns after Improvement of Songkhla Port

a) Cargo handling on the wharf of Songkhla port, and truck transportation

See Pattern ii) shown in Table 9 of the report.

b) Cargo handling on the wharf of Songkhla port, and railway transportation

See Pattern iv) shown in Table 9 of the report.

5. A calculation simillar to that shown in Section 31 of the report is worked out for each major city embraced in Songkhla's foreign trade hinterland for each of the above transportation patterns. Table B-3 below is obtained from this calculation.

Table B-3 Saving of Transportation Cost of Import Cargoes to Major Cities in Songkhla's Hinterland

Unit: Baht/ton

Major Cities in Songkhla's Hinterland	Changwats in Songkhla's Hinterland	(1) Patterns before Songkhla's Improvement			(2) Patterns after Songkhla's Improvement		
		a) Secondary Transportation from Bangkok to Songkhla	b) Railway Transportation from Bangkok to Songkhla	c) Secondary Transportation to Closest Port to Destination	a) Truck Transportation from Songkhla	b) Railway Transportation from Songkhla	Difference of Transportation Cost between Patterns (1) and (2)
Hadyai	Songkhla	195	224	195	94	-	101
Phattalung	Phattalung	228	233	228	127	135	101
Trang	Trang	244	231	244	143	162	88
Kantang	Kantang	252	233	252	151	165	101
Nakhon Si Thamarat	Nakhon Si Thamarat	280	229	280	179	154	75
Surathani	Surathani	395	205	195	294	169	64
Yala	Yala	227	254	197	127	139	70
Pattani	Pattani	-	-	195	105		90
Narathiwat	Narathiwat	254	260	197	155	146	51

The cost of transportation to changwants of Phattalung, Songkhla and Satun which are within the port's domestic trade hinterland can also be cut down by 101 Baht/ton. By applying the aforementioned E/F ratio, the savable cost (economic cost) is set at 87 Baht (= 101 x 0.86).

The cost of transportation to changwats of Nakhon Si Thamarat, Trang, Pattani, Yala and Narathiwat which are considered to be embraced in the port's foreign trade hinterland will be reduced by a maximum of 87 Baht and a minimum of 30 Baht, so that the average savable cost is 59 Baht/ton.

With respect to Changwat Surathani which will be additionally included in Songkhla's hinterland after the port is improved into a deep sea port, the average savable transportation cost will be 15 Baht/ton since the maximum and minimum savings are estimated to be 30 Baht/ton and zero respectively.

On the basis of the changwat-wise cargo traffic generating volume shown in Table B-4, the saving of transportation cost for all import cargoes can be calculated by taking weighted average as follows.

$$87 \times 0.524 + 59 \times 0.412 + 15 \times 0.064 = 70.9 \text{ Baht/ton}$$

It is assumed that the saving of cost obtained from the above calculation will not change during the period of benefit observation.

Table B-4 Changwat-wise Cargo Generating Volume in 1980 (Import - Latent Cargo Volume)

Unit: 1,000t

Area	Changwat	Steel Materials	Fertilizers	Total	Percentage
	Phattalung	2.9	4.4	7.3	
a	Songkhla	35.7	4.3	40.0	
	Satun	2.5	1.0	3.5	
	Sub Total	41.1	9.7	50.8	52.4
	Nakhon Si Thamarat	7.4	5.8	12.7	
	Narathiwat	4.1	1.0	5.1	
b	Trang	4.8	1.0	5.8	
	Yala	11.3	0.3	11.6	
	Pattani	3.9	0.9	4.8	
	Sub Total	31.5	8.5	40.0	41.2
c	Surathani	4.7	1.5	6.2	6.4
	Total	77.3	19.7	97.0	100

6. Taking the per ton saving of transportation cost calculated above, the annual benefit derivable from Songkhla port's improvement in terms of transportation cost can be obtained as shown in Table B-5.

Table B-5 Benefit by Saving of Transportation Cost

Cargo volume in 1,000t
Benefit in 1,000 Baht

	Export		Import		Total Benefit
	Cargo Volume	Benefit (A) x 28.5	Cargo Volume (B)	Benefit (B) x 7.09	
1974	0	0	0	0	0
1975	157	4,475	13	922	5,397
1976	183*	5,216	17*	1,205	6,421
1977	208	5,928	22	1,560	7,488
1978	236	6,726	27	1,914	8,640
1979	264	7,524	35	2,482	10,006
1980	299	8,522	44	3,120	11,642
1981	334	9,519	57	4,041	13,560
1982	336*	9,576	64*	4,538	14,114
1983	418	11,913	92	6,523	18,436
1984	446	12,711	117	8,295	21,006
1985	456	12,996	148	10,493	23,489
1986	478	13,623	160	11,344	24,967
1987	501	14,279	173	12,266	26,545
1988	525	14,963	187	13,258	28,221
1989	549	15,647	202	14,322	29,969
1990	576	16,416	218	15,456	31,872
1991	580*	16,530	220*	15,598	32,128
1992	"	"	"	"	"
1993	"	"	"	"	"
1994	"	"	"	"	"
1995	"	"	"	"	"
1996	"	"	"	"	"
1997	"	"	"	"	"
1998	"	"	"	"	"

Notes: 1. Asterisked (*) figures indicate the cargo volume limited due to the berthing capacity.

2. The export/import ratio in and after 1991 is set at the value in 1990.

C. Port Revenues and Administration Cost

Table C-6 shown below is prepared from the calculation of the port revenues and administration cost worked out according to the method elucidated in Section 85 of the report.

Table C-6 Port Revenues and Administration Cost

Unit: 1,000 Baht

	Revenues			Administration Cost		
	Foreign Trade	Domestic Trade	Total	Foreign Trade	Domestic Trade	Total
1974	0	0	0	0	0	0
1975	19,550	350	19,900	12,750	170	12,920
1976	23,000*	450	23,450	15,000*	220	15,220
1977	26,450	510	26,960	17,250	280	17,530
1978	30,250	680	30,930	19,730	340	20,070
1979	34,390	810	35,200	22,430	410	22,840
1980	39,450	950	40,400	25,730	480	26,210
1981	44,970	1,060	46,030	29,330	530	29,860
1982	46,000*	1,170	47,170	30,000*	580	30,580
1983	58,650	1,280	59,530	38,250	640	38,890
1984	64,750	1,400	66,150	42,230	700	42,930
1985	69,460	1,530	70,990	45,300	770	46,070
1986	73,370	1,670	75,040	47,850	830	48,680
1987	77,510	1,810	79,320	50,550	910	51,460
1988	81,880	1,960	83,840	53,400	980	54,380
1989	86,370	2,120	88,490	56,330	1,060	57,390
1990	91,310	2,250*	93,560	59,550	1,130*	60,680
1991	92,000*	2,250*	94,250	60,000*	1,130*	61,130
1992	"	"	"	"	"	"
1993	"	"	"	"	"	"
1994	"	"	"	"	"	"
1995	"	"	"	"	"	"
1996	"	"	"	"	"	"
1997	"	"	"	"	"	"
1998	"	"	"	"	"	"

Note ; Asterisked (*) figures indicate the cargo volume limited due to the berthing capacity.

D. Meteorologic Study

Table D－1 Climatological Data

Period : 1951 ~ 1965

Item \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Temperature(℃)													
Mean	26.7	27.1	27.5	28.4	28.7	28.4	28.1	28.1	27.9	27.3	26.7	26.5	27.6
Mean Max	29.4	30.1	31.1	32.6	33.0	32.8	32.6	32.6	32.2	31.1	29.7	29.2	31.4
Mean Min	23.9	24.0	23.8	24.1	24.4	23.9	23.5	23.6	23.5	23.5	23.6	24.8	23.9
Ext Max	34.0	34.8	36.0	37.4	37.5	37.3	36.7	37.5	37.4	36.4	35.2	33.4	37.5
Ext Min	19.1	23.6	17.7	20.5	21.8	20.9	20.6	19.9	21.0	21.0	19.9	20.5	19.1
Relative Humidity(%)													
Mean	77.8	77.3	77.4	77.9	80.2	79.0	79.5	79.0	80.5	83.9	85.0	82.0	80.0
Mean Max	87.3	87.6	90.5	92.3	99.2	92.2	92.5	92.3	92.9	94.8	94.1	91.4	92.3
Mean Min	69.5	67.3	61.2	63.7	63.6	61.9	62.2	26.1	63.0	68.6	73.6	73.3	65.8
Rainfall													
Mean(mm)	121.1	41.7	37.5	59.6	127.5	88.5	122.7	117.7	125.6	291.9	494.5	414.9	2.043.2
Mean rainydays(day)	12.5	5.7	5.4	7.4	13.9	11.1	12.4	13.7	15.1	21.3	22.4	20.2	161.1
Evaporation(mm)	135.4	119.0	107.4	99.9	86.6	90.0	86.0	86.4	82.5	68.8	68.0	91.7	1.121.7

Source : Songkhla Metrological Station

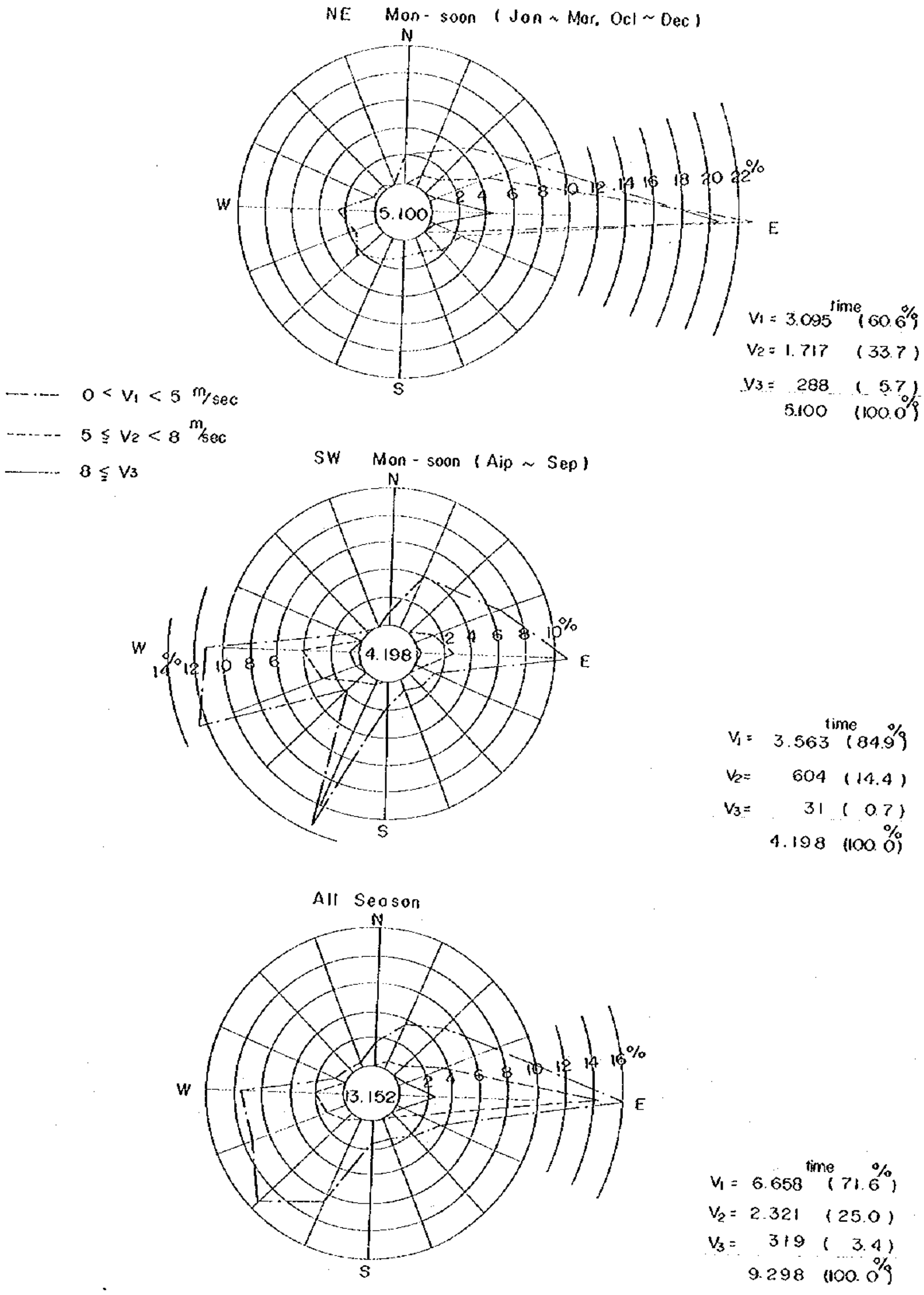


Fig D-1 Wind Rose by season ('68 ~ '70)

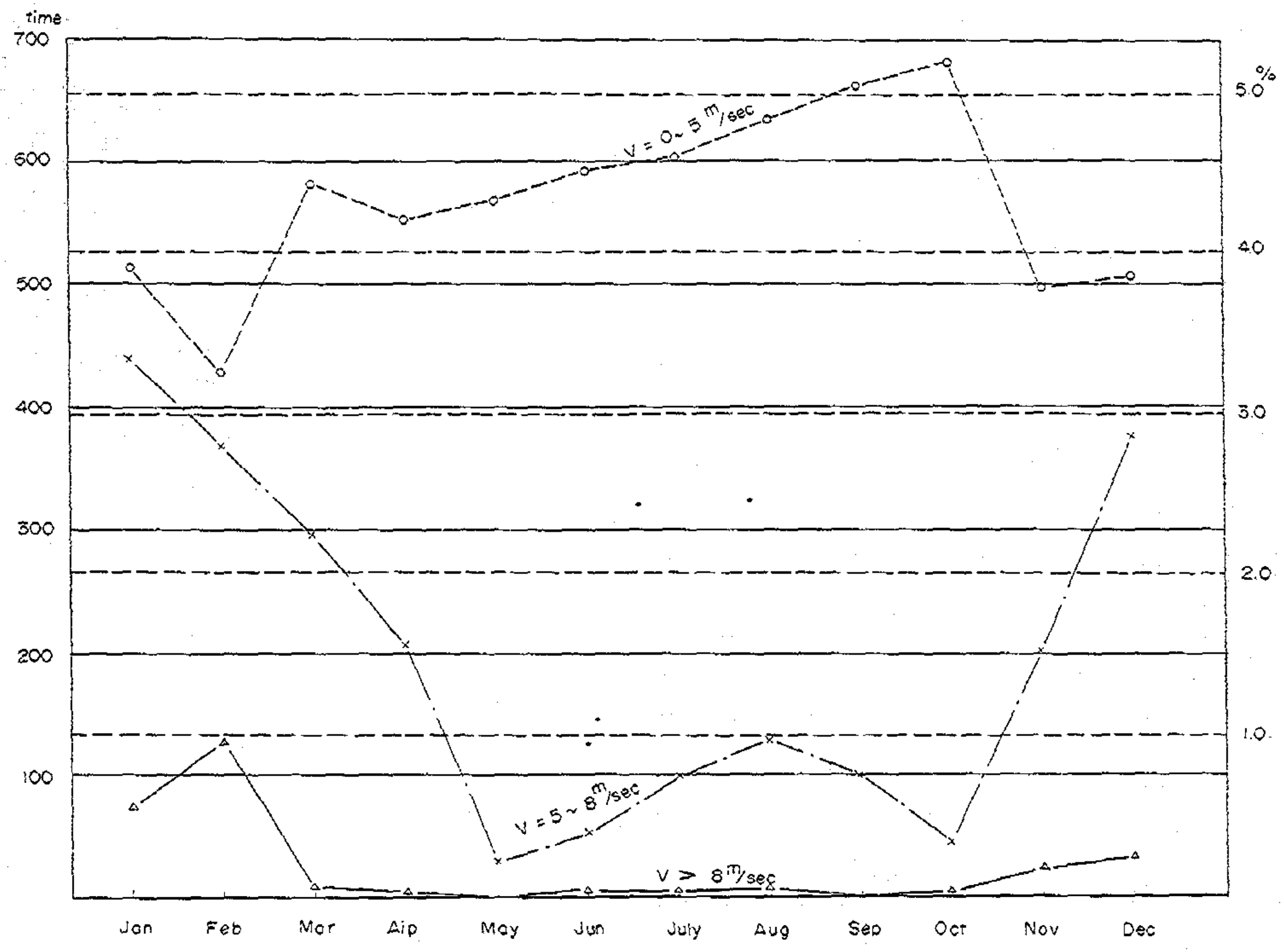


Fig D-2 Frequency of Wind by Month and Speed ('68 ~'70)

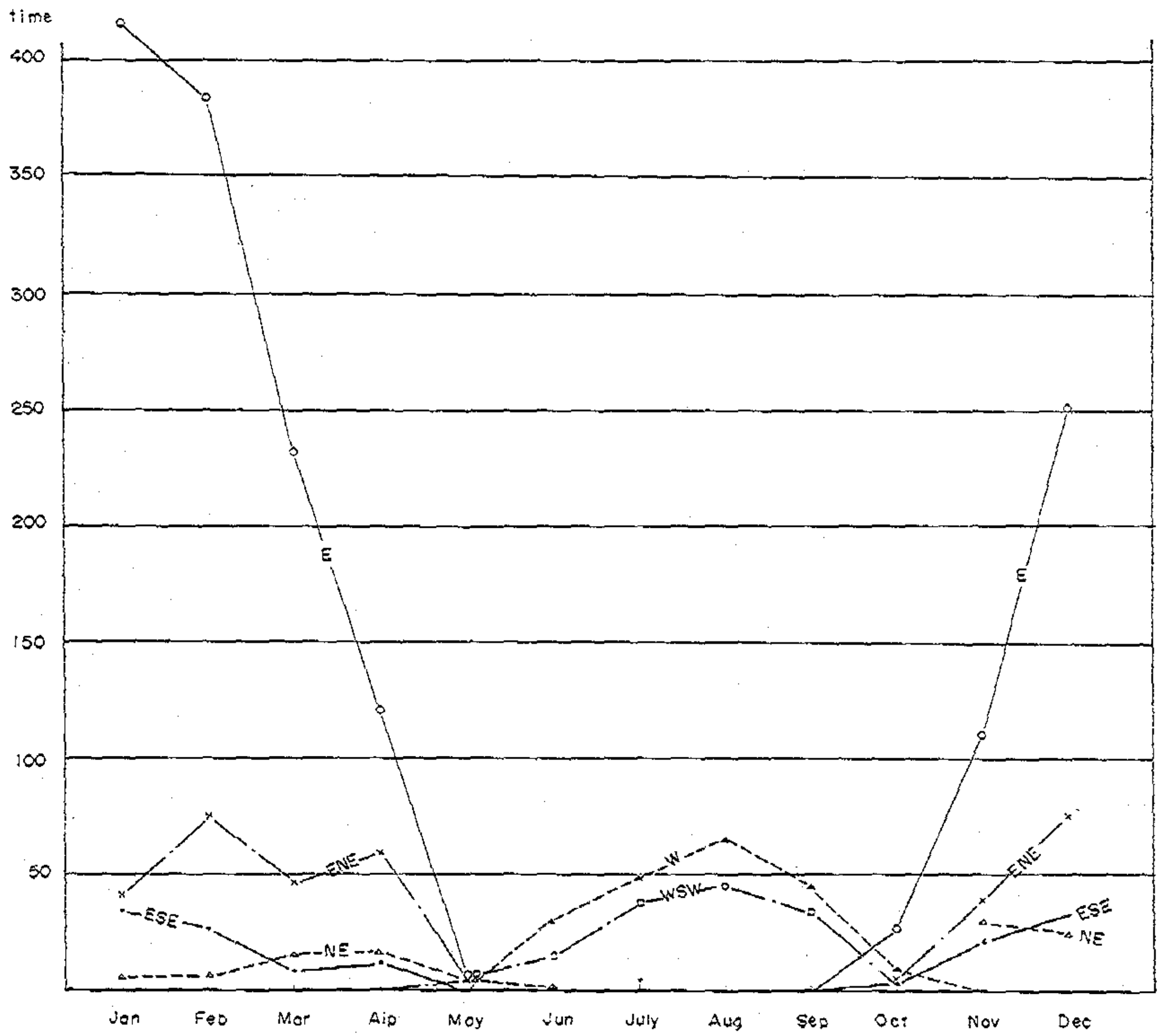


Fig D-3 Frequency of Wind Exceeding 5 m/sec by Direction ('68 ~ '70)

E. Soil Survey

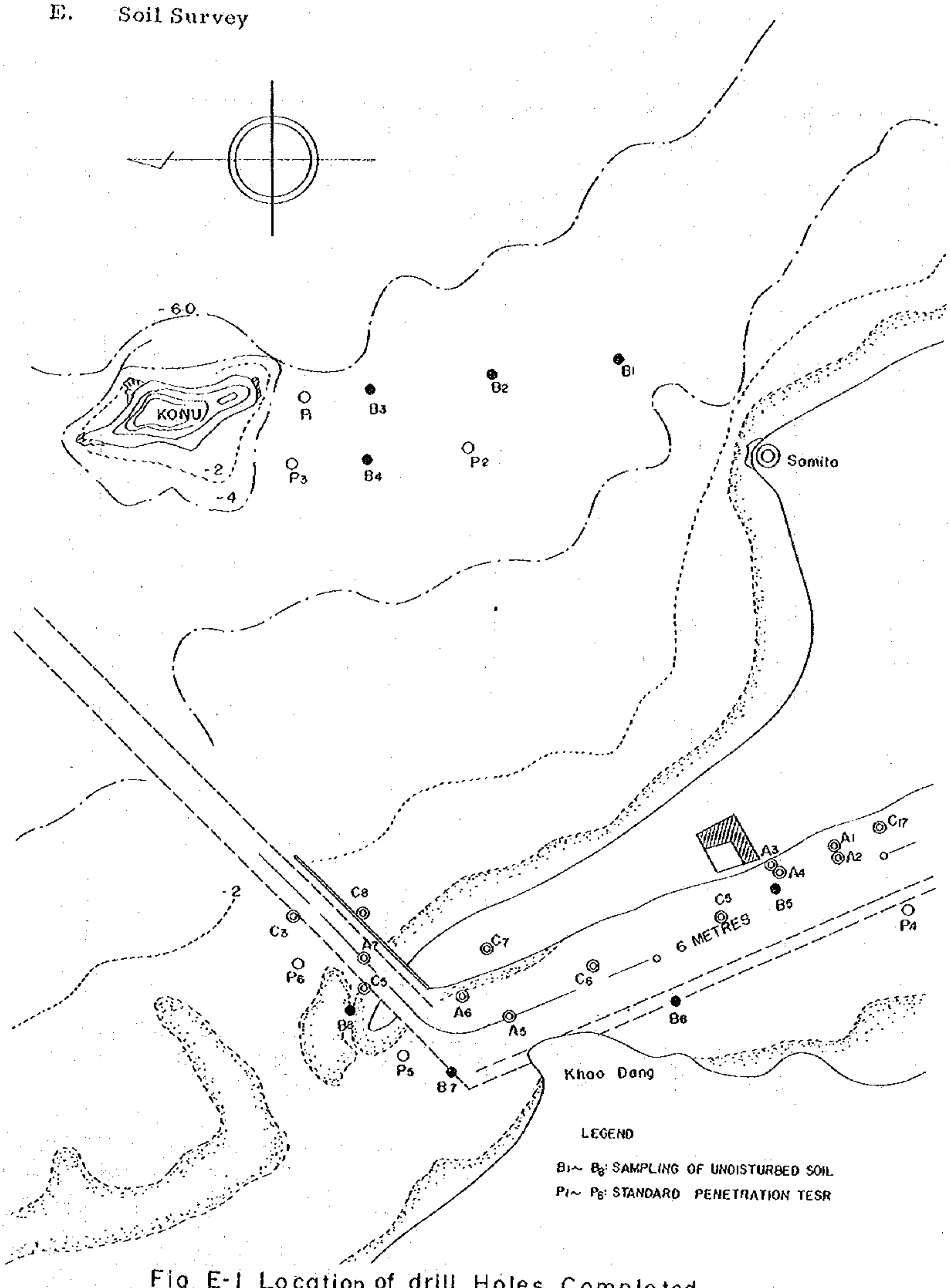


Fig E-1 Location of drill Holes Completed

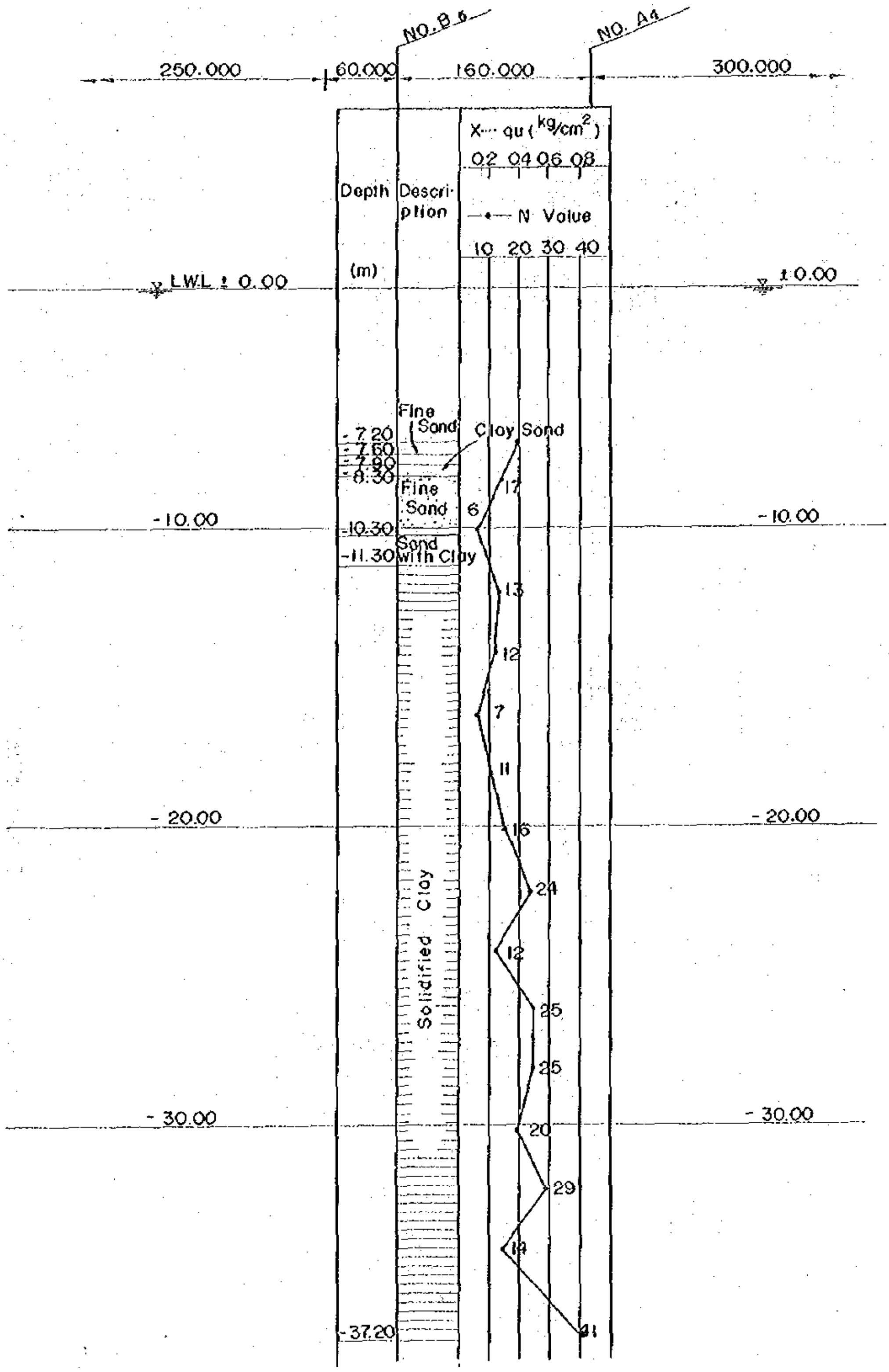


Fig E-2 Figure of Stratification

(Neighbourhood of Inner Harbour)

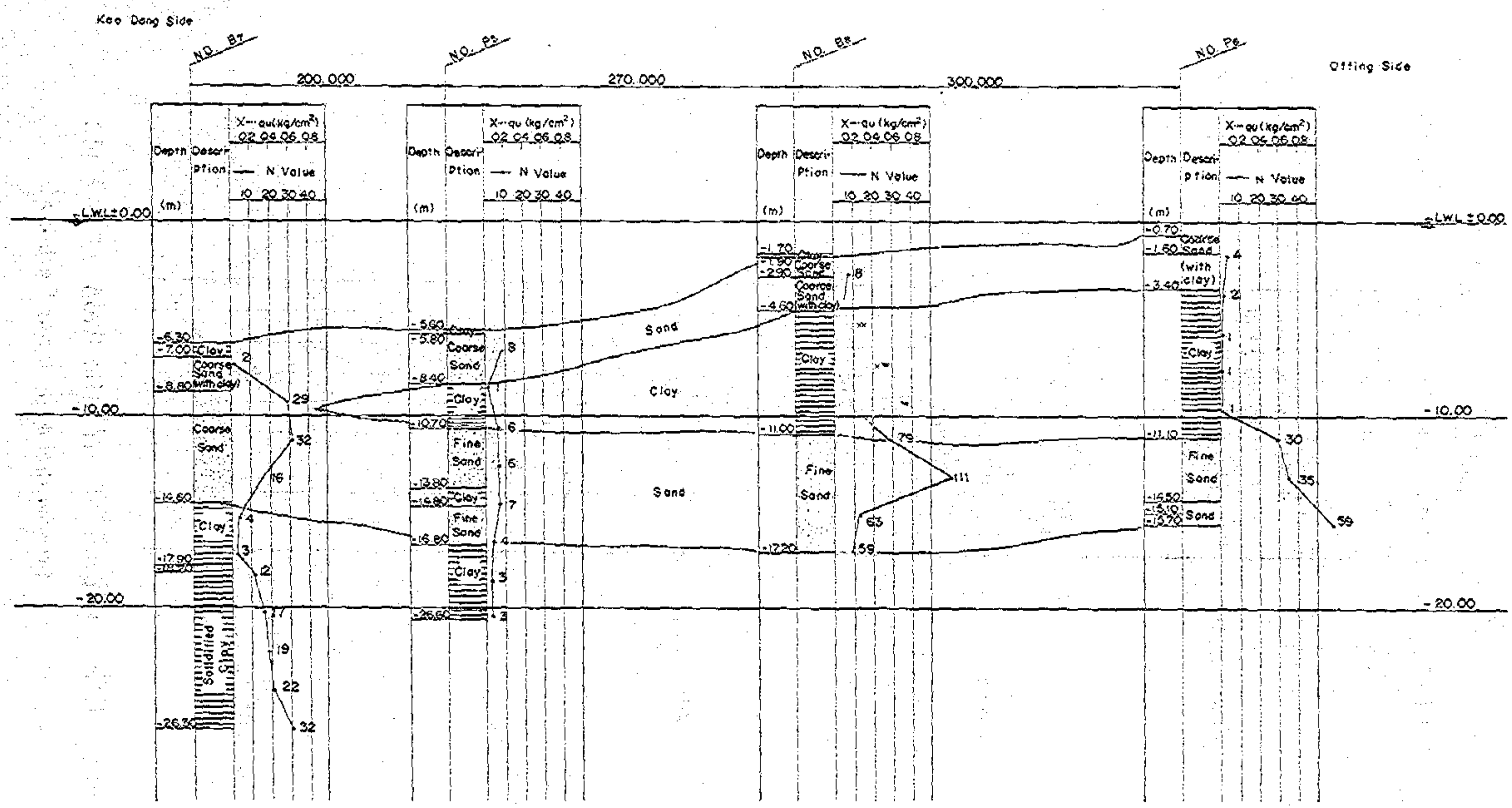


Fig E-3 Figure of Stratification

(Neighbourhood of Training Dyke)

S : V : 1/200
H : 1/3.000

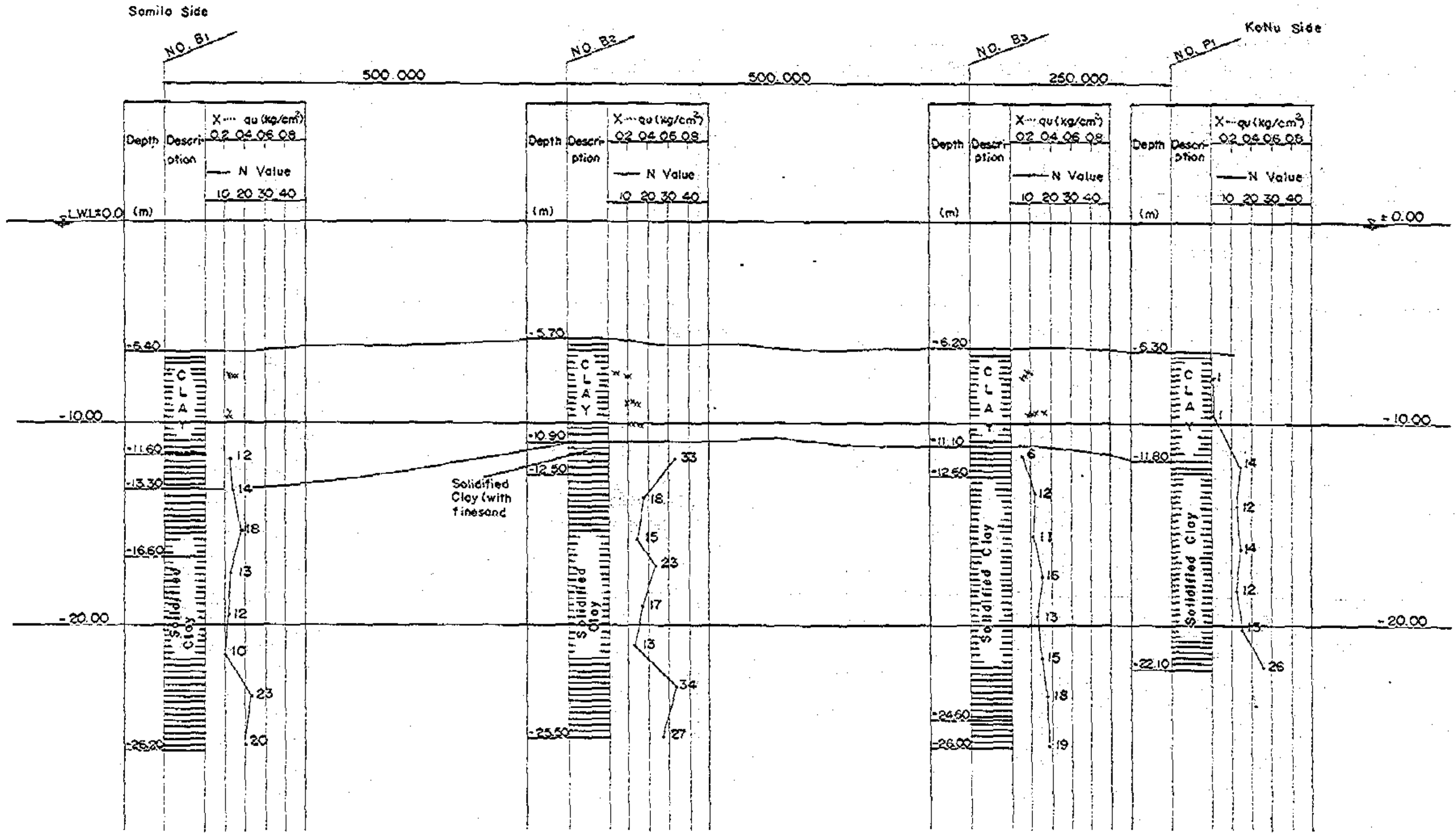


Fig E-4 Figure of Stratification S: V: 1/200 H: 1/5,000

(Neighbourhood of Outer port)

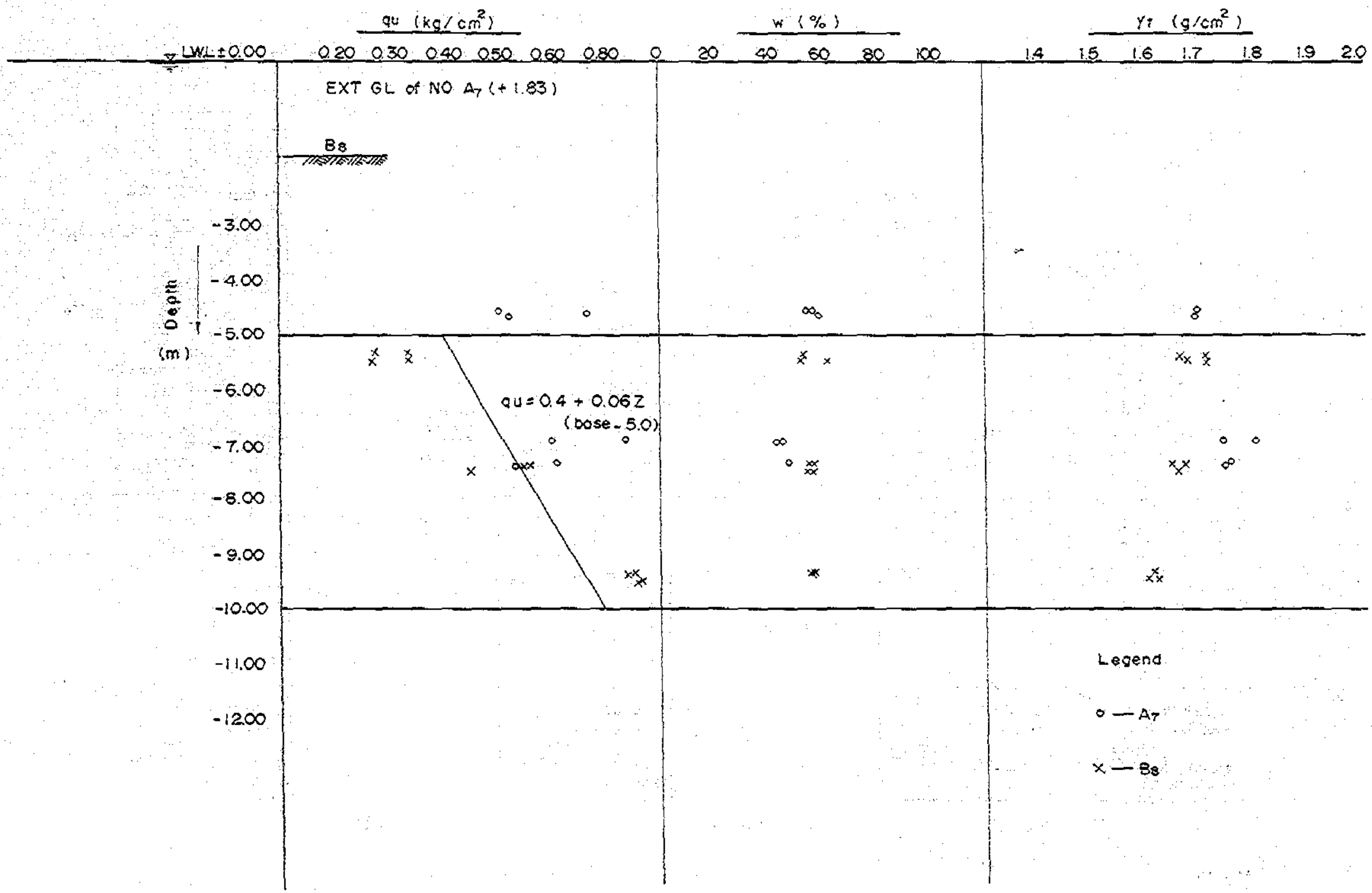


Fig E-5. Corelation of NO. A_7, A_8 of qu. w. γt (Neigh bourhood of Training Dyke)

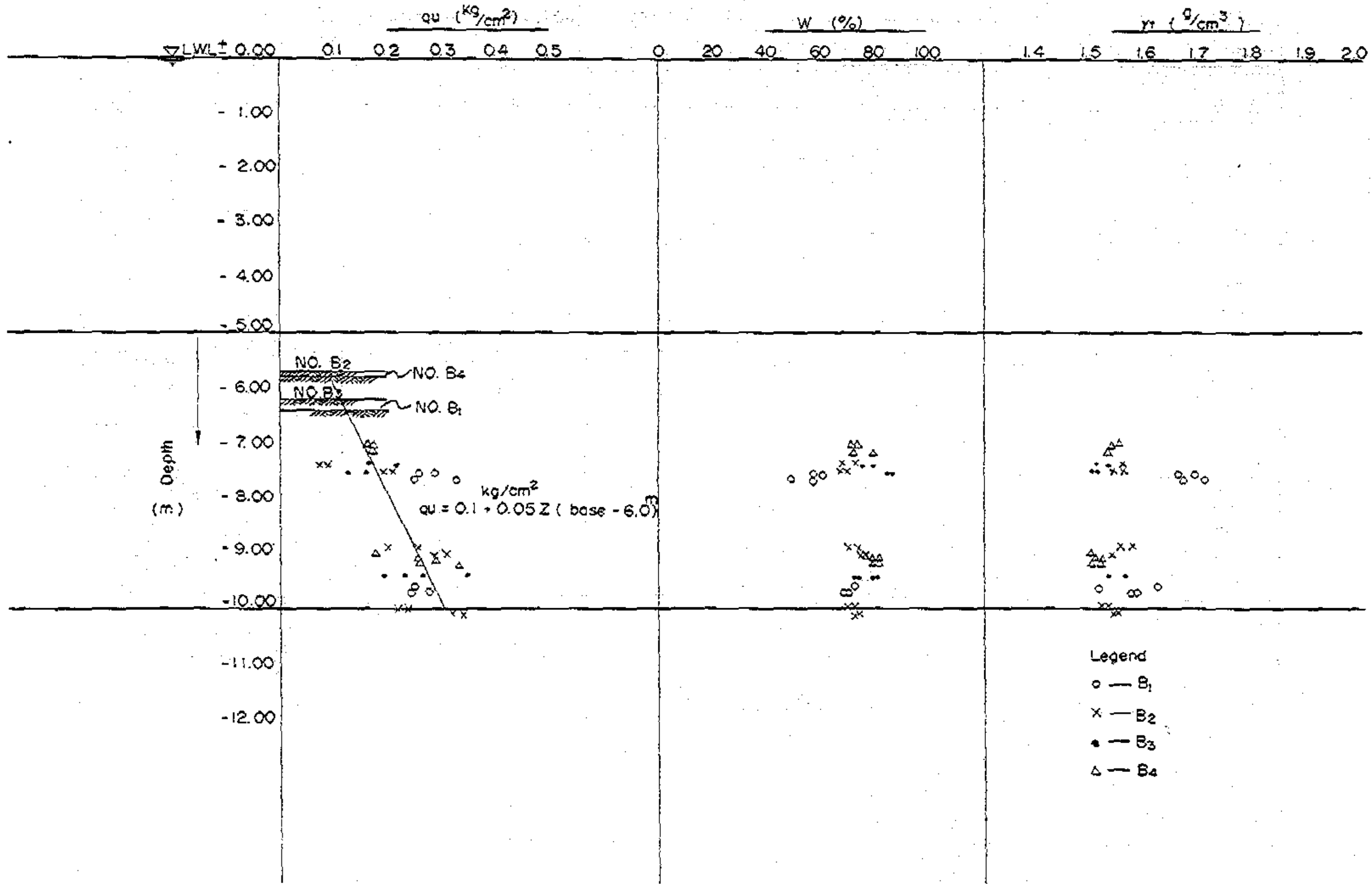


Fig E-6 Corelation of NO. B_1, B_2, B_3, B_4, qu, W, γ_t

(Neigh bour hood of Outer port)

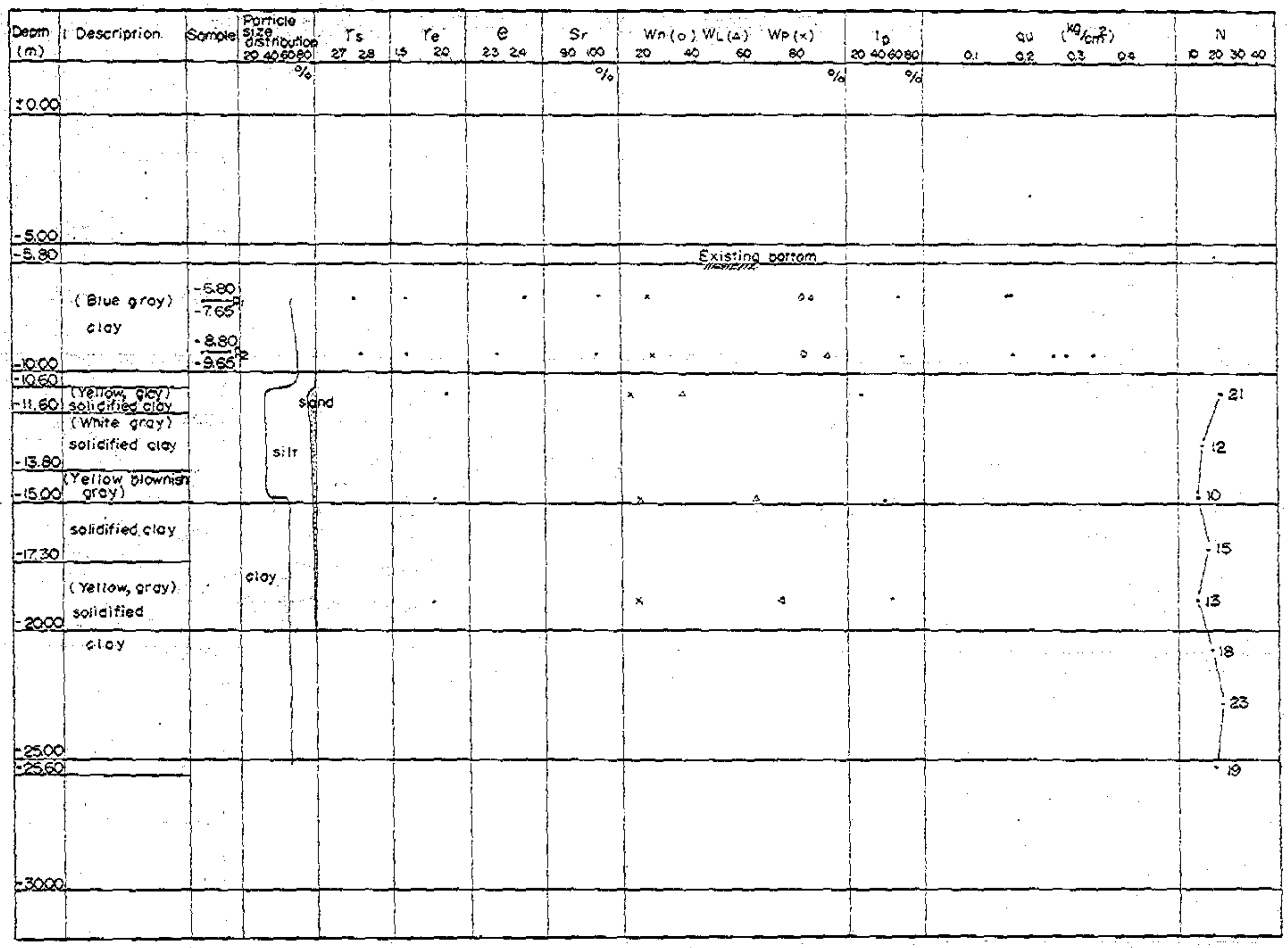


Fig E-7 Index Properties of Soils
(Bor. NO B4 Outerport)

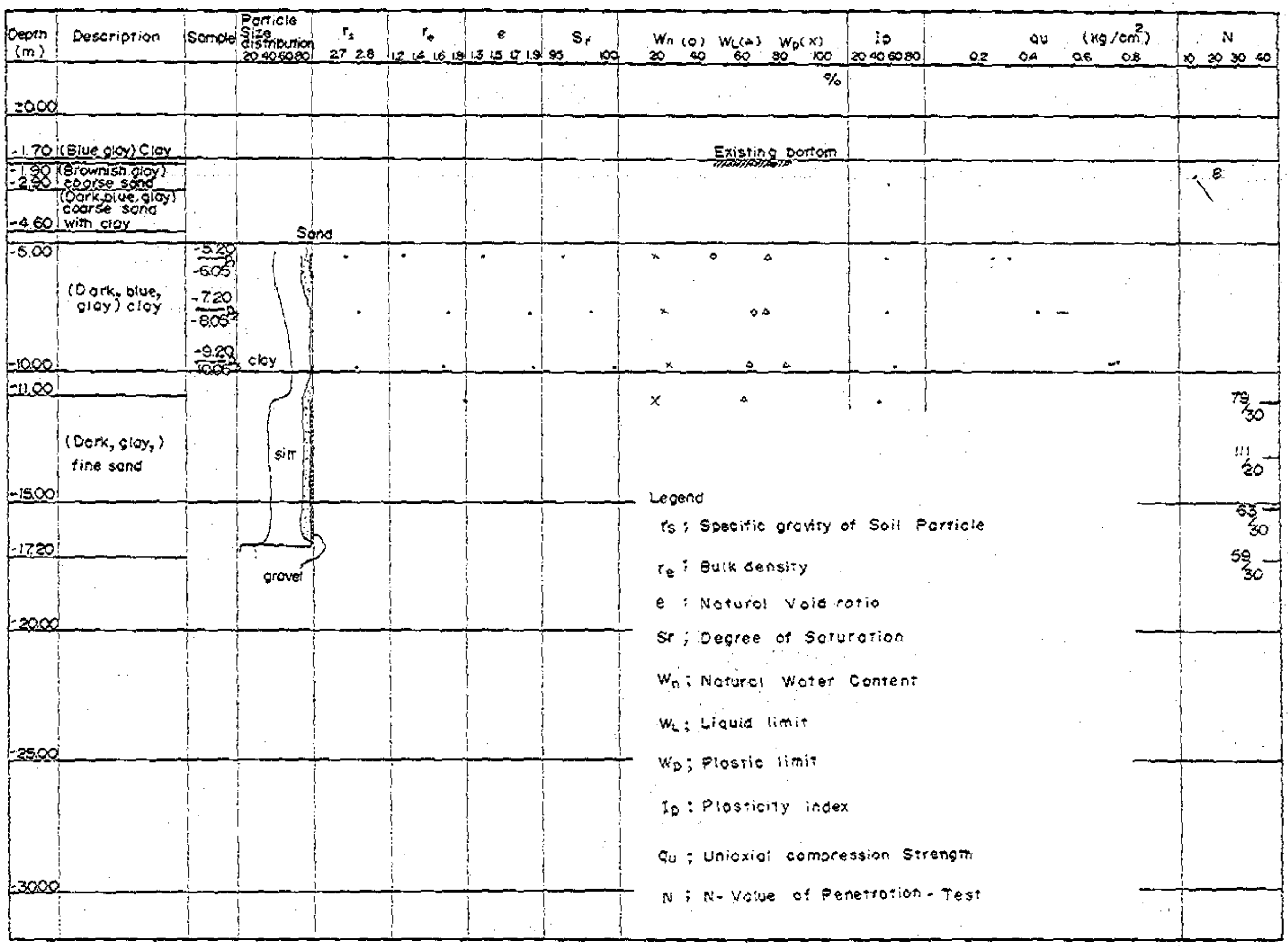


Fig E-8 Index properties of Soils Bor. NO B8 (Lake Outlet)

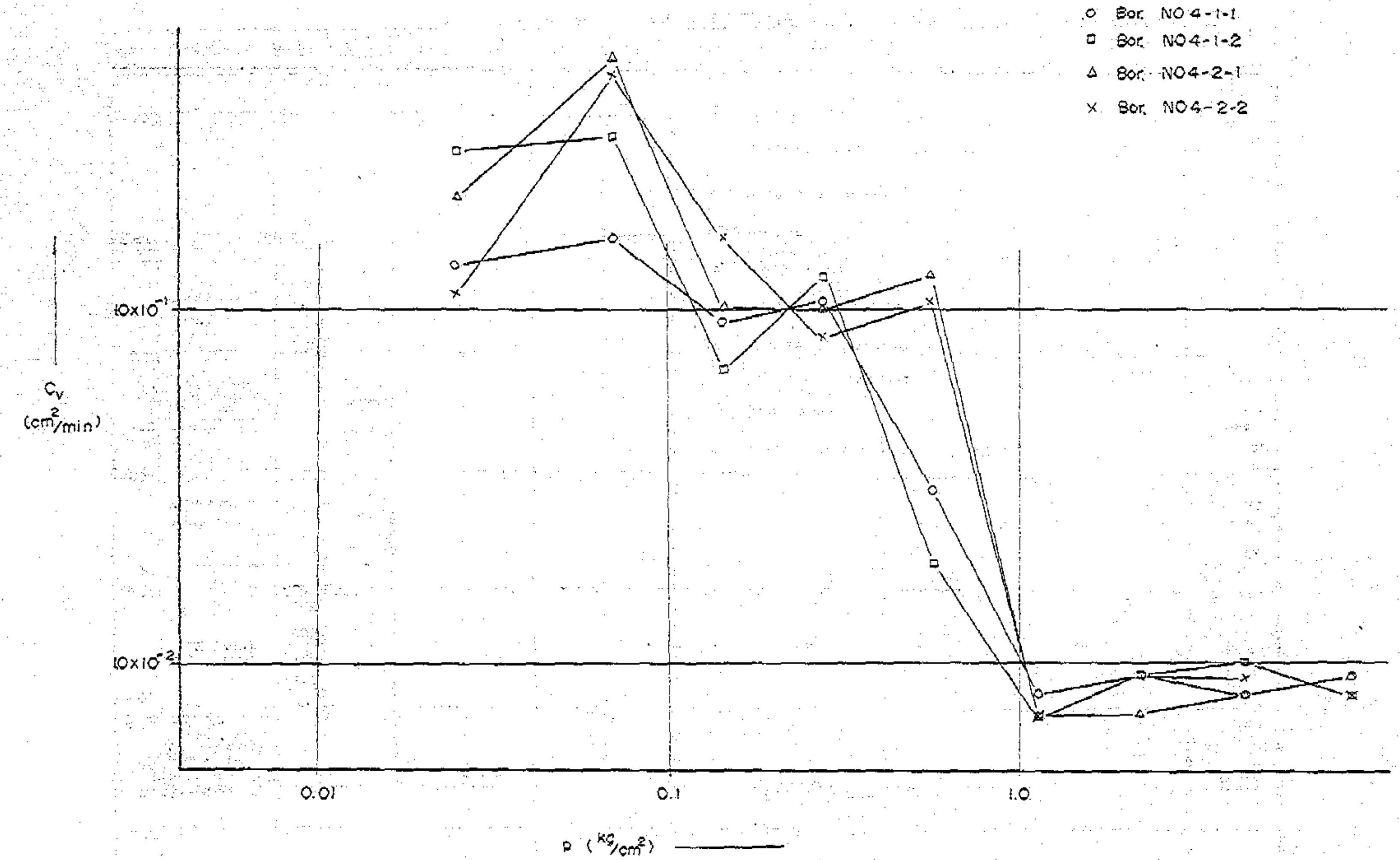


Fig E-9 Bor.NO. B4. Cv-P curve

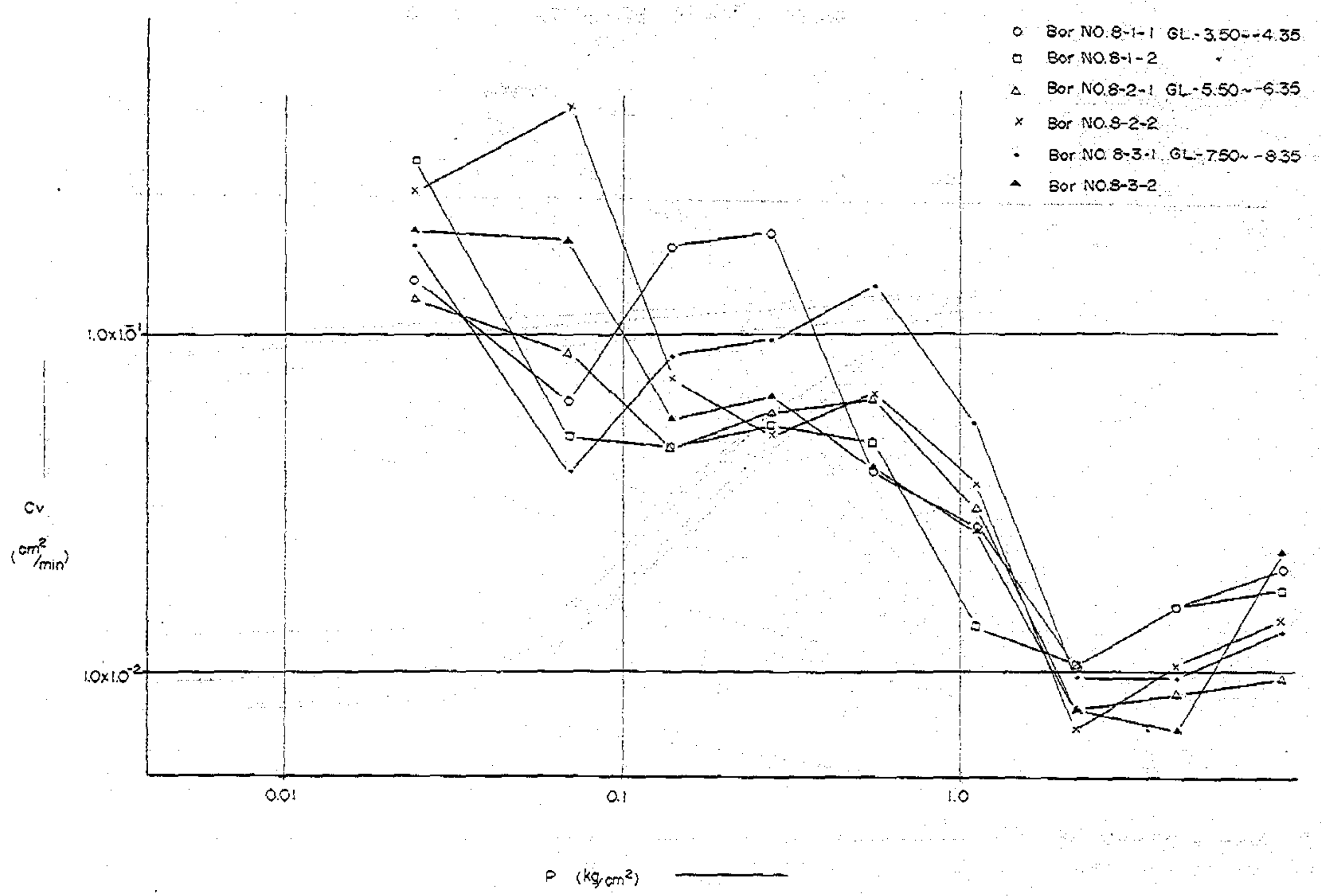


Fig E-10 Bor.NO.8 Cv-P curve

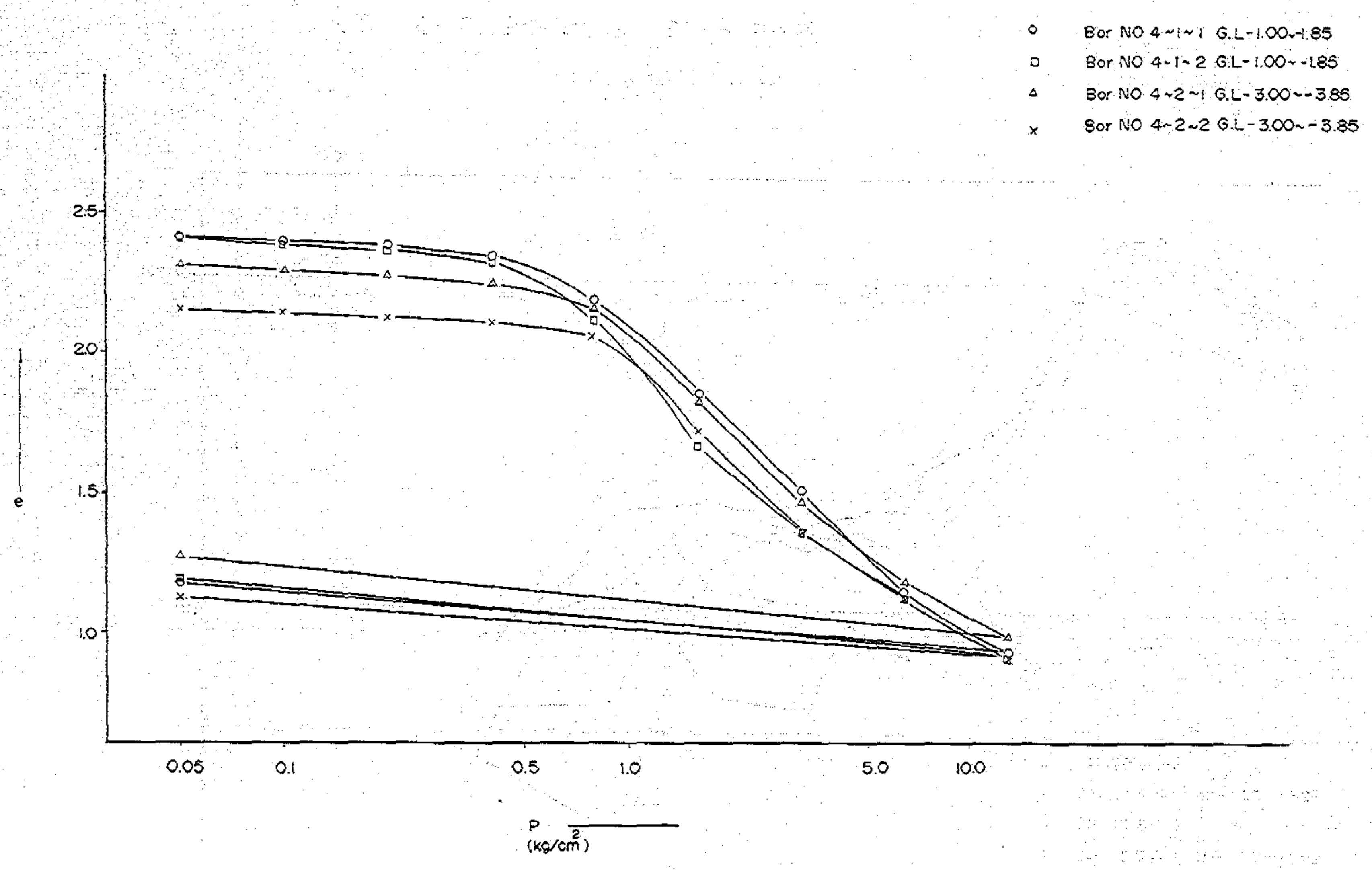


Fig E-11 Bor.NO B4. e-log P curve

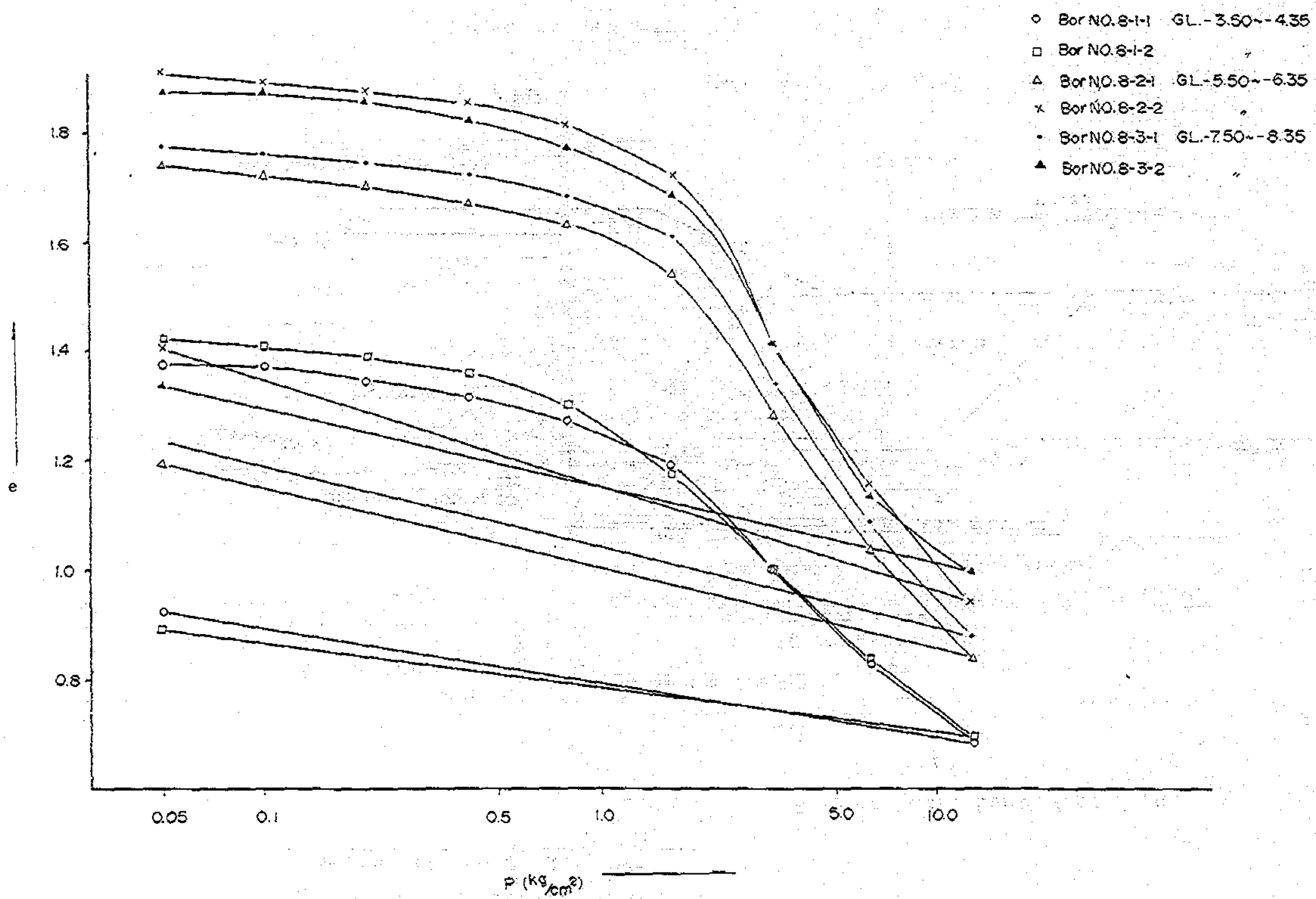


Fig E-12 Bor.NO B8 e-log P curve

F. Alternative Construction Plans for Major Structures

Section of −8.0^M Quay Wall

Unit ; m B Plan (Lake Outlet Area Plan)

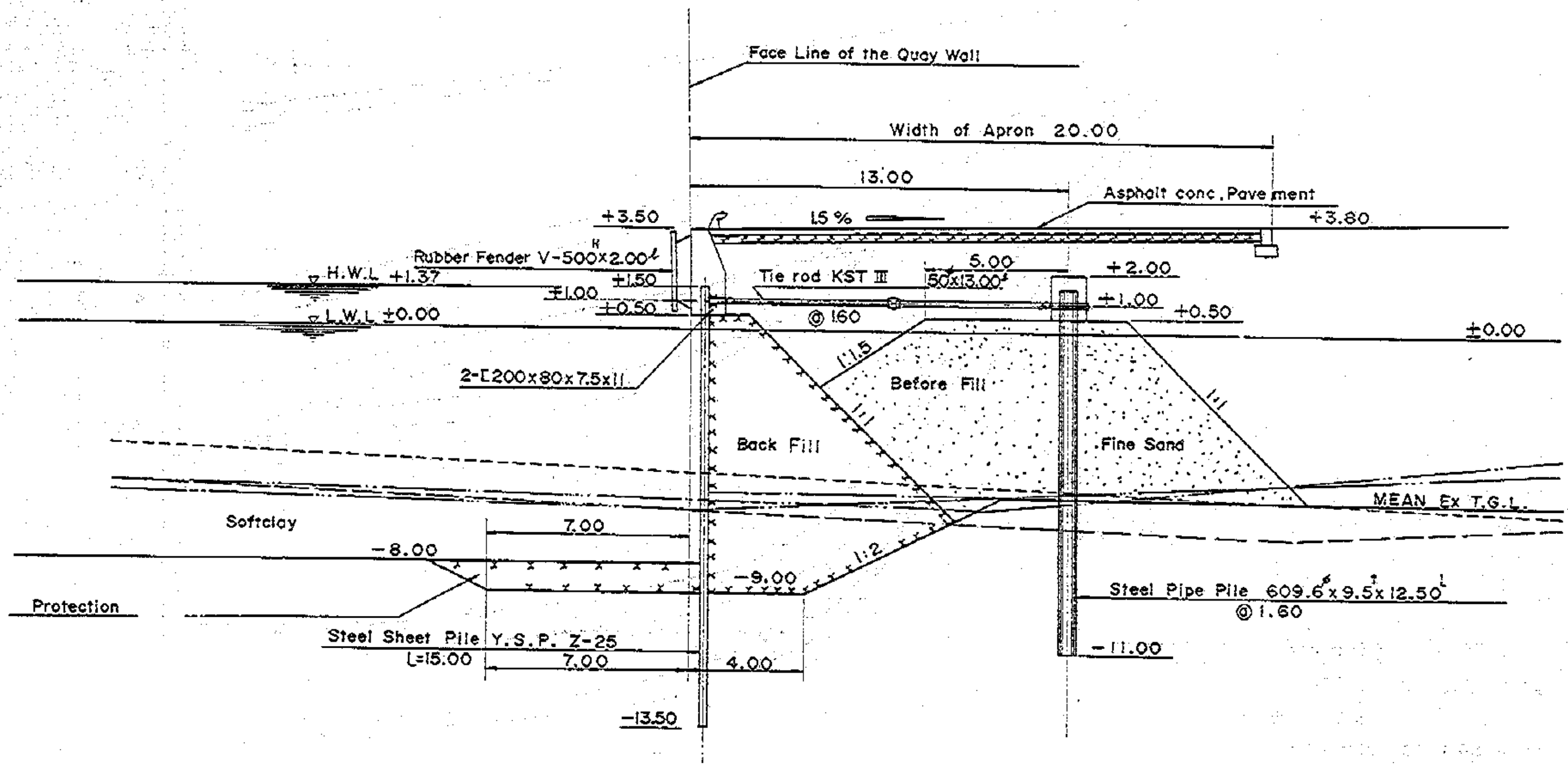


Fig F−1 Comparative Design

Section of Sea wall

Unit ; m   B Plan (Lake Outlet Area Plan)

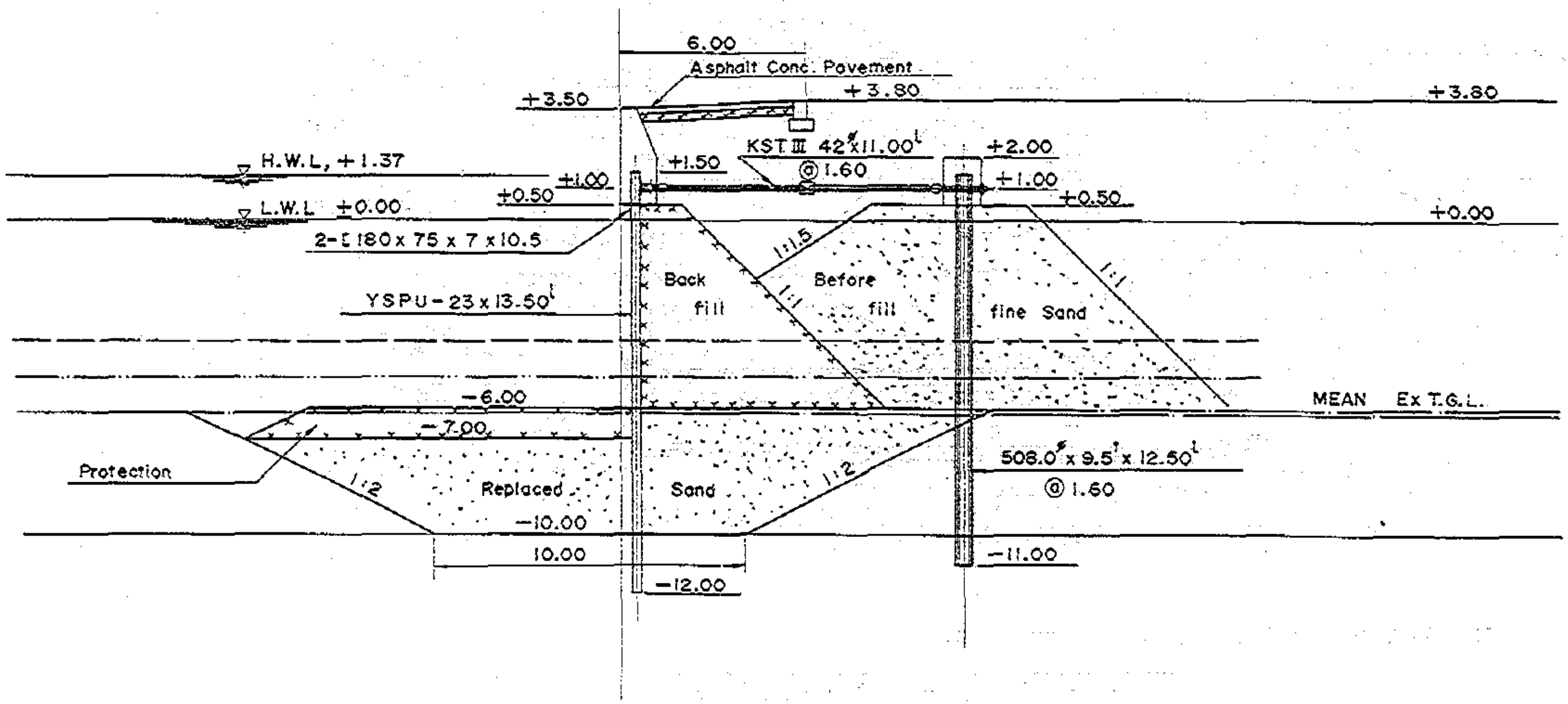


Fig F-2 Comparative Design

Cross Sect. of −8.0^M Quay Wall

Unit ; m   C Plan(Outer Sea Area Plan)

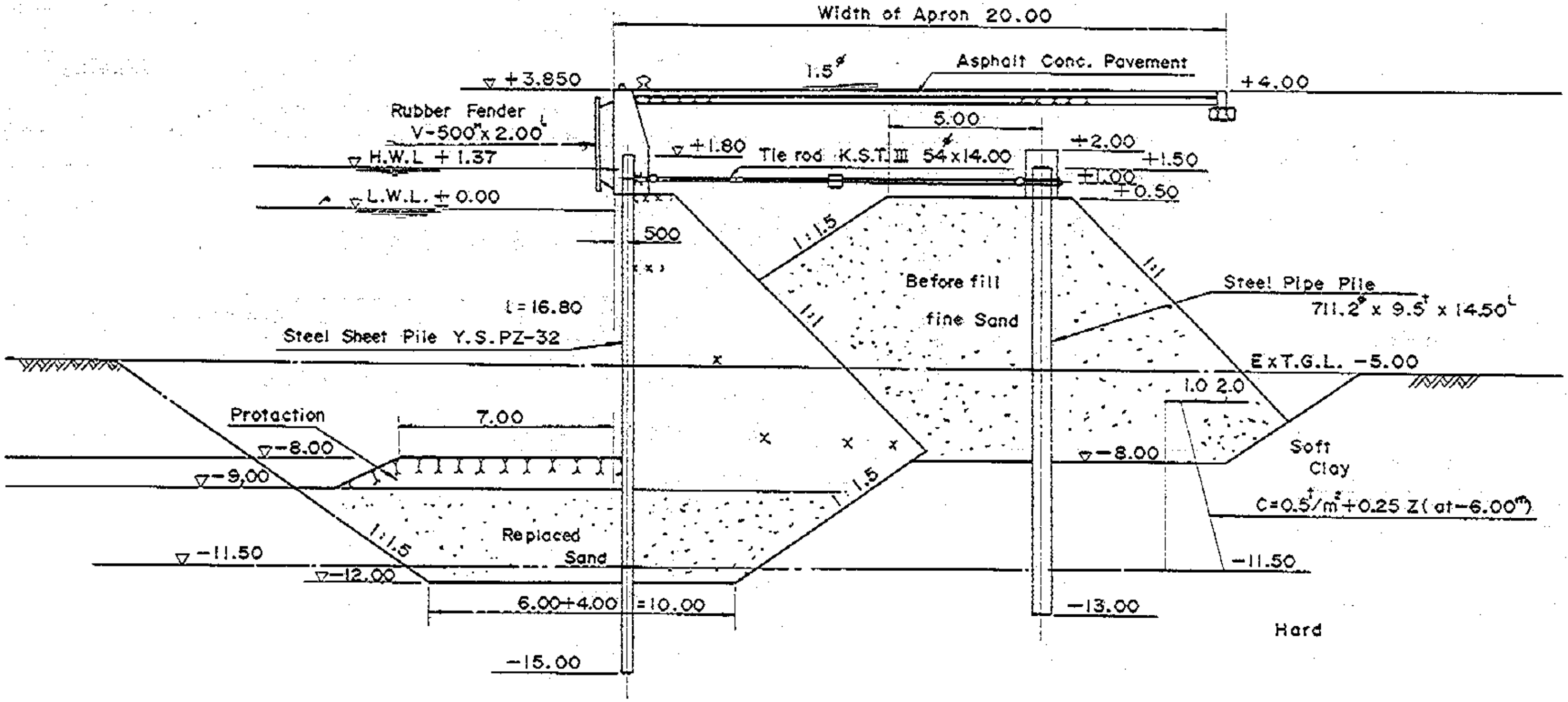


Fig F−3 Comparative Design

Cross Section of -5.5^{M} Quay Wall

Unit ; m C Plan (Outer Sea Area Plan)

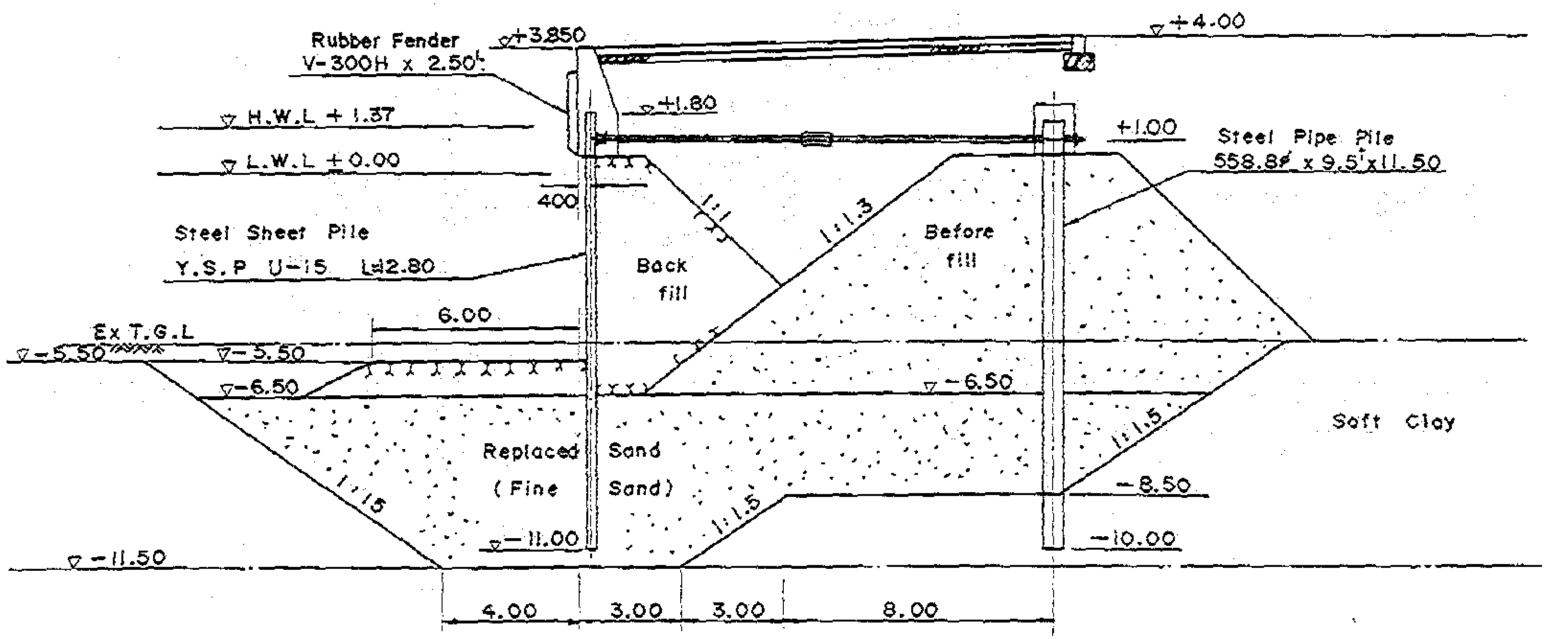


Fig F-4 Comparative Design

Section of Training Dyke L1 (Part Of Curvature) A Plan Reference Data — I

Unit : m

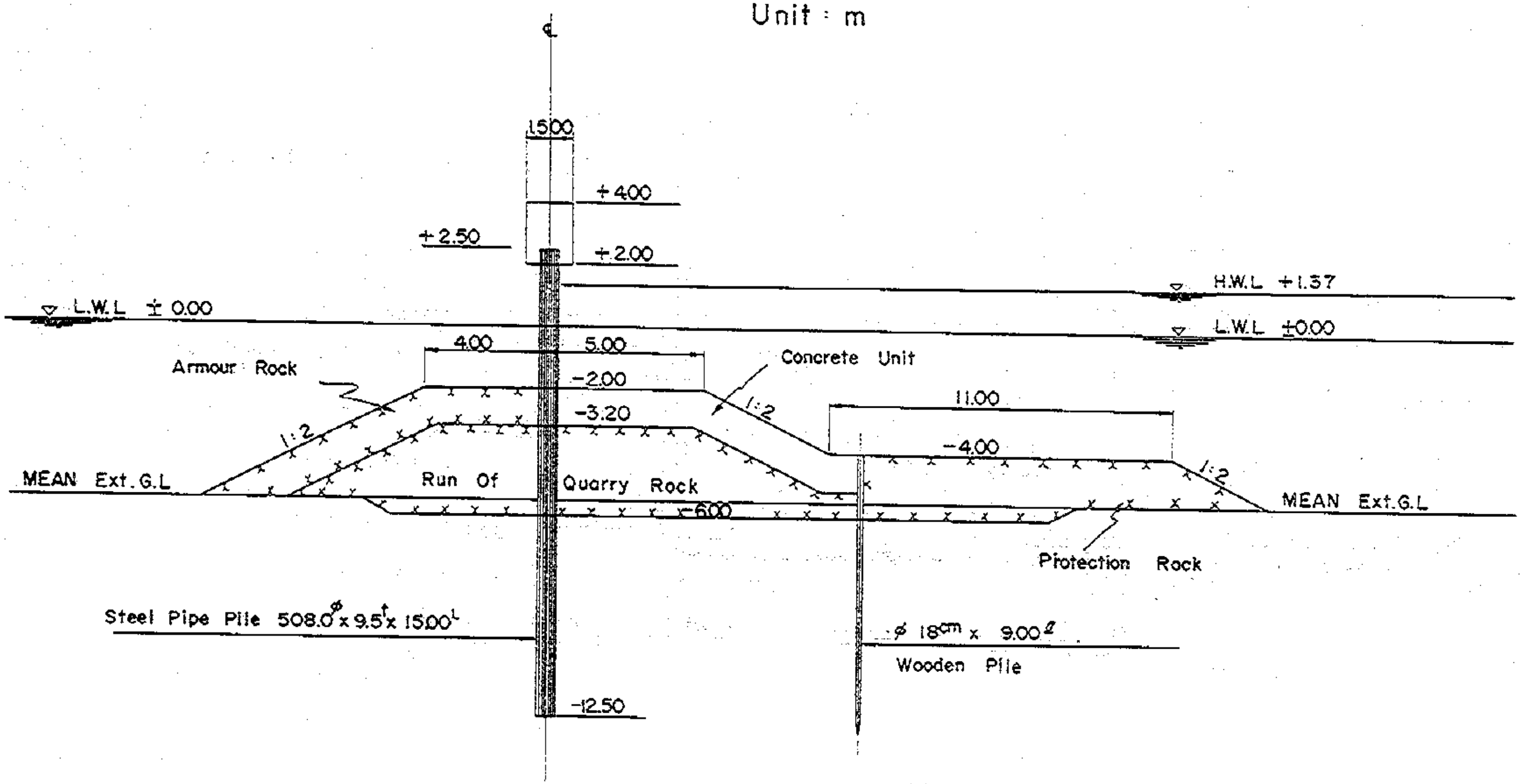


Fig F—5 Comparative Design

Section of Training Dyke L_1 (Part Of Curvature)   A Plan Reference Data — 2

Unit : m

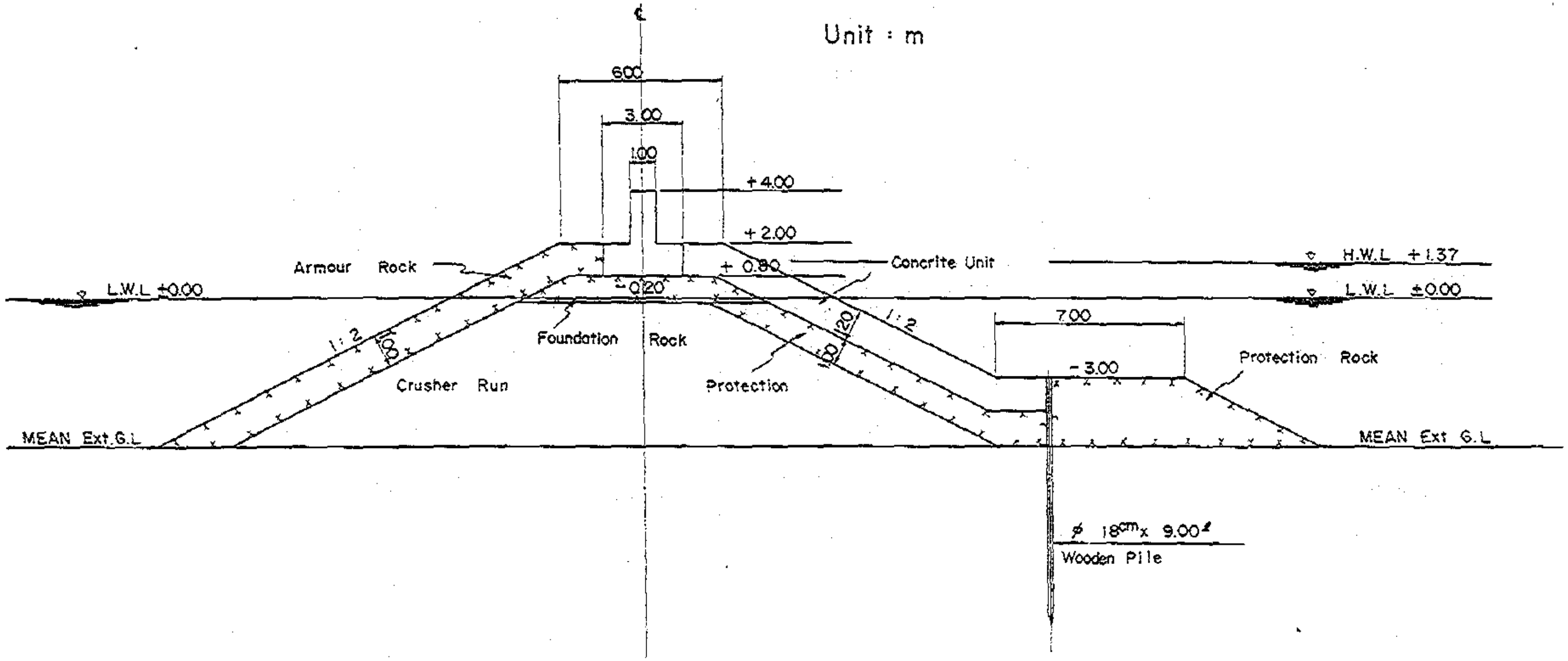


Fig F—6 Comparative Design

Section of Training Dyke (Part of Curvature)　　A Plan Reference Data

Unit : m

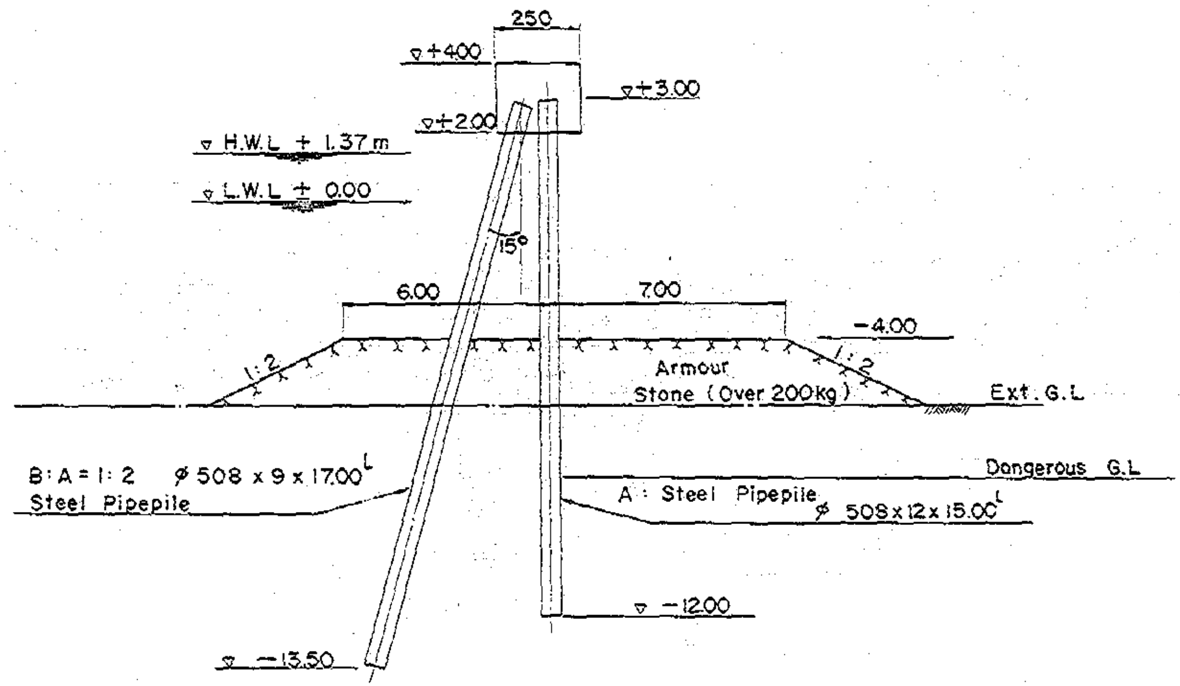


Fig F — 7 Comparative Design

Section of Training Dyke (Part of Curvatuve) A Plan Reference Data

Unit : m

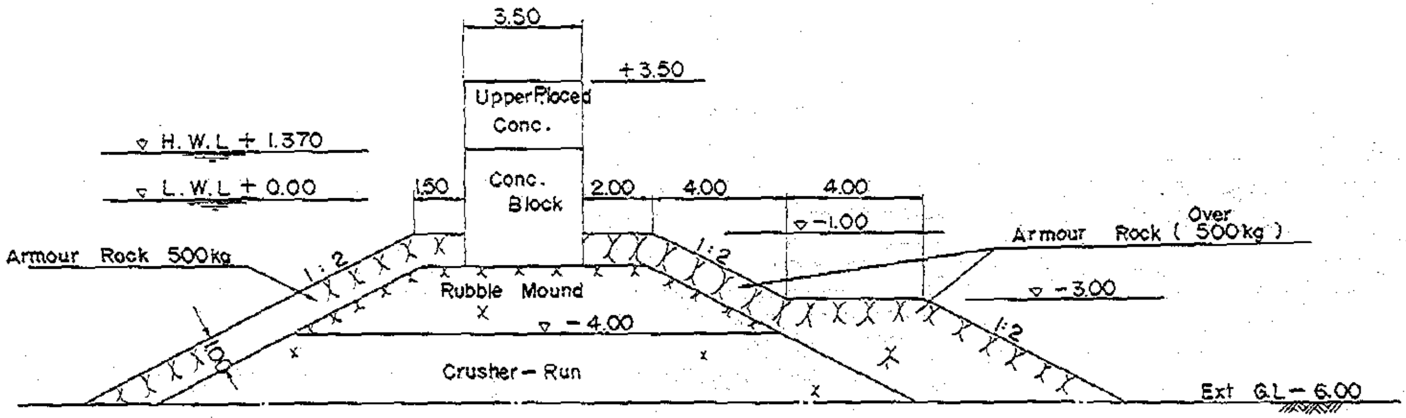


Fig F-8 Comparative Design

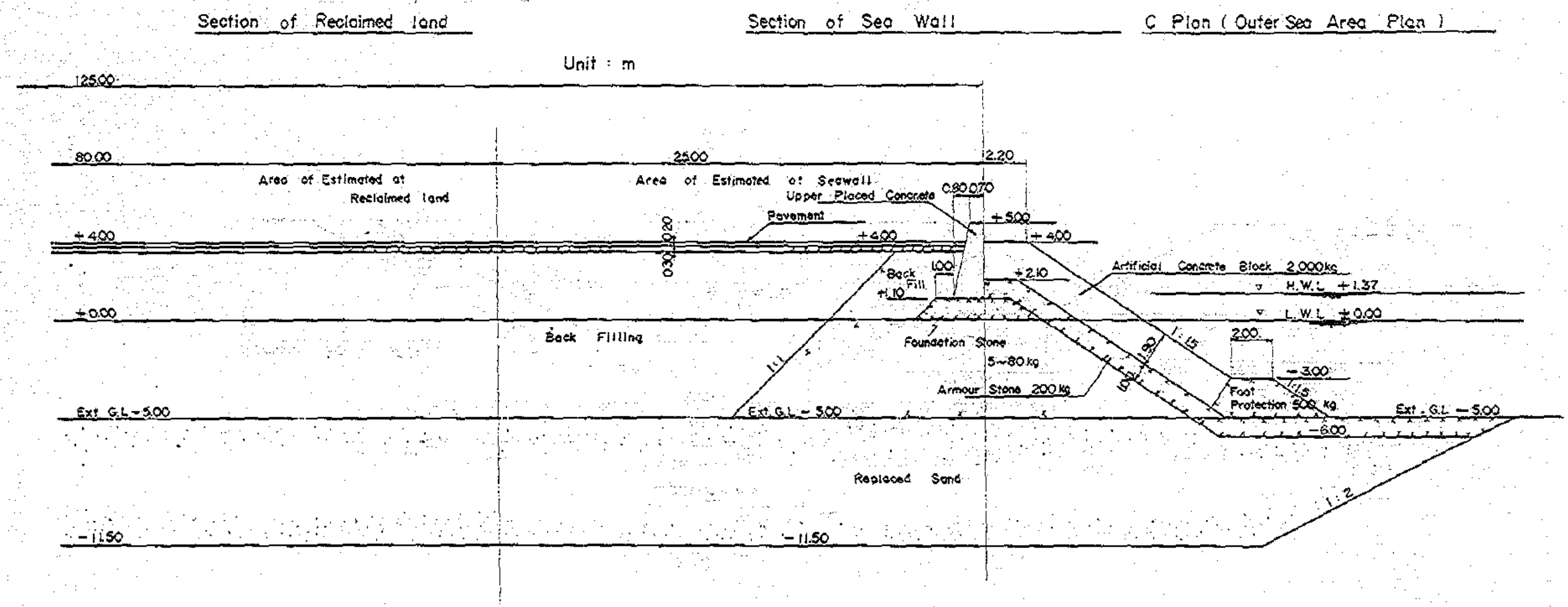


Fig F— 9 Comparative Design

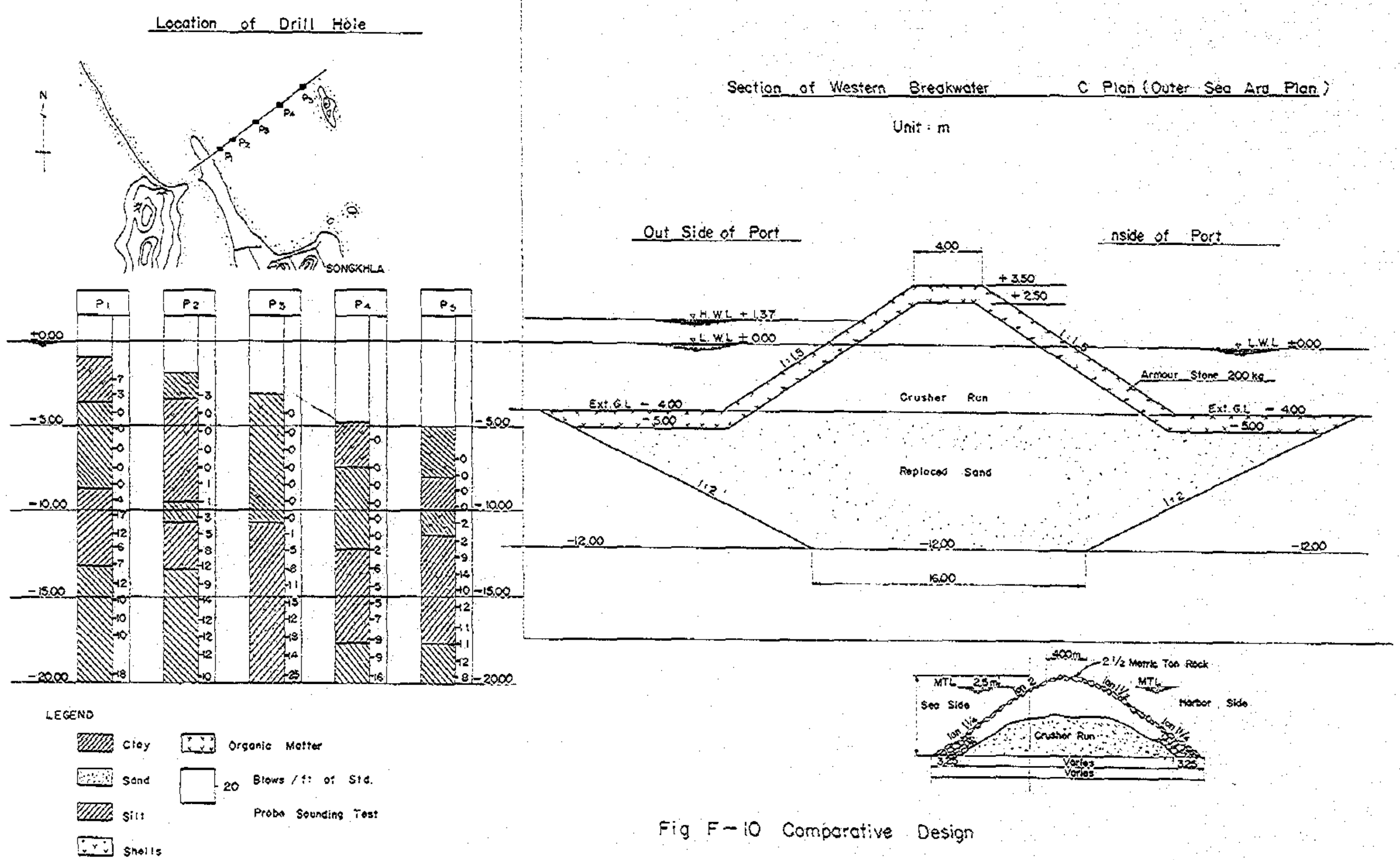
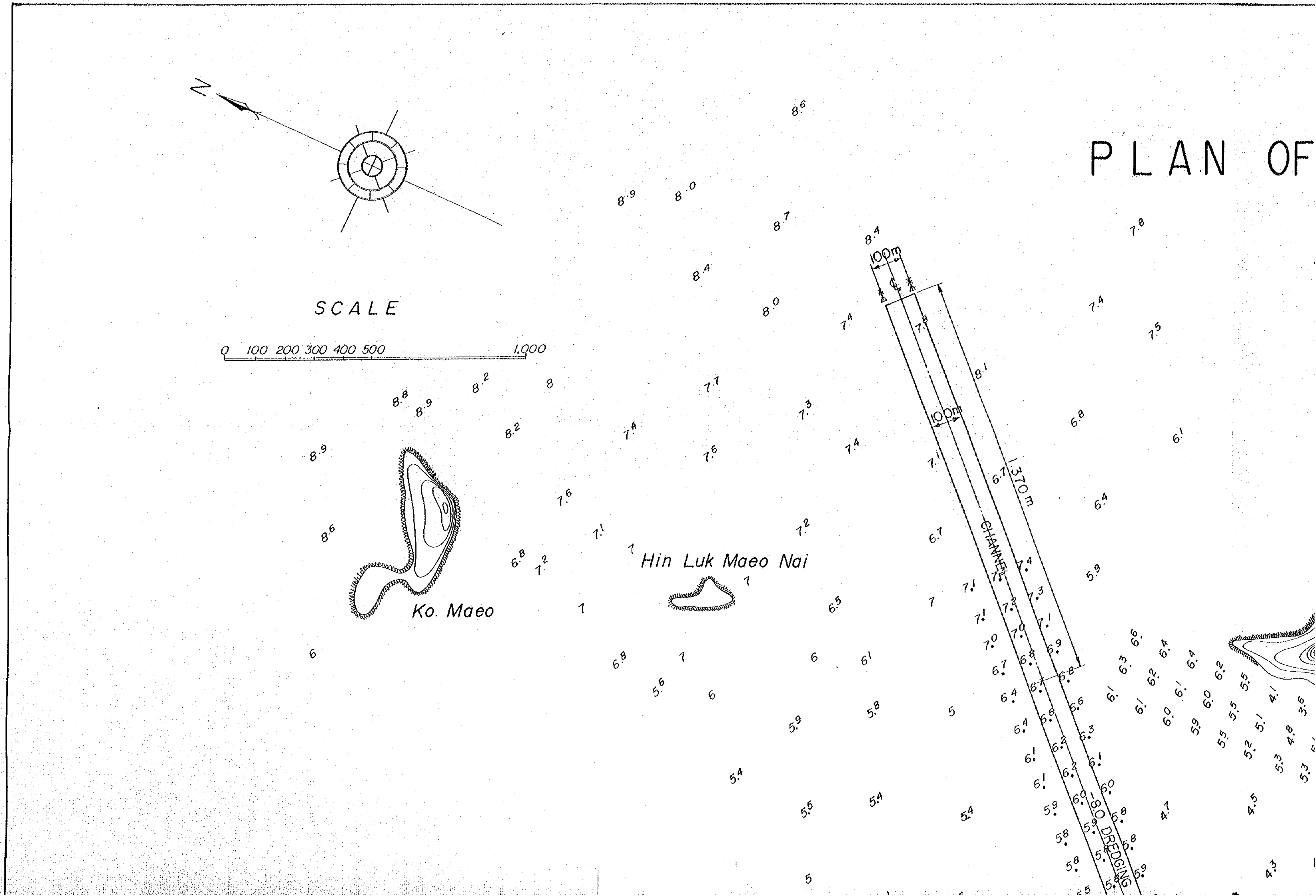
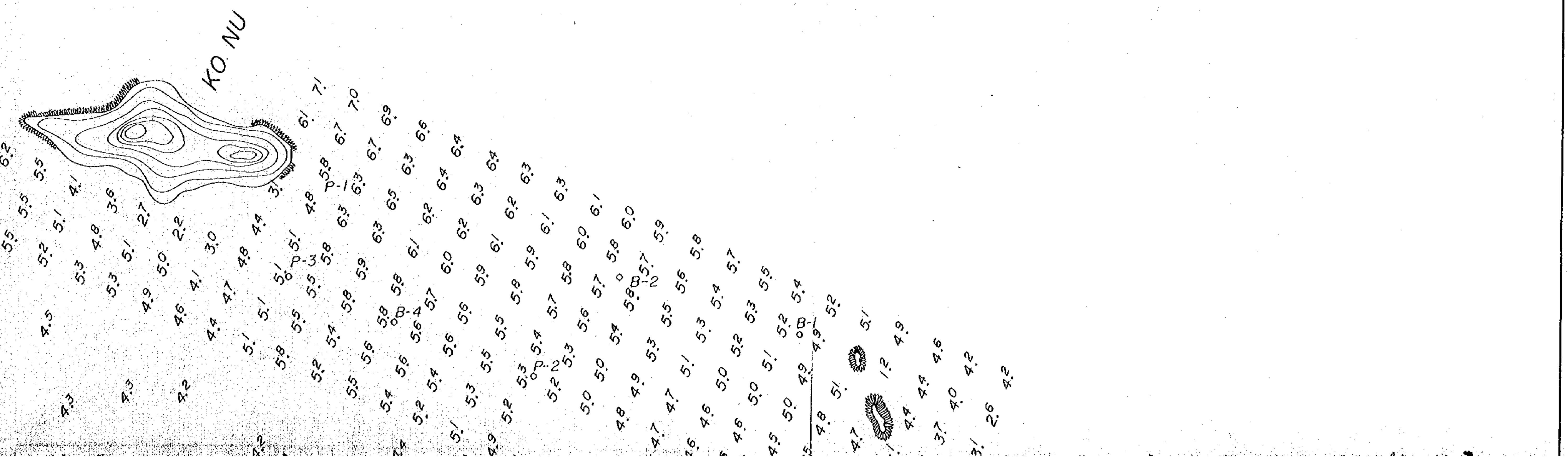
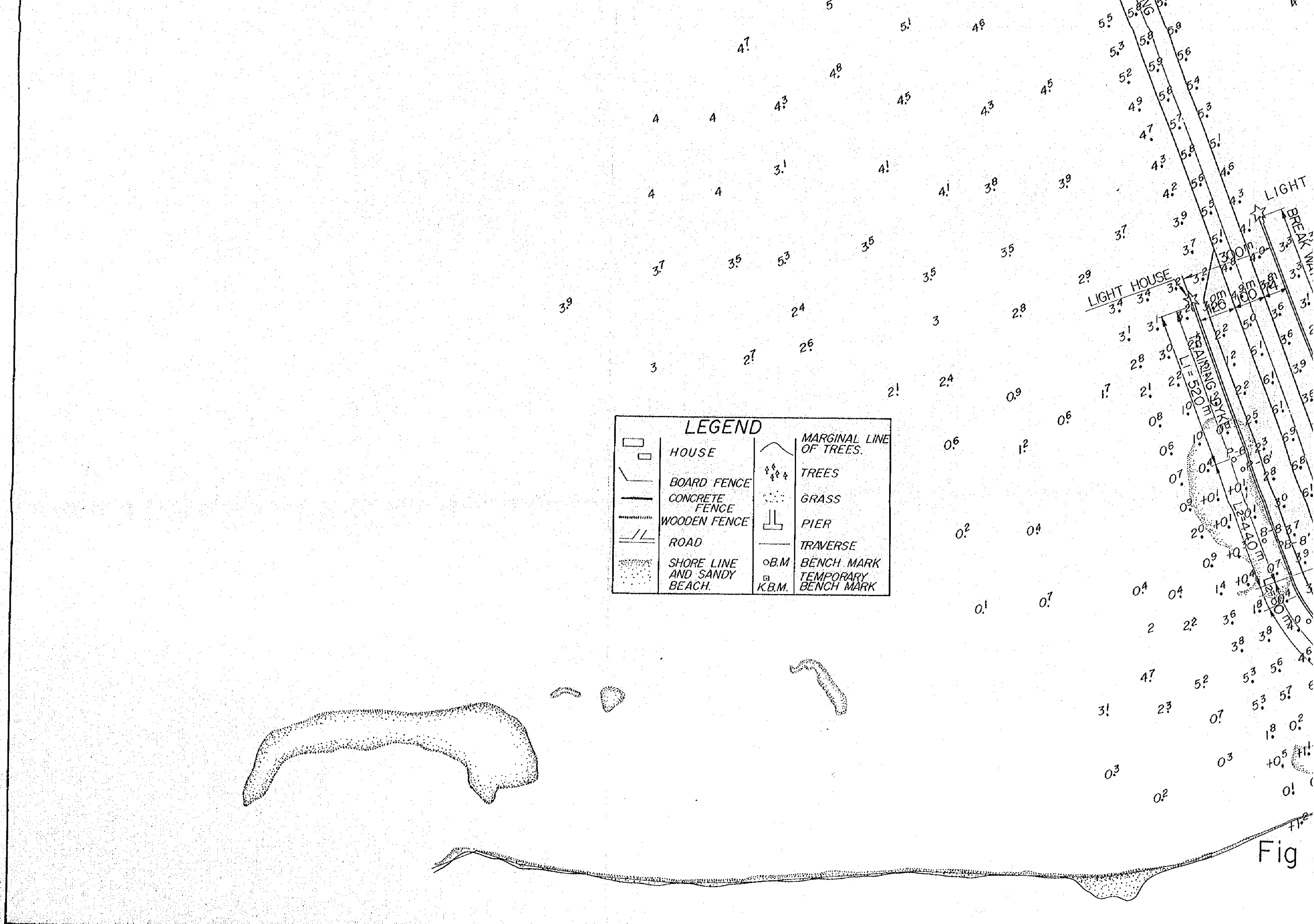


Fig F-10 Comparative Design


PLAN OF
N
SCALE
0 100 200 300 400 500 1,000
Ko. Maeo
Hin Luk Maeo Nai
100m
1,370 m
CHANNEL
DREDGING

N OF SONGKHLA PORT




LEGEND
HOUSE
BOARD FENCE
CONCRETE FENCE
WOODEN FENCE
ROAD
SHORE LINE AND SANDY BEACH.
MARGINAL LINE OF TREES.
TREES
GRASS
PIER
TRAVERSE
B.M BENCH MARK
K.B.M. TEMPORARY BENCH MARK
LIGHT HOUSE
LIGHT
TRAINING DYKE
L1 = 520 m
L2 = 440 m
300 m

Fig

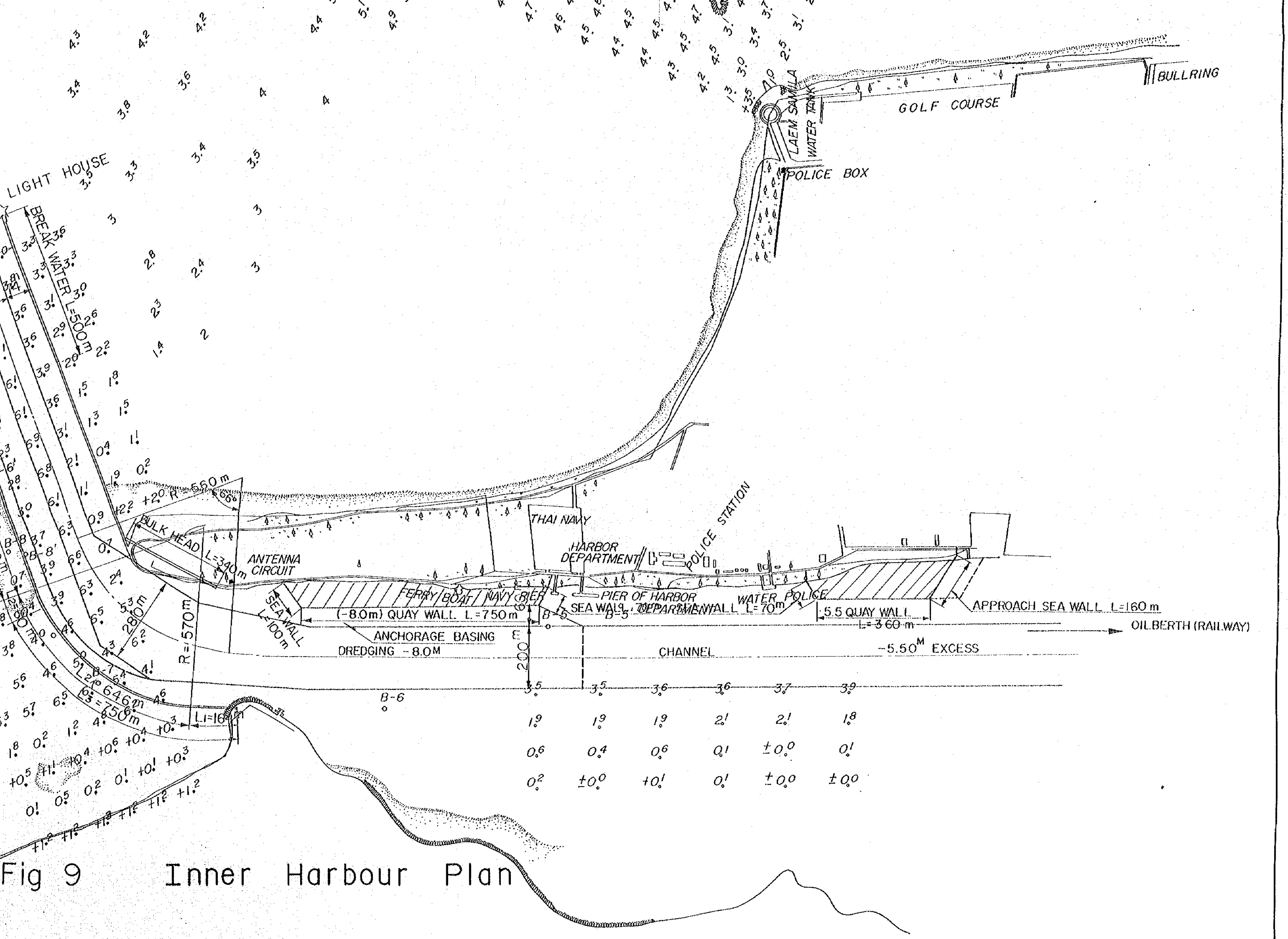


Fig 9 Inner Harbour Plan