PAKISTAN
REPORT OF PHITTI CREEK PORT CONSTRUCTION PROJECT

FEBRUARY 1973

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

NOTE

In accordance with the agreement between the Government of Pakistan and Japan in 1970, the Japanese Survey Team carried out engineering and economic survey for the construction of Phitti Creek Port in Pakistan. Based on their field investigation in January/February 1971 and the data supplied to them by July 1971 by the Government of Pakistan, the team completed and subinitted an interim report. The draft of the final report, however, could not be submitted before March 1972 due to war in the Indo -- Pakistan sub-continent to our regret. The team visited Pakistan from the 18th to the 28th October 1972 to discuss their draft report with the officials of the Government of Pakistan.

During the period of one year which elapsed between the completion of the draft report and the visit of the Japanese team to Pakistan, a few developments took place which changed the original concept and scope of Phitti Creek Port Development Plan considerably.

These developments were.:

1) Separation of East Pakistan resulting in considerable change in the economy and trade pattern of West Pakistan.
2) Decision of the Government of Pakistan to devalue Pakistani currency.
3) Decision of the Government of Pakistan to shift the site of the proposed Karachi Steel Mill from Buleji to Pipri as coveyed to us by Mr. S.Z.H. Rizvi, Project Director, Phitti Creek Project, in his letter No. PCP/2558 dated the 17th August 1972 (copy attached).
4) Collection of additional data, especially hydrographic, hydraulic and soils data, of the Creeks system which brought out many more favourable features of this area for the development of a port.

The impact of these changed circumstances on the concept and scope of development of Phitti Creek Port was discussed by the team with the officials of the Government of Pakistan including Mr. Q. Islam, Deputy Chairman, Mr. Aftab Ahmed Khan, Additional Secretary and Mr. S.H. Mir, Chief, Transport and Communications, Planning Commission, during their visit to Pakistan in October 1972.

At these meetings, it was decided that although the exact scope of Phitti Creek Development was changed, the draft report may be finalized in its present form without accounting for these changes. Furthermore, this report has served a useful purpose because it establishes the following facts:–

1) The report proves that out of three sites, namely Phitti Creek, Western Backwater of Karachi Harbour, and Sonmiani, Phitti Creek is the most suitable site for the Second Port in West Pakistan.
2) Although the site of the first stage of the development of Phitti Creek for handling dry bulk cargo is changed from Khiprianwala Island to Pipri, it does not present any problem either for maintenance of navigation channel or handling of bulk cargo. In fact, the new site at Pipri is superior to Khiprianwala Island as it would avoid expensive road and railway bridges over Korangi Creek and is near to present inland transportation and utilities system.
3) There is no change of site as far as oil handling facilities and location of petro-chemical industries at Bundal Island are concerned.
4) The report forms an important reference material for the preparation of a Master Plan for Pipri site.
5) This report also helps in taking a definite decision to develop Phitti Creek as second port even before the final feasibility and project report for Pipri site is prepared.

If it is desired to use Phitti Creek for relieving traffic congestion at Karachi Port by establishing an anchorage and lighterage facilities at Phitti Creek immediately, the report will provide the necessary guide lines.

Under this background, the present report is finalized and submitted in the original form in which the draft was prepared about a year ago except for correction of misprints of numbers and words, revision of the ambiguity of expression of sentences, clarifications, reparaphrasing etc., in accordance with our letter dated the 28th October 1972 to Mr. S.H. Mir, Chief, Transport and Communications, Planning and Development Division, Government of Pakistan. (Copy attached)

A supplementary report on the feasibility of constructing port facilities for handling dry bulk cargo at Pipri is also added which answers various questions referred to the team by Mr. S.Z.H. Rizvi, Project Director, Phitti Creek Project in his letter dated the 17th August 1972.

February, 1973

Hajime Sato

Dr. HAJIME SATO

Chief, the Japanese Survey Team
Director General,
Japan Port and Harbour Association

Copy of letter No. PCP/2558 dated the 17th August 1972 from Mr. S.Z.H. Rizvi, Project Director, Phitti Creek Project, to Dr. H. Sato, Chief of the Japanese Survey Team.

Naval Headquarters,
Karachi

From: S.Z.H. Rizvi,
Project Director

Dear Dr. Sato,

1. A few developments have taken place since we received your draft report. The Government of Pakistan is seriously considering the possibility of constructing Karachi Steel Mill at Pipri in place of Buleji as shown in our drawing No. PCP/50-E. A feasibility study has been commissioned for this purpose.

2. In this context, we have surveyed the seven mile long reach of Kadiro-Gharo Creek from Khiprianwala Island to Pipri. Our hydrographic chart No. D-17/72 of these creeks is enclosed. You will observe from this chart that a channel of about 600 ft. width with minimum depth of about 36 ft. is available upto the point where port facilities are tentatively proposed to be located for the steel mill. Further investigations are in progress.

3. The Hydraulics Research Station, Wallingford, has been recently consulted regarding the prospects of developing Kadiro Creek. They have assured us that they do not anticipate any difficulty in developing Kadiro Creek if steel mill is required to be served at Pipri. They have also assured us that we can rely on the maintenance dredging estimates given in their previous reports for detailed port planning.

4. The Government's decision to construct steel mill at Pipri in place of Buleji, the existence of a deep water channel right upto proposed steel mill site and results of various other investigations have, therefore, slightly changed, our previous concepts of Phitti Creek development. Now, we envisage that the development of Phitti Creek could possibly be carried out on the following lines:–

i) Phase I: Immediate Plan

Establishment of an anchorage with lighterage facilities to handle construction material and machinery for the steel mill during the construction stage. This anchorage may also handle other cargo such as wheat, rice, fertilizers, salt etc. to relieve present port congestion and to act as standby to Karachi Port.

ii) Phase II: Short-Term Plan

Establishment of proper port facilities to handle wheat, rice, fertilizers, cement, etc., as recommended in your draft report but to be located at Pipri at the position shown in our drawing No. PCP/50-E, in place of Khiprianwala Island and to be combined with port facilities for the steel mill using 25,000 D/W ships according to the following requirements:–

	Iron ore	Coal	Total
1977	610,000 t/yr.	440,000 t/yr.	1,050,000 t/yr.
1978	1,365,000 "	900,000 "	2,265,000 "
1979 (Full production)	1,984,000 "	1,182,000 "	3,166,000 "

The port facilities for the steel mill are required to be completed by December, 1976 according to present schedule of the construction of the Steel Mill.

Oil handling facilities at Bandal Island may also be included in this plan to take "over-flow" from the present oil handling capacity of Karachi Harbour.

iii) Phase III: Long-Term Plan

Oil handling facilities and petro-chemical industries to be located at Bandal Island as recommended in your draft report using 50,000 D/W ships but other port facilities to be located at Pipri. The draft upto Pipri may also be increased to take ships upto 50,000 D/W for the steel mill in the Long-Term Plan.

5. As you are aware, the Southern Bar Channel has least depth of 20 ft. The minimum size of ship that could use Phitti Creek Anchorage under the Immediate Development Plan may, therefore, be as follows:–

Fair weather from October to April

Depth	+ 20 feet
Tidal benefit	+ 7 feet
Keel clearance	– 2 feet
Permissible draft	25 feet
Permissible size	10,000 DWT

Rough weather from May to September

Depth	+ 20 feet
Tidal benefit	+ 7 feet
Keel clearance	– 5 feet
Permissible draft	22 feet
Permissible size	8,000 DWT

The above suggested keel clearances are in accordance with the current practice at Karachi Harbour for similar sizes of ships.

6. In your Long-Term Development Plan you have recommended a navigation channel 900 feet wide and 42 feet deep for standard ship size of 50,000 D/W class viz.

Length	771 feet
Beam	105 feet
Draft	39 feet

I would suggest for your consideration and consultation with the Japanese Pilotage Authorities whether following criteria could be adopted for channel dimensions in the Long-Term Plan for taking 50,000 D/W ships upto Pipri for iron ore and coal ships for the proposed steel mill:–

a) Width of channel to be governed by the following empirical formulae:

$3B + 200 = 105 \times 3 + 200$
$= 515$ feet

$3/4L + 50 = 3/4 \times 771 + 50$
$= 629$ feet

Taking an average of the two figures, the width of the channel comes to 572 feet. A channel width of 600 feet with side slopes 1 : 10 for the approach channel and 1 : 6 for harbour channel with provision for adequate tug attendance may, therefore,

be adopted in the arly stages of Long-Term Plan till shipping is increased to such an extent as to need two way traffic. The width of the approach channel may then be increased to 750 or 900 feet as may be considered necessary.

b) Depth may be governed by the following criteria:

	Design Ship 50,000 (Draft 39 feet)				
	Approach Channel		Harbour Channel	Turning Basin	Berth
	May to Sept.	Oct. to April			
Depth	38	38	36	37	42
Tidal benefit	7	7	6	5	Nil
Keel clearance	–6	–4	–3	–3	–3
Permissible draft	39	41	39	39	39

We have prepared tide tables for Phitti Creek for the years 1972 and 1973 which show that there is 92% probability of having High Water more than 7 feet above datum. Tidal heights at Pipri are same as at Phitti Creek entrance. The tidal benefit of 7 feet may, therefore, be utilized to a great advantage in economizing capital dredging.

I may also mention that in most terminals a certain amount of ship delay due to port closure for bad weather is considered acceptable. In view of this, a 6 feet clearance for 10 feet waves may be considered reasonable for channel conditions with soft bottom.

7. We have completed field and laboratory tests of 36 trial borings in Phitti, Jhari, Korangi Creeks and Adjoining Area including two borings – one on Pipri mainland (M-12) and the other in Gharo Creek (Cr. 8). I am enclosing a report on these borings. In addition to this, we are carrying out 12 more borings on Pipri mainland and 3 more borings in Kadiro Creek. The results of these bore holes will be available shortly.

8. We hope to install three wave rider buoys shortly – one each for deep sea, extension of Southern Approach Channel and inside Phitti Creek. Besides, this, additional hydraulic observations are also planned to be carried out in the creeks system shortly.

9. In view of these recent developments, I shall request you to please be prepared for discussions on possible amendments which we may suggest to you to consider in the recommended plans given in your draft report during your forthcoming visit to Pakistan.

Looking very much forward to meeting you again,

Yours very sincerely,

(S.Z.H. Rizvi)

Dr. H. Sato,
Chief, Japanese Survey Team,
Overseas Technical Co-operation Agency,
Government of Japan,
Ichigaya, Shinju-ku,
TOKYO – (Japan)

Copy of letter dated the 28th October 1972 from Dr. H. Sato, Chief, Japanese Survey Team to Mr. S.H. Mir, Chief, Transport and Communications Section, Planning and Development Division, Government of Pakistan.

Oct. 28, 1972

Mr. Sadaqat Hasav Mir,
Chief, Transport & Communication,
Planning & Development Division,
Ministry of Finance, Planning & Development,
ISLAMABAD

Dear Mr. Mir,

1. The draft report which has already submitted to your Government was made based on the data available till July, 1971. I want to submit the final report of the Phitti Creek port development plan after revising the ambiguity of the expression of sentences and misprints of numbers, words etc.

2. I was informed from Mr. Rizvi's letter addressed to me dated Aug. 17, 1972, that the Government of Pakistan is eagerly considering the construction of the steel mill at Pipri instead of Buleji and in this connection the Pakistani Government also has the intention of the construction of bulk cargo handling facilities at Pipri that was expecting to construct at Khiprianwala Is.

3. In the connection of the above mentioned matters, I want to submit the report of "Brief Study of the Proposed Pipri Port Development Plan" as the supplemented material to the final report above mentioned.

4. The intention (The way of thinking) of the Japanese Government is as follows. The project study of the Pipri Port Development Plan is another thing of that of Phitti Creek and is to be conducted by contract of the two Governments as a new project.

5. The Government of Pakistan considers the realization of Pipri port as one of the important and eager matters among its policy. The Government of Pakistan wants the early completion of the study.

In order to save the time, the prior to the decision of the contract of two governments, the Government of Pakistan has the desire to carry out the survey which is able to be done by the Government of Pakistan by using Japanese and local consultants. I am willingly to inform these eager intention of the Government of Pakistan to the Japanese Government after coming back to Japan.

Dr. Hajime Sato

Hajime Sato

Chief, the Japanese Survey Team
Director General,
Japan Port and Harbour Association

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GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of Pakistan, has decided to undertake a survey for the Phitti Creek Port Construction Project in West Pakistan and entrusted the Overseas Technical Cooperation Agency with the implementation of the survey.

To ensure satisfactory implementation of the survey in view of the vital importance of this project for the economic growth and establishment of a new world-trade port, the Overseas Technical Cooperation Agency on its part organized a preliminary survey team made up of three expert engineers, headed by Mr. Yasuo Hisada, Director of the Division for Disaster Prevention, Bureau of Ports & Harbors, Ministry of Transport, and sent it to West Pakistan over the period from June 21 to July 2, 1970.

Following this preliminary survey team, a main survey team comprising eight expert engineers, headed by Dr. Hajime Sato, Director General of the Japan Port & Harbor Association, was sent to West Pakistan over the period from January 25 to February 20, 1971. The purpose of this survey team was to make a detailed study of the Phitti Creek area, a proposed port construction site, from both the technical and economic viewpoints to draw up a port construction plan for the establishment of a second world-trade port in addition to the Port of Karachi, the only world-trade port in West Pakistan, and to make a comparison between Phitti Creek and other alternative plans such as the extension of Karachi Port and the development of Sonmiani district.

Thanks to the kind cooperation of officials concerned of the Pakistan Government, field survey was carried out smoothly on schedule and a report of survey is now ready for presentation.

It is my sincere desire that this report will contribute to the construction of a new world-trade port, and that by doing so it will promote friendly relations between Pakistan and Japan and promote technical and economic exchange between the two countries.

Finally, I would like to take this opportunity to express my appreciation and gratitude to all the members of the survey team for the work well done and to the Pakistan Government agencies.

February, 1972

K. Tatsuke

KEIICHI TATSUKE

Director General
Overseas Technical Cooperation Agency

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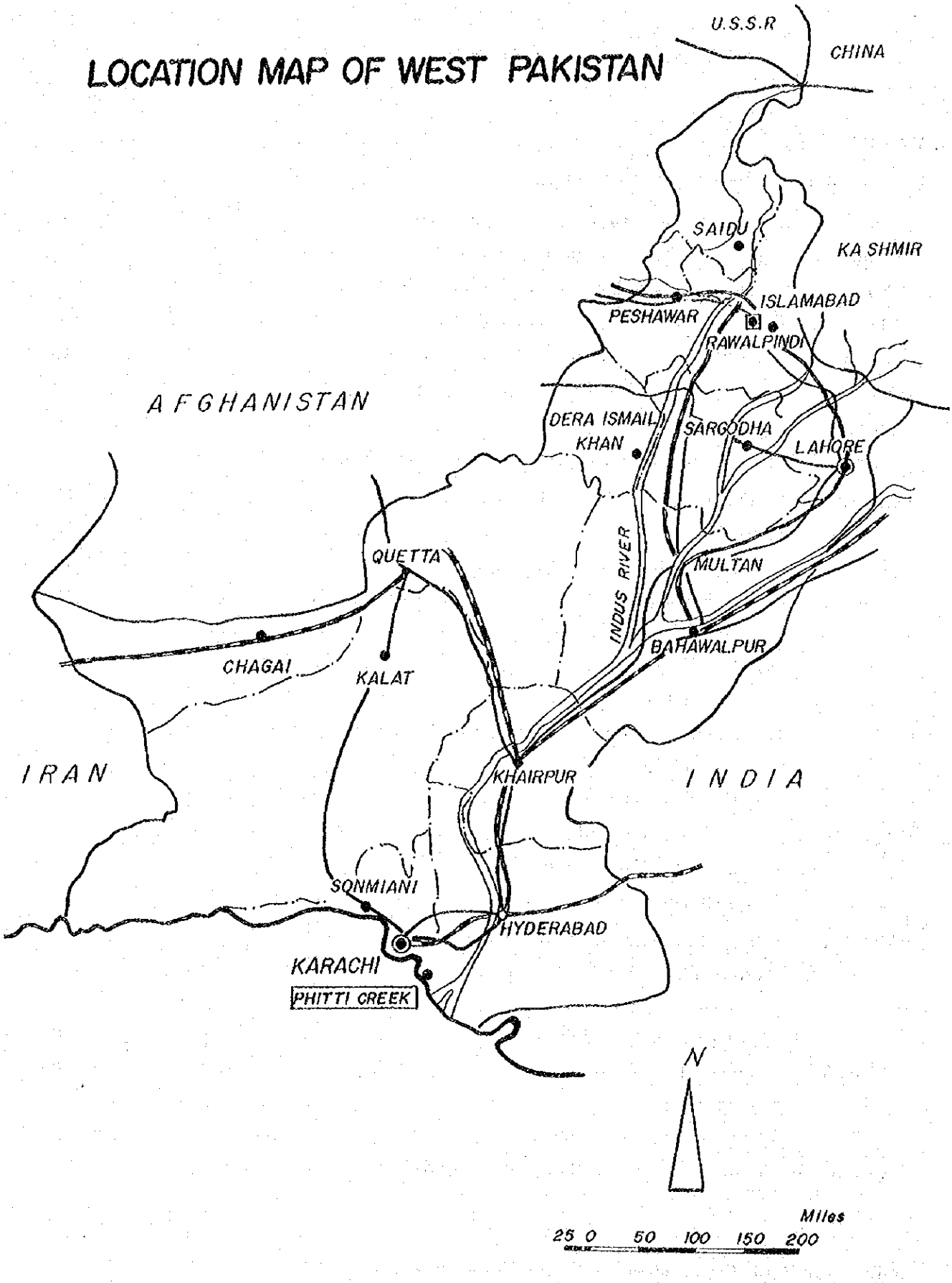

LOCATION MAP OF WEST PAKISTAN
U.S.S.R
CHINA
SAIDU
KA SHMIR
ISLAMABAD
PESHAWAR
RAWALPINDI
AFGHANISTAN
DERA ISMAIL KHAN
SARGODHA
LAHORE
INDUS RIVER
QUETTA
MULTAN
BAHAWALPUR
CHAGAI
KALAT
IRAN
KHAIRPUR
INDIA
SONMIANI
HYDERABAD
KARACHI
PHITTI CREEK
N
Miles
25 0 50 100 150 200

INTRODUCTION

INTRODUCTION

1. Purpose of Survey

In West Pakistan the economy has been expanding rapidly since her independence at the annual growth rate of 4% in the overall economy. Industrial production, in particular, has shown a remarkable growth rate of 8%. In addition, there has been a rapid increase in the population of Karachi, the largest commercial city in West Pakistan, from some 400,000 in 1947 to well over three millions at present. With this remarkable growth of economy, the volume of cargo traffic at the Port of Karachi, the only world-trade port in West Pakistan, has also been increasing at a rapid pace. Under these circumstances, the Pakistan Government propose to construct a second world-trade port in the vicinity of Karachi. The Government of Pakistan approached the Japanese Government through ECAFE to undertake a technical and economic survey on the prospect of this project. The Japanese Government, after consultation with the Government of Pakistan, and ECAFE, decided to undertake the survey on bilateral basis between Pakistan and Japan. The technical and economic survey included field investigation and data analysis, planning and preparation of a report.

2. Guideline of Survey

As a first step, a preliminary survey team was sent to Pakistan for consultation with the Pakistan Government on the feasibility of the project, timing of the visit of main team, duration of survey, composition of the team and objectives of the survey to ensure satisfactory implementation.

The preliminary survey team had laid down the following items as subjects of discussion with the Pakistan Government.

(1) Policy and enthusiasm of the Pakistan Government for the project.

(2) Terms of reference and scope of technical cooperation between the Governments of Pakistan and Japan.

(3) Extent of data collected by Pakistan Government for the project.

(4) Possible assistance from Pakistan Government for the implementation of the survey.

As a result of consultation with the Pakistan Government, it became apparent that the Pakistan Government wished to construct a new harbour which could perform the following functions in the field of port and harbour development in West Pakistan:—

(1) To serve as an industrial port for waterfront industries.

(2) To serve as a second commercial port to supplement Karachi Port, the only world-trade port in West Pakistan, and alleviate traffic congestion at the Port of Karachi and in the hinterland brought about by a rapid increase in cargo traffic.

To fulfill these requirements, it was considered necessary that the new harbour should have a depth of (—) 42 feet and its facilities include the following:—

(1) Facilities required for a large industrial port capable of handling bulk cargo of various types.

(2) Loading and unloading facilities such as sheds, silos and cargo handling equipments.

(3) Port transport facilities including dock roads and dock railway sidings.

Most of the major ports in the world which have continued to flourish uptil now with

their long history are now coming to a turning point, and the Port of Karachi is no exception.

This change in the trend of ports has been brought about by two factors. One is the change in ship itself as seen in the increase of the size of ships, particularly of bulk-carrier, mechanization of cargo handling, and containerization of general cargo. Another factor is the expansion of the city area in the hinterland resulting in the struggle between the port and the city for more land space. This expansion has brought about further traffic congestion in the city section, greatly hampering smooth distribution of commodities.

After a careful study of technical and economic evaluation of the above conditions, Phitti Creek was selected as the primary site for harbour construction and the extension of the Port of Karachi and Sonmiani as alternative plans.

As for hydraulic aspect of the survey, which is of prime importance for the success of this project, the results of a study conducted by the Hydraulic Research Station, Wallingford, England, were used in accordance with the agreement made with the Pakistan Government.

3. Scope of Survey

The survey, which was intended to obtain basic information for the new harbour construction project, covered the following items:—

(1) A survey of the future cargo traffic through ports in West Pakistan.

(2) A survey of the potential of waterfront industries in West Pakistan.

(3) Investigations on the need of a new harbour in West Pakistan.
   a) Volume of cargo traffic
   b) Increase in the size of ships
   c) Synchronisation with inland transportation system
   d) Port-oriented industries

(4) A study of environmental conditions at the three proposed sites

(5) Port planning for Phitti Creek
   a) Preparation of a master plan (long-range)
   b) A study on the maintenance of approach channel and anchorage
   c) Estimate of construction cost (long-range)
   d) Preparation of a short-term plan

(6) A study on investment efficiency

(7) A comparative study of the three proposed sites

4. Composition of Survey Team

Preliminary Survey Team

	Name	Assignment	Occupation at the time of Dispatch
Head	HISADA, Yasuo	General	Director, Division of Disaster Prevention, Bureau of Ports and Harbours, Ministry of Transport
Member	NAGATOMO, Fumiaki	Survey	Deputy Chief, 2nd Engineering Section, the 4th District Port Construction Bureau, Ministry of Transport
Member	YOSHIKAWA, Masahiro	Planning	Chief, Planning Sub-Section, Division of Waterfront Industrial Areas, Bureau of Ports and Harbours, Ministry of Transport

Main Survey Team

	Name	Assignment	Occupation at the time of Dispatch
Head	SATO, Hajime	General	Dr. of Engineering, Director-General of Japan Port & Harbour Association (Former Director-General, Bureau of Ports & Harbours, Ministry of Transport)
Deputy Head	TSURUTA, Senri	Hydrography	Dr. of Engineering, Head, Hydraulics Division, Port & Harbour Research Institute, Ministry of Transport
Member	SENGOKU, Zenshiro	Design & Construction	Acting-Director, Steel Structure Development Department, Nippon Steel Corporation
Member	GODA, Yoshimi	Hydrography	Chief, Wave Laboratory, Port and Harbour Research Institute, Ministry of Transport
Member	NAKAMURA, Ryuji	Port & Harbour Planning	Deputy-Director, Planning Division, Bureau of Ports & Harbours, Ministry of Transport
Member	MORIHIRA, Michio	Design & Construction	Deputy-Director, Construction Division, Bureau of Ports and Harbours, Ministry of Transport
Member	HASHIKAWA, Takashi	Transport Economy	Chief, 1st Planning Sub-Section, Planning, 3rd District Port Construction Bureau, Ministry of Transport
Member	MUKUNOKI, Yoshio	Coordination	Development Research Division, Overseas Technical Cooperation Agency

5. Pakistani Counterparts

In the course of field survey the wholehearted cooperation was extended to the team by various agencies of the Pakistan Government. In particular, the Phitti Creek Project Cell, Planning Division, newly created at the project site by the Pakistan Government for the purpose of materializing the world-trade port construction project and directed by Mr. S.Z.H. Rizvi, joined the Japanese team in the field survey and greatly contributed to the successful conclusion of the survey:-

Acknowledgment is made to the agencies listed below for their support and cooperation extended to the survey team.

(1) Planning Commission, Government of Pakistan
(2) Planning Division, Government of Pakistan
(3) Phitti Creek Project Cell, Planning Division, Government of Pakistan
(4) Karachi Master Plan Department, K.D.A. f Pakistan
(5) Directorate General, Ports and Shipping, Government of Pakistan
(6) Hydrographic Directorate, Pakistan Navy
(7) Karachi Port Trust
(8) ECAFE

6. Itinerary of Survey Team

Field survey by the preliminary survey team covered a period from June 21 to July 2, 1970. Activities of the main survey team included field survey, data collection, data processing, exchange of views with the Pakistan Government agencies and the presentation of an interim report to that government, covering a period from January 25 to February 20, 1971.

The following is a summary of the itinerary of the survey team.

Preliminary Survey Team (June 21 through July 2, 1970)

Jun. 21	Flight from Singapore to Karachi, West Pakistan. A courtesy call at the Japanese Consulate General and the Pakistan Government offices in Karachi, followed by consultation with the Pakistan Government officials on the future activities.
Jun. 22 through Jun. 25	Field tour of the Phitti Creek, Sonmiani, Karachi Port and the neighboring areas of Karachi City.
Jun. 26	Internal work within the team.
Jun. 27	Flight from Karachi to Islamabad. Courtesy call at the Japanese Embassy and the Pakistan Government, followed by consultations.
Jun. 28	Flight from Islamabad to Karachi.
Jun. 29	Consultations with the Pakistan Government officials in Karachi.
Jun. 30	Flight from Karachi to Bangkok.
Jul. 1	Courtesy call at the Japanese Embassy and ECAFE's Transport Department, followed by consultations.
Jul. 2	Departure for Japan.

Main Survey Team (Jan. 25 through Feb. 20, 1971)

Jan. 25	Departure from Tokyo
Jan. 26	Arrival in Karachi, West Pakistan. Courtesy call at the Japanese Consulate General and the Pakistan Government offices in Karachi, followed by consultations. A survey tour of Karachi City and neighboring areas.
Jan. 27	Courtesy call at the Pakistan Navy, followed by consultations and exchange of views. Flight from Karachi to Islamabad.
Jan. 28	Courtesy call at the Japanese Embassy, followed by exchange of views.
Jan. 29	Courtesy call on the Pakistan Government officials followed by exchange of views. Flight from Islamabad to Karachi.
Jan. 30 through Feb. 12	Field survey of Phitti Creek, Karachi Port, Sonmiani and neighbouring areas. Exchange of views with officials of the Pakistan Government in Karachi. Data collection and personal interviews to obtain necessary information.
Feb. 13	Flight from Karachi to Lahore. Data collection in Lahore.
Feb. 14	Flight from Lahore to Islamabad.

Feb. 15	A call to the Japanese Embassy to make an interim report and to bid farewell.
Feb. 16	Call on the Pakistan Government officials to make an interim report and to bid farewell. Flight from Islamabad to Karachi.
Feb. 17	A call at the Japanese Consulate General and the Pakistan Government offices in Karachi for consultation and to bid farewell.
Feb. 18	Flight from Karachi to Bangkok.
Feb. 19	A call at the Japanese Embassy and ECAFE to make an interim report.
Feb. 20	Departure for Japan.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

Taking advantage of its geological location and topographical features, Karachi Port has long been flourishing as a base of marine transport along the west coast of the Indo – Pakistan sub-continent to the Persian Gulf.

In 1880 the Karachi Harbour Board was established by the Bombay Government and in 1886 the independent Karachi Port Trust was established. The Port of Karachi with its long history has been under continuous development by human power for nearly 100 years.

Since independence in 1947, the Government of Pakistan has been stepping up efforts for the improvement of agriculture and industrialization of the country. As a result, the economy has been expanding steadily since her independence at an average annual growth rate of 4% and the industry, in particular, has been growing at a high growth rate of 8%. The GNP in the year 1969/70 reached Rs 7,500 crores. The population, on the other hand, has also increased at a high average annual growth rate of around 3% in the past 10 years and exceed the 132 million level in the year 1969/70. As a typical example of these developments, the port city of Karachi has turned to a gigantic city with a population of over 3 million and is now undergoing various changes to create a new modern city. The population at Karachi City may reach a figure of 12 ~ 15 million by the end of this century.

With these as background, the volume of cargo traffic through the Port of Karachi, the only seaport in West Pakistan, has doubled in every ten years since the year 1949/50. The volume of cargo traffic through the port in the year 1969/70 reached 9.3 million tons.

With this rapid increase in the volume of cargo traffic, the present Karachi Port shows an astonishingly high annual berth occupancy rate of 110%. Also, the volume of cargo handled at the wharves has reached 540 tons per foot of wharf in the past one year, already exceeding the saturation point.

What is specially noteworthy is the fact that the Karachi Port Trust has been providing dredging of 2 ~ 3 million barge tons annually over the past 10 years to meet the increase in the size of ship in recent years.

With a view of coping with such a sharp increases in demands for marine transport and alleviating the congestion of city traffic brought about by the rapid expansion of Karachi City, the Government of Pakistan has prepared a plan to construct a new port in the vicinity of the present Karachi Port.

The survey team made a survey on the feasibility of the new port project by conducting field investigations centering on the Phitti Creek, which was recommended by the Pakistan Government as a potential project site, over a period from January 26 to February 17, 1971. This report has been prepared on the basis of the findings of this survey.

As for hydraulic aspect, an important factor for the selection of a site for port construction, the results of a study conducted by the Hydraulics Research Station, Wallingford, England, which were made available to the team by the Pakistan Government were used. Forecast of the future cargo traffic and port-oriented industries was based on the Fourth Five-Year Plan with the target year of 1974/75 and the Perspective Plan with the target year of 1984/85, both worked out by the Government of Pakistan, and other related data available.

Based on the above analysis, the survey team has come to the following conclusions and recommendations:–

(1) That the function of the present Karachi Port which has been playing an important role in the course of its history should be respected.

(2) That improvement of Karachi Port will be continued also in the future as a port for general cargo.

(3) That the proposed site of port construction needs to be capable of meeting the recent trend of the increase in the size of ships and have room to meet the future transport innovation which is difficult to predict at this stage.

(4) That the survey team recommends the Phitti Creek as the site which fulfills the above requirements.

(5) That modern bulk cargo handling equipment should be provided at Phitti Creek Port and that a site for port-oriented industries should be provided in the Phitti Creek area under a short-term plan with the target year of 1974/75 and under a long-range plan with the target year of 1984/85.

The contents of this report may be summarized as follows.

1. On the basis of the economic plans prepared by the Government of Pakistan, the volume of cargo traffic through ports in West Pakistan is estimated at 17.2 million tons in the year 1974/75, an increase of 1.9 times over the 9.3 millions tons for the year 1969/70 and at 34.7 million tons in the year 1984/85, an increase of 3.7 times over the year 1969/70.

2. Similarly on the basis of the economic plans of the Pakistan Government, the future size of waterfront industries in West Pakistan is estimated to require additional location of industries for production of three million tons of steel and 1504 BPSD of oil refining in addition to the industries already established or under planning.

3. Karachi Port handled 9.3 million tons of cargo in the year 1969/70, far exceeding its normal cargo handling capacity and resulting in the delay of berthing and congestion of cargo traffic through the port. In order to cope with this situation, the need for the expansion of port facilities is very urgent. However, the expansion of the present Karachi has a limit and therefore, it is essential to develop a new port which is capable of meeting the need of new transport system of the future.

As it is necessary to locate waterfront industries commensurating with the expansion of the economy in West Pakistan and start construction of the industrial complex in 1975 at the latest, it is essential to step up efforts for providing basic facilities for this purpose as early as possible.

4. For these reasons, there is urgent need to construct a new port with a water depth (−)42 feet and a capacity several times larger than that of the present Karachi Port to accommodate ships of the 50,000 D/W class and provide an industrial estate with a total area of more than 1,000 hectares.

5. As for the site of port construction, three locations, namely Western Backwater of Karachi Harbour, Sonmiani and the Phitti Creek, have been suggested.

As a result of a study on the maintenance of the required depth of approach channel and anchorage, an important factor for the construction of a deep-water port, on the basis of the report by H.R.S. and others, it was concluded that a depth of 42 feet can be maintained at the Phitti Creek, that there is need of providing large scale maintenance dredging at Karachi Port and that the maintenance of a deep approach channel and anchorage is extremely difficult at Sonmiani.

In addition to the hydrological factors, the three proposed sites have also been compared with regard to the following:–

(1) Availability of land for port oriented industries

(2) Inland transport links

(3) Relation with the existing cities

(4) Effect on regional development

(5) Air and water pollution

(6) Availability of industrial water, power, gas etc.

(7) Future expansion of the port

(8) Construction cost

The comparison shows that Phitti Creek excels the Western Backwater of Karachi Harbour and Sonmiani. The second choice will be Western Backwater and the last will be Sonmiani.

6. The scope of Phitti Creek Port should be such that it will have a reasonable share with Karachi Port in handling cargo. Phitti Creek Port is to handle mainly bulk cargo and petroleum products and is to handle 3.6 million tons of cargo based on traffic forecasts for the plan year 1974/75 and 26.2 million tons of cargo for the year 1984/85.

Under the short-term plan (target year of 1974/75) for Phitti Creek Port, a 20,000 D/W class wharf (a depth of –34 feet) with 5 berths and related cargo handling equipment, silos and sheds are to be provided at Khiprianwala Island. For navigation of ships, dredging is to be provided to maintain a channel with a depth of –27 feet and a width of 600 feet.

In order to provide communication between Khiprianwala Island and Korangi Mainland, construction of a four-lane road bridge (also carrying industrial water main and power transmission lines) with a clearance of 12 feet over the Korangi Creek is to be planned.

Under the long-term plan (target year of 1984/85) for Phitti Creek Port, deep-water wharves for ships of the 50,000 D/W class (with a depth of –42 feet) with 6 berths, wharves for ships of the 20,000 D/W class (with a depth of –34 feet) with 14 berths and related cargo handling equipment, silos and sheds are to be provided at Khiprianwala and Bundal Islands. Also, a plan is to be worked out to make approximately 920 hectare of land available for industrial complex and 513 hectare of land for port-related facilities.

For navigation of ships, dredging of a channel with a depth of –42 feet and a width of 900 feet is to be planned.

The road bridge is to have additional 4 lanes, and construction of a double-track railraod bridge and an oil pipeline in parallel with the road bridge is to be planned.

The cost of construction required under the project is as follows:

Rs (crores)

	Total	Local Currency	Foreign Currency
Short-term plan	16.76	6.64	10.12
Long-term plan	67.74	29.28	38.46

The amount of initial dredging of the channel and estimated amount of annual maintenance dredging under the short-term plan and long-term plan respectively are shown below.

	Initial dredging of channel	Annual maintenance dredging of channel
Short-term plan	2,580,000 m³ (–27 ft. x 600 ft.)	315,000 m³
Long-term plan	17,400,000 m³ (–42 ft. x 900 ft.)	553,000 m³

7. Economic analysis to determine economic feasibility of the port project was based on the following conditions.

(1) Business analysis was aimed to obtain cost-benefit ratio and internal rate of return.

(2) Port revenues were calculated on the basis of the present wharfage for Karachi Port and additional benefit derived from quick turn-round of ships was added as a special rate.

(3) Port expenditures were calculated by taking into account the results of Karach Port.

The cost-benefit ratio (discount rate of 6%, with a study period of 30 years) thus obtained is 1.43 under the short-term plan and 1.99 under the long-term plan. The internal rate of return (with a study period of 30 years) obtained is 9.8% under the short-term plan and 13.5% under the long-term plan. From the above discussion, it may be concluded that the project is economically justified.

Prior to the implementation of this project, special attention must be paid to the following.

1. In planning construction of a deepwater port on the coast of West Pakistan which faces the Arabian Sea where there is intensive littoral drift, the question of how well the channel and anchorage can be maintained will decide the advisability of port construction.

In this connection, studies and investigations have been made on littoral drift for some time either by the Pakistan Government or K.P.T. and a tentative conclusion has been drawn for the Phitti Creek as a result of the survey by H.R.S.

However, it is extremely difficult to give a clear-cut answer to the question of littoral drift and therefore, studies and investigations will have to be continued also in the future.

It is also advisable to provide extensive soundings at the project site continuously and conduct an exploration including test diggings at the planned route of the channel at the same time.

In planning dredging of the approach channel to attain a depth of –42 feet after obtaining a depth of –27 feet, it is advisable to progress the work step by step and proceed to the next phase after making a full study of the progress of siltation instead of providing dredging straight out.

2. Although the plan contained in this report is based on the Fourth Five-Year Plan and Perspective Economic Plan presented to the team by the Government of Pakistan, it is necessary to adapt the plan to the future change in the economy and social conditions with flexibility.

As for the forecast of cargo traffic through ports, the survey team was provided with a Draft Report of E.I.U. by the Government of Pakistan. After a careful study of the report,

it was concluded that the estimate made by the team should be used without modification. It is recommended, however, that revisions be made to the estimate, as necessary, according to the changes in economic and social conditions or the future economic plans.

Though the planning of this project is based on the economic plans worked out by the Government of Pakistan, changes in economic and social conditions, which were not anticipated in the earlier plans, must be expected as a matter of course. The project planning, therefore, must not be rigid in nature but must be flexible so as to meet the future changes in economic and social conditions.

3. The plan contained in this report has been prepared by the Survey Team on the basis of the findings of a field survey conducted in January 1971. It is recommended that a detailed feasibility study be made on the continuous basis while giving due consideration to the future change in economic and social conditions.

4. In planning this project, due consideration was given to such related matters as the sharing of functions with Karachi Port and the development of Karachi Metropolitan Region, but it is important to make further efforts for coordination with such related organizations as K.P.T. and K.D.A. in the future.

5. Although the project plan calls for construction of a port equipped with modern and efficient facilities, it is of vital importance that a careful study is made on the type of port management body and operating method in order to obtain optimum results from these facilities.

6. In the financial analysis of the project, the period of redemption and rate of interest on the loan have been taken on the basis of the current rates generally used for loans and grants As these conditions are subject to changes in the course of time, the financial analysis should be carried out under different conditions as and when such changes occur.

The rate of wharfage for Phitti Creek Port has been determined mainly on the basis of the rates used at Karachi Port. However, Phitti Creek Port is a deep-water port with a primary purpose of handling bulk cargo and cannot necessarily be compared with Karachi Port in this respect. It is important, therefore, that a comprehensive study is made on the type of cargo, the merit of quick turn-round of ships and cargo and the advantage of larger ships to be used in future so that rational wharfage rates could be calculated.

PART I

NEED FOR A NEW HARBOUR IN PAKISTAN

PART I. NEED FOR A NEW HARBOUR IN WEST PAKISTAN

Chapter 1. Estimate of Cargo Traffic through West Pakistan Ports

In the year 1969/70 Pakistan's population was 132 million and its Gross National Product (GNP) was Rs. 7,500 crores (current cost). The population has been increasing constantly every year at a remarkable rate of around 3% on the average over the past ten years. To elevate the standards of living and promote the welfare of the people, the Pakistan Government has prepared three economic development plans so far. The current economic development plan is the Fourth Five-Year Plan, which started in the year 1970/71 and aims at attaining its objectives in the year 1974/75, providing guidelines for the economic policy of the country. Under the Fourth Five-Year Economic Plan the population in the year 1974/75 is estimated at 151.5 million. The Plan calls for stepped-up efforts for industrialisation of domestic economy as well as expansion of agriculture which has been the center of nation's industry with a view of increasing the GNP to Rs. 10,900 crores (current cost) in the year 1974/75, about 1.4 times the GNP for the year 1969/70. For this reason, the Fourth Five-Year Plan lays down objectives for political, economic social and industrial developments, and provides measures required for attaining these objectives.

(cf. APPENDIX 1-1, 1-2)

As the manifestation of the objectives of Pakistan's economic program for the period following the year 1974/75, a perspective plan aimed at attaining its goal in the year 1984/85 was prepared in parallel to the Third Five-Year Plan (announced in 1965). The perspective plan estimates the population of Pakistan in the year 1984/85 at 187 million and aims at attaining economic self-sufficiency by elevating the standards of living fourfold compared with that in the planning stage and increasing the GNP to Rs. 18,100 crores in the year 1984/85.

(cf APPENDIX 1-3)

The survey team made the estimate of the volume of cargo traffic through West Pakistan ports for the year 1974/75 on the basis of the economic targets and guidelines for the Fourth Five-Year Plan prepared by the Pakistan Government. Though the estimate of the volume of cargo traffic through the ports in the year 1984/85 was made in accordance with the perspective plan, necessary guidelines required for the estimate were not available. For this reason, several assumptions had to be made for the estimation by the survey team.

Although the figures of the estimate on the volume of cargo traffic were to be checked against the EIU Report provided by the Pakistan Government, the said report was not ready by the time the present survey report was drafted. The main items assumed for the estimation of port transport demands for the year 1984/85, are as follows:

(1) The economy of West Pakistan in the year 1984/85 will be capable of attaining self-sufficiency in the supply of key commodities. For commodities which will still be short in supply, it will be necessary to depend on overseas markets for their supply.

(2) As to the breakdown of the estimate, export and import of wheat and rice are considered necessary because of the gap between supply and demand. Per-capita consumption of wheat in the year 1984/85 is estimated at 275 lbs. and that of rice at 60 lbs. It is also assumed that the production of both wheat and rice will increase at an annual rate of 5% in the 1975/80 period and at an annual rate of 3% in the 1981/85 period.

(3) For exports of cement, an increase of 50% over the year 1974/75 is estimated.

(4) Per-capita consumption of iron & steel in Pakistan in the year 1984/85 is estimated at 32 kg. Demand in West Pakistan, assumed to account for 2/3 of total demand in Pakistan, will be met fully by the production in West Pakistan. It is considered that coal, iron ore and iron scrap required for the production will be imported in the amount commensurate to the production scale.

(5) Export of sugar is estimated to be almost the same as that for the year 1974/75.

(6) Demands for nitrogenous and superphosphate fertilizer are assumed to be catered fully in finished goods by domestic industry. Raw materials required for their production and potassic fertilizer are assumed to be imported. Amount of import of fertilizers is estimated by taking into account the growth of agricultural production.

(7) Per-capita consumption of fuel in Pakistan in the year 1984/85 is estimated at 380 coal-kg, and 50% of this consumption is considered to be dependent on petroleum. It is assumed that the demand in West Pakistan will account for 3/4 of the total demand in Pakistan, which will be fully met by domestic refining of crude oil to be imported. Construction of petro-chemical plants commensurate to the production level of naphtha at the oil refinery is also considered.

(8) For cotton, transport demand is estimated from the difference between production and consumption. Consumption is expected to double by the year 1974/75, while the production is estimated by using an annual growth rate of 5% for the period from 1976 to 1980 and of 3% for the period from 1981 to 1985, which is the same for wheat and sugar.

(9) For cotton textile industry which is one of the key industries in West Pakistan, it is estimated that 50% of the total production will be exported.

Table 1 shows the cargo traffic through West Pakistan estimated on the above premises and assumptions. According to this table, the cargo traffic in the year 1974/75 will increase to 17.2 million tons, about 1.9 times that for the year 1969/70 and that in the year 1984/85 it will reach 34.1 million tons, about 3.4 times that for the year 1969/70.

(cf. APPENDIX 3-1, 3-2)

The previously-mentioned EIU's traffic forecast for the Karachi Port Expansion Feasibility Study (draft report) was made available to the survey team when this report was nearing completion. After studying figures in the forecast, it was concluded that the estimate on cargo traffic made by the survey team should be used for the current project without modification for the following reasons:

(1) that the EIU's Report is only a Draft Report which has not been approved by the Pakistan Government;

(2) that the forecast is made only on the dry cargo and no forecast is made on all cargo items;

(3) that the outlook for industry in West Pakistan given in the forecast is too pessimistic and as a result, production scale of key industries is held at low level;

(4) that the estimate on the exports of cement and wheat is too low; a more aggressive forecast should be made for the following reasons:

Cement industry (as is the case with textile industry) is a key industry in West Pakistan, its expansion must be planned strategically. For this purpose, positive efforts must be made to promote export to foreign countries.

As for wheat, export to East Pakistan should be promoted from the stand-point of preventing outflow of foreign exchange. If the worldwide trend of food shortage is taken into consideration, exports to South Asian countries and African countries can be expected to increase further.

(cf. APPENDIX 3-3)

Table 1. Summary of Cargo Traffic Forecast by Trade Flow 1969/70 ~ 1984/85

(in '000 tons)

	Total			Foreign						Coastal					
				Import			Export			Import			Export		
	1969~70	1974~75	1984~85	1969~70	1974~75	1984~85	1969~70	1974~75	1984~85	1969~70	1974~75	1984~85	1969~70	1974~75	1984~85
1. Dry Bulk															
1) Wheat	354	373	1,650	225.5	–	–	1.7	–	230	..	–	..	126.8	373	1,420
2) Rice	584.3	1,552	2,700	–	–	–	103.8	600	1,200	–	–	..	480.5	952	500
3) Molasses	136.3	150	150	–	–	–	136.2	150	150	..	–	..	0.1	–	–
4) Cement	665.7	2,000	3,000	0.6	..	–	253.7	1,000	1,500	–	–	–	411.4	1,000	1,500
5) Iron & Steel	337.9	1,595	400	334.7	1,595	400	–	–	–	3.2	–	–	–	–	–
6) Coal & Coke	84.1	710	2,730	84.1	710	2,730	–	–	–	–	–	–	–	–	–
7) Iron Ore	35.9	1,360	5,800	–	1,360	5,840	34.3*	–	–	–	–	–	16*	–	–
8) Sugar	26.5	285	200	–	–	–	–	184	200	–	–	–	26.5	31	–
9) Fertilizer	696.4	396	1,150	687.6	396	710	–	–	440	–	–	–	8.8	–	–
10) Miscellaneous	218.9	220	280	–	–	–	80.4	80	100	27.9	30	70	110.6	110	110
11) Intransit Afghanistan Cargo (Wheat)	55.1	60	120	55.1	60	120	–	–	–	–	–	–	–	–	–
12) Total	(3,195.1)	(8,631)	(17,680)	(1,387.6)	(4,181)	(9,760)	(610.1)	(2,014)	(4,320)	(31.1)	(30)	(70)	(1,166.3)	(2,466)	(3,530)
2. Oil															
1) Crude Oil	3,300.8	5,200	11,600	3,300.8	5,200	11,600	..	–	–	–	–	–	–	–	–
2) Petroleum Products	687.5	340	–	1.0	–	–	678.7	340	..	–	–	–	7.8	–	–
3) Total	(3,988.3)	(5,540)	(11,600)	(3,301.8)	(5,200)	(11,600)	(678.7)	(340)	..	–	–	–	(7.8)	–	–
3. General															
1) Cotton	185.1	445	510	–	–	–	102.9	235	90	–	–	–	82.2	210	420
2) Textile	132.1	160	320	–	–	–	111.4**	160	320	–	–	–	20.7**	..	–
3) Miscellaneous	1,728.1	2,190	3,570	813.1	1,050	1,500	359.2	470	900	289.3	330	500	266.5	370	670
4) Intransit Afghanistan Cargo	110.2	190	330	110.2	190	330	–	–	–	–	–	–	–	–	–
5) Total	(2,155.5)	(2,985)	(4,730)	(923.3)	(1,240)	(1,830)	(573.5)	(865)	(1,310)	(289.3)	(330)	(500)	(369.4)	(550)	(1,090)
4. Grand Total	(9,338.9)	(17,156)	(34,010)	(5,612.7)	(10,561)	(23,190)	(1,862.3)	(3,219)	(5,630)	(320.4)	(360)	(570)	(1,543.5)	(3,016)	(4,620)

Notes: 1. Figures marked with * include the volume of ore other than iron-ore.
2. Figures for textile include only figures for cotton textile, except the figures marked with ** which include other textiles.

Chapter 2. Present State and Limitations of Karachi Port

The Port of Karachi has grown as the only major port in West Pakistan; cargo traffic through the port in the year 1969/70 amounted to 9.3 million tons and the number of ships entering the port in the same period reached 1,600. The cargo traffic through the Port of Karachi is increasing rapidly and has almost doubled in every ten years since the year 1949/50.

The berthing facilities that cater for this cargo traffic include three oil berths, deep-water wharves (28′ to 34′ in depth) with 24 berths and a lighterage wharf 4,235 feet long (8′ to 24′ in depth). Besides, there are 13 mooring buoys. General cargo other than petroleum is handled mainly at the deep-water wharves with 24 berths. The total length of these wharves is 10,022 feet (under operation in 1969/70), and the total volume of cargo being handled at these wharves alone amounts to 550 tons per foot.

As for utilisation of berthing facilities, the rate of occupancy of the quay is 110% on the average (in the year 1969/70) and sometimes more than two ships have to be moored side by side at the same berth.

(cf. APPENDIX 6-1, 6-2)

As is evident from the pervious discussion, facilities of Karachi Port are being used to the maximum extent. Judging from the fact that the volume of cargo handled at the quay amounts to 550 t/ft. and in view of the condition of cargo handling equipment, it is certain that the actual handling of cargo at the quay has reached the level nearly twice the normal capacity of 300 t/ft.

The facts that the occupancy of mooring facilities shows an abnormally high rate of 110% and that a ship entering the port has to wait at anchor for its turn for an average period of 35 hours (recorded in the year 1969/70) clearly indicate inadequacy of facilities. Average waiting time for the year 1966/67 has been as much as 106 hours.

Under these conditions, there is no more room in the capacity of facilities at Karachi Port. Unless measures are taken to expand the capacity of the port immediately, there is a possibility that only a small increase in the volume of cargo traffic will cause a total confusion at the port. The adverse effect of this on the economy of Pakistan in the form of higher freight costs cannot be over emphasized. For example, taking an average figure of $2,000 per day as operating cost of a ship, the ships demurrage for the year 1969/70 alone have been in the order of $4.7 million equivalent to loss of 2,330 ship-days.

Adequate equipment required for handling a large quantity of bulk cargo is also not provided. The shed and open storage yard also lack sufficient floor space. This situation may be unavoidable in the case of an old port, but it certainly hampers smooth flow of cargo traffic through the port.

A study of the history and the present state of Karachi Port from a hydrographical point of view leads to a conclusion that the required depth of water at Karachi Port has been maintained partly by the storage effect of the Western and Eastern Backwaters.

The approach channel for large ships carrying raw materials for heavy and chemical industries must have a certain depth, but the maintenance of a required water depth for the channel, particularly at the harbour entrance, will be difficult in this case from a hydrographical point of view if reclamation is allowed on a large scale. This aspect is further discussed in Part IV.

Thus reclamation of the backwater area for the future expansion of port facilities will have to be restricted considerably. The above fact may not be a major problem in the construction of piers of a certain size but will certainly present a serious problem for the construction of a large pier in the future.

The Western Backwater occupies a fairly large surface area. However, since reclamation of backwater area will present hydrological problems, use of land existing behind the waterline will be unavoidable for locating heavy and chemical industries. In the sea area behind the waterline, where the city area and military zone occupy a large portion, the availability of land for industrial purposes is very limited. Therefore, location of big industries or expansion of plant facilities on a large scale will be quite difficult.

Moreover, if heavy and chemical industries are located in the Western backwater area, there is a possibility of causing air pollution in the city area of Karachi or the Manora resort area, an oasis for the city people, by the effect of the monsoon.

If the industrial location is to be planned as part of the port construction project, considerable amount of pollutants are expected to be discharged from industrial plants even though strong anti-pollution measures are taken by the industries. As the present Karachi Port has only one outlet, addition of industrial waste water to the existing city sewage and used oils dumped from ships will further aggravated the pollution of the present Karachi Port to a very serious point.

As far as inland transportation from and to Karachi Port is concerned, the Port area is situated southwest of Karachi City and borders directly on the city area. I.I. Chundrigar and Maulvi Tamizuddin Khan Roads linked to the National Highway. Mauripur Road linked to the RCD and Super Highways, M.A. Jinnah Road which runs through the center of the City and Harris Road converge in one point near the gate of the Karachi Port. For this reason, the area near the gate of the port is extremely congested with traffic of trucks originating in Karachi Port and also with city traffic. All the roads on which the traffic of trucks originating in Karachi Port is dependent, are routed through the congested city area except Mauripur Road (this also has the disadvantage of level-crossing with railways). When the future increase of city traffic is taken into consideration, the situation of transport by trucks originating in Karachi Port is expected to be worsened further.

The railways from Karachi Port connect to the main railway line in the east and to the Circular Railway in the north. Although the main railway line is double-track and there is still room in overall transport capacity, the marshalling yards for freight cars lacks in capacity. The Circular Railway is single-track and used almost entirely for local passenger trains. The passenger transport accounts for 70% of the total volume of transportation on it. When the future increase in the number of commuters is taken into consideration, it is very doubtful whether the existing railways will be able to meet adequately the increase in the cargo traffic.

(cf. APPENDIX 5-4)

Furthermore, there is no possibility of developing on inland waterway system for West Pakistan if Karachi remains the only port.

To sum up, the present port of Karachi is faced by the following problems:–

1) Lack of berthing capacity
2) Lack of bulk cargo handling capacity
3) Lack of storage capacity

4) Proximity to down-town area
5) Road congestion
6) Railway congestion
7) Hydraulic problems
8) Lack of enough land for port-oriented industries
9) Air pollution
10) Harbour pollution
11) Shipping congestion
12) Unfavourable sea approach conditions

Chapter 3. The Outlook for Port-Oriented Industries

Concerning the future industrial location in West Pakistan, appropriate distribution of industries in the inland area is considered essential for the balanced development of this vast country. However, there are some industries, location of which in the inland area is not appropriate or totally impossible because of their nature and therefore has to be founded in the waterfronts.

Some of the factors which necessitates the location of industries on waterfronts are as follows:

(1) Industries which depend largely on overseas supply of raw materials and are dependent on marine transportation.

(2) Industries which require a large quantity of plant water and derive benefit by using sea water as cooling water.

(3) Industries which depend largely on overseas supply of raw materials and export most of their products to overseas markets.

(4) Such industries as ship-building industries which are directly related to the sea.

In the future industrial location in West Pakistan, main industries that come under the aforementioned category are oil-refining, petro-chemical, iron and steel, ship-building and thermal power industries. The textile industry which is now importing raw yarn to be woven into cloth also comes under this category. However, with the improvement of spinning technology in the future, the need of locating this industry in the waterfront will be lessened.

Table 2 shows the type and scale of industries, location of which in the waterfront in the year 1984/85 is considered appropriate. The conditions and assumptions used for this estimate have already been discussed previously.

(cf. APPENDIX 2-3)

Table 2. Type & Scale of Industries

Type of Industry	Production Scale
Oil refinery	250,000 barrels per day
Petro-chemical plant	200,000 tons (Ethylene per year)
Steel mill	4,000,000 tons (Crude steel)
Thermal power station	500,000 kW
Shipyard	5,000 ~ 20,000 G/T (Capacity of dock)
Steel-related industries	(Steel pipe, machinery, ferro-chemical, etc.)
Petro-related industries	(Synthetic resin, Synthetic detergent, etc.)

Besides these, the industries that are not covered by this project but are likely to be located in the waterfront are non-ferrous metal industry including aluminium refining and processing industry, food industry including canning industry and lumber processing industry.

Chapter 4. The Need for a New Harbour

As previously stated in Chapter 1, cargo traffic through ports in West Pakistan is expected to increase rapidly centering on bulk cargo and petroleum with the expansion of the national economy. Consequently, smooth cargo traffic through the ports and the establishment of a water front industrial complex will be the key to the future growth of the economy in West Pakistan.

For this reason, it is essential for West Pakistan to be provided with a harbour which is equipped with facilities of a sufficient water depth and a capacity several times greater than that of the present Karachi Port, and with an industrial complex directly related to the port.

In planning the construction of a harbour and the establishment of an industrial complex it is essential that the following requirements are fulfilled.

(1) Construction of harbour facilities capable of handling cargo traffic which is expected to increase to 17.2 million tons in the year 1974/75 and further jump to 34 million tons in the year 1984/85 with the expansion of the economy in West Pakistan.

(2) Securing a large water depth to the extent possible in order to minimize the cost of marine transportation in view of the ever increasing cargo traffic.

(3) Installation of large efficient bulk cargo handling equipment and construction of corresponding cargo storage facilities in order to minimise the cost of cargo handling at the port.

(4) Procurement of land covering an area of 1,000 hectare (2,500 acres) or more for the establishment of an industrial complex directly related to the port.

(5) Construction of roads, railway lines, and fuel pipelines in order to secure inland transportation fully capable of meeting traffic demands originating in the port and waterfront industrial complex.

(6) Securing additional land space and water basin in order to meet with flexibility, the future expansion of traffic demands and transportation innovation.

To fulfill the above requirements, development of the Western Backwater area of Karachi is also conceivable. For the development of this area, however, a solution must be provided to such major questions as inland transport, availability of land, environment pollution and future expansion of facilities. In addition, the increase of water depth in the harbour beyond the present level is also considered difficult.

To expand the economy of West Pakistan, therefore, it is essential to provide a large harbour at a place other than Karachi.

A series of studies and surveys have been made of Sonmiani Bay as an alternative harbour construction site. Our study of Sonmiani, however, shows that this site lacks qualifications to fulfill various requirements of a new harbour and therefore is not considered suitable for port construction. Our reasons are given in Part IV.

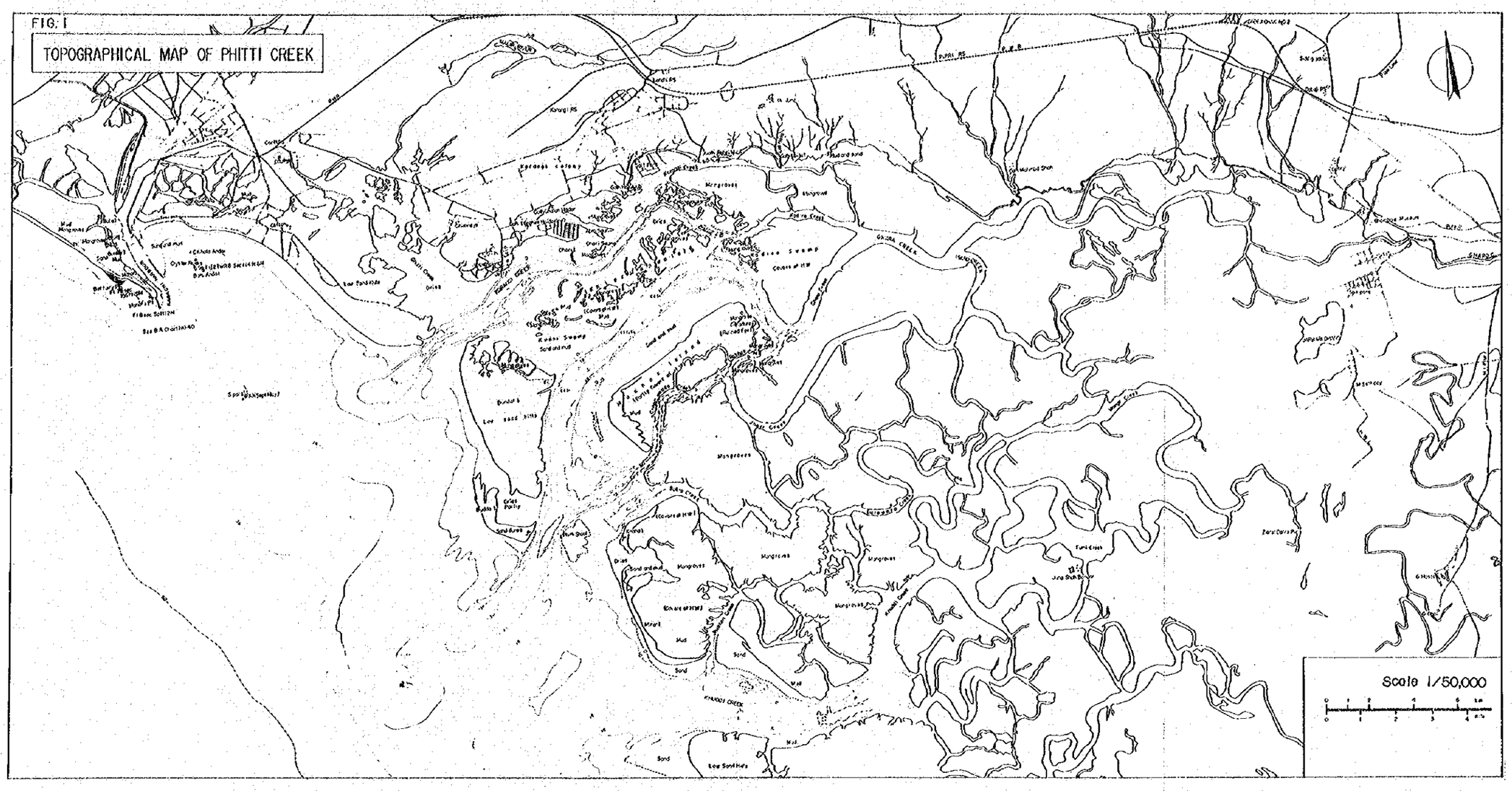
As far as the third site, namely, Phitti Creek is concerned, a fairly deep approach channel with minimum depth of 20 feet below datum (against minimum depth of 4 feet at Sonmiani) and an anchorage and harbour channel with large depths are already available. Preliminary studies on the maintenance of approach channel and anchorage at Phitti Creek against siltation have shown encouraging results. In addition, this site is considered qualified to fulfill various requirements of a new port and suitable for port construction.

PART II

A STUDY OF GEOGRAPHICAL CONDITIONS OF PHITTI CREEK

FIG. 1

TOPOGRAPHICAL MAP OF PHITTI CREEK



2. Topography

The Phitti Creek cuts into the land from the open sea in the direction of NNE, curves to the north in the vicinity of Buddo Island (sand dunes) and further bends to the northeast at a point about 5 miles from the first curve, forming a gentle S-shape. The distance from Buddo Island to the Kadiro Swamp, the deepest section on its extension, is approximately 10 miles. There is a wide sand bar at a depth of 20 feet in front of the mouth of the creek near Buddo Island and the depth greater than 20 feet is seen only beyond a point 7 miles from there.

The width of the Phitti Creek is about 1.0 miles between the contours of DL ± 0 near the mouth and about 0.6 mile between −20 feet contours. Within the creek the width is 1,500 feet to 2,500 feet between −20 feet contours. The creek has a maximum depth of 60 feet and the total surface area having a depth greater than 20 feet is about 3.7 sq. miles. Entrance of ships of the 3,000 D/W class is possible even today at all stages of tides and the entrance of ships of the 5,000 D/W class will be practical with the help of high tide. During fair weather, ships of upto 8,000 D/W can enter Phitti Creek on a Spring High Water. To the north of the creek, there is a chain of islands – Buddo Island, Bundal Island and Khiprianwal Island. These islands are either sand banks or swamps, part of which become submerged under water at high tide. Vegetation of mangrove becomes thicker toward the innermost of the creek; there is a dense wood of mangrove in and around the proposed site. The elevation of the island is approximately 0 to 10 feet. To the south, there is Muchak Island, the elevation of which is lower than the proposed site. In front of Muchak Island extends a vast swamp with a width of about one mile, which dries up at low tide.

The Phitti Creek has a long stretch from its mouth to the innermost section, and because of its curved section with a good sheltering effect, it provides a clam anchorage in its inward section. The Karangi Creek is connected to the Phitti Creek through Kadiro Creek which has a least depth of 9 feet below datum. Accordingly, ships of less than 8 feet in draft are able to navigate as far as the Korangi Creek via the Kadiro Creek at all stages of tides.

3. Geological Features

Soil exploration of the entire area of the Phitti Creek has not yet been conducted. However, boring had already been begun at key points before the survey by the team and part of the results was examined by the team at the site. A summary of boring data which were obtained from the subsequent boring is shown in Appendix 12.

According to the boring data, it may be said that in general the surface layer extending to a depth of −30 feet to −40 feet from the present surface of foundation consists of ordinary sand with the N value of 10 to 30. The thickness of the surface layer is 20 feet on the average. Below the surface layer is a clay layer extending to a depth of −70 feet to −100 feet. Further below there is a dense sand or gravel layer. These layers are considered to have sufficient bearing power as a foundation of structures.

Since no test results are available on the nature of intermediate clay layer, an accurate judgment cannot be made on such aspects as shearing strength and consolidation. Judging from the results of penetration tests, however, installation of such light structures as steel sheet pile quaywall and landing stage is considered possible without providing any special treatment to the foundation because of the hard and compact supporting layer at the bottom. The sand in the surface layer can be dredged easily with conventional suction dredgers. The dredged sand may be used for filling-up land.

4. Meteorology

(a) General

The climate in the north of the Arabian Sea where the Phitti Creek lies is featured by the southwest monsoon in summer and the northeast monsoon in winter. During the May ~ October period the southwest monsoon is predominant with high humidity and strong sunlights. In the November ~ April period the northeast monsoon prevails, lowering the temperature and mitigating the heat to some extent. In the southwest monsoon, strong wind blows, sometimes recording the Beaufort scale of 6 to 7. The annual rainfall is not sufficient for the growth of vegetation.

(b) Temperature

There are small seasonal fluctuations of temperature. The temperature is lowest in January ranging from 82°F to 51°F and is highest in May ranging from 96°F to 75°F.

(c) Rainfall

In general there is very little rainfall along the coast of West Pakistan and the number of rainy days is also small. The months in which rainfall occurs more than once number only four: January, February, July and August. Annual precipitation is about 8 inches and the number of rainy days through the year is less than 10.

(d) Visibility

The number of days with clouds is small and the visibility is fair throughout the year. The visibility data for each month is shown in Table 21.

(e) Wind

Within a range of 800 miles to the west along the coast the occurrence of gales is not frequent. The gales occurring within a range of 150 miles from Karachi accounts for only 5% of the total occurrence observed at Karachi. The occurrence of gales is most frequent in the southwest monsoon season of June and July. From November to May the northeastern monsoon prevails, bringing winds with mean wind force of 2 in the Beaufort scale, and the mean wind force during the May ~ September period reaches the Beaufort scale of 4 to 5. Wind data for Karachi is shown in Table 22. As is evident from the table, winds with the Beaufort scale of more than 8 are seldom experienced.

According to the statistics on cyclonic storms in the Arabian Sea during the period from 1881 to 1949, cyclonic storms occur in the months of April, May, June, October, November and December. The occurrence per year is less than two on the average. A record shows considerable damages caused by a cyclonic storm which hit Karachi in 1902.

5. Tide and Tidal Current

The tidal range at Karachi Port is 10.1 feet at the equinoctial spring tides (−0.7 feet to +9.4 feet). The theoretical maximum astronomical tide is +11.9 feet. The tide at Karachi Port is more of the diurnal tide rather than the semidiurnal tide with different phases between them, and shows a large variation in continuous high tide levels. Tides in the Phitti Creeks system are similar to Karachi Harbour. At Bundal Island (entrance to Phitti Creek), tides are slightly higher than Karachi by a factor of 1.1 and reach Bundal Island after 10 minutes from Karachi.

The velocity of the tidal current at a point 3,000 feet off the tip of Monara Breakwater

at Karachi Port is 1 and 1/4 knots in the direction of east at normal tidal range. The tidal current becomes weak as go further off from this point and decreases to about 1/2 knots at a point 2 miles off this point. At the entrance to Karachi Port the tidal current develops a speed of about 1.3 knots at flood tide. At the Phitti Creek continuous observation of the tidal current has been maintained at the stations located in and out of the creek. The velocity of tidal current in front of the proposed port construction site is about 2.0 knots (3.5 ft./s) at the maximum and average 1.2 knots, and that of tidal current outside the entrance to the creek is less than one knot. Although the direction of the tidal current deviates from that of the proposed alignment of approach channel by about 32°, it does not seem to present any problem for navigation.

6. Waves

Waves along the coast of West Pakistan including the Phitti Creek are under the influence of the monsoon as in the case of winds. During the NE monsoon season the sea is generally calm and during the SW monsoon season waves are constantly high.

Observations of waves were made intermittently off Karachi Port during the period from December 1968 to August 1971 with pressure type wave recorders and a buoy type recorder.

The monthly means of the significant wave height and period during the observation period obtained from the observation data are shown in Fig. 2. Due to the fact that the observation period was relatively short and intermittent and that the type of wave recorders and the locations of the wave recorders changed several times, the results are not sufficient as statistical data. The figure shows, however, that the mean significant wave height exceeds one meter during the May ~ September period and that it reaches about 2.5 m at the peak of the June ~ July period. The wave period, meanwhile, is around 8 sec. on the monthly average during the SW monsoon season when the sea is rough and 10 to 13 seconds during the NE monsoon season when the sea is calm. In other words, waves during the SW monsoon season represent wind waves and those in the NE monsoon season represent swels.

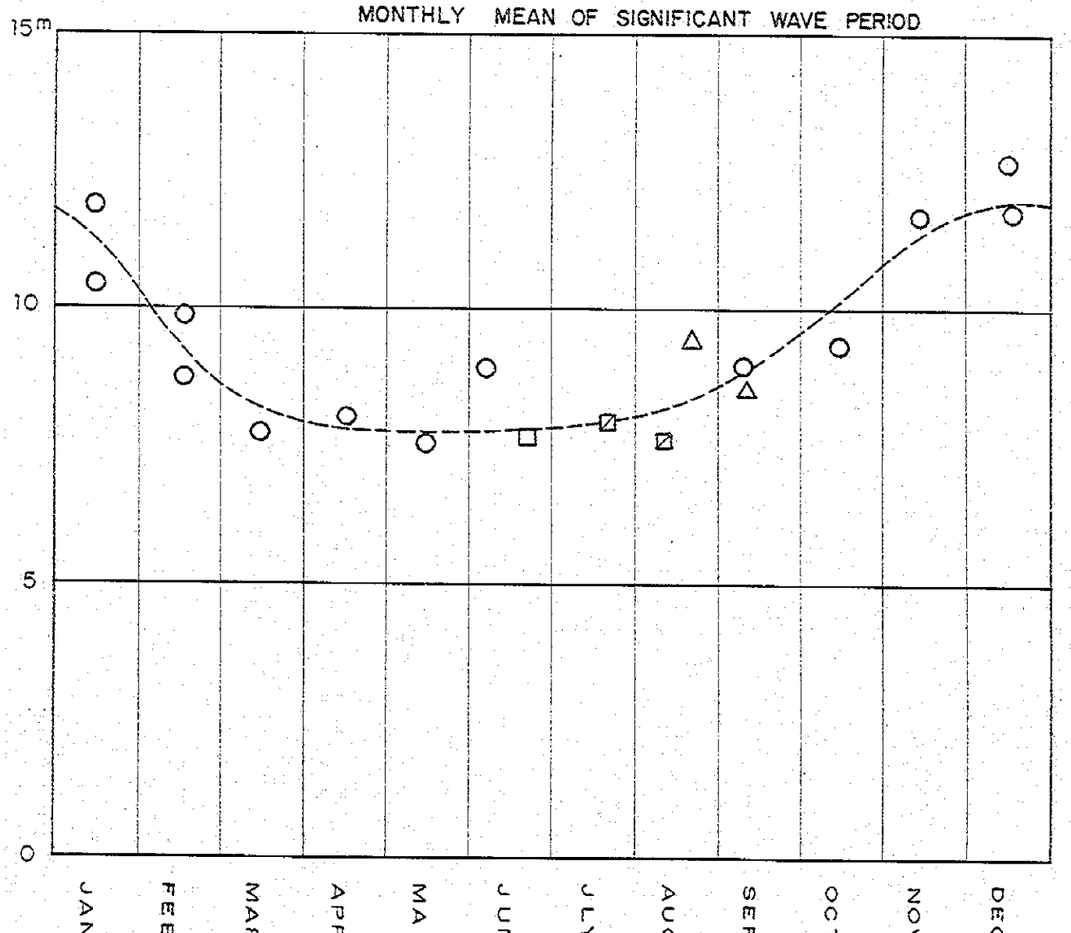
As for the wave direction, the Pakistani Navy recorded the wave direction twice daily at PNS HIMALAYA when a Wave Rider Buoy was anchored at a point approximately 50 km off the shore during the wave observation period from June 9 ~ July 11, 1971.

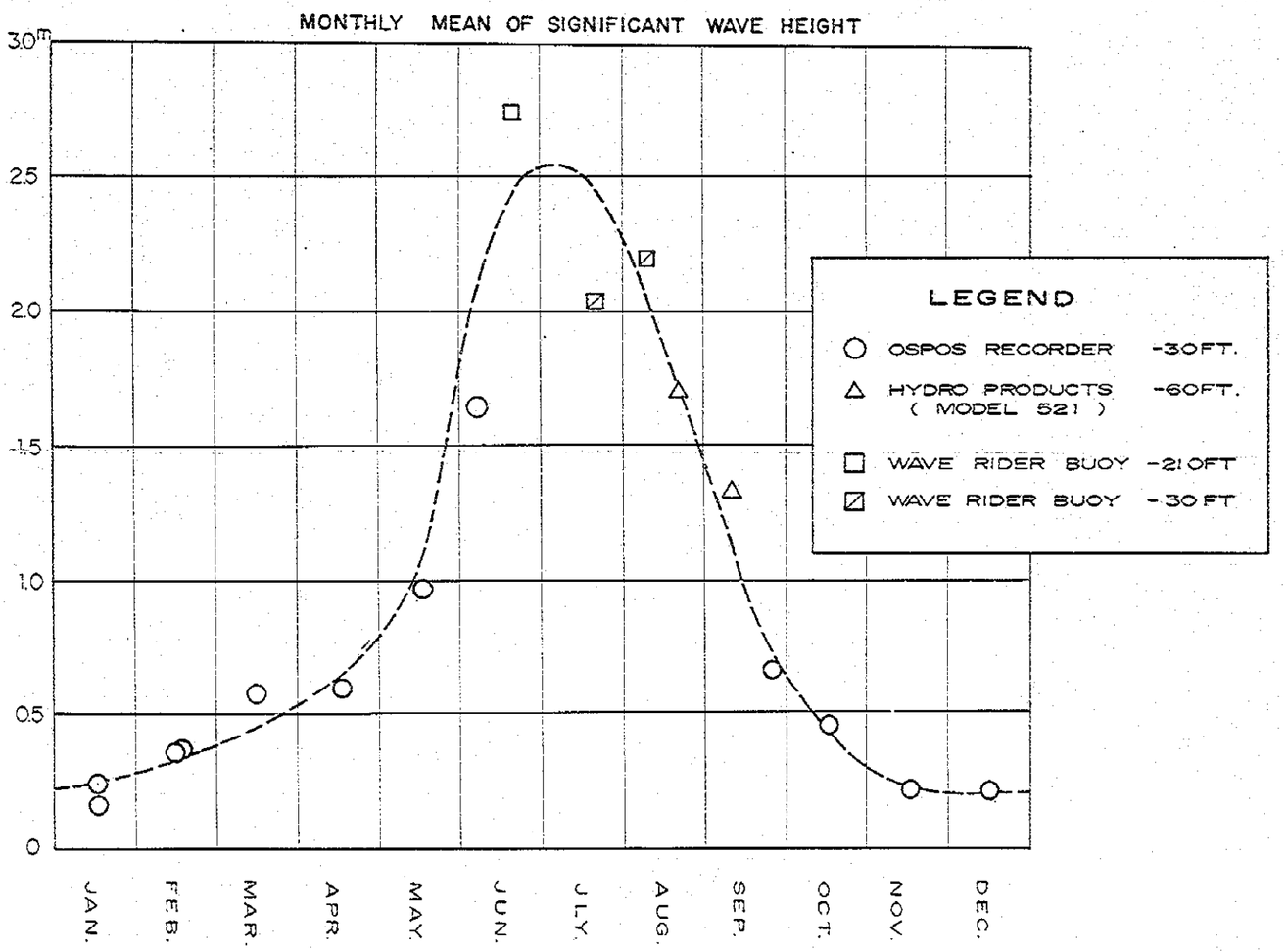
According to this record, the wave direction is within the range of 215° ~ 242° and the mean wave direction is about 237°.

The maximum wave height during the observation was ($H_{1/3}$) max. = 4.2 m which was recorded at 20:00 hrs., June 29, 1971. However, when the facts that the fetch is relatively long in the Arabian Sea, that a strong wind blow continuously during the monsoon season and that the wave height observed by ships is great, as will be discussed at a later stage, are taken into consideration, waves of the significant height of 5 to 6 m are expected during a heavy storm.

One of the characteristics of waves during the SW monsoon season is that once waves become high, the same condition lasts for many days. For example, the record of wave observation with a Wave Rider Buoy during a period of 33 days from June 9 to July 11, 1971 shows the minimum wave height of ($H_{1/3}$) = 1.7 m and that the significant wave height obtained from the observation conducted 6 times a day came below 2.0 m only in three days out of a total of 33 days. The wave characteristics around the mouth of the Phitti Creek is considered not to differ greatly from that off Karachi Port. For the inner basin of the Phitti

Fig. 2 WAVE OBSERVATION DATA OFF KARACHI COAST.





Creek, the wave height is considered to be fairly small because of the constructed mouth and curved section of the creek. Such a distribution of wave height was also recognized from the aerial photographs of this region taken during the SW monsoon season. Also, sounding of the creek, tidal current observation and other surveys were conducted during the SW monsoon season of 1970. This indicates the fact that the operation of a small boat for observation purpose was possible and the wave height inside the creek was relatively small.

The Hydraulic Research Station, Wallingford, England, meanwhile, has summarized data obtained from visual observations of waves by ships navigating in the area in lat. 10° ~ 20°N and long. 60° ~ 70° (Marsden Square 66) as the basic data required for estimating the amount of littoral drift along the coast from Karachi Port to the Phitti Creek. According to this data, the occurrence probability of waves with a wave period of 5.5 ~ 15.5 seconds during the May ~ September period is 16.7% within the range of 195° ~ 225° wave direction, 40.7% within the range of 225° ~ 255° and 15.7% for the range of 195° ~ 225° (the remainder is mainly for waves with a period of less than 5.5 seconds and waves with other wave directions). The significant wave heights within the range of 255° ~ 285° wind direction with the exceedance probability of 1%, 10% and 50% are about 8 m, 5.5 m, and 4 m, respectively. Since the wave direction and wave height vary by the effects of wave refraction and frictional damping at the sea bottom by the time waves move from the Marsden Square 66 to the coast of Karachi, the Hydraulic Research Station estimates the wave characteristics along the coast of Karachi by taking into account such effects for calculation. As the wave characteristics thus estimated have not been listed in its report, the reliability of the estimation cannot be determined. It seems, however, that the estimation takes slightly greater values for both the wave height and the wave period than the measured values.

7. Littoral Drift

The littoral drift along the coast of West Pakistan is influenced by waves during the SW monsoon season and the eastward littoral transport is predominant generally to the west of Karachi Port. However, the littoral drift between the entrance to Karachi Port and the Phitti – Khuddi Creeks shows many complicated changes under the influence of local geographical features. According to the report EX557 (1971) by the Hydraulic Research Station, the northward littoral transport is predominant off the central section of Bundal Island and to the north of the Island and the southward littoral transport is predominant up to halfway between the northern approach channel and the southern approach channel. To further south, it is said that littoral transport changes its course to the north. As littoral transport changes its direction to the north or the south according to the wave direction, the amount of littoral drift which silts up the dredged channel is equal to the total amount of littoral drift moving in both directions. The total amount of littoral drift is estimated at about 1.2 million cubic yard per year for each of the northern approach channel and the southern approach channel.

This estimate represents the amount of bed materials carried along the shore within the breaker zone. As has been discussed in the planning of a new harbour for the Phitti Creek, dredging of an approach channel in the open sea with a greater depth may also result in silting up of a channel in the offshore outside the breaker zone. This is because the bed materials are constantly moved around by waves also in the offshore and the motion decreases in magnitude as the depth of water becomes greater. The Report EX575 by the Hydraulic Research Station estimates that the amount of sediment silting up in the approach channel dredged to a depth of –42 feet will be about 7.2 million tons per year for the northern approach channel and about 960,000 tons per year for the southern approach channel. On the basis of these sedimentation studies, the H.R.S. have recommended that the southern bar channel should be developed as approach channel to the Phitti Creek.

Chapter 2. Hydraulic Feasibility of Constructing a New Port at the Phitti Creek

1. Previous Hydraulic Studies of the Phitti Creek

In July 1969, the Government of Pakistan requested the Hydraulic Research Station, Wallingford, England to conduct a study on the hydraulic feasibility of constructing a new deep-water port in the region of the Phitti Creek. The Hydraulic Research Station submitted a report in September 1969 on the basis of hydrographic surveys during the period of 1848 to 1968, a limited amount of field measurement data, and other relevant documents. The report, entitled "Phitti-Jhari Creek" and numbered EX461, concluded that the construction of a deep-water port in the Phitti Creek is, in principle, feasible.

The report also recommended the collection of field data as an essential pre-requisite of sound engineering judgement.

The field data collection was subsequently carried out by the Hydrographic Directorate of the Pakistan Navy, during the NE monsoon season of 1969/70 and the SW monsoon of 1970. Under the request of the Government of Pakistan, the Hydraulics Research Station undertook the analysis of the data so collected. The Station submitted an interim report in July 1970 discussing data from the NE monsoon only and a report in May 1971 discussing the analysis of data of both NE and SW monsoon seasons as well as the application of wave refraction study for the coast from Karachi to the Phitti Creek; the report was entitled "Phitti Creek: field survey and wave refraction study" and numbered EX557.

In this report, the Hydraulics Research Station has given the following views and recommendations:

(1) A training wall between Khiprianwala and Bundal Islands is not initially necessary because the area shows evidence of stability over a century.

(2) It is recommended that the Korangi Creek should be crossed by an open bridge, because the closure of the Korangi Creek will increase the flow through the Phitti Creek by some 30% and the increase is almost certain to be accompanied by substantial channel re-alignment.

(3) No measures are necessary to stabilize adjacent creeks, but maintenance of a regular survey programme is recommended.

(4) A training wall extending to the crest of the bar for a length of some 5 miles should be viewed as a last resort in case when the natural rate of infill of a dredged channel is found excessive, and investigation of the siltation rate of exposed channel should be pursued first.

(5) In the absence of training works, the Southern Approach Channel appears preferable to the Northern, because the shallower natural depths on the Northern alignment must lead to more breaking of waves, and consequently to more agitation of the bed material.

(6) A pilot cut to give temporary improvements of access depth should await the results of a limited trial dredging experiment.

The Hydraulic Research Station concludes the report EX557 as follows:–

"The success of the project appears now to depend on the question of siltation in the approaches. Further study of this will involve the collection of improved wave data; a more comprehensive calculation of the siltation rates; and trial dredging."

The calculation of siltation in the approach channels was consequently carried out by the Hydraulic Research Station, which submitted in October 1971 the report EX575 entitled "Phitti Creek: estimates of siltation in approach channels" and the report EX574 entitled "Karachi and adjacent coast: wave refraction diagrams and littoral drift calculation"; the latter report provides basic information of the former calculation. The contents of these reports will be discussed in Section 2.3, but it is pointed out here that one of conclusions of the report EX575 is such that any further investigation including trial dredging should concentrate on the Southern Channel because the Northern Channel would have excessively large rate of siltation compared to the Southern Channel.

2. **Stability of the Phitti Creek Channel**

The channels in the Phitti Creek are considered stable in the long-term period. The hydrographic surveys from 1848 to 1968 indicate that the location of the main channel has changed little although the outlet of channel has been gradually deepened and extended towards the offshore. It is also observed that the adjacent Chhan Waddo Creek is a completely new development since 1848.

In the short-term period, however, the channels in the Phitti Creek show considerable variations. The four hydrographic surveys from October 1968 to July 1970 reveal the existence of local variations of water depth more than 10 feet and horizontal movements of contours more than 250 feet in a period of several months. The surveys also show several patches of scouring and accretion more than 18 feet in one year. Such local variations of water depth in a short-term period are well expected because the bottom sediments consisting of sand are exposed to the strong current which varies its velocity from time to time with the tides. There is a possibility, however, that the above variations of water depth are due to scale effect as the comparison was made on the basis of charts of different scales varying from 1/25,000 to 1/10,000. This requires confirmation and, therefore, hydrographic surveys should be continued for proper alignment of navigation channel and basins so that the increased depth are maintained with the minimum of maintenance dredging.

The long-term stability of the main channel nevertheless favors the construction of wharves in the Phitti Creek. With layout and construction of wharves which will cause minimum disturbance of currents in the Phitti Creek, the problem of siltation in fairways and anchorages will not arise.

3. **Quantity of Maintenance Dredging in the Approach Channels**

In the report EX461 of 1969, the Hydraulics Research Station made a rough estimate of the magnitude of maintenance dredging, the results being in the order of 0.5 million cubic yards per year for the Northern Channel and 0.1 million cubic yards per year for the Southern Channel. In the report EX557 of May 1971, however, the Hydraulic Research Station discarded these estimates based on more refined calculations, stating that "this calculation was recognized to be founded on particularly inadequate assumptions" (refer to page 6), and gives the new order-of-magnitude prediction of infill rate of dredged channels as several million tons per year, discarding the estimates given in the 1969 Report. The report EX575 of October 1971 presents the following estimates as the results of detailed calculation: gross siltation quantities of 6.06 and 7.21 millions of tons per year for the Northern Channel at the channel depth of –24 feet and –42 feet, respectively, and of 0.49 and 0.96 millions of tons per year for the Southern Channel at the channel depth of –24 feet and –42 feet, respectively.

The prediction is strongly dependent on the accuracy of the offshore wave statistics, and

reliability of the equations to estimate sediment transport rate. The Hydraulics Research Station has estimated the wave statistics of the Phitti Creek on the basis of the ship observation data of waves in the Marsden Square 66 (60° ~ 70°E and 10° ~ 20°N) in combination with the calculations of wave refraction, wave attenuation by bottom friction, wave shoaling, and energy dissipation by wave breaking for wave transformation from the Square 66 to the Phitti Creek.

As to the equations for sediment transport rates, two methods are employed. One is for the sediment transport in the longshore direction in shallow water, which is regarded to be directly proportional to the longshore component of wave power. The other is for the infil rate into a channel, which is estimated by a new formula for sediment transport on a horizontal bed, derived from experiments in the Coastal Engineering Research Center of Washington, D.C.

The Hydraulics Research Station expresses the opinion that the results represent the best estimate of likely siltation that can be made with present knowledge of hydraulic science. Though the Survey Team agrees with the opinion, the team feels the difference between the quantities of siltation in the Northern and Southern Channels, the former being eight to twelve times the latter, rather excessive. The difference seems to have originated from different angles of wave approach to the channels and different depths of present seabed, but detailed examination is not possible because the details of calculation are not given. In any case, as the Hydraulic Research Station comments the figures quoted are rough estimates based on calculation with several presumptions and they may be well out by a factor of two or three. Thus the Hydraulic Research Station recommends the execution of some trial dredging in order to verify the findings, and the Survey Team agrees with the recommendation of the Hydraulics Research Station.

4. Necessity of Further Hydraulic Study

In the interim note which the Survey Team submitted in February 1971, the Survey Team pointed out several questions concerning hydraulic aspects of the project, stating that the Team shall expect these questions to be clearly answered by the final report to be submitted by the Hydraulic Research Station, Wallingford, England. (Refer to paragraph 8.) In the letter of February 16, 1971, addressed to the Additional Secretary, Planning Commission, Government of Pakistan, we have requested the following questions to be forwarded to the Hydraulic Research Station:

(1) Effect of waves on sedimentation in the new channel

(2) Wave climates in and outside the Phitti Creek

(3) Easiness of ship navigation into and from the Phitti Creek

As discussed in the foregoing sections, the questions raised in the interim note have been answered to a certain extent. The most important question of the quantity of maintenance dredging has been given a likely estimate. The wave climate outside the Phitti Creek is being clarified by the wave observation data. Nevertheless, the estimate of siltation is a result of calculation without confirmation of field data, and the data of wave observation at the site are still insufficient for constructing usable wave statistics. Therefore the Survey Team considers the execution of the following hydraulic study necessary for solidifying the feasibility of the new port project at the Phitti Creek:

(1) Trial dredging on the alignment of the Southern Channel and measurement of actual quantity of siltation during a SW monsoon season.

(2) Continuous recording of waves at a point in the extension of the Southern Channel, and analysis of wave statistics there.

(3) Observation of wave conditions in the Phitti Creek for the period over one year, and clarification of wave climate there.

PART III

DEVELOPMENT PLAN
FOR THE PHITTI CREEK

PART III. DEVELOPMENT PLAN FOR THE PHITTI CREEK

Chapter 1. Long-Term Plan

The water depth at the mouth of the Phitti Creek is approximately 20 feet below the datum level and about 27 feet below the mean high water. The maximum depth of water in the creek is 60 feet and the area with a depth of more than 20 feet is 3.7 sq. miles. Consequently, navigation of vessels of the 3,000 D/W class is possible throughout the year without help of tide and navigation of vessels of the 5,000 D/W class also becomes possible during the mean high tide. However, on a rise of tide, a vessel of 8,000 D/W could enter Phitti Creek during fair weather.

The water depth required for navigation of vessels of the 50,000 D/W class throughout the year is 42 feet below the datum level and the amount of dredging required for providing a navigation channel with a width of 900 feet and a depth of 42 feet is estimated at 17.4 million cubic meters. The amount of dredging required for providing a navigation channel (600 feet wide) with a depth of 27 feet, the same depth of Karachi Port, is estimated at 2.58 million cubic meters. Soils at the sea-bed are mainly sand, which is satisfactory for anchoring and provides easy dredging. Though the velocity of tidal current in the Phitti Creek is 2.0 knot, the movement of the current is regular and therefore presents no problem for navigation.

Moreover, various creeks connected to the Phitti Creek can allow navigation of small crafts of the 300 D/W class easily. These creeks can be utilized as inland waterways to provide a link with the inland areas in the future after being given required works. Development of the coastal area along these creeks by making the best use of the inland waterways will then be a natural process.

In the vicinity of the Phitti, Jhari and Korangi Creeks there are some large islands and tidelands. Of these, Bundal Island, Khiprianwala Island, Bundal South Island and the tideland in front of the Korangi Mainland are especially large in size. The land section (about H.W.L.) of the three islands directly facing the Phitti-Jhari Creeks has an area of 2,000 hectares, and increases to 5,600 hectares if the tideland section (above D.L.) is included. As for soil conditions, the surface layer is composed of sand and therefore a required bearing power of ground is readily available.

For this reason, the Phitti Creek area is considered most convenient for communication with the inland area. Although Khiprianwala Island will be submerged under water at a high tide if left as it is, raising ground level by 3.3 feet will turn it to a satisfactory land. Bundal Island can also be turned to a useful land in its original form when an approach road is provided. This approach road can be provided without difficulty by constructing a simple levee between Khiprianwala Island and Bundal Island, because the area between the two islands is extremely shallow and the velocity of tidal currents is not great. Once Khiprianwala Island and Korangi Mainland are linked together, communication between Bundal Island and Korangi Mainland can be easily provided.

There is a vast plain to the north of the Phitti Creek. The main artery of communication such as railways and road network extend to the northern region where West Pakistan's population, economy and industry are distributed. Immediately behind the Phitti Creek industrial development is being progressed, centering around two oil refineries and a number of textile mills. In this section is situated the Korangi area with a population of 300,000. The city of Karachi, the central city in the south, is approximately 15 miles to the west.

Communication with Karachi is provided by the existing road, but a new road project is also being planned by KDA. Commuter railway service from Karangi to the city center is also likely to be provided in the near future. Communication between the Phitti Creek and the central section of the northern region of West Pakistan by road is readily available via the National Highway. Construction of a railway line connecting the port to the Karachi – Hyderabad Main Line through Pipri Marshalling Yard, will provide easy transportation of cargo to the inland area in the north and to the city of Karachi in the west. For supply of water which is essential to regional development, the Karachi Metropolitan Development project envisages supply of about 1.3 million ton/day (280 MGD) from the Indus River, Supply of 630,000 ton/day (140 MGD) has already begun in this area. Because the area east of this creek is a flat land, no major problems are expected to be encountered in laying water mains.

(1) Basic Policy for Development

The cargo traffic through ports in West Pakistan in the year 1984/85 is expected to reach 34 million tons, about 3.8 times the figure of 9.3 million tons for the year 1969/70. This rapidly increasing cargo traffic is to be handled at Karachi and Phitti Creek Ports with appropriate distribution of the share of functions by taking into account such characteristics as economic, social and natural conditions in the hinterland of the respective port. The type of cargo handled at Phitti Creek port is to be bulk cargo, excluding general cargo and those cargo destined to Afghanistan, which will be handled at Karachi.

Petroleum products are to be handled only at Karachi Port for the time being, but because of the limited space available at Karachi Port, all petroleum products are to be handled at Phitti Creek in the future to ensure safety of the Port of Karachi. Commercial port facilities are to be provided at Khiprianwala and a waterfront industrial complex is to be located centering on Bundal Island. For the present, development of Khiprianwala is to be commenced at first.

In utilizing these areas arrangement of facilities and plants must be made properly so that waterfronts may be utilized effectively and at the same time, due consideration must be given to the future expansion of facilities with flexibility. As for the areas in the islands and tidelands other than those covered by the current project, the land is to be retained as a reserve and development of these areas is to be withheld until a definite plan is worked out in the future. In the hinterland of the commercial port area distribution facilities (warehouses, truck terminals, etc.) and commercial facilities (office buildings for port-related industries, shops, restaurants, etc.) are to be arranged. Other port-related industries and such facilities as housings for port employees, plant employees and their families and school buildings, all of which are not necessarily required to be located on the waterfronts, are to be arranged in the area around Korangi Mainland. In order to provide a physical link between Phitti Creek and the inland area, construction of a road and a railway line with sufficient capacity is contemplated. Where road and railway cross each other and the trunk road and the city street meet each other, a level crossing is to be provided for the time being, but sufficient land space is to be secured so that an overpass may be provided in the future. Sufficient land space for roads is also to be secured for future expansion of roads to meet the increase of traffic demands and at the same time, construction of utility facilities is to be planned along with the road project.

In order to provide a physical link with Karachi Port in the future, a road network plan which provides an approach to Clifton is to be worked out. In arranging a waterfront industrial complex, due consideration must be given to the prevention of environmental pollution

such as air pollution by making a careful study of the wind direction and other elements.

Industrial pollution prevention programs (standards for exhaust from plant stacks, disposition of waste water, noise, etc. and countermeasures) are to be worked out at the earliest opportunity and legislation is to be made so as to legalize the installation of a desulfurizing device in plant stacks, waste water treating facilities, etc. and each plant which will be located in this site. Also, a plan is to be worked out for installation of joint waste water treatment facilities and waste oil treatment facilities to prevent sea water pollution by waste oil.

(2) Estimate of Cargo Traffic Through Ports

The share of Phitti Creek Port and Karachi Port for cargo handling was determined as follows. (Refer to APPENDIX 3-3)

(a) All passenger traffic is to be handled by Karachi Port.

(b) All general cargo is to be handled by Karachi Port.

(c) Import of iron ore and coal/coke required by the Steel Mill for its present designed capacity of one million tons, is to be handled by Karachi Port. (If a decision is taken to shift the Steel Mill site from Buleji to a more suitable site east of Karachi, this cargo will be handled at Phitti Creek.)

(d) All other bulk cargo

All petroleum cargo is to be handled at Karachi Port up to the year 1974/75 and the volume of petroleum cargo is to be reduced gradually in the subsequent period to ensure safety of Karachi Port and the petroleum cargo is to be handled only at Phitti Creek in the year 1984/85 and thereafter.

The volume of cargo traffic through Karachi Port except petroleum cargo in the year 1969/70 amounted to 5.46 million tons exceeding the normal capacity of the port. Addition of three berths now under construction and eight more under future projects to the existing facilities will increase the normal cargo handling capacity of Karachi Port to 5.5 million tons in terms of general cargo except petroleum. Although the normal cargo handling capacity of Karachi Port in the year 1984/85 is estimated at 5.5 million tons in terms of general cargo except petroleum (Refer to APPENDIX 6-4) a capacity of 5.9 million tons, a little over the normal capacity, will have to be allowed for the year 1974/75 by taking into account the progress of the construction of Phitti Creek Port.

For the time being, it is considered that the cargo amounting to 2.2 million tons, destined to the new steel mill planned west of Karachi City, will be handled at Karachi Port. As shown in the summary of estimated cargo traffic in Table 3, the volume of cargo traffic through Phitti Creek Port for the plan year 1974/75 will amount to 3.6 million tons and that in the year 1984/85 will reach 26.2 million tons. This figure includes 11.6 million tons of petroleum. Meanwhile, the volume of cargo traffic at Karachi is estimated at 13.6 million tons (including 5.5 million tons of petroleum) in the year 1974/75 and 7.8 million tons in the year 1984/85. The reason for the smaller cargo traffic in the year 1984/85 than in the year 1974/75 is that handling of petroleum at Karachi Port will be suspended for safety of the port and that handling of bulk dry cargo will be transferred to Phitti Creek.

Table 3. Share of Phitti Creek Port and Karachi Port for Cargo Handling

(Unit: '000 T)

	1969/70		1974/75		1984/85	
	Commodity	Volume	Commodity	Volume	Commodity	Volume
Phitti Creek			Dry bulk	3,577	Dry bulk	14,600
			Wheat	373	Wheat	1,650
			Rice	1,552	Rice	2,200
			Cement	1,500	Cement	3,000
			Fertilizer	152	Fertilizer	1,150
			(Phosphate rock)		Iron & Steel	300
					Coal & coak	1,990
					Iron ore	4,310
					Oil	11,600
			Total	3,577	Total	26,200
Port of Karachi	General	2,266	General	2,985	General	4,730
	Dry bulk	3,195	Dry bulk (A)	2,889	Dry bulk (A)	750
			Molasses	150	Molasses	150
			Sugar	215	Sugar	200
			Wheat (Afg.)	60	Wheat (Afg.)	120
			Miscellaneous	220	Miscellaneous	280
			Iron & steel	1,500	Dry bulk (B)	2,330
			Fertilizer	244	Coal & coak	740
			Cement	500	Iron & steel	100
			Dry bulk (B)	2,165	Iron ore	1,490
			Coal & coak	710		
			Iron & steel	95		
			Iron ore	1,360		
	Oil	3,988	Oil	5,540		
	Total	9,339	Total	13,579	Total	7,810
All West Pakistan	General	2,266	General	2,985	General	4,730
	Dry bulk	3,195	Dry bulk	8,631	Dry bulk	17,680
	Oil	3,988	Oil	5,540	Oil	11,600
	Total	9,339	Total	17,156	Total	34,010

Remarks: Dry bulk (B): Cargoes for steel mill at the west site of Karachi.

(3) Port Planning

The maximum tonnage of ships, which is the main factor for deciding the size of a port, is determined by the type and volume of cargo traffic through the port, distance to the shipping and receiving countries and the correlation with the cost of construction and maintenance of the port. Recently, attention has been focused on the advantage of transporting bulk cargo by larger vessels and as a result, an oil-tanker of the 370,000 D/W class and an ore-carrier of the 120,000 D/W class have already been built. For grain-carriers, vessels of the 50,000 D/W class are in general use.

In view of the short distance to the Middle East from which petroleum is to be transported to this port, the maximum tonnage of an oil tanker entering this port is to be 50,000 D/W. As the transport distance for iron ore and coal is not considered great and in view of the production scale of the new steel mill, the maximum tonnage of an ore-carrier is to be

50,000 D/W as in the case of an oil-tanker. Since the grain is exported mainly to East Pakistan or to Middle East countries, the maximum tonnage of a grain-carrier is to be 20,000 D/W.

The main objectives of this port are to handle bulk cargo for West Pakistan, provide a site for port-related industries and handle cargo originating in these industries. The type and size of the waterfront industries, important factors for the project planning, are shown in Table 4.

Major industries among those listed are as follows:

(a) Oil Refinery

The oil refining capacities required to meet the demands in West Pakistan in the year 1974/75 and in the year 1984/85 are estimated at 130,000 barrels/day and 310,000 barrels/day respectively. Of the total capacity of 130,000 barrels/day for the year 1974/75, 100,000 barrels/day is to be refined at Karachi and the remaining 30,000 barrels/day is to be refined in the northern area. This increase in the capacity is to be provided by the increase in the capacity of the existing facilities.

At the Phitti Creek an oil refinery with a capacity of 150,000 barrels/day is to be constructed by the year 1984/85.

(b) Petro-Chemical Industry

On the assumption that the total demands for naphtha in Pakistan in the year 1974/75 will be met by the domestic petro-chemical industry, a petro-chemical plant with a capacity of one million tons of naphtha (250,000 tons in terms of ethylene) is to be constructed. This plant will also produce 300,000 tons of urea and 125,000 tons of polyethylene. For the typical production process, refer to Appendix: 3-2.

(c) Iron and Steel

Demand for iron and steel in West Pakistan in the year 1974/75 is estimated at 2.25 million tons. Of this, 750,000 tons are expected to be produced by the new steel mill being planned and the greater part of the remainder is expected to be imported from foreign countries. Of the total demand for crude steel amounting to 4 million tons in the year 1984/85, one million tons are to be supplied by the new steel mill under the current project after expansion of facilities and 3 million tons are to be supplied by a steel mill which will be planned for the Phitti Creek in the future.

(d) Power and Shipbuilding Industry

For the supply of power to the industrial complex and to the public, a power plant with a capacity of 500,000 KW is to be constructed. Also, in proportion to the increase in the number of ships entering the port, a shipyard equipped with a maintenance dock is to be planned at first and the one equipped with a shipbuilding dock is to be planned in the future. As part of the combinat of the steel mill, steel products processing industry or steel-oriented industries are also to be planned. The subject for a future study will be the distribution to the inland area of some steel-related industries which are not necessarily required to be located close to the steel mill for the economic development of the inland area even though it may result in a decrease in efficiency.

A summary of the above discussion is shown in Table 4. The total land area required for industrial location in the year 1984/85 with some allowance is estimated at about 1,000 hectares and the requirement for industrial water for the same period is estimated at 280,000 tons/day. The number of employees then will be 28,000 (by Japanese standard).

Table 4

Kinds of Industries	Capacity	Area ('000m²)	Number of Employees	Water Consumption ('000 tons/day)	Electricity Consumption ('000 KWH/day)	Material	Product	Complex
Oil Refinery	150,000 50,000 x 1 unit 100,000 x 1 unit (Kerangi Site) BPSD 100,000 Existing Factories	3,000 (3) 1,500	600	Water 40 Sea Water 60	35 10	'000 tons Crude Oil 6,800 Crude Oil 4,800	Naphtha 700 '000 tons Gasolite 1,500 Fuel 400 Heavy Oil 3,500 L.P.G. & others 700 Naphtha 300 Gasoline 1,100 Fuel 300	(1) ----- Petrochemical Industry 700 (2) ----- Power Station 600 Iron Steel 35 (3) ----- Petrochemical Industry at Koreoghi Site 300
Petro chemical	Ethylene 200,000 tons 50,000 tons x 2 100,000 x 1	3,000 (3) 1,500	1,500	Water 30 Sea Water 320 400	160 (including 50 self-generated)	Naphtha 700 (1)	Urea 200 Polyethylene 90 Polysthylene 30 S.B.R. 40 Others 350	
Iron & Steel	Crude Steel tons/year 3,000,000	5,000 (3) 3,000	11,500	Water 100 Sea Water 350 400	175 (Self-generated)	Iron Ore 4,310 Coal 1,990 Scrap 300 Heavy Oil 42 (2) Lime Stone 80	Pig Iron 100 Billet 1,000 Medium section 600 Flat 1,500	----- Dock ----- Dock
Ship Building	Building Dock G/T 5,000 x 2 units 10,000 x 1 unit	100	1,200	Water 4 Sea Water 15	5	Steel		
Power	500,000 KW KWH 125,000 x 4 units	1,000	250	Water 5 Sea Water 2,000		Heavy Oil 600 (2)	500,000 KWH	----- Oil Refinery 85 (Phitti Creek) ----- Petro-chemical 110 ----- Ship Building 5 ----- (1) 50 ----- (2) 50
Related Industries (1)		1,000	3,000	Water 75	50	From Petrochemical		
Related Industries (2)		1,000	10,000	Water 25	50	From Iron Steel		
Total		15,100 (3) 10,000	28,000	276	415 175			

Notes: 1. Related industries (1) shown are those industries related to oil refining-petrochemical industrial combinat, including synthetic resin, synthetic resin paint, binding materials of synthetic resin type, synthetic detergent, nitric acid, ammonium nitrate, chemical engineering machine maintenance shop, etc.

2. Related industries (2) shown are those industries related to steel-shipbuilding combinat, including ferro-chemical, steel pipe manufacturing, drum manufacturing, fire brick manufacturing, machine industry, etc.

3. Provision for future extension.

Major port facilities to be provided at Phitti Creek Port are as follows:

(a) Approach Channel and Anchorage

Assuming that the maximum tonnage of an oil tanker and ore-carrier entering the port is 50,000 D/W, the required depth and width of the main approach channel are to be 42 feet and 900 feet respectively.

The approach channel within the port is to have a depth of 42 feet and a width of 900 feet up to the point of the steel mill and the channel toward the innermost of the port is to have a depth of 34 feet and a width of 600 feet.

In principle an extra space of 300 feet is to be provided between the mooring facilities and the approach channel as a basin for mooring operation. A turning basin having a diameter of 1,500 feet is to be provided for vessels of the 50,000 D/W class and the one having a diameter of 1,200 feet is to be provided for vessels of the 20,000 D/W class on the premise that tugboat will be used for turning. In planning approach channels and anchorages, a careful study must be made so as to avoid alteration of geographical features of the present sea bottom to the extent possible.

The maximum bending angle of approach channel is to be less than 30° and navigation aids are to be provided for every two miles on the main approach channel and at such points in the port where there are variations in water depth, as required. Guide marks

are also to be provided in the line of sight on the main approach channel. The standard sizes of ships used for the planning are shown in Table 5.

Table 5. Standard Ship Sizes

	D/W	Length	B	Draft
Oil Tanker	50,000	754'	105'	39'
Ore Carrier	50,000	771'	105'	39'
Ore Carrier	20,000	590'	75'	32'
Cargo Ship	20,000	595'	69'	32'

(b) Deepwater Wharf

The mooring facilities for large ships which will be required in the year 1984/85 are to be equipped with 20 berths. Table 6 is a summary of required cargo handling equipment and other supporting facilities. (Refer to APPENDIX 7-1)

Table 6. Required Mooring Facilities

Type of cargo handled	Tonnage of ship	Depth of water	Total length	Number of berths	Cargo handling equipment	Remarks
	D/W		ft.			
Crude oil	50,000	42	890	3	Loading arms	Plant wharf (oil)
Iron ore	50,000	42	890	2	Man-trolley unloaders	Plant wharf (ore)
Coal	50,000	42	890	1	Man-trolley unloaders	Plant wharf (ore)
Scrap	20,000	34	690	1	Orange Peel Gloves	Plant wharf (ore)
Cement	20,000	34	690	4	Level luffing cranes	Cement silo
Grains	20,000	34	690	6	Level luffing cranes	Grain silo
Fertilizer	20,000	34	690	2	Level luffing cranes	
Phosphate rock	20,000	34	690	1	Level luffing cranes	

(c) Lighterage Wharf

A wharf (300 feet) with a depth of 10 feet is to be provided at the north side of the main wharf as a port service facility for use by tugboats, lunches and fireboats. In the future when the size of the port is expanded, it is desirable to have such a port service facility located at the center of the port. Also, a wharf (150 feet) with a depth of 10 feet is to be planned at the foot of a bridge to be constructed over the Korangi Creek.

(d) Roads and Railways

The volume of traffic generated at the Phitti Creek in the year 1984/85 is expected to reach 37,000 automobiles/day and 1,800 freight cars/day. Transportation of crude oil and petroleum products is assumed to be made by pipeline. (Refer to APPENDIX 8)

In order to meet such a traffic demand, a trunk road 160 feet wide with an 8-lane driveway is to be planned. In Korangi area two 4-lane roads, one for connection with the National Highway and the other with Karachi are to be constructed. The road linking Bundal Island with the commercial port area is to have four lanes and sufficient space is to be secured for the future expansion. In securing land for construction of a trunk road, it is advisable to secure land in the width of 300 feet where possible for the future expansion and grade separation. It is also advisable to provide a space about 30 feet wide at the center section of the trunk road for use as utility area, which will also be used as medial divider.

In order to provide a physical link between the Phitti Creek and Karachi Port, construction of a road between Bundal Island and Clifton is to be planned and the required land space is to be secured.

A double-track railway line of 5′ ~ 6″ gauge is to be constructed to link the wharves and industrial complex with Pipri marshalling yard.

Communication between Korangi Mainland and the Phitti Creek is to be provided by constructing a railway-road bridge having a clearance of 12 feet above H.W.L. A clearance of 12 feet will be sufficient for the passage of small fishing crafts. Large fishing vessels entering a new fishing port planned for the east side of the bridge are to navigate through the Phitti-Jhari Creek and the Korangi Creek.

(e) Fishing Port Facilities

The fishing ports located at such places as Ibrahim Hyderi at the Korangi Creek accommodate approximately 900 fishing crafts at present. Each of these fishing ports, however, is too small in capacity and has poor communication with the trunk road in the hinterland. Under such a condition, the Pakistan Government propose to construct a new fishing port in the Korangi area and three sites have been selected for a comparative study. The selected sites are Ibrahim Hyderi where the present fishing port is located, the area east of the salt manufacturing plant and a section of Khiprianwala facing the Phitti Creek.

Here, an examination of these proposed locations will be made from the standpoint of harbour construction.

The Ibrahim Hyderi site presents no problem in relation to the current Phitti Creek Port Project, but the construction of a bridge with a clearance of 12 feet to Phitti Creek with Khiprianwala will restrict the passage of large fishing boats. The site east of the salt manufacturing plant, if a fishing port is constructed on the east side of the bridge, will enable large fishing boats to use the port. When the fishing port is arranged adjacent to the working craft base being planned under the current project, joint use of related facilities will be possible and great benefit will be derived.

The section of Khiprianwala facing the Phitti Creek is the area which should be reserved for the future use as a site of commercial port area. Under the current project, construction of a wharf for small crafts belonging to the port is also planned.

From the above discussion, the ideal site for construction of a fishing port is the area east of the salt manufacturing plant (NEDECO's Report on Fishing Port at Korangi Creek Near Karachi – Pakistan, July 1970 also mentions advantages of this site). In order to maintain harmony with the harbour project, the fishing port is to be constructed on the east side of the bridge adjacent to the working craft base.

(f) Power and Water Supply

Power demand in the industrial complex alone in the year 1984/85 is estimated at 415,000 KWH/day. Since a thermal power plant with a capacity of 500,000 KW is scheduled to be constructed at the Phitti Creek district in the year 1984/85, there is no need of laying cables for the total demand to the Korangi district. Therefore, a plan is to be worked out for laying cables with an 5,000 KVA capacity which is considered to be required until the operation of the thermal power plant.

Consumption of water in the year 1984/85 is estimated at 276,000 tons/day (61.5 MGD) in the industrial complex and 18,000 tons/day (4 MGD) in the port area. To supply

water to the industrial complex, the industries themselves must provide an industrial water supply system at their own cost. To supply water to the port area, including drinking water to the industrial complex, construction of a water main having a capacity of 21,000 tons/day (4.6 MGD = consumption in summer) will be required. However, a 24-inch main is to be laid from the beginning in anticipation of the future increase in demand. (cf. APPENDIX 7-3)

(g) Oil Pipeline

As all the petroleum products will be handled at Phitti Creek Port from the year 1974/75 on to ensure safety of Karachi Port, it is necessary to construct an oil pipeline from the Phitti Creek district to the existing oil refineries in the year 1984/85 is estimated at 4.8 million tons, a pipeline having a diameter of 16 inches is to be laid along the road.

All petroleum products except naphtha are to be transported to Korangi by pipeline. For the transportation of petroleum products to the inland area of West Pakistan by rail, a distribution center is to be established at Pipri. For distribution to Karachi city, storage is to be provided in the southern section of Korangi, from which delivery is to be made by tank lorry. A pipeline is to be provided for the transportation of oil from the Phitti Creek to each distribution center. For this purpose, 12-inch pipelines are to be laid from the oil refineries to Pipri by the industry at its own cost. (cf. Fig. 3)

(h) Land Use

A land use plan is shown in Fig. 4. Key industrial plants are located at the foremost tip of the district toward the sea so that industrial pollution of the hinterland by the S.W. monsoon which may be held to a minimum. Housings for plant employees do not have to be located close to the industries by specially providing land for that purpose through reclamation. For this purpose, it is advisable to locate a housing district in the Korangi Mainland in conjunction with the Karachi Metropolitan Development Project. Fig. 4 shows arrangements of these facilities and land use.

(4) Construction Plan

The estimate of cargo traffic at the port is made for two phases, for the year 1974/75 and for the year 1984/85. The cost of construction under the long-range plan is shown in Table 7. In order to allow partial use of the port in the year 1974/75, an approach road to Khiprianwala is to be constructed and dredging of approach channel (27 feet deep) at the entrance of the Phitti Creek is to be provided. At the same time, two wharves with a depth of -34 feet are to be constructed to provide 2 berths for cement and 3 berths for food grains.

Designs of the main structures are as follows:

1) Wharves and Cargo Handling Equipment

a) Oil Berth

The total requirement for crude oil by the refinery is imported and the volume of crude oil handled at the port is estimated at 11,600,000 tons in the year 1984/85. For the tankers of the 50,000 D/W class, a wharf of -42 feet depth with 3 berths is to be constructed. The mooring facilities are to consist of dolphins for berthing and platforms cranes and for communication with the shore. Six loading-arm type cranes each having a capacity of 750 t/hr. (two cranes/berth) are to be provided. Dolphins are to be of the lateral resistance piles, and top-fixed type. As for the external force applied to the dolphin, the impact by ship's berthing is considered. Figures 5 ~ 7 show standard

cross-sections of dolphins and other structures.

b) Iron Ore Berth

The amount of iron ore import is estimated at 4,310,000 tons per year. For ore-carriers of the 50,000 D/W class, two berths of –42 feet are to be constructed. For handling 1,990,000 tons of coal per year, one coal berth is to be provided to accommodate carriers of the 50,000 DWT class. For mooring facilities, the detached-pier type was adopted in consideration of the cargo handling equipment to be used. It is advisable, therefore, to operate man-trolley unloader lengthwise on the detached pier, transfer coal to open storage yard by belt-conveyor and use a stacker for loading and unloading. The capacity of the man-trolley unloader is to be 1,000 t/hr. Besides, to handle 3,000 tons of scrap steel annually, which is essential to maintain quality of steel, a scrap steel berth of –34 feet depth is required to accommodate carriers of the 20,000 DWT class equipped with an orange peel gloves (150 t/hr.). Figures 8 ~ 10 show typical cross-sections of iron ore berth, coal berth and scrap steel berth, respectively. For detached pier, separate designs were adopted for the section where ships are brought alongside and which is subject to a tremendous horizontal force, and for the foundation of cargo handling equipment that is subject to the load of man trolley unloaders. Therefore, the pile members comprise lateral resistance piles and the bearing piles subject to vertical force. Design of scrap steel berth is the same as that described in paragraph (c).

c) Cement, Grain and Fertilizer Berths

Items that are likely to be exported from Phitti Creek Port in the future include cement, grains, urea and potassic salt. In order to handle these cargo items at the port, a total of 12 berths of –34 feet depth are required: namely, 4 berths, 6 berths, one berth and one berth for respective items mentioned above.

Mooring facilities are to be of a steel pipe pile type as shown in Fig. 10. For loading and unloading, a belt-conveyor line and level luffing cranes for cement, a belt-conveyor line for grain and a belt-conveyor and level luffing cranes for fertilizer will be required. Figures 11 ~ 13 show layout plans of these equipment.

2) Road, Railway and Bridge

As the port construction site at the Phitti Creek is separated from the mainland by the Korangi Creek, construction of road, railway and a bridge is essential to provide a means of communication. In view of the scale of the Phitti Creek Port Project, construction of a four-lane road (two lane on each side of traffic) and a double-track railway is advisable. The railway is to be of a broad gauge track to commensurate with the existing line. The bridge spanning the Korangi Creek is to have a clearance of 12 feet above H.W.L. Typical cross-sections and a side view of road, railway line and bridge are shown in Figures 14 ~ 16 respectively.

For calculation of the cost of construction, reference was made to boring data and other information obtained from Messas Pakistan Techno-Consult.

FIG. 3

PROPOSAL FOR A NEW PORT AT PHITTI CREEK

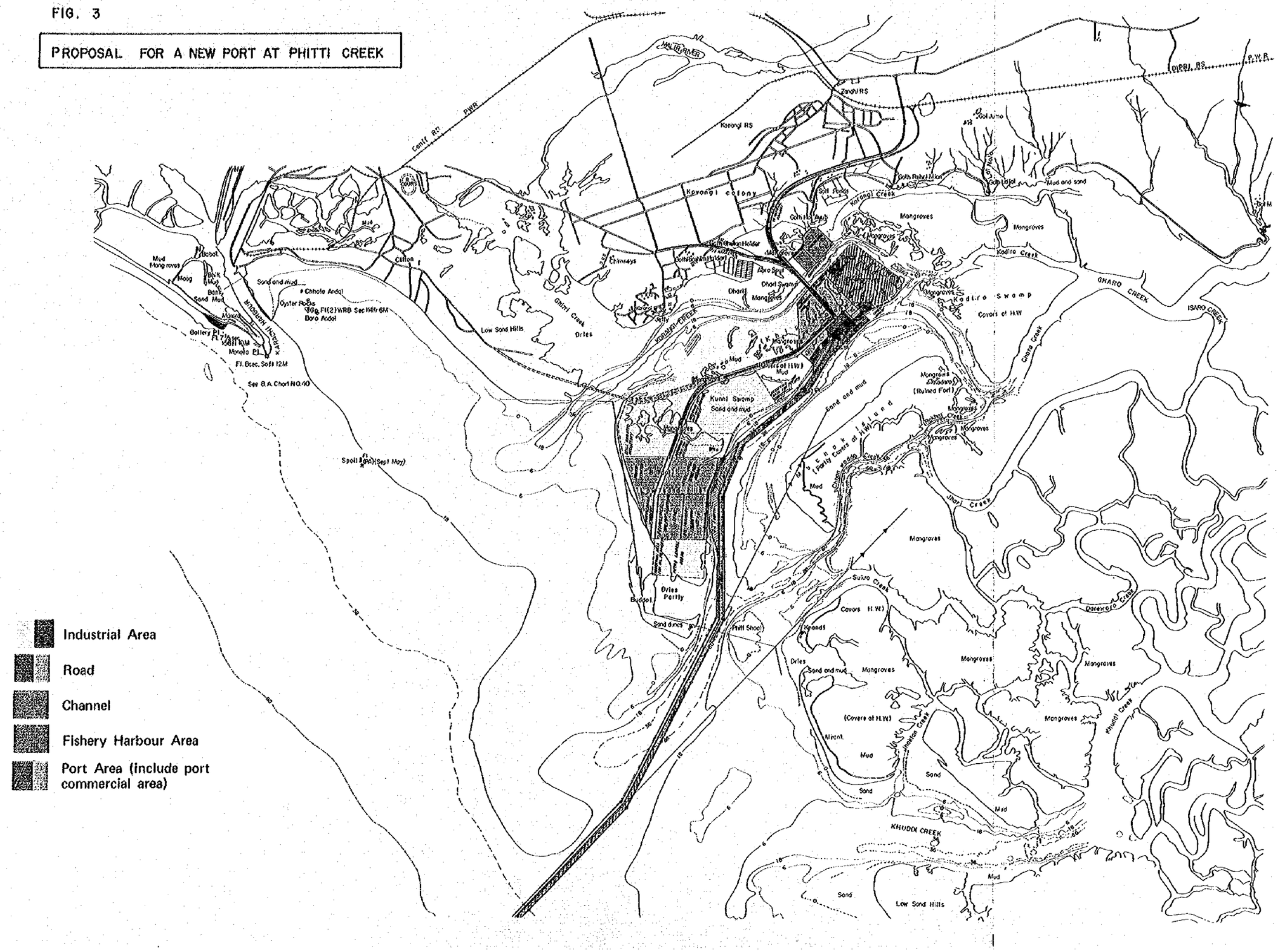


FIG. 4

PROPOSED LAND USE AT PHITTI CREEK

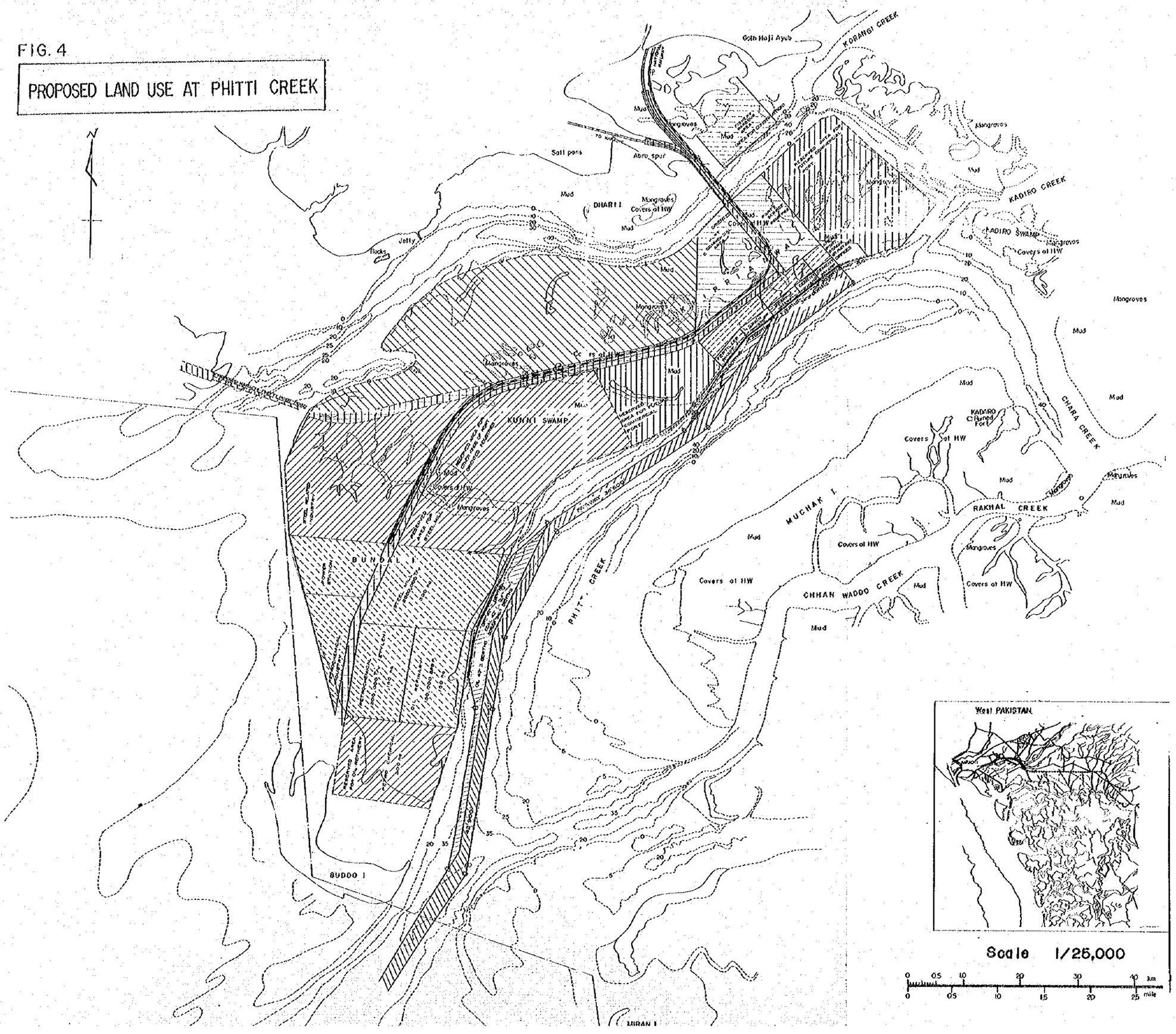
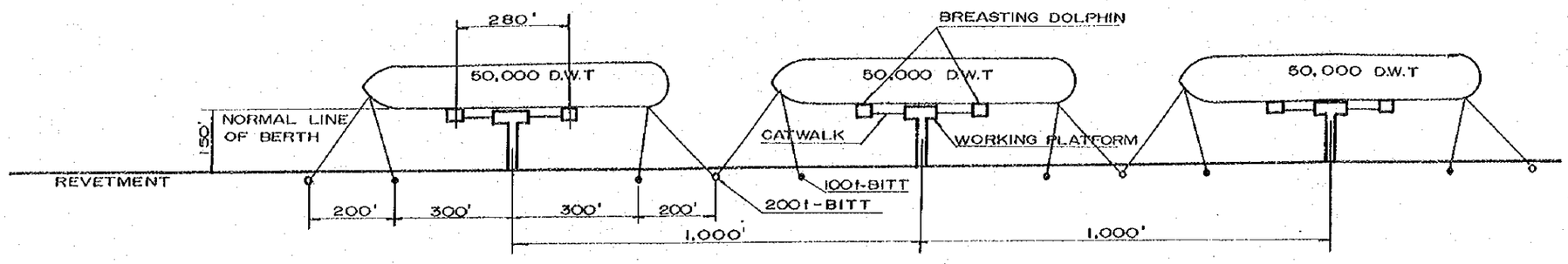


Fig. 5 ARRANGEMENT OF OIL BERTH

GENERAL LAYOUT

SCALE 1" to 300'



LAYOUT OF BERTH

SCALE 1" to 100'

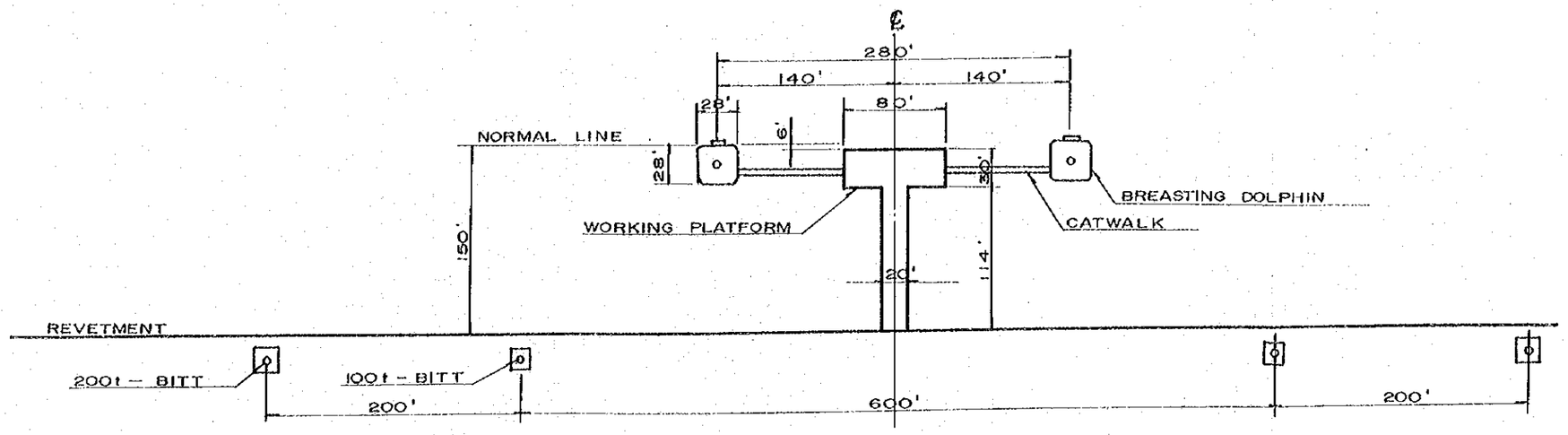
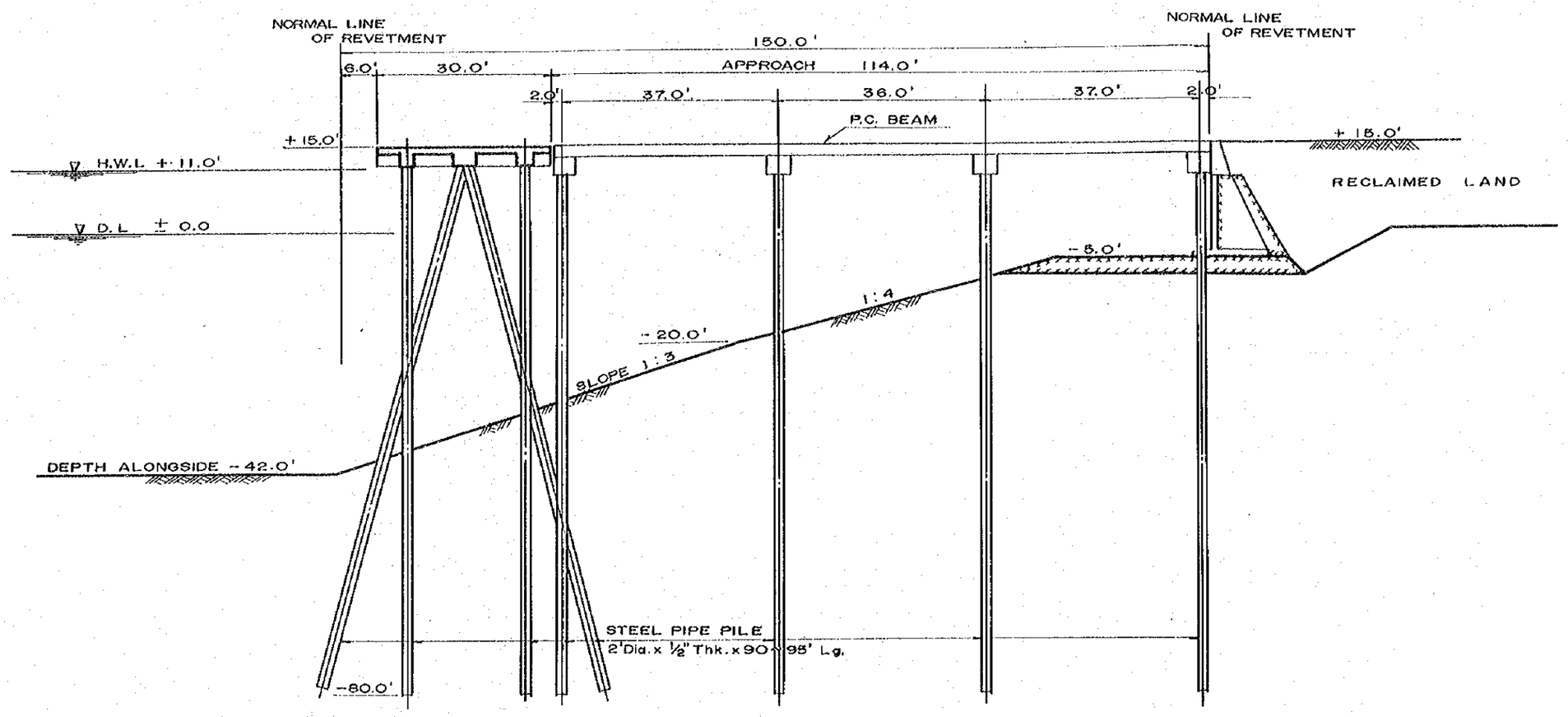


Fig. 6 OIL BERTH WORKING PLATFORM SCALE 1" to 20"

TYPICAL CROSS SECTION



PLAN

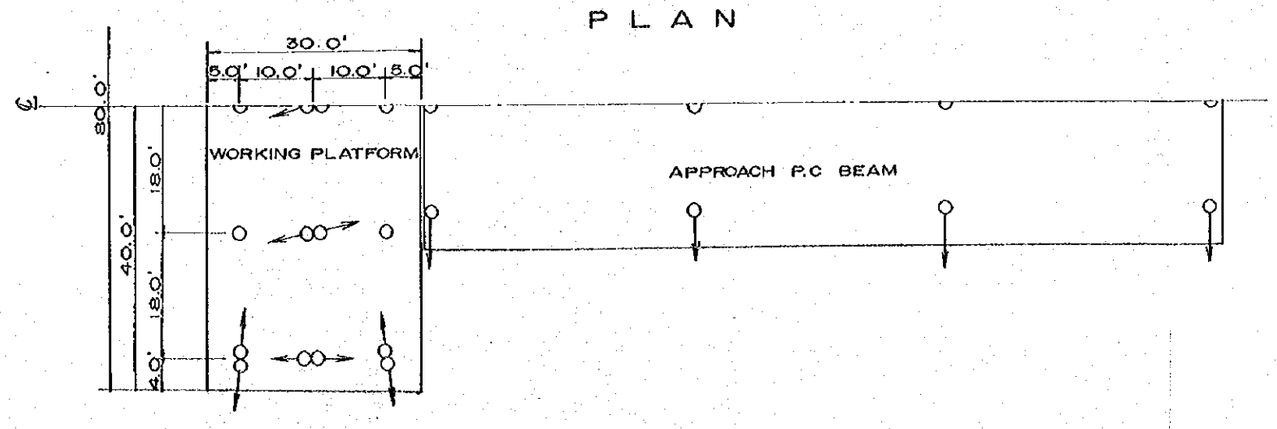


Fig. 7 OIL BERTH BREASTING DOLPHINE

FRONT VIEW

SCALE 1" to 10'

SIDE VIEW

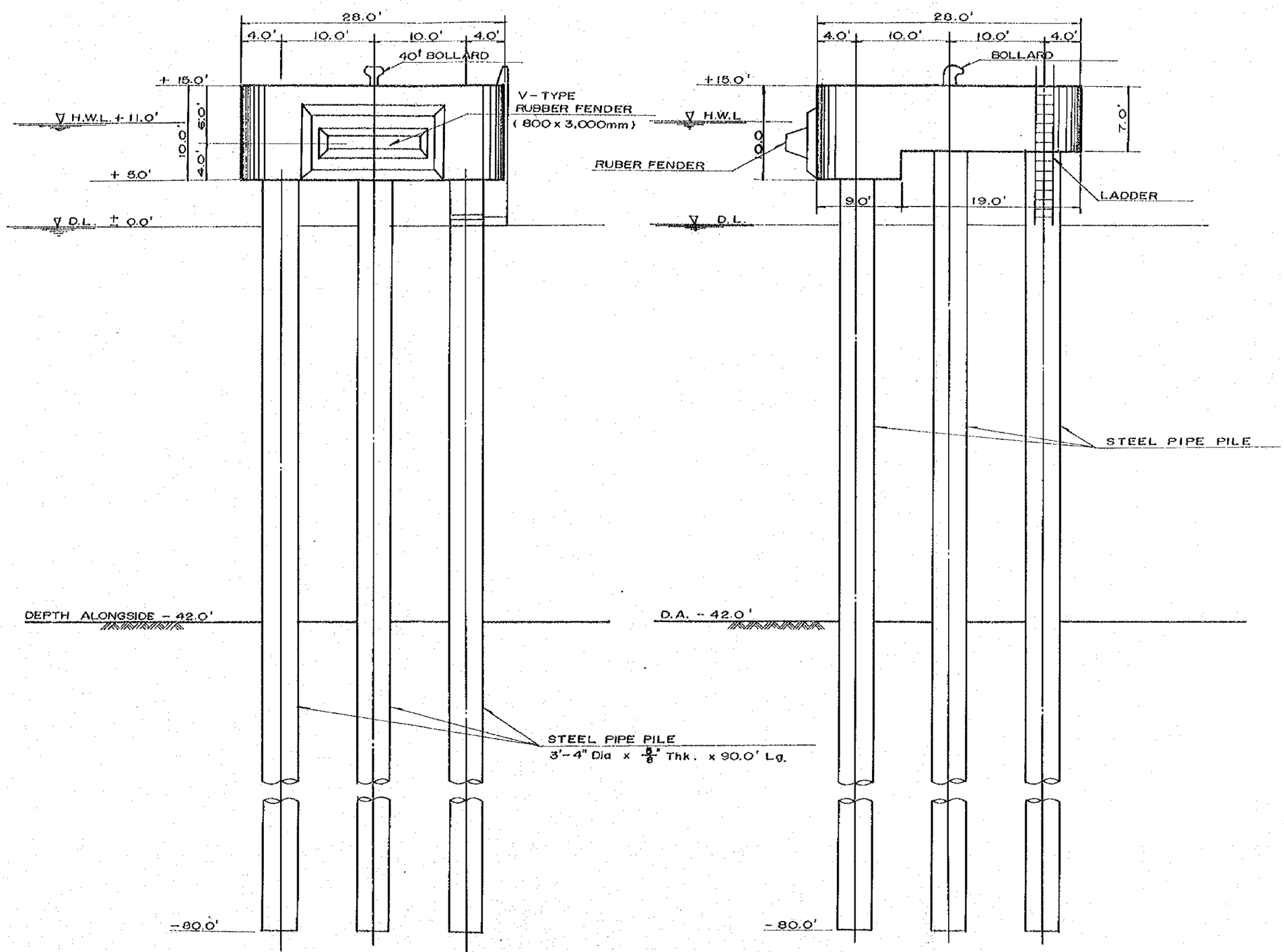
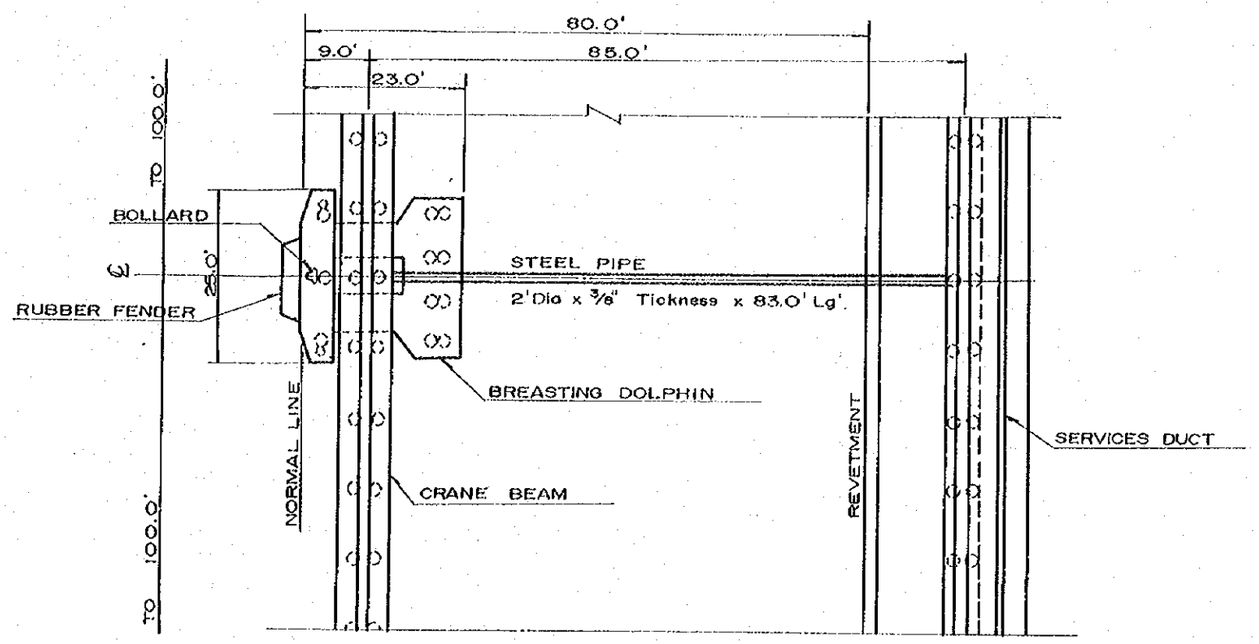


Fig. 8 ORE AND COAL BERTH DETACHED PIER

PLAN

SCALE 1" to 20'



GENERAL LAYOUT

SCALE 1" to 300'

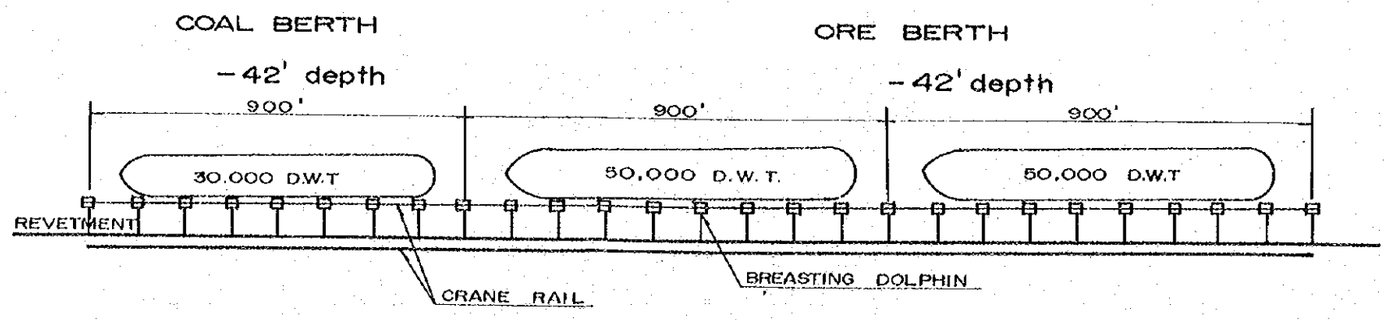


Fig. 9 ORE AND COAL BERTH DETACHED PIER

SCALE 1" to 20'

TYPICAL CROSS SECTION

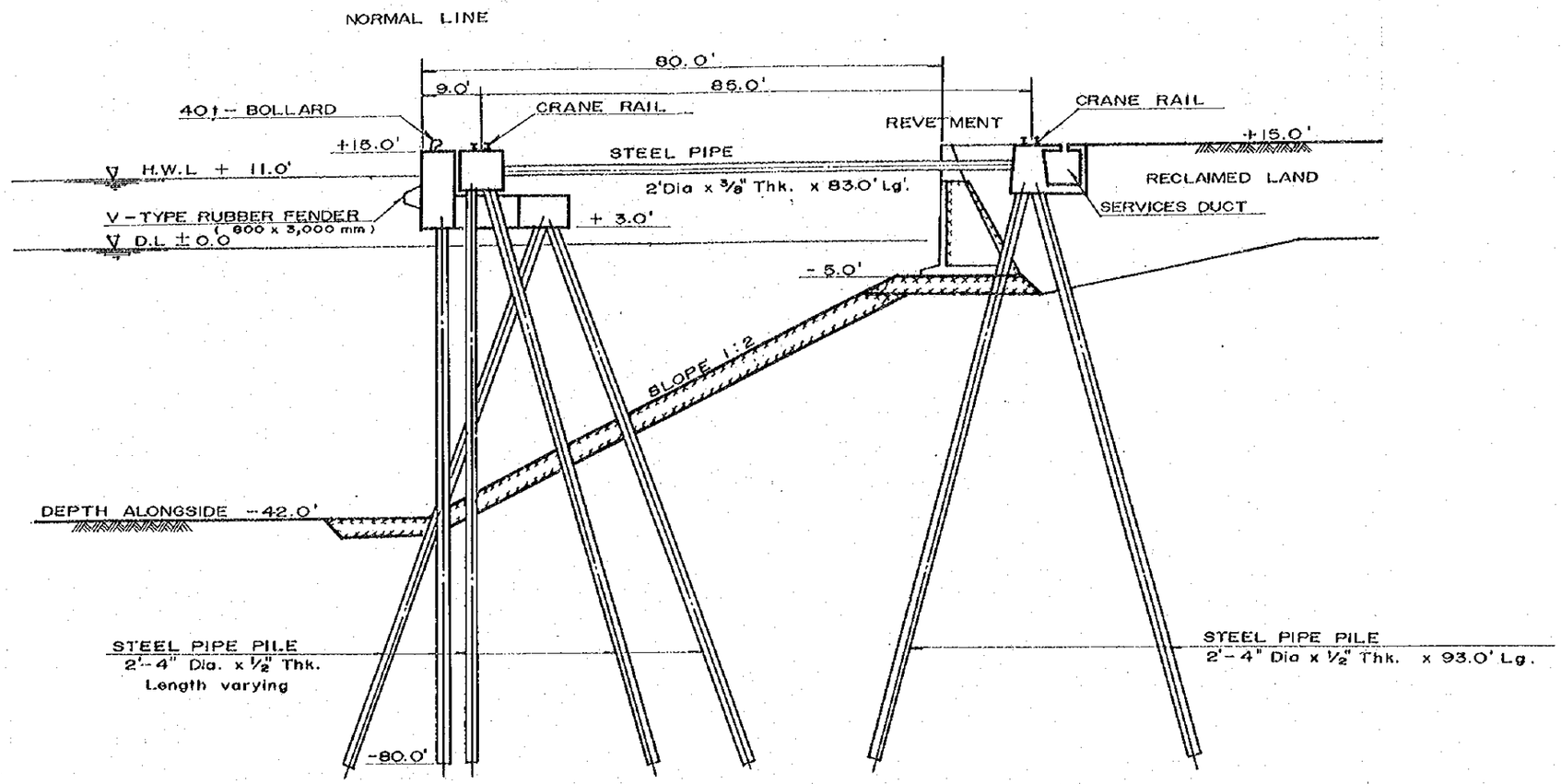


Fig. 10 SCRAP, CEMENT, GRAIN AND FERTILIZER BERTH

SCALE 1" to 20'

TYPICAL CROSS SECTION

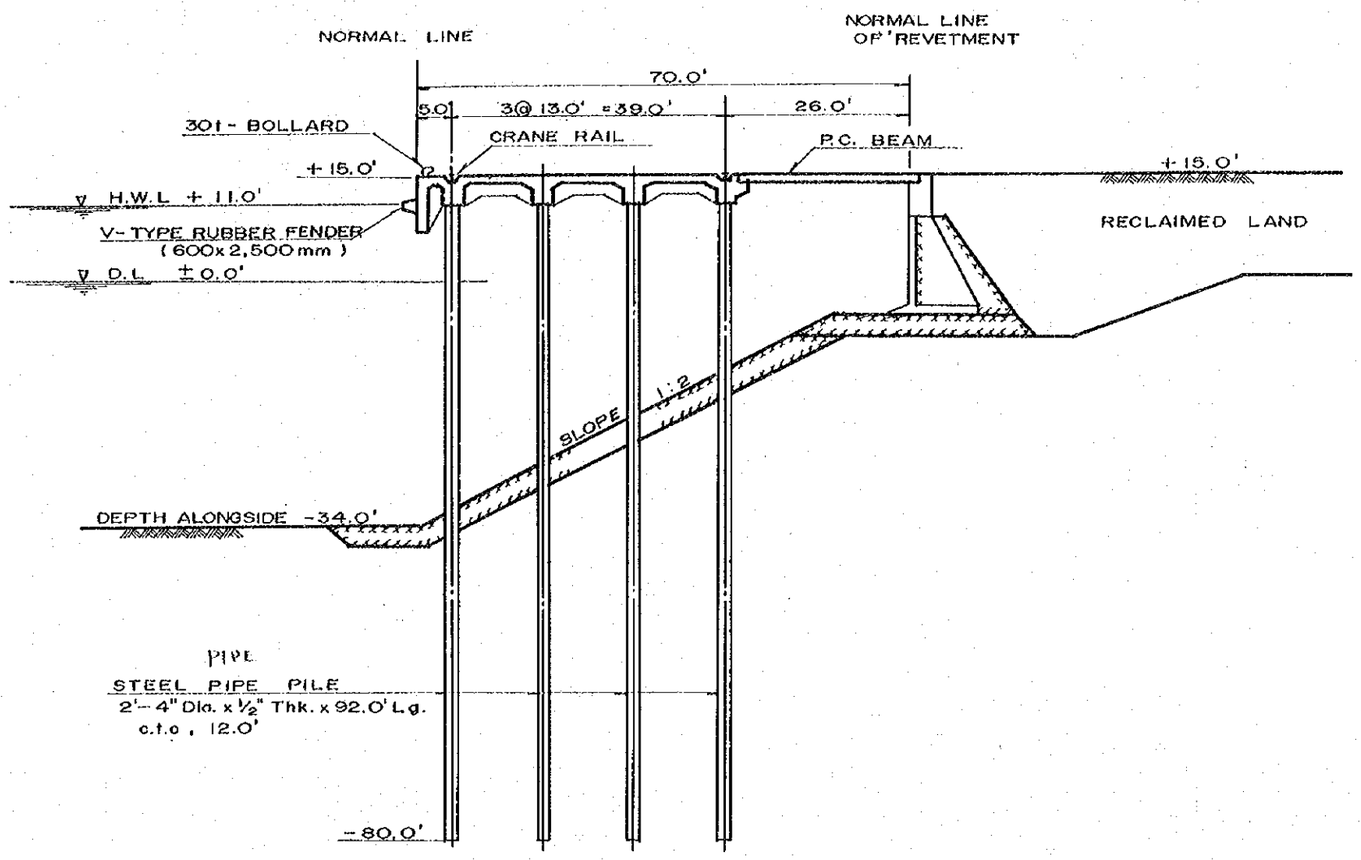
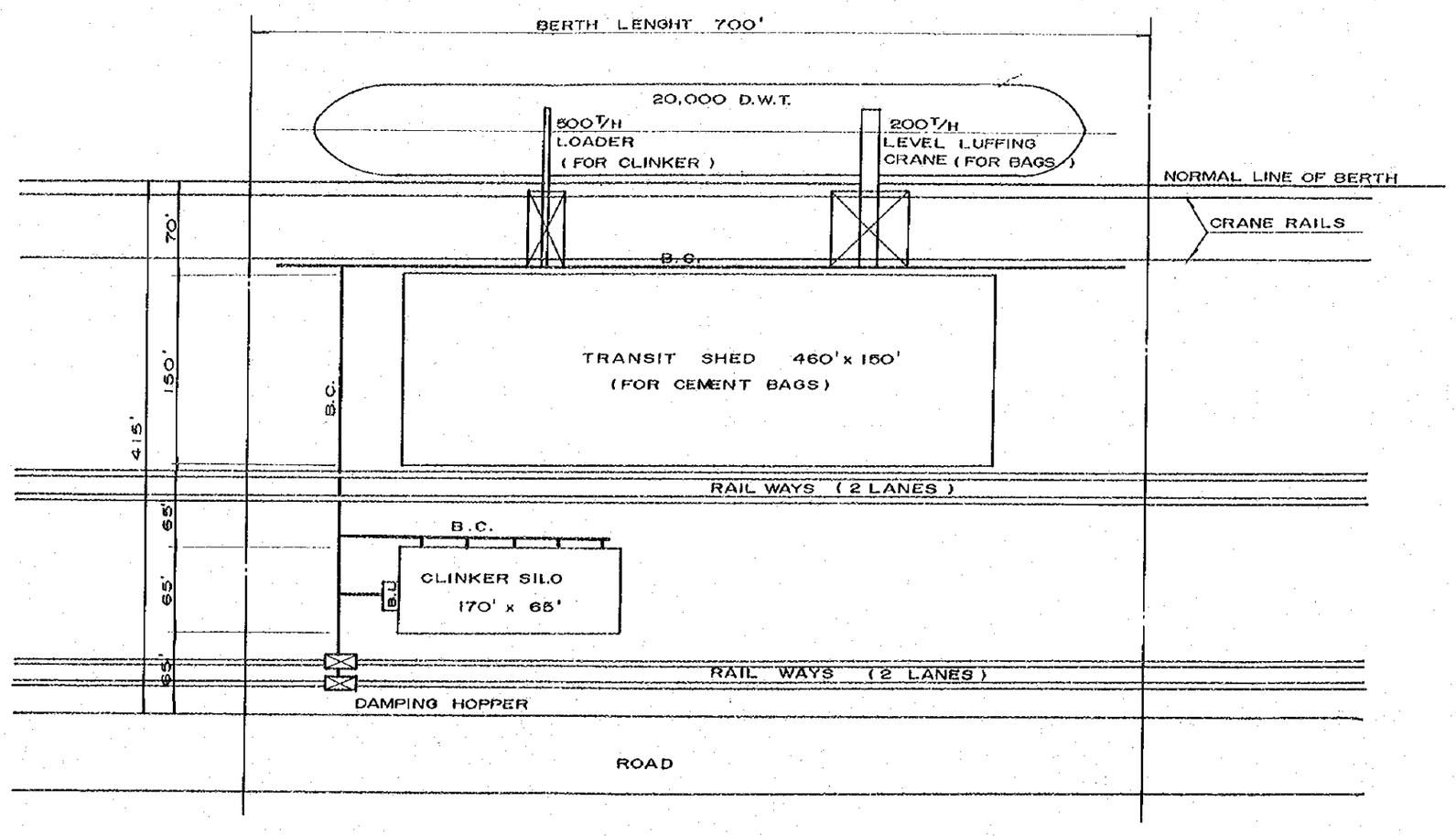


Fig. 11 ARRANGEMENT OF HANDLING EQUIPMENT CEMENT BERTH

SCALE 1" to 100'

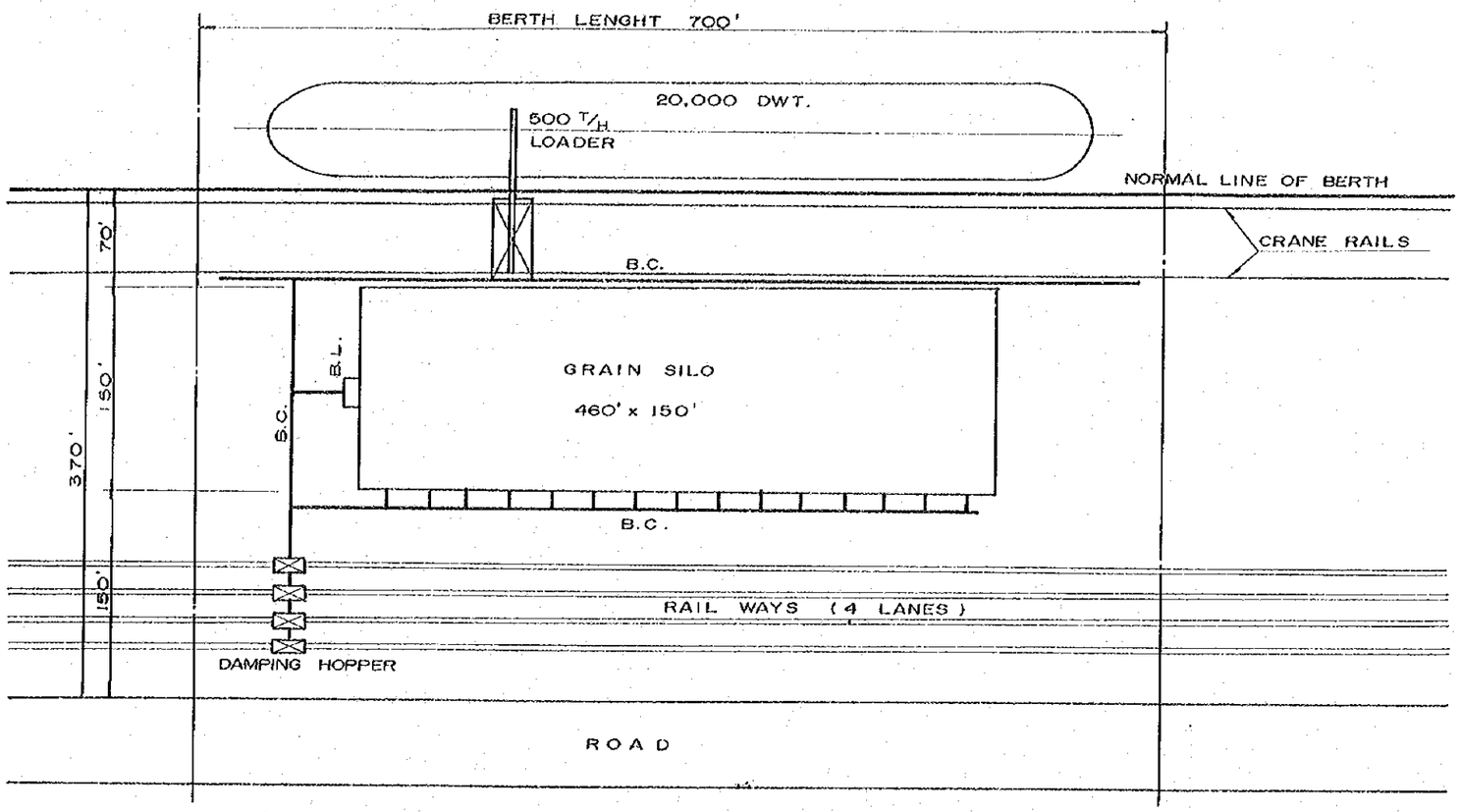


LEGEND :

B.C : BELT CONVEYOR
B. L. : BUCKET LIFT

Fig. 12 ARRANGEMENT OF HANDLING EQUIPMENT GRAIN BERTH

SCALE 1" to 100'

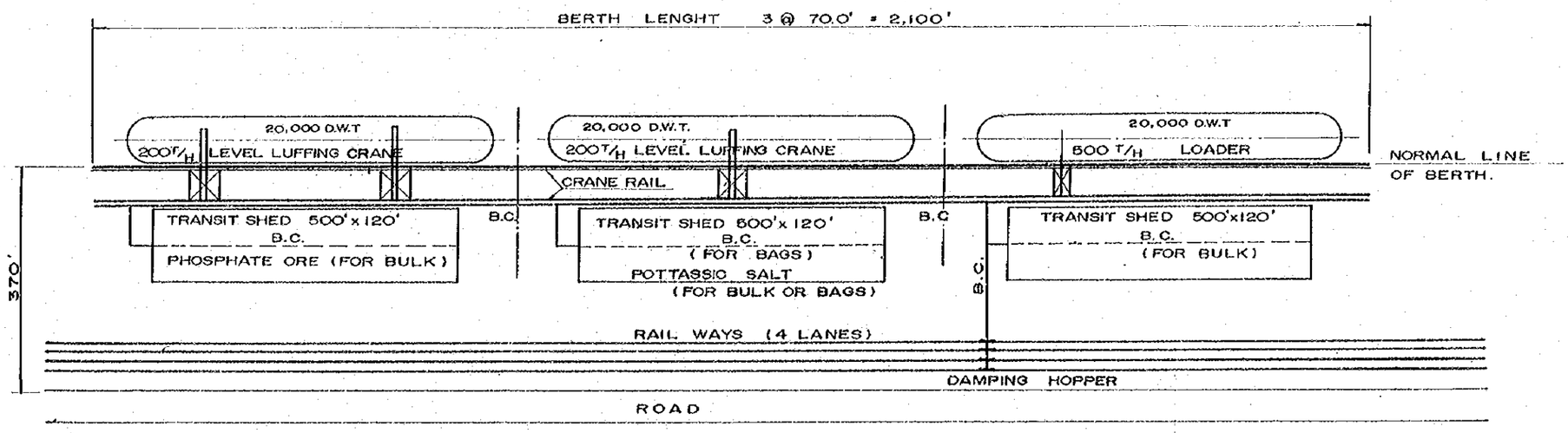


LEGEND :

B.C. : BELT CONVEYOR
B.L. : BUCKET LIFT

Fig. 13 ARRANGEMENT OF HANDLING EQUIPMENT FERTILIZER BERTH

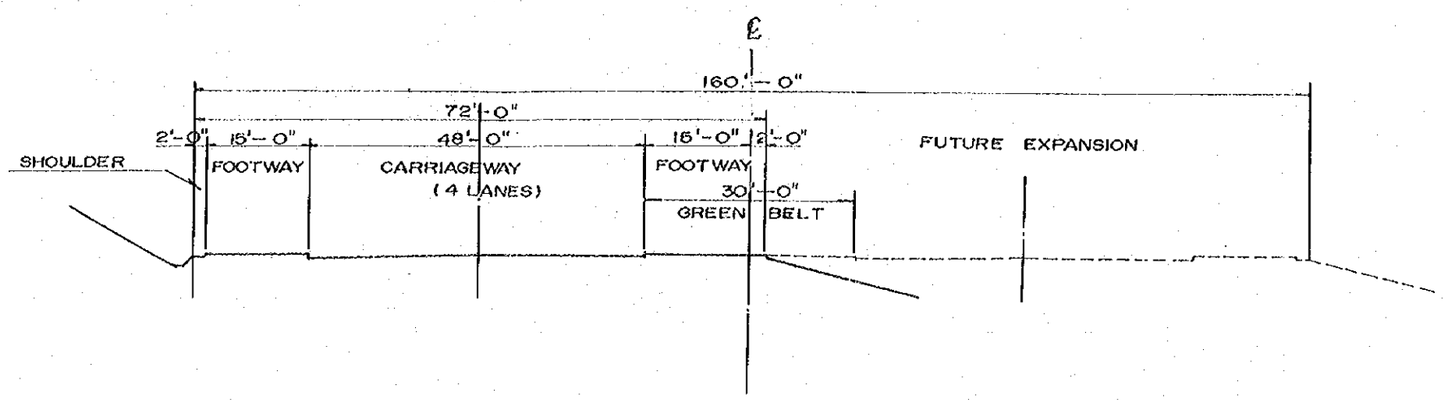
SCALE 1" to 200'



LEGEND :

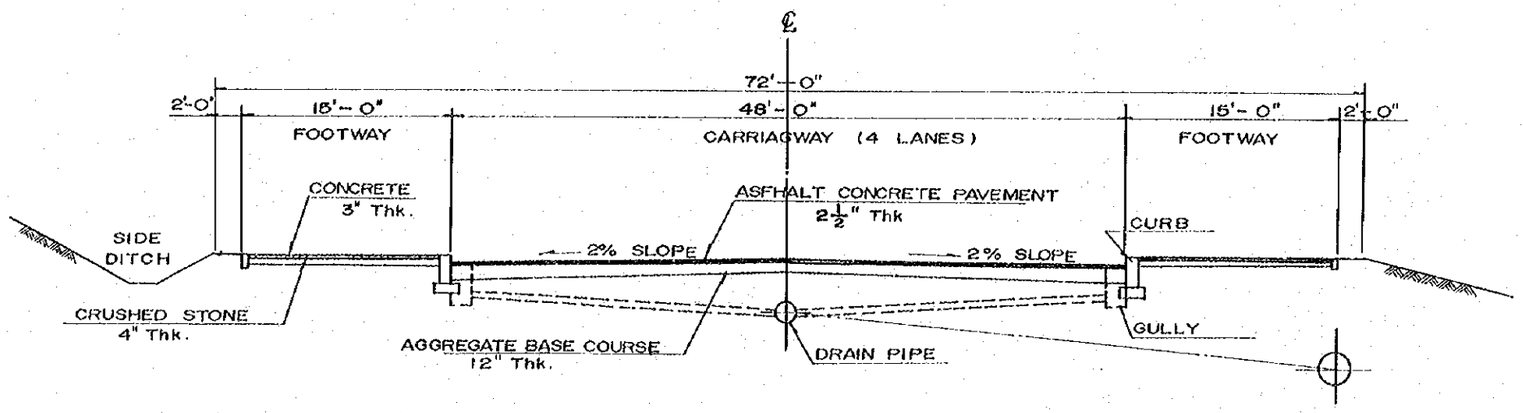
B.C. : BELT CONVEYOR

Fig. 14 TYPICAL SECTION OF ROADWAY



TYPICAL SECTION OF ROADWAY

SCALE 1" to 20'

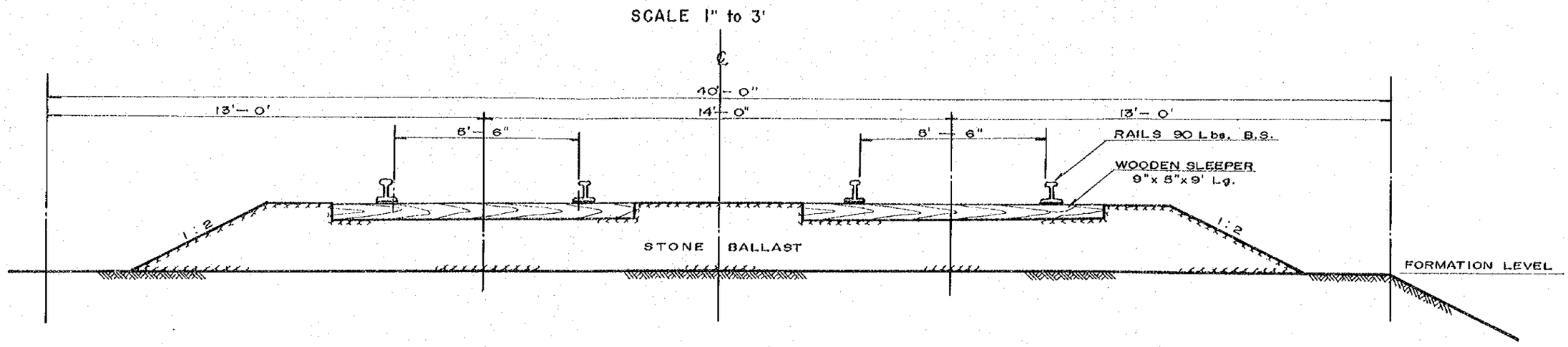


DETAILS OF ROADWAY

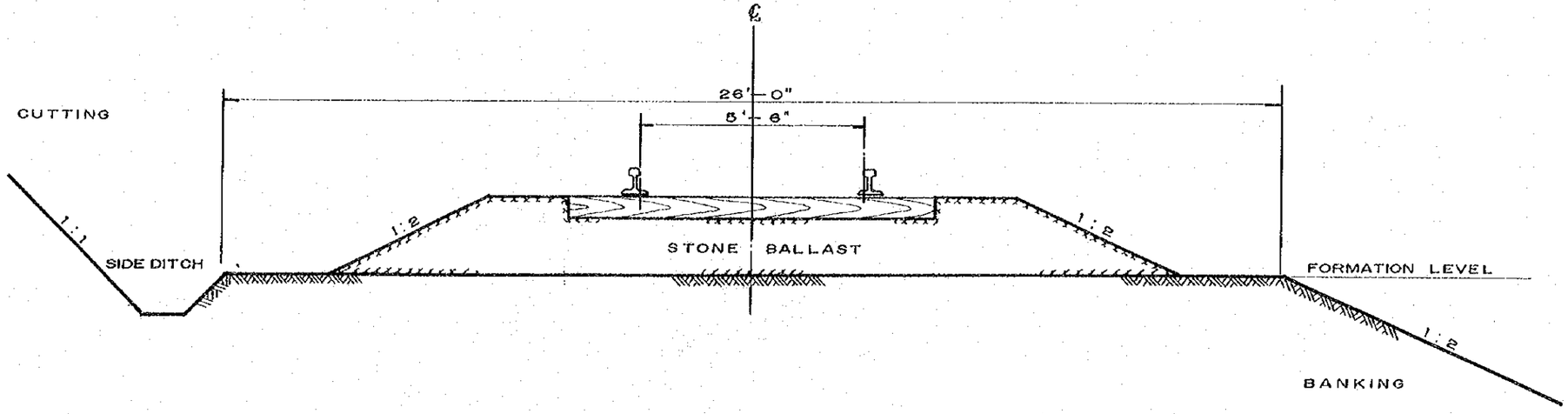
SCALE 1" to 10'

Fig. 15 TYPICAL SECTION OF BROAD GAUGE RAILWAYS

SCALE 1" to 3'



DOUBLE TRACK

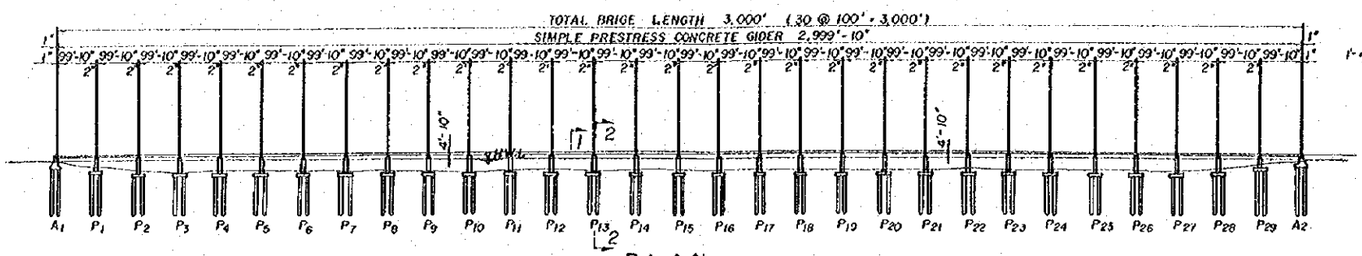


SINGLE TRACK

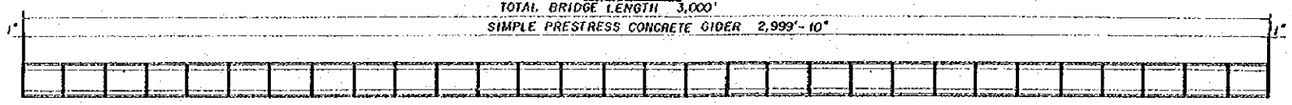
FIG. 16

(ROAD BRIDGE) CLEARANCE : 12 ft

ELEVATION

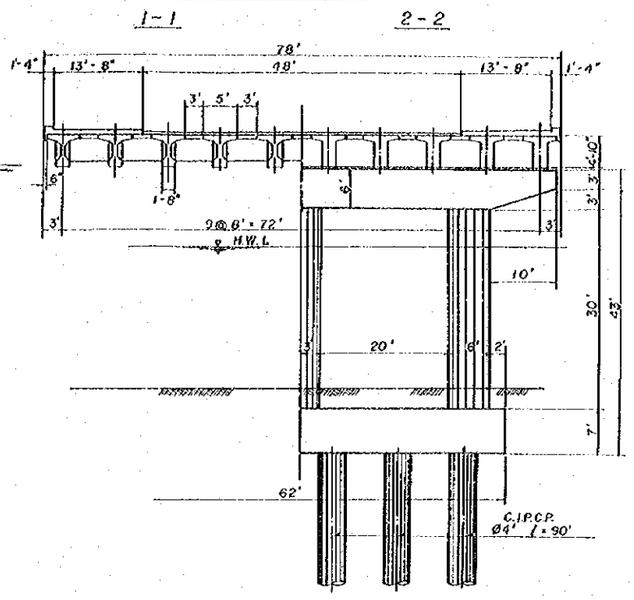


PLAN



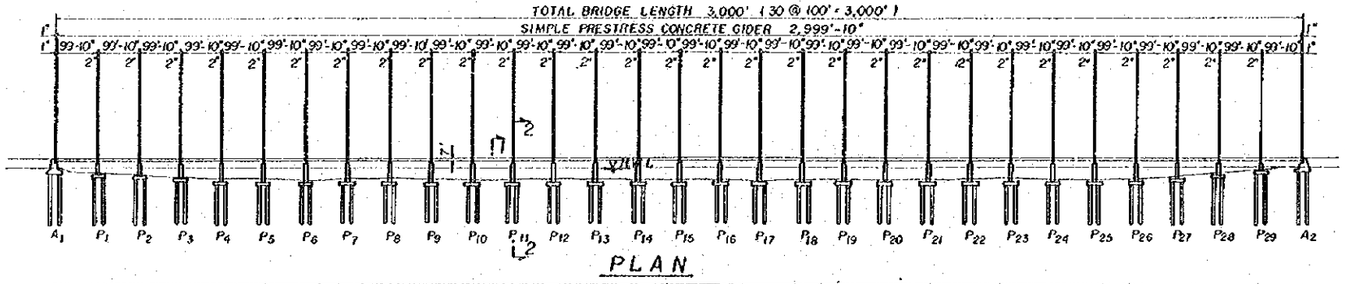
CROSS SECTION

1-1 2-2

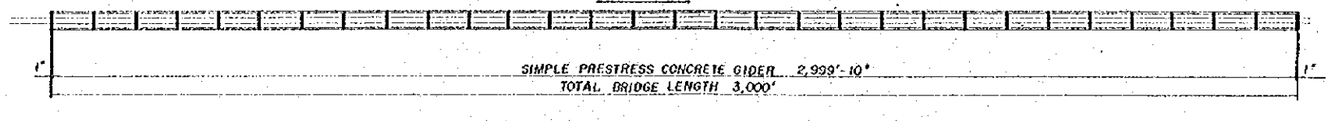


(RAILWAY BRIDGE) CLEARANCE : 12 ft

ELEVATION



PLAN



CROSS SECTION

1-1 2-2

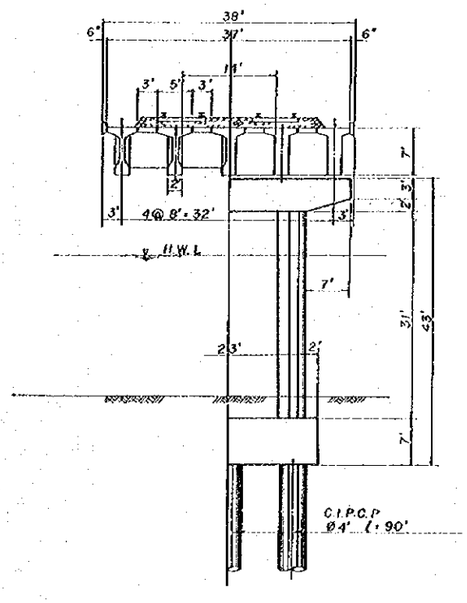


Table 7. Cost Estimation of Long Range Plan

Rs Crore

Facilities	Quantity	Local Currency	Foreign Currency	Total
Dredging				
Outer Harbour	17,400,000m³	2.71	5.42	8.13
Inner Harbour	3,610,000m³	0.56	1.12	1.68
Quay Wall				
Iron Ore (-42')	2 berth	1.58	1.06	2.64
Coal (-42')	1 berth	0.79	0.53	1.32
Oil (-42')	3 berth	1.32	0.88	2.20
Scrap (-34')	1 berth	7.81	5.24	13.05
Bulkcargo (-34')	13 berth	7.81	5.24	13.05
Lighterage Wharf (-10')	450 berth	0.21	0.15	0.36
Road				
Banking	25,300m³	0.01	0	0.01
Pavement (4 lanes)	23,000m³	0.76	0	0.76
Pavement (8 lanes)	3,900m	0.27	0	0.27
Bridge (4 lanes)	2	2.82	0.97	3.79
Over Bridge (4 lanes)	1	0.50	0.17	0.67
Railway				
Banking	220,000m³	0.10	0	0.10
Rail	22,400m	1.25	0.46	1.71
Bridge	1	0.77	0.26	1.03
Reclamation				
Commercial Area	5,260,000m³	2.55	0	2.46
Fishery Yard	1,000,000m³	0.54	0	0.54
Work Yard	50,000m³	0.02	0	0.02
Utilities				
Power, Gas, Water	8,500m	0.21	0.34	0.55
Navigation Aid				
Light Buoy	20	0.12	0	0.12
Range Light	2	0.05	0	0.05
Tug Boat	5	0	0.67	0.67
Cargo Handling Equipment Industrial Area				
Iron Ore (Man-Trolley Unloader)	4	0.65	3.68	4.33
Coal (Man-Trolley Unloader)	2	0.33	1.83	2.16
Belt Conveyor	1,600m	0.06	0.37	0.43
Belt Conveyor (loading)	3	0.03	0.17	0.20
Oil (loading arm)	6	0.04	0.20	0.24
Commercial Area				
Scrap (level luffing crane)	2	0.08	0.53	0.61
Cement (level luffing crane)	4	0.22	1.22	1.44
(Loader)	4	0.12	0.68	0.80
(Belt conveyor)	1,600m	0.06	0.37	0.43
Grain (loader)	6	0.18	1.02	0.20
(Belt conveyor)	2,400m	0.10	0.54	0.64
Fertilizer (level luffing crane)	3	0.16	0.92	1.08
(Belt conveyor)	1,200m	0.05	0.27	0.32
Silo				
Cement, etc.	4	0.21	1.23	1.44
Grain	6	1.14	7.14	8.82
Warehouse				
Cement	4	0.28	0.79	1.07
Phosphate	1	0.06	0.18	0.24
Building	1	0.60	0	0.60
Pipeline	26,000m	0.05	0.05	0.10
Total		29.28	38.46	67.74

Chapter 2. Short-Term Plan

(1) Urgency of Development and Scale of Project

The cargo traffic through Karachi Port in the year 1969/70 amounted to 913 million tons, far exceeding the normal capacity of the port with the resultant delay in berthing and departure of ships and the congestion of cargo. For the smooth growth of economy in West Pakistan along the line laid down by the Fourth Five-Year Plan, it is essential to make vigorous efforts to promote foreign trade which is one of the basic elements of the national economy. In this connection, early solution of the problem arising from a shortage of port facilities is of vital importance. The development of such key industries as iron and steel and petroleum industries, a stepping-stone for the future growth of the nation's economy, is said to be promoted mainly by expanding the existing plants and constructing new small and medium plants up to the year 1974/75 under the current plan. For the development of key industries after the year 1974/75 however, it is essential to construct a number of large plants for these industries. In view of the fact that construction of these large plants requires a long period of time, it is absolutely important to work out a master plan at the earliest opportunity and to have a port, land and water resources ready for use prior to the establishment of an industrial complex.

To break the bottleneck in cargo traffic and to provide a basis for industrial development after the year 1974/75, the Phitti Creek Development Project must be implemented as early as possible. For the plan year 1974/75, the target of cargo traffic at the port has been set at 3.6 million tons, which will be centered on the shipment of dry bulk cargo such as food grains and cement on the basis of the estimate mentioned in PART III, Chapter 1. The maximum tonnage of ships that will be accommodated by the port in that period is to be 20,000 D/W.

(2) Port Planning

(a) Approach Channel and Anchorage

The main approach channel is to have a depth of 27 feet and a width of 600 feet. Although this depth is not sufficient for navigation of a ship of the 20,000 D/W class at the low tide, navigation of such a ship is considered possible when the rise of sea level above the mean at the mean high tide is utilized to the best advantage. Waiting for the turn of the tide is not considered to present any serious problem.

For the approach channel within the port, use of the present basin is considered sufficient. Where the depth is less than 34 feet in the approach to the wharf, partial dredging is to be provided.

For turning basin, no special work on the existing basin will be required if the turning is made when the ship is not loaded (because ships are loaded only one way for the time being). However, as dredging for reclamation will be required eventually, making the use of this dredging for providing a required anchorage is also conceivable.

(b) Deepwater Wharf

Location of mooring facilities for large ship is to be on the side of Khiprianwala as shown in the figure in consideration of the relations to the communication with land area, reclamation of the sea and approach channel. The type and size of mooring facilities required for the first phase of the project are shown in Table 8 below.

Table 8. Size of Mooring Facilities

Type of cargo	Volume of cargo traffic (1,000t)	Tonnage of ships to be accommodated (D/W)	Depth of water (ft.)	Total length	No. of berth	Cargo handling equipment	Remarks
Grain	1,925	20,000	34		3	Two 500 t/hr. unloaders	Three grain silos
Cement	1,500	20,000	34		2	One 500 t/hr. unloader One 200 t/hr. level luffing crane	Two cement silos
Phosphate rock	152						Two sheds

For grain storage facilities, three silos each measuring 75 feet in height and 69,000 ft² in floor area and having a capacity of 53,000t are to be provided for rice and wheat. For storage of cement clinker, two silos each measuring 70 feet in height and 11,000 ft² in floor area and having a capacity of 13,000t are to be provided. In addition, two sheds each having a floor area of about 65,000 ft² are required for storage of cement in bags and phosphate rock.

(c) Working Craft Base

A landing stage of 10 feet in depth and 150 feet in length is to be constructed on the side of the Korangi Mainland on the Korangi Creek as a base for working crafts. The approach road to the landing stage is to be linked with the trunk road at the foot of the bridge. This approach road is to be used also as passageway to the fishing port.

(d) Road

For the estimated traffic volume of 13,500 automobiles in the year 1974/75 (Refer to APPENDIX 8), a 72 feet-wide trunk road with a 4-lane roadway is to be constructed. This 4-lane roadway is one part of the 8-lane road planned under the overall project. In securing land for road construction a width of 300 feet is to be secured where possible in order to allow future expansion of road width.

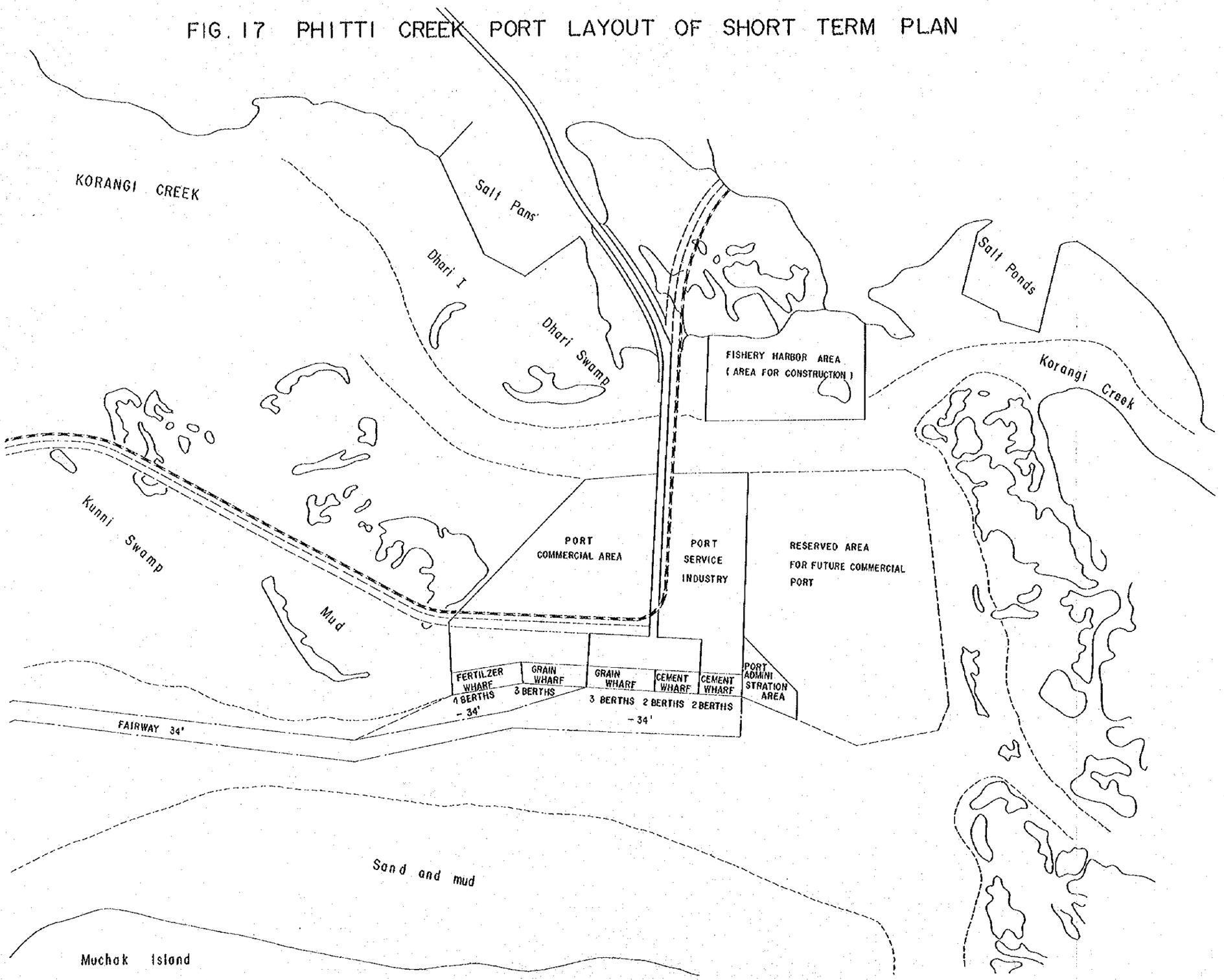
To provide a means of communication between the Korangi Mainland and the Phitti Creek, a bridge having a clearance of 12 feet (above H.W.L.) is to be built over the Korangi Creek.

In the first phase of the project, construction of railways and oil pipelines is not required.

(e) Power and Water Supply

Power demand in the year 1974/75 will be mainly for the operation of large cargo handling equipment and belt-conveyors. In order to meet such power demand, underground cables having a capacity of 2,000 KVA are to be laid from the Korangi district to the port area. These underground cables are to be laid in the 50 feet-wide section of the trunk road, which is reserved for use as medial divider of the future trunk road and to be suspended from the bridge span when crossing a creek. Though the demand for water is estimated at 3,000 tons/day (6.7 lahk gallons/day in summer) for the time being, a 24-inch main is to be laid from the beginning to allow extra capacity for the future. With this main a supply capacity of 20,000 tons/day (45 lahk gallons/day) can be expected. Like power transmission cable, the water main also is to be laid from the Korangi

FIG. 17 PHITTI CREEK PORT LAYOUT OF SHORT TERM PLAN



district and buried beneath the medial divider of the trunk road.

(f) Land Use

Under the land use plan, the minimum land area required for construction of wharves and certain port facilities is to be provided. The total area of planned land use is to be 68.5 hectares and the quantity of filling earth for reclamation is estimated at 688,000 m³. The land use plan is shown in Figure 17.

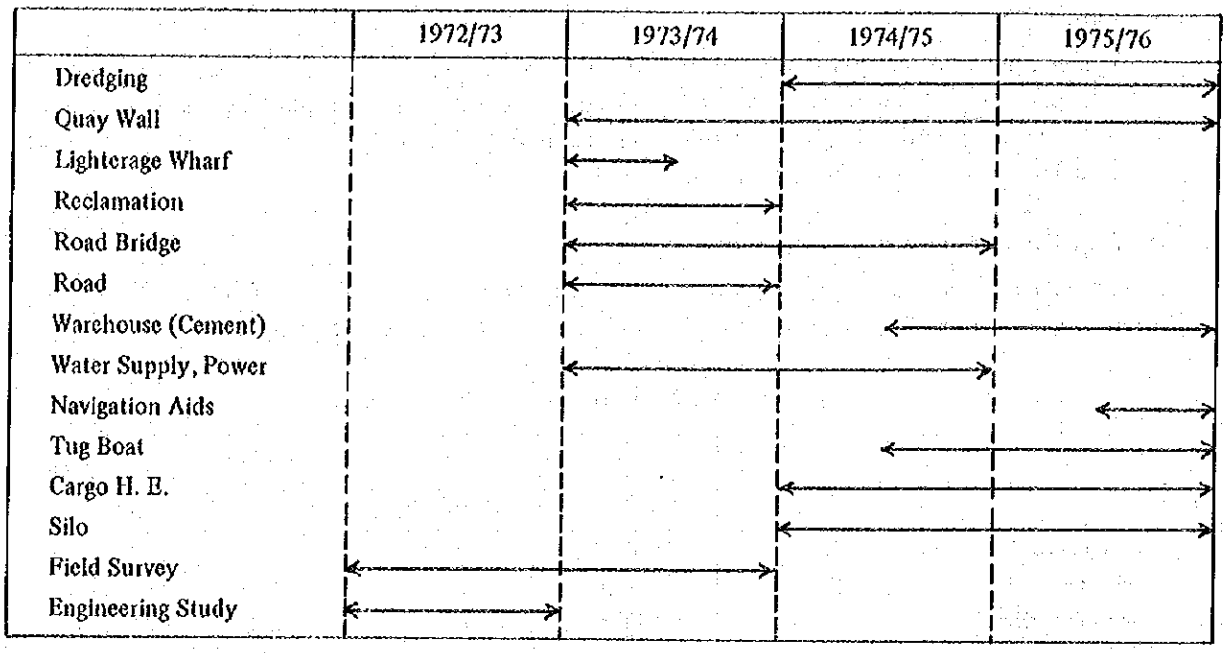
(3) Construction Plan

The cost of construction and the construction schedule for the Phitti Creek Harbour Project for the short-term plan are shown in Table 9 and Table 10 respectively.

Table 9. Cost Estimation of Short-Term Plan

Facilities	Quantity	Local Currency (Crore Rs)	Foreign Currency (Crore Rs)	Total (Crore Rs)
Dredging of the Channel (-27 ft.)	2,580,000m³	0.40	0.80	1.20
-34' quay wall	5 berth	2.85	1.91	4.76
Lighterage wharf	150 ft.	0.07	0.05	0.12
Reclamation	688,000m³	0.32	0	0.32
Road Bridge (4 lanes)	1	1.42	0.47	1.89
Road (4 lanes)	4,500m	0.15	0	0.15
Warehouse (for cement)	2	0.15	0.38	0.53
Utilities (water, electric power)	5,500m	0.09	0.15	0.24
Navigation Aid	1	0.17	0	0.17
Tug Boat (2000 ps.)	2	0	0.27	0.27
Silo (Cement)	2	0.11	0.61	0.72
Silo (Grain)	3	0.57	3.57	4.14
Cargo Handling Equipment				
Belt Conveyor (Cement)	400 m/berth	0.03	0.18	0.21
Loader (Cement)	2	0.06	0.34	0.40
Level Luffing Crane (Cement)	2	0.11	0.61	0.72
Belt Conveyor (Grain)	400 m/berth	0.05	0.27	0.32
Loader (Grain)	3	0.09	0.51	0.60
Total		6.64	10.12	16.76

Table 10. The Construction Schedule for the Short-Term Plan



Chapter 3. Economical Appraisal of Project

1. Financial Examination

In order to determine the feasibility of the Phitti Creek Harbour Project from an economic point of view, a financial examination of the scheme will be made hereinafter.

In this study, however, only the port facilities and the harbour-oriented land will be taken up and the industrial land and the fishing port facilities will be excluded from the discussion. This is due to the fact that the use of Bundal Island for industrial estate will eliminate almost completely the requirement for investment for land formation and that the fishing port facilities should be given its own study independent of other facilities.

(a) Methodology of Financial Examination

1) As the parameters to be used in the econometric analysis of harbour business, the cost-benefit ratio and internal rate of return, both of which are often used in the cost-benefit analysis must be obtained first.

The cost-benefit ratio is the ratio of annual benefit to the cost discounted by the present value and is expressed by the following formula:

$$B_0/C_0 = \sum_{i=1}^{n} B_i/(1+r)^i / \sum_{i=1}^{n} C_i/(1+r)^i \quad \cdots\cdots (1)$$

where: C_0, B_0 = cost and benefit converted to the year previous to the start of construction

C_i, B_i = cost and benefit in the i-th year after the start of construction

r = discount rate

n = number of years for which study is to be made

The ratio B_0/C_0 is determined automatically when the annual cost C_i, benefit B_i, discount rate r, and the number of years under study n, are provided.

2) The discounted present value of the project converted to the year previous to the start of construction, meanwhile, may be expressed by the following formula.

$$Pv = \sum_{i=1}^{n} (B_i - C_i)/(1+r)^i \quad \cdots\cdots (2)$$

where: Pv = present value of the project converted to the year previous to the start of construction

B_i, C_i = cost and benefit in the i-th year after the start of construction

r = discount rate

n = number of years for which study is to be made

If the discount rate equivalent to Pv = 0, is denoted by R, it is defined as the internal rate of return and can be obtained as the solution of the following:

$$0 = \sum_{i=1}^{n} (B_i - C_i)/(1+R)^i \quad \cdots\cdots (2)'$$

As is evident from the above definition, there is no need to take into account the rate of interest or depreciation cost for B_i and C_i, and the profitability of the project may be evaluated by obtaining only the discount rate r.

(b) Business Analysis of Port Management

1) Here discussions will be limited to the operating entity of Phitti Creek Port and a study will be made on the profitability of the port management.

Cost and Revenue

i) The project cost is to include the cost of construction for all facilities of Phitti Creek Port (including related lands) and maintenance cost for fairway and basin, but it does not include interest during construction. The facilities to be examined in the cost analysis are as follows:

Fairway, basin, deepwater wharf, lighterage wharf, warehouse, silo, cargo handling equipment, road, railway, other facilities (including water and electric facilities and pipe lines), port-related land.

ii) Capital investment for each year under the construction plan mentioned in Part III, Chapter 1, 2 is shown in Table 11. Investment of capital funds was presumed to be made according to the construction schedule for the period from the year 1972/73 to the year 1975/76, and in equal share for the period from the year 1976/77 to the year 1984/85. For the cost of maintenance dredging, the cost of maintenance dredging of fairway and basin was considered. From the results of a study made in Part II, Chapter 2, the cost for dredging the 27 feet-deep fairway and basin amounting to 315,000 m^3/year was considered for the short-term plan and the cost of dredging for the 42 feet-deep fairway and basin amounting to 553,000 m^3/year was considered from the year following the completion of capital dredging.

On the cost of construction and the maintenance cost, the portion corresponding to foreign currency is to be multiplied by 1.75 in value in view of the present monetary situation in Pakistan.

Table 11. Cost of Construction and Cost of Maintenance Dredging (1973/74 to 1984/85)

Crore Rs. (Unit: 1,000$)

	Cost of Construction	Cost of Maintenance Dredging	Total	Remarks
1973/74	4.01 (8,354)		4.01 (8,354)	
1974/75	10.56 (22,000)		10.56 (22,000)	
1975/76	9.79 (20,396)		9.79 (20,396)	
1976/77	8.11 (16,900)	0.22 (460)	8.33 (17,360)	
1977/78	8.02 (16,700)	0.22 (460)	8.23 (17,160)	
1978/79	8.02 (16,700)	0.22 (460)	8.23 (17,160)	
1979/80	8.02 (16,700)	0.22 (460)	8.23 (17,160)	
1980/81	8.02 (16,700)	0.39 (807)	8.41 (17,507)	
1981/82	8.02 (16,700)	0.33 (807)	8.41 (17,507)	
1982/83	8.02 (16,700)	0.39 (807)	8.41 (17,507)	
1983/84	8.02 (16,700)	0.39 (807)	8.41 (17,507)	
1984/85	8.02 (16,700)	0.39 (807)	8.41 (17 507)	
Total	96.60 (201,250)	2.88 (5,068)	99.43 (206,318)	

Note: Because of the rounding up of figures with fractions more than 0.5 inclusive and cutting away the rest of fractions in converting the dollar to the rupee, the total sum of the rupee in the column of total does not match the figure in the bottom line. As the figures of the rupee and dollar shown in the column of total are the sum of the converted figures on annual basis and are rounded off, they do not match one another when converted again.

iii) The net profit which is obtained by deducting the expenditure from the port revenue was considered as the benefit. The method of calculating the revenue and expenditure will be discussed hereinafter.

The port revenue is generated against the port facilities and services offered by the administrator of Phitti Creek Port.

The amount of port revenue was determined by multiplying per-ton revenue (or per-gross tonnage revenue) practised at Karachi Port by the total volume of cargo (or gross tonnage of ships) to be handled at Phitti Creek Port each year. The volume of cargo and the gross tonnage of ships to enter Phitti Creek Port each year are shown in APPENDIX 9-1.

In calculating the port revenue the use of the present tariff table for Karachi Port in its original form was avoided as it would have only complicated the work, and instead a simple tariff table for Karachi Port as shown in Table 12 was prepared with reference to the Karachi Port Administration Report 1967/68. As a considerable reduction in cargo handling time can be expected for grain and cement (clinker) as compared with Karachi Port, special rate of charges as shown in Table 13 was worked out by which part of the benefit derived from a quick dispatch of ships due to a shortened cargo handling time may be charged against the ship-owners. (Refer to APPENDIX 9-2)

As for port-related land, the rent equivalent to the interest of capital investment for land formation can be expected. However, the amount is too small compared to the total revenue and therefore was not included in the current study.

Table 12. Port Revenue Per Ton of Cargo and Per Gross Tonnage of Ships

	Rate of Charge	Remarks
1. Wharfage		
1) Grain (Export)	2.0 Rs/ton	Determined from the charges practised at Karachi Port
2) Oil (Export & Import)	4.0	
3) Coal, Ore, Phosphate Rock (Import)	3.0	
4) Cement (Export)	2.3	
5) Others (Import)	4.5	Determined from the charges practised at Karachi Port except for oil
(Export)	4.0	
2. Storage	4.0	1) Determined from the charges practised at Karachi Port except for oil 2) Cargo under this category excludes oil, and coal and coke
3. Cranage	0.8	1) Determined from the charges practised at Karachi Port except for oil 2) Cargo under this category excludes oil
4. Berth Fees	320 Rs/1,000 N.R.T.	Determined from the charges practised at Karachi Port
5. Port Dues	400 Rs/1,000 N.R.T.	
6. Pillotage Fees	370 Rs/1,000 N.R.T.	
7. Miscellaneous	0.6 Rs/ton	Determined from the charges practised at Karachi Port

Table 13. Special Rates for Grains and Cement (Clinker)

	Special Fees	Remarks
1. Grain (Rice, Wheat)	1.9 Rs/ton	
2. Cement (Clinker)	2.6	

From the above, the port revenue for each year may be calculated as follows:

Table 14. Revenue of Phitti Creek Port

1,000 Rs (1,000$)

	Revenue	Remarks
1976/77	35,460 (7,387)	Revenue commensurating with the total volume of cargo to be handled in the year 1974/75.
1977/78 1979/80	49,634 (10,340)	Revenue commensurating with the total volume of cargo to be handled in the year 1977/78.
1980/81 1984/85	148,161 (30,867)	Revenue commensurating with the total volume of cargo to be handled in the year 1982/83.
1984/85	175,748 (36,614)	

v) As for expenditure, the maintenance cost, working expenses and general charges, all of which are required by the administrator of the port in offering the use of facilities and services, were considered.

Expenditure of Phitti Creek Port was presumed to be as follows with reference to the expenditure of Karachi Port in the year 1967/68. (Refer to Table 15)

Table 15. Expenditure of Karachi Port (1967/68)

(1,000 Rs)

	Expenditure	Per ton expenditure	Remarks
	M.Rs.	Rs/ton	
1. Working expenses	15,679	1.8	Pay, allowances, contingencies, stevedoring, etc.
2. General	8,341	1.0	Contribution to Provident Fund Water Supply, Publications, Chairman's salary, etc.
3. Repairs and maintenance cost	12,020	1.4	Warehouses, Tugs, Cranes, Signal Stations, etc. (except maintenance dredging)
4. Total	35,770	4.2	

a) While the working expense per ton of cargo at Karachi Port is 1.8 Rs, the working expenses at Phitti Creek Port is estimated at about 10% of that at Karachi because of the modern highly efficient facilities available at Phitti Creek. However, in consideration of the abundant labour force available in Pakistan and in order to be on the safe side for calculation, the working expenses per ton of cargo was determined to be 0.5 Rs or 30% of that at Karachi Port.

b) The same principle may be applied to general charges. However, due to the fact that general charges cannot be trimmed as drastically as the working expenses, the general charges at Phitti Creek Port was determined to be 0.5 Rs/ton or 50% of that at Karachi Port (1.0 Rs/ton at Karachi Port).

c) Repairs and maintenance cost were determined to be 1% of the capital cost excluding dredging cost and the cost of reclamation by filling up.

On the basis of the above concept, per-ton expenditure of Phitti Creek Port may be calculated as shown in Table 16. With the use of this table, the total expenditure of the port may be calculated as shown in Table 17.

Table 16. Per-ton Expenditure of Phitti Creek Port

	Per ton expenditure	Remarks
1. Working expenses	0.5 Rs/ton	30% of the expenditures at Karachi Port was considered.
2. General charges	0.5	50% of the expenditures at Karachi Port was considered.
3. Repairs and maintenance cost	1% of capital cost	

Table 17. Expenditure of Phitti Creek Port

	Expenditure	Remarks
1976/77	5,836 (1,216)	
1977/78 to 1979/80	8,390 (1,748)	
1980/81 to 1984/85	28,224 (5,880)	
1984/85	34,406 (7,168)	

(c) Results of Analysis and Comments

1) The analysis was made on the project for both the short-term plan and the long-range plan. The study is to cover a period of 30 years from the year of completion. Therefore, an attempt will be made to obtain benefit/cost ratio and internal rate of return for this period. When a 6% discount rate is used in the light of the prevailing official rate in West Pakistan (5% as of October 1971, IMF statistics) and in consideration of the public nature of the project, the benefit/cost ratio becomes 1.43 for the short-term plan and 1.99 for the long-range plan and the internal rate of return is 9.8% for the short-term plan and 13.5% for the long-range plan, as shown in Table 18 and Table 19, respectively.

The internal rate of return of more than 12% is generally interpreted as an indicator of soundness of a specific project.

The low internal rate of return under the short-term plan is considered natural when the fact that the short-term plan includes such pre-investments as the cost of dredging, road and bridge, which overlaps the investment under the long-range plan, is taken into consideration. Therefore, the soundness of the project should not be judged by the internal rate of return under the short-term plan but by the internal rate of return under the long-range plan.

Inclusion of investment for railways, water, gas and electricity in the cost of construction is aimed at clarifying the extent of the total investment and therefore the revenue from these facilities are not considered for the calculation of the total investment. Consequently, the internal rate of return is expected to increase further when the commercial management of the port is taken into consideration.

As for port revenue used for calculating the internal rate of return, the same wharfage as used at Karachi Port was used. However, Phitti Creek Port is expected to be equipped with modern facilities for cargo storage as compared with Karachi Port and as a result, dependable storage of cargo with sufficient protection against theft and damage can be expected. Because of this, coupled with efficient stock of cargo, a higher turnover ratio of capital can be expected. In view of such advantages of Phitti Creek Port, increase in the wharfage should also be considered.

In the current calculation the rent of land is not included in the port revenue. When the rent of land is taken into consideration, the internal rate of return will be further improved.

The above analysis is based on the direct costs and direct benefits (revenues). It is considered that an economic analysis of the Plan in the usual sense is not required at this stage because:

i) the need for a second port in West Pakistan is established in this report;

ii) Phitti Creek site has been established as the best site for the Second Port out of the three sites considered, namely Western Backwater of Karachi Harbour, Sonmiani and Phitti Creek;

iii) the "Internal Rate of Return" of the long term plan is already quite high without even considering indirect benefits.

Table 18 Business Analysis of Phitti Creek Port (Short-term Plan)

	a) Investment cost US$1,000	b) Maintenance cost US$1,000	c) Revenue US$1,000	d) Expenditure US$1,000	e) Net profit (=Benefit) c) – d) US$1,000	f) Net benefit e) – a) – b) US$1,000	g) Cost a) + b) US$1,000	h) Cost 6% discounted US$1,000	i) Benefit 6% discounted US$1,000	j) Net benefit 9% discounted US$1,000	k) Net benefit 10% discounted US$1,000
1973/74	8,354					-8,354	8,354	2,881		-7,664	-7,594
75	22,000					-22,000	22,000	19,580		-18,517	-18,182
76	20,396					-20,396	20,396	17,125		-15,749	-15,324
77		460	7,387	1,216	6,171	5,711	460	364	4,886	4,044	3,899
78		460	7,387	1,216	6,171	5,711	460	343	4,609	3,710	3,544
79		460	7,387	1,216	6,171	5,711	460	324	4,349	3,403	3,222
80		460	7,387	1,216	6,171	5,711	460	306	4,102	3,122	2,930
81		460	7,387	1,216	6,171	5,711	460	289	3,870	2,865	2,663
82		460	7,387	1,216	6,171	5,711	460	272	3,651	2,629	2,421
83		460	7,387	1,216	6,171	5,711	460	257	3,444	2,411	2,201
84		460	7,387	1,216	6,171	5,711	460	242	3,249	2,212	2,000
85		460	7,387	1,216	6,171	5,711	460	228	3,065	2,029	1,819
86		460	7,387	1,216	6,171	5,711	460	216	2,892	1,862	1,654
87		460	7,387	1,216	6,171	5,711	460	203	2,728	1,708	1,501
88		460	7,387	1,216	6,171	5,711	460	192	2,574	1,567	1,367
89		460	7,387	1,216	6,171	5,711	460	181	2,428	1,438	1,242
90		460	7,387	1,216	6,171	5,711	460	171	2,290	1,319	1,129
91		460	7,387	1,216	6,171	5,711	460	161	2,161	1,210	1,027
92		460	7,387	1,216	6,171	5,711	460	152	2,038	1,111	933
93		460	7,387	1,216	6,171	5,711	460	143	1,923	1,018	848
94		460	7,387	1,216	6,171	5,711	460	135	1,815	934	772
95		460	7,387	1,216	6,171	5,711	460	128	1,711	858	701
96		460	7,387	1,216	6,171	5,711	460	120	1,615	786	638
97		460	7,387	1,216	6,171	5,711	460	114	1,523	688	580
98		460	7,387	1,216	6,171	5,711	460	107	1,437	662	527
99		460	7,387	1,216	6,171	5,711	460	101	1,356	608	479
2000		460	7,387	1,216	6,171	5,711	460	95	1,279	557	436
1		460	7,387	1,216	6,171	5,711	460	90	1,207	511	396
2		460	7,387	1,216	6,171	5,711	460	85	1,138	469	360
3		460	7,387	1,216	6,171	5,711	460	80	1,074	430	327
4		460	7,387	1,216	6,171	5,711	460	76	1,013	395	298
5		460	7,387	1,216	6,171	5,711	460	71	955	362	271
6		460	7,387	1,216	6,171	5,711	460	67	902	332	246
								49,899	71,284	3,320	-666

Benefit-cost ratio when 6% discounted B_0/C_0 = 71,284/49,899 = 1.43

Internal rate of return $R = 9 + \frac{3,320}{3,320 + 666} = 9.8\%$

Table 19. Business Analysis of Phitti Creek Port (Long-range Plan)

	a) Investment cost US$1,000	b) Maintenance cost US$1,000	d) Revenue US$1,000	d) Expenditure US$1,000	e) Net profit (=Benefit) c) – d) US$1,000	f) Net benefit e) – a) – b) US$1,000	g) Cost a) + b) US$1,000	h) Cost 6% discounted US$1,000	i) Benefit 6% discounted US$1,000	j) Net benefit 13% discounted US$1,000	k) Net benefit 14% discounted US$1,000
1973/74	8,354					-8,354	8,354	7,881		-7,393	-7,328
75	22,000					-22,000	22,000	19,580		-17,229	-16,928
76	20,396					-20,396	20,396	17,125		-14,135	-13,767
77	16,900	460	7,387	1,216	6,171	-11,189	17,360	13,751	4,886	-6,862	-6,625
78	16,700	460	10,340	1,748	8,592	-8,568	17,160	12,823	6,420	-4,650	-4,459
79	16,700	460	10,340	1,748	8,592	-8,568	17,160	12,097	6,056	-4,116	-3,904
80	16,700	460	10,340	1,748	8,592	-8,568	17,160	11,412	5,714	-3,642	-3,424
81	16,700	807	30,867	5,880	24,987	7,480	17,507	10,924	15,677	2,814	2,622
82	16,700	807	30,867	5,880	24,987	7,480	17,507	10,362	14,790	2,490	2,300
83	16,700	807	30,867	5,880	24,987	7,480	17,507	9,776	13,952	2,204	2,018
84	16,700	807	30,867	5,880	24,987	7,480	17,507	9,223	13,163	1,950	1,770
85	16,700	807	36,614	7,168	29,446	11,939	17,507	8,700	14,634	2,754	2,478
86		807	36,614	7,168	29,446	28,639	807	378	13,805	5,847	5,214
87		807	36,614	7,168	29,446	28,639	807	357	13,024	5,174	4,574
88		807	36,614	7,168	29,446	28,639	807	337	12,287	4,579	4,012
89		807	36,614	7,168	29,446	28,639	807	318	11,591	4,052	3,519
90		807	36,614	7,168	29,446	28,639	807	300	10,935	3,586	3,087
91		807	36,614	7,168	29,446	28,639	807	283	10,316	3,173	2,708
92		807	36,614	7,168	29,446	28,639	807	267	9,732	2,808	2,376
93		807	36,614	7,168	29,446	28,639	807	252	9,181	2,485	2,083
94		807	36,614	7,168	29,446	28,639	807	237	8,662	2,199	1,828
95		807	36,614	7,168	29,446	28,639	807	224	8,171	1,946	1,603
96		807	36,614	7,168	29,446	28,639	807	211	7,709	1,722	1,406
97		807	36,614	7,168	29,446	28,639	807	199	7,272	1,524	1,234
98		807	36,614	7,168	29,446	28,639	807	188	6,861	1,349	1,082
99		807	36,614	7,168	29,446	28,639	807	177	6,473	1,194	949
2000		807	36,614	7,168	29,446	28,639	807	167	6,306	1,056	833
1		807	36,614	7,168	29,446	28,639	807	158	5,761	935	731
2		807	36,614	7,168	29,446	28,639	807	149	5,435	827	641
3		807	36,614	7,168	29,446	28,639	807	141	5,127	732	562
4		807	36,614	7,168	29,446	28,639	807	133	4,837	648	493
5		807	36,614	7,168	29,446	28,639	807	125	4,563	573	432
6		807	36,614	7,168	29,446	28,639	807	118	4,305	507	379
7		807	36,614	7,168	29,446	28,639	807	111	4,061	449	332
8		807	36,614	7,168	29,446	28,639	807	105	3,831	398	292
9		807	36,614	7,168	29,446	28,639	807	99	3,614	352	256
10		807	36,614	7,168	29,446	28,639	807	93	3,410	311	225
11		807	36,614	7,168	29,446	28,639	807	88	3,217	276	197
12		807	36,614	7,168	29,446	28,639	807	83	3,035	243	173
13		807	36,614	7,168	29,446	28,639	807	78	2,863	216	152
14		807	36,614	7,168	29,446	28,639	807	74	2,701	191	133
15		807	36,614	7,168	29,446	28,639	807	70	2,548	169	117
								149,234	296,725	3,706	-3,615

Benefit-cost ratio when 6% discounted B_0/C_0 = 296,725/149,234 = 1.99

Internal rate of return $R = 13 + \frac{3,706}{3,706 + 3,615} = 13.5\%$

2. Repayment Plan

In order to provide guidance for the preparation of a repayment plan which is to be worked out prior to the implementation of the Phitti Creek Harbour Project, a draft of repayment plan and others for the short-term plan will be given below.

(a) Annual Redemption

The amount of annual redemption of the facilities may be obtained from the following formula.

$$\text{Annual redemption of facilities} = \frac{\alpha \times i}{(1+i)^n - 1} \times \text{Cost of construction}$$

where; n = service life

i = interest rate: $i = 5.0\%$

α = percentage of the cost of construction to be redeemed.

With the fixed service life of each facility, the rate of redemption $[a = i/(1+i)^n - 1]$ may be obtained as shown in the table below.

	Service life year	$a = i/(1+i)^n - 1$	α (%)
Fairway Basin			
Quay wall	50	0.004777	75
Lighterage wharf	50	0.004777	75
Road bridge	50	0.004777	100
Pavement	20	0.030242	100
Reclamation by filling up			
Warehouse	30	0.015051	80
Silo	30	0.015051	80
Electric and Water Facilities	30	0.015051	80
Navigation Aids	15	0.046342	100
Tag Boat	15	0.046342	100
Cargo Handling Equipments	15	0.046342	100

1) Annual redemption for all the facilities will be as shown in the following table.

Crore Rs

	Cost of construction to be redeemed Rs (Crore)	$a = i/(1+i)^n - 1$	Annual redemption for each facility Rs (1,000)
Quay wall	6.19 (4.76)	0.004777	221.8
Lighterage wharf	0.16 (0.12)	0.004777	5.7
Road bridge	2.24 (1.89)	0.004777	107.0
Pavement	0.15 (0.15)	0.030242	45.4
Warehouses	0.82 (0.53)	0.015051	98.7
Silo	8.00 (4.86)	0.015051	963.2
Electric and water facilities	0.35 (0.24)	0.015051	42.1
Navigation aids	0.17 (0.17)	0.046342	78.8
Tag boat	0.47 (0.27)	0.046342	217.8
Cargo handling equipments	3.68 (2.25)	0.046342	1,705.4
Total			3,485.9

Note: The cost of construction given is shadow price. The cost in brackets is original cost as given in table 9.

In view of the fact that the short-term plan terminates three years after the start of construction and that the service life of the facilities is relatively long, depreciation of the facilities was presumed to start after the year 1976/77.

2) Annual Repayment

The amount of annual repayment for borrowed money was determined to be the balance of annual net profit of the part after a deduction of annual redemption and annual cost of maintenance dredging. The amount of repayment for each year is shown in the following table.

1,000 Rs

Year	Port revenue (Net profit)	Deduction		Repayment
		Duplication	Maintenance	
1976/77	29,621	3,486	2,208 (460)	23,927
1977/78	29,621	3,486	2,208 (460)	23,927

3) Repayment Plan

a) Amount of Repayment

The amount of annual repayment was calculated on condition that the portion corresponding to foreign currency of the borrowed money carries a 4.5% annual interest and that the principal and interest are to be repaid equally over a period of 20 years upon completion of the work. The amount of annual repayment may be obtained from the following formula.

$$X = \frac{i(1+i)^n}{(1+i)^n - 1} B \quad \cdots\cdots (1)$$

$$B = A(1+i)^n$$

where: A = amount of borrowed money
B = amount of principal to be repaid
X = amount of annual repayment
i = annual interest rate
n = number of years required for repayment
n_0 = number of years requiring payment of interest during construction

Assuming i = 0.045 and n = 20.

$$X = \frac{0.045 \times 1.045^{20}}{1.045^{20} - 1} \qquad B = 0.076876B$$

Assuming the repayment starts in the year following the completion of the work:

$$B = 17{,}700{,}000 \times (1 + 0.045)^3 + 80{,}900{,}000 \times (1 + 0.045)^2 + 78{,}600{,}000 \times (1 + 0.045)$$

$$= 20{,}200{,}000 + 88{,}350{,}000 + 82{,}140{,}000 \fallingdotseq 190{,}700{,}000 \text{ Rs}$$

$$X \fallingdotseq 14{,}700{,}000 \text{ Rs}$$

Therefore, the amount of annual repayment for borrowed money (portion corresponding to foreign currency) is 14,700,000 Rs.
For repayment of borrowed money corresponding to local currency a major portion of the balance after a deduction of 14,700,000 Rs from the net profit, amounting to 6,500,000 Rs (6% interest), is considered.

b) Repayment Plan

As shown in Table 20, repayment of the portion corresponding to foreign currency completes in 20 years by the payment of 14,700,000 Rs annually.
Meanwhile, repayment of the portion corresponding to local currency also completes in 20 years.

Table 20. Plan for Repayment of Borrowed Money

(1,000 Rs)

	Repayment	Foreign Currency					Local Currency				
		Amount of Investment	Amount repaid			Balance	Amount of Investment	Amount repaid			Balance
			Interest 4.5%	Principal	Total			Interest 6.0%	Principle	Total	
1976/77	23,927	190,700	8,600	6,100	14,700	184,600	75,000	4,500	2,000	6,500	73,000
78	23,927	(Including	8,300	6,400	14,700	178,200	(Including	4,400	2,100	6,500	70,900
79	23,927	Interest)	8,000	6,700	14,700	171,500	Interest)	4,300	2,200	6,500	68,700
80	23,927		7,700	7,000	14,700	164,500		4,100	2,400	6,500	66,300
81	23,927		7,400	7,300	14,700	157,200		4,000	2,500	6,500	63,800
82	23,927		7,000	7,700	14,700	149,500		3,800	2,700	6,500	61,100
83	23,927		6,700	8,000	14,700	141,500		3,700	2,800	6,500	58,300
84	23,927		6,400	8,300	14,700	133,200		3,500	3,000	6,500	55,300
85	23,927		6,000	8,700	14,700	124,500		3,300	3,200	6,500	52,100
86	23,927		5,600	9,100	14,700	115,400		3,100	3,400	6,500	48,700
87	23,927		5,200	9,500	14,700	105,900		2,900	3,600	6,500	45,100
88	23,927		4,800	9,900	14,700	96,000		2,700	3,800	6,500	41,300
89	23,927		4,300	10,400	14,700	85,600		2,500	4,000	6,500	37,300
90	23,927		3,800	10,900	14,700	74,700		2,200	4,300	6,500	33,000
91	23,927		3,400	11,300	14,700	63,400		2,000	4,500	6,500	28,500
92	23,927		2,800	11,900	14,700	51,500		1,700	4,800	6,500	23,700
93	23,927		2,300	12,400	14,700	39,100		1,400	5,100	6,500	18,600
94	23,927		1,800	12,900	14,700	26,200		1,100	5,400	6,500	13,100
95	23,927		1,200	13,500	14,700	12,700		800	5,700	6,500	7,400
96	23,927		600	12,700	13,300	0		400	7,400	7,800	0

PART IV

A COMPARISON WITH ALTERNATIVE PLANS

PART IV. A COMPARISON WITH ALTERNATIVE PLANS

Chapter 1. Western Backwater of Karachi Port

1. General Features

The Western Backwater is a vast tidal basin extending to the west of the West Wharf of the present Karachi Port. This basin is connected to the existing channel via the Baba Channel.

The basin covers an area of approximately 15 square miles. The depth of water is 5 to 10 feet in the channel section and the greater part of the basin is a mud flat land with elevations of 1 to 6 feet above the chart datum. The part facing the sea is a mangrove swamp of fairly dense vegetation. Judging from its topographical feature, the basin is considered as the only site which allows the future extension of Karachi Port.

The Layari river flowing into the basin has no substantial discharge except at the time of heavy rainfall.

The tidal current in the vicinity of the entrance to the basin has a velocity of about 1.4 knot at normal tidal range. As the present condition of the basin is maintained through balanced natural conditions for a long period of time, it is certain that any change in the present condition resulting from such works as reclamation will bring about major changes in the hydrographic structure of the basin, which will be discussed in the next section.

Following is an outline of tide and tidal current of the basin summarized on the basis of the Karachi Port Master Plan prepared by K.P.T. and the Report of Survey for Phitti Creek prepared by H.R.S.

According to the observations made at Karachi Port, the equinoctial spring tides fluctuate between -0.7 feet and +9.4 feet from K.P.T. datum line with a tidal range of 10.1 feet. The maximum range of the theoretical astronomical tide is 11.9 feet.

The tidal range at the western tip of the Western Backwater is 9 inch lower than that at the port entrance.

According to the report on Phitti Creek by H.R.S., the tide at the Phitti Creek is more of the diurnal tide rather than the semi-diurnal tide with different phases between them and shows a wide, difference in the continuous high tide level. The report defines the spring tide as the tide over 7.5 feet and the neap tide as the tide below 5.2 feet and gives the mean range of the spring tide as 8.8 feet and that of the neap tide as 3.7 feet.

Tidal current measured at a point 3,000 feet off the tip of the Morara breakwater of Karachi Port has a speed of 1-1/4 knot in the direction of east at normal tidal range and it decreases to about 1/2 knot at a point 2 miles off the previously mentioned measuring point. At the port entrance the tidal current changes to flood current with a velocity of about 1.3 knot.

In the Phitti Creek, tidal observations have been conducted several stations located on the stretch of the creek and outside of the port entrance. According to the available data with some adjustments made to the tidal range, the velocity of tidal current in front of the proposed port construction site is 3.5 ft./s (Approximately 2.0 knots) as the maximum and 1.2 knots on the average and the velocity outside of the port entrance is less than one knot. The direction of tidal current deviates from the direction of the proposed channel on the

Table 21. Data on Visibility Conditions at Karachi

Visibility / Month	No. of Days with Visibility				
	Upto 1,100 yds	1,100 yds to 2.5 miles	2.5 to 6.25 miles	6.25 to 12.5 miles	over 12.5 miles
Jan.	0.1	0.9	12	13	5
Feb.	0.5	1.5	7	11	8
Mar.	0	1.6	7	14	8
Apr.	0	0.7	5	16	8
May	0.3	0.6	9	20	1
June	0	4	16	9	1
July	0	7	19	5	0.1
Aug.	0	2	18	9	2
Sept.	0.3	0.4	6	20	4
Oct.	0.5	1	6	12	12
Nov.	0.4	1.6	11	11	6
Dec.	0	0.9	11	15	4

Table 22. Data on Wind Conditions for Karachi

Month	No. of days with wind force				Percentage No. of days of wind from								Calm	Mean wind speed m.p.h.
	8 or more	4-7	1-3	0	N	NE	E	SE	S	SW	W	NW		
Jan.	0	2	28	1	28	33	10	2	2	4	8	12	1	6.2
Feb.	0	3	23	2	25	26	9	2	1	17	14	17	1	6.3
Mar.	0	3	29	1	12	6	2	0	2	17	39	20	0	8.2
Apr.	0	4	26	0	4	2	1	0	1	30	50	10	0	9.7
May	0	51	16	0	1	1	0	1	3	38	51	5	0	11.6
June	0	19	11	0	1	1	1	1	2	44	47	3	0	12.7
July	0	21	10	0	1	0	0	0	2	41	50	6	0	12.8
Aug.	0	18	13	0	0	0	0	0	1	39	55	4	0	11.9
Sept.	0	7	23	0	2	1	0	0	1	32	58	6	0	10.3
Oct.	0	2	28	1	15	11	3	0	2	18	34	18	0	6.6
Nov.	0	2	26	2	33	26	7	2	3	6	9	15	0	5.3
Dec.	0	2	29	0	33	39	7	1	2	5	5	9	0	5.9

south by about 32 degrees, but this deviation is not considered to hinder navigation in any way.

2. Hydrographic Analysis

(1) General

It may be said that the present Karachi Port faces three hydraulic problems. These are (a) siltation of harbour basins, (b) filling-up of approach channel at the port entrance and (c) pollution of port basin. With the present Karachi Port, these problems have not developed to a serious stage. The volume of maintenance dredging being carried in the port and at the port entrance is in the order of one million cubic yard per year. Pollution of port basin is believed to be caused mainly by the influx of city waste water and used oils disposed from ships, but the pollution is held to a certain level by the effect of seawater exchange with the open sea.

When it comes to the development of the Western Backwater as a new port site, however, it is very probable that the above-mentioned problems will become more serious. In

other words, construction of a new port will inevitably be accompanied by reclamation by filling-up, thus reducing the surface area of the backwater considerably. As the tidal current flowing in and out of Karachi Port is indispensable for the maintenance of tidal volume in the Western Backwater, reduction in the surface area of the backwater will reduce the speed of tidal current in and out of the port. As the decrease in the velocity of tidal current in turn reduces the effect of tidal flushing which contributes to the maintenance of the required depth of the present Karachi Port, there is every possibility of the accelerated siltation in the basin and at the port entrance. The decrease in the velocity of tidal current also reduces the effect of seawater exchange between the port basin and the open sea, thus allowing the pollutants to remain in the port longer and causing more pollution of the port basin.

If the industrial location is to be planned as part of the port construction project, a considerable amount of pollutants is expected to be discharged from industrial plants even when strong anti-pollution measures are taken by the industries. As the present Karachi Port has only one outlet, addition of industrial waste water to the existing city sewage and used oils dumped from ships will further aggravated the pollution of the present Karachi Port to a very serious point.

As the channel at the port entrance must be dredged to obtain a larger depth and must be extended to outside of the Manora breakwater if a new port is to be constructed, there is a possibility of siltation in large amount at this portion of the channel.

The following is an analysis of the possible decrease in the velocity of tidal current at the port entrance and of the extent of siltation at the channel.

(2) Decrease in the velocity of tidal current at port entrance resulting from reclamation

KPT with a growing interest in this problem has been conducting a series of hydraulic model tests in Karachi City, and the survey team has had an opportunity to observe one of these tests. It seems that the tests have been progressing smoothly with enthusiasm and efforts of the staff and a definite conclusion is expected to be drawn shortly.

Here, an attempt will be made to analyze the relations between the surface area of the backwater and the velocity of tidal current at the port entrance by simplifying the problem. According to the Master Plan Report (1967) prepared by the Karachi Port Trust, the tidal range at the innermost section of the Western Backwater is about 9 inches less than that at the East Wharf of Karachi Port located closest to the open sea. Although the report does not specifically mention the tide at the time this measurement was taken, it gives a tidal range of 10.1 feet at spring tide. When compared with this, tidal range at the innermost section of the backwater is lower by approximately 7%. Also, the phase lag is seldom seen at the highest tide and the phase lag at the lowest tide is said to be about one hour.

The fact that there are no substantial differences in tidal range and there is a very little phase lag between the port entrance and the innermost section of the backwater indicates that there is a sufficient section area of the port entrance (approximately 6,000 m^2) against the surface area (approximately $4 \times 10^7 m^2$ at high tide and $10^7 m^2$ at low tide) of the port basin and the backwater; thus the velocity of tidal current at the port entrance is in direct proportion to the surface area and tidal basin in the port basin and the Western Backwater. Even when the fact that the surface area of the Western Backwater differs between high tide and low tide is taken into consideration, the result of numerical calculation shows that the velocity of tidal current at the port entrance is in

direct proportion to tidal range. (cf. APPENDIX 10)

Accordingly, reclamation of the Western Backwater should lead to a decrease in the velocity of tidal current at the port entrance in the amount proportionate to the extent of decrease in the surface area resulting from reclamation. Of course, it is difficult to make a clear-cut judgement as to what extent the decrease in the velocity of tidal current at the port entrance should be allowed. This is due to the fact, (a) that the effect of tidal flush is not appreciated quantitatively at present and (b) that there is no clear-cut explanation as to the amount of pollutants and the extent of the effect of seawater exchange by tidal current on the prevention of pollution of port basin at present. However, the velocity of tidal current, which delays sedimentation of suspended load and prevents deposition of silts, has a minimum critical value which is determined by the volume and type of suspended load. Accordingly, siltation in the basin and channel is expected to increase in the ratio greater than that of the decrease in the surface area of the Western Backwater resulting from reclamation. Significant increase in the volume of siltation in the port basin as a result of the decrease in the velocity of tidal current was seen when the Chinna Creek was opened to the open sea in the course of historial development of Karachi Port. At that time, the problem was solved by closing the second outlet of the port and centering tidal volume at the present port entrance.

In any event, reclamation of the Western Backwater of Karachi for port construction will be restricted to a certain extent in view of the anticipated increase in the volume of siltation resulting from the decrease in the velocity of tidal current and the progress of pollution in the port basin.

(3) Siltation problem in approach channel

The silts now being removed from Karachi Port by maintenance dredging are considered to consist mainly of the deposit of sediment load from the Layari River and other open drains through the city and the deposit of suspended load carried from outside of the port by tidal current. In order to increase the depth of the approach channel from the present −27 feet to −36 feet, the channel must be extended outside of the sheltered area provided by the Manora breakwater by more than one mile. To increase the depth of the channel to −40 feet, an additional extension of the channel by one mile (K.P.T. Master Plan Report 1967, P.32) will be required. Protection of the approach channel by breakwater or submerged breakwater may help to reduce the volume of siltation, but construction of these structures will require an enormous capital investment. Besides, the submerged breakwater which is aimed at saving the cost of construction is liable to become the source of hazard to the navigation of ships. Therefore, it is very probable that the approach channel will be left unprotected by breakwater or submerged breakwater and that the silts in the channel will have to be removed by annual maintenance dredging to maintain the required depth of the channel.

The question is how much silts will accumulate in the channel annually. Siltation of the approach channel is due to: (a) deposition of littoral drift within the breaker zone and (b) the transfer of bed materials by waves in the offshore area. In other words, siltation of the approach channel is due to the agitation and transfer of bed materials by waves and differs considerably in nature from the deposits of sediment in the present basin and port entrance. To estimate the volume of silts in the approach channel, data on wave height, wave period and wave direction obtained by observations covering a period of at least one year must be provided. For estimation on the volume of silts in the approach channel, wave data alone is not sufficient but a survey on the direction

and velocity of littoral drift must be conducted and test dredging must be provided to determine the amount of siltation.

The Karachi Port Trust fully realizes the implication and is progressing its own study through wave observations, analyses of refraction and surveys on littoral drift by its own effort or by assigning the task to other organizations. In 1971, K.P.T. conducted its first test dredging. When the results of these observations, tests and surveys are analyzed and summarized, there will be a way to estimate the amount of siltation of the approach channel. It is regrettable to say, therefore, that until such time there is no reasonable way to make estimation on the amount of siltation in the approach channel.

Chapter 2. Sonmiani District

1. General Features

Sonmiani is situated in lat. 25°25′ N and long. 66°37′ E, approximately 60 miles northwest of Karachi Port and faces the Mekran Coast. Sonmiani and the neighbouring areas have not been urbanized and are featured only by some fishing villages. Roads are the only means of communication but the roads themselves are not in satisfactory condition in the vicinity of Sonmiani.

This area, however, is recommended as an alternative site for construction of a new port in Karachi.

The proposed site in Sonmiani is located on the Miani Hor. The Miani Hor is a shallow lagoon measuring 38 miles in length and 3 to 7 miles in width. It is separated from the open sea by low sand dunes. It is surrounded by mangrove swamps and the exposure of a vast land is seen at low tide. It is linked to the Arabian Sea through a channel about 1-1/4 nautical miles in width.

Hamlets are located only on the east side of the tideland and forms Sonmiani Dumb. Two rivers, the Poral and Windar Rivers, flow into the Miani Hor. A considerable amount of sediment load is carried by these rivers at the time of heavy rainfall which occurs only on rare occasions.

The section between the northern edge of the lagoon and Sonmiani Dumb consist of stable sand dunes. While the sand dune in the vicinity of Dumb is comparatively flat, those in the vicinity of Sonmiani reach a height of about 100′. On the north and south edges are migratory dunes. The Miani Hor was originally an open bay, and it is assumed that the extension of the shoal from the west over a long period of time formed the present geography.

The opening of the lagoon is maintained by high velocity of tidal current at ebb and flow of tide and the balance of force is well maintained. The depth of water reaches 60′ in some part, but otherwise it is generally shallow and the depth is 30′ or less in the vicinity of Dumb. The water depth fluctuates rapidly at the opening. Except for the section where the depth is 30′ ~ 40′, the shoal is completely exposed at low tide, thus forbidding navigation of ocean going ships. Waves of the open sea seldom reach this point.

2. Hydrographic Analysis

From a hydrographic point of view, the Sonmiani district has two distinguished features. One is the rapid tidal current flowing in and out of a vast lagoon called "Minani Hor" and the other is a sand bar (approximately –5 feet at the deepest point) developed at the entrance of the lagoon. The Sonmiani Port Development Plan calls for dredging at the entrance of the lagoon to provide a channel with a depth of –35 feet. The plan also calls for construction of the West Jetty 9.2 km long and the East Jetty approximately 1.8 km long to prevent siltation of the channel. These two jetties are aimed at intercepting littoral drift and at the same time promoting the effect of tidal flush by confining tidal current along the Jetty.

For the implementation of this development plan, the advisability of constructing such huge jetties may be pointed out as a major question from the standpoint of economic soundness of the project. From a hydrographic point of view, there also is question as to what extent the tide level and tidal current in the Minani Hor will change by the construction of jetties and the opening of a channel. If a channel with a depth of –30 feet is to be provided without constructing jetties (phase I/A) for reasons of the duration of construction period, the

question is whether the siltation of the channel will be within the range that can be taken care of by annual maintenance dredging. Even when jetties are constructed, there will still be a considerable amount of silts in the channel in the section toward the open sea and annual maintenance dredging will still be required.

First, an attempt will be made to analyze the change of tidal current which may result from dredging in providing a channel.

According to the Second Port Study Report (1967), tidal current in front of Dumb village in the Minani Hor has a maximum velocity of 2.2 knots and that at the entrance of the lagoon is expected to reach a speed of 6 knots (See P.63). The main difference between the Sonmiani district and the Karachi district is that the water surface area of the tidal compartment for the former is about $5 \times 10^8 m^2$ at high tide and $10^8 m^2$ at low tide for the former, 10 times or more greater than that for the latter. Consequently, the tidal range in the Minani Hor is estimated to be considerably small due to the restriction on the amount of flow of tide at the entrance Also, the tidal current at the present entrance to the lagoon is considered to be influenced greatly by the resistance of water course in the vicinity of the entrance. When jetties are constructed and a channel is dug, it is expected that the tidal range in the Miani Hor will increase and the velocity of tidal current will also increase as a result of the decrease in the resistance of water course and the increase in the sectional area of the channel. As the sectional area of channel also increases in the vicinity of the entrance, there will be no significant change in the mean velocity. Of course, these changes of tide and tidal current will bring about partial scouring or sedimentation at the entrance or in the inner area of lagoon and changes in the water course.

As previously stated in the section for the western Backwater of Karachi, the amount of siltation in the channel cannot be estimated at this stage due to lack of sufficient wave data. However, while the approach channel of Karachi Port requires digging of the sea bottom from the present depth of about -27 feet to -29 feet to a depth of -36 feet to -40 feet, Sonmiani requires digging of shallow sea bed from a depth of -5 feet to -10 feet to obtain a depth of -35 feet, thus leaving a great difference in elevation between the channel section and the surrounding seabed. The surrounding seabed is within the breaker zone as a matter of course and there will be constant transport of littoral drift. In the case of Karachi Port, meanwhile, the seabed around the channel is outside of the breaker zone toward the open sea. Even if a -30 feet approach channel is to be provided in the Sonmiani district without constructing jetties, siltation far greater than that for the approach channel at Karachi Port must be expected. Maintenance of the required depth for the section not far from the entrance of the lagoon can be expected to some extent by the effect of tidal flush, but its effect on the entire length of the approach channel cannot be expected. If a very pessimistic view is taken, maintenance dredging of the magnitude equal to that of the initial dredging will have to be provided annually.

Chapter 3. Comparison Between Phitti Creek, Karachi and Sonmiani

General features and the hydrographic characteristics of Phitti Creek, Karachi and Sonmiani have already been discussed. Here, therefore, a comparison of construction costs between the three proposed sites will be made. In the calculation of construction costs such facilities as wharves and piers which are common to all the three sites and therefore require the same amount of construction cost were not included. As a result, the works included in the comparison are breakwater, dredging, reclamation, roads (including bridges), railways (including bridges), electricity, gas and water facilities. Table 23 shows a comparison of construction cost between three sites. The depth of water and the width of approach channel and the number of berths for each of cases 1, 2 and 3 are as follows:

Case 1: Depth –34 feet, width of channel 600 feet, 5 berth wharves

Case 2: Depth –34 feet, width of channel 600 feet, 10 berth wharves

Case 3: Depth –42 feet, width of channel 900 feet, 5 berth wharves

Table 23. Comparison of Construction Costs

(Unit: 10,000,000 Rs)

	Phitti Creek			Karachi			Sonmiani		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Breakwater	–	–	–	–	–	–	10.67	10.67	
Dredging	3.23	3.23	9.80	7.56	8.40	14.00	11.23	11.23	
Reclamation	0.32	0.64	0.64	0.39	0.99	0.41	0.28	0.56	
Roads (including bridges)	2.04	2.04	2.59	0.13	2.19	2.15	3.05	3.05	
Railways (including bridges)	–	1.51	2.64	–	1.69	1.59	9.31	9.31	
Electricity, Gas and Water	0.35	0.35	1.05	0.21	0.27	0.23	3.43	3.43	
Bulkhead	–	–	–	0.53	0.53	0.53	–	–	
Total	5.94	7.77	16.72	8.82	14.07	18.91	37.97	38.25	

A BRIEF STUDY
OF
THE PROPOSED PIPRI PORT DEVELOPMENT PLAN

1. Feasibility of Port Development

The Pipri area is equipped with many favorable conditions as stated below and may be considered as one of the most suitable sites for the development of a port in Pakistan.

(a) The Pipri area adjoins a creek which is little influenced by waves and provides a suitable anchorage for vessels. Moreover, the creek is linked to the Arabian Sea via the Phitti Creek and Kadiro Creek, both of which are navigable by large vessels.

(b) A vast land space suitable for port and industrial development is available in the area which also provides sufficient room for future expansion of port and industrial facilities.

(c) Natural conditions of the creek do not seem to present any specific problems for port development and the geology of the site does not seem to cause any specific problem for dredging and construction of port and harbour structures judging from the available boring data on the field and laboratory tests of 62 bore holes.

(d) The area occupies an important position in the main traffic route that links the city of Karachi with various inland cities and is conveniently located for linking the port with inland transportation system.

(e) The area does not seem to have any specific problems for port development also with respect to other location conditions such as the availability of water, power, gas, labour supply etc.

2. A Study of Port and Harbor Planning

(a) Approach Channels

1) Water Depth of Approach Channels

i) In the water basin that adjoins the Pipri area, the Southern Bar is the shallowest point with a depth of 20 feet. When it is desired to use the Pipri area without dredging the channel, the entry of vessels up to the 5,000 D/W class will be possible even under rough weather condition by using the tidal range to the best advantage. The draft may be increased to 8,000 D/W in fair weather.

ii) When it is desired to make the Pipri area accessible to 25,000 D/W ore carriers under rough weather condition, it is necessary to secure a depth of at least 33 feet in the approach channel by making the best of the tidal range. If the required width (at this depth) is obtained, the entry of an ore carrier of the 30,000 D/W class will be possible under fair weather condition.

iii) If the entry of a 50,000 D/W ore carrier is desired under rough weather condition, it is necessary to secure a depth of at least 38 feet in the approach channel by making the best of the tidal range.

2) Width of Channel

i) For vessels of the 5,000 D/W class which are navigable at the minimum water depth of 20 feet now maintained at the Southern Bar, a double way channel to Pipri Port may be secured without dredging. As far as the Kadiro Creek is concerned, a channel with a depth of 26 feet and a width of 460 feet may be obtained without dredging, which is considered sufficient enough for use as a double way channel for vessels of the 8,000 D/W class.

ii) According to the Japanese Port and Harbour Structures Design Standard, the width

of an approach channel may be 0.5 time the overall length of the ship in the case of one-way channel. On the other hand, however, the Japanese ship manoeuvering authorities recommend based on their experience that the minimum width of an approach channel should be five times the beam of the ship involved under normal condition and that the width should be 1.0 ~ 1.3 times the overall length of the ship under adverse conditions. If this recommendation is to be followed, a 25,000 D/W ore carrier requires a channel with a width of at least 420 feet (with a depth of 33 feet). With this width of the channel, the Kadiro Creek will have to be equipped with high-powered tugboats as well as necessary navigation aids. As for the Southern Bar Channel, it is advisable to maintain a width 1.0 ~ 1.3 times the overall length of the ship, or 580 ~ 760 feet, in consideration of the possible yawing caused by high waves.

Similarly for ore carriers of the 50,000 D/W class, the Kadiro Creek will require a width at least five times the beam of the ship involved or 530 feet, and for the Southern Bar Channel, it is desirable to secure a width of 1.0 ~ 1.3 times the overall length of the ship or 800 ~ 1,000 feet. Furthermore, the tugboats must be provided in all cases.

iii) In the case of double way channel, the Japanese Port and Harbour Structures Design Standard specifies the width of a channel as 1.0 ~ 1.5 times the overall length of the ship involved. The Japanese ship maneuvering authorities, meanwhile, recommends on the basis of empirical data that the width of a channel should be at least eight times the beam of the ship involved.

Provision of a double way channel for vessels of the 25,000 D/W class or more will entail considerable amount of dredging even for the Kadiro Creek. Therefore, the approach channel to Pipri Port should be an one-way channel also from the viewpoint of safety of navigation. In such a case, however, a means of traffic control for one way passage must be provided.

3) Alignment of Channel

For the long and narrow channel like the Kadiro Channel, it is advisable to eliminate curved portions as much as possible and maintain the angle of bend at less than 30 degrees. Further, the S-shape curve should be avoided as much as possible. It may also be necessary in the future to alter the alignment of the channel in the creek to allow the passage of larger vessels.

(b) Differences between the Pipri Port Development Plan and the Phitti Creek Port Development Plan

Main differences between the Pipri Port Development Plan and the Phitti Creek Development Plan are as follows.

1) As the Pipri Port Development Plan calls for the use of part of the main land and does not require construction of a bridge contrary to the Phitti Creek Port Development Plan which calls for the use of an island as a site for port construction, the former is more advantageous than the latter both in cost and construction work.

2) Since the proposed site for port construction in the Pipri area is located close to the main traffic route, the Pipri Port Development Plan is more advantageous than the Phitti Creek Port Development Plan with respect to cost of road and railway construction. Besides, the Pipri area is still under developed as compared with the Korangi area and

this fact makes the construction of roads and railways much easier.

3) Since the Pipri Port Development Plan envisages the use of land areas of a greater elevation for industrial location as compared with the proposed industrial site in Bundal Island on the Phitti Creek, land formation (cut and file) and land use under the Pipri Port Development Plan must be planned carefully.

4) If a steel mill is to be located in an inland area under the Pipri Port Plan, installation of a long conveyer system will be required for transportation of raw materials from the pier as compared with the case of the Phitti Creek Port Development Plan.

5) Vessels calling at Pipri Port must navigate by way of the Phitti Creek and Kadiro Creek, which means the Pipri Port Development Plan requires additional dredging in part of these creeks depending on the size of ships as compared with the case of Phitti Creek Port.

6) Though Pipri area is equipped with many favorable conditions for port development, an accurate prediction cannot be made at present for the future trend toward the increase in the size of ships in the shipping world, the expansion of operating scale of industries or the extent of industrial development centering on the manufacture of goods for export. In this connection, it is highly probable that Phitti Creek port is used to meet the changes in future requirements.

3. Subjects of Future Study

Main subjects which should be given further attention and study in future in relation to the development of a port in the Pipri area may be pointed out as follows.

(a) Since the port development in the Pipri district requires mainly the use of the existing land space of a comparatively high ground level, vertical and horizontal use of land and waterline must be planned with the emphasis placed on the layout of industrial plants while taking into account various elements in order to ensure efficient transport of commodities (mainly raw materials).

(b) The Pipri Port Development Plan entails navigation of vessels through three narrow channels, namely, the Southern Bar Channel, Phitti Creek and Kadiro Creek. For this reason, it is necessary to dredge these three channels to maintain the required condition as navigation channel. The question, therefore, is whether the required water depth can be obtained by dredging and whether the construction of port and harbour structures will have any harmful effect on the maintenance of the channel. For this reason, it is important to continue a basic study of these creeks, conduct a series of tests in the channel prior to the start of port construction and design port and harbour structures of the type which will not alter the existing condition of the channel.

(c) In view of the possible increase in the volume of sea traffic in the future and the possibility of shoaling and the effect of waves on the channel, it is essential to make a study to determine the optimum depth of the Southern Bar Channel to minimize the total cost (dredging and ship operating cost).

(d) It is also probable that the entry of ships is delayed sometimes during the SW Monsoon in the summer if channel depths are kept to the minimum, thereby affecting the capacity of the channel considerably. However, in most terminals a certain amount of ships delay due to port closure for bad weather is considered acceptable. In any case, since

the effect of strong winds on the manoeuverability of vessels cannot be ignored, it is essential to conduct meteorological survey along the creek to obtain necessary data. If port closure for bad weather is expected as a result of the analysis of this data, either the width and depth of the approach channel should be increased or a provision for keeping sufficient stockpiling of raw materials during the SW Monsoon season should be made at the Steel Mill.

A general plan showing proposed development at Pipri as an alternative to Khiprianwala Island furnished by the Phitti Creek Project Cell is attached with which we agree, in principle.

FIG. 18

PROPOSAL FOR A NEW PORT AT PHITTI CREEK