MINISTRY OF INFORMATION,
COMMUNICATIONS AND TRANSPORT
THE REPUBLIC OF KIRIBATI

NO. 1

# BASIC DESIGN STUDY REPORT
# ON
# THE PROJECT FOR IMPROVEMENT OF
# BETIO PORT
# IN
# THE REPUBLIC OF KIRIBATI

MARCH, 1997



JAPAN INTERNATIONAL COOPERATION AGENCY
TETRA CO., LTD.



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# PREFACE

In response to a request from the Government of the Republic of Kiribati, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Betio Port and entrusted the study to the Japan International Cooperation Agency (JICA).

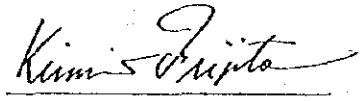
JICA sent to Kiribati a study team from August 12 to September 4, 1996.

The team held discussions with the officials concerned of the Government of Kiribati, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Kiribati in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kiribati for their close cooperation extended to the teams.

March, 1997



Kimio Fujita
President
Japan International Cooperation Agency

March, 1997

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Improvement of Betio Port in the Republic of Kiribati.

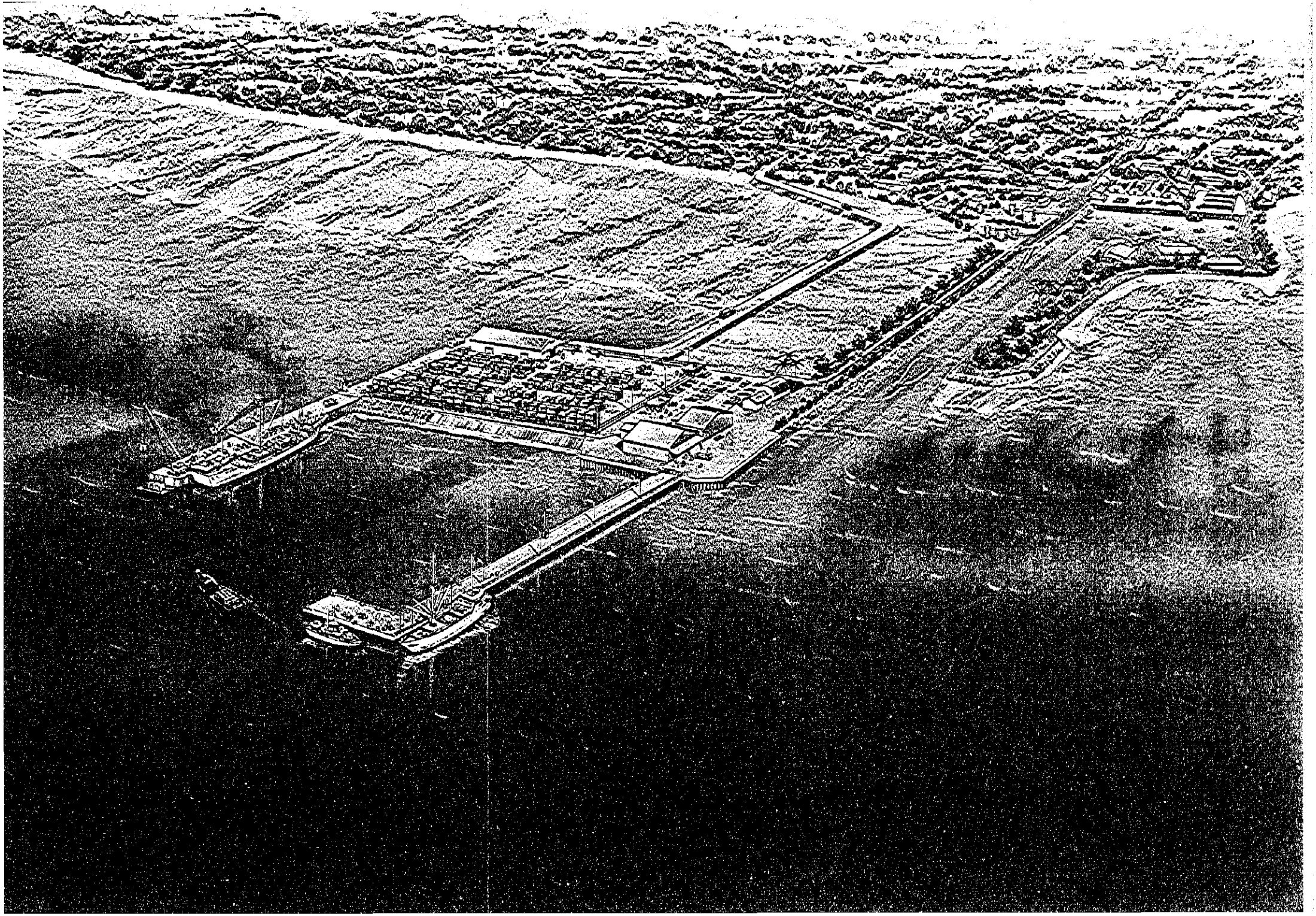
This study was conducted by Tetra Co., Ltd., under a contract to JICA, during the period from July 26, 1996 to March 3, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Kiribati and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

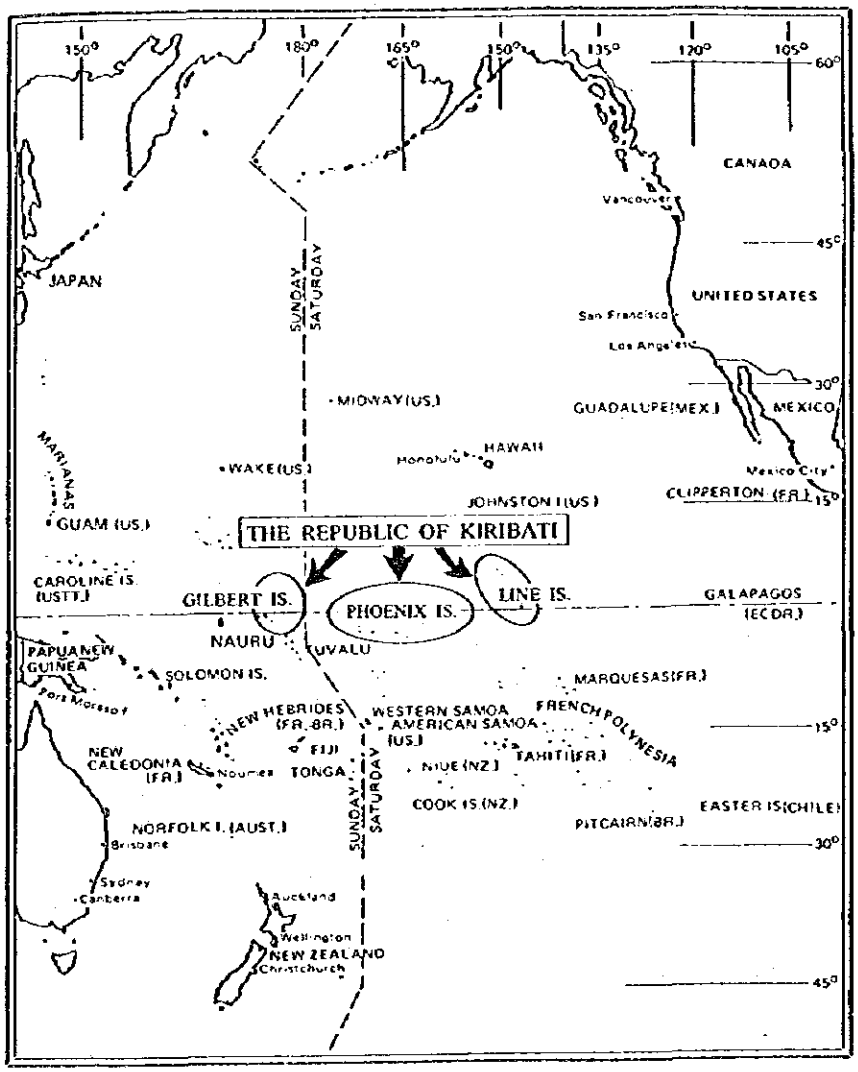
Finally, we hope that this report will contribute to further promotion of the project.

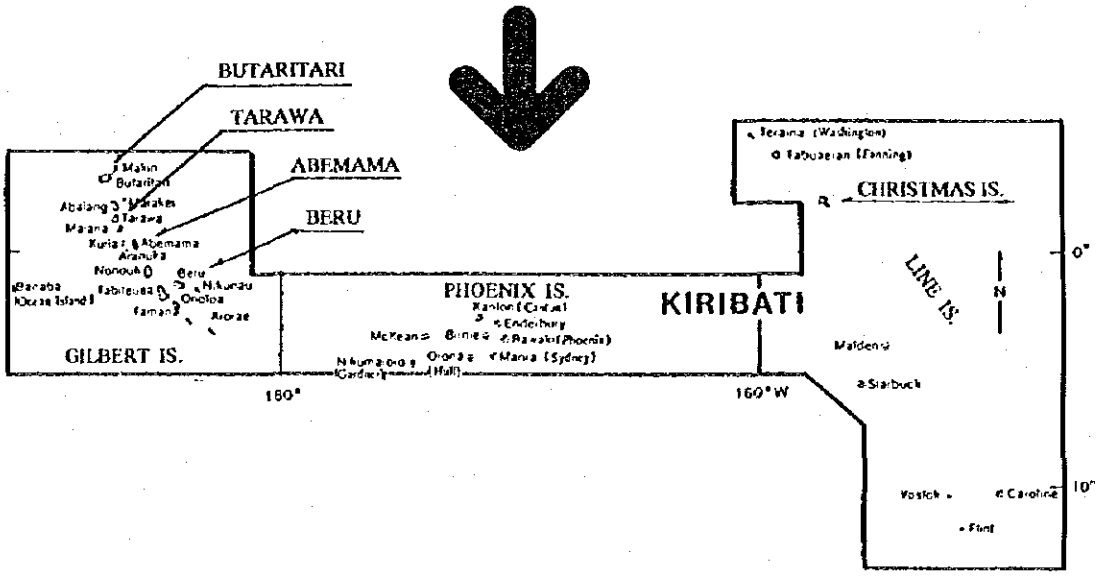
Very truly yours,

Tatsuo Fuke

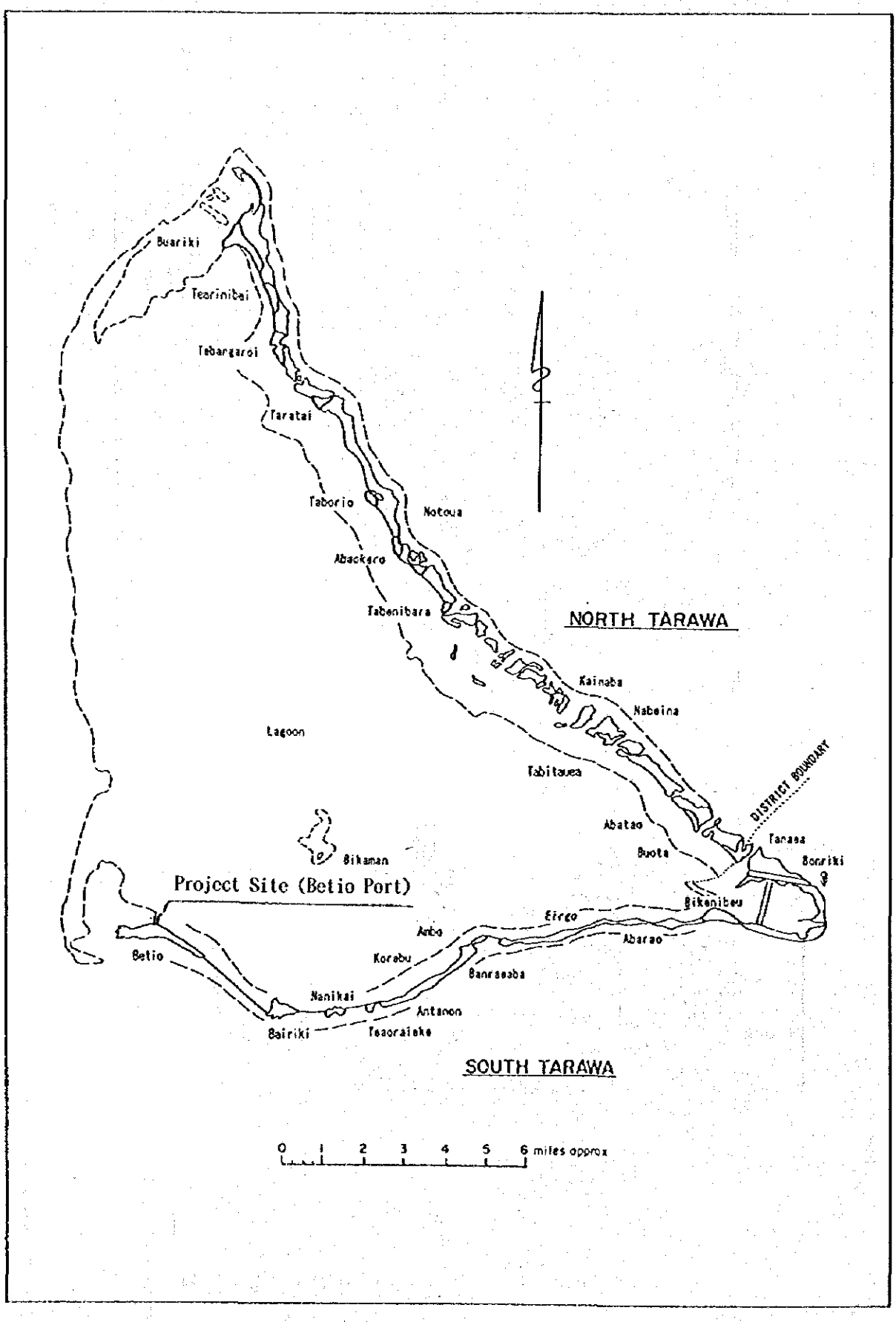
Tatsuo Fuke,
Project Manager,
Basic Design Study Team on
the Project for Improvement of Betio Port
Tetra Co., Ltd.






LOCATION OF THE REPUBLIC OF KIRIBATI




TARAWA ATOLL

Preface
Letter of Transmittal
Perspective / Location Map
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## List of Figures

## List of Tables

## Abbreviations

| | | |
|---|---|---|
| ASCL | : | Atoll Seaweed Company Ltd. |
| AS$ | : | Australian Dollar |
| BHL | : | Bali Hai Line |
| BSL | : | Betio Shipyard Limited |
| BTC | : | Betio Town Council |
| CCS | : | Chief Container Service |
| CDL | : | Chart Datum Line |
| DL | : | Datum Line |
| DWT | : | Dead Weight Tonnage |
| EEZ | : | Exclusive Economic Zone |
| ESCAP | : | Economic and Social Commission for Asia and the Pacific |
| GDP | : | Gross Domestic Product |
| GRT | : | Gross Registered Tonnage |
| JICA | : | Japan International Cooperation Agency |
| KCCS | : | Kiribati Cooperative Copra Society |
| KCWS | : | Kiribati Cooperative Wholesale Society |
| KOIL | : | Kiribati Oil Limited |
| KPA | : | Kiribati Ports Authority |
| KPAA | : | Kiribati Ports Authority Act |
| KSSL | : | Kiribati Shipping Services Limited |
| LOA | : | Length Over All |
| MENRD | : | Ministry of Environment and Natural Resources Development |
| MESD | : | Ministry of Environment and Social Development |
| MFA | : | Ministry of Foreign Affairs |
| MFEP | : | Ministry of Finance and Economic Planning |
| MHWS | : | Mean High Water Level Spring |
| MLWS | : | Mean Low Water Level Spring |
| MICT | : | Ministry of Information, Communication and Transportation |
| MOIL | : | Mobile Oil Kiribati |
| MSL | : | Mean Sea Level |
| MTC | : | Marine Training Center |
| MWE | : | Ministry of Works and Energy |
| NIWA | : | National Institute of Water & Atmospheric Research Ltd |
| NRT | : | Net Registered Tonnage |
| PFL | : | Pacific Forum Line |
| PUB | : | Public Utility Board |

| | | |
|---|---|---|
| PVU | : | Plant and Vehicle Unit |
| PWD | : | Public Works Division, MWE |
| SCK | : | Shipping Corporation of Kiribati |
| SPT | : | Standard Penetration Test |
| SS | : | Suspended Sediments |
| TEU | : | Twenty-feet Equivalent Unit |
| TKL | : | Telecom Kiribati Limited |
| TSKL | : | Telecom Services Kiribati Ltd |

# CHAPTER 1

# BACKGROUND OF THE PROJECT

# CHAPTER 1 BACKGROUND OF THE PROJECT

The Republic of Kiribati consists of many islands scattering over 4,500km east- west and 1,800km north- south of wide expanse of the Central Pacific Ocean. The total land area is 810km$^2$, while the nation's Exclusive Economic Zone (EEZ) covers 3.5 million km$^2$. The Republic of Kiribati has a population of 77,600 in 1995 with the rate of population increase of 1.9% since 1985. Major export commodities are copra and fish however, trade balance has shown a heavy deficit since exhaustion of phosphate in 1979. Most islands of the country are made up of coral rocks with poor soil for agricultural activities and hence the people lives depend on import for most of foods and living necessaries.

Due to these peculiar geographical and social conditions, sea transport constitutes lifeline supporting its economic activities, while port facilities are indispensable infrastructure connecting sea and land transport for foreign and domestic cargoes. However, the major port of the country, Betio, the important port of Line Islands Group, London Wharf in Christmas Island and all the other outerisland ports suffer serious deterioration of port function due to long absence of improvement investment to port facilities.

Betio Port is a sole gate for foreign trade and a center of domestic sea transport. However, no significant improvement work has been done to the port since the development works of port facilities for small boats have been implemented in 1950's. In consequence, Betio Port confronts problems of inefficient and unsafe port operation due to deterioration of the facilities which are insufficient in capacity. Current situation of the port is that the port could not maintain required port functions without immediate rehabilitation and improvement. Betio Port is not well provided for worldwide trend of containerization and a sole port depending tug and barge instead of direct wharf handling in the Pacific region.

Considering above situation, the Government of the Republic of Kiribati sets out the Eighth National Development Plan (1996 - 1999) and emphasizes the importance of ports development sector.

# CHAPTER 2

# CONTENTS OF THE PROJECT

# CHAPTER 2 CONTENTS OF THE PROJECT

## 2-1 Objectives of the Project

### 2-1-1 Background of the Project

Betio Port plays a key role as the center of sea transport not only for the international cargoes but also for the domestic cargoes and passengers. Passengers are transported with general cargoes by medium size cargo vessels rendered to the interisland sea transport, but since those vessels can not berth alongside in the port due to the small and shallow basin, passengers are obliged to be transferred by barge between shore and vessels anchoring off-shore and are in danger of falling out of barge on the way. Further an adequate facility for waiting is not available, and in some cases, passengers have to wait on barge in a strong sun-shine for a long time until the vessel becomes ready for boarding.

### 2-1-2 Objectives of the Project and Outline of the Request

In 1993, the Government of Kiribati made a request for "The Study on Ports Development in Kiribati" to the Government of Japan to solve the above-mentioned problems and constraints and encourage nation's economic development through the port development.

The Government of Japan, responding to the request, implemented the said Study from March 1993 to March 1994, in which the conceptual plan for ports development of Betio Port and London Wharf in Christmas Island targeting the year 2005 was formulated and the improvement plan for Betio Port requiring the urgent improvement was proposed.

The request made by the Government of Kiribati in the present project focuses the implementation of the improvement plan for Betio Port targeting the year 2000 proposed in the "Ports Development Plan in Kiribati". The outline of the request is shown in Table 2-1-1.

**Table 2-1-1 Outline of the Request**

| Facilities/Equipments | Outline |
|---|---|
| a. Wharf | 6 m deep and 80 m long |
| b. Container Yard | 17,000 m² |
| c. Dredging | approximately 140,000 m3 |
| d. Administration Office | 350 m² |
| e. Cargo Shed | 800 m² |
| f. Passenger Terminal | 560 m² |
| g. Access Road | 955 m |
| h. Rehabilitation of Existing Port | 130 m |
| i. Navigational Aids | 1 lump sum |
| j. Maintenance Dredging Equipment | 1 lump sum |
| k. Cargo Handling Equipment | 1 lump sum |

## 2-2 Current Condition of Betio Port

### 2-2-1 Existing Facilities of Betio Port

#### (1) General Description of Betio Port

Betio Port is located at 1°21.4'N; 172°55.9'W (Betio Islet at the south-east end of South Tarawa Atoll, Gilbert Islands) and plays a roll of the main port of Kiribati. The layout of the port is formed by the breakwaters named East and West Moles. The East and West Moles protect an approach channel and a basin from waves and siltation.

On the tip of East Mole, buildings of Te Mautari and Marine Patrol are located and a fisheries jetty constructed with assistance from United Kingdom is extended from the tip of the Mole. The jetty serves for fishing vessels, tankers, patrol boats and domestic cargo/passenger vessels. The pipe lines for unloading oil from tankers and bunkering are installed along the jetty from Mobil tank yard.

The old wharf for handling containers is located in the inmost part of the basin, where containers carried with flat barges are landed. The land area at the back of the wharf is used for container stacking and cargo storage.

The shipyard and slipway were constructed opposite the wharf for repair and maintenance services and the slipway was extended to 75 m in 1967/68 with provision of the existing buildings.

The outline of existing facilities at Betio Port is shown in Figure 2-2-1 and the principal facilities of Betio Port including cargo handling equipments are summarized below and listed in Table 2-2-1.

##### 1) East and West Moles

The basin and approach channel of the port is made up by the two breakwaters of East and West Moles having a length of 610 m and 305 m respectively. Crown heights of the breakwaters were originally 10.3'(3.14 m) and the present heights vary between 2.90 m and 3.00 m.

The structure of the mound slope of Moles is shown in Figure B-1 of Appendices B. The mound slope is 1:1.5 and is protected with bagged concrete.

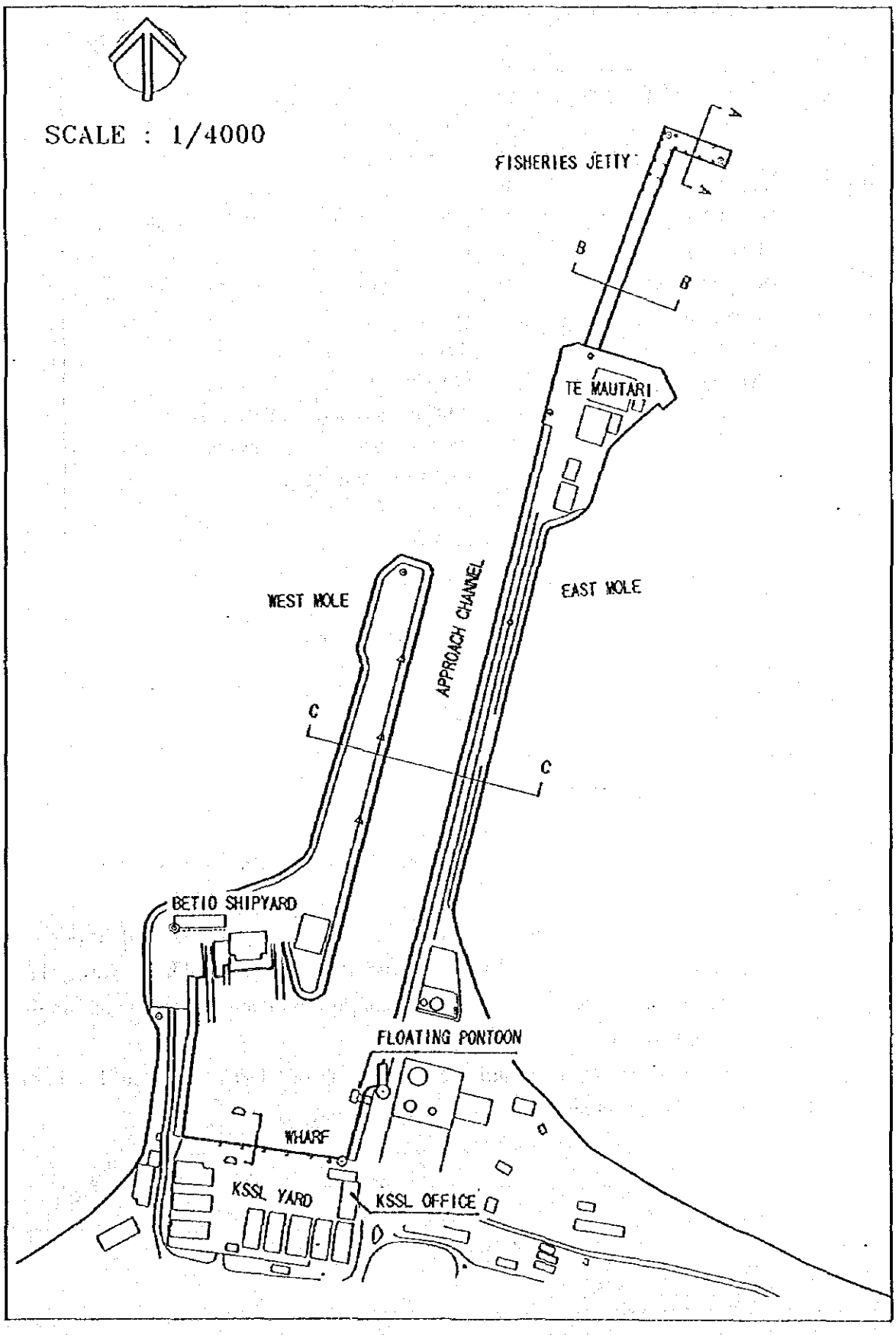



**Figure 2-2-1 Outline of Existing Facilities in Betio Port**

**Table 2-2-1 Port Facilities and Cargo Handling Equipments in Betio Port**

| Facilities/Equipments | Number | Remarks |
|---|---|---|
| East Mole | 1 | 610m long |
| West Mole | 1 | 305m long |
| Fisheries Jetty | 1 | 220m long in total, 4 berths |
| Wharf | 1 | 130m long, abt 92m in net wharf length |
| Navigational Aids | 10 | 8 buoys and 2 beacons |
| KSSL Office Building | 1 | 534m² in total floor area |
| KSSL Shed | 7 | 351m²×5, 330m²×2 |
| KCWS Shed | 1 | 351m² |
| Open Yard | 1 | abt 3,200m² |
| Tug Boat | 3 | 210HP×2boats, (2×127HP)×1boat |
| Barge | 3 | 18.35m×6.65m×1.5m, 18.00m×6.50m×1.5m |
| | | 18.00m×6.80m×1.5m |
| Mobile Crane | 1 | 25 ton |
| Fixed Crane | 1 | 32.5 ton |
| Crane Truck | 1 | 3 ton |
| Forklift | 3 | 2.5 ton |
| Chassis Trailer | 12 | 3 ton×8, 25 ton×4 |
| Prime Mover | 2 | 25 ton |

### 2) Approach Channel and Basin

The approach channel and basin are calm water areas protected by the above-mentioned breakwaters.

A cross section of the approach channel is shown in Figure B-2 of Appendices B. The original channel was 60'(18.3 m) wide and dredged to 10'(3.05m) below D.L. Since the construction of the port, the water area in the port has been shoaled about 1 m due to a long term sedimentation.

The inner basin was originally dredged to D.L. -13'(3.96m) and has been also shoaled to D.L.-1 to -3 m deep due to sedimentation.

### 3) Wharf

The wharf for landing container cargoes is located in the innost part of the basin and is utilized by barges and small crafts.

The wharf measures 130 m and usable length of the wharf is reduced to 92 m because of shallow water depth, seawall slopes of the both ends and stairway at the eastern end of the wharf.

The typical cross section of the wharf is shown in Figure B-3 of Appendices B. The structure of the wharf is of steel sheet piles with a concrete anchor wall. Front sheet piles of Frodingham No.3 of 32'-6" long are originally driven to secure water depth of 13'(3.96 m) but the present seabed is shoaled to about D.L.-2 m deep due to sedimentation.

### 4) Fisheries Jetty

The new fisheries jetty was constructed in 1986/87 with UK assistance for promotion of fishery industry. The facility is outlined in Figure B-4 of Appendices B and provides four berths shallower than 6 metres as follows:

Berth No.1 49.8 m
Berth No.2 45.0 m
Berth No.3 32.6 m
Berth No.4 38.8 m

The structure of the jetty is an open-type pier with steel pipe piles and its concrete superstructure of 10 metres wide deck is used as an apron for cargo handling. An approach trestle to the jetty is 126 m long and pipelines for bunkering, oil unloading and fresh water and electric wires are laid on its west side.

The jetty can not allow container handling, since the jetty is designed for handling only conventional cargo.

### 5) Open Yard, Sheds and KSSL Office

Figure 2-2-2 shows the present layout of the open yard and sheds.

Both the concrete-paved apron and unpaved yard is used for stacking containers. Due to insufficient cargo handling equipment and storage area, full containers are stacked up to 6, 7 high in the range of safety swing reach of the fixed crane, only on-shore equipment to lift a full container. Empty containers are stacked 3 to 4 high by using a mobile crane outside the fixed crane's swing range. The container yard is about 3000 $m^2$ but area of stacking slots is limited to about 1000 $m^2$. The yard is usually congested by vehicles taking delivery of container cargoes. Unstuffing of FCLs is done at ground level (sometimes even at 3rd tier level) where the FCL is located. This is largely prompted by the extreme lack of space.

Fixed lighting system has been recently installed for night work.

All the sheds in the yard are listed in Table 2-2-2 with their present states. Three sheds are used for storing copra, three sheds for break bulk cargoes and one shed for cement. KCWS owns a grain shed in the yard also.

The KSSL office is in a fairly large size building housing its management and other staff on the second floor of 267 $m^2$ while the ground is used for a store room and workshop.

**Table 2-2-2 Current Condition of Sheds in Betio Port**

| Shed No. | Dimensions/Area | Use | Holding Capacity | Structural Type and Current Condition |
|---|---|---|---|---|
| 1 | 12.2m×28.8m<br>=351m² | Copra | 1,000 ton | A "Nissen Hut" type with steel frames in concrete base.<br>No lighting and many leaky places in the roof |
| 2 | 12.2m×28.8m<br>=351m² | Copra | 1,000 ton | A "Nissen Hut" type with steel frames in concrete base.<br>No lighting and many leaky places in the roof |
| 3 | 11.7m×28.2m<br>=330m² | Break Bulk | 132 ton | Steel frames in concrete base.<br>A few lighting tubes available but not satisfactory.<br>Leaky places in the roof and walls. |
| 4 | 12.2m×28.8m<br>=351m² | Break Bulk | 141 ton | A "Nissen Hut" type with steel frames in concrete base.<br>Leaky places in the roof and walls. |
| 5 | 11.7m×28.2m<br>=330m² | Break Bulk | 132 ton | Steel frames in concrete base.<br>A few leaky places in the roof. Poor lighting system. |
| 6 | 12.2m×28.8m<br>=351m² | Copra | 1,000 ton | A "Nissen Hut" type with steel frames in concrete base.<br>No lighting and many leaky places in the roof |
| 7 | 12.2m×28.8m<br>=351m² | Cement | 1,000 ton | Steel frames in concrete base.<br>Many leaky places in the roof. |
| KCWS | 12.2m×28.8m<br>=351m² | Grain | 1,000 ton | Steel frames with corrugated iron sheet.<br>Leaky places in the roof. |
| Total area: 2,766m² | | | | |

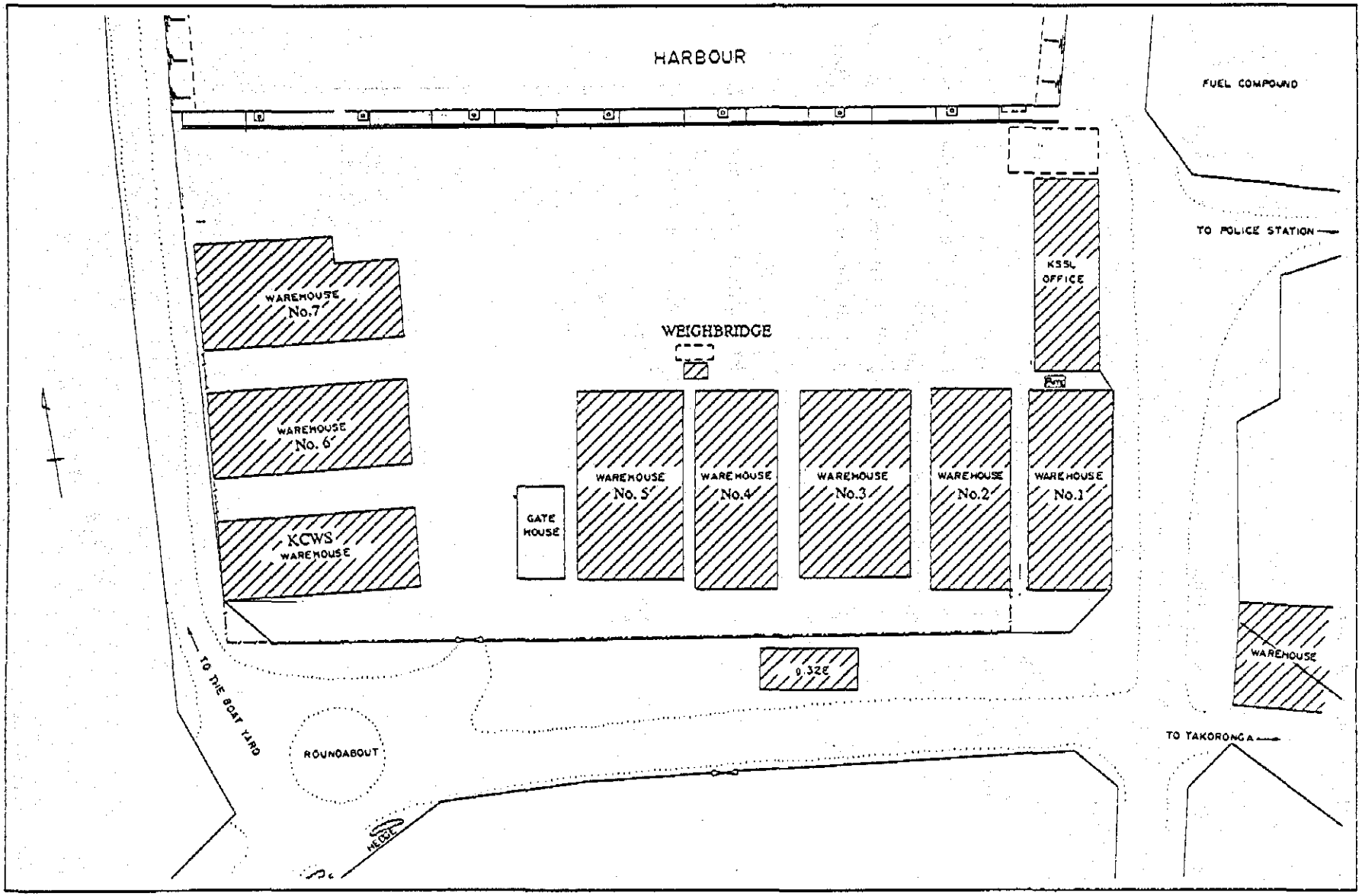



**Figure 2–2–2 Layout of Open Yard, Sheds and KSSL Office in Betio Port**

### 6) Navigational Aids

Location and current condition of navigational aids in Betio Port are shown in Figure B-5 and Table B-1 of Appendices B, respectively. Most buoys are deteriorated, all the lights for buoys are illfunctioned and the charted names are not readable, so that night navigation is not allowed in the port.

### 7) Cargo Handling Equipments and Floating Equipments

Cargo handling equipments and floating equipments owned by KSSL are listed in Table 2-2-3. The fixed crane in the container yard plays a sole role to handle full containers to land from barges. The crane was donated by the Australian Government in 1993 and the main structure was manufactured in 1978.

There is no other equipment for handling full containers in the yard. Insufficient numbers of container handling equipment and small container yard are bottlenecks in improving efficiency of cargo handling.

**Table 2-2-3(1) Cargo Handling Equipments owned by KSSL**

| Type | Number | Capacity | Acquisition Year |
|---|---|---|---|
| TADANO mobile crane | 1 | 25 ton | unknown |
| Favco fixed crane | 1 | 32.5 ton | 1993 |
| Crane truck | 1 | 3 ton | unknown |
| Bulldozer | 1 | D3 | unknown |
| Forklift | 3 | 2.5 ton | 1993 |
| Tractor | 2 | --- | 1985 |
| Chassis trailer | 8 | 3 ton | unknown |
| Chassis trailer | 4 | 25 ton | unknown |
| Prime mover | 2 | 25 ton | unknown |

Table 2-2-3(2) Floating Equipments owned by KSSL

| Type | Number | Capacity/Dimensions | Acquisition Year | Manufacturer |
|---|---|---|---|---|
| Tug boat (Tabuariki) | 1 | 210 HP | 1976 | Betio Shipyard |
| Tug boat (Riiki) | 1 | 210 HP | 1976 | unknown |
| Tug boat (Teraoi) | 1 | 2×127 HP | 1978 | unknown |
| Barge No.6 | 1 | 18.35m×6.65m×1.5m | 1986 | Betio Shipyard |
| Barge No.7 | 1 | 18.00m×6.50m×1.5m | 1986 | unknown |
| Barge No.8 | 1 | 18.00m×6.80m×1.5m | 1988 | unknown |

## (2) Deterioration of Facilities in Betio Port

### 1) Steel Sheet Pile Wharf

The steel sheet piles of the wharf has been badly corroded in a splash zone with many holes from which backfill soil is escaping. Wooden fenders originally installed in the frontage have been all lost allowing further damages by ship's collision.

To assess an economical remaining life of the wharf, thickness of steel sheet pile was measured with an ultrasonic thickness-meter and the results are shown on Table 2-2-4. The three measured sheet piles represent the present state of the corrosion. Measurement point No.1 is located at 11 metres from the east end; No.2 is at 46.5 metres from the east end; and No.3 is at 73.6 metres from the east end.

Table 2-2-4 Measurement Results of Steel Sheet Pile
Thickness (m/m)

| | Elevation | | |
|---|---|---|---|
| Point No. | + 1.0 m | ± 0.0 m | - 1.0 m |
| No.1 | - | 5.9 | 8.9 |
| No.2 | - | 5.4 | 9.1 |
| No.3 | 8.2 | 4.9 | - |

Note: Blanks mean that measurement failed due to rough surface.

Original thickness of Frodingham No.3 used in a front wall is 10.7 mm and the table shows original thickness of the sheet piles are reduced about 50%.

### 2) East and West Moles

East and West moles have been thoroughly inspected and their current conditions are summarized in Figure B-6 and Table B-2 of Appendices, respectively. The slope protection with bagged concrete are damaged in many places and filling sand of the moles are exposed to wind waves.

An urgent repair to the moles are required to prevent further damage and eventual collapse.

## 2-2-2 Port Activities

### (1) Sea Transport Sector

#### 1) Foreign Trade

Shipping lines currently having ships' calling at Betio Port are two foreign shipping lines and one government-owned shipping line named KSSL as follows:

i) The Chief Container Service (CCS) makes a monthly call and serves between Australia and Betio.

ii) The Bali Hai Line (BHL) makes a bimonthly call and serves between Japan and Betio.

iii)The local shipping line, Kiribati Shipping Services Limited (KSSL) serves New Zealand, Betio and Majuro and makes a feeder service to Tuvalu and Suva.

The above-mentioned three major shipping lines, CCS, BHL and KSSL share approximately 55%, 20% and 25% of the total cargo throughput, respectively. KSSL has taken over sea transport services connecting Kiribati, Fiji, New Zealand from Pacific Forum Line since September, 1994 and has been chartering a medium size container carrier, Novikovo (4,160 DWT) since February, 1996.

While CCS replaced Papuan Chief (10,683.2 DWT), a main carrier of Australian cargoes to Kiribati, with Baltimar Boreas (3,182.6 DWT), a medium size container carrier, in July, 1994 due to unavailability of Papuan Chief by maritime accident, but CCS started to put Papuan Chief in the shipping line again in April, 1995.

Shipping routes are shown in Figure B-7 of Appendices B.

#### 2) Domestic Trade

The domestic shipping is being serviced by 23 small vessels mostly belonging to KSSL and other small private companies. Local vessels only work when no international vessel is in port. KSSL was established in 1991 as a government-owned self-financial organization from a former semi-governmental "Shipping Corporation of Kiribati" (SCK) and occupies about 70% in domestic sea transportation. Private ship operators include three privately operated shipping companies, Waysam Kum Kee, Fern and Mat, while informal sector consists of church or provincial office operating small inter-island ships.

### (2) Ships' Call

Table 2-2-5 shows ships' call at Betio Port by ship's type for the period of 1991 to 1995. It shows that an average number of vessels calling at the port is 55 a year.

Since the multi-purpose carrier named Matangare was provided by Japan, container carriers have been increasing in the number of call. On the contrast, general cargo vessels have been decreasing in the number of call.

Table 2-2-6 shows frequency of principal ships' call in 1995. The number of call by Matangare owned by KSSL and Acoriano chartered by KSSL shares more than 50% with biweekly call. BHL made bimonthly call with Pacific Islander only. CCS made monthly call with a rotation of a large size carrier such as Papuan Chief and others, since Baltimar Boreas had been replaced.

Table B-3 of Appendices B shows arrival draft and DWT of container vessels called the port in 1995. Matangare recorded its arrival draft in the range between 4.5 m and 2.0 m. Maximum draft was 7.2 m for Pacific Islander.

Table B-4 and Figure B-8 of Appendices B shows accumulated distribution of arrival draft of cargo vessels called the port. It shows that vessels not larger than Matangare shared about 60% of total number of ship's call at Betio Port.

Table B-5 of Appendices B shows dimensions of domestic vessels owned by KSSL, private ship operators and informal sector.

**Table 2-2-5 Number of Ships' Call at Betio Port, 1991 to 1995**

| Year | Container Carrier | General Cargo Ship | Tanker | Copra Carrier | Total |
|---|---|---|---|---|---|
| 1991 | 31 | 7 | 10 | 2 | 50 |
| 1992 | 30 | 6 | 14 | 4 | 54 |
| 1993 | 29 | 15 | 11 | 5 | 60 |
| 1994 | 40 | 3 | 11 | 2 | 56 |
| 1995 | 42 | 0 | 9 | 3 | 54 |

**Table 2-2-6 Frequency of Principal Ships' Call at Betio Port, 1995**

| Vessels | Nos. of Call | Type of Service |
|---|---|---|
| Matangare | 15 | Regular service by KSSL |
| Acoriano | 8 | Regular service by KSSL |
| Pacific Islander | 6 | Regular service by BHL |
| Aleksandrov | 2 | Regular service by CCS |
| Coral Chief | 2 | Regular service by CCS |
| Highland Chief | 2 | Regular service by CCS |
| Maj Sif | 2 | Regular service by CCS |
| Baltimar Boreas | 1 | Regular service by CCS |
| Papuan Chief | 1 | Regular service by CCS |

### (3) Cargo Handled

#### 1) Foreign Cargo

Foreign cargo statistics are summarized in Table 2-2-7 and Figure B-9 (1) of Appendices B. Past trend shows a steady increase with slight fluctuation. Total tonnage increased from 34,275 ton in 1985 to 73,268 ton in 1995 at an annual growth rate of about 8%. In 1995, Betio Port handled total cargoes of about 73,268 ton comprising import container cargoes 53%, import break bulk cargoes 15%, import bulk fuels 9%, export copra 18% and export general cargoes 5%.

**Table 2-2-7 Export/Import Cargo Statistics at Betio Port, 1985-1995**

Unit: Freight Ton

| Year | Import | | | | | | Export | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Container | TEU | Break Bulk | Sub-total | Bulk Fuel | Import Total | Copra | General Cargo | Export Total | |
| 1985 | 15,083.9 | 784 | 5,019.8 | 20,103.7 | 5,091.2 | 25,194.9 | 8,516.5 | 563.7 | 9,080.2 | 34,275.1 |
| 1986 | 14,511.4 | 733 | 17,562.0 | 32,073.4 | 5,295.2 | 37,368.6 | 3,490.2 | 682.3 | 4,172.5 | 41,541.1 |
| 1987 | 18,880.5 | 982 | 10,095.8 | 28,976.3 | 6,311.4 | 35,287.7 | 3,898.0 | 807.6 | 4,705.6 | 39,993.3 |
| 1988 | 18,845.4 | 932 | 8,299.1 | 27,144.5 | 7,125.9 | 34,270.4 | 8,778.0 | 764.8 | 9,542.8 | 43,813.2 |
| 1989 | 22,638.7 | 1,243 | 7,000.0 | 29,638.7 | 6,605.1 | 36,243.8 | 8,622.0 | 1,390.8 | 10,012.8 | 46,256.6 |
| 1990 | 29,044.6 | 1,547 | 7,417.1 | 36,461.7 | 7,569.2 | 44,030.9 | 3,664.0 | 1,283.7 | 4,947.7 | 48,978.6 |
| 1991 | 26,196.6 | 1,373 | 4,636.0 | 30,832.6 | 8,910.2 | 39,742.8 | 5,308.0 | 1,043.5 | 6,351.5 | 46,094.3 |
| 1992 | 25,380.9 | 1,294 | 6,949.4 | 32,330.3 | 9,463.8 | 41,794.1 | 9,907.0 | 823.1 | 10,730.1 | 52,524.2 |
| 1993 | 31,079.9 | 1,549 | 9,704.3 | 40,784.2 | 9,125.2 | 49,909.4 | 8,587.0 | 3,454.1 | 12,041.1 | 61,950.5 |
| 1994 | 32,849.0 | 1,519 | 7,794.4 | 40,643.4 | 9,598.8 | 50,242.2 | 9,306.4 | 3,608.3 | 12,914.7 | 63,156.9 |
| 1995 | 38,827.1 | 1,917 | 10,849.1 | 49,676.2 | 6,554.1 | 56,230.3 | 13,113.6 | 3,924.8 | 17,038.4 | 73,268.7 |

#### a) Export Cargo

Remarkable feature of export cargo is, as shown in Figure B-9 (2) of Appendices B, overwhelming share of copra and its fluctuation. Production of copra is controlled by rainfall and the production drops after the year of small rainfall. In the past 10 years, the largest export volume was recorded at 13,113 ton in 1995, while the smallest in 1986 at 3,490 ton being about one fourth of the largest. The other export cargoes total in order of 1,000 ton in recent years consisting of fish, seaweed, etc. and also show considerably high fluctuation.

b) Import Cargo

Major import cargoes are containerized foodstuff and other daily requirements and bulk fuel imported from Fiji. Containerized cargoes have been increasing with comparatively small fluctuation, while the volume of break bulk cargoes increases when a large project requiring break bulk construction materials is implemented as shown in Figures B-9 (3) and (4) of Appendices B.

Bulk fuel does not show significant yearly fluctuation falling in order of 5,000 to 9,000 ton.

Containerization rate has shown a steady increase from about 60% in mid eighties to 80% after 1990.

c) Transshipment Cargo

Until mid 1993, when KSSL commenced transshipment service to Tuvalu by Matangare, almost all the imported cargoes have been locally consumed. Thereafter, the import cargoes are broadly classified into three categories, namely cargoes consumed in South Tarawa, cargoes transshipped to Outer Islands and cargoes transshipped to Tuvalu. Transshipment cargo throughput to Tuvalu is in order of 3,000 ton.

2) Domestic Cargo/Passenger

Statistics of the domestic cargo and passenger carried by private ship operators and informal sector are not recorded and whole picture of domestic cargo and passenger movement is estimated by the record kept by KSSL.

a) Domestic Cargo

Domestic cargoes carried by KSSL vessels are shown in Table B-6 (1) and Figure B-10(1) of Appendices B. In 1995, domestic cargoes totaled at about 21,400 ton with outward general cargo accounting for 56%, inward general cargo for 8% and inward copra for 36%.

b) Domestic Passenger

Table B-6 (2) and Figure B-10 (2) of Appendices B show domestic passenger statistics. In 1995, KSSL vessels carried about 7,000 persons. Numbers of inward and outward passengers are almost the same and interisland passengers account for about 5 % of total. Passenger traffic from 1990 to 1994 exceeded the past trend due to transport of a large number of immigrants to Line Islands.

## (4) Cargo Handling Operation

### 1) Container and General Cargo

Betio is currently a lighterage port, and cargo is transferred from vessel to shore or vice-versa by using a barge towed by tug. Larger international vessels anchor offshore and interisland vessels of the Kiribati Shipping Services Ltd. anchor near to the port. Containers ex foreign vessels are handled in the same manner, which is cumbersome, slow and costly with double handling.

To transfer the containers and general cargo from vessel to shore or vice-versa, the stevedores go on board the foreign/local vessels, and using the ship's gear, discharge the containers/general cargo onto 3 flat top barges which are then towed one by one to the wharf.

A fixed tower (second-hand) crane on shore is used to unload the full FCLs onto the stack at the wharf side. This stacking area is heavily congested as it was not originally destined for container stacking hence the FCL containers are sometimes stacked 6, 7 high in a block in a very tight area (approx. 75m x 35m) leaving hardly any room for handling general cargo. There is practically no wharf apron.

A mobile crane is used to unload general cargo from the barges onto trailers for transfer to open storage or in the sheds. Sometimes this mobile crane is used to transfer empty containers from stack at the wharf to the barges for eventual export.

The Study team has examined the usage of container stacking area on 19th of August, 1996. As a result, the total number of containers stacked there were 292 TEUs, of which 180 TEUs were full containers and 112 TEUs were empty containers.

### 2) Cycle Time of Vessel to Shore Operations

#### a) Container Cargo Handling

Time required for towing barge between wharf and vessel varies depending on towing power, load, wind, etc. The towing time measured averaged at 12 min. one way. Time for loading and un-loading container to/from barge measured at 4-5 min/piece. The on-shore fixed crane requires about 8 min/piece consisting of gross handling time of 2-4 min/piece and remainder for temporary repositioning operation of unintended container. The on-shore mobile crane is used for handling empty container and required operation time is almost the same as that of the fixed crane.

#### b) Copra Handling

Major export cargo of copra is transported by both KSSL and private ships. Copra is handled in gunny bag each weighing 50 kg and they are lifted from ship by rope 15 bags in one hook. Cycle time of one lifting operation is about 3-5 minutes depending on efficiency of ship's gear giving handling rate of 9-15 t/h. In a copra shed, about 20 labourers are employed to unload copra from truck and the handling rate is measured at about 15 t/h.

#### c) Non-containerized Cargo Handling

The operations for non-containerized cargo are carried out in similar fashion as container from vessel to wharf, but are put on trailers when they reach the wharf, and then transferred to sheds storage or open yard. There is also serious congestion in the open yard for open storage because cargo-owners are not charged to the common practice of charging storage rental (say) 3 days after completion of discharge. Obviously cargo-owners take advantage of this unusual way of charging storage rental and leave the cargo in the sheds until the last moment.

The productivity of general cargo (including bundled timber) is comparatively slow at about 10-12 tons per gross gang hour. Lack of suitable equipment is part of the cause.

Handling rates are summarized as below:

<Container Cargo>

| | Ship | Tug/Barge | Wharf |
|---|---|---|---|
| Handling Time | 4–5 min/TEU | 12 min/trip | 12 min/TEU |

<Non-containerized Cargo>

| | Ship>Shed |
|---|---|
| Handling Rate | 10–12 t/h |

<Copra>

| | Ship>Wharf | Truck>Shed |
|---|---|---|
| Handling Rate | 9–12 t/h | 12 t/h |

**3) Ships' Turnaround Time**

Ships' turnaround times (including waiting time) are not properly summarized for management information and control, although basic data are recorded. Night pilotage is not available, but international vessels are given priority in servicing until their containers/general cargo fully unloaded or loaded. Local inter-island vessels suffer the low priority. Even with this privilege, international vessels take 2–3 days to unload FCLs and load Empties for repositioning as exports are almost non-existent except seaweed, and copra in bulk. This imbalance of import FCLs and export FCLs is one reason why the freights on Kiribati cargoes are remarkably high.

**4) Working Hours**

The working hours for the various staff are as follows:-

a) **Monday-Sunday**
Operations (Cargo Handling) Staff - overseas vessels
0800 hours -1615 hours = 7 1/4 plus 3 3/4 hours overtime
= 11 hours, 2 shifts

b) **Monday-Friday**
Operations (Cargo Handling) - Domestic vessels
0800 hours -1615 hours = 7 1/4 hours

c) **Monday-Friday**
Office (non-operations) staff
0800 hours -1615 hours = 7 1/4 hours

### 5) Maintenance and Repairs (KSSL)

An Engineer is responsible for maintaining all port equipment with 3 technicians and a workshop which is not properly equipped. Major repairs have to be sent to an outside private workshop or carried out by the PVU workshop. Tugs are repaired by Betio Shipyard, which is the only place available, but repair costs are high.

It is necessary for the Port to be able to handle most of the maintenance and repair work for the F/Lifts and mobile cranes except major overhauls. Steps should be taken to equip the workshop accordingly.

A stock of spare parts is being maintained and no difficulty in obtaining spares has been experienced.

## (5) Problems and Constraints

### 1) Container Handling Operation

A tug and barge operation incurs otherwise unnecessary additional handling cost, but is, if efficiently operated with enough number and capacity of equipment, not a system lowering cargo handling productivity of the port. A tug and barge system can be economically adopted in the case where construction of a deep water berth requiring high capital investment may not be justified by a small volume of port cargoes and a tug. Betio Port, favoured with calm and wide water area inside a lagoon, handles relatively small volume of port cargoes with a tug and barge system. Container cargoes have increased in recent years and the capacity for cargo handling has been saturated. So that any further increase of cargo could not be allowed without considerably high increase of handling cost due mainly to insufficient area of container yard.

The flow of present container cargo handling between vessel and wharf is, based on the observed data, schematically outlined below;

- Handling equipment are; one ship's crane, one onshore fixed crane and three trains of tugs and barges plying between vessel anchoring offshore and wharf.

| Ship | 3 Barges<br>3 Tugs | Wharf |
|---|---|---|
| 1 crane | | 1 crane |

- Handling efficiencies are:

| | Sailing time (one way) | |
|---|---|---|
| 4.5 min/TEU | 12 min | 8 min/TEU |

Overall handling efficiency is controlled by slower wharf operation at the rate of 8 min/TEU. Idle time of vessel is 3.5 min/TEU if sufficient number of tugs and barges are provided. The required number of tug and barge are calculated as below:

One barge carries 6 containers and working time required for vessel and shore is:

| Vessel | Tug and barge | Wharf |
|---|---|---|
| 27 min | 12 min | 48 min |
| | 12 min | |

Required number of tugs and barges = (48+27+12+12)/48
= 2.06 ..3 sets

The above calculation clearly shows the bottleneck of the existing port operation.

**2) Existing yard**

Allocation of container stacking slots is shown in Figure 2-2-3 and as shown most of the yard area is occupied by custom and KSSL offices and seven cargo sheds. Open yard area is fully packed up with container and non-container cargo storage area and passage which is too small to permit smooth and efficient yard operation. Total area including office, shed and storage yard is 80 x 130 = 10,400 $m^2$ and a usable area for stacking container and passage is only 40 x 80 = 3,200 $m^2$. There are 50 slots stacked 5 high within the reach of the fixed crane installed at the center and 28 slots stacked 4 high by a mobile crane on both sides of the fixed crane. The total storage capacity of the existing container yard is calculated as follows;

| | |
|---|---|
| Area within the fixed crane | 50 slots x 5 tiers = 250 TEU |
| Area handled by mobile crane | 28 slots x 4 tiers = 112 TEU |
| | Total 362 TEU |
| Stacking density of container is: | 3,200/362 = 8.8 $m^2$/TEU |

This density is too high when compared with a normal figure about 15 $m^2$/TEU of container yard. Average time for handling containers stacked at random four high is about double that for containers stacked two high due to time consuming moving operation of containers stacked low.

The other factor lowering the handling efficiency is unavailability of a temporary working area and equipment on the wharf apron. The fixed onshore crane bears double functions of unloading containers from barge and stacking those in the yard. Entire apron area is used for stacking containers. Even if the existing wharf could accommodate a container vessel alongside, the cargo handling efficiency would not be improved much without expanding the area of container yard. Insufficient area of container yard does not allow effective means for improving cargo handling efficiency of introducing such yard equipment of large crane, forklift, etc.

A thorough consideration will be given to the above problems in port planning and designing for the improvement of Betio Port in subsequent chapters.

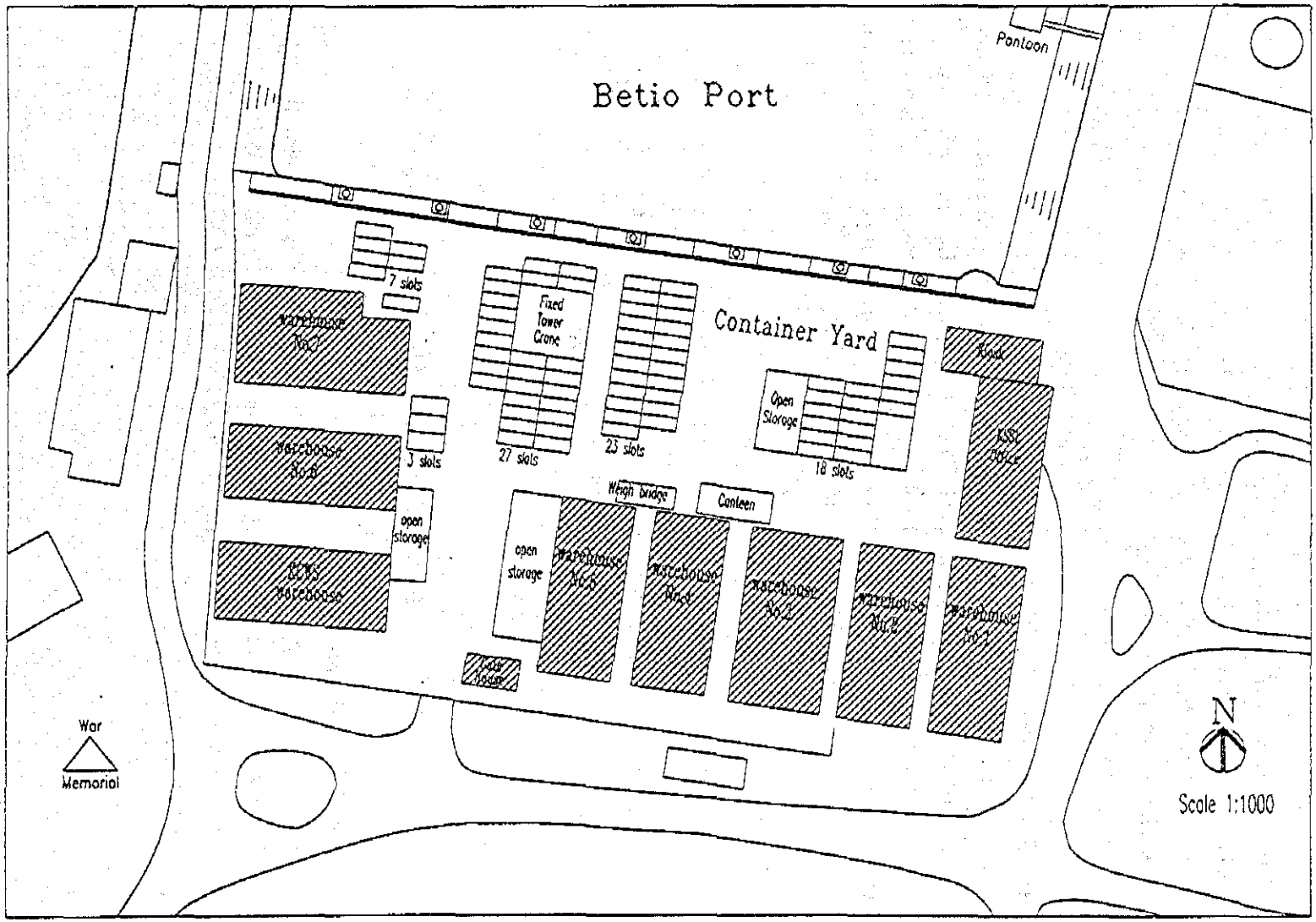



**Figure 2-2-3 Container Stacking Slots Allocation**

## 2- 3 Natural Condition

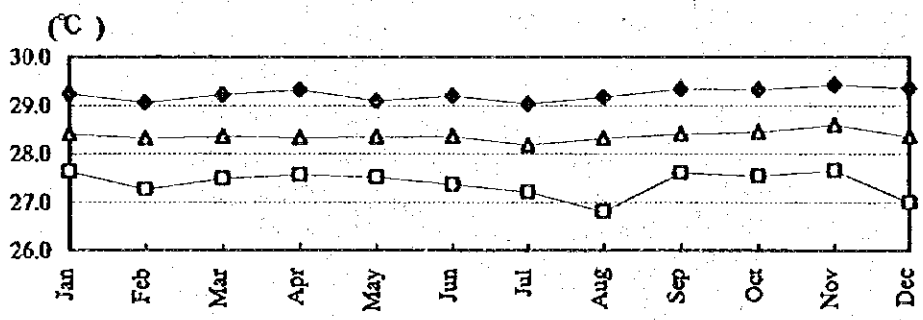
### 2- 3- 1 Climatic Conditions

The weather in Kiribati belongs to tropical oceanic climate. Temperature varies little and relative humidity is high throughout the year. The predominant wind direction is east. Dry season is from May to October, while wet season is from November to April.

The climatic data observed in the Betio weather station (latitude: 1° 21', longitude: 172° 55.5') located at southern side of project site will be discussed for the project site.

#### (1) Temperature

Figure 2- 3- 1 shows the monthly changes in the maximum, mean and minimum temperature for 15 years from 1981 to 1995. The difference of monthly mean temperature between the maximum (November, 29.4℃) and minimum (August 26.8℃) is approximately 3℃, which highlights that the difference of temperature between the dry and wet season is small. The annual mean temperature is 28.4℃.

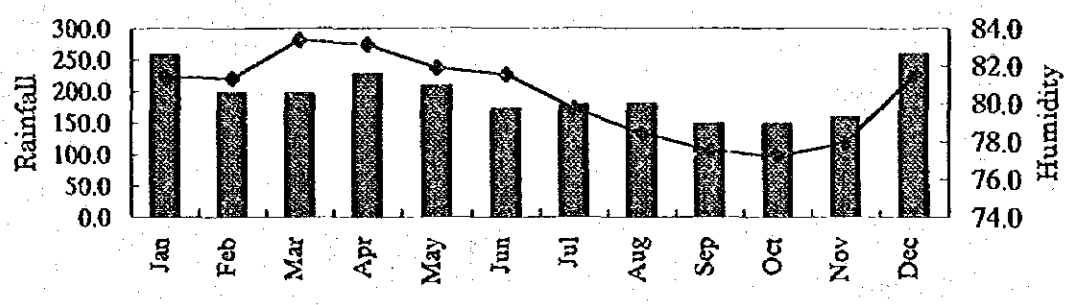



(Source: Betio Weather Station)

**Figure 2- 3- 1 Monthly Changes in Mean Temperature in Betio**

#### (2) Humidity and Rainfall

Figure 2- 3- 2 shows the changes in monthly mean humidity and rainfall. The mean humidity is about 80% and varies little throughout the year. The rainfall is recorded in both the dry and the wet season. The annual mean rainfall is 2,300mm. Droughts occur from time to time.




(Source: Betio Weather Station)

**Figure 2- 3- 2 Changes in Monthly Mean Humidity and Rainfall in Betio**

### (3) Wind Direction and Speed

Table 2- 3- 1 and Figure B- 11 of appendices B show the frequency of occurrence of wind by speed and direction and the wind rose observed in the Betio weather station for 3 years from 1991 to 1993. These data show that the percentage of predominant wind direction in the project site ranges from north to east with occurrence of 70%. Frequency of occurrence of wind speed more than 5m/s and 10m/s are 31.3% and 1.0%, respectively.

The climate in Tarawa atoll is relatively calm without the influences of cyclones. Tarawa atoll located in the South Pacific close to the equator is not affected by cyclones. The westerly wind due to generation of small depressions rarely occurs in January and February and its speed is not more than 20m/s as mentioned above.

**Table 2- 3- 1 Frequency of Occurrence of Wind by Speed and Direction in Betio (1991 - 1993)**

(Unit: %)

| Speed \ direc. | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Calm | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0~2.5 | 1.5 | 1.3 | 1.5 | 1.4 | 1.6 | 0.8 | 0.9 | 0.8 | 0.7 | 0.5 | 0.3 | 0.4 | 0.7 | 0.6 | 0.5 | 0.8 | 12.6 | 26.9 |
| 2.5~5.0 | 3.4 | 5.0 | 5.3 | 4.8 | 5.4 | 3.1 | 1.8 | 1.4 | 1.4 | 0.9 | 1.1 | 1.2 | 1.8 | 1.4 | 1.4 | 2.4 | 0.0 | 41.8 |
| 5.0~7.5 | 2.5 | 2.6 | 2.2 | 2.5 | 4.5 | 1.7 | 1.0 | 0.6 | 1.0 | 0.5 | 0.6 | 0.7 | 1.3 | 0.8 | 1.0 | 1.4 | 0.0 | 24.9 |
| 7.5~10.0 | 0.5 | 0.4 | 0.4 | 0.3 | 0.7 | 0.3 | 0.2 | 0.1 | 0.3 | 0.2 | 0.3 | 0.3 | 0.6 | 0.3 | 0.3 | 0.2 | 0.0 | 5.4 |
| 10.0~15.0 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 1.0 |
| 15.0~20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20.0~25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25.0~30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30.0m/s~ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 8.0 | 9.4 | 9.4 | 9.1 | 12.2 | 5.9 | 3.9 | 3.0 | 3.4 | 2.2 | 2.4 | 2.7 | 4.6 | 3.2 | 3.2 | 4.8 | 12.6 | 100.0 |

## 2-3-2 Topography

The island of Tarawa is a typical atoll with a lagoon inside. There are scattered small islands made up with coral rocks on the reef and through beach erosions in the lagoon.

This study executed the topographic and sounding survey and the results are shown in Figure 2-3-3 and 2-3-4, respectively.

The new wharf site is of sandy seabed being slightly off a reef edge and sand ground type. Its water depth is between DL-2 and DL-4m. The new container yard and the access road areas are flat and sandy with the ground levels between DL±0 and DL+0.5m.

Figure 2-3-4 shows the locations of buildings and fruit trees along the connection of the new access road and the existing paved road.

## 2-3-3 Sea Conditions

### (1) Tide and Current

The tide level chart is shown in Figure 2-3-5, which observed in "The Study on Ports Development in Kiribati (JICA)". Around the mouth of the existing Betio Port, the highest speed of tidal current is 30cm/s and the mean speed is 18cm/s.

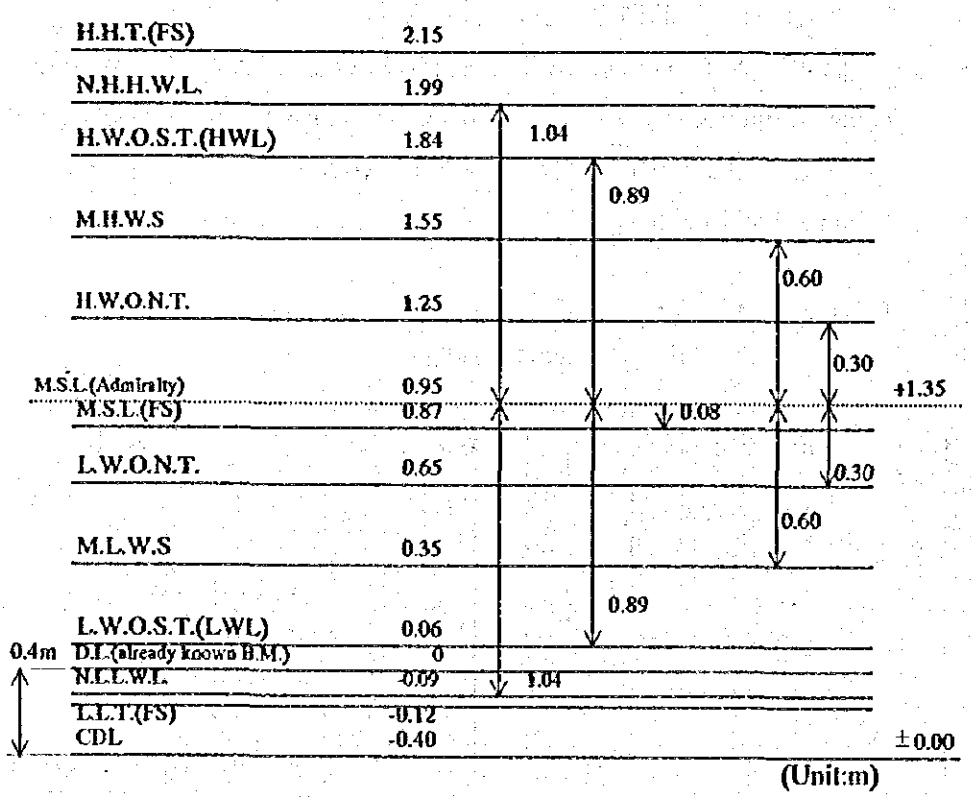



**Figure 2-3-5 Tide Level Chart**

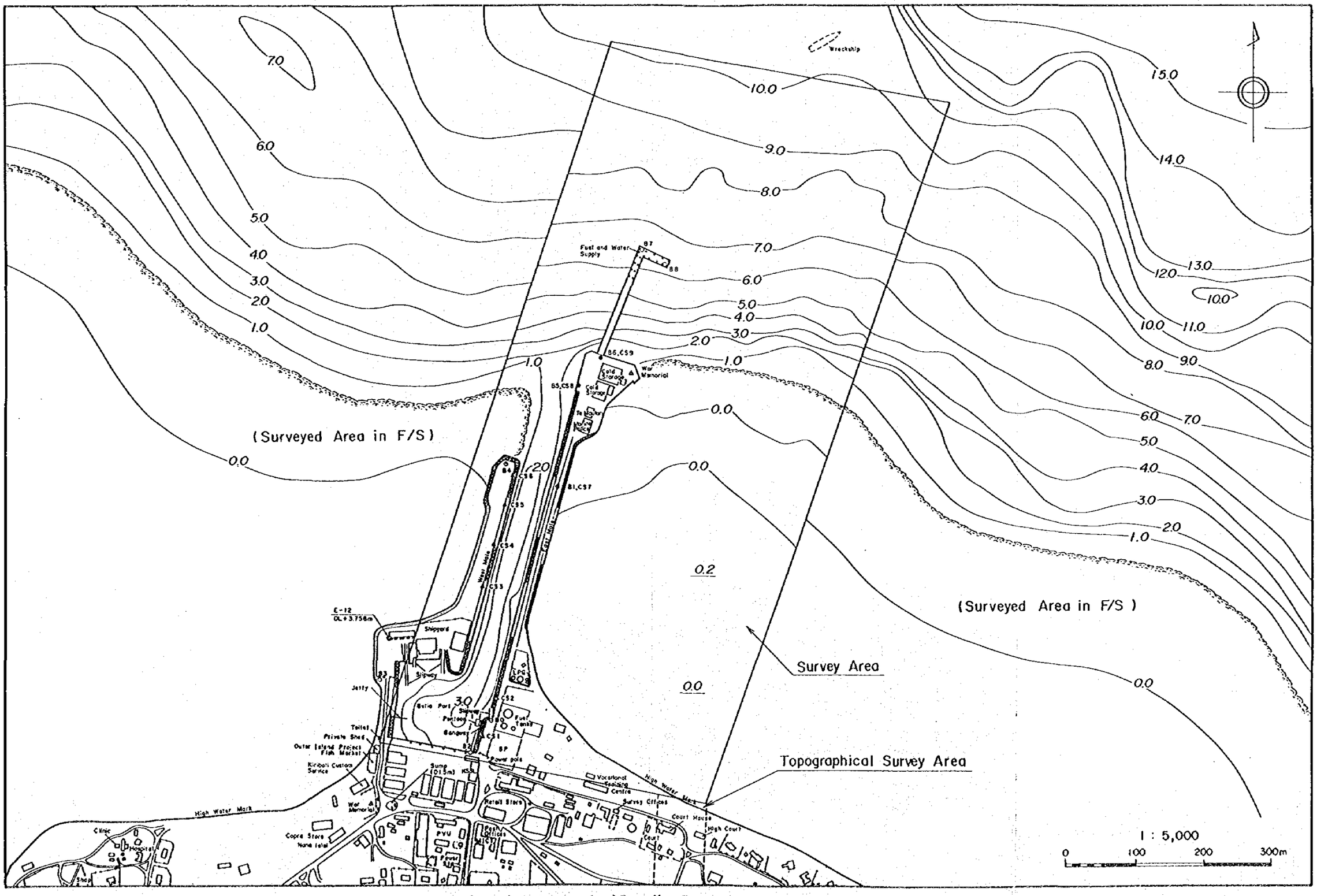



**Figure 2-3-3 Result of Sounding Survey in the Project Site**

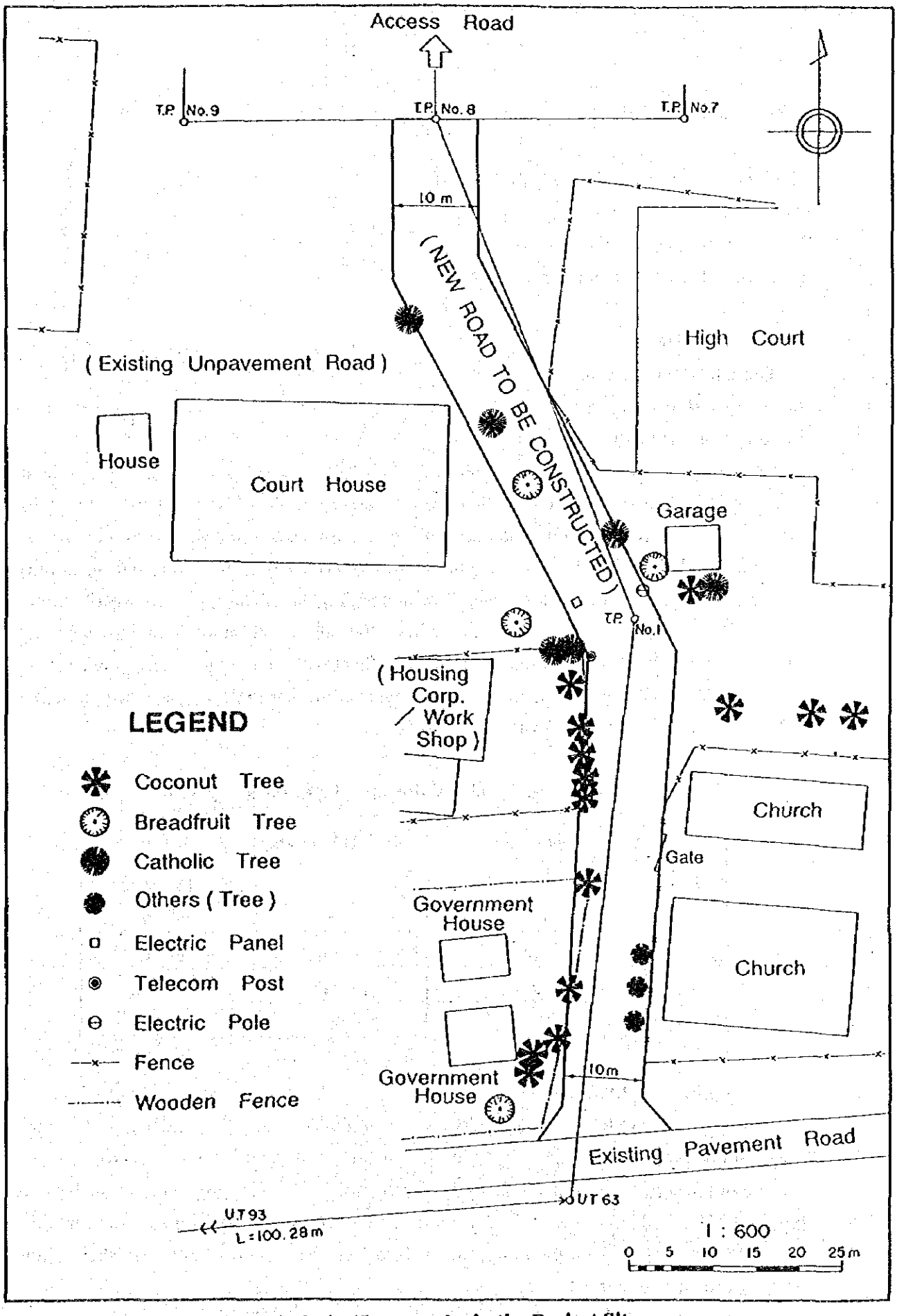



**Figure 2-3-4 Topography in the Project Site**

## 2-3-4 Soil Conditions

This study executed the soil investigation with 5 marine borings (BH1 - 5) in the project site. The location of the boring points and the boring logs are shown in Figures 2-3-6 and 2-3-7, respectively. From the boring logs and the summary of laboratory test results (see Table 2-3-2), the soil conditions in the project site are characterized as follows;

### (1) Properties

The strata consist from the surface to the bottom a coral gravel layer with coral sand (more than 10m deep), a coral rock layer and a coral gravel. 5 boring points have no difference in a soil nature and each layer thereon is characterized as follows:

Coral gravel with coral sand lies with a thickness of 14m in the surface layer and the N value by SPT (Standard Penetration Test) varies largely 3 to 50. A coral rock layer with more than 50 N value lies with a thickness of 1 to 2m around 5 to 6m deep from the surface. The sieve analysis gives that the medium grain size (D50) is 1 to 30mm and uniformity coefficient (Uc=D60/D10) is more than 10, which highlights a good grain size distribution.

In the middle layer below 14m deep from the surface coral rock underlies with a thickness of 2 to 3m. The N value is more than 100 classified as a very hard coral rock.

Under the middle layer, coral gravel with coral sand similar to the surface layer underlies and is compacted dense with N value of 13 to 50.

**Table 2-3-2 Summery of N Value and the Laboratory Test Results**

| Layer (Depth) | Surface(- 14m) | Middle(14 - 17m) | Bottom(17m -) |
|---|---|---|---|
| N Value | 3～50 | 50以上 | 13～50 |
| D50 | 1～30mm | 5～6 | 2～20 |
| Uc (D60/D10) | 10以上 | 10以上 | 10以上 |
| Liquid Limit | 17～35% | 20～23% | 22～36% |
| Specific Gravity | 2.8 | 2.8 | 2.8 |

### (2) Engineering Evaluation

Soil properties are judged as a good strata generally for dredging works and sheet piling works in this project. A design depth of all structures and facilities is in the surface layer. N value of the surface layer is 3 to 50 and no difficulties of the dredging work of the basin is expected. Its dredged soil will be very good as a backfilling material for the new container yard behind the basin. Furthermore, the surface layer have no difficulties in sheet piling works for the new wharf.

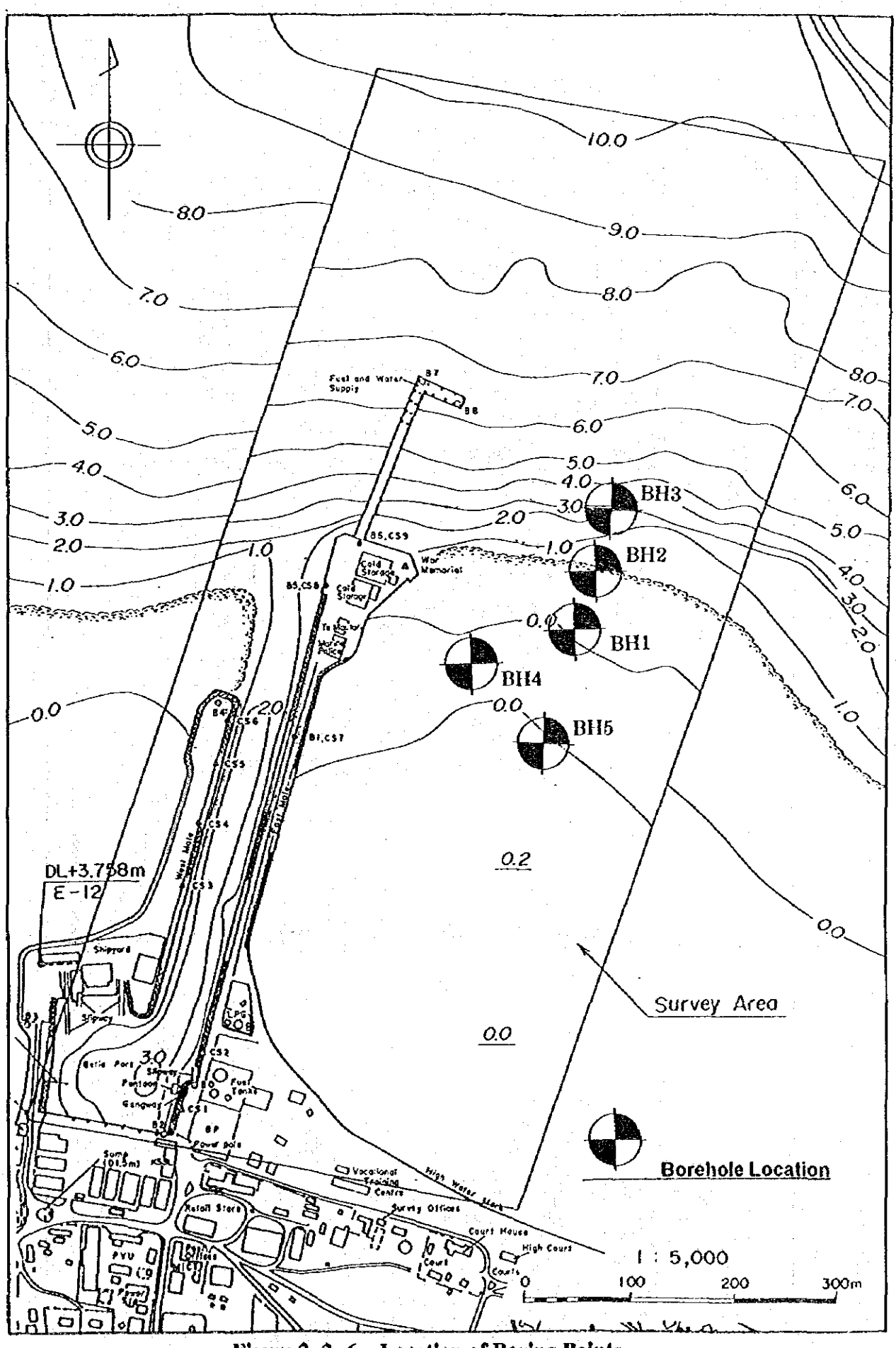



**Figure 2- 3- 6 Location of Boring Points**

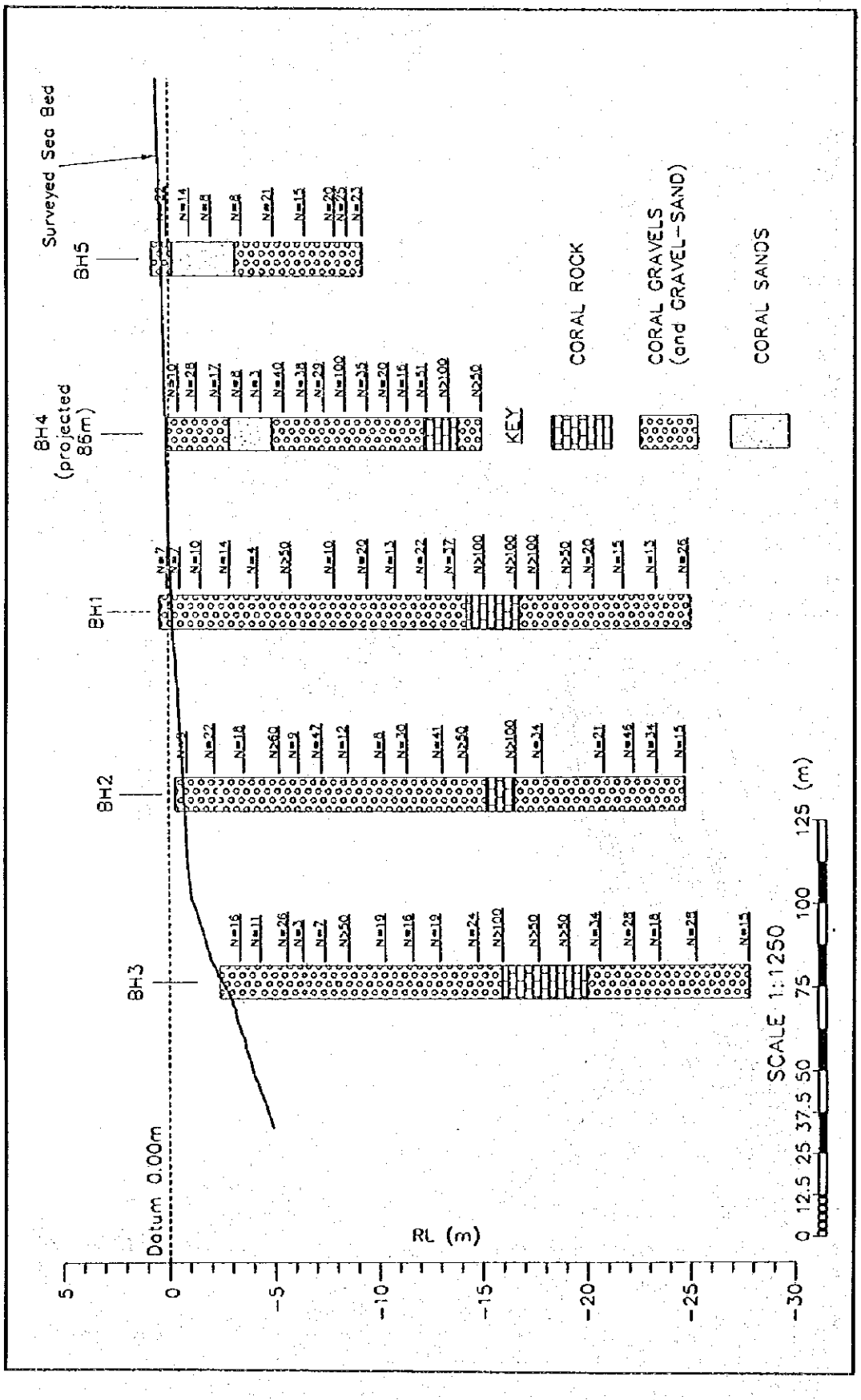



**Figure 2- 3- 7 Boring Logs**