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**BASIC DESIGN STUDY REPORT  
ON  
THE PROJECT FOR EXTENSION OF NUKU'ALOFA  
FORESHORE PROTECTION  
IN  
THE KINGDOM OF TONGA**

**February, 1988**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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国際協力事業団		
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## PREFACE

In response to the request of the Government of the Kingdom of Tonga, the Government of Japan has decided to conduct a basic design study on the Project for Extension of Nuku'alofa Foreshore Protection and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Kingdom of Tonga a study team headed by Dr. Hiroshi Hashimoto, Director of the River Department, Public Works Research Institute, Ministry of Construction from October 30 to November 19, 1987.

The team had discussions on the Project with the officials concerned of the Government of Tonga and conducted a field survey in the Nuku'alofa Area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Tonga for their close cooperation extended to the team.

February , 1988



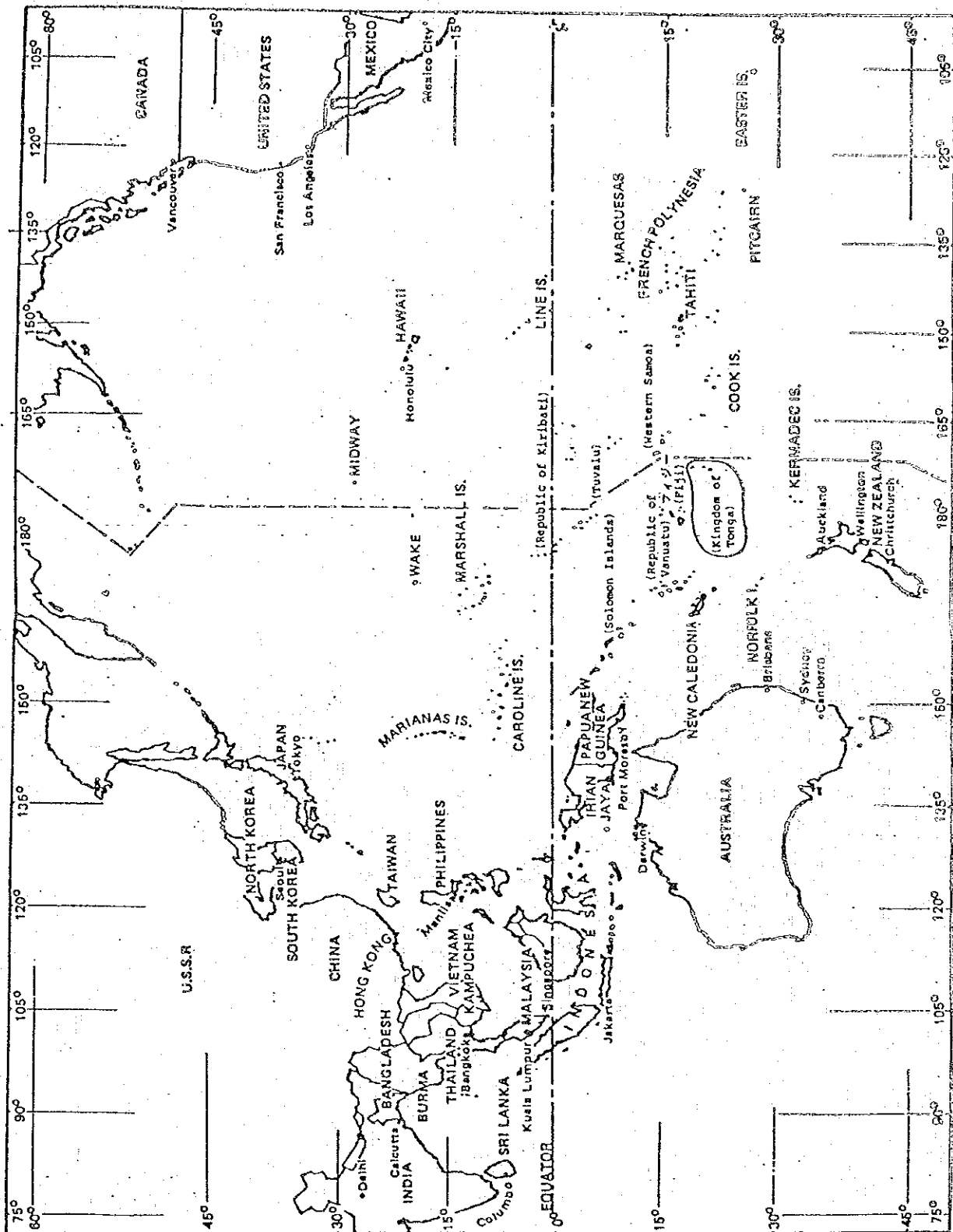
Kensuke Yanagiya

President

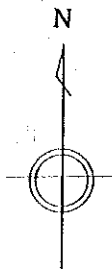
Japan International Cooperation Agency







Location Map (1)

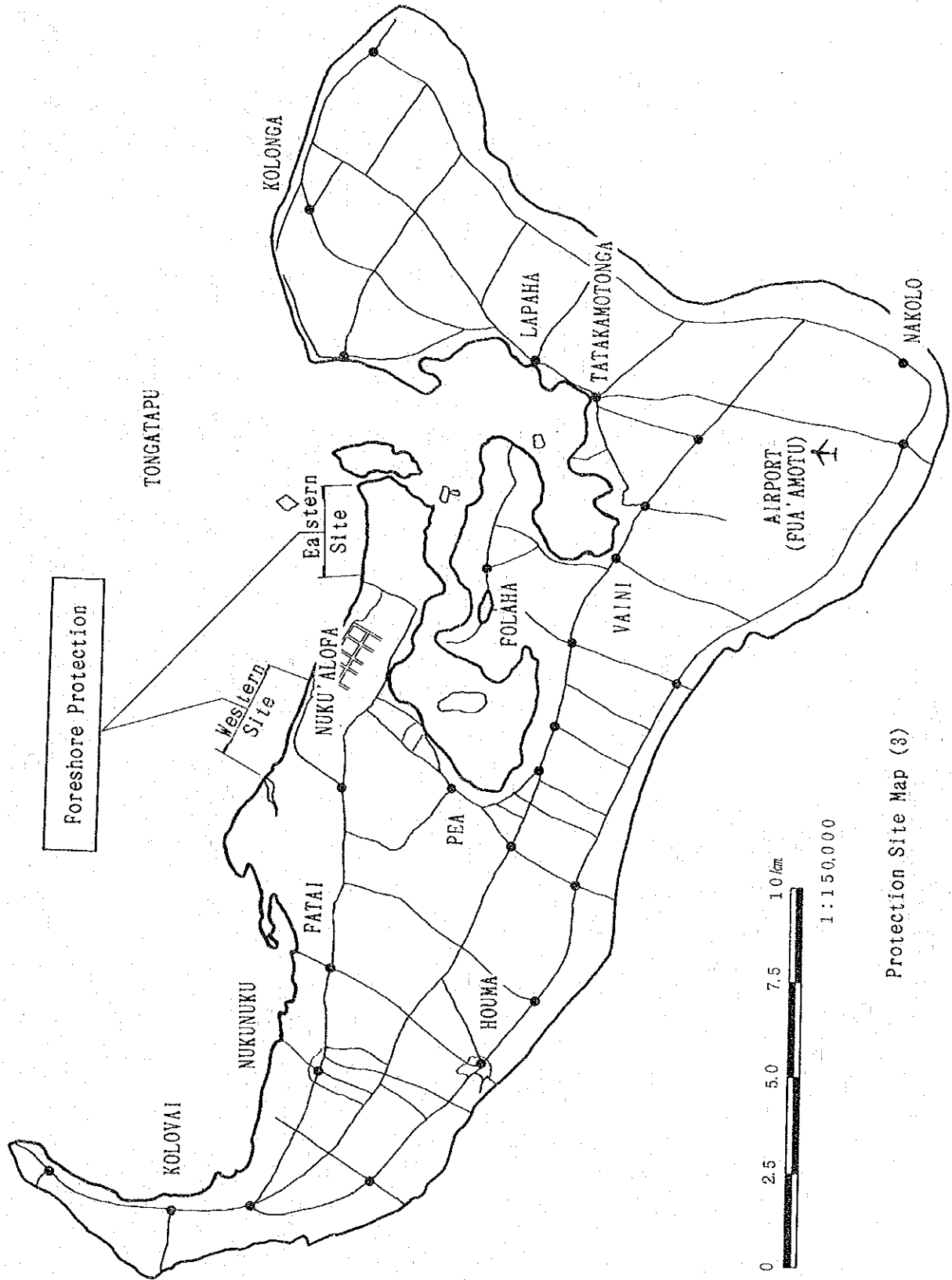


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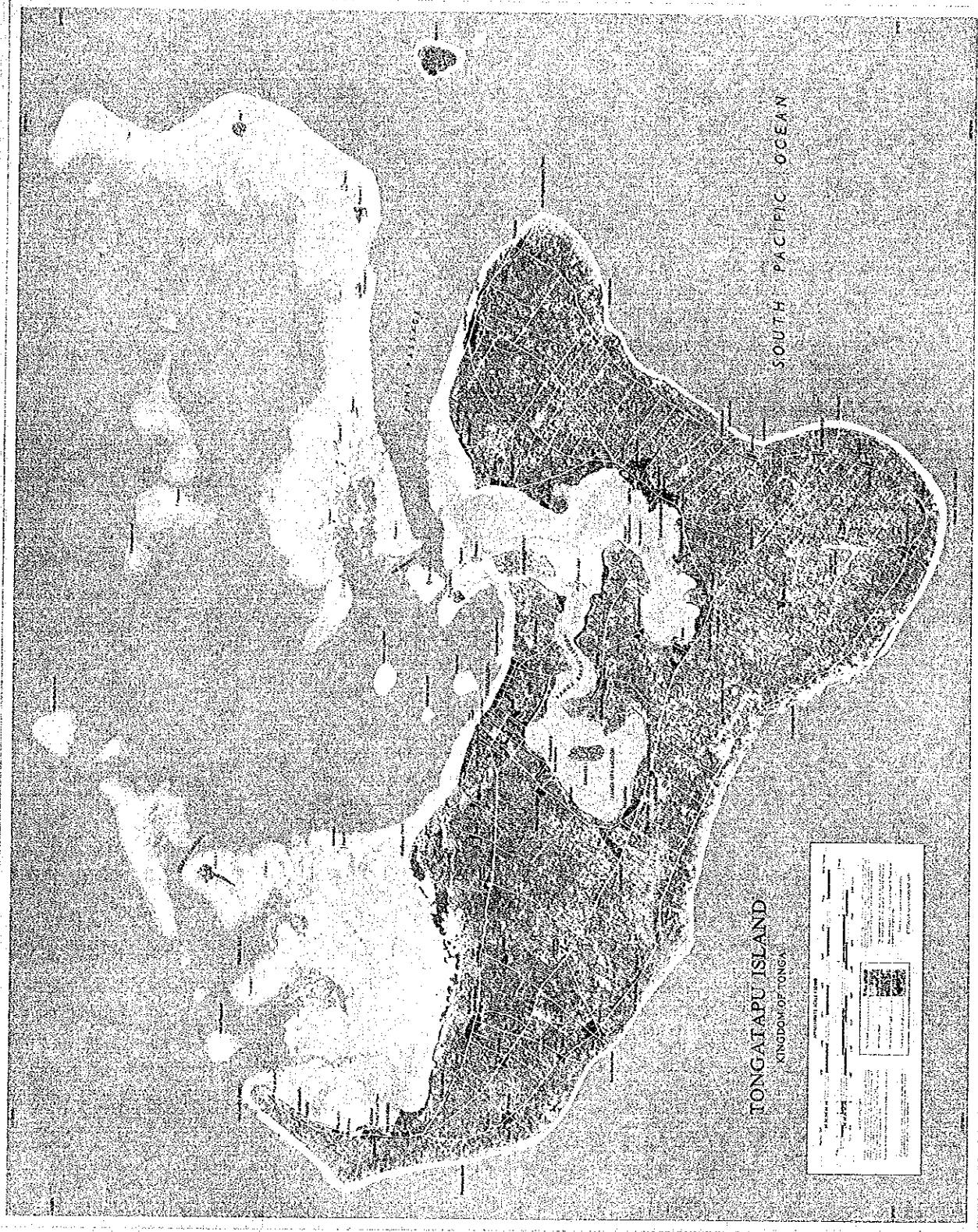
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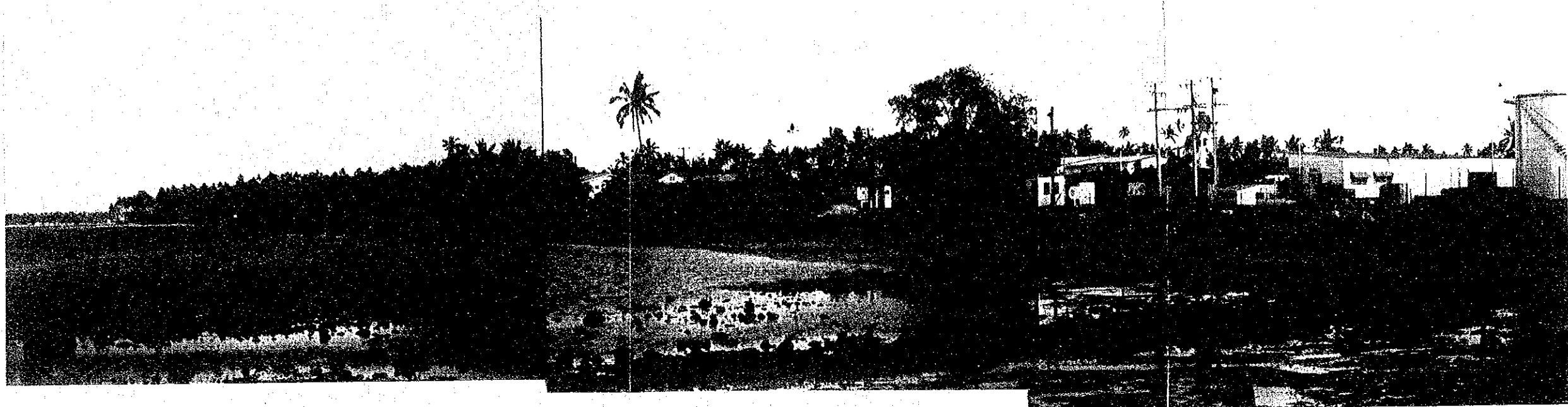
Location Map (2)



Protection Site Map (3)



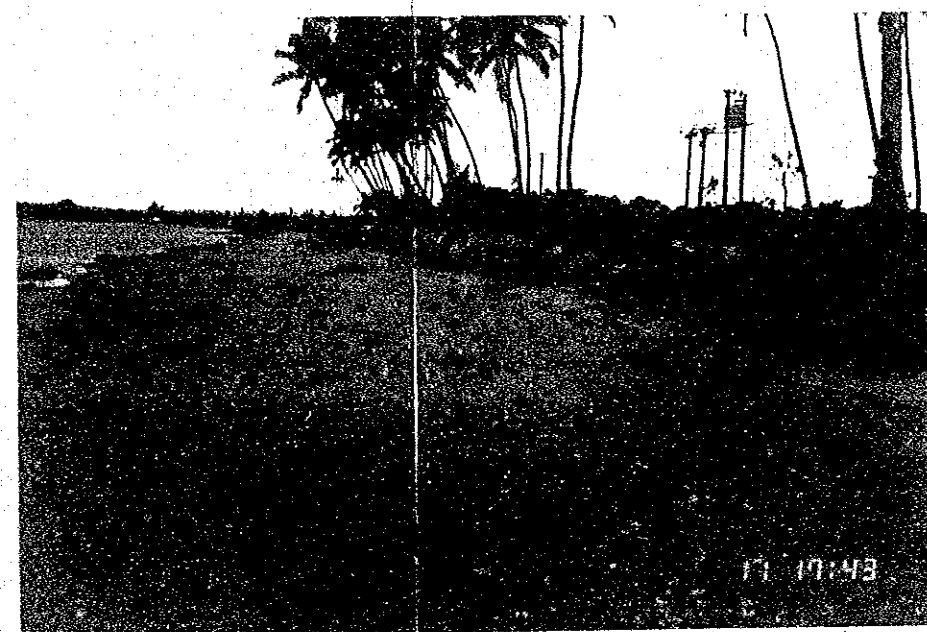




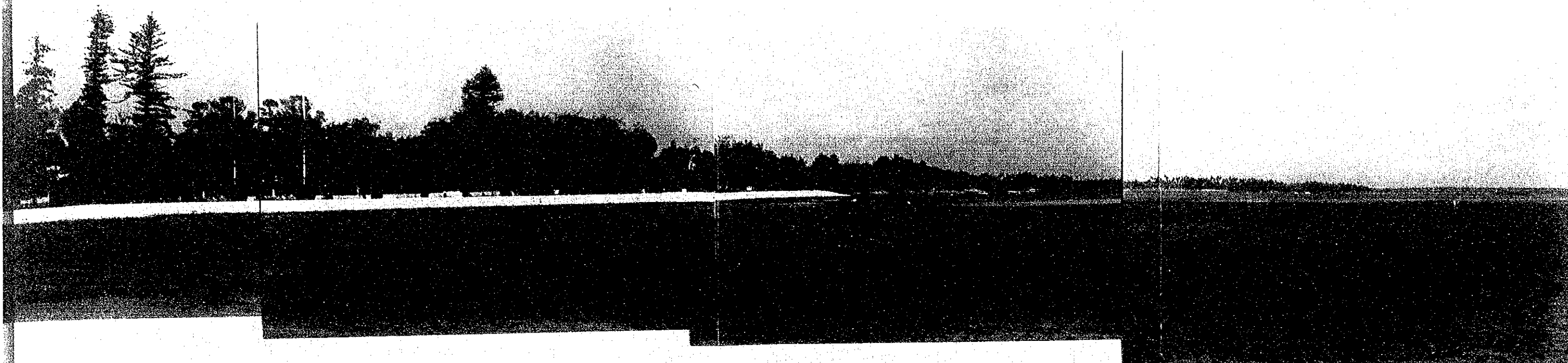
Panorama of Eastern Seashore



Existing Condition of Parapet (Eastern Seashore)



Existing Condition of Stone Masonry (Eastern Seashore)



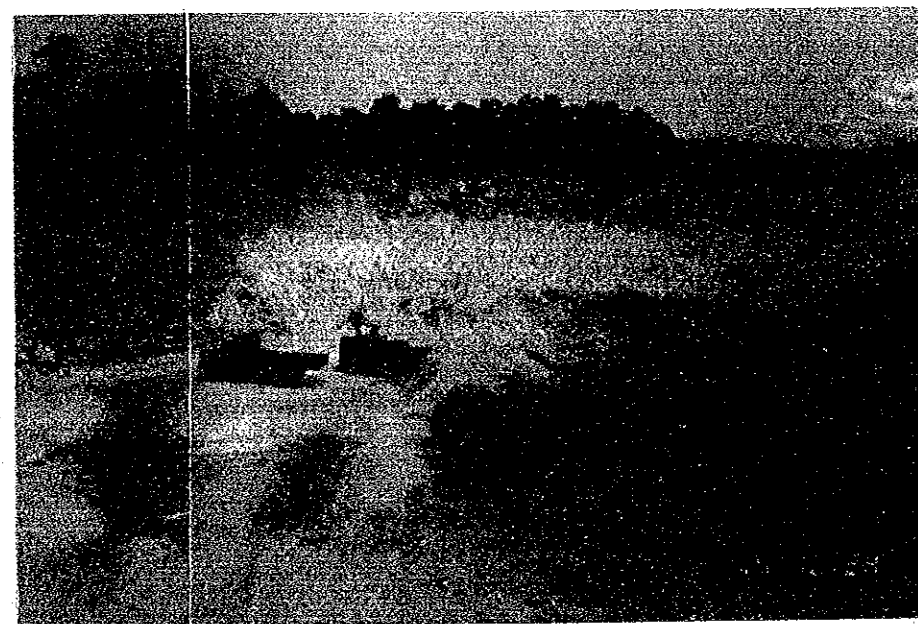
Panorama of Western Seashore



Existing Condition of Stone Masonry (Western Seashore)



Damadge of Stone Masonry  
(Western Seashore)



Farm Quarry





# SUMMARY



## SUMMARY

The Kingdom of Tonga (hereinafter referred to as "Tonga" ) consists of 169 islands and is a typical island country. It is located between latitudes 15 ° S to 23 ° 30'S in the South Pacific Ocean.

Nuku'alofa City, the capital, is located in the northern part of Tongatapu, the country's largest island. The Nuku'alofa coast, the Project Study Area, is about 8.7 km long and is located to the north of Nuku'alofa City.

Nuku'alofa City is the centre of the country's political and economic activities. The Project for Extension of Nuku'alofa Foreshore Protection is considered as a most important Project to implement for maintaining city functions, in carrying out development project implementation, and in protecting people's lives and property.

Sections of the existing concrete parapet and stone structure of the foreshore protection work were either partially or completely destroyed by Cyclone Issac that hit the country on March 3, 1982.

Behind the foreshore protection structure, houses, oil storage tanks and the Fisheries Agency's facilities exist, and plans are being made to construct resort facilities, a seaside park, and a golf course in the area. Thus, the urgency for undertaking the rehabilitation of the damaged foreshore protection structure has increased dramatically.

With aid from the West German Government, the Government of Tonga completed the rehabilitation work that began in 1983 on about a 3.2 km long Nuku'alofa City section of the approximately 8.7 km long protection structure. About 5.5 km of the structure still remains in need of rehabilitation work.

Immediately after learning of the damages inflicted by Cyclone Issac, the Government of Japan granted the Government of Tonga U.S. \$20,000 in financial aid and ¥25,000,000 worth of medical aid.

In view of the above background, the Government of Tonga established the Project for Extension of Nuku'alofa Foreshore Protection and requested grant aid from the Government of Japan for the purpose of rebuilding the 5.2 km of the foreshore protection structure that remains unimproved.

In response to the Government of Tonga's request, the Government of Japan decided to conduct a Basic Design Study and directed the Japan International Cooperation Agency (JICA) to dispatch a Basic Design Study Team to Tonga for the period of October 30 to November 19, 1987.

The Study Team held discussions with the officials concerned of the Government of Tonga, conducted field surveys, and collected data. Upon returning to Japan, the Study Team prepared the Basic Design Study based on the results of the field surveys.

Basic aspects of the Project for Extension of Nuku'alofa Foreshore protection are as follows:

- (1) The foreshore protection construction boundary is about 5.2 km in length. It takes in 2.5 km of Nuku'alofa's eastern extension and about 2.7 km of the western extension.  
The remaining 0.3 km section of the unrehabilitated structure is a part of the harbour area. But, as the harbour area is included in a future development project, this 0.3 km section was excluded from this Project.
- (2) The new foreshore protection structure shall be a rubble mound type. An artificially nourished beach shall be made in front of the structure to properly utilize the beach area and for retaining the scenic appearance of the coastal area.
- (3) The section of the foreshore protection structure's western extension in front of the swamp area, and a 170 m section of the eastern extension's eastern end were designed to prevent overtopping waves. Artificially nourished beach will not be placed in front of these sections.
- (4) The construction period shall be planned by taking into consideration construction costs and environmental problems.

- (5) Taking into account the importance and priority of the foreshore protection work, the western extension shall be built prior to the eastern extension.
- (6) As it is impossible to procure major construction materials and equipment in Tonga, they will be shipped in from Japan for the sake of construction safety and procedure.
- (7) The protection structure shall be a type that will only require a minimum amount of maintenance and management in the future.

The outline of the Foreshore Protection Structure Construction Project is as follows:

Project Area	Northern Beach of Nuku'alofa City, Tongatapu Island
Length of Protection Structure	Eastern Extension: Approximately 2.5 km Western Extension: Approximately 2.7 km Total Length: Approximately 5.2 km
Structure Type	Stone masonry Type
Structure Shape	Stone structure made of coral rock and artificially nourished beach with coral sand. Crown Height of Eastern Extension Structure: +2.8 to +2.3 m Crown Height of Western Extension Structure: +3.3 to +3.6 m

Coral blocks that are obtainable in Tonga will be used as the basic material for the construction of the protection structure. As it will be impossible to procure construction equipment in Tonga, it will be shipped in from Japan in order to carry out Project work safely and within a prescribed period of time.

The Government of Tonga will undertake the following:

- (1) Provide access roads from the main roads to the quarries and the construction liaison office.

- (2) Provide land temporarily for the construction liaison office, warehouse, stockyard, motor pool, etc.
- (3) Install water and electric supply lines and telephone cables to the construction liaison office site.
- (4) Remove shipwrecks.

The Ministry of works will be the Project implementation agency. It will also undertake the management and maintenance of the protection structure.

Project cost to be borne by the Government of Tonga is estimated to be about T\$12,800.

The Project construction period, after the signing of the Exchange of Notes by both Governments, is scheduled, and will include the detailed design and tendering periods, as follows:

- (1) Phase I Construction (construction of about 2.7 km of the foreshore protection structure's western extension)

After the signing of the Exchange of Notes, it will take 11.5 months to complete Phase I construction: two months for preparing the detailed designs; one and a half months for tendering; one month for procuring and shipping construction equipment and materials, and seven months to accomplish the construction work.

- (2) Phase II Construction (construction of about 2.5km of the foreshore protection structure's eastern extension)

After the signing of the Exchange of Notes, it will take 9.2 months to complete Phase II construction: one and a half months for preparing the detailed designs; one month for tendering; six months to accomplish the construction work, and seven tenths of a month for shipping construction equipment back to Japan.

By accomplishing Phase II's detailed designs and tendering during the Phase I construction period, it is expected to take 18.2 months to complete the Project construction.

The Project's protection structure will normally require no maintenance or repair work. However, if extraordinary high storm surges or waves inflict damages to the protection structure, the Ministry of Works, having experience in managing and maintaining the foreshore protection structure, will perform the repair work. Therefore, no problems should be encountered in maintaining or repairing the Project's protection structure.

Implementation of the Project will contribute to the restoration of Nuku'alofa City's functions, accelerate the implementation of development projects, protect the lives and property of the people, and, as a result, speed up the country's economic development and upgrade the people's living standards. It would be extremely worthwhile to carry out the Project with grant aid cooperation from the Government of Japan.





## TABLE OF CONTENTS

PREFACE .....		I
PROJECT LOCATION MAPS .....		II
SUMMARY .....		VIII
TABLE OF CONTENTS		
CHAPTER 1	INTRODUCTION .....	1-1
CHAPTER 2	PROJECT BACKGROUND .....	2-1
2.1	General Description of the Country .....	2-1
2.2	Socioeconomic Conditions of Tonga .....	2-2
2.3	Natural Conditions .....	2-3
2.3.1	Geology .....	2-3
2.3.2	Climate .....	2-4
2.3.3	Cyclones .....	2-5
2.4	Social Environment .....	2-5
2.4.1	Roads .....	2-5
2.4.2	Harbour .....	2-5
2.4.3	Water Supply and Sewerage System .....	2-6
2.4.4	Electricity .....	2-6
2.4.5	Telephones .....	2-6
2.5	Development Plan .....	2-6
2.5.1	National Development Plan .....	2-6
2.5.2	Related Development Projects .....	2-7
2.6	Background and Contents of the Request .....	2-8
2.7	Foreshore Protection Structure's Present Conditions and Problems .....	2-10
CHAPTER 3	PROJECT CONTENTS .....	3-1
3.1	Objectives and Contents .....	3-1
3.2	Examination of the Contents of the Request .....	3-1
3.3	Present Conditions of the Project Site .....	3-3
3.4	Outline of Project Foreshore Protection Structure .....	3-3
3.5	Project Implementing Agency .....	3-4
CHAPTER 4	BASIC DESIGN .....	4-1
4.1	Basic Design Policy .....	4-1
4.2	Design Criteria .....	4-2
4.2.1	Design Wave Height and Period .....	4-2

4.2.2	Design Tide Level .....	4-19
4.2.3	Allowable Rate of Overtopping .....	4-23
4.3	Basic Plan .....	4-26
4.3.1	Calculation of Wave Height and set-up on Reef .....	4-26
4.3.2	Examination of the Rate of Overtopping .....	4-29
4.3.3	Calculation of Required Weight of Stone Masonry .....	4-31
4.3.4	Determination of the Final Crown Height .....	4-33
4.3.5	Structure Crown Width .....	4-33
4.3.6	Beach Material .....	4-34
4.3.7	Foreshore Protection Cross Sections .....	4-38
4.4	Construction Plan .....	4-41
4.4.1	Construction Policy .....	4-41
4.4.2	Construction Method .....	4-45
4.4.3	Construction Boundary .....	4-50
4.4.4	Construction Supervision Plan .....	4-51
4.4.5	Material and Equipment Procurement Plan .....	4-52
4.5	Project Implementation Schedule .....	4-56
4.6	Management and Maintenance Costs .....	4-57
4.7	Project Cost Estimate .....	4-57
CHAPTER 5	PROJECT EVALUATION .....	5-1
5.1	Project Implementation Effects .....	5-1
5.2	Propriety of Project Implementation .....	5-2
CHAPTER 6	CONCLUSION AND RECOMMENDATIONS .....	6-1
6.1	Conclusion .....	6-1
6.2	Recommendations .....	6-1

## APPENDICES

I.	Minutes of Discussions .....	A-2
II.	Members of the Basic Design Study Team .....	A-9
III.	Schedule of the Study Team .....	A-10
IV.	List of Interviewed Personnel .....	A-13
V.	Contents of the Fifth Five-year Development Plan .....	A-14
VI.	Meteorological Data .....	A-15
VII.	Result of the Tidal Observation .....	A-17
VIII.	Result of Seabed Material Surveys .....	A-18
IX.	Damage by Cyclone Issac .....	A-24
X.	List of Data Collected in Tonga .....	A-26

## LIST OF FIGURES

3-1	Utilizing of Hinterland of Foreshore Protection .....	3-5
3-2	Organizational Structure of the Government of Tonga .....	3-6
3-3	Organizational Structure of the Ministry of Works .....	3-7
4-1	Passing Routes of Cyclones .....	4-5
4-2	Passing Route of Cyclone Issac and Estimated Wind Speed .....	4-6
4-3	Detail Route of Cyclone Issac .....	4-7
4-4	Wind Speed Distribution and Time .....	4-8
4-5	Wind Speed Distribution and Time Change .....	4-9
4-6	Wilson's Wave Developing Curves .....	4-10
4-7	Wave Height in the Breaking Zone .....	4-14
4-8	Average Water Level Change Caused by Irregular Wave in Shoaling Water .....	4-14
4-9	Wave Height Estimation by Angular Spreading Method .....	4-17
4-10	Wave Refraction Diagram .....	4-18
4-11	Tide Observation Location Map .....	4-19
4-12	Zoning for Protection Structure Design .....	4-26
4-13	Wave Height in the Breaking Zone .....	4-28
4-14	Average Water Level Change Caused by Irregular Wave in Shoaling Water .....	4-28
4-15	Expected Rate of Overtopping Diagram .....	4-30
4-16	Relationship Between Beach Front Slope and $d_{50}/H_o$ .....	4-34
4-17	Shoreline Erosion and Accretion .....	4-35
4-18	Seabed Material Survey Locations .....	4-37
4-19	Protection Structure Cross Sections .....	4-38
4-20	Quarry Location Map .....	4-43
4-21	Quarrying Flow Chart .....	4-45
4-22	Flow Chart of Protection Structure Construction .....	4-48
4-23	Project Implementation Schedule .....	4-56

## LIST OF TABLES

4-1	Major Tidal Harmonic Constants .....	4-20
4-2	Critical Rate of Overtopping .....	4-24
4-3	Referential Rate of Overtopping .....	4-24
4-4	Reef Features .....	4-27
4-5	Wave Height and set-up on Reef .....	4-29
4-6	Protection Structure Crown Height .....	4-31
4-7	Value of $K_D$ .....	4-31
4-8	Comparison of Construction Periods .....	4-41
4-9	List of Construction Equipment Owned by the Ministry of Works .....	4-53
4-10	List of Construction Equipment Owned by Local Contractors .....	4-53
4-11	List of Required Construction Material .....	4-54
4-12	List of Required Construction Equipment .....	4-55



# **CHAPTER 1 INTRODUCTION**





## CHAPTER I INTRODUCTION

Based on the Fifth Five-year Development Plan, the Kingdom of Tonga is presently attempting to develop commercial and industrial zones in an effort to attract business enterprises for the purpose of augmenting the country's production, increasing the national income, and upgrading the standards of living and culture of the Tongan people.

Nuku'alofa City, capital of Tonga, is the centre of the development programme; many plans are already in the making.

On March 3, 1982, Cyclone Issac inflicted heavy damage to about 8.7 km of the Nuku'alofa foreshore protection structure. About 3.2 km of the structure has been repaired, but about 5.5 km still remains in a damaged condition.

The topography of the coastal area is only 1.0 m higher than the high water level. In some areas, the inland area is lower than the coastal area. Therefore, it is extremely difficult to protect Nuku'alofa City from storm surges and high waves under existing conditions. From the viewpoint that the foreshore protection structure plays a very important role in preserving city functions and the lives and property of the people, allowing the capital's political and economic activities to be carried out in safety, and enabling the promotion and implementation of urban development projects, the present structure is inadequate (in terms of scale and quality) and is in urgent need of rehabilitation.

In view of the above, the Government of Tonga established the Project for Extension of Nuku'alofa Foreshore Protection to rehabilitate the remaining 5.5 km length of damaged protection structure, and requested grant aid cooperation from the Government of Japan in order to accomplish this task.

In response to the Government of Tonga's request, the Government of Japan entrusted the study to the Japan International Cooperation Agency (JICA). JICA dispatched a Basic Design Study Team to Tonga for the period of October 30 to November 19, 1987. The Team was headed by Dr. Hiroshi Hashimoto, Director of the River Department, Public Works Research Institute, Ministry of Construction.

The Basic Design Study Team conducted the following studies for the purpose of examining the appropriateness of the Project for receiving grant aid cooperation from the Japanese Government:

- (1) Analysis of the Project background and the appropriateness of the Project contents.
- (2) Study of other priority projects related to the Project.
- (3) Examination and discussions concerned with the Project contents and its scale.
- (4) Confirmation of the Project implementation system, management and maintenance system, and construction related responsibilities to be borne by the Government of Tonga.
- (5) Tide observations, cross section survey, seabed material survey, quarry survey, and construction equipment survey.

The Minutes of Discussions were prepared based on the above studies and discussions, and were signed by the Study Team and officials concerned of the Government of Tonga

Based on the results of the field surveys, the Project's contents, scale, construction period, costs, and propriety were studied and, as a result, this report, the "Basic Design Study on the Project for Extension of Nuku'alofa Foreshore Protection" was prepared.

The names of the Study Team members and the officials concerned of the Government of Tonga, and the Study Team's schedule and the Minutes of Discussions are attached to this report as Appendices.

## **CHAPTER 2 PROJECT BACKGROUND**



## CHAPTER 2 PROJECT BACKGROUND

### 2.1 General Description of Tonga

Tonga, a Polynesian country, is located east of Fiji and south of Western Samoa. Tonga's 169 islands are scattered in an area that covers 360,000 km<sup>2</sup> between latitudes 15° S to 23° 30' S and longitudes 173° W to 177° W. Tonga is a typical island country and its total land area is 750 km<sup>2</sup>.

Geographically, Tonga is made up of three island groups and two other islands: the Vavau Group to the north, the Ha'apai Group in the center, and the Tongatapu Group to the south; Niuafu'ou and Niuatoputapu islands are to the north of the Vavau Group.

There are volcanoes in the northern and western regions of the Tonga Island Group. The 1,030 m high cone-shaped volcanic island of Kao that is located at the northwestern edge of the Ha'apai Group is the highest mountain in Tonga.

The islands located in the central and southern parts of Tonga have flat topographies of upheaved coral-reefs.

Tongatapu Island, on which the Tongan capital Nuku'alofa is located, is flat. Its highest elevation is 65 m above sea level. Generally, soil on the Tongan Islands consists of coral limestone and is not suitable for farming. On the island of Tongatapu, however, the soil is fertile and is suitable for farming.

The 1985 estimated population was 102,190. 68.7% of the population, or about 70,000 people, live on Tongatapu Island; 30,000 people are concentrated in the Nuku'alofa area.

After gaining its independence in 1970, Tonga joined the various special agencies of the United Nations. Presently, it is an associate member of the Economic and Social Committee of Asia and the Pacific (ESCAP), the South Pacific Forum (SPF), the Asian Development Bank (ADB), the South Pacific Committee (SPC), etc.

## 2.2 Socioeconomic Conditions of the Project Area

The industrial structure of Tonga has at its centre the primary industry, agriculture.

The country produces such export oriented fruits and vegetables as bananas, copra, watermelons, tomatoes, vanilla, etc.

As for the manufacturing industry, there are coconut fiber processing companies, copra drying companies, coconut processing companies, fish canning companies, and sawmills. However, due to the small market size, the small amount of domestic resources, and the lack of funds for development purposes, these companies operate on a very small scale.

The country's 1985 Gross Domestic Product (GDP) was T\$ 73 million (T\$ 715 per capita).

In 1985 foreign trade showed a deficit of T\$ 50 million. The trade deficit was barely offset by money sent from Tongans living abroad, money earned through tourism, foreign loans, and grant aid from foreign countries.

An immediate big problem for the Tongan economy is the increase in unemployment.

In addition to the increase in unemployment among the younger generation, there recently has been a reduction in the number of workers permitted to emigrate to New Zealand and Australia due to stricter working permit regulations in those countries. Emigration had been one way of keeping the country's unemployment rate down.

In order to resolve the previously outlined problems, it will be necessary to establish and redevelop industries to stimulate the influx of foreign revenue. Redeveloping rural agriculture related industries, establishing small-scale manufacturing industries, developing tourism related industries, and making effective use of the country's available resources could contribute greatly in overcoming the prevailing economic problems of Tonga.

The rehabilitation of Nuku'alofa City's foreshore protection structure is absolutely necessary if stable social and economic activities are to be maintained, and if the lives and property of the people are to be safely protected.

Taking into consideration the propagation effects of Nuku'alofa City's economy on the rural areas, foreshore protection takes on added importance.

## 2.3 Natural Conditions

### 2.3.1 Geology

#### (1) General Description

The Tonga Island consist of upheaved coral reefs and volcanoes. The islands run parallel to the western side of the Tonga Trench that stretches in an east-northeast direction. The Tonga Trench is the second deepest trench in the Pacific Ocean; it is about 3,000 km long, 100 km wide, and at its deepest point has a depth of 10,882 m. The upheaved coral reefs (Tongatapu Island, the Ha'apai Island Group, and Vavau Island) are located on the Asia-Australian Plate. Volcanoes (Late Island, Kao Island, and Falcon Island) are located on the west side of the Tofa Trough.

Tongatapu Island's highest elevation is 65 m above sea level. The island top almost evenly slopes towards the northwest.

#### (2) The Construction Site of The Foreshore Protection Structure.

The construction site of the foreshore protection structure is within the range of 10 m from the oceanfront to the existing protection structure.

Soil conditions in the vicinity of the construction site are as follows:

Depth	Soil Condition
0 to 0.4 m	Sand or coral particles
0.4 to 7.5 m	Fine sand or coral particles (silty)
7.5 to 9.0 m	Tuff

Judging from the existing structure, the soil bearing strength is assumed to be more than 3 to 4 tons/m<sup>2</sup>. During the field survey period, the Study Team conducted a settlement study survey of the approximately 3.2 km long rehabilitated foreshore protection structure that was built with aid from West Germany. The study revealed no significant settlement of the structure.

As the Project's planned foreshore protection structure has almost the same shape and unit weight as the rehabilitated structure, it is considered that the soil bearing strength will be satisfactory and that no settlement will occur at the new structure site.

#### 2.3.2 Climate

Tonga is situated in the oceanic subtropical climate zone. Trade winds blow throughout the year -- the winds are mild during the winter (May through August), and strong during the summer (December through April). The prevailing wind directions are from the southeast and east-southeast, having about a 70% frequency.

In Nuku'alofa, the hot and humid season is from December through April. The average temperature is about 25°C. Heavy precipitation occurs during the summer months, especially during the January-March period when it surpasses 250 mm/month. The humidity reaches about 75% during this time of the year.

On the other hand, from May through November, it is cool and dry. The average temperature is about 22°C. The monthly precipitation is less than 130 mm and the humidity becomes about 65%. The average annual temperature is 24°C.

The average annual precipitation, as recorded from 1975 through 1985, is about 1,600 mm.



### 2.3.3 Cyclones

From December through April, Tonga is subjected to hot humid weather. This time of the year is known as the cyclone season.

Cyclones created near the equator rapidly increase in strength as they travel southward. Together with heavy rains and strong winds, cyclones inflict heavy damage on agricultural crops, boats and houses.

Cyclone Issac was spawned in the ocean area far to the northeast of Vavau Island. On March 2, 1982, Issac, on its southward journey, passed over the Tonga Islands carrying maximum winds of 61 m/sec near its centre. This cyclone caused a great deal of damage to the islands.

## 2.4 Social Environment

### 2.4.1 Roads

Tonga has about 300 km of paved roads. 190 km of these roads are on Tongatapu Island. The major roads in Nuku'alofa City are simply made with compacted crushed coral stone topped with asphalt. The management and maintenance of roads are carried out by the Ministry of Works.

The approximately 20 km long road that leads from the Project site to a quarry is from 6 to 12 m wide; it is paved with asphalt. There will be no problem transporting foreshore protection structure construction material over this road.

### 2.4.2 Harbour

The Queen Salote Wharf is in the Project Area. It is 100 m long. The attractive Queen Salote Harbour is protected by offshore coral reefs and small island; its depth is 13 m. Presently, the harbour is being expanded as part of the Fourth Five-year Development Plan with aid from the Australian Government.

During 1985 a total of 83,857 tons of cargo was handled at the harbour. 801 ships entered the harbour during that year.

#### 2.4.3 Water Supply and Sewerage System

The Tonga Water Board is carrying out water supply services in Nuku'alofa City. Ground water is the supply source, and, as it contains large amounts of calcium and some salinity, it is of hard water quality. However, it satisfies the drinking water standards of the World Health Organization (WHO). The water supply amount in Nuku'alofa City is 32,000 m<sup>3</sup> per day.

In areas where water supply systems have not been developed, collected rain water is used for drinking.

The sewerage system is not well developed. Sewerage is treated by the storage infiltration method.

#### 2.4.4 Electricity

The Tonga Electric Power Board is in charge of supplying electricity. 5,850 kw of electrical power is provided by diesel generators. The supplied voltages are 415V 3 phase, and 250V single phase. Because of the high fuel costs, the Government of Tonga is studying the feasibility of generating electricity by means of solar energy, trade winds, and wave forces.

#### 2.4.5 Telephones

The country's telephone system is controlled by the Telegraph and Telephone Department, which is directly under the jurisdiction of the Prime Minister's Office. In 1985 there were 2,673 telephones in the country.

### 2.5 Development Plan

#### 2.5.1 National Development Plan

The Government of Tonga is proceeding with the Fifth Five-year Development Plan (from 1986 to 1990). The long-term objectives of the Plan are as follows:

- To strengthen the country's production and increase national income.
- To rectify the inequality of social and economic levels between urban and rural areas.

- To upgrade the people's living and cultural standards, and to preserve the natural environment.
- To promote friendship and cooperation with foreign countries for social and economic development purposes.
- To improve the environment in order to improve national living standards. Except for a few agriculture and industry projects, the majority of the development projects in the planning stage are related to infrastructures and social services.

The contents of the Fifth Five-year Development Plan are attached as Appendix VI.

The Project for Extension of Nuku'alofa Foreshore Protection is listed in the Fifth Five-year Development Plan as an important project for protecting the social foundations of the country's capital, where most of the political and economic activities are concentrated.

#### 2.5.2 Related Development Projects

- (1) Nuku'alofa Foreshore Protection Construction (about 3.2 km of the centre section).

From August 1983 through October 1986, Tonga, with aid from West Germany, constructed an approximately 3.2 km long centre section of the nearly 8.7 km long Nuku'alofa foreshore protection structure. This project was implemented to protect the most important area, the Nuku'alofa City centre, from cyclones. However, behind both extensions of the protection structure there are a fuel storage area, recreational facilities, and houses. The subject of protecting these places is of utmost importance. If the unrehabilitated extensions are to remain in their present condition, there will be flooding in the centre areas by the overtopping seawater entering at the unrehabilitated areas.

- (2) Tongatapu Island Road Construction

The long-term road construction plan in the Fifth Five-year Development Plan is as follows:

Classification	Length (Km)	Cost (T\$ 1,000)
• Arterial Road	90	5,000
• Principal Road	80	1,250
• Branch Road	40	500
• Agricultural Road	50	425

The road network is a basic infrastructure for maintaining stable economic activities. Thus, it is extremely important to protect the roads from cyclones.

### (3) Tourism Related Development Projects

Preservation of the natural environment in the development construction site area is a very important subject to be taken into consideration if development projects are to proceed.

Tourism related development projects in Nuku'alofa City are as follows:

- Construction of a national museum.
- Construction of a seaside park to be used by residents and tourists alike.
- Construction of golf courses at the eastern outskirts of Nuku'alofa City.
- Development of multipurpose seaside resort facilities.
- Improvement of the Dateline Hotel facilities and its services.

### (4) Fish Pond Construction

It is planned to construct fish ponds in the swamp areas located in the western part of Nuku'alofa City. These ponds will contribute not only to the improvement of the food situation, but to the condition of the fish canning industry as well. The foreshore protection structure is necessary to provide protection to the fish ponds and to promote a stable fish pond development project.

## 2.6 Background and Contents of the Request

In March 1982, Cyclone Issac, which was spawned in the ocean area to the northeast of Vavau Island, passed over the islands of Tonga. The storm

packed winds having a maximum velocity of 61 m/sec over a radius of 160 km as it travelled southward over the Tongan Islands. Issac destroyed the foreshore protection structure, houses, farmland, roads, airport and harbour facilities, etc.

Major damage caused by Cyclone Issac is listed below:

- Death toll: 6
- Houses destroyed: Several thousand  
(damage estimated at T\$ 10 million)
- Total damages: T\$ 18.7 million T\$
- Inundated area: a 2 km by 1 km area

The Government of Japan gave US \$20,000 in financial aid, and 25 million yen worth of medical supply aid to Tonga.

Accordingly, the Government of Tonga established the Nuku'alofa Foreshore Protection Rehabilitation Plan and, in 1983, started the rehabilitation work. However, only the 3.2 km centre section of the protection structure was completed. Both extensions of the structure (about 5.2 km long) still remain in a severely damaged condition due to the lack of construction funds.

Because of the extremely long delay of the Fourth Five-year Development Plan due to the extensive damage inflicted by Cyclone Issac, the Government of Tonga established the Project for Extension of Nuku'alofa Foreshore Protection, making the following items the key points of the Project:

- i) To rebuild the remaining 5.2 km of the foreshore protection structure.
- ii) That Tonga be allowed to retain the construction equipment upon completion of the Project.
- iii) To provide on-the-job training for local workers, operators, and mechanics during the construction period.

The Government of Tonga requested grant aid from the Government of Japan to implement the Project. The Government of Japan decided to study the Government of Tonga's request and entrusted the study to the Japan International Cooperation Agency (JICA). JICA dispatched the Basic Design Study Team to Tonga from October 30 to November 19, 1987. Dr. Hiroshi Hashimoto, Director of the River Department, Public Works Research Institute, Ministry of Construction, headed the Study Team.

## 2.7 Foreshore Protection Structure's Present Condition and Problems

The total length of the Nuku'alofa foreshore protection structure is about 8.7 km. In March 1982 most of the structure was either destroyed or severely damaged. The approximately 3.2 km long centre section of the structure was rehabilitated during a three year period that commenced in August 1983. As of this day, however, the remaining length of the structure is still in a damaged or deteriorated condition.

The present conditions of the eastern and western seashores in the vicinity of the foreshore protection structure are as follows:

### (1) Eastern Seashore:

- No protection structure exists 400 m from its eastern tip; in this range there is only natural beach.
- A gravity type concrete parapet and a stone masonry protection structure, having a crown height of +2.0 m, remains between the natural beach and the western harbour. However, most of this structure is either partially or completely destroyed.
- As a result of the design study, the required crown height of the foreshore protection structure was determined to be from +2.8 to +2.3 m. If the crown height is any lower, a cyclone having the same magnitude as Issac would cause wave overtopping resulting in severe damage to the area.

### (2) Western Seashore

- Except for the mangroves in front of the Department of Fisheries, only a gravity type concrete parapet and stone masonry structure

having a crown height of +2.0 m exists in the entire section. One section of the structure is completely destroyed; almost all other sections are partially destroyed.

- As a result of the design study, the necessary crown height of the protection structure must be from +3.30 m to +3.0 m. As the existing structure has a much lower crown height, it might be completely destroyed if a cyclone should hit. Further, as the land behind the structure is low, it can be assumed that overtopping waves will cause the area to become inundated.





## **CHAPTER 3 PROJECT CONTENTS**



## CHAPTER 3 PROJECT CONTENTS

### 3.1 Objectives and Contents

On March 3, 1982, Cyclone Issac swept across the Tonga Islands. The eye of the storm hit Tongatapu Island -- Nuku'alofa City, the country's capital, is located on this island -- and inflicted heavy damage. For this reason, the Government of Tonga established the Project for Extension of Nuku'alofa Foreshore Protection and, for its implementation, requested grant aid cooperation from the Government of Japan. The key points of the Project are as follows:

- (1) To reconstruct the remaining unimproved 5.2 km of the foreshore protection structure.
- (2) For Tonga to retain the construction equipment after Project completion.
- (3) To provide on-the-job training of local workers, operators, and mechanics during the protection structure construction period.

### 3.2 Examination of the Contents of the Request

The Basic Design Study Team confirmed the request contents with the officials concerned of the Government of Tonga, and held discussions with the officials on matters relating to the Project. The Team also conducted surveys of the existing foreshore protection structure, and collected area information and other pertinent data.

As a result, it is considered that if the existing foreshore protection structure remains in its present condition, it will be very difficult to maintain important city functions, and protect the lives and property of people in Nuku'alofa if and when a storm, such as Cyclone Issac, strikes again.

The following conclusions were reached after the discussions were held:

- (1) Reconstruction of the Foreshore Protection Structure:
  - The eastern extension will extend up to the end of the planned coastal road. The western extension shall end in the swampy area

on the opposite bank of the river. The total length of the new structure is to be about 5.2 km.

- Initially, a harbour and its planned expansion areas of 300 m long were included in the Project Area, but this has been cancelled.
- There is a plan to widen the coastal road at a future date. For this reason, the shoulder of the land side crown of the new foreshore protection structure will be placed at a minimum distance of 20 m from the land side boundary line of the planned road.
- The protection structure's waterfront area is used by local inhabitants for catching fish and collecting shellfish. Also, the area is used as a mooring basin. Simply designed access ways shall be installed at five locations along the structure.

(2) Supply of Construction Equipment to be used in Project Construction that will be transferred to the Government of Tonga:

Initially, the request of the Government of Tonga stated that the transferred construction equipment would be used for the maintenance and management of the Project structure and for constructing new protection structures in areas not included in the Project. The Project structure will not require a great deal of management and maintenance work; thus, after its completion, the construction equipment will not be needed. Furthermore, the Government of Tonga presently has no definite plans for the equipment's use. For these reasons, the supply of construction equipment has been excluded from the Project.

(3) On-the-job Training of Local Workers, Operators, and Mechanics during the Structure Construction Period:

The training of personnel is beyond the scope of the Japanese grant aid programme; therefore, it was eliminated from the Project. However, as local operators will be hired for the Project construction, the transfer of techniques will actually be accomplished.

### 3.3 Present Conditions of the Project Site

The area behind foreshore protection structure is being utilized as the site for Nuku'alofa City's basic urban function facilities.

There is a housing area oil storage tanks behind the eastern extension of the foreshore protection structure. Plans are presently being made to construct a seaside park, resort facilities, and a golf course in the area.

A commercial zone, houses, a fish pond, and the Fisheries Agency's facilities are situated behind the structure's western extension.

As the areas behind both the eastern and western extension are lower than the coastal area, they may incur flood damage if a cyclone reached the Project Area.

Existing and future plans for utilizing the areas behind foreshore protection structures are shown in Fig. 3-1.

### 3.4 Outline of Project Foreshore Protection Structure

Project Area	Northern Beach of Nuku'alofa City, Tongatapu Island
Length of Protection Structure	Eastern Extension: Approximately 2.5 km Western Extension: Approximately 2.7 km Total Length: Approximately 5.2 km
Structure Type	Stone masonry Type
Structure Shape	Stone structure made of coral rock and artificially nourished beach with coral sand. Crown Height of Eastern Extension Structure: +2.8 to +2.3 m Crown Height of Western Extension Structure: +3.3 to +3.0 m

Coral blocks that are obtainable in Tonga will be used as the basic material for the construction of the protection structure.

As it will be impossible to procure construction equipment in Tonga, it will be shipped in from Japan in order to carry out Project work safely and within a prescribed period of time.

### 3.5 Project Implementing Agency

The Ministry of Works will be responsible for the Project structure construction; they will carry out the management and maintenance of the structure after its completion.

The position of the Ministry of Works within the Tongan Government organization and its structural organization are shown in Figs. 3-2 and 3-3. The Ministry of Works is in charge of construction and management of infrastructures; its annual budget is approximately 450 million yen. Present ongoing projects include the following:

- The Queen Salote Wharf Expansion Project
- The Fauha Fishing Port Construction Project
- The Kolonga-Niutoua Road Construction Project
- Vuna road Construction Project
- The Ha'apai Airport Construction Project
- The Housing Construction Project

The Ministry of Works is also expected to undertake road, airport, harbour, shore protection, electric supply, and building construction projects as part of the Fifth Five-year Development Plan.

As the Ministry of Works has a great deal of project implementation experience, the construction of this Project, which is to be their responsibility, will surely be achieved in a smooth and reliable fashion.

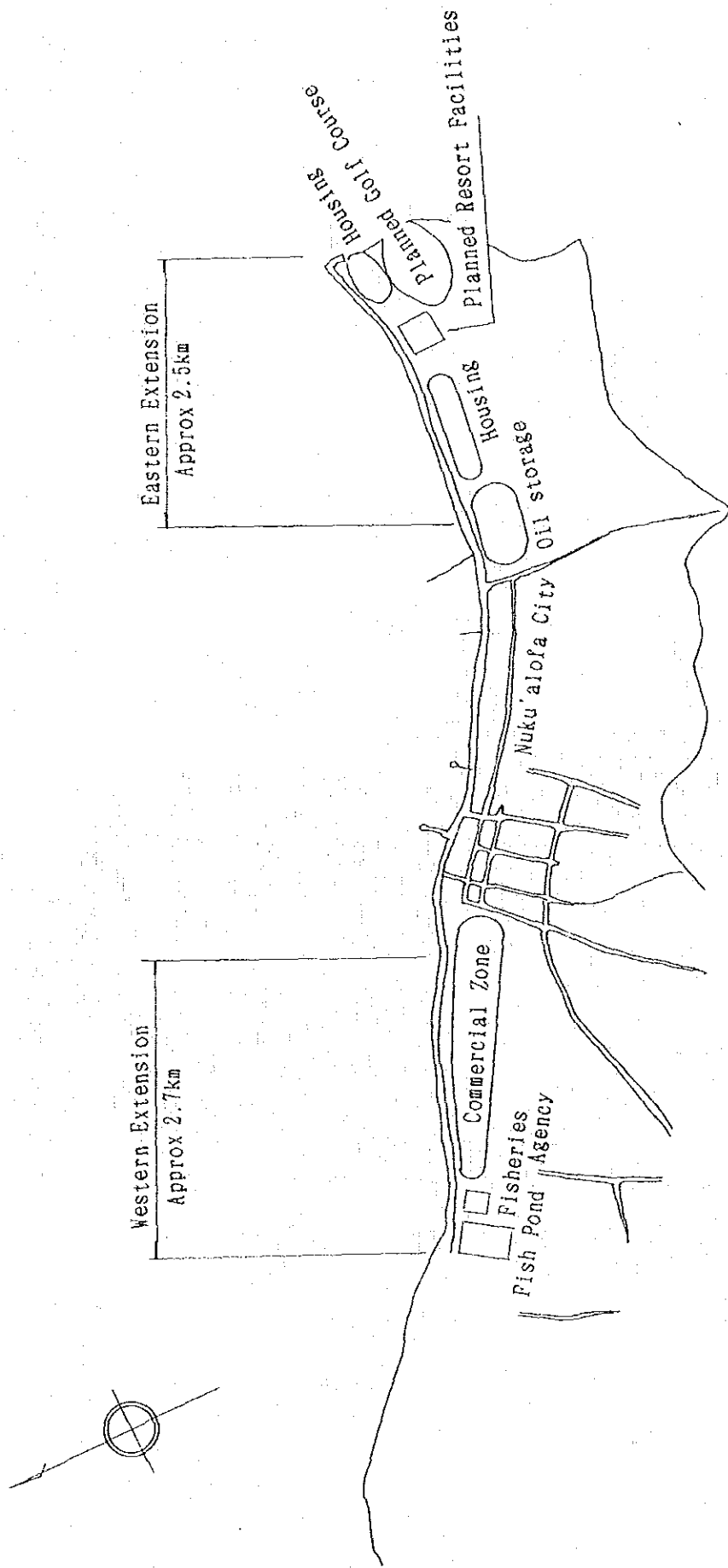


Fig 3-1 Utilizing of hinterland of Foreshore Protection

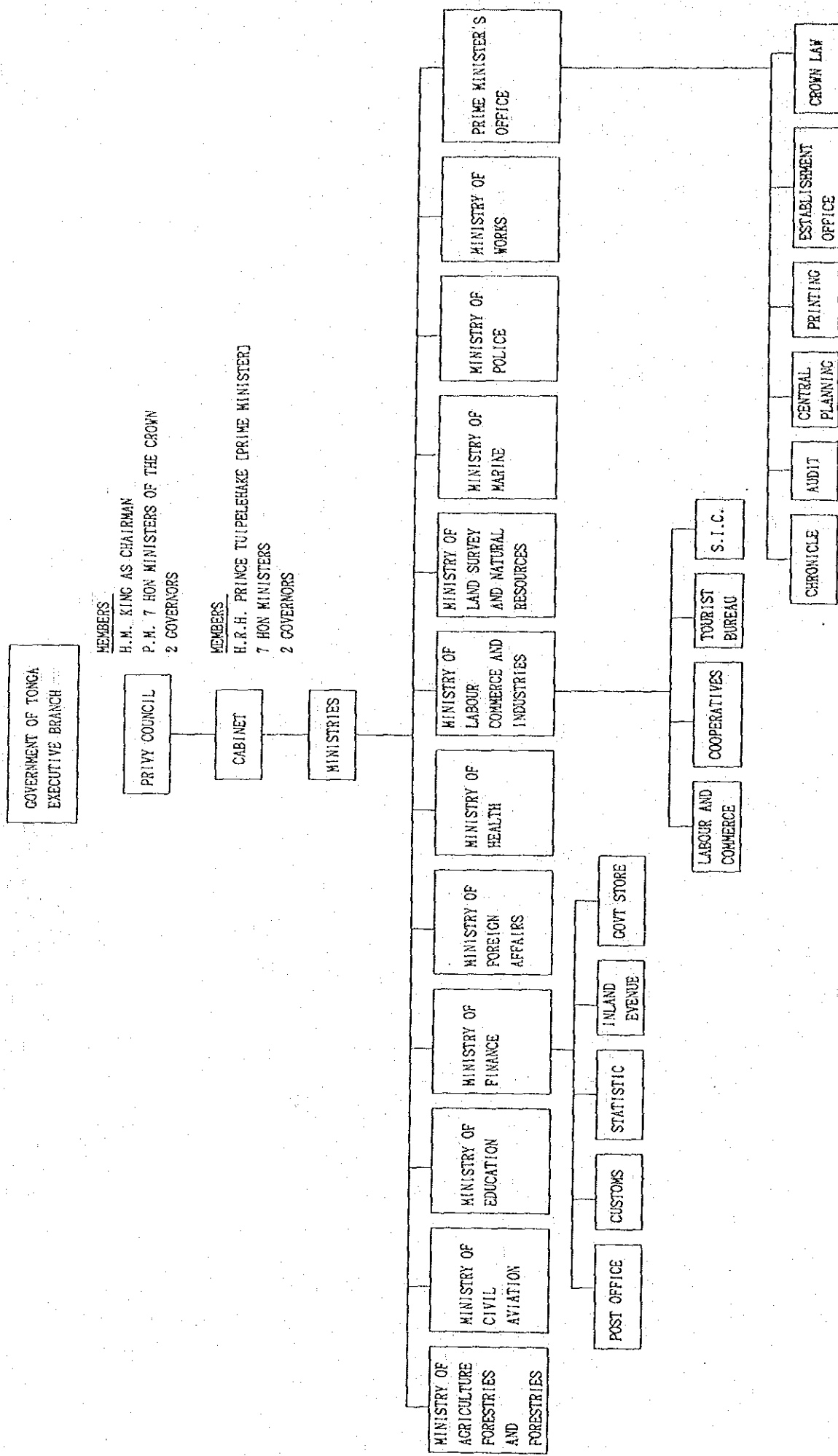


Fig 3-2 Organizational Structure of the Government of Tonga



MINISTRY OF WORKS TONCA

MINISTER OF WORKS  
DIRECTOR OF WORKS

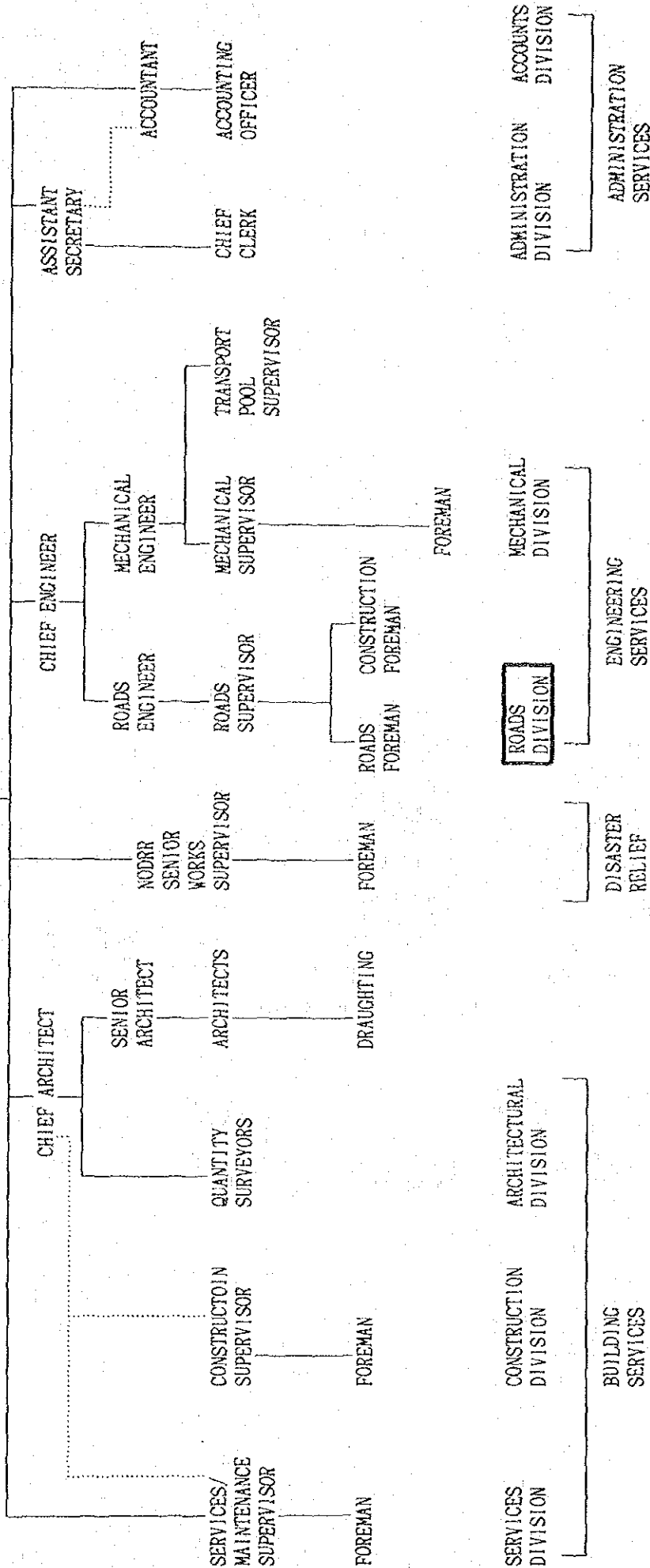


Fig 8-3 Organizational Structure of the Ministry of Works



## **CHAPTER 4 BASIC DESIGN**



## CHAPTER 4 BASIC DESIGN

### 4.1 Basic Design Policy

The objective of the Project is to protect Nuku'alofa City, Tonga's political and economic centre, from cyclone damage.

The beach in the Project Area is an excellent habitat for valuable tropical marine life. It is also widely used by local residents and tourists for recreational purposes, such as bathing, fishing, etc. Special attention must therefore be paid to the construction of the foreshore protection structure in order not to damage the gifts of nature nor the scenic beauty of the beach area.

The basic design policy for the foreshore protection structure is as follows:

- (1) The foreshore protection structure will be about 5.2 km in length; the eastern extension is to be about 2.5 km long, and the western extension will be about 2.7 km long.
- (2) Locally available construction equipment and materials will be utilized as much as possible.
- (3) The foreshore protection structure shall be of a type requiring minimum future maintenance and management.
- (4) By taking into account the proper use of the beach and the scenic appearance of the coastal area, an artificially nourished beach will be made in front of the new foreshore protection stone masonry structure.
- (5) As the foreshore protection in front of the swamp area at the western extension is planned only for preventing overtopping waves, an artificially nourished beach will not be made there.
- (6) In order to maintain sufficient river channel width, no artificially nourished beach will be made in front of the foreshore protection