MINISTRY OF RESOURCES AND DEVELOPMENT
REPUBLIC OF PALAU

No. 1

# BASIC DESIGN STUDY REPORT ON THE PROJECT FOR IMPROVEMENT OF FACILITIES FOR FISHING VILLAGES IN NORTHERN-STATES IN THE REPUBLIC OF PALAU

MARCH, 1997



JAPAN INTERNATIONAL COOPERATION AGENCY
OVERSEAS AGRO-FISHERIES CONSULTANTS, CO., LTD.

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# PREFACE

In response to a request from the Government of the Republic of Palau, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Facilities for Fishing Villages in Northern States and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Palau a study team from November 3 to November 27, 1996.

The team held discussions with the officials concerned of the Government of Palau, and conducted a field study at the study area. After the team returned to Japan, further studies were made, 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 Palau for their close cooperation extended to the teams.

March, 1997

Kimio Fujita
President
Japan International Cooperation Agency

# Letter of Transmittal

March, 1997

We are pleased to submit to you the basic design study report on the Project for Improvement of Facilities for Fishing Villages in Northern States in the Republic of Palau.

This study was conducted by Overseas Agro-Fishries Consultants Co., Ltd., under a contract to JICA, during the period from October 28, 1996 to March 31, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Palau and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

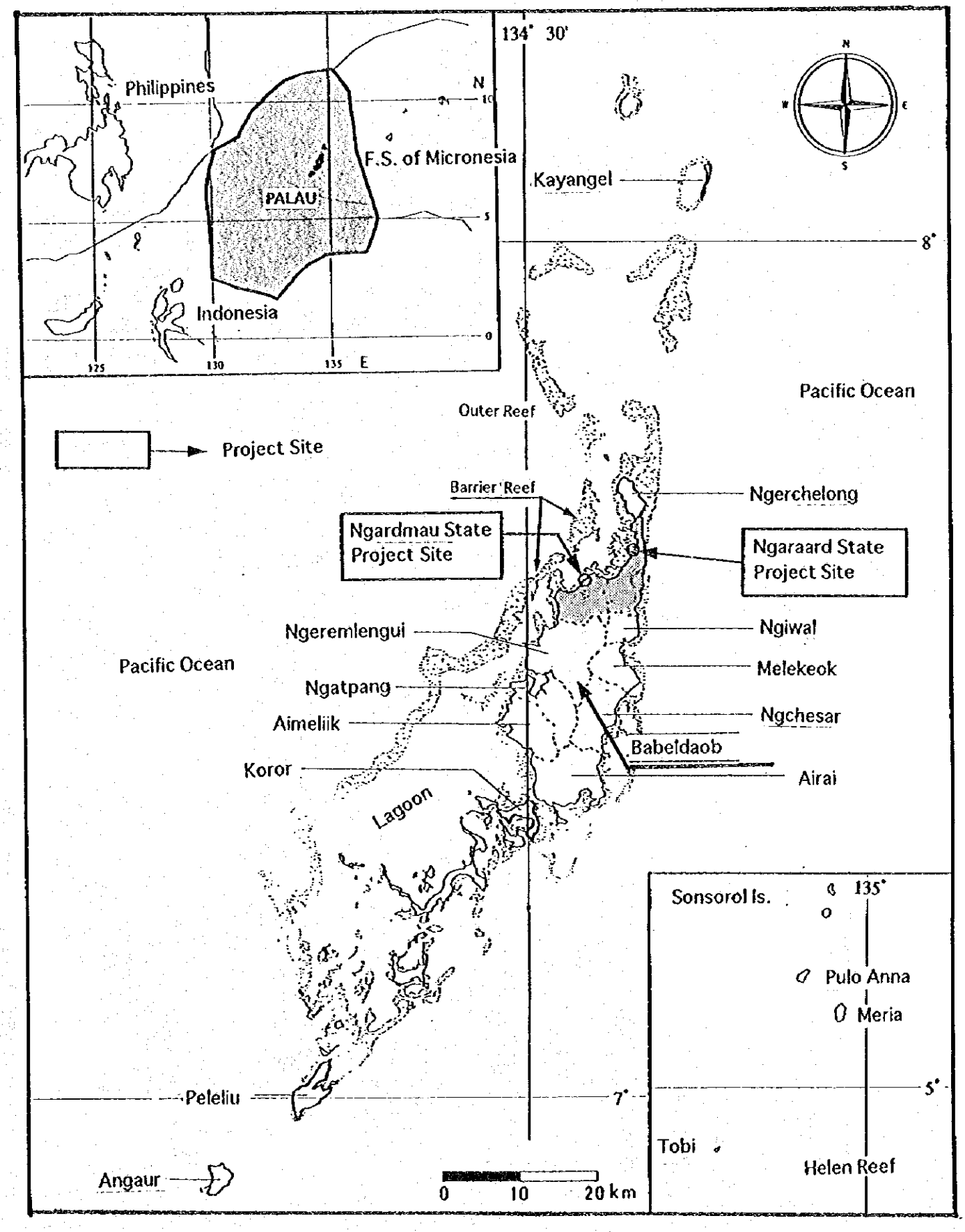
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Nobuo Itoi
Project manager,
Basic design study team on
Project for Improvement of Facilities
for fishing villages in Northern Stste
Overseas Agro-Fishries Consultants Co., Ltd.

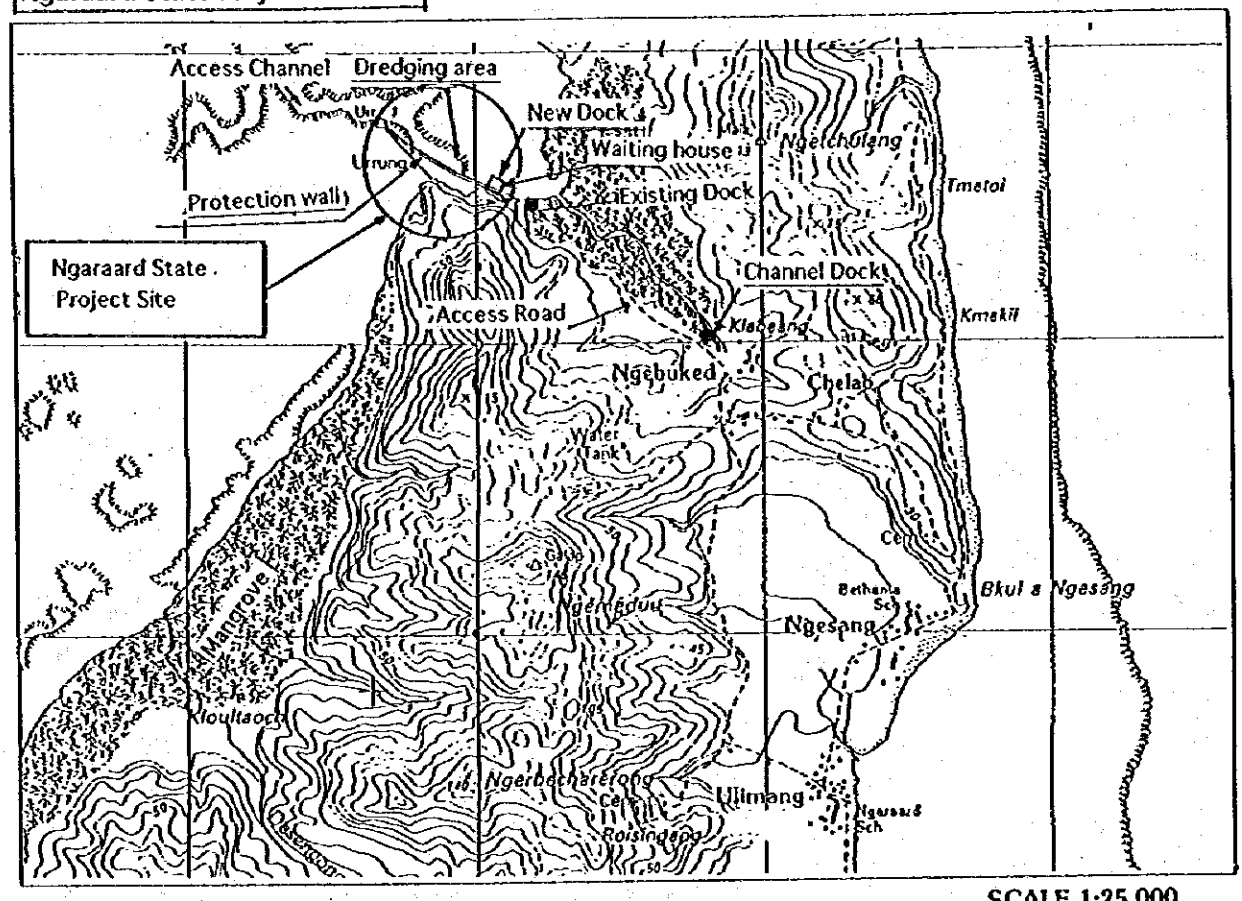
# THE REPUBLIC OF PALAU

## (1) LOCATION MAP



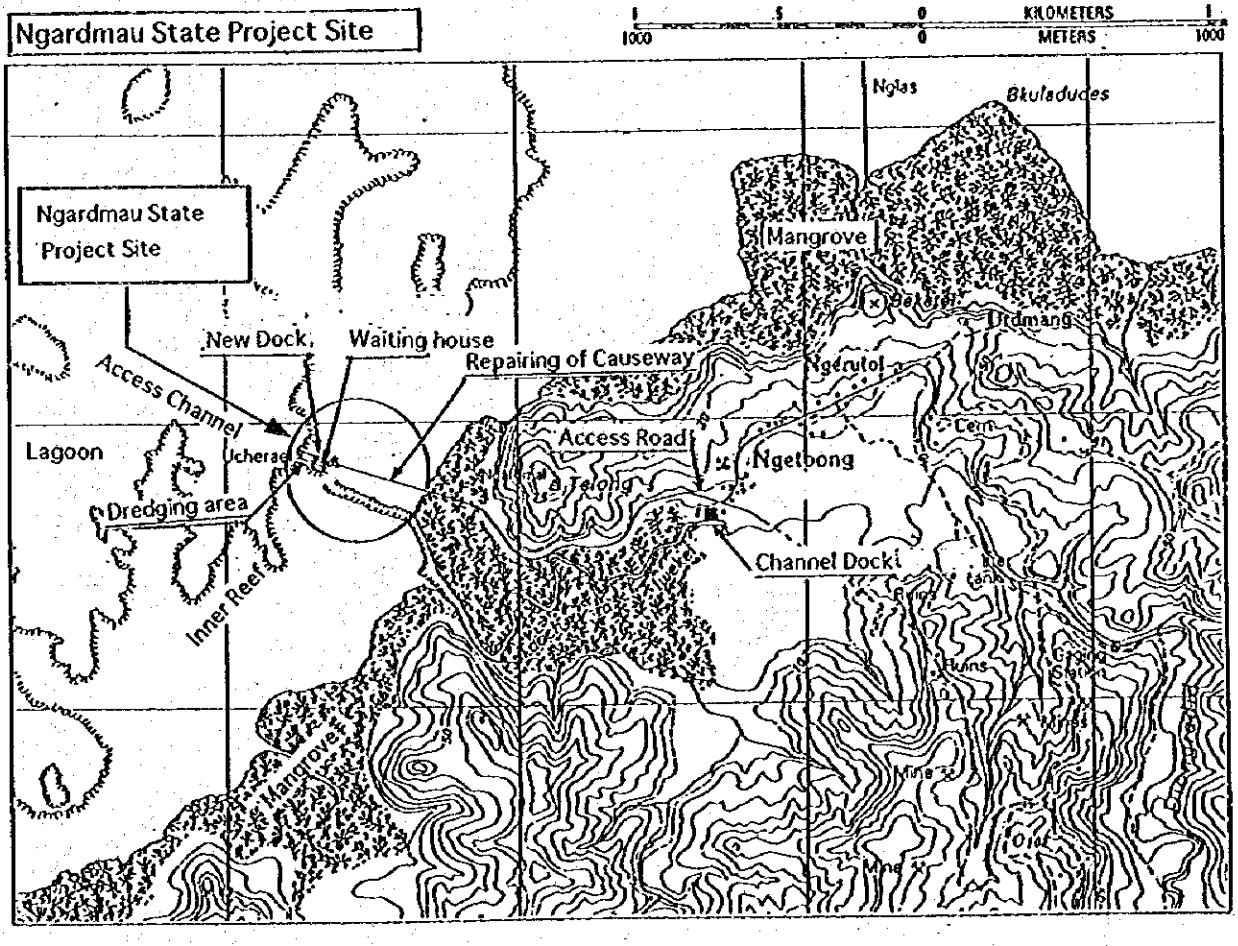
## (2) SITE LOCATION MAP

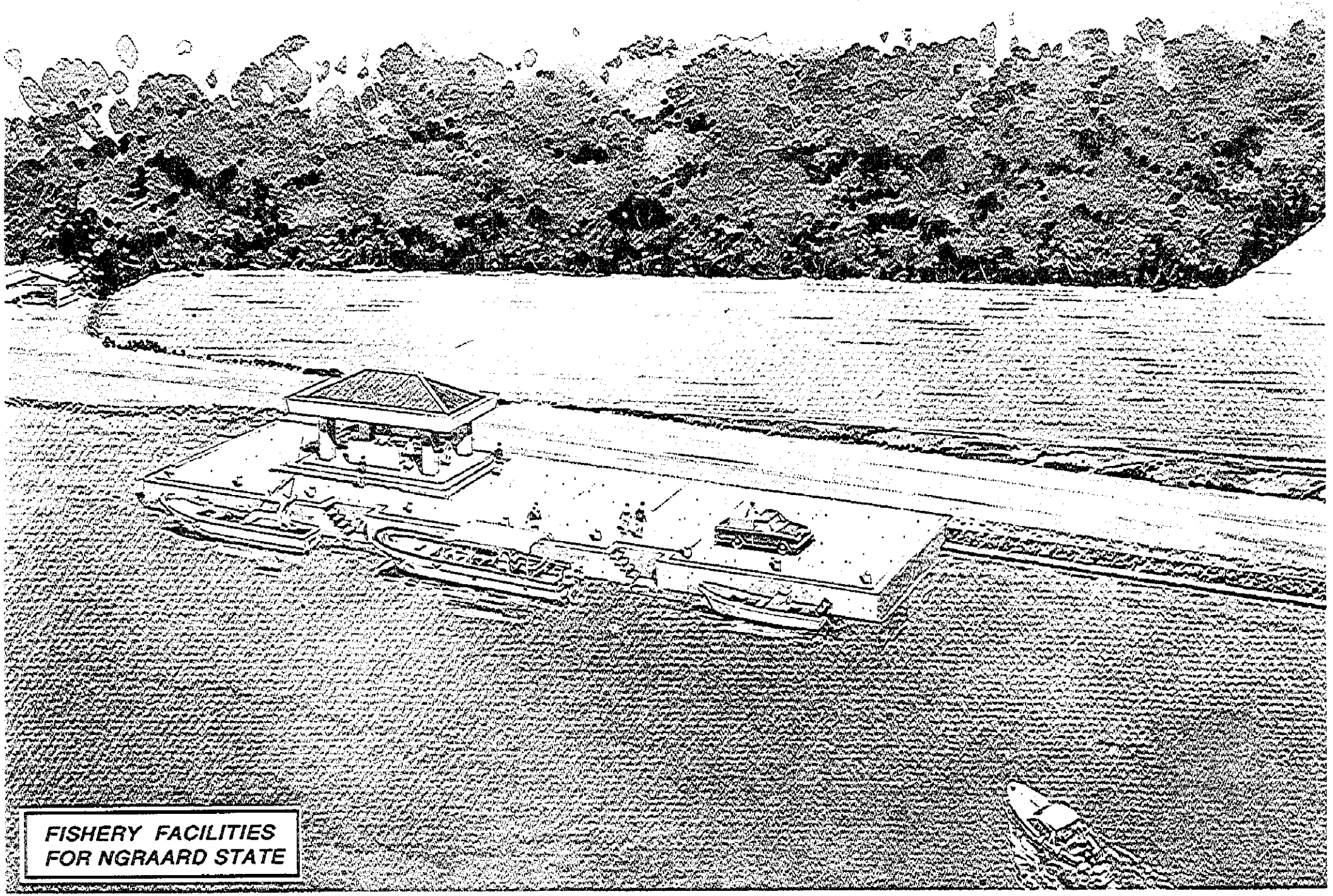
Ngaraard State Project Site

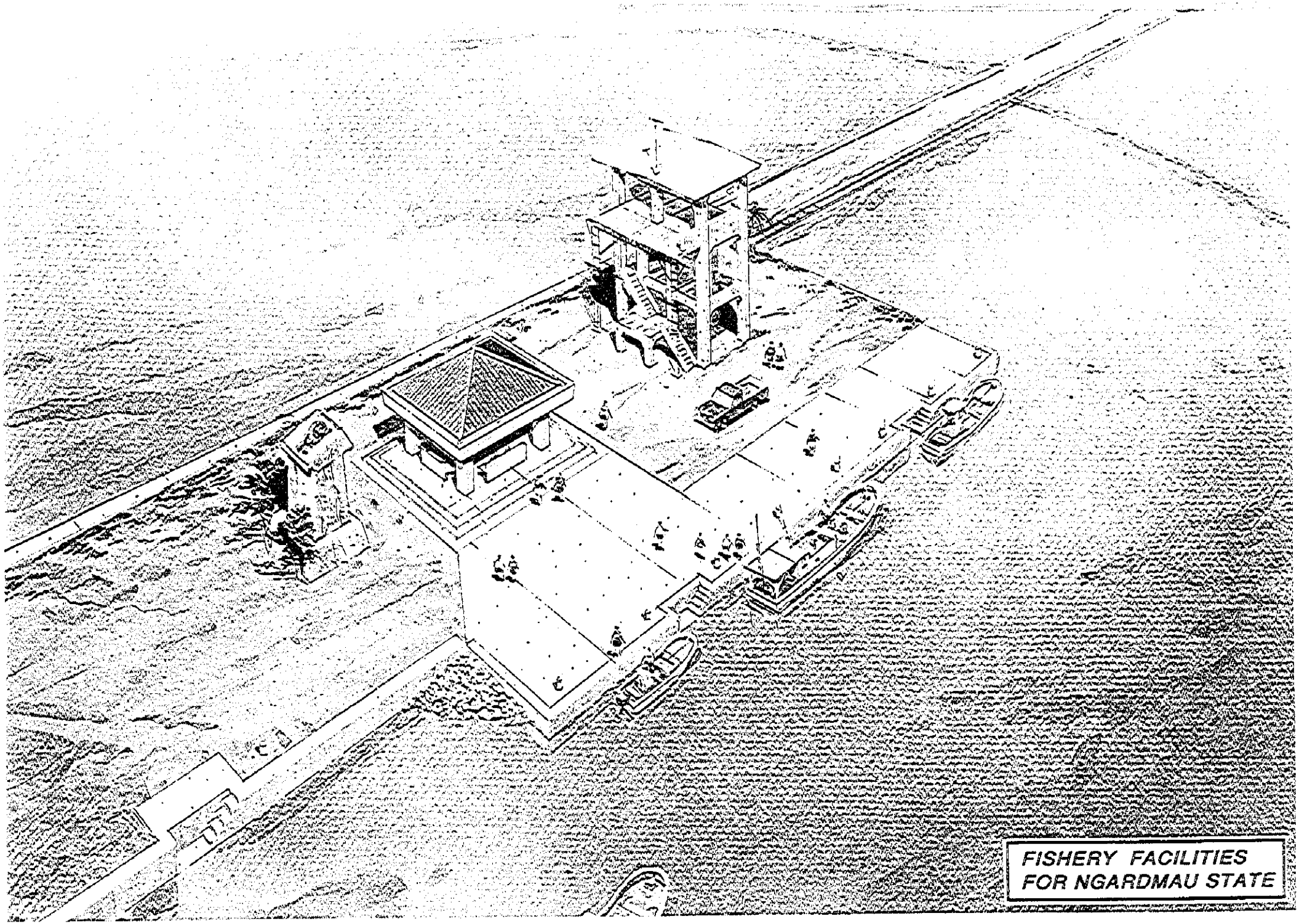



SCALE 1:25 000

Ngardmau State Project Site




FISHERY FACILITIES
FOR NGRAARD STATE


FISHERY FACILITIES
FOR NGARDMAU STATE

# Abbreviation

| Abbreviation | Full name |
|---|---|
| [Common terms]<br>CFA | Compact of Free Association |
| DCA | Division of Cultural Affairs, Ministry of Community and Cultural Affairs |
| DMR | Division of Marine Resources |
| EEZ | Exclusive Economic Zone |
| EIA | Environmental Impact Assessment |
| EQPB | Environmental Quality Protection Board |
| ESCAP/POC | Economic and Social Commission for Asia and the Pacific<br>Pacific Operation Center |
| IBC | International Bridge Corporation |
| MRD | Ministry of Resources and Development |
| NOAA | National Oceanic and Atmospheric Administration U.S.A |
| PFFA | Palau Federation of Fishing Associations |
| PNCC | Palau National Communication Corporation |
| UBC | Uniform Building Code |
| UHCLC | University of Hawaii Sea Level Center |
| [Construction-related terms]<br>CDL | Chart Datum Level |
| HHWL | Highest High Water Level |
| HWL | High Water Level |
| LLWL | Lowest Low Water Level |
| LWL | Low Water Level |
| RC | Reinforced Concrete |

## CONTENTS

# CHAPTER 1 PROJECT BACKGROUND

The Republic of Palau is a small archipelago country situated at the western edge of the Caroline Islands. In October 1994 Palau gained independence as a free association with the United States of America. It is the world's last trust territory of the United Nations.

In the short term, however, Palau's economy depends upon foreign aid from the U.S.A. and other nations. Financial aid based on the Compact of Free Association with the U.S.A. accounts for approximately 80% of foreign revenues and the national budget (FY 1996). For this reason the ROP Government has finalized the Palau National Master Development Plan, which extends over five 5-year development periods and terminates in FY 2020. Its two main policies are promotion of tourism and controlled exploitation of marine resources. Now underway, the project focuses on developing the economy, industries and infrastructures.

The objectives of the first term economic development project are economic self-reliance, fostering of manpower resources, development of natural resource potential, and sustainable local growth. The goal is economic independence within the next 13 years, during which time the Compact funds may be used.

Palau's tourism and fishery industries are vital to earning foreign exchange. Tourist-related earnings comprise 24% of the GDP. The number of foreign visitors to Palau has rapidly increased (from 5,057 in 1981 to 53,229 in 1995), and the tourism industry is viewed as the key to economic independence. Offshore fishery also enhances foreign exchange earnings by issuing licenses to foreign fishing boats and by using Palau as a transit port of fresh tuna for the Japanese market, in a joint venture with foreign enterprises. Few people of Palau participate in offshore fishing, however.

Small scale fishery has steadily progressed from fishing for private consumption to commercial fishing. The development of fisheries and increase in production have reduced resources mostly around the capital Koror. The situation endangers local residents' food supply so long as there is an increased demand for food from reef resources. Therefore the Government of Palau has a plan to develop an outer reef deep water fishery in the northern states where future development is anticipated; to ensure equilibrium between fishery progress and managed use of resources, and to aim at balanced development among the states.

Japan has provided grant aid to develop the sectors in question as follows:

| | | |
|---|---|---|
| 1981. | Small scale fisheries promotion | (11 small ice making plants, small boats and fishing gear). |
| 1987-89. | Fishing community development project; Terms I, II, III | (construction of fishing port facilities at 4 sites). |
| 1992. | Small scale fisheries prevalence project | (fishing techniques training boat for marine resource department). |
| 1993. | Local fishing community development project | (fishery support facility, transport boats, etc. for Peleliu state). |
| 1994. | Marine products distribution improvement project | (Process and sales facilities for Koror; ice making plants, etc. for Ngaremlengui). |
| 1995. | Small scale fisheries development in northern area | (incl. fishery support facility for Kayangel; fishing boats, gear, etc. for 4 northern states). |

Labor conditions for fisherman nevertheless remain hard, because many ports and wharves are outmoded. Development of docking facilities, boat access channel, sea wall, etc. for the fishing community is vital to safe, efficient small scale fisheries and to the large fishing boats needed in the outer reef deep water fishery.

These facilities are also important in energizing local industries, since they are used by fishing village residents as major access points for marine and material transport.

In view of the above situation, the Government of the Republic of Palau requested of Japan grant aid for the development of fishing community facilities, to promote small scale fisheries and other local industries and to improve local living conditions.

This request led to the Government of Japan's decision to conduct a basic design study. Japan International Cooperation Agency sent a basic design study team to research the area from Nov. 3 to Nov. 27, 1996.

The project, based on the first term economic development project, follows the basic policy of small scale fisheries development previously implemented through Japanese grant aid. In particular it is seen as a multiplex infrastructure development for fishing communities of Ngaraard and Ngardmau states in the northern area where infrastructures are underdeveloped. The improvement of fishing community facilities with docking functions contributes to the Small Scale Fisheries Promotion Project for the Northern Area itemized in the FY 1995 Japanese grant aid; and it is consistent with the aims of the Palau Fisheries Development

Project.

The request contents are as follows.

(1) Facilities

1) Ngaraard: Docking facilities, shoreline protection wall, access road improvement, boat access channel dredging and waiting house.

2) Ngardmau: Docking facilities, access road improvements, boat access channel dredging and waiting house.

(2) Equipment (Ngaraard and Ngardmau states)

Loading and unloading equipment (crane truck); one for each state.

# CHAPTER 2 PROJECT CONTENTS

## 2-1 Project objectives

Palau has a wealth of fishing legends which indicate an ancient, deep-rooted relationship between islanders and ocean. The ocean plays an important role not only as a source of food but also as a domestic traffic route. Many islanders still see the ocean more for its benefits as a marine resource in the territorial water and as a tourist resource than as a natural scenic environment. Docking facilities, access roads, causeway, etc. have long been considered indispensable links between ocean and villages.

The Government of Palau enacted a small scale fishery ordinance effective October 1994 concerning fishing restrictions in the reef and surrounding area. At the same time it began developing an offshore reef fishery in the northern states where future development is anticipated. Nevertheless the situation is discouraging for the following reasons: many wharves are small, outmoded and deteriorating; the water is shallow in the fishing boat dock and in the channel linking the wharf to the fishing ground; and the tide exceeds 2 m. Problems in the project areas of Ngaraard and Ngardmau are listed below.

Ngaraard state

(1) Boat use is limited by tidal range, since the existing simple wharf and channel are narrow ( about 10 m), and water is shallow (CDL-0.2~±0m). Moreover, passenger boarding and disembarking; and handling of fish, agricultural products, general materials, etc. cannot be conducted in a safe, efficient manner. There are no hospitals, and sick or injured people requiring urgent medical treatment must be transferred to the capital Koror; a difficult procedure under the present circumstances.

(2) There is no cargo handling facility and cargo handling is now done manually, which is inconvenient and dangerous, particularly for heavy freight, e.g. fish boxes with ice, drum cans and construction materials.

(3) The existing wharf built by local residents is not structurally strong enough (and already partially deteriorating), and does not ensure safety of users and cargo.

Ngardmau state

(1) Due to the shallow water of the existing wharf and channel upstream of the estuary (CDL -0.3 ~-0.5m), outboard motorboats and other small boats can go in and out only 4-6 hours per day, depending on the tide level. This presents difficulties for fishery and material transport.

(2) The state government has repaired part of the current wharf at the project site, but the water depth at its front is 20-30 cm. at low tide, making it hard even for small outboard motorboats to align with the berth.

(3) Since the wharf ground is not flat and there are no cargo handling facilities, conditions are hazardous for freight handling of ice-packed fish boxes (150-200 kg.), drum cans (200 kg.), construction materials, outboard motors, and small boats (400-600 kg.); and also for boarding and alighting of tourists (especially children and old people).

The development of fishing village facilities is urgently needed to promote safe, efficient small scale fishery with existing small fishing boats, and to introduce and efficiently manage the large fishing boats needed in offshore reef fishery.

The facilities requested are used not only by people engaged in fishery, but also by local residents as major access stations of marine and physical transport for fishery and agricultural products, food, daily commodities, construction materials and equipment, fuel, etc. They are used daily by tourists and government workers from the Metropolitan area and by visitors from other states. It is imperative that the facilities be developed and improved.

The project is consistent with the goal of the Palau Fisheries Development Project. In particular, better facilities to improve fishing port functions in both Ngaraad and Ngardmau northern states will enhance the Small Scale Fisheries Development Project in the Northern States itemized in the 1995 grant aid request to Japan. The project will also facilitate effective management of production materials and equipment ( fishing boats, gear, etc.) granted by the previous project, thereby raising the entire standard of small scale fishery in the area.

As a result of research, discussion and also input from government workers, state governors, fishermen and local residents, the project's three objectives are summarized as follows.

1) Small scale offshore fishery development in Palau's northern area, where infrastructure is underdeveloped.

2) Traffic and transport facility improvements in Palau for safer, more amenable living conditions.

3) Promotion of fishery and agriculture in the northern area, and local development targeting the tourism industry as the key to future growth.

The project is intended for the northern area. Its goals are to maintain reef resources by developing wharf and other related facilities with fishing port and distribution functions in the two states; to enlarge the supply of fishery products for Koror by facilitating offshore fishery in the unused area around the reef; and to improve the following functions while promoting Palau's small scale fishery.

- Small scale fishery-related functions

  Fishery : Mooring, anchoring, repairing, fishing preparation, and fish catch unloading.

  Distribution of fishery products : Mutual access from fishing village to fishing ground, and from fishing village to fish market.

- Infrastructures

  : Connection of marine and land routes, transit base, cargo handling and transport.

  : Convenience, safety and communication for local community and residents.

  : Resting, waiting, refuge, and storage of commodities for distribution.

## 2-2 Basic concept of the project

### 2-2-1 Suitability and necessity of the project

Palau's fishery is of two basic types: small scale fishery by the people of Palau in the coastal area; and large scale fishery with foreign boats in Palau's EEZ of 200 nautical miles.

Large scale fishery should be developed by issuing foreign fishing agreements or by inviting joint ventures, since at the present time it is not feasible to own domestic vessels and foster fishermen for this purpose. In the future offshore fishery will

develop by gradually giving to the people of Palau opportunities to participate, with the ultimate aim of using domestic fishing vessels.

Since about 1980 the Government of Palau has taken the initiative in small scale fisheries by introducing and spreading modern fishing methods and by promoting commercial fishery for the sale of fish. Since 1990, however, reef resources have been in decline due to the expanding economy and fish catch. Therefore the Government has begun to develop medium scale fishery mostly in the offshore reef area in the North.

The wharves in project sites Ngaraard and Ngardmau are small, outmoded and deteriorating. Research and examination have confirmed that small scale fishery, offshore reef fishery, and local industries are unlikely to be activated there in the future.

The water is shallow in the existing wharves and channels of the two states. There is insufficient cargo handling space and equipment. The shoreline protection wall along the channel (Ngaraard) and the causeway (Ngardmau) that includes part of the access road are both deteriorating. These conditions inhibit safe, efficient fishing and transport of man and materials. The project aims to solve these problems and improve working conditions for fishermen as well as infrastructures for local residents by the construction of a wharf with docking functions, channel dredging, causeway construction works, and by causeway restoration.

Table 2-1 Scale and utilization conditions of project facilities.

| | Present | Post -project |
|---|---|---|
| Ngaraard state | Population: 421 (5 villages, 91 households, and 88 female high school students)<br>Full time fishermen : 16 ( Note 1) | |
| | Hours that subject boats can arrive and depart, dock, and load and unload.<br>4~6 hours/day | Hours that subject boats can arrive and depart, dock, and load and unload.<br>24 hours/day |
| | [1] No. of boats used (25~30/day)<br>Subject boats of Ngaraard as home port<br>- Local fishing boats:<br>L =7.2m x B= 1.8m x D=0.7m x 23 boats<br>- Multi-purpose transport boat :<br>L = 11.2m x B = 3.0m x D = 1.8m x 1 boat | [1] No. of boats used (35~50/day)<br>Subject boats of Ngaraard as home port<br>- Local fishing boats:<br>L =7.2m x B= 1.8m x D=0.7m x 23 boats<br>- Multi-purpose transport boat :<br>L = 11.2m x B = 3.0m x D = 1.8m x 1 boat<br>- Mid size fishing boat:<br>L= 10.8m x B = 2.8m x D = 1.6m x 1 boat |
| | Visitor boats<br>- Boat owned by school:<br>L = 13.5m x B = 3.6m x D =0.9m x 1 boat<br>- Tourist boat: L = 11.0m (few others/day)<br>- Berge: L = 13.0m (Once/2 months) | Visitor boats<br>- Boat owned by school:<br>L = 13.5m x B = 3.6m x D =0.9m x 1 boat<br>- Tourist boat:<br>L = 11.0m (few others/day)<br>- Berge: L = 13.0m (Once/2 months) |
| | [2] Major transport and quantity<br>- Fish 135kg/day<br>- Agricultural products 4,400kg/week<br>- Daily commodities, fuel, etc. $218,400/year | [2] Major transport and quantity<br>- Fish 150kg/day<br>- Agricultural products 5,000kg/week<br>- Daily commodities, fuel, etc. $250,000/year |
| | [3] Users<br>- Local residents 60 people/week<br>- Visitors, travelers, tourists 30 people/week | [3] Users<br>- Local residents 70 people/week<br>- Visitors, travelers, tourists 40 people/week |

| | Present | Post -project |
|---|---|---|
| Ngardmau state | Population: 162 (3 villages, 40 households)<br>Full time fishermen : 19( Note 2) | |
| | Hours that subject boats can arrive and depart, dock, and load and unload.<br>4~6 hours/day | Hours that subject boats can arrive and depart, dock, and load and unload.<br>24 hours/day |
| | [1] No. of boats used (25~30/day)<br>Subject boats of Ngardmau as home port. | [1] No. of boats used (35~50/day)<br>Subject boats of Ngardmau as home port. |
| | - Local fishing boats:<br>L =7.2m x B= 1.8m x D=0.7m x 10 boats<br>Visitor boats<br>- Tourist boat: L = 11.0m (5~10 others/day)<br>- Berge: L = 13.0m (Once/2 months) | - Local fishing boats:<br>L =7.2m x B= 1.8m x D=0.7m x 12 boats<br>- Mid size fishing boat:<br>L= 10.8m x B = 2.8m x D = 1.6m x 1 boat<br>Visitor boats<br>- Tourist boat: L = 11.0m (5~10 others/day)<br>- Berge: L = 13.0m (Once/2 months) |

| | | |
|---|---|---|
| | [2] Major transport and quantity<br>- Fish 454kg/week<br>- Agricultural products 454kg/week<br>- Daily commodities, fuel, etc. 230kg/week | [2] Major transport and quantity<br>- Fish 500kg/week<br>- Agricultural products 900kg/week<br>- Daily commodities, fuel, etc. 680/week |
| | [3] Users<br>- Local residents 100 people/week<br>- Travelers, tourists 50 people/week<br>- Visitors (research, observation, etc.) 20 people/week | [3] Users<br>- Local residents 200 people/week<br>- Travelers, tourists 100 people/week<br>- Visitors (research, observation, etc.) 40 people/week |

Source : Census 1995, Data of State Government, and Statistics of the Division of Marine Resources.

Note 1, 2 : No. of fishermen who sold fish at the two major shops. The actual number of people engaged in fishing is approximately triple that figure.

Project facilities are grouped into 6 categories by function, and are all essential to solving the above-mentioned problems. Since the functions are interrelated, goals may be met by properly developing each facility.

A crane truck was considered most appropriate for simple cargo handling equipment for its cargo handling capacity, mobility, durability, and easy maintenance and management.

The project provides a variety of docking-related equipment and facilities in Ngaraard and Ngardmau states, where offshore reef fishery development is underway. The aims are: to alleviate problems when fishing and other boats enter and leave port and when people embark and disembark; and to ensure safety when cargo is handled and transported. The functions of these project facilities are listed below.

Table 2-2 Functions of project facilities

| Functions | Facilities/Equipment |
|---|---|
| 1. Docking, mooring, anchoring, holding, and refuge for subject boats using facilities. Connection of sea and land routes. Transit base for material transport. | Wharf (both states) |
| 2. Access between wharf and fishing ground for fishing boats. Safe entry into, and departure from, port. Mutual access between wharf and market for subject boats using facilities. | Access road improvements<br>Channel dredging (Both states) |
| 3. Water depth maintenance of channels Maintenance and protection of causeway | Access road improvements<br>Shoreline protection wall (Ngaraard) |
| 4. Distribution and transportation of products, daily commodities, people and tourists, between fishing village and wharf. | Causeway restoration (Ngardmau ) |
| 5. Resting, waiting, refuge, communication for users, and temporary storage of products and materials. | Waiting house (Ngardmau ) |
| 6. Fishing preparation for fishing boats, landing of fish catch, maintenance of small boats and outboard motor, and safe, efficient handling of heavy cargo. | Simple cargo handling equipment<br>(both states) |

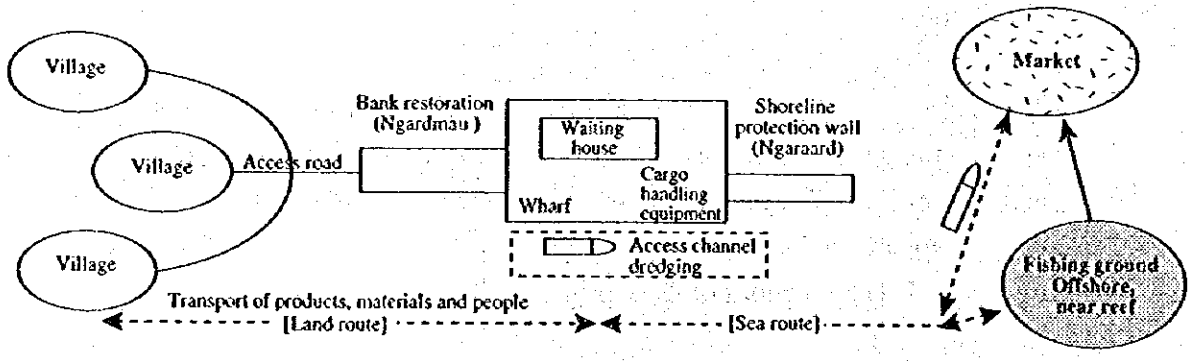



Figure 2-1 Project facility structure

The project seeks to promote small scale fishery and offshore reef fishery in the northern marine area, and to improve docking facilities and cargo handling equipment, which are presently inadequate and an obstacle to local industries.

2-2-2 Examination of project components

After research and consultation, it was concluded that the facilities and equipment listed below will most effectively achieve project goals. After consulting with Palau's government officials, a decision was made to omit from the project access road

restoration, since that was done, and in the future would be undertaken, by the respective governments. It was agreed to improve Ngaraard's shoreline protection wall and to restore its embankments, which are part of the access roads and in such need of repair that Palau would have difficulty restoring them alone.

Table 2-3 Fishery facilities of Ngaraard

| Classification | Facilities | Scale and specification outline |
|---|---|---|
| Facilities of civil works | Wharf | 40 m length x 9 m depth<br>Steel sheet-pile tie rod system |
| | Shoreline protection wall | 350 m length<br>3 stage gabion<br>causeway embankment(approx. 420 m long x 8 m wide) |
| | Channel dredging | Dredging area: about 6,650 $m^2$<br>Average dredging depth : 1 m<br>Water depth : LWL-2.0 m<br>Width : 20 m |
| Structure | Waiting house | RC one-story<br>Floor area 29 $m^2$ |

Table 2-4 Fishery facilities of Ngardmau

| Classification | Facilities | Scale and specification outline |
|---|---|---|
| Facilities of civil works | Wharf | 38 m l x 6 m d<br>Steel sheet-pile tie rod system |
| | Causeway restoration | 13 restoration sections<br>Restoration to original condition<br>Turnout (10 m long x 3 m wide) |
| | Channel dredging | Dredging area: approx. 2,900 $m^2$<br>Average dredging depth : approx. 1.2 m<br>Water depth : LWL-2.0 m<br>Width : 20 m |
| Structure | Waiting house | RC one-story<br>Floor area 29 $m^2$ |

Table 2-5 Simple cargo handling equipment ( both states)

| Classification | Content | Specifications |
|---|---|---|
| Cargo handling equipment | Crane truck | Maximum lifting capacity : 2 tons<br>Boom length : 2.4~4.3 m<br>Full length : Approx. 6,000 mm<br>Diesel engine power : 75~85 hp<br>Max. carrying capacity : 2 tons x 2 trucks |

2-2-3 Examination of contents and scale of facilities and equipment

(1) Docking facility

1) Berth

The scale of the maneuvering basin facility was set to ensure sufficient water for mooring and berth, taking into account docking situations such as lies alongside or lies astern, and fishing boats' movements such as turning.

1)-1 [Ngaraard site]

① Project site

The project site was shifted about 50 m. closer to the sea to avoid overlapping with a compact road being planned on north of the present access road.

At the Ngaraard site some small fishing boats can also moor in the partially deteriorated old dock behind the newly built dock. But the new facility must have mooring and waiting areas, since mid-size boats will be unable to enter inward from the new dock when the compact road is completed.

② Seawall length

Seawall length should be set to ensure enough space (length) for berth (landing, fishing preparation, cargo handling, boarding, waiting and resting), and maneuvering (docking and turning). Margin length is calculated for rope mooring (lies alongside), but not for anchoring (lies astern).

③ Apron

A waiting house should be built on the dock. There should also be adequate space for cargo handling, temporary area for freight, materials, etc. considering the use of crane trucks.

The sea wall front line is located at the edge of new channel slope bottom, 9 m. far from the shoulder of access road embankment, with regard for existing channel and access road positions to minimize channel excavation. This ensures space to build a waiting house to keep the distance (5 m.) from the rear of the wharf. However, the width of the apron at the front of the waiting house is then about 2.5 m.; less than half of the design specification of 6 m.

Space required for cargo handling, freight storage, and working should be provided based on the land area for the waiting house (4.4 m. x 6.6 m.).

④ Maneuvering basin depth

The maneuvering basin should be wide enough and deep enough for boats to enter and leave the pier. But due to dredging restrictions the channel width is set at 20 m.

1)-2 Ngardmau site

① Project site

In the extended project dock area there is a state-government restored RC dock (water depth CDL -0.4m, Length =36m) which can accommodate 5 small fishing boats. The new wharf must be long enough to simultaneously accommodate mid-size fishing boats, regular sightseeing ferries, and tourist and berge boats. In coordination with the old dock, the total length is set at 38.8 m.

② Dock length and apron

The dock is aligned with the existing sea wall on the old dock's south side. The structural specifications of the concrete sea wall built earlier are unknown. The water depth in front of seawall is shallow CDL-0.4 m. If the front line of the project dock is built to align with the existing sea wall, and the front base is dredged to the required depth of CDL-2.0 m, the

existing sea wall foundation has risks to damage and collapse, which means that the concrete sea wall could slide and collapse. Therefore the project wharf's front line is shifted from the existing wall's front line to about 6 m. front-ward. Thereby the sea wall is stabilized. The distance from the project front line to the existing structures behind the wharf is lengthened (6 m. + 8 m. = 14 m.), and the apron width between the waiting house and the dock is set at approx. 10 m. This ensures space for light trucks to be turned.

Behind the project site is a former dock area (present site) of approx. 2,160 $m^2$ (24m x 90m) for bauxite loading. This existing site should be used for the waiting house and also construction yard. The project quaywall is built about 6 m. offshore (southward) from the existing dock for reasons given below;

i) The existing dock (leaning and partially collapsed) in the project site should be buried by land fill, since removing or restoring it consumes too much time and cost.

ii) The boat access channel and navigation area should be dredged to CDL-2.0 to keep 6 m of distance from the existing dock; otherwise the channel side (entry side) of the existing dock could fall toward the shore side.

iii) There must be ample space for cargo handling, boarding and materials, temporary storage of goods, etc.

③ Maneuvering basin width

Maneuvering basin refers to a water area of sufficient depth for boats to turn around when they align with the wharf and when they leave it. The maneuvering basin width required for turning is 3L (L = boat length) = 3 x 11m ≒ 30 m.

2) Sea wall crown height and water depth

The sea wall crown height is determined by natural conditions (tide level, design waves, and sea level rise), the subject vessel's freeboard and design rule. The water depth in front of sea wall is moderately set with a margin, because in time sediment will naturally occur (50 cm/20 years max.).

Sea wall length (Ngaraard/40.0 m., Ngardmau /38.0 m.)

Sea wall crown height (HWL= CDL + 1.8 m.)

① HWL +0.6 m. = 2.4 m. Rule / p136

② HWL + H 1/ 3 x 1 / 2 = 1.8 +0.5 m. = 2.3 m.

③ HWL + ( sea level rise by typhoon) = 1.8 + 0.5 m. = 2.3 m.

(CDL+2.5 m. for both sites, including margin)

Front depth : water level of subject fishing boat stern + margin 0.5 m. = 1.2 + 0.5 = 1.7 m. (Rule)

(CDL-2.0 m. for both sites, including margin)

(2) Boat access channel dredging [both states]

1) Calmness in channel and berth

Table 2-6 Rate of frequency for wind velocity and wave height

| Measured value | | Ngaraard | Ngardmau | Estimated value | |
|---|---|---|---|---|---|
| Wind direction | | N,NE,NW | S,SW,W | Wave direction | |
| Wind velocity (m/sec) | less 5 m. | 76.3% | 77.3% | less 30 cm. | Wave height tt 1/3 (m) |
| | 5.1-10 | 23.0% | 20.8% | 30-60 cm | |
| | over 10.1 | 0.7% | 1.9% | over 60 cm | |

(Note) Wave height estimated by SMB method.

Wind velocity and direction obtained over 1095 day period ( Jan. 1993 - Dec. 31, 1995).

Table 2-6 summarizes the frequency rates of calmness at each site's channel and berth. The Table shows that waves over 60 cm. high (meaning small fishing boats have difficulty docking) occurs on 3 days of the year in Ngaraard and on 7 days of the year in Ngardmau . One may conclude that in general both sites are good as fishing ports.

2) Extension, width, and water depth of channel dock

The length of access channel is determined to 420 m. from the end of the existing road. The 50 m. section beyond wharf is a maneuvering margin area for mid-size fishing boats and for reducing mud sedimentation.

The channel dredging width is not selected the 3L required for boats' turning around, but the minimum width (bottom) of 2L ≒ 20m for navigation of one

mid-size fishing boat (L = 10.8m). Channel depth is CDL-2.0 m., the same as for the sea wall front.

[Ngardmau ]

The access channel is extended to a total of approx. 110 m. from the port mouth (where there is a sharp increase in water depth) extending 20 m. beyond the project wharf. The front area and inner project dock has a set width of 3L ≒ 30 m. and will serve to facilitate docking and prevent mud sedimentation.

Like Ngaraard, the bottom width of the channel entrance is 2L = 20m. The channel and dock water depth is set at CDL-2.0 , the same as for the sea wall front.

(3) Shoreline protection wall

[Shoreline protection wall of Ngaraard]

If the channel depth is set by CDL (Chart Datum Level) -2.0m.), the interval should be more than 2.5 m. wide between the channel's west side slope and the shoreline protection wall (gabion structure).

However, the Environmental Quality Protection Bureau (EQPB) permits the state government to dredge a channel area width of 100 feet (approx. 30m) from the existing dock. Therefore the channel cannot be extended to the other side of the bank (Even if it were possible, the construction cost would be high, since the shallow coral reef area would have to be dredged).

Dump trucks carrying dredge earth will frequently come and go on the present access road. The amount of fill and roadbed material is estimated at 800,000 $m^3$ for a total extension of 80 km. by 10 m. (width) x 1m (thickness)/extension 1 m. = 10 $m^3$/m. If one fourth is supplied from the project site, the amount of dredged earth is 200,000 m.3/3 years ≒ 183 $m^3$/day. Therefore the number of truck trip is estimated at 36 per day, with a peak of 54 per day (1.5 times the average).

Without a sufficiently wide access road (2 car lane width: 2 x 3.0 m. =6 m.) and road shoulders of at least 1 m., the simple channel revetment by the access road could collapse and the road fill run off into the channel, reducing its water depth. The road shoulders and the edge of access channel dredging should mostly be 7 m.

apart. The channel side of the road fill should be reinforced by the shoreline protection wall to prevent sliding damage by heavy machinery traffic.

The access road should be simply paved, since, as said earlier, heavy construction vehicle traffic is expected for some time.

: Extension : 420 m. x 8 m. (Both road shoulders 2 x 1.0 m. = 2 m.)

: Pavement : 20 cm. coral sand/gravel

(Thickness) 10 cm. crushed stone

Finished height : CDL+2.5 m. of present height

Shoreline protection wall is constructed on channel side only.

: Extension of shoreline protection wall
(420 m.- (sea wall portion) 50 m.- (front portion) 20 m.=350 m.

: Revetment of front portion
(20 m.+10 m.+10 m.)=40 m.

In Ngaraard, the entire stone covered slope on the present access road's channel side has collapsed as follows, which were kept in mind when designing the new protection wall.

1) Structure

- The former protection wall is presumed to be a low (1 m.), vertical, stone-fill structure.
- There is no material to prevent wash-out of (e.g. filter sheet) the coral sand/gravel inner filling through the covering stone.

2) Causes of collapse

- Falling of dry stone fill (too small stones) by wave action in strong winds.
- Wash-out of sand fill by ordinary wave (and wake wave) action.
- Aggravation of falling dry stone fill
- Aggravation of sand fill accretion.

3) Countermeasures

- Use larger stones (50kg/stone → 100kg or more/stone) = higher

construction cost.

- Use covering stone connected by cement mortar (or stones of present size or smaller are placed in wire cage).

- Apply filter sheet on back of protection wall to prevent inner sand fill accretion.

If the shoreline protection wall is constructed at the edge of the existing causeway, it prevents even ordinary vehicles from going through, because the road section behind this causeway is a narrow 2.7 m. The road behind the wall must therefore be widened. There must also be enough road shoulder space between the protection wall and the road to protect the wall from damage by large dump trucks or heavy construction machinery traffic.

In light of the above conditions, the road's width is determined as: Road width (6 m.)+Both side shoulders (1 m. x 2 = 2 m.) = 8 m.

[Restoration of causeway to original state in Ngardmau] (see Attachment 5-2-3)

The state road (access road) from the village to the project site (which is the former bauxite loading wharf and far into the sea from the coast line), is linked by a causeway( height CDL+3 m., width 5 m., length approx. 455 m.). Built over 50 years ago, the causeway's stone masonry on both sides is extensively damaged, and parts of the road surface (shoulders) have sunk. Therefore safe passenger and vehicle traffic on the causeway could not be guaranteed in these conditions.

It was also evident that the state governments, lacking sufficient funds and technological expertise, could not undertake restoration alone.

About 450 m. of the causeway in Ngardmau is used as an access road to the front dock, but its width is only 5 m. (effective width is 3.5 m. after subtraction of shoulder widths: 2 x 0.75 m. = 1.5 m.). Accordingly one or two turnouts were proposed, and it was decided that one turnout was enough for the site, even considering future traffic.

- Turnout 1 x (10/16 m.) x 3 (width)

- The pavement is partially damaged by the collapse of each stone masonry wall on the access road. The damaged areas should be restored to their original

condition.

- Maintenance of damaged pavement parts (inc. shoulders): identical material/bauxite + coral gravel
- Final height of top surface = CDL + 3 m. (preserve present height)

As shown in Attachment 5-2-3, the stone masonry walls on each side of the access road are considerably damaged for reasons cited below;

1) Structure
   - The former structure is estimated as a vertical (gradient 1 : 1/10) dry masonry wall 50 cm. thick (max. 30 kg. stones ). The inner filling material is presumed to be a smaller coral pack (as in the sea wall's north side).
   - Was there any wash-out preventive material (blinding/filter sheet, etc.) between the top surface paving material and gravel filling ?
   - 30 cm. square RC curb block is placed to prevent erosion of the paving material and stone fill.
   - The protection wall foundation (built directly on sea bottom) has no stone fill mound.

2) Causes of collapse

(Phenomena)
- A : Entire collapse
- B : Half collapse( upper part only or lower part only)
- C : Light collapse (some stone erosion of upper, middle part)

   - There is no foundation, and sea bottom sediment has not been removed. The dry masonry has been deformed by sinking.
   - Loose stone fill falls off by strong wave.
   - Repeated fall off increases the extent of damage.
   - The damage does not involve a falling off of the inner stone fill.
   - The road shoulder paving is loose and eroded at the upper collapsed part (B) and the stone fall off part (C)

3) Countermeasures (restoration of damaged parts only)

- Measures to prevent sinking of stone fill bottom (stone filled mound, etc.)
- Measures to prevent fall off when covering stone sinks (front supporting, wet masonry, mortar grouting, etc.).

The length of access road revetment of the 450 m. causeway in need of repair is determined as follows:

- Restoration of damaged parts of each side of causeway (450 m).

North side 144 m./8 parts ⇒ 144+2 m. x 8 parts = 160 m.

South side 146 m./5 parts ⇒ 146+2 m. x 5 parts = 156 m.

Total 316 m. (repaired length)

Besides these repairs, a protection wall must be built on the project site to prevent the inundation of water from the collapsed north/west dock. A temporary yard for heavy machinery should also be built by reclaiming and leveling the area behind the dock.

The protection wall built in the side face behind the project site must have a minimum length of 25 m. + $\alpha$ .

(4) Waiting house

[Waiting house in Ngaraard site]

The scale of the waiting house is determined from research data estimates of the number of project dock users, as follows.

- On an ordinary day there will be 40 passengers and fishermen.
- On a day with users overlapping for various purposes, there will be 75 people.
- In this project, dock use by passengers is estimated at 2 cycles a day and waiting house use at 30 people a day.

This project facility will be used by many small roofless boats that are susceptible to rain. In certain weather conditions, a long retention time can be expected. The facility will also be used for recreation (including lunch) and communication. It is estimated that 35 people will occupy the waiting house at the same time, but since

this is an infrequent occurrence, the waiting house is designed to accommodate 15 people at one time.

[Waiting house in Ngardmau ]

- In the same manner the scale of the waiting house in Ngardmau is determined as follows.
- On an ordinary day there will be 40 passengers and fishermen.
- On a day with multi-purpose users there will be 75 people.
- In this project, passenger dock use is estimated at 2 cycles a day and waiting house use at 30 people. For reasons given before the waiting house is designed to accommodate 15 users.

(5) Other facilities

① Bitt / Mooring Ring

Two ton mooring bitts for mid-size fishing boats are installed at 5 m. intervals on the dock.

Several mooring rings for small boats are installed on dock steps to be built at two locations.

② Fender

Due to the frequency of boats and the present condition of Palau's fishing ports, no fenders will be installed.

③ Light beacon / Marker

A marker is fixed on one side of the access channel at the port mouth to indicate shallow water areas.

④ Access road shoulder indicator

Shoulder indictors prevent heavy machinery from entering into the road shoulders, especially at the Ngaraard site.

(6) Simple cargo handling machine

Any large cargo, such as fuel drum cans (200 kg.), fish refrigerator boxes (200

liters : 100~150 kg.), outboard motors, small FRP boats, agricultural products, private construction materials (timber, pipe, tin roof material, concrete block, gravel, cement) requires onsite cargo handling machinery.

The all-purpose diesel crane truck was selected after considering specifications of crane truck type and crane tonnage capacities, because it can easily load and unload the above-mentioned cargoes, has many public utility functions, and is easy and inexpensive to maintain.

Selected machine type : Diesel engine powered truck.
Capacity : 2 tons
Normal crane capacity : 2 tons

Table 2-7 Outline of facility and machinery scale

| Facility / Equipment | Ngaraard | Ngardmau |
|---|---|---|
| Docking facility | Dock length:<br>L = Required length (m) for boats to moor along dock ( berth length when mooring)<br>= Σ(boat length + margin length(m) )<br>= Σ(L + 0.15L)<br>= local fishing boat + multipurpose boat + school-owned boat<br>= 7 x 1.15 + 11.2 x 1.15 + 13.5 x 1.15<br>= 8.05 + 12.88 + 15.53 = 36.43<br>NB. dock length = 40m with ref. to navigating margin. | Dock length:<br>L = Required length (m) for boats to moor along dock ( berth length when mooring )<br>= Σ(boat length + margin length(m) )<br>= Σ(L + 0.15L) = local fishing boat + mid-size fishing boat + berge<br>= 7 x 1.15 + 10.8 x 1.15 + 13.0 x 1.15<br>= 8.05 + 12.42 + 14.95 ≒ 36m<br>NB. dock length = 38m. with ref. to navigating margin |
| Access channel dredging | Access channel/Maneuvering water area width for navigation : Due to dredging area restrictions, the width is set at 20m, the same as access channel.<br>Access channel water depth :<br>Water depth of channel and navigation area.<br>= 1.2m + 0.8m = 2.0m<br>Designed with (LWL ±0m standard)<br>Access channel width : standard width = 5B~8B = 5 x 2.8m~8 x 2.m = 14m~22.4m.<br>Besides above formula, width is set at 7 x 2.8 m ≒ 20 m. for existing channel width, permitted dredging area, and surrounding topography. | Access channel/Maneuvering water area width for navigation :<br>Required width for boats to turn: 3L (boat length) = 3 x 11m ≒ 30m.<br>Water depth of access channel : same as for Ngaraard site.<br>Access channel width : Same as for Ngaraard site. |