No. 9

THE BASIC DESIGN STUDY ON THE MAJURO FISHING BOAT CHANNEL PROJECT IN MARSHALL ISLANDS

MARCH 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of Marshall Islands, the Government of Japan decided to conduct a Basic Design Study on Majuro Fishing Boat Channel Project and entrusted the survey to the Japan International Cooperation Agency. The J I C A sent to Marshall Islands a survey team headed by Mr. Sunao SAKAI, Disaster Prevention and Coastal Protection Div., Fishing Boat Dept., The Fisheries Agency, from December 11 to 25, 1981.

The team had discussions with the officials concerned of the Government of Marshall Islands and conducted a field survey in Majuro Atoll. 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.

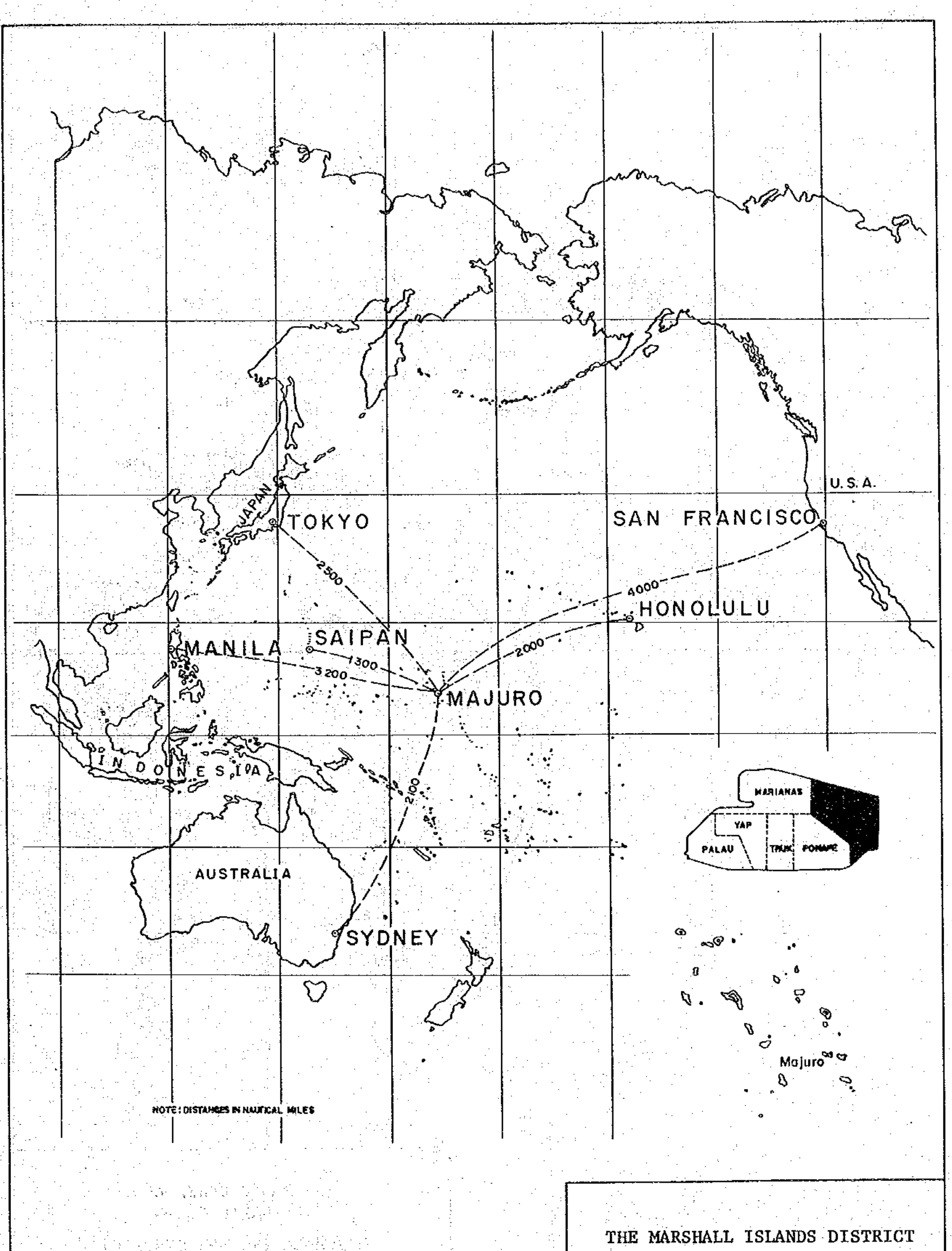
I wish to express my deep appreciation to the officials concerned of the Government of Marshall Islands for their close cooperation extended to the team.

March 1982

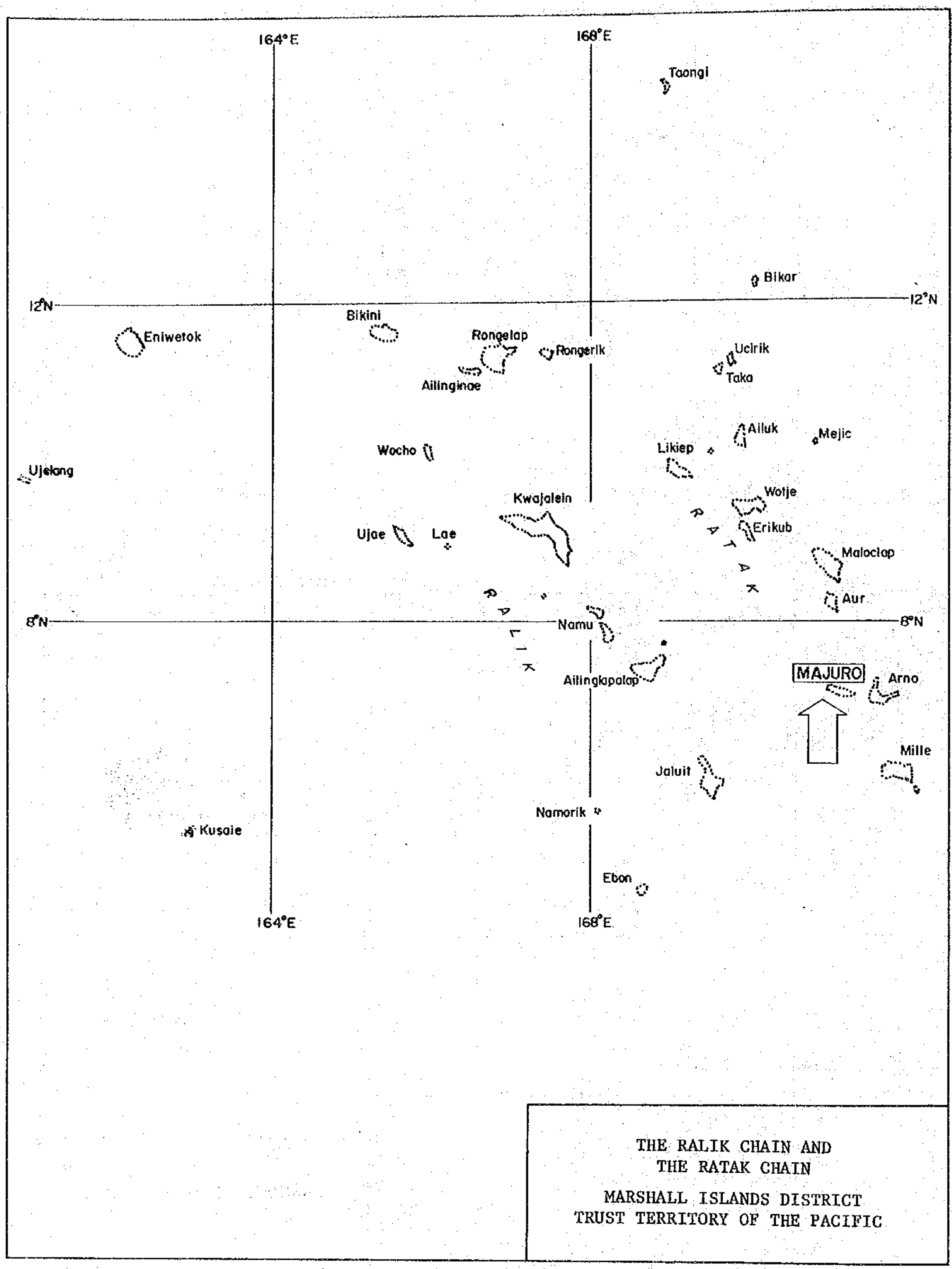
Keisuke Arita

President

Japan International Cooperation Agency

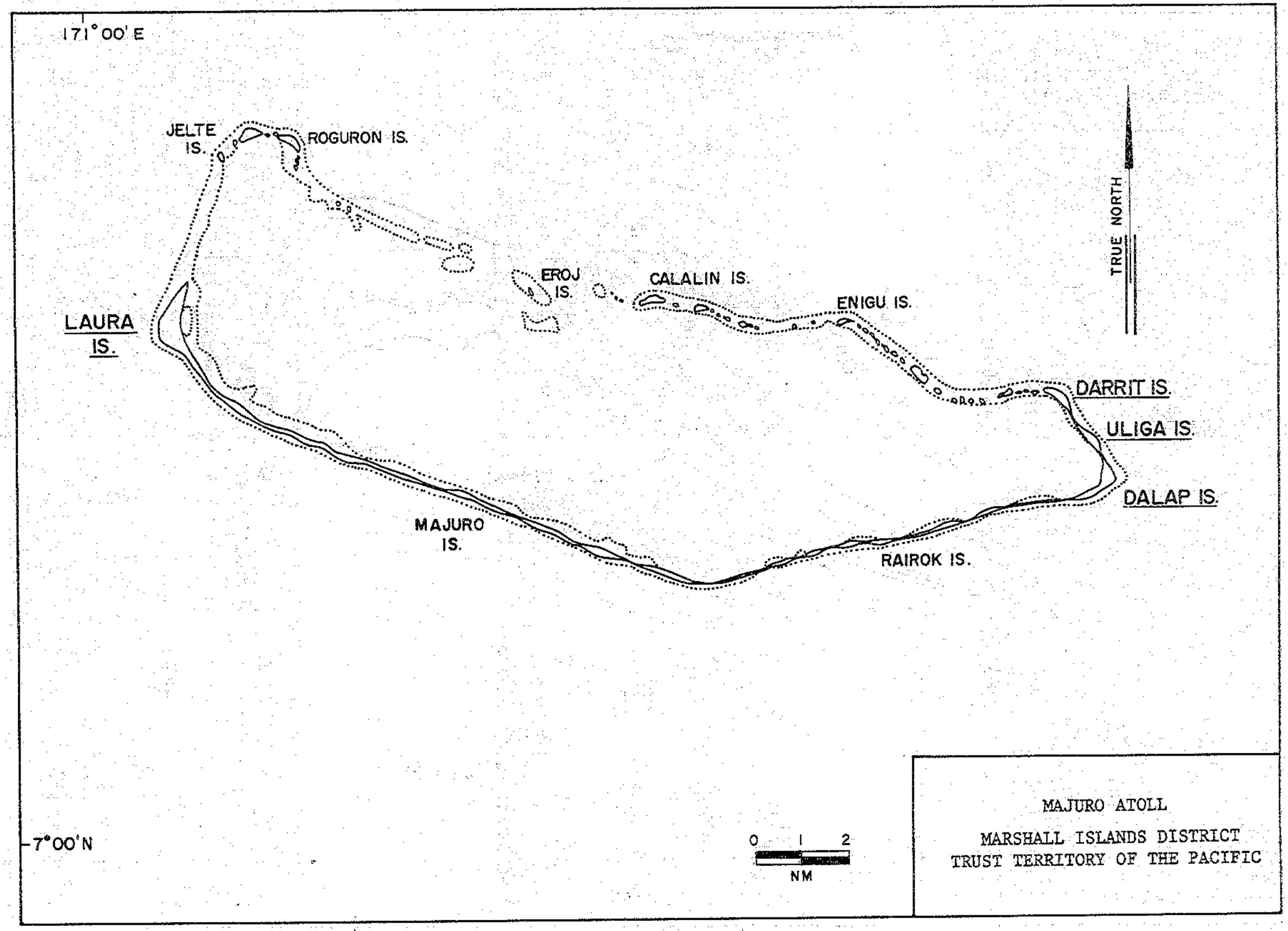


THE MARSHALL ISLANDS DISTRICT



THE RALIK CHAIN AND
THE RATAK CHAIN

MARSHALL ISLANDS DISTRICT
TRUST TERRITORY OF THE PACIFIC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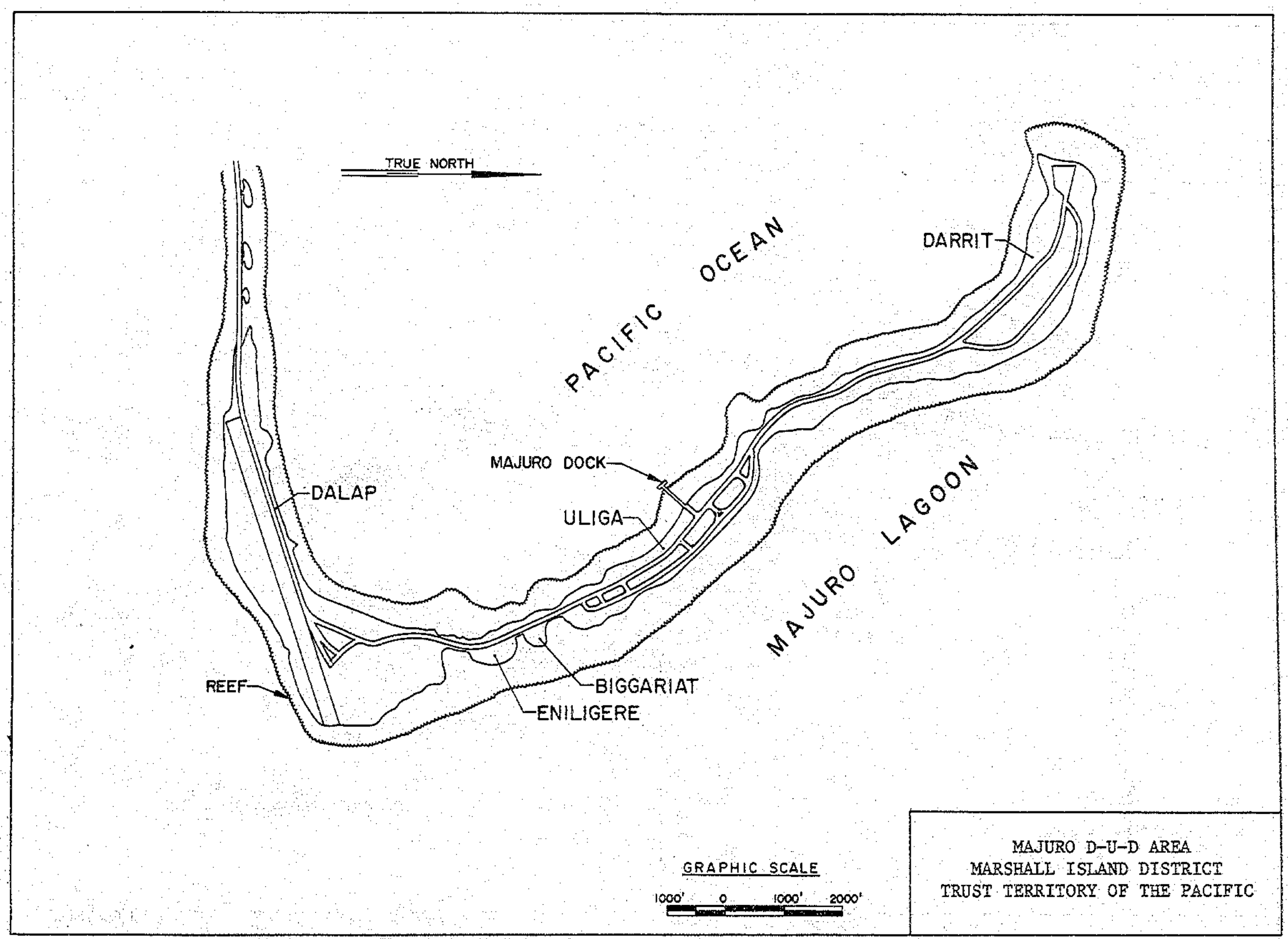
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MAJURO D-U-D AREA
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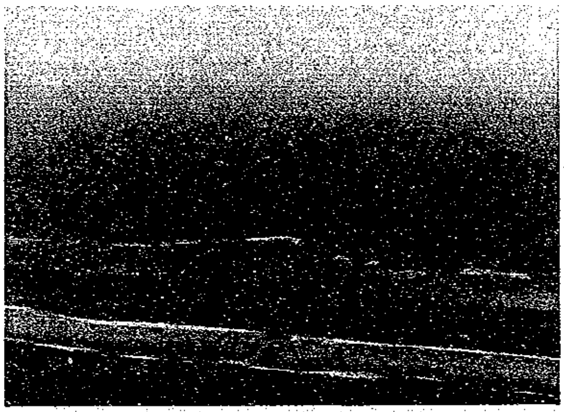
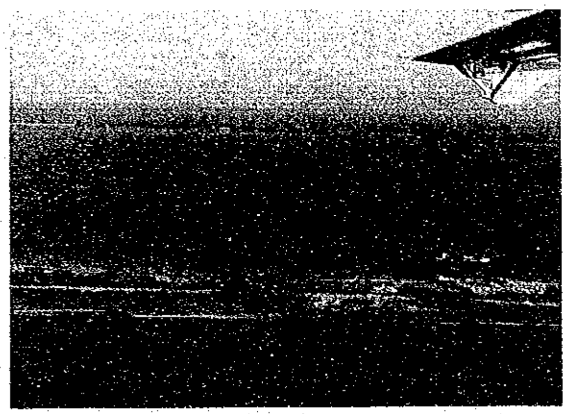
Air view of DUD area

Reef at the low tidal range and actual road through the palm grove (Rightside, Lagoon)

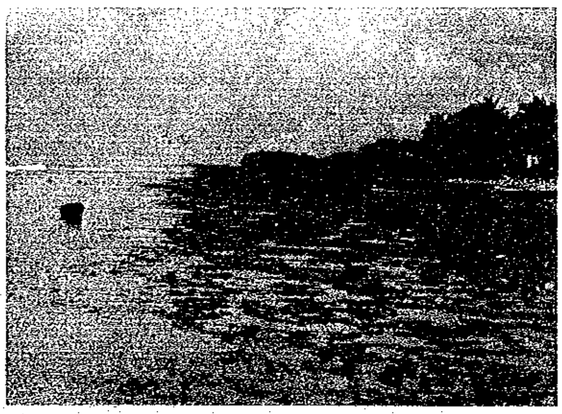


Distant view of Calalin channel

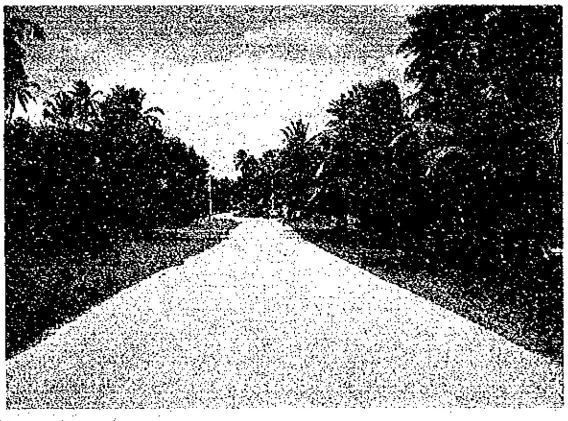


Projected site of the channel and the bridge

Reef, lagoon side

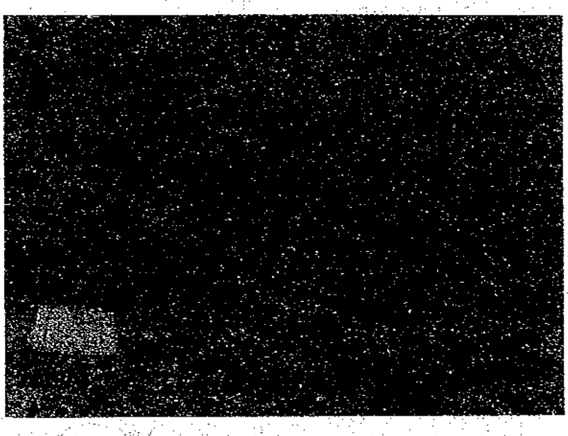


Reef, ocean side

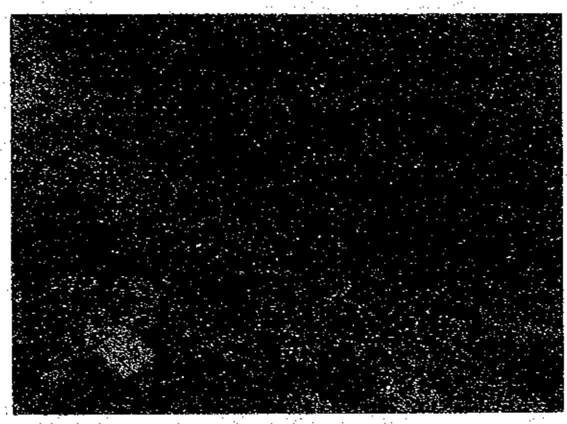


Road to Laura

Road at the projected site

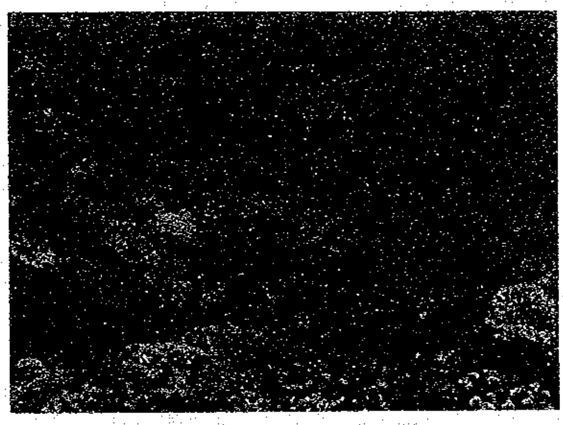


Sea floor at the projected site (lagoon side)

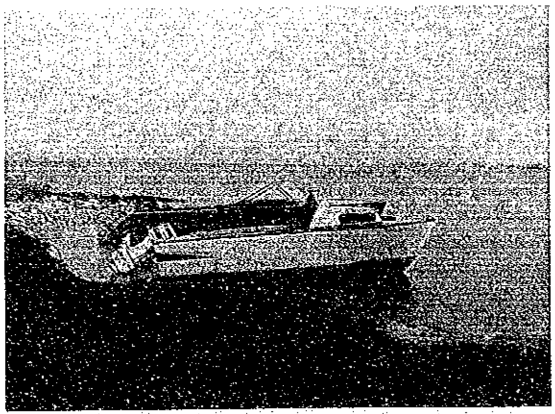


Sea floor at the projected site (lagoon side)

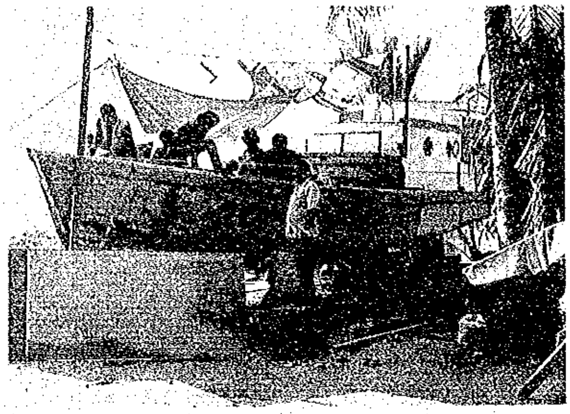
Sea floor at the projected site (Ocean side)



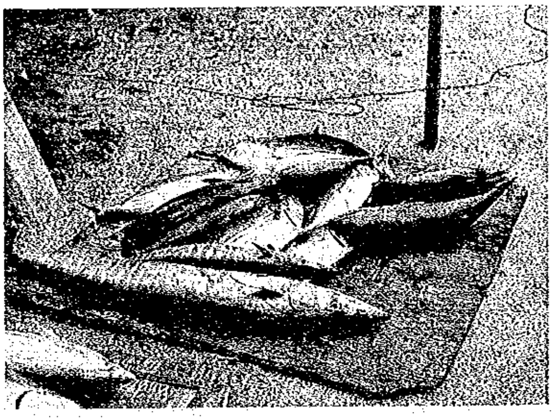
Sea floor at the projected site (Ocean side)



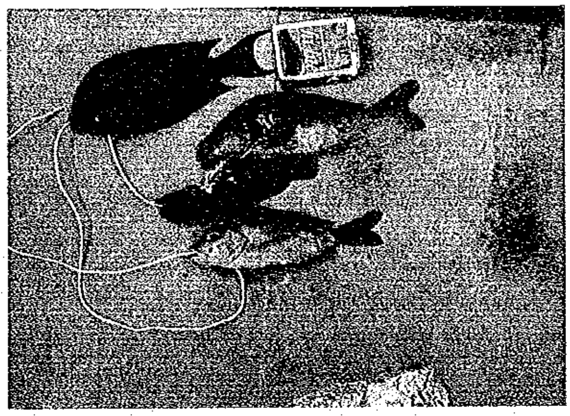
Anchoring fishing boats (Lagoon side)



Remodeling fishing boats and fishermen

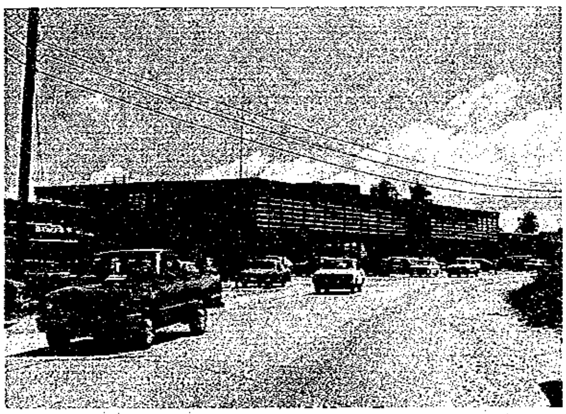


Fishes



Fishes

Uliga area



Darrit area

Summary

SUMMARY

The Majuro Atoll of the Marshall Islands consists of low flat islands and shallow reefs that surround the lagoon stretching about 40 km in the E-W direction and about 10 km in the S-N direction, and the Arno Atoll, about 20 km in the east, is included in the economic area of Majuro Atoll. This ocean area is a favored fishing ground of skipjack and tuna. The foreign fisheries, especially Japanese skipjack and long line fisheries, are active in the area.

The local fisheries in the Majuro/Arno area are in small scales mainly operated with small boats, which sail out of the lagoon to the outside ocean through the Calalin Channel at the north side, and the exploitable fishes are reef fishes, bottom fishes in the lagoon and fishes that circulate the atoll. These catches are landed to the Majuro Fishermen's Cooperative Association (MFCA).

The Marshall Islands depends on import for almost all foodstuff needed and even the demand for fishes cannot be satisfied with their own catches. Therefore, importance of fish as a protein source will grow as the population grows in the future.

Blessed with the rich ground and ample fishing labor force, the Majuro Atoll has a high fishery potentiality, and development of the fishery will substantially contribute to economical development on the Majuro Atoll.

Because of the Long Island Road connecting the east and west ends, that was constructed toward the end of 1950, in the Majuro Atoll, the Calalin Channel is the only channel for boats to sail between the lagoon and ocean. The government of the Marshall Islands planned excavating a part of the existing road, installing a fishing boat channel and a bridge over it from the viewpoint that providing a new fishing boat channel would play an important roll to develop the fisheries of the district.

The purposes of this study were selection of the optimum site of the channel and bridge, establishment of the channel excavation plan, and basic design of the bridge over the channel. Based on these study results, effect of fisheries by small boats in the southern fishing ground of the atoll,

economy related to the location of proposed site and bridge/channel construction, fish migration in and out of the atoll resulting from opening the channel and effect of lagoon water to flush itself through tidal change, the best plan to implement this project were prepared.

Once this project is realized, small fishing boats can safe access through the year to southern fishing grounds which are extrmely difficult to reach. This will help to develop the fisheries on Majuro Atoll, and since the water will be circulated between the lagoon and ocean, the lagoon water can be allowed to breathe again.

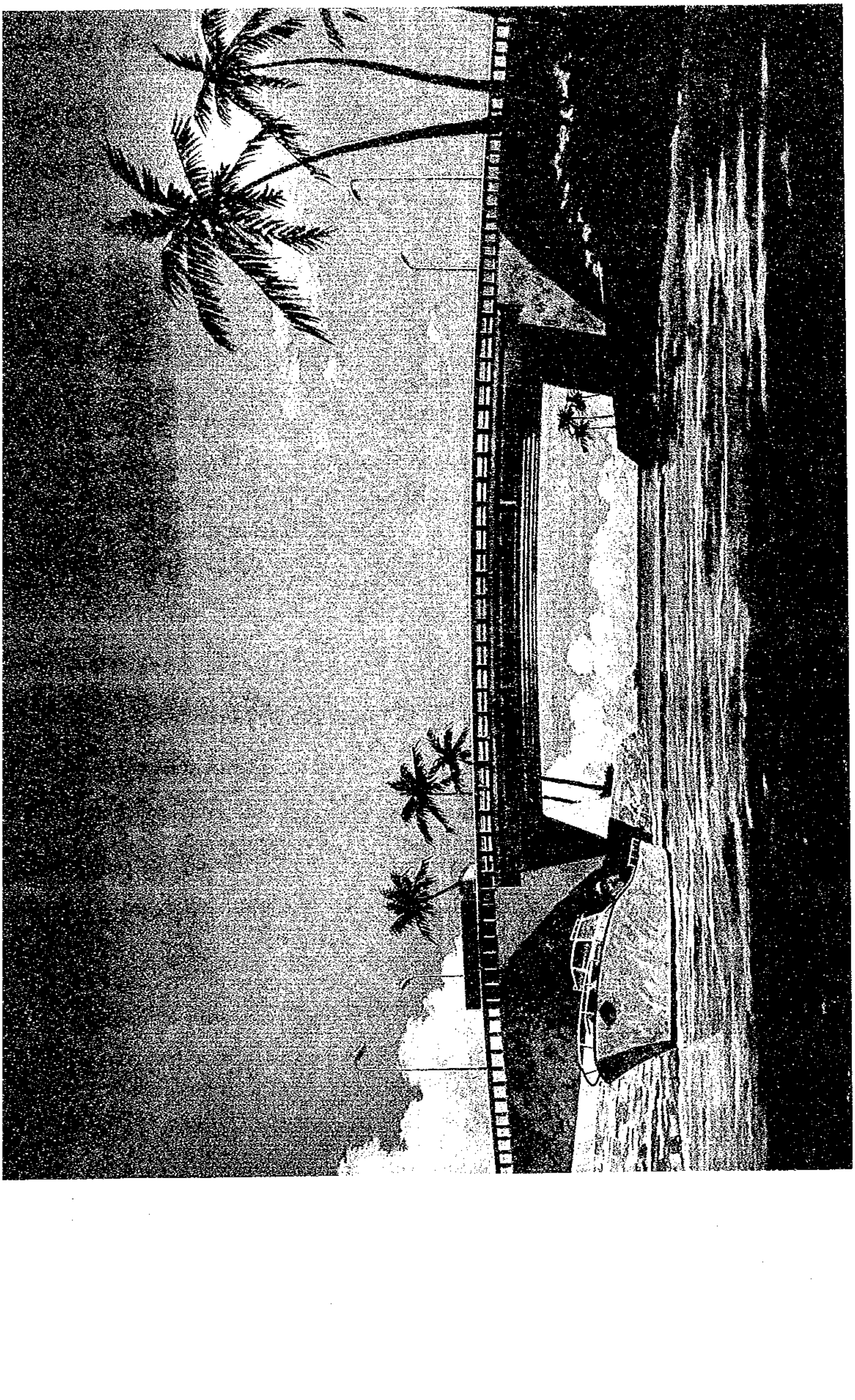
Vicinity of the new port in the southeastern part of the Majuro Atoll was selected as the site for the fishing boat channel in consideration of economical benefit and social effect.

The size of the channel was determined for 20 m wide and 2 m deep to allow two fishing boats sail freely and the clearance was determined to be 5 m in consideration of the mast height and wave height, after carefully investigating the boats in the atoll.

A concrete bridge is planned because of areal conditions of the site and this will help to reduce maintenance expenses of the bridge. The bridge length is 30.9 m, giving enough space for the channel and substructure, and the width is 9.3 m allowing two vehicle lanes and pedestrian passage. The road to and from the bridge is 10.5 m wide allowing two vehicle lanes and pedestrian passage (including shoulder), with the maximum longitudinal gradient of 5% and crossfall of 2%.

When the fishing boat channel and bridge are constructed, increase of the catch can be expected since the boats will consume less amount of fuel and can operate for a longer time than before. Also, since communication with the Arno Atoll, situated about 20 km east of the Majuro Atoll, will become easy, the livelihood of the inhabitants will be stabilized and safety of fishing boats will increase.

The project realization by the grant of the Japanese government is of great significance, and effect of such aid will really be substantial.



CONTENTS

APPENDIX TABLES, FIGURES AND METHODOLOGIES

I Introduction

1. INTRODUCTION

The Majuro Atoll, political, economical and industrial center of the Marshall Islands consists of low flat islands that surround the lagoon stretching about 40 km in the E-W direction and about 10 km in the S-N direction, and reefs that surround the islands.

The atoll south side is connected by Long Island Road from the east end to the west end, and there is an airport in the middle of the road. New port facilities are located in the east end of the lagoon, and vessels come in and out through the Calalin Channel only located at about the center of the north side of the atoll.

Industry of the Majuro Atoll is limited to copra, and the atoll relays on import completely for the foodstuff, industrial products and energy resources.

The sea area around the Marshall Islands is a favored fishing ground of skipjack and tuna and foreign fishing vessels operate in this area actively. For economical development of the Marshall Islands utilization of the rich fish resources is greatly expected, but at present, the current Majuro fishery is mainly the traditional home consumption type depending on small boats.

One of the major obstacles for development of the fishery is the danger to small boats for their passing through the Calalin Channel during the period of November through February when the seasonal wind blows much, and actually the catch during this period is very low.

To avoid using the north side channel and to provide a safe channel to the ocean to small boats through the year, a project of installing a channel for fishing boats by excavating a part of the southern atoll was established.

What the project aims at are, not to mention of higher safety in sailing out and in for fishing, increase of catch resulting from saving of the fuel in the sailing to the southern fishing ground and extension of operating hours, closer communication with the Arno Atoll of about 20 km in the east, which is in the economic area of the Majuro Atoll, promotion of fish migration resulting from direct contact of water between the lagoon and ocean, and cleaner water in the lagoon around the channel.

From the standpoint of these benefits, the Government of the Marshall Islands made a request to the Japanese government for a grant to installing a channel for small fishing boats by excavating the south side atoll.

Upon receipt of the request, the Jopanese Government determined to study the basic design of fishing boat channel. Japan International Cooperation Agency dispatched a basic design study team headed by S.Sakai(Disaster Prevention and Coastal Protection Div., Fishing Port Dept., the Fisheries Agency) (Table 1). The purpose of dispatching the survey team was to review the feasibility of the project and effect of the aid related to the construction of the fishing boat channel in the south side of the Majuro Atoll and construction of a bridge over the channel for automobiles.

The following points were investigated:

(1) Setting of the site, range and scale appropriate for the planned fishing boat channel and bridge.

(2) Selection of the optimum bridge plan, basic designing, calculation of approximate project cost, and preparation of implementation schedule.

(3) Social and economical evaluation of the project and review of applicability of Japan's grant aid.

(4) Preparation of basic plan report resulting from the above reviews.

The survey team had thorough discussions on the background and purpose of the request with the related parties of the Marshall Islands (Table 2) and conducted the field survey (Table 3) for 18 days from December 11 to December 29, 1981.

The minutes of the discussions are attached to the end of this report.

II Marshall Islands Fisheries

II. FISHERIES OF MARSHALL ISLANDS

1. Outline

Marshall Islands has an esclusive economic zone that extends to about 1.3 million sq.km and the country is blessed with abundant pelagic fishes like skipjack and tuna. However, majority of these pelagic fish resources are caught by foreign fishing vessels from Japan, Korea, Taiwan and Philippines.

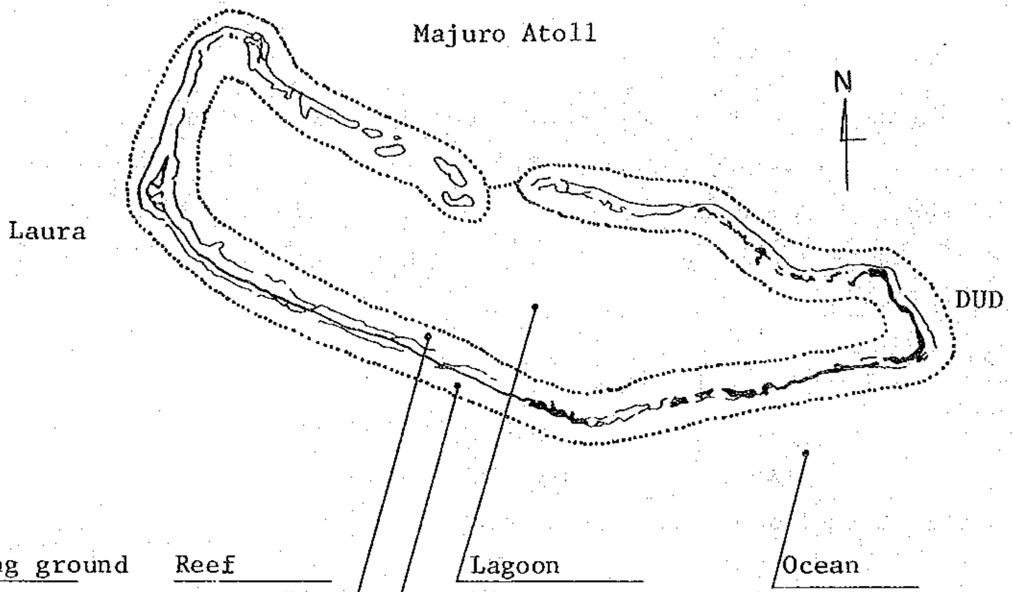
The fisheries of the Marshall Islands are very small in the scale and the only exploitable pelagic fishes are limited to those that approach the islands. Also reef fishes and bottom fishes of the lagoon are the objectives of local fisheries.

The Majuro Atoll forms the center of the fisheries of the Marshall Islands, and the catches are distributed to consumers through the fishermen's cooperative association. Fisheries in other atolls and islands exist for home supply and consumption of people only.

2. Fisheries of Majuro Atoll

2.1 Outline

The fishing ground, method and major fish species of the Majuro Atoll are shown below. The major fisheries are trolling of pelagic fishes like skipjack and tuna in the ocean area, spear or net fishing of reel fishes like rabbit fishes and parrot fishes around the reef, and hook fishing of bottom fishes like groupers and snappers in the lagoon (Table 4).



Fishing ground	Reef Inner reef Outer reef	Lagoon	Ocean
Fishing method	Spear or net fishing	Hook fishing	Trolling
Major fish group	Reef fishes	Bottom fishes	Pelagic fishes
Fish species	Rabbit fishes Mullets Parrot fishes Rudder fishes Trigger fishes Bat fishes	Groupers Snappers Soldier fishes Big eyes Emperors Needle fishes Thread fishes	Alcabore Yellowfin tuna Bigeye tuna Skipjack tuna Wahoo Sail fishes Black marlin Mackerels Dolfin Needle fishes Flying fishes

Fig. 1 Majuro Atoll Fisheries

2.2 Catch

About 65% of the total landing in the Majuro Atoll was delivered to the Majuro Fishermen's Cooperative Association (MFCA), and the annual total MFCA landing during the years of 1978 through 1980 was in the range of 62 to 173 tons as shown below. It is said that the sharp decrease of the landing in 1980 was caused by the decrease of fishing boats resulting from the rise of the fuel price.

Table 1 Fish Landing to MFCA by Major Fish Group

Unit: Ton

Year	Pelagic fishes	Reef fishes	Bottom fishes	Lobsters	Total
1978	94.3	30.7	10.6	0.2	135.8
1979	135.7	24.4	12.4	0.1	172.6
1980	41.7	16.1	3.9	0.1	61.8

The ratios of landings of major fish groups are 70 to 80% of pelagic fishes, 14 to 26% of reef fishes, and 6 to 8% of bottom fishes. Pelagic fishes were landed to MFCA 67 times a month on the average, and the average landing of pelagic fishes per operation was 116 kg. The landing shows a trend of becoming less frequent in winter to early spring when strong winds blow and become frequent in August to October when the climate is mild (Tables 5 through 7, Methodologies 1 and 2).

2.3 Fishing boats

Majority of fishing boats in the Majuro Atoll are small boats of 5 to 6 m long equipped with two outboard engines of 55 to 100 HP. It is difficult to determine the exact number of the boats since no registration system has been established, but from the MFCA information, the following numbers are assumed (Tables 8 through 10):

About 50 boats in the Darrit, Uliga and Dalap (DUD) areas
About 20 boats in the Laura and other areas

2.4 Fishermen

About 280 fishermen are landing the catch to MFCA, and about 20 out of them are fully working on fisheries. Catches of these full time fishermen occupy majority of the landing to MFCA. Those who work on fisheries as a side job catch fishes for self consumption mainly and they sell the catches to MFCA or foodshops for additional income only when they have surplus. (Table -11)

3. Fish Distribution

Fishes that are delivered to MFCA are directly sold to consumers by MFCA. Fishes that are not distributed through MFCA take the route of fishermen to retail shops and then to consumers.

4. Fish Consumption

Protein foodstuff consumed in the Majuro Atoll consists of fish and meat. The fish can be divided into local fish, imported canned fish and imported frozen fish, and the meat can be divided into imported poultry, pork, beef and processed meat.

Estimated per capita consumptions of local fish, canned fish and chicken which are cheaper than local fish, are shown below (Methodologies 3 through 5):

Table 2 Consumptions of Fish and Chicken

	Gross	Net
Fish		
Local fish	22.8 kg/year	12.1 kg/year
Canned fish	12.1 kg/year	6.4 kg/year
Total	34.9 kg/year	18.5 kg/year
Chicken	7.7 kg/year	5.9 kg/year
Total (net)	-	24.4 kg/year

24.4 kg of the net total is equivalent to 46.0 kg of gross fish foodstuff.

5. Fish Prices

Price differences by fish species are small at the retail level of local fish, and it is generally about $1.00 per pound (¥550 per kg). Prices per pound of canned fish are $0.8-0.9 for boiled mackerel and $1.5-1.8 for sardine cooked with tomato, and retail price of chicken is about $0.8 per pound. Prices of local fishes are higher than those of canned sardine and mackerel and chicken meat (Table 12).

6. Ground Facilities

The following ground facilities related to fisheries exist in the Majuro Atoll:

(1) Refrigeration warehouse

MFCA	100 tons (-25°C)
New port	200 tons (-25°C)
Old pier	150 tons (-25°C)

(2) Ice-making machine

MFCA	5 tons a day

III Outline of Project Site

III. OUTLINE OF PROJECT SITE

1. Road Conditions

The Majuro Atoll has a paved road of 6.5 m wide in the southern half of the atoll for about 56 km.

The speed limit is 35 miles per hour in most parts, but 25 miles per hour and 15 miles per hour in the city zone and in neighborhood of schools, respectively. Also, there are raised obstacles, called "Bump", of about 5 cm high crossing the road as vehicle speed control in neighborhood of a village. In the DUD area, ditches which serve as drainage as well, cross the road. These are no houses in the project site. The road is straight and no obstacle is there.

2. Traffic Situation

There is no data on the Majuro traffic situation.

The traffic flow was measured at the site 3 times a day, and the average was turned out to be 160 vehicles per hour. From this result, the average daily traffic volume on the road is estimated about 2000 veh/day. The cars that passed through the site were mostly small cars. Heavy vehicles such as school bus, trailer truck and tank rolley to and from the airport pass through the site occasionally.

3. Geographical Characteristics

The general geography is that there are islands of less than 3 m altitude in the atoll, and reefs of 0 m level stretch out to the lagoon and ocean sides.

4. Geology

In general Majuro Atoll is an elongate ring of coral limestone (reef rock) and coral debris island.

The coral reefs forming the road basement are made up light tan coral limestone mixed with shells.

5. Situation of Sea Bottom around Project Site

The sea bottom situation at the lagoon side and oceanic side were investigated through diving observation down to the depth of 20 m.

5.1 Lagoon Side

5.1.1 Situation of sea bottom

(1) 0-5 m depth
The sea water along the shore line was always whitish affected by the dredging in the area. The sea bottom is a boulder zone of gentle slope, but the excavated area with dynamite is sand-clay type.

(2) 5-20 m depth
The sea bottom is a sharp slope of 30 to 40 degree, either covered boulder zone or sand mixed with small boulders.

5.1.2 Living situation of corals

(1) 0-5 m depth

Corals are scarce and live sporadically. Colonial corals with dead and white periphery were recognized.

(2) 5-20 m depth

No living corals were recognized.

5.1.3 Living situation of fish

Fish is extremely scarce. A few small coral fishes were recognized around corals living in shallow areas.

5.2 Ocean Side

5.2.1 Situation of sea bottom

(1) 0-1 m depth

The reef flatly expands in the width of 100 m and its offing side forms the swell zone.

(2) 5-10 m depth

The sea bottom forms a slope of about 30 degree and is covered by hermatypic corals.

(3) 10-20 m depth

The sea bottom forms a slope of about 60 degree and is covered by hermatypic corals.

5.2.2 Living situation of corals

In the slope outside of the wave breaking zone, various hermatypic corals grow thickly and fungiid single corals (non-hermatypic corals) were recognized often.

5.2.3 Living situation of fish

In the slope outside of reef end, various hermatypic corals grow thickly and fungiid single corals (non-hermatypic corals) were recognized.

6. Construction Circumstances

6.1 Contractors

There are two contractors: Pacific International Inc. (P.I.I.) and International Bridge Corp. (I.B.C.) in Majuro. P.I.I. is the only integrated construction company having the headoffice in Majuro, and engaging in many construction work in the Marshall Islands as the local contractor.

I.B.C. has the base in Guam. It worked in construction of the Majuro Airport facility related and the road, and the company has experienced many projects in Guam and Micronesian islands.

6.2 Current Constructions

As of this moment, the major constructions being proceeded in Majuro are construction of the new power plant, landfill for fuel tanks and construction of a hotel (reinforced concreate 2-story building).

In Majuro, two large construction projects were completed in the past: the airport and new port.

6.3 Labor Situation

Majuro Atoll lacks engineer and skilled laborers for construction works and at present, many expatriates are employed by local contractors.

6.4 Materials and Equipment

Majuro has required number and variety of construction machines for current construction circumstances if those owned by the government and private concerned are put together. If machines owned by private concerns are not enough, the government lent sometimes governmentally owned machines.

Majority of governmentally owned machines are new, but in general, the machine life is extremely short because of saline corrosion. Very old machines are used for construction works. Available materials in Majuro are coral sand and rocks only. But other construction materials like cement, reinforcement bars, steel plate, hard stones for concrete are mainly imported from Hawaii. Unless for specific concrete structures, crashed coral sand and stones are used as aggregate for cement concrete and asphalt concrete.

6.5 Construction Cost

While labor charges are considerably low, the materials are very expensive since they have to be brought in from outside. This substantially raises the construction cost.

The rocks used for road protection are prepared by exploding coral reefs with dynamite and they are not available at low prices.

6.6 Ability of Local Contractors

Based on the records of local contractors in the past constructions, it is observed that they can manage basic works of construction such as concrete laying, crashing coral reefs for material collection and land filling. However, special or large scale works like bridge building must be conducted by foreign firms.

7. Ownership of Land

In the Marshall Islands, private ownership of land is recognized and the land belongs to individual owners. However, there are no problem of land acquisition on the reefs.

8. Selection of Project Site

8.1 Selection Conditions

The following conditions were taken up in selecting the site for installing the fishing boat channel:

(1) Safety of fishing boats must be secured under the Majuro weather condition of E-EN trade winds (annual frequency of 69%). For this reason, the preferable channel location is at the south side of the atoll.

(2) Small fishing boats must be able to get the best benefit out of the channel. In other words, the following points are very important:

- The channel must be close to fishermen and mooring site.
- The channel must be located in a site of convenient communication with the fish market.
- The channel must allow easy access to the fishing ground.

(3) The water channel must be able to provide efficiency in communication with the neighboring Arno Atoll.

(4) The channel, once installed, must have a great effect on improving the water quality.

(5) There must be enough space for construction of the bridge and access roads.

(6) The site must be easily available.

(7) The construction cost should not be high.

8.2 Determination of Channel Site

8.2.1 Selection of site for channel

Several areas were studied in selecting the site for the channel and the over bridge.

The sites of A, B, and C (as shown in Fig.2 of the next page) were selected as the possible site based on the investigation in the atoll. Namely, they are Site A that is an adjacent area to the new port, Site B that is in the west of the Nauru living quarter and Site C that is west of the airport.

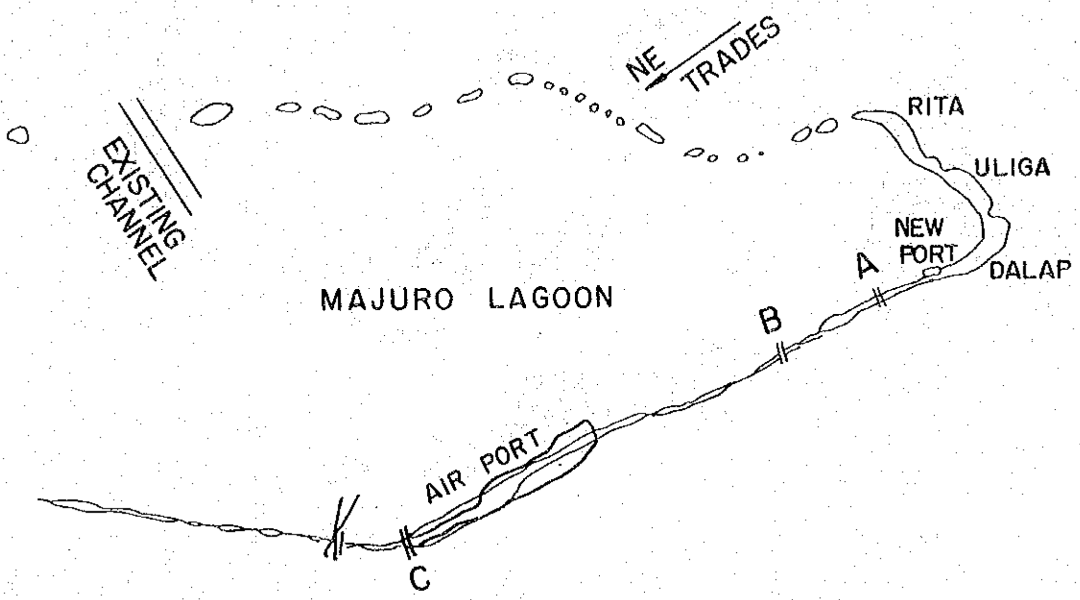


Fig. 2 Location Map of Probable Sites

8.2.2 Determination of project site

In consideration of the conditions listed in Section 8.1, Site A was selected as the most practical and economical solusion to the numerous problems:

(1) Majority of the Majuro Atoll inhabitants live in the DUD area at the east side, and majority of shipping boats concentrate in DUD. Also, the fish market is within the new port premises. Therefore, the channel should be as east as possible, and Site A satisfies this requirement.

(2) The channel is most convenient for communication with the Arno Atoll, located at about 20 km in the east of Majuro, if it is installed at the east side.

(3) Contamination of water is proportionate to concentration of the population, and since many facilities are in the Dalap area, the neighborhood is apt to be contaminated. For this reason also, installation of the channel at the east side is more effective.

(4) The government of the Marshall Islands has had a plan for installing a channel, and a part of the reef in Site A has already been excavated. This makes the construction cost lower than that in other sites.

There are no significant differences between Site A and other sites on other conditions.

IV Contents of the Project

IV. CONTENTS OF THE PROJECT

1. Objectives and Contents

Objectives of this project are the construction of channel for small fishing boats and the construction of bridges, approach roads and utility appurtenances.

2. Design Policy

The basic principle regarding design policy of this project is the ease of maintenance and repair of the relevant facilities after their completion. On the other hand, with regard to the selection of the construction materials and construction method to be adopted in this project, special attention is paid in order to use as much as possible the construction materials available in the Majuro Atoll.

3. Design Specifications

3.1 Specifications of the Channel

3.1.1 Tidal range

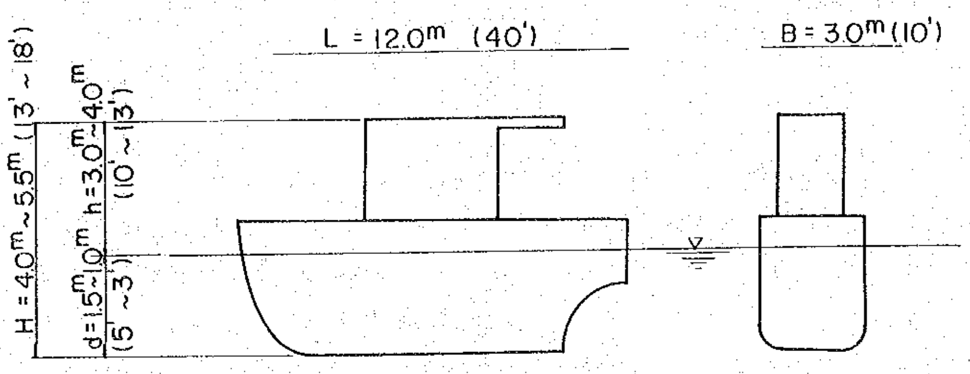
In this project the tidal range assumed to have the average values listed below.

	Tidal range	Planned elevation
HWL	+1.8 m	EL 1.8 m
MWL	+0.9 m	EL 0.9 m
MLLWL	±0.0 m	Reference level

where, HWL : High water level
MWL : Mean water level
MLLWL : Mean lower low water level

3.1.2 Dimensions of the fishing boats

The dimention of fishing boat taken into design consideration should be as follows:



where, H: Overall height L: Overall length

h: Mast height B: Overall width

d: Draught

Fig.3 Size of Fishing Boat

3.1.3 Specifications of Channel

(1) Width of channel

The width of channel should be 20.0 meters in bottom of the channel.

The channel is designed to make possible the simulations navigation of two fishing boats in opposite directions.

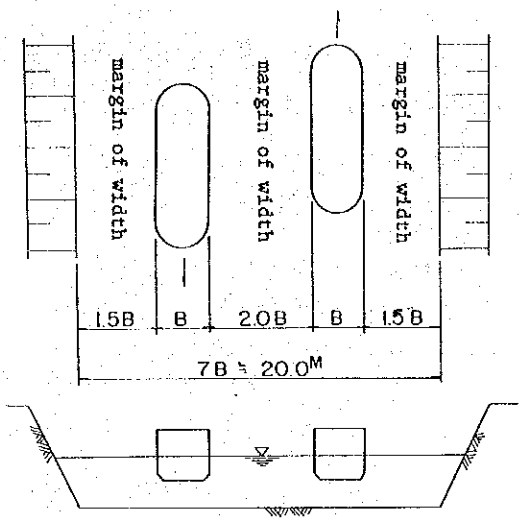


Fig. 4 Width of Channel

(2) Water depth

Water depth of channel should be 2.0 meter below MLLWL.
Generally, the required water depth of the channel is given by the following formula.

Channel water depth = Draught of boat + 2/3 x Navigable wave height

Assuming that the navigable wave depth is 1.0 m.

Channel water depth = 1.5 m + 2/3 x 1.0 m = 2.0 m

(3) Clearance

Height of navigation should be 5.0 meters above HWL.
The clearance is assumed to consist of the mast height, 1/2 x wave height and margin of height

Clearance = 4.0 m + 1/2 x 1.0 m + 0.5 m = 5.0 m

3.2 Specifications of the Bridges and Approach Roads

3.2.1 Length of Bridge

Assuming a channel width of 20 m and a margin of width of 5.0 m for the substructure, the bridge is required to have the following effective span length.

$$\ell = 20.0 + 5.0 \times 2 = 30.0 \text{ m}$$

It is therefore required to have the following overall length, by adding the girder end length 0.24 × 2 = 0.90 m to the aforesaid effective span length.

$$L = 30.9 \text{ m}$$

3.2.2 Road width composition

(1) Road width of the bridge

Carriage way	3.25 m × 2 (double lane)	= 6.50 m
Walkway	1.00 m × 2 (both sides)	= 2.00 m
Curb	0.40 m × 2 (both sides)	= 0.80 m
Total		9.30 m

(2) Road width

Carriage way	3.25 m × 2 (double lane)	= 6.50 m
Walkway	1.00 × 2 (both sides)	= 1.00 m
Shoulder	1.00 m × 2 (both sides)	= 2.00 m
Total		9.30 m

3.2.3 Slope

Longitudinal slope	Maximum 5%
Transversal slope	1.0% parabola

3.3 Design Standards

3.3.1 Live load

Live loas should be adopted equivalent to HS20-44 of the ASSHTO

3.3.2 Strength of material

(1) Concrete (Compressive strength of 28 day concrete)

Superstructure	Main girder	400 kg/cm^2 minimum
	Cast-in-place	300 kg/cm^2 minimum
Substructure	Reinforced concrete	210 kg/cm^2 minimum
	Plain concrete	160 kg/cm^2 minimum

(2) Steel materials (yield point stress intensity)

Reinforcement bar	3,000 kg/cm^2 minimum
Prestressing tendon	15,000 kg/cm^2 minimum
Steel plate	2,400 kg/cm^2 minimum

(3) Asphalt concrete

In accordance with the specifications of the ASTM, in case of using coral reef rock.

4. Basic Design

4.1 Channel for Fishing Boat

4.1.1 Influence of tidal current

The speed of the tidal current in the channel after its completion is calculated as follows. The major factors influencing the tidal current speed in the channel are the tidal range in the lagoon and in the ocean at a given time and the difference of tidal levels between them. According to data investigation, during period of 9 months ranging from March through November of 1981, the difference of tidal range occurring at the project site is as follows.

High tide maximum	0.35 m
High tide average	0.18 m
Low tide maximum	0.35 m

The tidal current speed in the channel is calculated as follows, by using the aforesaid difference of tidal range (Methodology 6).

High tide maximum	6.1 knot
High tide average	4.5 knot
Low tide maximum	2.1 knot

The tidal current speed exceeds 6.1 knots only at the occasion of 7 successive days with high tide, occurred in March, during the aforesaid period of 9 months of survey. It is presumed that these tidal current speeds have no influence at all on the navigation of fishing boats through the channel. The tidal current speed has different values at the high tide and at the low tide even when the difference of tidal range is the same, because the length of channel is assumed to be 45 m at high tide, while at low tide the said length is assumed to be 250 m.

4.1.2 Design of channel

The cross section of the channel has a width of 20 m at the bottom, depth of -2.0 m MLLWL and a slope of 1:0.5 at both sides. The bottom of the channel has a finished level of MLLWL -2.0 m. The slope at both sides of the channel will have bare finishing, with no protection lining. However, concrete lining will be provided only at the upper extremity of the channel slope in front of the abutment of the bridge and within an extension of 10 m at the right and left sides of the said abutment.

The channel will have a constant width throughout its whole extension, with no widening at the entrance and exit.

4.2 Bridges

4.2.1 Selection of type of bridges

The following types of bridge are applicable to the present case, which requires an effective length of = 30 m.

a. Post-tensioning PC girder bridge

b. Composite steel girder bridge or steel plate girder bridges

A comparative study on the aforesaid types of bridge was made, taking into consideration the conditions at the project site, and the following observations were obtained.

° From the structural point of view, both types of bridge are applicable for this effective span requirement.

° From the economical point of view the two types of bridge do not present differences as the costs required for construction of the substructure are the same.

° From the point of view of ease of construction the two types of bridge do not present major differences, but the plate girder type is advantageous to some extent in view of the smaller weight to be hoisted.

° From the point of view of comfort of traffic, the PC girder type bridge is the most advantageous one. The PC girder bridge causes less vibrations to the vehicles.

° From the point of view of ease of maintenance the PC girder is the most advantageous one. The plate girder is prone to rust due to the influence of sea breeze.

Post-tensioning PC girder type bridge was selected for superstructure, in view of the considerations presented above.

As for the substructure, a gravity type, direct foundation on coral reef rock as bearing surface, was selected.

4.2.2 Structural design

(1) Superstructure

The main girder has a "T" shape cross section, and five main girders are used for the superstructure of this bridge. Aggregate of hard type will be used for concrete of both main girders and cross beams of this bridge. Both expansion joints and supports of this bridge will be made of rubber, by taking into consideration the resistance against corrosion.

(2) Substructure

The abutment of the bridge will be a gravity type structure. Reinforcing bars will be used in the parapet wing and in the shoes bed.

Crushed coral reef rock will be used for aggregate of concrete. However, the shoes bed will be made of concrete using hard aggregate.

4.3 Access Road

4.3.1 Road pavement

The approach roads will be paved with asphalt concrete. Crushed coral reef rock will be used for sub-base course.

The pavement will have a thickness of 50 mm, while the sub-base course will have a thickness of 200 mm.

4.3.2 Landfill and subgrade

Mixed material composed mainly of coral sand and stone will be used for landfill and subgrade.

4.3.3 Detour

The detour will be constructed at the lagoon side. The width of the detour will be 6.0 m and the road surface will be finished by rolling compaction of coral sand and crushed stone.

After completion of the detour it will be considered part of the levee body and therefore it will not be removed, with exception of the part corresponding to the channel. The elevation of the detour will be approximately the same as the existing road.

4.3.4 Revetment

Rubble mount (1 through 1.5 ton) will be piled up to the elevation of the surface of the existing road, because the extremity of the slope at the ocean side is subject to the force of the waves. The revetment slope will be provided with two protection layers, namely, the crushed stone layer (70 cm thick) and the rubble layer (50 cm thick). Filter cloth will be provided between the road body and the crushed stone layer, in order to prevent erosion. The slope gradient is designed by 1:2.

4.4 Design of Utility Appurtenances

4.4.1 Water Supply Mains

The existing water supply mains (ø12" diameter) will be working during the period of construction of bridge and approach road and after that it will be changed at an appropriate occasion with the new water pipe with an approximate extension of 300 m to be constructed together with the bridge. At that occasion, the installation of an air valve equipment will be required at the center of bridge, and accordingly, space for the air valve and its maintenance should be taken into consideration in the design.

Steel pipe will be used partially in the bridge and at the changeover point.

4.4.2 Traffic safety facilities

A centerline visible also during the night will be provided at the slope sections of the road before and after the bridge. This nocturnal visibility of the centerline will be attained by installing cat's-eyes able to reflect the light of the headlights of cars at intervals of approximately 5 m along the centerline. These cat's-eyes can be used semipermanently without requiring maintenance and repair if their wearing due to the friction of the tires of vehivles is prevented.