12.7.3 Proposed Land Use

As discussed in the Master Plan, Sections 7.7 and 8.9, this area aims at providing:

a. buffer zone against wave overtopping during a cyclone, and
b. public space, roads, parking area, bus terminal and park during the normal climatic condition.

Addition to these areas, area for movable facilities should be provided.

a. Movable first-food shops
b. Movable souvenir shops

Presently an area of 1,500 m^2 in the East bank of Avatiu Stream was allocated for these shops by the Survey Department. The Department estimates increase of this type of shop in the future.

Survey Department was also responsible to the festival area for "the South Pacific Arts Festival in 1992" to be held in Rarotonga Island. This area was allocated at the northern area of present movable shop area. This facility is very important to attract not only the local people but also tourists. This festival park should be maintained for permanent use.

According to the Port Improvement Master Plan, it is recommended that another port area in 1.5 ha should be expanded to the eastern bank of Avatiu Stream.

Table 12-13 shows the recommended land use of the Port Park Complex.

Table 12-13 Land Use in Port Park Complex

Category	Scale	Required Area (m^2)		
a. Apron for seawall	7.0 m wide	350 m x 7 m	=	2,450
b. Road and access	6 ha x 25 %		=	12,000
c. Future port area			=	15,000
d. Movable shops area		100 m x 30 m	=	3,000
e. Festival Park		60 m x 70 m	=	4,200
f. Car Park	270 vehicles	270 x 17 m^2	=	4,500
g. Bus Terminal		2 m x 1,800 m^2	=	3,600
h. Park	6 ha x 20 %			12,000
i. Others				3,250
	Total			60,000 m^2

Note: Cyclone buffer zone will be seaside 30 m of above.

12.7.4 Parapet Wall

A. Height of Concrete Parapet Walls

Proposed elevation of wall tops:

+4.5 m	at Avarua East
+5.5 m	at Avarua/Avatiu Coast

Since the existing ground elevations are MSL+3.3 m and +4.3 m for the former and the latter respectively, the parapet wall height is 1.2 m.

These elevations were decided upon mainly to mitigate excess wave overtopping exceeding an allowable level. This was discussed in Sections 12.2 "Design Criteria" and 12.3 "Preliminary Design: Avarua Coast".

Both proposed heights are the limit of height to see the horizon.

To neutralize barrier-like look of the wall, it is proposed to provide a 70 cm high lawn-covered earth mound immediately behind the wall. Fig. 12-17 shows a typical arrangement.

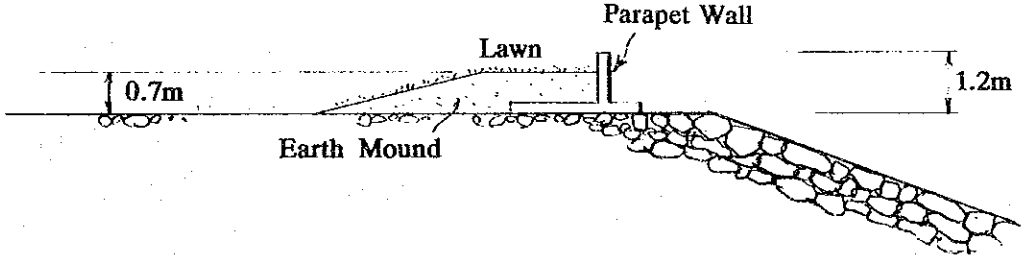


Fig. 12-17 Typical Parapet Wall Arrangement (Earth Dike)

Another alternative is:

+4.0 m	at Avarua East
+5.0 m	at Avarua/Avatiu Coast

In this case the wall height is only 70 cm and more open view can be maintained. This arrangement should be restudied during the detailed design.

B. Accessibility to Foreshore

Accessibility to the foreshore area and the beach can be provided by constructing a concrete staircase as shown in figure below.

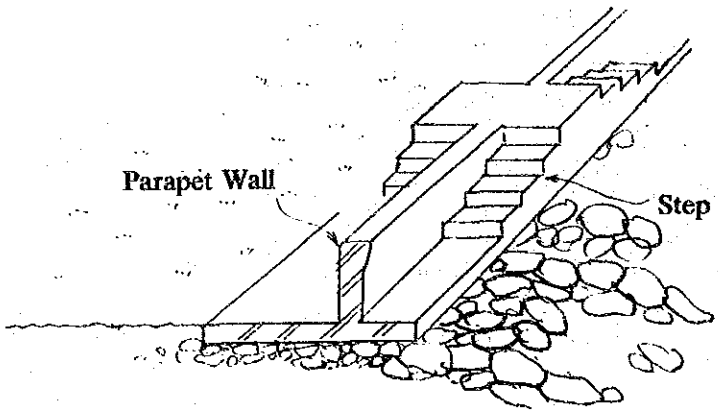


Fig. 12-18 Concrete Staircase

C. Effective Use of the Wall

The inside face of the parapet wall can be utilized both as a pedestrian path and a space for benches.

Fig. 12-19 shows a typical arrangement.

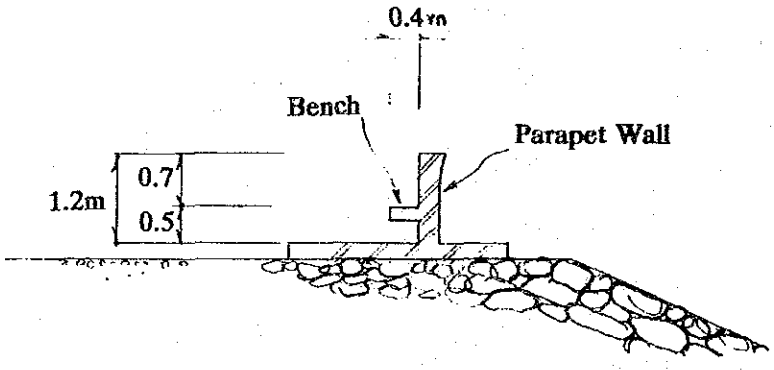


Fig. 12-19 Built-in Bench

12.7.5 Other Considerations

A. Pedestrian Walkway and Access

A 380 meter and 850 meter long access will be required in the complex for Avarua East and Avarua/Avatiu Coast respectively. The, 380 meter access in Avarua/Avatiu Coast is included in the project.

The access is 6 meters wide.

The 1.8 m wide pedestrian walkway and is located behind the parapet wall.

B. Plantation

It is proposed to provide the Complex with a plantation. This arrangement aims at:

a. Improving the landscape
b. Providing shade
c. Earth stabilization

C. Car Parking Space

A 4,500 m^2 of space is required for parking 270 vehicles. According to the MOW plan (Job No. C.D91-30), about 250 parking slots are already funded in the 1991 budget. Thus, the present parking space requirements are covered by the MOW work. However, it is recommended that a car parking area be reserved for a future 270 vehicles in the Complex.

Chapter 13: Short-term Development Plan: Port Improvement

Chapter 13 Short-term Development Plan : Port Improvement

This chapter deals with Short-term Development including the preliminary design of port improvements together with the refinement of the general layout. Major port improvement in the Short-term Development will be conducted at Avatiu Harbour. Minor improvements to Avarua Harbour will also be performed.

13.1 Formulation of Short-Term Development Plan

13.1.1 Objective

In Section 8, the Master Plan of Port Improvement was presented together with its background information. This plan was developed to meet the requirements in Year 2010. The proposed plan in this Chapter will indicate a short-term plan to meet the urgent requirements for the Year 1997.

The main objectives of the Short-Term Development Plan are as follows:

1. To construct the required facilities in view of the port traffic forecast.
2. To prepare the facilities and the equipment to enhance safety as mentioned in the Master Plan.

The Short-Term Development Plan is one of the stages in the Master Plan, which is elaborated from the view of the above objectives and includes a feasibility study from the financial point of view of the port management body and an economic point of view of the national economy.

Note A feasibility study will be discussed in Chapter 16. A preliminary financial study is carried out only for the port improvement. However, an economic study is conducted for an integrated project containing the port improvement and the coastal protection.

In port improvement study, Avatiu Harbour has a priority for development in this stage because this port is the most important life line in Rarotonga. If the cargo handling in this port is stopped for a long period of time, the life of the people in this island would be adversely affected.

According to the traffic forecast, the growth of traffic up to 1997 is moderate, thus the primarily objective is to ensure the safety of port users and vessels. Another important objective is to build the fisheries sector in Avatiu Harbour as recommended in the Master Plan.

The Master Plan indicates also that Avarua Harbour should be developed as a marina by the year 2010.

In the Short Term Development Plan, the number of pleasure boats entering Avatiu Harbour exceeds the capacity of the marina, and thus the need for a marina in Avarua Harbour. The required dimension of the facility for marina in Rarotonga is estimated based on the result of the Port traffic forecast in Chapter 8 of Volume 1.

As shown in Chapter 12, the existing damaged facilities in Avarua Harbour will be reconstructed for maintaining safety of users, mostly tourists. Breakwater alignment will be also modified, not only from the coastal protection view point, but also in anticipation of large marina construction in the future.

13.1.2 Planning Premises

(1) Deep-sea Port Area

1) Cargo Handling Volume

The cargo handling volume for the deep-sea berths at Avatiu Harbour in 1997 was already forecasted in Chapter 8 of Volume 1. Table 13.1.1 shows the cargo handling volume for the deep-sea berths at Avatiu Harbour in 1997.

For details of the cargo volume forecast, turn to Chapter 8 of Volume 1.

2) The Size and Number of Calling Ships

The size of large vessels and cargo handling volume per vessel at Avatiu Harbour in 1997 will not be changed from the current situation. (Refer to Chapter 8 of Volume 1) Tables 13.1.2 and 13.1.3 show the size of the large vessels, cargo handling volume per vessels and the number of calling ships, including calling yachts, at Avatiu Harbour in 1997.

Table 13.1.1 Cargo Handling Volume for The Deep Sea-Berth in Avatiu Harbour

Year	1997		2010	
	Demestic trade Outward	International Trade Inward	Domestic trade Outward	International Trade Inward
Conventional cargo for break bulk (tons)	2400	11655	2800	11315
Container cargo (tons)	0	20800	0	25900
Liquid bulk cargo (tons)	0	13602	0	15893
Number of Container for Inward & Outward (TEUs)	0	2780	0	3460

Table 13.1.2 Maximum Size of Vessels

L.O.A.	(m)	93.0
Beam	(m)	14.0
Full Draft	(m)	6.8
D.W.T.	(tons)	3,000.0

Table 13.1.3 Number of Calling Vessels and Cargo Handling Volume per Vessel

Year	Semi-container vessel for international trade			Conventional vessel for domestic trade	
	Number of Calling vessels (Number)	Number of container per vessel for inward & outward (TEUs)	Conventional cargo per vessel for Inward (Tons)	Number of Calling vessels (Number)	Conventional cargo per vessel for outward (Tons)
1997	40	70	291	16	148
2010	50	70	171	20	148

(2) Fishing Port Area

The volume of caught fish and the number of fishing boats in 1997 were already estimated in Chapter 8 of Volume 1. Table 13.1.4 shows the volume of caught fish and the number of fishing boats at Avatiu Harbour in the target year of the Short-Term Development Plan.

Table 13.1.4 Number of Fishing Boats and Volume of Caught Fish

Year	1997	2010
Number of fishing boat (Number)	35	50 or 60
Volume of Caught fish (Tons)	170	200

13.2 Required Port Facilities

13.2.1 Deep-sea Port Area

(1) Quaywall and Storage

Confirmation of the required number of berths is made using the same methods as shown in Volume 1, as is the determination of required cargo handling facilities.

The maximum number of yachts simultaneously staying in Avatiu and Avarua Harbours in 1997 is approximately 33 yachts, 60 percent of which are moored at the south side wharf in Avatiu Harbour. The remainder of the yachts can be moored at Avarua Harbour.

Of those yachts moored at Avatiu Harbour, the draft is 1.5 meters or more while the draft of the remaining yachts is less than 1.5 meters. It is assumed that the average beam of the former is approximately 4.5 meters and the average beam of the latter is approximately 3.5 meters.

The required width of mooring per yacht in case of mooring at Avatiu and Avarua Harbour for Fig. 13.2.1 are calculated by the following formula.

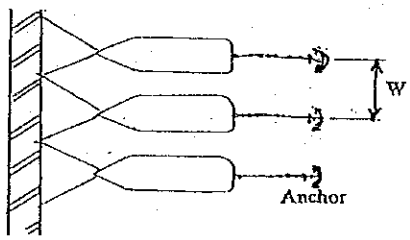


Fig. 13-2-1 Yacht Berthing Arrangement

$$W = 1.0 + B$$
$$= 1.0 + 4.5 = 5.5 \fallingdotseq 6.0$$
$$W = 1.0 + 4.5 = 5.5 \text{ ---------- Avatiu Harbour}$$
$$W = 1.0 + 3.5 = 4.5 \text{ ---------- Avarua Harbour}$$

where, W : Width of the mooring per yacht (m)

B : Beam of the yacht (4.5 m)

The results of the calculation show that the width of the mooring per yacht at Avatiu and Avarua Harbour are approximately 6.0 meters and 4.5 meters respectively.

The berth occupancy rate for large vessels at the foreign trade berth of the East wharf in Avatiu Harbour in 1997 is approximately 27 percent. So, the number of foreign Trade berth will not have to be increased in the Short Term Development Plan.

Table 13.2.1 shows the required number of deep-sea berths for foreign trade and the required container cargo handling facilities.

Table 13.2.1 Required Number of Deep-sea Berths for Foreign Trade and Container Cargo Handling Facilities

	Required number or area	Note
Number of deep-sea berth (No.)	1	Table 13.2.1 (a)
Container freight station (Sq.m)	330	Table 13.2.1 (b)
Container yard (Sq.m)	10,500	Tables 13.2.1 (c) and 13.2.1 (d)

Table 13.2.1(a) Berth Occupancy Rate of Deep-sea Berth

Year	Kind of vessels	Number of Berth	Cargo Handling Capacity prt Berth (tons/day)	Average Cargo Volume per Vessel (tons)	Number of Vessels per Year	Berth Occupancy Rate (%)
1997	General Cargo	1	391	811	40	22.8
	Tanker	1	835	972	14	4.5
	Total					27.2

Table 13.2.1(b) Container Freight Station in 1997

A	Mc	Dw	P	w	r	Dy
333.8	6,240	7	1.5	1.3	0.5	302

Where
- A: Required floor area of CFS (Sq.m)
- Mc: Annual cargo volume of containerized cargo through CFS (tons)
- Dw: Dwelling time at terminal (days)
- P: Peak ration
- w: Volume of cargo per unit area (tons)
- r: Utilization rate of CFS floor
- Dy: Operating days (days)

Table 13.2.1(c) Marshaling Yard

Am	Hc	d	Mi	P	As
5,103	1.5	0.22	70	1.6	15.0

Where
- Am: Area of marshaling yard (Sq. meters)
- Hc: Average staking height of container
- d: Utilization rate of marshaling yard
- Mi: Average number of containers handled per vessel (boxes)
- As: Area of a slot (Sq. meters)
- P: Peak ration

Table 13.2.1(d) Container storage yard in 1997

Ay	M	Hc	d	As
5,430	119	1.5	0.22	15.2

Where
- Am: Required area of container storage yard (Sq. meters)
- M: Required storage number of containers (TEU)
- Hc: Average staking height of container
- d: Utilization rate of marshaling yard
- As: Area of a slot (Sq. meters)

The present deep-sea quay wall at the East wharf in Avatiu Harbour will have to be repaired in the Short-Term Development Plan stage because there are many chinks and openings under the water surface on the concrete sheet pile of the deep-sea quay wall.

As mentioned in Section 8 of Volume 1, large calling vessels have to use a tugboat for entering and turning. The required width of the basin in front of the deep-sea wharf in case of using a tugboat is approximately 140 meters. Fig. 13.2.2 shows the berthing process in case of the mooring head out.

Already mentioned in the Master Plan, the transit sheds currently used in Avatiu Harbour do not need to be expanded in the Short-Term Development Plan because the cargo volume of foreign trade and domestic trade will not greatly increase in the Short-Term Development Plan stage. At present, the transit sheds have enough room for both sorting and storage.

According to Table 13.2.1, the required space of the container freight station (CFS) in 1997 is approximately 330 square meters, which is smaller than at present. It is estimated that the age of the present CFS will be only 5 or 6 years old following construction. Therefore, the present CFS will be able to continue functioning over the target year of the Short-Term Development Plan. The present CFS will be used past 1997 after moving it to a suitable position of the layout in the Short-Term Development Plan.

(2) Equipment

The following equipment will be required in the Short Term Development Plan:

Vessel's maneuvering	:	1 Tugboat (350 HP)
Navigational Aids	:	1 Buoy (to indicate the boundary between the deep-sea area at commercial port and the shoal area at the fishery port)

Fig. 13.2.2 Vessel Turning Pattern and Required Turning Basin

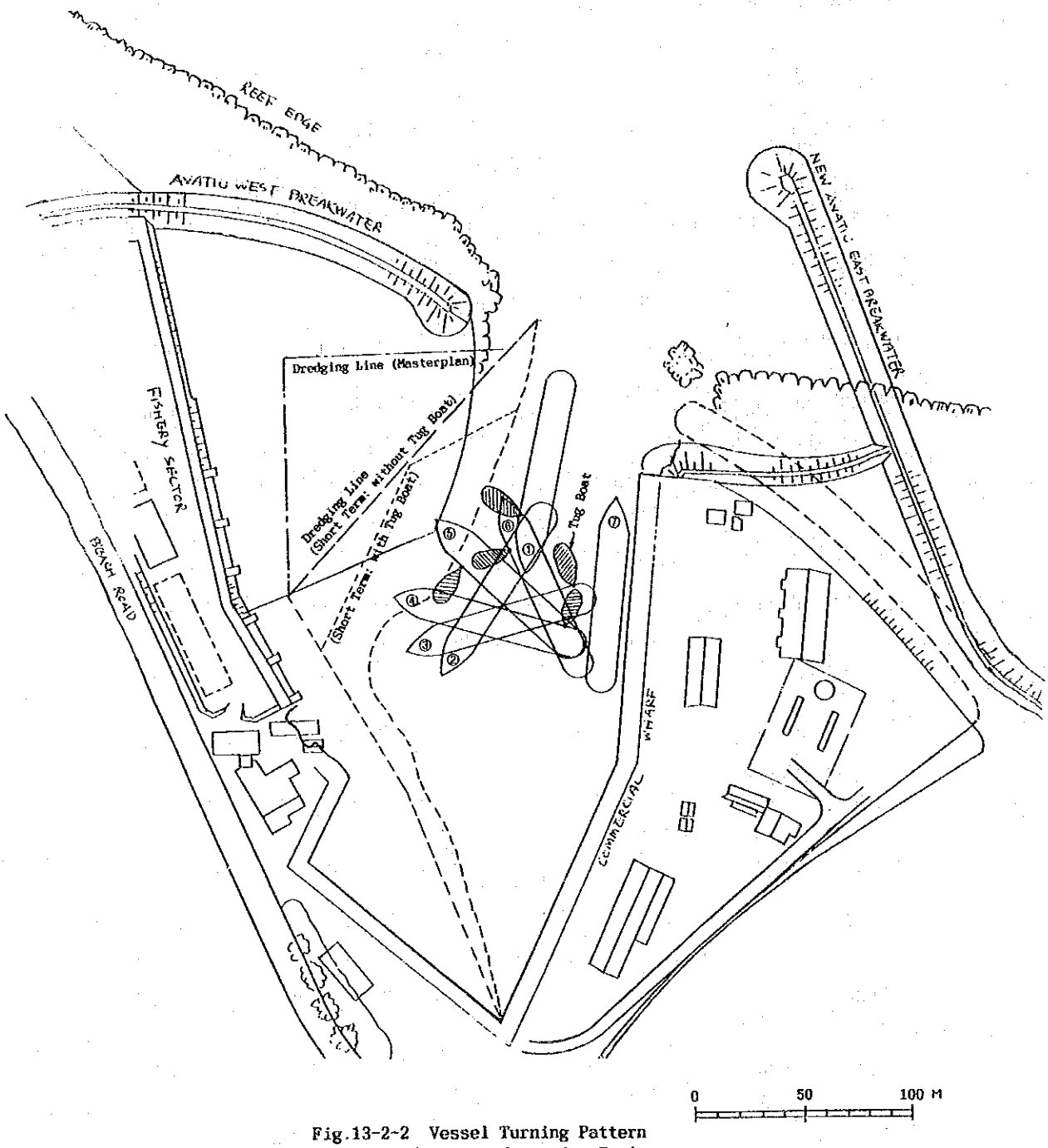


Fig.13-2-2 Vessel Turning Pattern and Required Turning Basin

Container handling	:	2 Large forklift (20 tons) 1 Tractor-trailer (for transportation between the marshaling and storage yard and between the alongside and the marshaling yard)
Conventional cargo handling	:	1 Forklift (2.5 tons for use on board) 1 Forklift (5 tons for around opeartion use)

A forklift (2.5 tons) is used for both container cargo handling in CFS and conventional cargo handling. Conventional cargo handling equipment is used for both foreign trade and domestic trade.

13.2.2 Fishing Port Area

The difference in volume of the caught fish between the Short-Term Development Plan in 1997 and the Master Plan in 2010 is not large. The number of fishing boats at Avaitu Harbour in 1997 is the same total number of fishing boats at Avatiu and Avarua Harbours as at present.

Therefore, the landing wharf, the lay-by wharf and the marketing hall will have to be constructed at Avatiu Harbour considering the number of fishing boats at present as per the policy of the Master Plan. The length of the landing wharf and lay-by wharf are 30 meters and 160 meters respectively which were determined using the same method as in Chapter 8 in Volume 1.

The depth of the wharf is 1.5 meter. The scale of the marketing hall is 200 square meters which is the same scale used in the Master Plan.

The current distribution system of caught fish will not change in the stage of the Short-Term Development Plan because the volume of caught fish in 1997 will not differ greatly from the current volume; also, the period between the completion time of this study and the target year of the Short Term Development Plan is only five years.

The scale of the ice plant will not have to be changed from resent scale in the Short-Term Development Plan.

At present yard for fishery sector is very limited. There is no space around the existing office of Marine Resources in Avatiu Harbour. In order to improve this situation, it is proposed to reclaim land between the existing slipway and West breakwater. This area can be utilized for:

a. fish marketing hall
b. new fishery office
c. ice plant
d. car parking
e. boat repairing

The retaining wall for reclamation can be partly utilized as tentative landing and lay-by wharfs. If all fishing boats can berth at the fishery sector in Avatiu Harbour West, management of the fishing port will be much easier and more economical.

13.2.3 Breakwater

(1) Avatiu Harbour

East breakwater will be expanded to create a longer sheltered approach channel keeping the stopping distance for calling vessels. West breakwater will be rehabilitated to protect not only commercial sectors but also fishery sector against cyclone waves.

West side area of Avatiu Harbour (the fishing port area in the Master Plan) will be partly improved in the Short-Term Development Plan. Therefore, the length of the East breakwater can be reduced to 280 meters from 310 meters in the Master Plan. Details of the breakwater arrangement are mentioned in section 13.6.

(2) Avarua Harbour

East breakwater will be expanded for maintaining a calm inner basin for small boats. This breakwater will be part of the retained seawall in the area behind the east side of Avarua Harbour.

West breakwater will be maintained as it is except its head.

Table 13-2-1 (e) Dimension of Fishing Boat

GT (TONS)	L.O.A (M)	Breadth (M)	Draft	
			Max (M)	Mini (M)
1	7	1.8	1	
2	8	2.2	1.2	
3	9	2.4	1.4	
4	10	2.6	1.6	
5	11	2.8	1.8	
10	13	3.5	2	1.9
20	17	4.3	2.2	2.1
30	20	4.7	2.5	2.3
40	22	5.2	2.7	2.5
50	24	5.5	2.9	2.6
100	30	6.5	3.7	3.2
150	35	7.2	4.2	3.5
200	4	7.6	4.6	3.8
500	55	9.4	5.9	4.5

Souce: Japanese standards.

Table 13-2-1 (f) Relation Between Area of Icemachine Building and Capacity of Icemachine

Capacity of icemachine (tons/day)		1	3	5	10	20	30	50	100
Capacity of storage room of ice(tons)		60	180	300	600	1100	1500	2000	3000
Area of icemachine building (sq.meter)	Icemachine room	24.8	48.4	69.4	86.6	178.2	231.0	376.8	762.4
	Storage room of ice	26.4	72.0	100.7	178.2	290.4	396.0	534.6	772.2
	Machinery room	-	23.1	33.0	49.5	79.2	66.0	89.1	138.6
	Electric supply room	-	-	-	-	-	-	19.8	33.0
	Office	-	9.9	12.4	24.8	46.2	39.6	62.8	52.8
	Others	3.3	11.6	12.4	19.8	33.0	59.4	76.3	161.7
	Total	54.5	165.0	217.9	358.9	627.0	792.0	1,148.4	1,910.7

Souce: "Gyokou keikaku no Tebiki", 1980

13.3 Operation and Management

This section deals with the operation and management for port and fishery.

13.3.1 Current Operation and Management

(1) Introduction

The Cook Islands comprise 15 islands which are classified as the North Group and the South Group.

In all islands except Rarotonga, Penrhyn and Suwarrow, loading/ unloading operations are carried out at anchorages outside the coral reef. Avatiu Harbour in Rarotonga serves as the ocean port for export/import activity and the distribution port for the remainder of the Cook Islands. Penrhyn, the biggest atoll of the Northern Group, has a well protected anchorage within the lagoon for coasters. Suwarrow harbours no economic activity but coasters can enter the lagoon and find safe anchorage.

Avatiu Harbour is the principal port, handling calls from vessels of the Shipping Company of New Zealand (SCNZ) and previously from the Hawaiian Pacific Line. It is also the base for inter island shipping among the Cook Islands operated by Silk & Boyd Ltd. and other private operators.

Avarua Harbour is utilized for fishing boats and pleasure boats.

The Government of the Cook Islands has a plan to allocate Avarua Harbour as a port for small craft since the fishery complex is planned at Avatiu Harbour in the near future. This arrangement is supported by the Master Plan.

(2) Port Administration

1) Organization of Ministry of Trade, Labour and Transport.

Responsibility for the construction, management and operation of the harbour rests with the Ministry of Trade, Labour and Transportation (TLT).

The TLT is composed of five divisions and also includes a Waterfront Commission.

The organization chart of TLT is shown in the following figure.

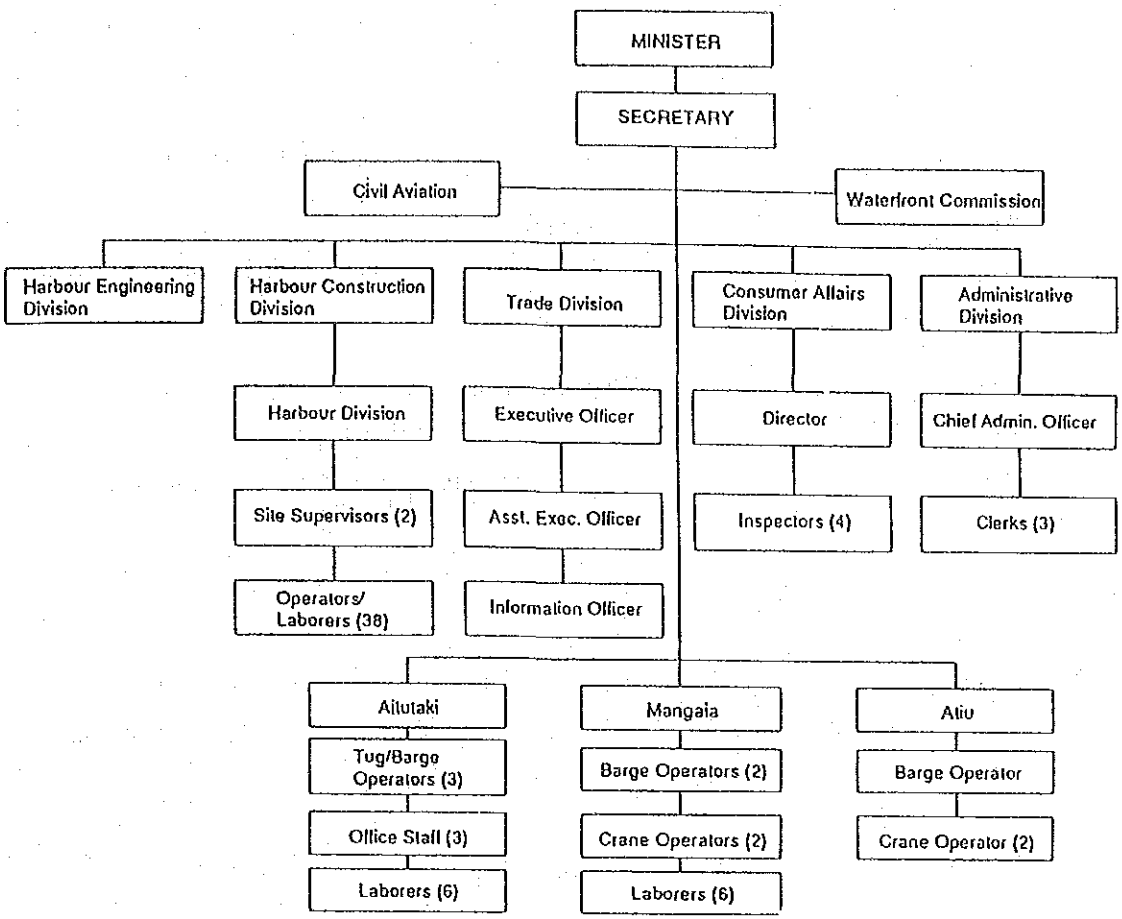


Fig. 13.3.1 Organization Chart of TLT

2) Organization of Waterfront Commission

The Waterfront Commission was established, following the passage of the Waterfront Industry Act, to take over the role vacated by the Union Steam Ship company of port administration, management and operations within the Cook Islands, but primarily for Avatiu Harbour in Rarotonga.

The Commission, set up as an Ad-Hoc Government Body, controls, regulates and levies fees and charges for all port users.

The Board of Commissioners consists of five members, two of whom are retired officers; the chairman who is also Secretary for the Department of Trade Labour & Transport. The Harbour Master and the other members are selected from both private and public sectors by ministerial appointment.

The commission offers comprehensive service to ship operators, importers and exporters, encompassing agency, stevedore, storage (Reefer/dry) and talley clerk functions.

The operations of the Commission are totally self-funded and independent of government finance. Assistance is occasionally sought from aid donor countries for capital development and purchasing.

(3) Other related organization (Marine Resources)

Responsibility for the management and development of the fishery port, fish aggregating development, shell fish farming and related research is borne by the Ministry of Marine Resources.

The organization chart of Marine Resources is shown in the following figure.

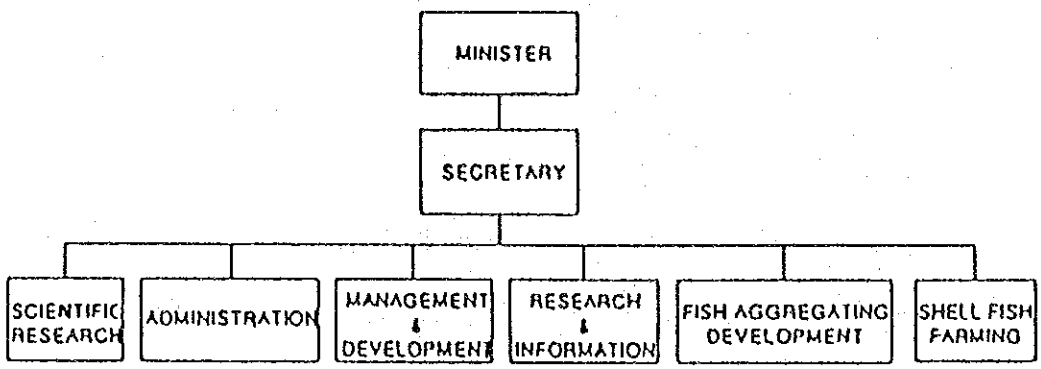


Fig. 13.3.2 Organization Chart of Marine Resources

(4) Port Operation

1) Shipping

International Shipping

International shipping operations for general cargoes into the Cook Islands are mainly provided under a Joint Shipping Services agreement between New Zealand, Niue and the Cook Islands. Under this agreement, two vessels, Aotea Link and Ngamaru III, are currently operated. Another vessel, Urte, was operated by a Hawaiian shipping service in 1991.

The schedules and the routes of those three vessels are shown in Table 8-2-1 in Volume I.

Of the three vessels, Aotea Link and Urte mainly transport containerized cargoes, though they are not full-container ships.

In addition to the above vessels, tankers operate at irregular intervals. Pacific Rover and Pacific Explorer are principally used for the transportation of liquid petroleum products from Lautoka (Vuda Point) Fuji, and Coral Gas for the transportation of LPG from Fiji. Particulars of the vessels are given in Table 8-2-2 a) and Table 8-2-2 b) in volume I.

Since the nominal depth of Avatiu Harbour is 6.2 m below M.S.L., vessels having more than a 5.5 to 6 meter full draft must be controlled before port entry into the harbour. Cargo vessels cannot enter the harbour in a fully loaded condition.

Recently, the composition and number of ships calling at Avatiu Harbour has shown the following tendencies: (1) number of pleasure boats is increasing rapidly, (2) number of cargo vessels is increasing gradually, (3) number of the oil tankers is decreasing gradually or remaining almost constant.
Fig. 8-2-1 in Volume 1 shows the number of ship calls at Avatiu Harbour form 1985 to 1991 (up to September).

The quay wall on the South side at Avatiu Harbour is used by small fishing boats and pleasure boats excluding large yachts. The large yachts are moored at deep-sea berths on the East side of Avatiu Harbour. The widths of the entrance channel and the turning basin at Avatiu Harbour are about 30 meters and 130 meters respectively, which are too small for large vessels that presently call. Avarua Harbour is used only by small pleasure and fishing boats. Figures 8-2-4 and 8-2-5 in Volume I shows the current plans of Avatiu and Avarua Harbours.

Inter-Island Shipping

Regular inter-island shipping services are provided by Cook Islands Shipping & Development Co. Ltd., using Manava II (approx. 400 G.T.).

Additionally, because no regular ferry or passenger boats are presently servicing the Cook Islands, passengers are transported by the above-mentioned inter-island vessel when need arises.

According to Fig. 8-2-1 in Volume I, more than 50 % of the total number of ship calls is accounted for by pleasure boat, mainly small cruisers and yachts. Those pleasure boats are principally moored at the cargo wharfs in Avatiu Harbour and moved as requested when a cargo ship arrives. It is undesirable to utilize the harbour for the above purposes as the number of calls for pleasure boats is expected to increase in the future.

Four large passenger ships called at Avatiu Harbour in 1991 (up to October), but could not enter the harbour due to a shallow depth basin and passengers were transported by shuttle boats to a wharf. In this case, a passenger intentionally or unintentionally avoids staying in the Cook Islands.

2) Cargo Handling

Overseas Cargo (Import and Export)

Imports from overseas, mainly from New Zealand, but also from Japan, Southeast Asia and Pacific ports (Fiji, Western and American

Samoa, Tahiti), are for consumption in Rarotonga or transshipment to the outer islands.

Cargo volume handled in 1990 in Avatiu Harbour was recorded at approx. 39,200 freight tons. Recently (1988 to 1990), total cargo volume handled has been increasing steadily, though the volume is still below its 1987 level.

The cargo volume handled in a recent 5-year period is shown in Fig. 8-2-2 of Volume I. Main imported commodities are foods, construction materials, motor vehicles/parts and petroleum products. Among these commodities, petroleum products such as gasolene, diesel oil, aviation gas and LPG etc. are increasing annually, excluding the year 1988 after Cyclone Sally attacked the Cook Islands.

Most cargoes are well containerized except liquid fuel and construction materials that are long and heavy such as cement, steel bars and plates, plywood etc. The cargo volume handled and ratio of containerization by main commodities are shown in Table 8-2-3 of Volume I.

All these cargoes are handled by the Waterfront Commission under control of T.L.T.

Domestic Cargo (Inward & Outbound)

Cargoes to and from the outer islands are all non-containerized. Inward cargoes are mainly agricultural produce and empty fuel drums either from local consumption or transshipments to overseas ports mainly from Aitutaki and Mangaia. Outbound cargoes are mainly fuel, construction materials and equipment, fertilizer and agricultural supplies, foods and beverages.

Outward cargo volume has been consistently recorded at approx. 2,000 to 2,200 freight tonnes in the last few years.

Other Services

Other vessels calling at Avatiu Harbour are:

a) Pacific Navigator - Pacific Rover and Pacific Explorer. These vessels are operated by Mobile Oil and deliver bulk fuel from Fiji. They call at Rarotonga about every four weeks on average.

b) Coral Gas. This vessel is operated by Boral Gas limited and provide bulk delivery of liquid propane gas about every 6 months.

c) A joint service, called the Bali Hai Service operating Pacific Islander and South Islander on a similar route to the Kyowa Line ships, calls at Rarotonga approximately every two months. The joint service was introduced in August 1981 and is provided by a consortium of the NYK Line, China Navigation Company Ltd. and Mitsui OK Lines Ltd. Both this service and that of the Kyowa shipping Company discharge cargo in Rarotonga which comprises items such as motor vehicles and accessories, electronic and household goods, clothing and textiles and some food stuffs.

d) In Avatiu Harbour, there are some fishery facilities under the control of Ministry of Marine Resources. Therefore, in the harbour, cargo vessels and some small fishing crafts are intermingle.

The ministry of Marine Resources has an idea to expand facilities and further the growth of the fishing industry.

(5) Current State of Port Management

As mentioned before, the port is managed by TLT and WFC. The TLT is mainly responsible for the construction of harbors and the WFC is in charge of stevedoring.

The TLT collects no specific revenues from port operations; sometimes maintenance work can't be conducted because of budget limitations.

The WFC generates revenues mainly from its stevedoring, wharfage, storage and equipment hire operations.

However, as is the case with most small developing ports, revenues generated are insufficient for planned upgrading and replacement of various capital items.

The three inescapable facts of life for this port are:

(i) Lack of cargo volume and the resultant lack of revenue,

(ii) Stemming from the above, the lack of financial resources needed for major upgrade and capital development of the port.

(iii) Operational overhead caused by the overlapping of organization and other expenses.

As for item (iii), the TLT is examining the possibility of adopting new functions to reduce overhead and to enhance port operation/management.

Table 13-3-2 shows the annual budget of TLT, and table 13-3-3 shows the profit/loss statement of the WFC.

13.3.2 Recommendation on current problems of port operation and management

1. Operation

To ensure safe and smooth operations of Avatiu Harbour the following countermeasures are recommended:

1) Breakwater

Alignment and Length

Because of the short breakwater, waves and swells can easily enter the port.
In such conditions, it is too dangerous to load or unload containers, so, as a result, the operation is obliged to stop.
Additionally, though it is not a recommended practice, there have been attempts to discharge containers onto trailers using ship's gear, sometimes causing serious damage to them.

Table 13-3-2 Annual Budget of TLT

Division	1991 - 1992 (ESTIMATE) Expenditure	Revenue	Balance	1990 - 1991 (Actual) Expenditure	Revenue	Balance
Administration	162,700			228,300		
Labour & Consumer Affairs	97,400	42,600	54,800	101,300	34,300	
Shipping	8,100	43,000		229,100	52,600	
Harbour Administration	359,500	34,000		391,400	36,900	
Small Business Advisory Unit	102,100	-		-	-	
Harbour Construction	138,700			275,700	-	
Trade & Commercial Development	134,100	183,000		163,500	230,900	
Harbour Engineers Div.	53,000			60,000		
Maritime Services	78,200			104,900		
AITUTAKI	133,700	21,200		182,900	18,700	
PENRHYN	34,100			44,000		
ATIU	65,400	12,000		82,700	300	
MANGANTA	108,200	85,000		153,900	10,600	
TOTAL	1,548,100	333,500		2,017,700	384,300	

Table 13-3-3 Profit and Loss Statement of Waterfront Commission

WATERFRONT COMMISSION PROFIT AND LOSS STATEMENT FOR THE YEAR ENDED 31 MARCH 1990	1990 S	1989 S
REVENUE		
Stevedoring	418,389	394,295
Storage	14,254	28,353
Wharfage	91,600	86,694
Forklift	39,471	38,468
Agency & Others	21,028	31,447
Other Revenue	35,217	32,349
Harbour Dues	6,515	7,152
Interest: National Bank NZ	-	14,204
Westpac Raro	-	3,087
TOTAL REVENUE	S626,474	S636,049
OPERATING EXPENSES		
Cost of Labour	292,841	259,236
Stevedoring	42,053	29,134
Repairs & Maintenance	20,946	6,511
Other Expenses	36,048	18,993
TOTAL OPERATING EXPENSES	391,888	313,874
ADMINISTRATION EXPENSES		
Commissioners Fees	4,150	6,700
Turnover Tax	39,694	31,487
Staff Wages/Salaries	96,024	76,466
General Office Expenses	12,704	9,395
Insurance/Compensation	19,014	17,902
Printing Stationery	9,906	2,620
Telecommunications	21,680	17,201
Travel/Accommodation	62,830	37,514
Legal Fees	8,917	3,730
TOTAL ADMINISTRATION EXPENSES	274,919	203,015
TOILET EXPENSES		
Wages - Cleaners	5,400	5,436
Repairs & Maintenance	-	81
Electricity	323	165
Supplies	2,525	1,731
	8,248	7,413
Depreciation	30,450	23,383
Loss on Disposal	8,993	-
TOTAL EXPENSES	714,498	547,685
NET LOSS FOR THE YEAR	($88,024)	S88,364
PLUS EXTRAORDINARY ITEM		
Insurance Recoveries	-	33,622
PROFIT AFTER EXTRAORDINARY ITEM	($88,024)	986

Moreover, because of the short approach channel and narrow basin, it is often difficult for ships to enter. According to the information obtained through interviews, when the wave direction runs counter to wind direction, it is more difficult and dangerous to enter port.
Therefore, a ship's stopping distance should be lengthened and the basin should be protected as much as possible by means of extending the breakwater.

Type of Structure

The current structural type of breakwater is rubble mound type. This is primarily because the procurement of stone material is relatively easy in the island and the construction work with it is also easy.
However, taking into account the damage inflicted by cyclones, the cross-section of the breakwater should be larger than before, especially at the tip of the breakwater.

2) Cargo handling yard

Determination of Working areas for heavy forklift

The waterfront commission has one forklift truck 25 ton capacity. It is suitable for pick up, transport over short distances, loading and stacking, preferably not more than two high.

However, it exerts high loads (front wheels) on the pavement. Therefore, it is advisable to keep the truck movements and travel distances to a minimum and restrict its movements to the designated paved areas only, especially when it is carrying a full load. Additionally, occasional 40ft containers (30.5 tons gross weight) should be unloaded and stripped at a designated quay apron.

Pavement of Operation Area

Although part of the operational area was paved with concrete, the rest of the handling yard was sealed bitumen.
It is recommended to pave the whole handling area with concrete because under the muddy and dusty conditions during rainy/windy situations, operating conditions can be very hazardous, eg. poor visibility, especially while moving containers using the 25t forklift truck.

As for the type of pavement, though asphalt pavement is generally recommended, concrete pavement should be used because of aforementioned reasons. The following areas should be paved.

- Wharf apron
- Maintenance shop area
- Loading point of containers

3) Equipment

Pontoon

Primary requirements include undertaking capital and maintenance dredging works at Avatiu Harbour.
Other requirements include future dredging work of Avarua and Ngatangia Harbours.

Additionally, the pontoon can be used for transiting heavy equipment and materials to the outer islands (e.g., Aitutaki, Managaina, Penrhyn).

Dredger

The acquisition of a small dredger might be considered to carry out major dredging works such as those proposed in the Master Plan.
However, the following points should be taken into consideration:

- small volume of dredged material
- high maintenance cost of dredger
- special training requirements
- Government budget limitation

The existing dredging method by TLT using a pontoon and crane on top would seen to be more suitable from an economic point of view.

2. Organization

Establishment of Port Authority

As aforementioned in "Current State of Port Management" section, to reduce overhead and enhance port operation/management, the establishment of a port authority is recommended.

The body should be streamlined with a view to maintaining high efficiency, though we can't avoid the aforementioned primary problems, such as lack of cargoes, and financial problems.
Therefore, from this point of view, the port management body may be separate from the existing organization.

The new organization chart examined by the team is shown in Fig. 13-3-3.

Further examination will be required by the Government based on the proposed chart.

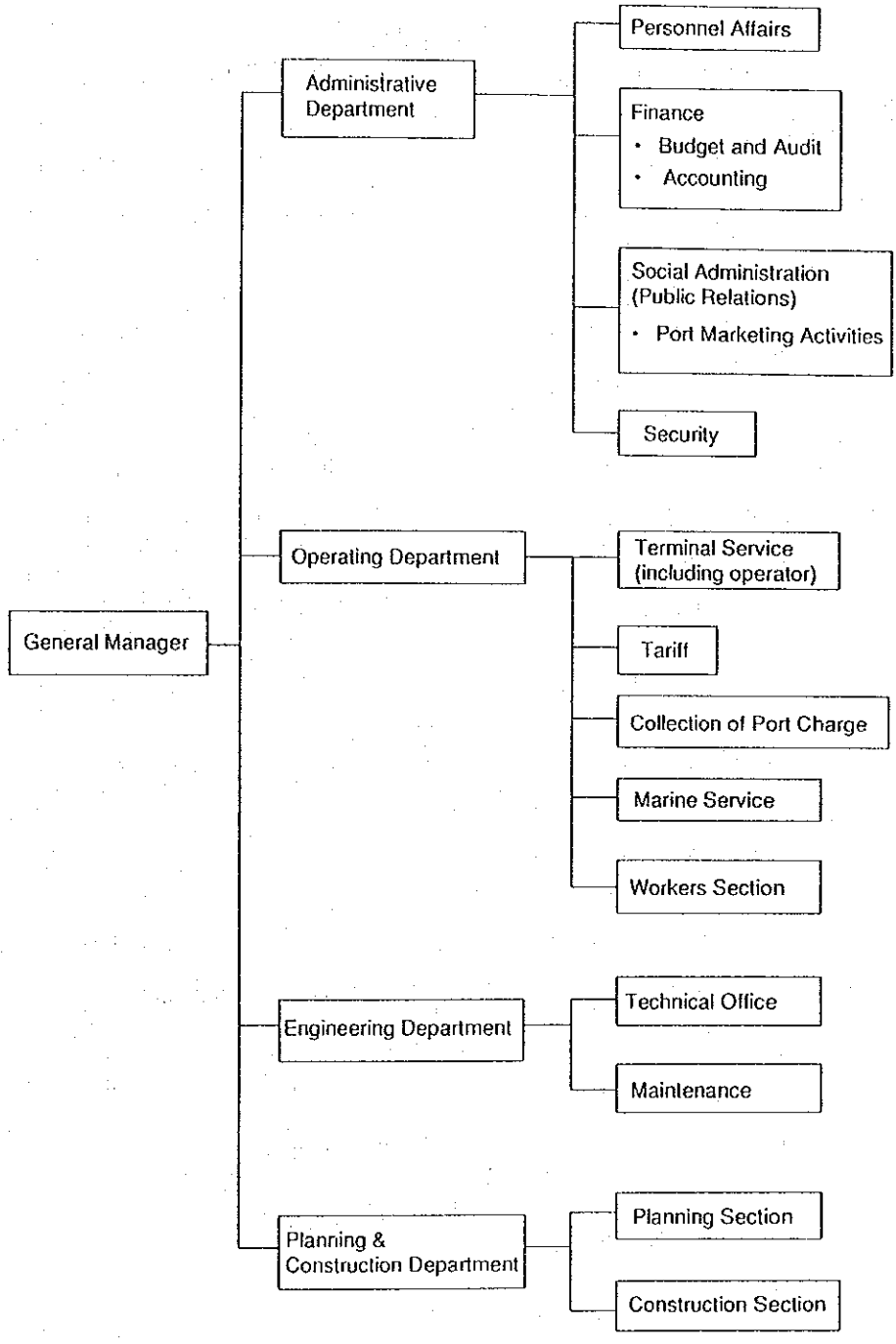
The Administrative Department is responsible for managerial and administrative affairs. The Operating Department is responsible for actual port operation, and the Engineering Department is responsible for the actual port operation and maintenance of equipment. The Planing Department is responsible for port planning, business planning and construction.

The main tasks of the port management body will be as follows:

- Maintenance and utilization of port facilities
- Provision of service like the tug service, etc.
- Supervision of daily port activities
- Port marketing activities

In the case of a new port, port marketing activities will be necessary for the purpose of attracting users, particularly at the initial stage. Ports grow primarily from the efforts of private companies, but port marketing activities by the port management body are also very important.

Fig. 13.3.3 Organization Chart of Proposed Port Management Body



13.4 Proposed Port Layout Plan

13.4.1 Avatiu Harbour

The Layout of the Short-Term Development Plan is a one of the stages to be completed by 1997 as part of the Master Plan. Therefore, the layout of the Short-Term Development Plan is determined based on the layout of the Master Plan considering the objective of the Short-Term Development Plan and the demand for facilities in 1997. Viz., the function of fishing port and commercial port are arranged at the West side and the East side in Avatiu Harbour respectively. The large foreign yachts will be moored at the south wharf where the depth is -4.0 meters.

Already mentioned in the Master Plan, the LPG tanks should be moved form the center of the port to outside the port area. But, according to the contract between the Cook Islands government and the owner of the LPG tanks, the LPG tanks can be moved only with the consent of the LPG tanks owner. Therefore, if consent isn't granted before beginning of the construction works for the Short-Term Development Plan, the LPG tanks can not be moved from their present location.

Taking this into consideration, two alternative layout plans of the East wharf are proposed in the Short-Term Development Plan.

Fig. 13.4.1 shows the alternative layouts of the Short-Term Development Plan for Avatiu Harbour. In Case - 1, the LPG tanks are moved outside the port area and in Case - 2, the LPG tanks stay at the center of Avatiu Harbour. The central area of the container yard at the East wharf which is used for international trade, is currently occupied by the LPG tanks. This not only obstructs international cargo handling operation but also forces a portion of the open yard behind the domestic berth which is designated for domestic trade, to be used for international trade. So, Case - 2 is not suitable for cargo handling operations. Therefore, it is judged that Case - 1 is better than Case - 2.

13.4.2 Avarua Harbour

Already mentioned in Section 13.1, in the Short-Term Development Plan, Avatiu Harbour has a priority for development in this stage because this port is the most important life line in Rarotonga.

However, the marina will have to be constructed at the East side in Avarua Harbour in the Short-Term Development Plan, because the number of pleasure boats entering Avatiu Harbour exceeds the capacity of the marina, and thus the need for a marina in Avarua Harbour.

The dangerous points for the user at Avarua Harbour, for example, the broken slab at the quay wall, will be repaired in the Short-Term Development Plan.

The East breakwater will be relocated based on the Master Plan from the both point of views of the coastal protection and port improvement. Thus, the East breakwater will lengthen by 70 m northward. However this length is about 60 m shorter than the Master Plan, since marina development in this stage is limited at the East wharf. The layout of the Short-Term Development Plan is shown in Fig. 13.4.2.

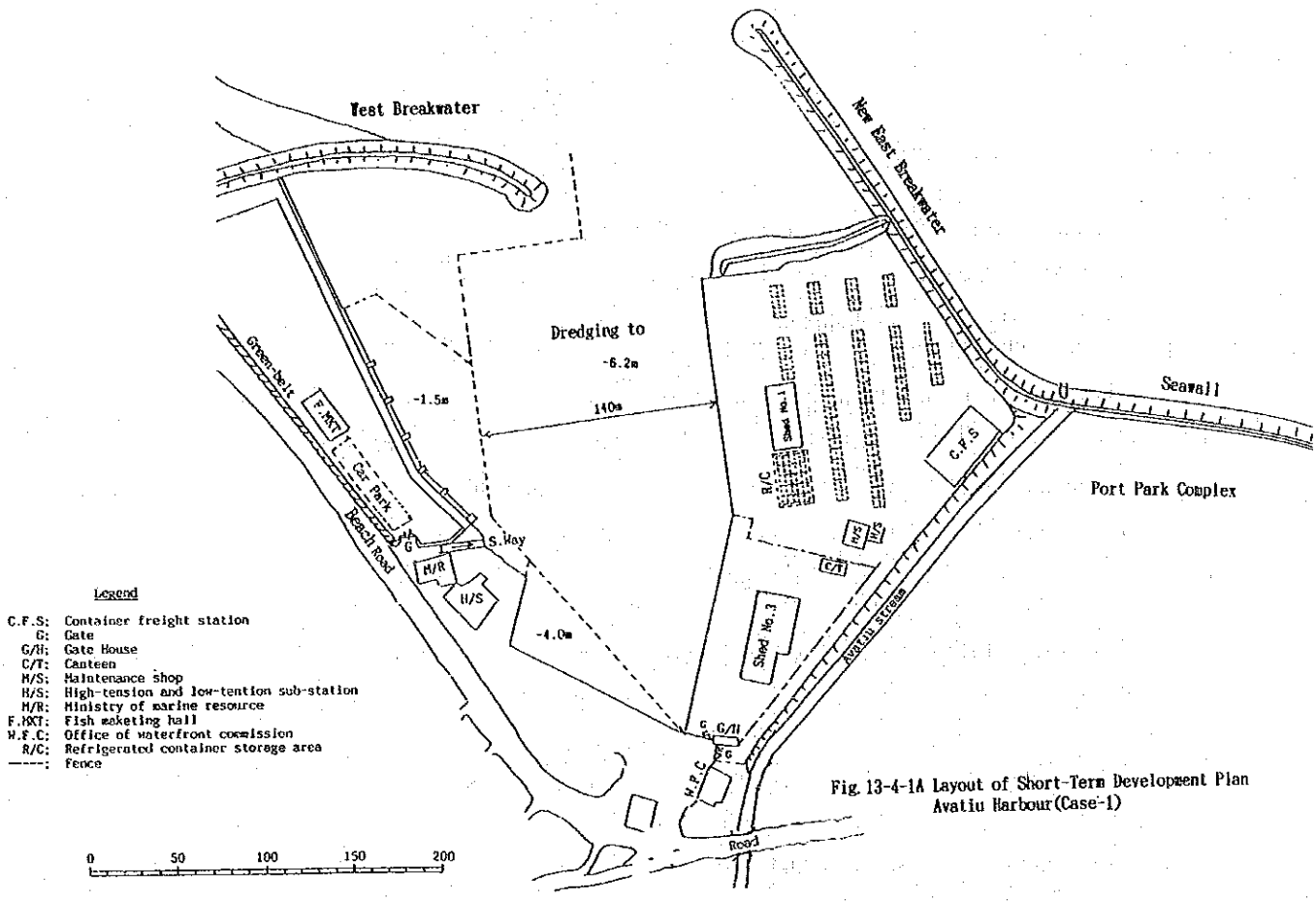


Fig. 13-4-1A Layout of Short-Term Development Plan
Avatiu Harbour(Case-1)

Fig. 13.4.1 A Avatiu Harbour Short-term Development Plan (Case-1)

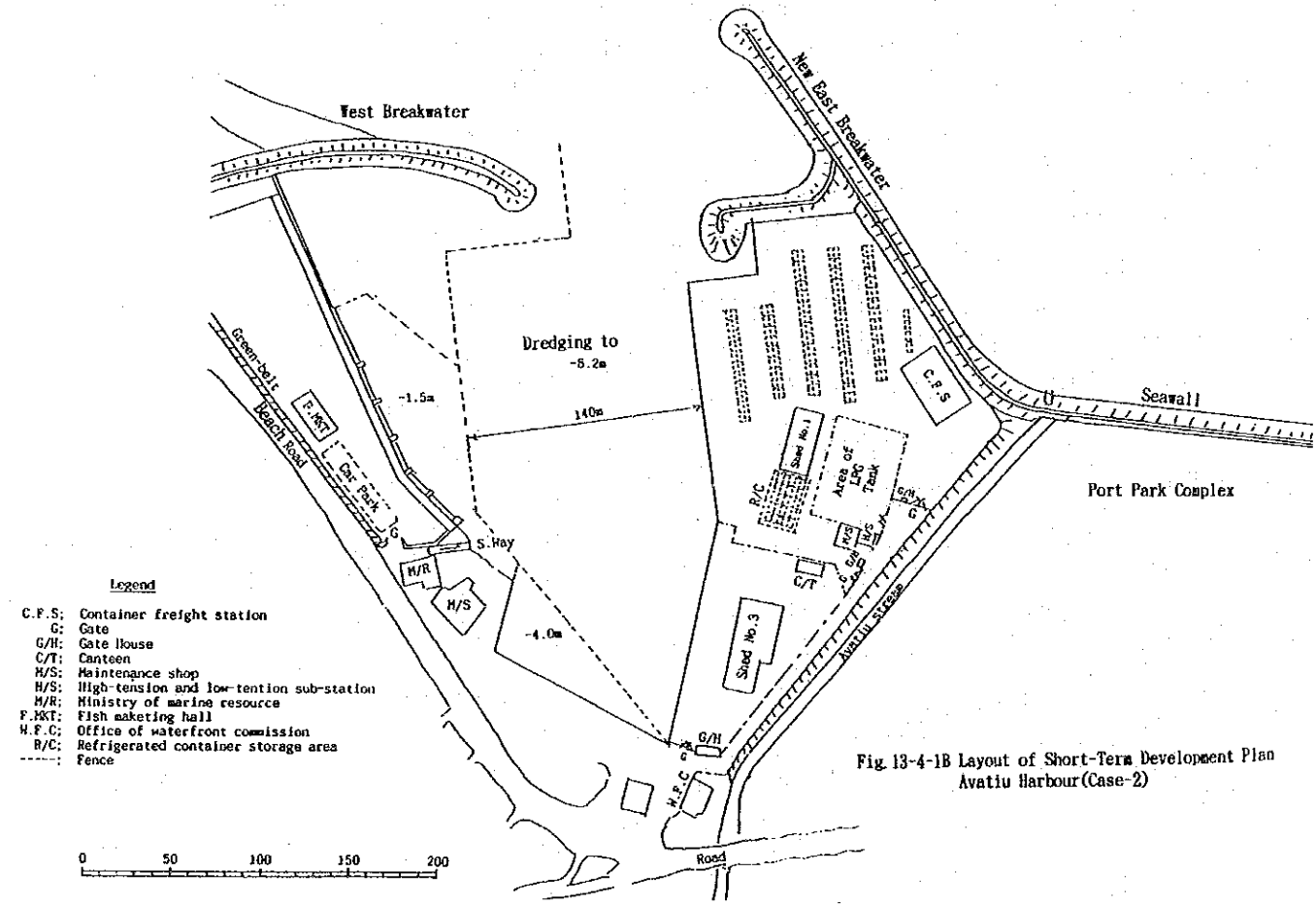
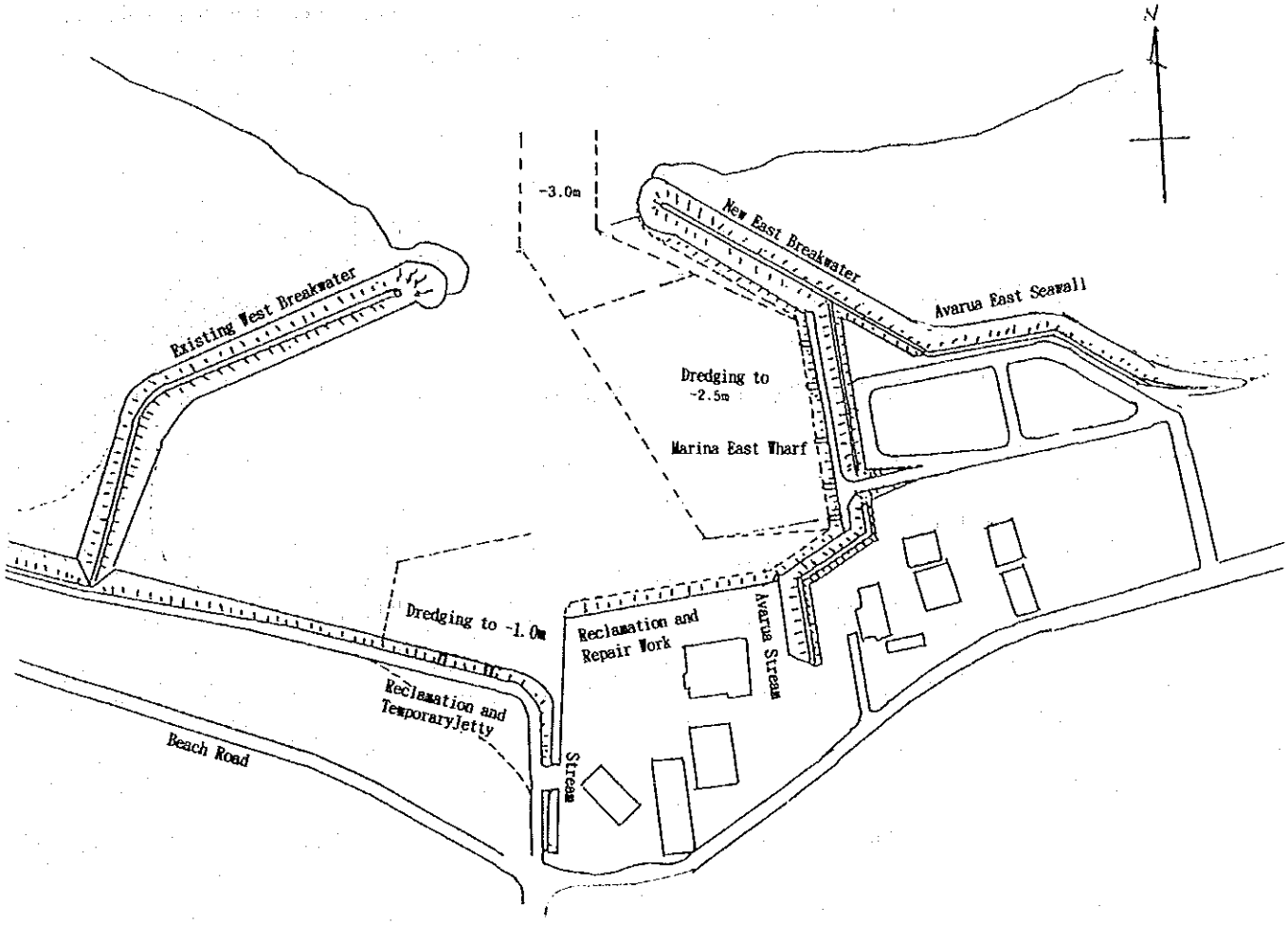


Fig. 13-4-1B Layout of Short-Term Development Plan
Avatiu Harbour(Case-2)

Fig. 13.4.1 B Avatiu Harbour Short-term Development Plan (Case-2)

Fig. 13.4.2 Avarua Harbour Short-term Development Plan



13.5 Design Criteria

Design criteria for the port improvement study are basically the same as those for coastal protection which were mentioned in section 12.2 "Design Criteria (for coastal Protection)". However, necessary descriptions will be repeated in this section together with particular conditions to design of port facilities.

13.5.1 Natural Conditions

1) Tides

All levels in survey data and section are related to a datum of mean sea level (MSL), however MLWS should be a datum for determine required water depth for vessel berthing and anchorage.

HAT	+ 0.7	
MHWS	+ 0.4	
MHWN	+ 0.2	
MSL (= DL)	± 0.0	• Survey and Drawings
MLWN	- 0.2	
MLWS	- 0.4	• Design of required water depth for vessels.
LAT	- 0.5	

2) Wave

a) Deepwater Wave off the norhtern coast (Significant Wave by Sally)

N 6° W

Ho = 8.1 m

T = 12.5 sec

Lo = $1.56T^2$ = 244 m

Shoaling deformation of deepwater wave should be based on the results of refraction diagram as shown in Fig. 8-6-1 and computer simulation as shown in the Fig. 12-4.

b) Wave for structural design of breakwater

Its is recommended to adopt propagating wave at breakwater location for design wave to determine the required armour rock weight by the Hudson formula. Design wave should be larger one between wave in subsection 8.6.1 and Fig. 12-4.

Note; In this report, two type of shoal water waves are estimated namely, computer simulated waves as showing in Fig. 12-4 and calculated waves by conventional means using the existing table and diagram as shown in subsection 8.6.1. The former considers affect of return current through the passage against incoming waves. The latter, however, ignores it. As a result, wave in the passage by conventional way is larger than simulated wave.
Although the simulated ones meet well with actual wave, it was judged that conventional ones are preferable to the design wave taking structural stability into consideration. Fig. 13-5-1 shows both waves at the centre of existing Avarua Passage, namely simulated wave and conventional wave.
Comparison on these two wave groups at Avarua Passage is shown in Table 13-5-1.

Table 13-5-1 Wave Height Comparison at Avarua Passage

Location	Simulated A (m)	Conventional B (m)	Ratio B/A	Distance from new breakwater (m)
Head of new east breakwater	2.7	3.5	1.28	±0
Reef edge (Point E)	3.9	4.9	1.25	50 m
120 m off reef edge (Point F)	6.0	7.4	1.23	170 m
Offshore (-50 m)	8.1	8.1	1.00	500 m

Note: Ratio B/A at head of new east breakwater is assumed by the study team.

Similar to the Avarua Passage, comparison of waves at Avatiu Passage is shown in Table 13-5-2.

Table 13-5-2 Wave Height Comparison at Avatiu Passage

Location	Simulated A (m)	Conventional B (m)	Ratio B/A	Distance from new breakwater (m)
Head of new east breakwater	3.6	4.6	1.28	±0
Reef edge (Point E)	3.2	4.1	1.28	-70 m
120 m off reef edge (Point F)	4.0	5.1	1.28	50 m
Offshore (-50 m)	8.1	8.1	1.00	500 m

As seen here, conventional waves show large intensity than simulated ones which may provide more real figures.

3) Water Level

(Astronomical tide MHWS)		(by Air drpression rise)		(Wave Set-up)
MSL + 0.40	+	0.30	+	(as shown in Fig. 12-5)

Refer to subsection 12.2.1.

4) Current

Tidal current in front of Avarua reef during the normal condition is 0.2 ~ 1.0 knots.

Coastal current during the cyclone should be based on the simulated data as shown in Fig. 13.5.2. Typical currents are as follows;

Near the beach front	0.5 m/sec
Near the reef	1.0 m/sec
In the passage	1.5 m/sec

5) Sub-soil Conditions

Soil condition in the lagoon is given in subsection 12.2.1. This paragraph deals with section of both passages, Avarua and Avatiu. Fig. 13-5-3 shows section of two passages and Fig. 13-5-4 shows location of sections.

Hard coral base appears -2 m to -7 m below seabed surface. No ground settlement by reclamation will be taken into consideration. Hard base is covered by coral sand depth of which layer changes place by place.

13.5.2 Structural Conditions

1) Materials

General conditions of the materials to be used for port improvement work are listed hereunder:

• Rocks, stones, gravel specific gravity	:	g = 2.65 Material sources are the government managed quarries including Black Rock.
• Reclamation material	:	g = 1.7, General earth taken from inland deposits or dredged material by project
• Concrete	:	with R-bars
• Unit Weight		γ = 2.45 t/m^3 for reinforced concrete γ = 2.30 t/m^3 for plain concrete

2) Required Weight of Armour Rocks

The required weight of rocks covering the slope surface directly receiving wave forces should be calculated by the Hudson formula.

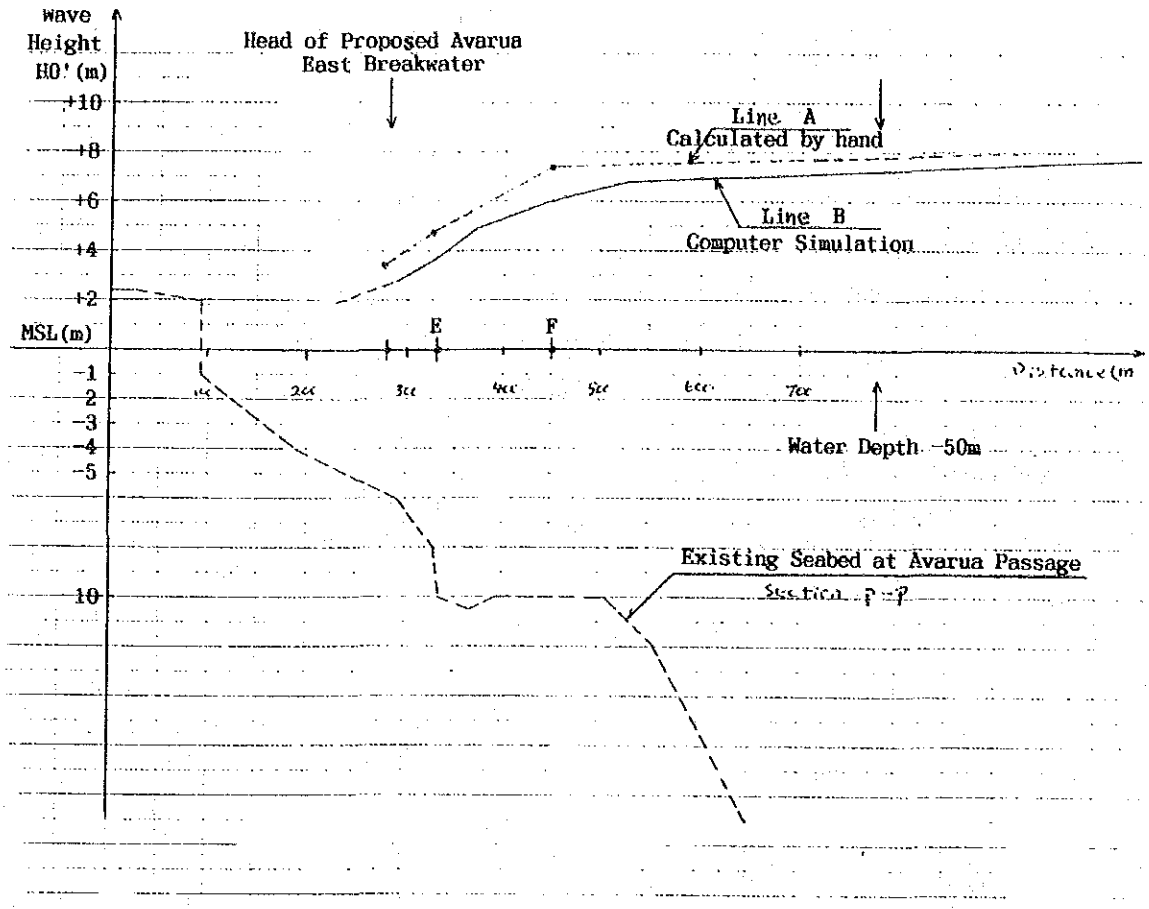


Fig. 13-5-1 Wave Height Comparison at Avarua Passage

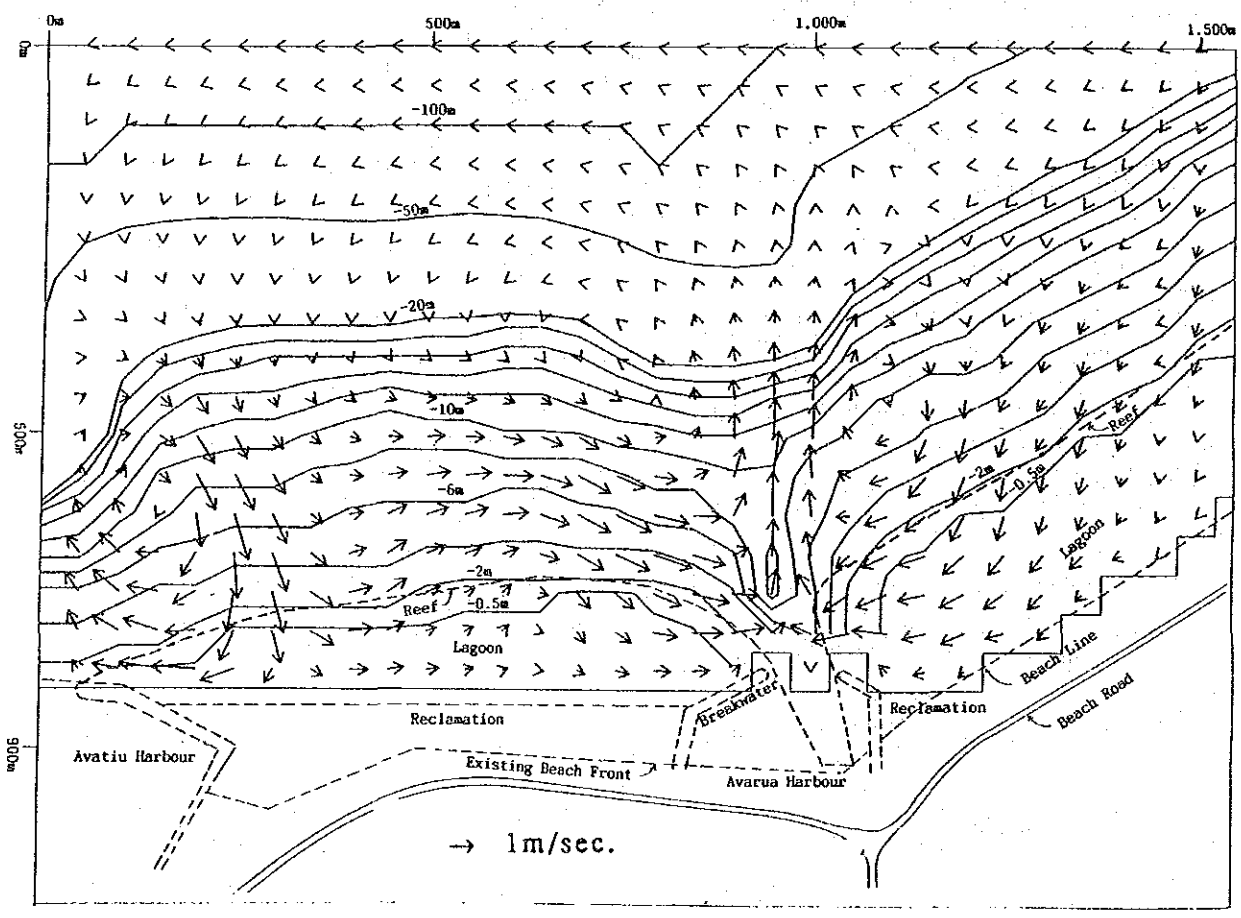


Fig. 13-5-2 Wave & Current Simulation Current Vector

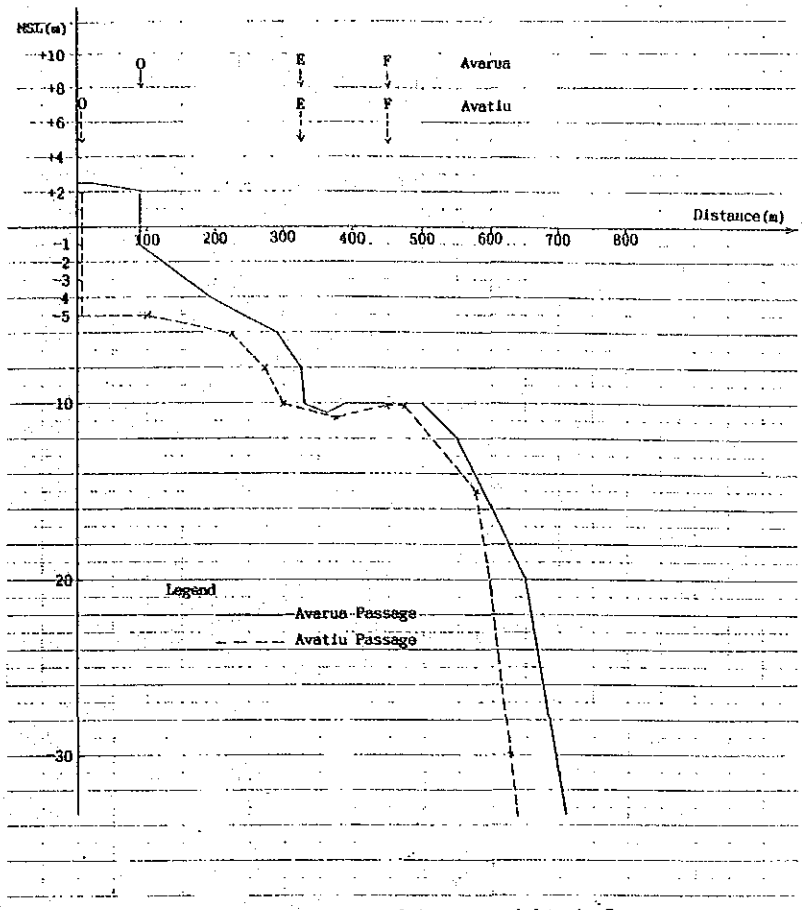


Fig. 13-5-3 Section of Avarua and Avatiu Paggage

Fig. 13-5-3 Section of Avarua and Avatiu Passage

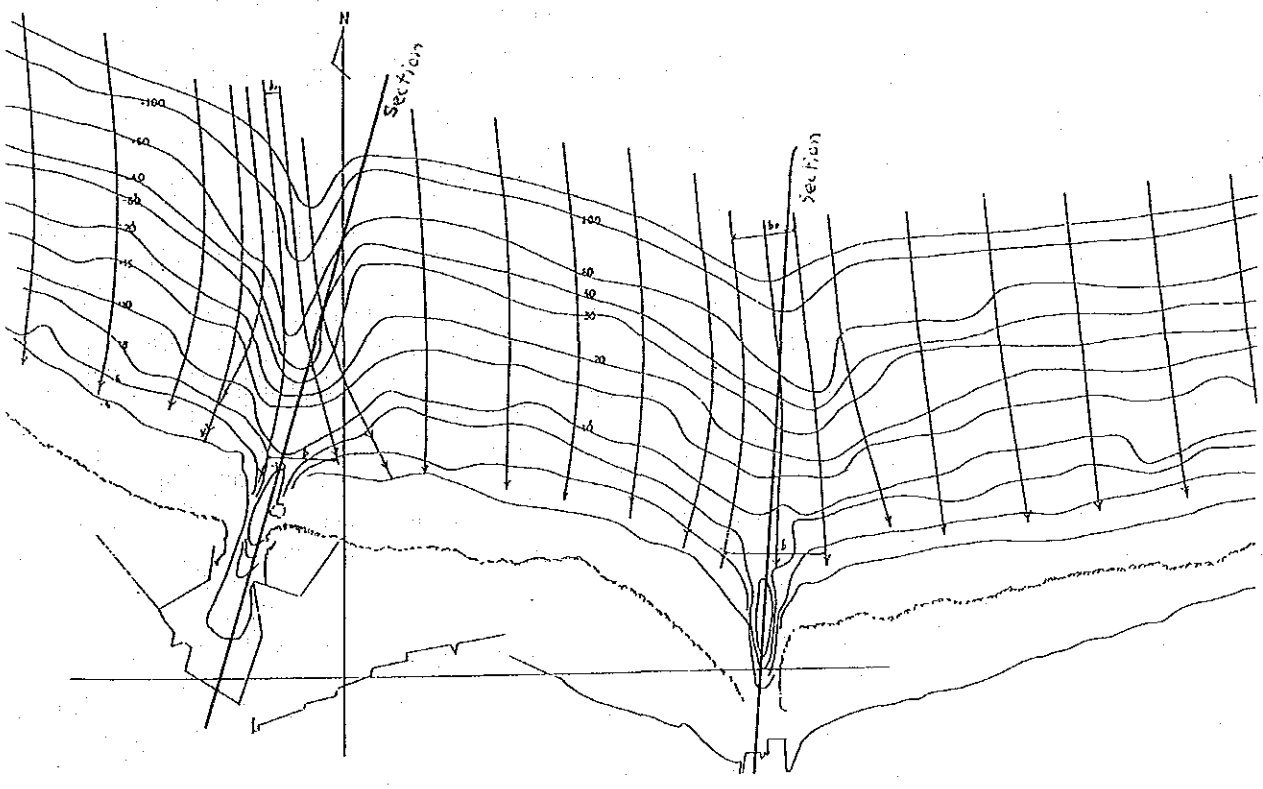


Fig. 13-5-4 Location of Section

$$W = \frac{\gamma_r H^3}{K_D (S_r - 1)^3 \cot \alpha}$$

where, W : Minimum weight of rubble or concrete blocks (ton)

γ_r : Unit weight of rubble or block in air (ton/m^3)

S_r : Specific gravity of rubble or block to sea water

α : Angle of the slope to the horizontal plane (degrees)

H : Wave height at site (m)

K_D : Constant determined by the armoring material and damage rate. Refer to item 3) of subsection 12.2.2.

It is recommended that an appropriate safety factor should be considered due to unknown factor of the high rush current on lagoon. Weight of covering layer at the breakwater head should be increased by 50 % against figure by the formula.

3) Loading Conditions

Following loads will be used for design of structures.

Location	Commercial Port	Fisheries Sector	Marina	Remarks
Wharf and Apron	2 ton/m^2	1 ton/m^2	-	
Were house	2 ton/m^2	1 ton/m^2	-	
Road and access	2 ton	14 ton	3 ton	Truck

Cargo handling machines will be considered in design as follows:

Location	Commercial Port	Fisheries Sector	Marina	Remarks
Wharf and Apron	15 ton	3 ton	3 ton	crane
Open Storage	15 ton	3 ton	3 ton	

In case of repairing of heavily damage structure, loading condition can be reduced by half of above criteria.

13.6 Rough Design : "Avarua Harbour"

This subsection deals with rough design of port facilities in Avarua Harbour.

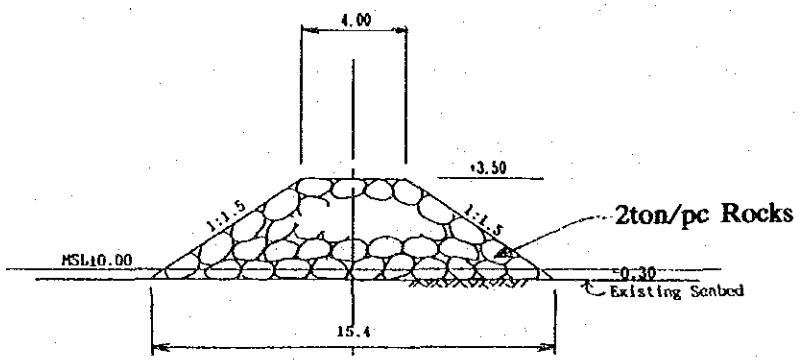
13.6.1 Basic Section and Type of Structure : East Breakwater

General layout of breakwater is shown in Fig. 13-6-2 and 13-6-3. Total length of East breakwater is 90 meters consisting landward 60 meters and top 30 meters. Design waves and specified armour sizes are shown in Fig. 13-6-2A.

A. Landward 60 meter (Section 2-1B)

Existing Avarua East breakwater will be removed seaward and rearranged accordingly. Section of the breakwater is rock mound type as shown in the following sketch:

Fig. 13.6.1A Section of Avarua East Breakwater (Landward 60 m)



According to the wave height in subsection 5.3.8, the wave height at the middle of this section is 2.0 m to 2.3 m. The required weight of rocks will be calculated by the Hudson's formula.

$$W = \frac{2.65 \times 2.3^3}{2.8 \times (2.65/1.03 - 1)^3 \times 1.5} = 0.162 \times 2.3^3 = 1.97 \text{ ton/pc}$$

Therefore, rocks of 2 ton size shall be used.

Crown top of the breakwater is determined as follows:

Top = (MHWS) + (Air Pressure) + (Wave Set-up) + (0.6 x Wave Height)

= MSL + 0.4 + 0.30 + 1.5 + 0.6 x 2.3

= MSL + 3.6 m

Therefore, the top of breakwater will be MSL + 3.5 m.

B. Head 30 meter (Section 2-1C)

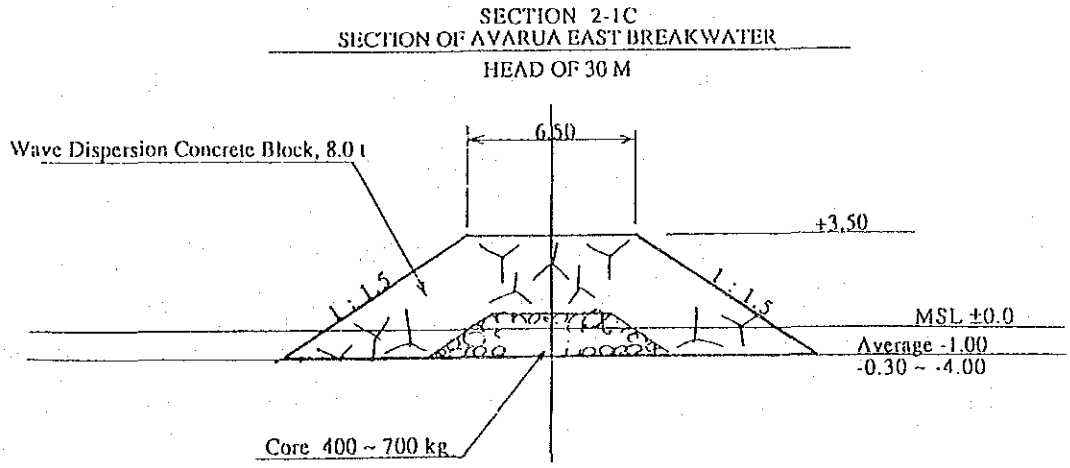
Basic structural type is rock mound with concrete armour units.

Wave height at this section in subsection 13.5.1 is 3.5 m. The required weight of rocks will be calculated by the Hudson's Formula. Wave dispersion concrete block will be used. Refer to item 3) of subsection 12.2.2.

$$W = \frac{2.30 \times 3.5^3}{8.4 \times (2.30/1.03 - 1)^3 \times 1.5} = 0.098 \times 3.5^3 = 4.20 \text{ ton/pc}$$

It is recommended to use concrete block instead of rock since larger rock than 2 ton is expensive. Concrete block in 8 tons is used since this section is head of the breakwater.

Fig. 13.6.1B Avarua East Breakwater, Head 30 M



13.6.2 Basic Section and Type of Structure : West Breakwater

A. Head 30 m (Section 2-4C)

Head 30 m of West breakwater should be strengthened due to same season to the East one.

Same section with the head of East breakwater will be used.

B. Part on the middle of Lagoon (section 2-4B)

In the Short-term Plan, the existing section will be maintained in order to minimize the cost. It is recommended to modify the existing one to the section 2-4B of Fig.13-6-3 (5/5).

13.6.3 Marina Wharf and Jetty : Avarua East and Stream Outlet (Section 2-2A)

Typical section of this wharf is shown in section 2-2A. Basic structural type is rock mound with concrete jetty for small boat berthing. Five jetties will be provided.

Seabed in front of the Marina wharf will be dredged up to MSL -2.5 m as shown in Fig.13.6.2. River dike for Takuvaine Stream should be protected by the same section.

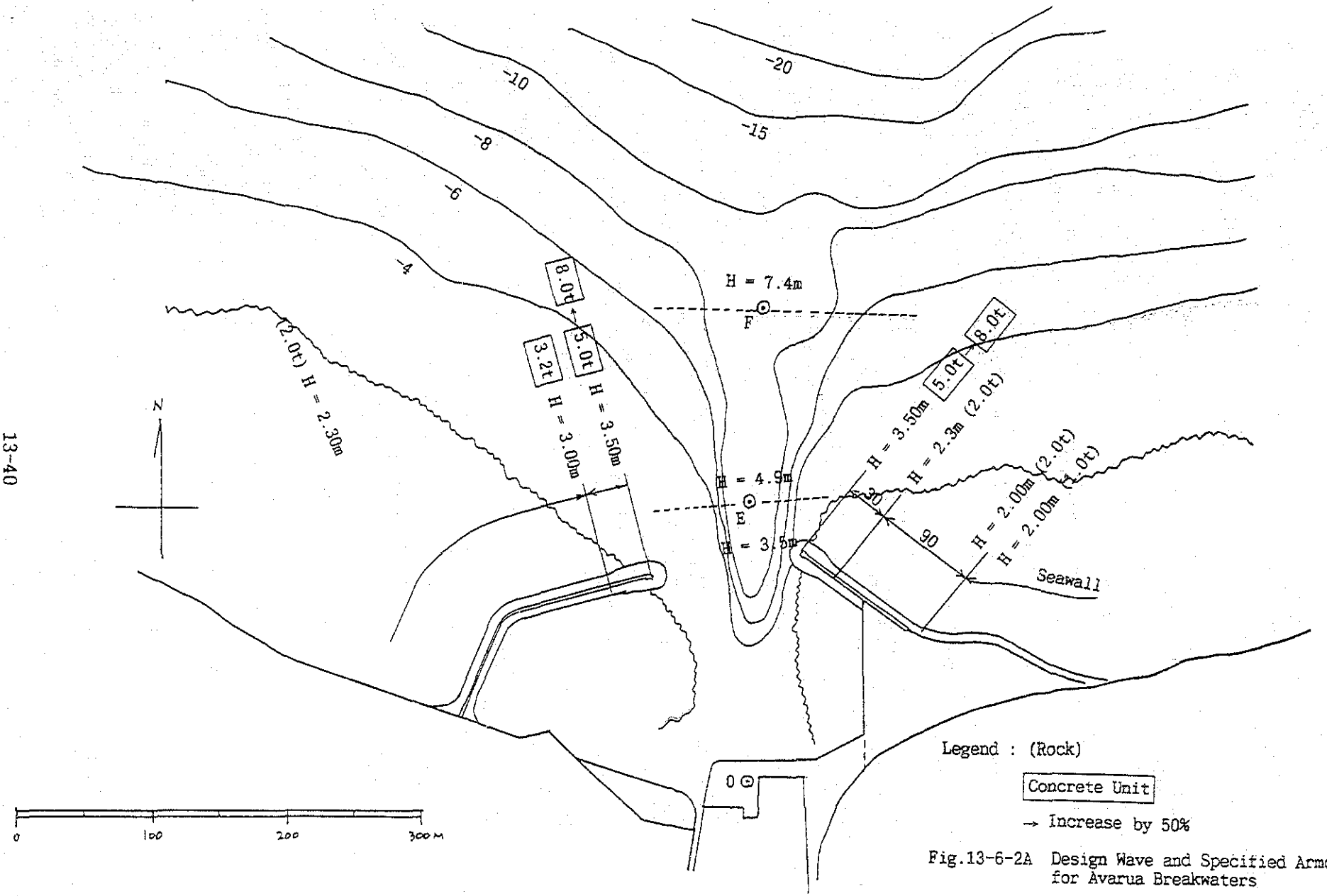
13.6.4 Repair of Existing Damaged Wharf

Existing wharf was severely damaged by Cyclones Val/Wasa and Gene. It is recommended to repair this for user's safety. In order to meet this, it is recommended that new reclamation of 15 m width will be conducted not only to protect damaged wharf but also to gain new land. Typical section is show in section 2-2B. Damaged apron concrete will also be improved by re-construction.

13.6.5 Basic Section and Type of Structure : Temporary Wharf behind West Breakwater

This wharf will be constructed at toe of MOW seawall and utilized as a temporary jetty that will be expanded in the future. A small quantity of dredging (to - 1.0 m) will be conducted to ensure a small boat basin. To save on construction cost, the wall will be a rock mound type provided with concrete block jetty for boat berthing as same as the Marina wharf.

The typical section is shown in section 2-3.



Legend : (Rock)

Concrete Unit

→ Increase by 50%

Fig.13-6-2A Design Wave and Specified Armour Size for Avarua Breakwaters

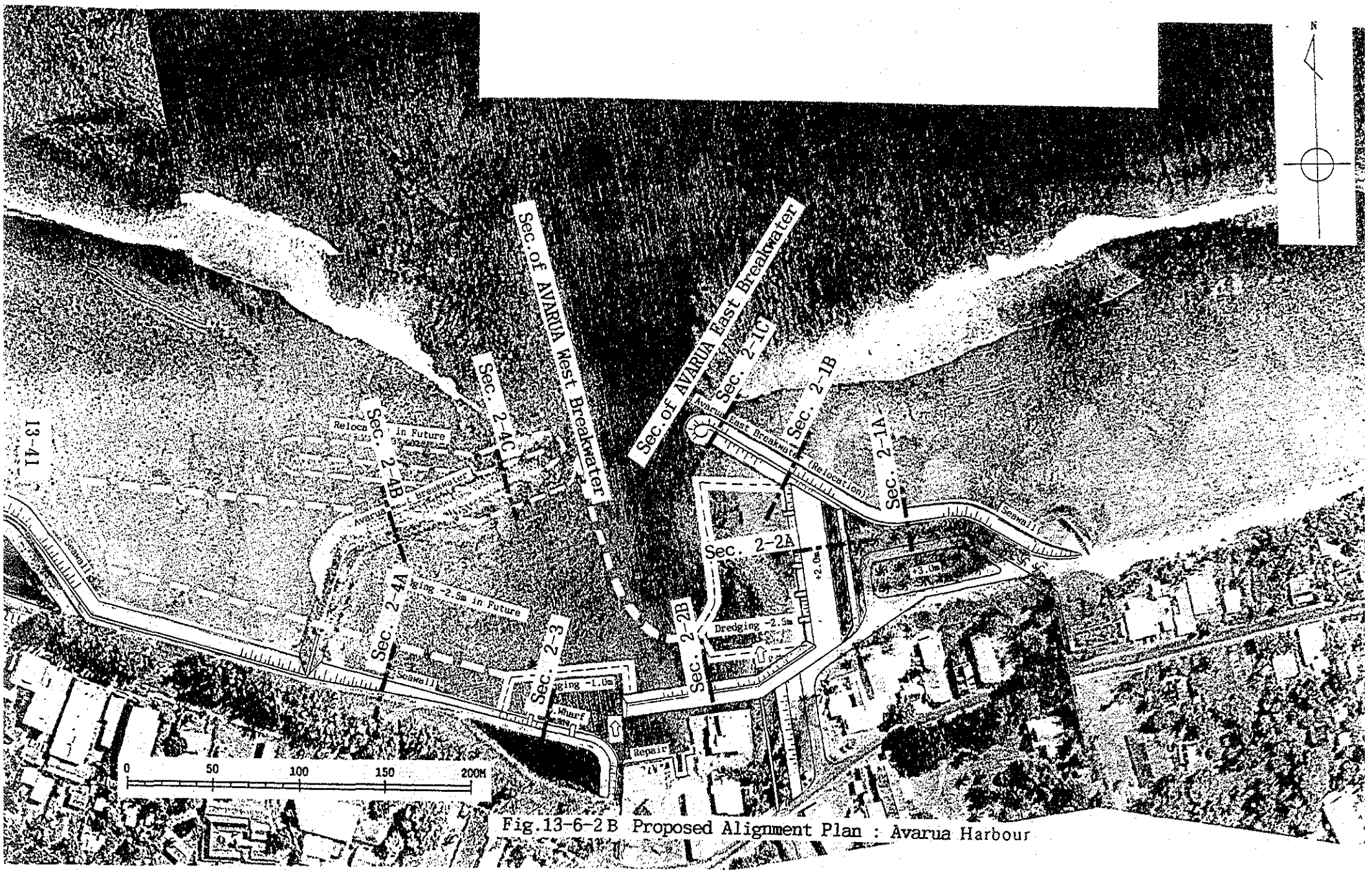
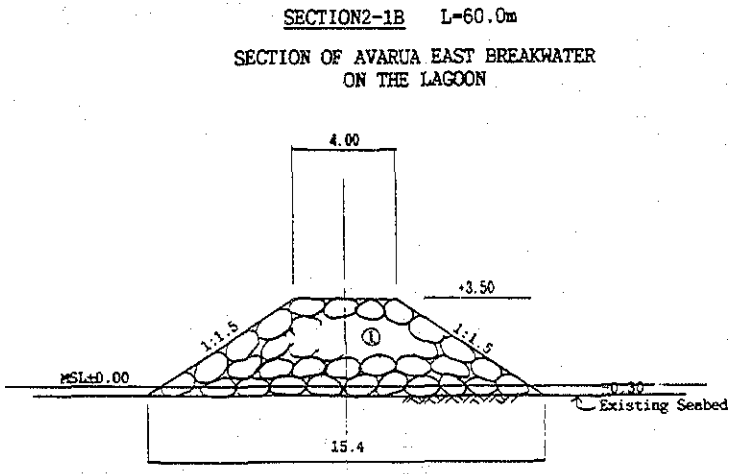
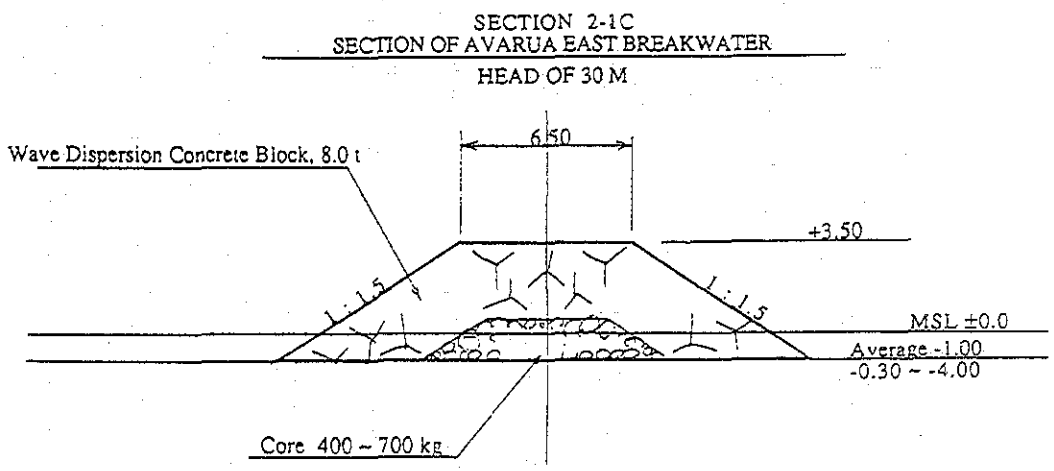


Fig.13-6-2B Proposed Alignment Plan : Avarua Harbour





Legend (General Materials)

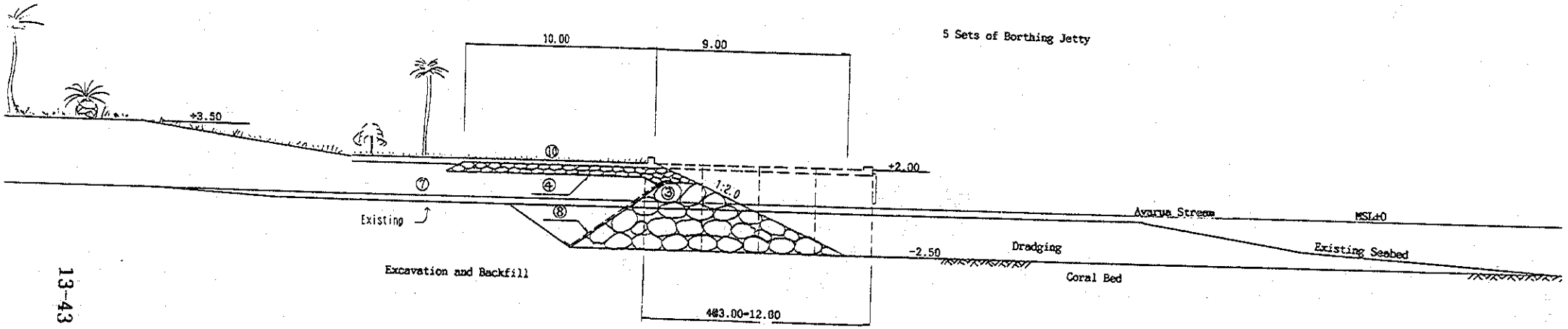
①	Armour Rock	2	ton/pc
②	〃	400~700	kg/pc
③	Core Rock	100~200	kg/pc
④	〃	10~100	kg/pc
⑤	〃	<10	kg/pc
⑥	Gravel		
⑦	Reclamation : General Earth		
⑧	Filter Sheet		
⑨	Parapet Wall		
⑩	Apron		

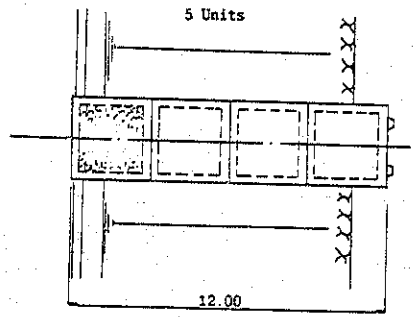
EXCV : Excavation

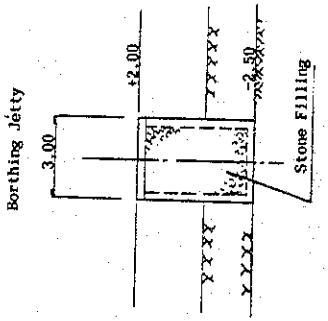
Fig. 13.6.3 Typical Section, Avarua Harbour, (1/5)

SECTION2-2A L=155.0m (= 85.0m + 70.0m)

AVARUA EAST STREAM WALL AND MARINA EAST WHARF







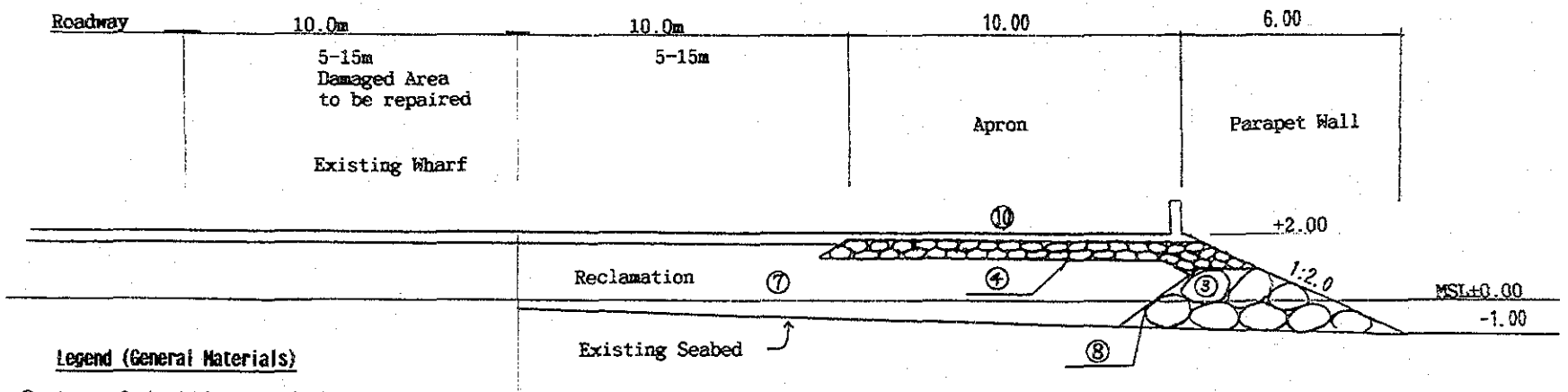
Legend (General Materials)

①	Armour Rock	1~2	ton/pc
②③④	〃	400~700	kg/pc
⑤⑥⑦	Core Rock	100~200	kg/pc
⑧	〃	10~100	kg/pc
⑨	〃	<10	kg/pc
⑤	Gravel		
⑦	Reclamation : General Earth		
⑩	Filter Sheet		
⑪	Parapet Wall		
⑫	Apron		
EXCV : Excavation			

Fig. 13.6.3 Typical Section, Avarua Harbour, (2/5)

SECTION2-2B L=155.0m (= 35m + 80m + 40m)

REPAIR WORK AND RECLAMATION
FOR THE EXISTING WHARF



Legend (General Materials)

① Armour Rock 1~2 ton/pc
② 〃 400~700 kg/pc
③ Core Rock 100~200 kg/pc
④ 〃 10~100 kg/pc
⑤ 〃 <10 kg/pc
⑥ Gravel
⑦ Reclamation : General Earth
⑧ Filter Sheet
⑨ Parapet Wall
⑩ Apron
EXCV : Excavation

Fig. 13.6.3 Typical Section, Avarua Harbour, (3/5)

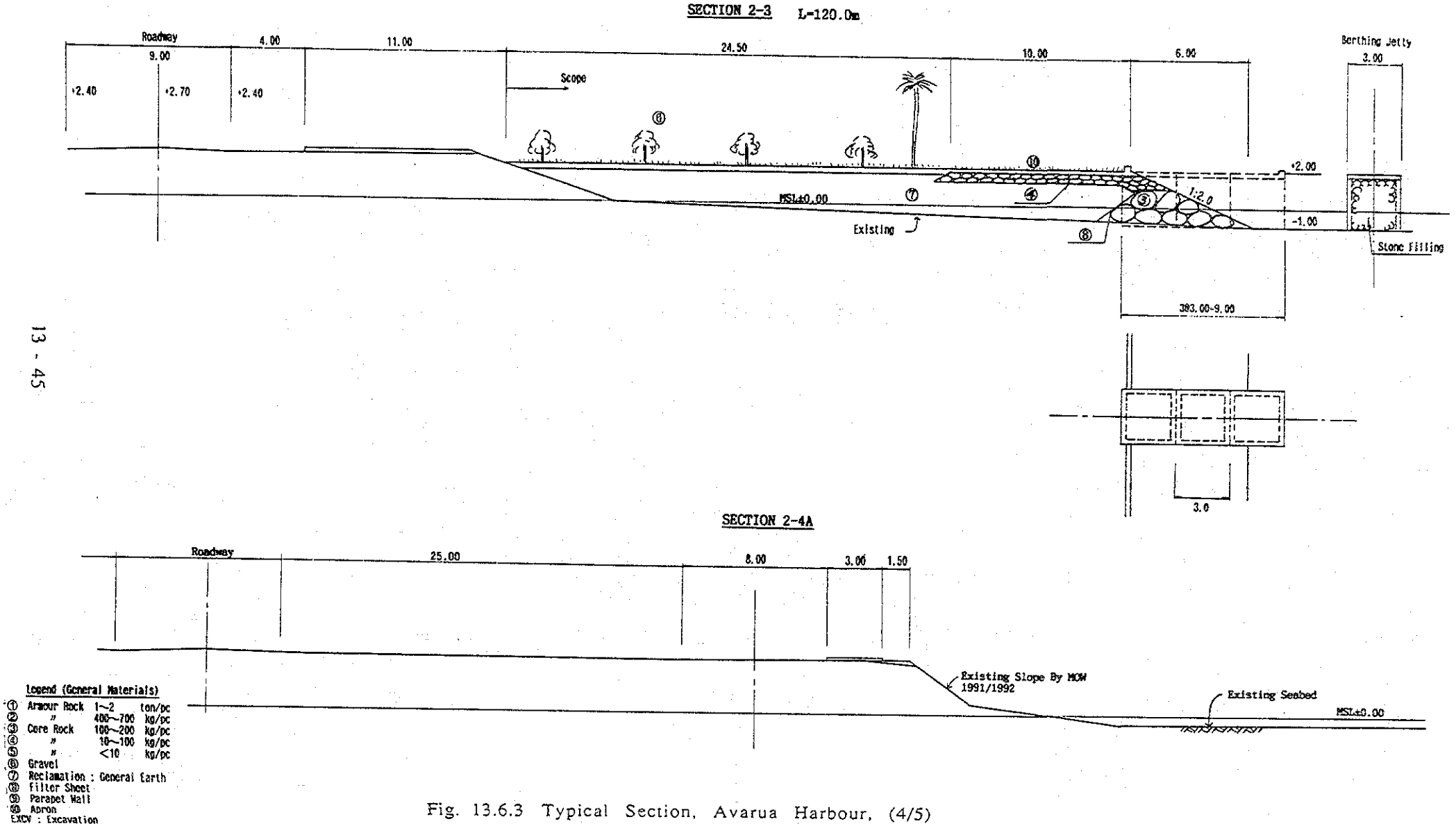
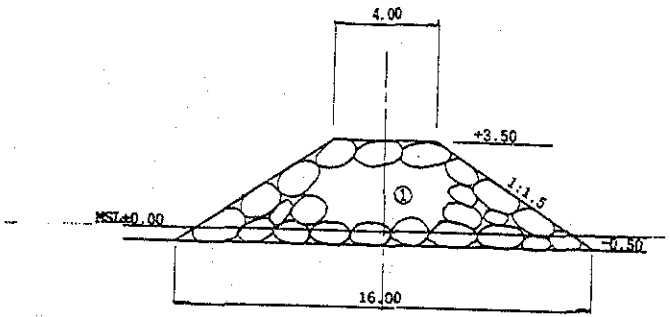


Fig. 13.6.3 Typical Section, Avarua Harbour, (4/5)

SECTION 2-4B

SECTION OF AVARUA WEST BREAKWATER
ON THE LAGOON



Legend (General Materials)

①	Armour Rock	2	ton/pc
②	〃	400~700	kg/pc
③	Core Rock	100~200	kg/pc
④	〃	10~100	kg/pc
⑤	〃	<10	kg/pc
⑥	Gravel		
⑦	Reclamation : General Earth		
⑧	Filter Sheet		
⑨	Parapet Wall		
⑩	Apron		

EXCV : Excavation

SECTION 2-4C

SECTION OF AVARUA WEST BREAKWATER
HEAD OF 30M

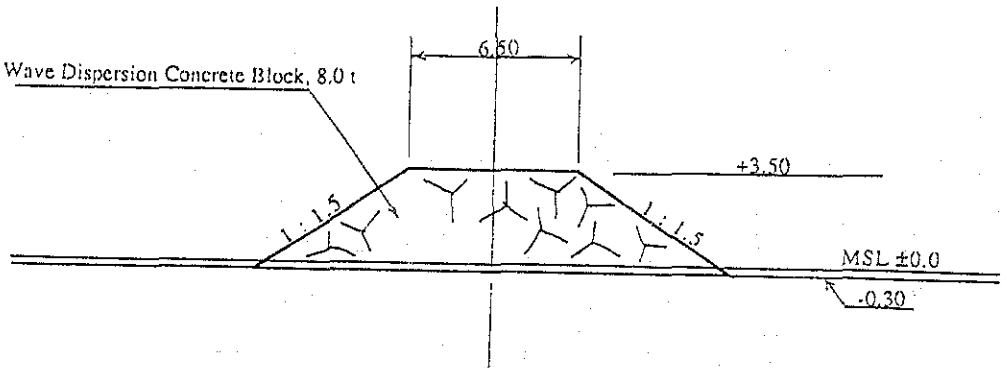


Fig. 13.6.3 Typical Section, Avarua Harbour, (5/5)

13.7 Preliminary Design : "Avatiu Harbour"

13.7.1 Basic Section and Type of Structure : East Breakwater

General layout of breakwater arrangement is shown in Fig.13.7.1H. Total East Breakwater length is 280 m consisting 130 m in shoal lagoon 50 m of lagoon end, 70 m in front of reef and 30 m head to passage of MSL -4.0 m.

Existing East breakwater will be relocated and extended toward offshore.

A. Shoal Lagoon Breakwater 130 m Long

The result of wave height study in subsection 5.3.8 shows that the wave height of this section is 1.46 m ~ 2.15 m. Therefore, the required weight of the rocks by Hudson formula is:

$$B = 50 \text{ m}$$

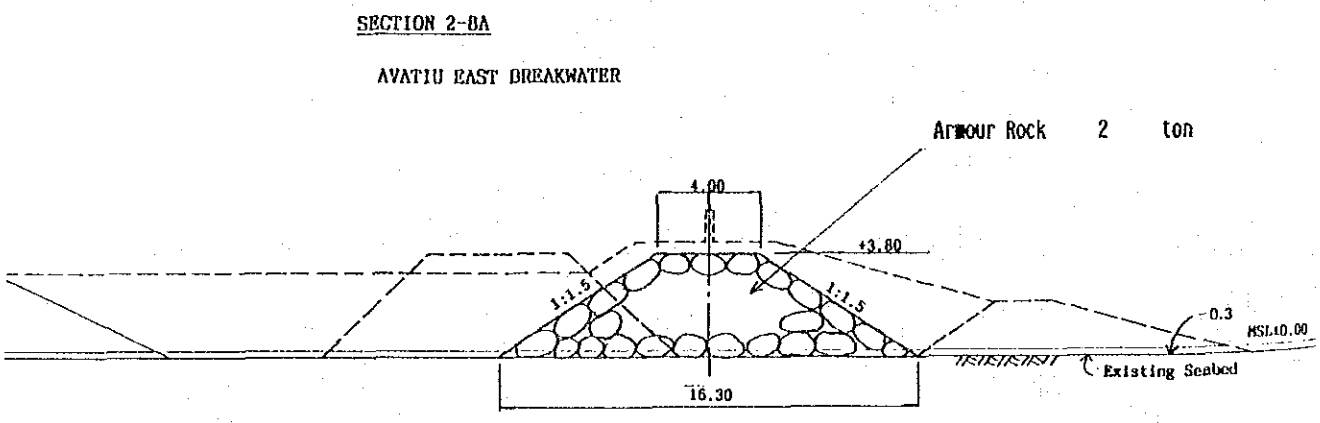
$$H = 2.15 \text{ m}$$

$$W = \frac{2.65 \times 2.15^3}{2.8 \times (2.65/1.03 - 1)^3 \times 1.5} = 0.162 \times 2.15^3 = 1.61 \text{ ton/pc}$$

Therefore, rocks of 2 ton size shall be used.

The crown top (MSL + 3.80 m) will be used for the extension.

Fig. 13.7.1A Avatiu East Breakwater, Landward 130 m



B. Lagoon End Breakwater 50 m Long

According to subsection 5.3.8, wave height at this section is 2.15 m ~ 2.70 m. Required armour rock size is calculated by Hudson's Formula.

$$B = 0 \text{ m}$$

$$H = 2.70 \text{ m}$$

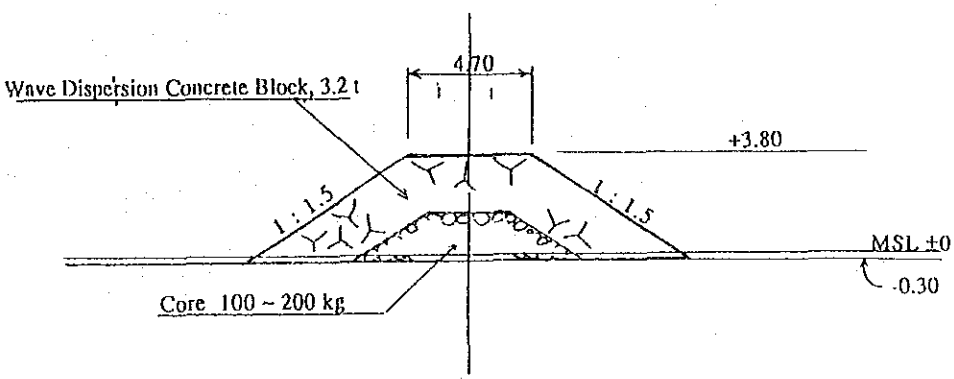
$$W = \frac{2.65 \times 2.70^3}{2.8 \times (2.65/1.03 - 1.0)^3 \times 1.5} = 0.162 \times 2.7^3 = 3.19 \text{ ton/pc}$$

Since required weight by armour rock exceeds in 2 ton, wave dispersion unit will be used.

$$W = \frac{2.30 \times 2.70^3}{8.4 \times (2.30/1.03 - 1.0)^3 \times 1.5} = 0.098 \times 2.70^3 = 1.93 \text{ ton/pc}$$

Therefore, 3.2 ton unit will be used. Required top width is 4.7 m by three unit laying. Bottom width on the core rock is 2.9 m by two unit layer.

Fig. 13-7-1B Avatiu East Breakwater, Lagoon End 50 M



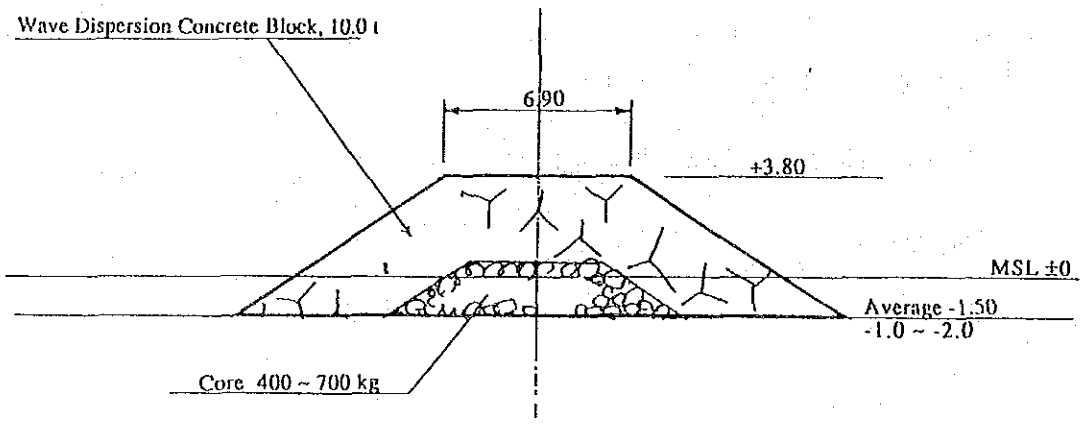
C. Reef Front Breakwater 70 m Long (-2.5 m)

Wave height of this section is 3.0 m ~ 4.5 m. Wave dispersion unit will be used.

$$W = \frac{2.30 \times 4.50^3}{8.4 \times (2.30/1.03 - 1.0)^3 \times 1.5} = 0.098 \times 4.50^3 = 8.93 \text{ ton/pc}$$

Therefore, 10 ton unit will be used. Required top width and bottom width are 6.9 m and 4.9 m respectively.

Fig. 13-7-1C Avatiu East Breakwater, Reef Front 70 M



D. Head 30 m

Basic structural type proposed is rock mound with concrete armour units.

Design wave height at this section is 4.5 m as shown in subsection 13.5.1. Required weight of wave dispersion unit is calculated by Hudson's Formula.

$$W = \frac{2.30 \times 4.5^3}{8.4 \times (2.30/1.03 - 1)^3 \times 1.5} = 0.098 \times 4.5^3 = 8.93 \text{ ton/pc}$$

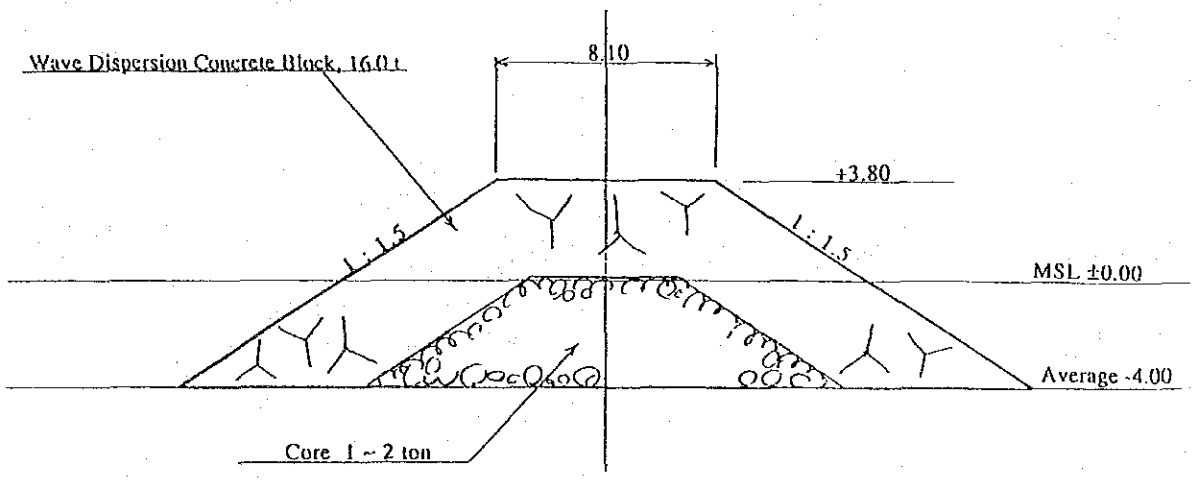
It is recommended to use 16 tons unit considering wave forces concentration to the head.

Crown top of the breakwater is calculated similar to Avarua.

Top Height = 0.4 m + 0.3 m + 0.6 m + 0.6 x 4.5
= 4.0 m

It is proposed to adopt MSL + 3.8 m as the existing crown top is.
Required top width and bottom width are 8.1 m and 5.7 m respectively.

Fig. 13.7.1D Avatiu East Breakwater, Head 30 m



13.7.2 Basic Section and Type of Structure : West Breakwater

A. Breakwater Landward

Total length of the existing West breakwater is 225 m. Breakwater landward means breakwater in land side 195 m. Basic structural type proposed is rock mound type similar to the existing one. It is assumed that design wave height here is about 2.2 m as shown in subsection 5.3.8.

Avatiu West breakwater was damaged by Sally and requires upgrading. The crown top height is calculated as follows:

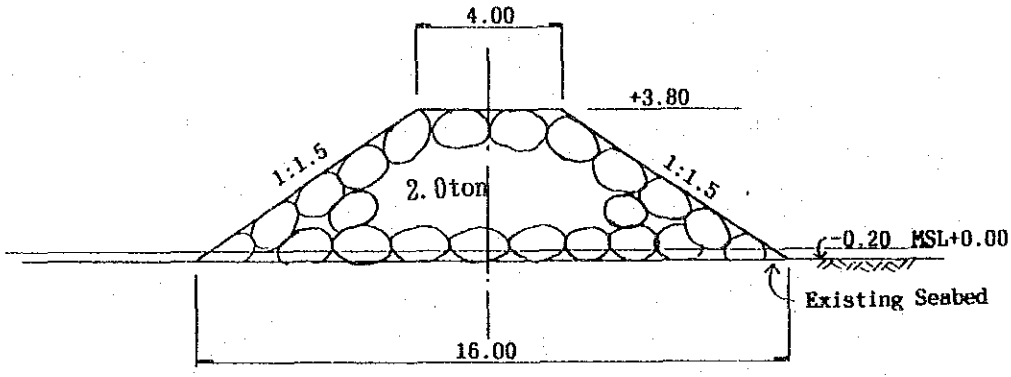
+ 0.4 m (MHWS) + 0.3 m (Air Pressure) + 1.5 m (Wave Set-up)
+ 0.6 x 2.2 m(Wave Height)
= MSL +3.50 m

Considering some allowance, MSL +3.80 m is used.

Calculated rock weight is 1.7 ton, therefore rocks of 2 ton size shall be used.

$$W = \frac{2.65 \times 2.20^3}{2.8 \times (2.65/1.03 - 1)^3 \times 1.5} = 0.162 \times 2.2^3 = 1.72 \text{ ton/pc}$$

Fig. 13.7.1E Avatiu West Breakwater, Landward 195 m



B. Head 30 m

Estimated wave height here is 2.7 m by subsection 5.3.8.

$$W = \frac{2.65 \times 2.70^3}{2.8 \times (2.65/1.03 - 1)^3 \times 1.5} = 0.162 \times 2.7^3 = 3.19 \text{ ton/pc}$$

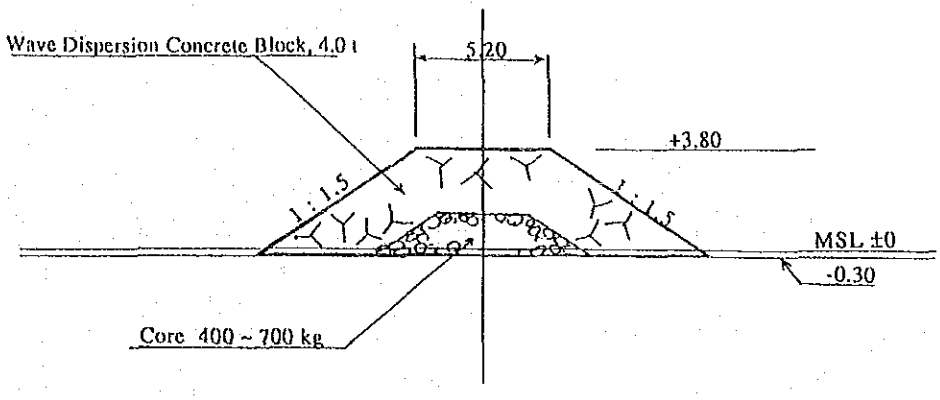
In case of rock mound type, required rock weight is 3.2 ton. It is preferable to limit rock size below 2 ton.

Therefore it is proposed to use wave dispersion unit.

$$W = \frac{2.30 \times 2.70^3}{8.4 \times (2.30/1.03 - 1)^3 \times 1.5} = 0.098 \times 2.7^3 = 1.93 \text{ ton/pc}$$

Proposed armour unit is 4.0 ton type, since this section is a head of breakwater. Required top width and bottom width are 5.2 m and 3.6 m respectively.

Fig. 13.7.1F Avatiu West Breakwater, Head 30 m



13.7.3 Basic Section and Type of Structure : Commercial Sector

Existing Avatiu internationl wharf is of concrete sheet-pile type constructed in 1982. Since there have been found a lot of gaps between the sheet piles next to each other, some backfilling materials were washed out and an urgent repair should be required.

Any critical gaps shall be covered by concrete as shown in Fig. 13.7.3. Such works are to be conducted by divers.

13.7.4 Basic Section and Type of Structure : Fisheries Sector

The lagoon inside the Avatiu West breakwater will partly be dredged to MSL -1.0 m for harbour fishing boats and landing wharf will be constructed.

The landing wharf will be provided with jetties of concrete block type as shown in Figs. 13.6.3 and 13.7.2.

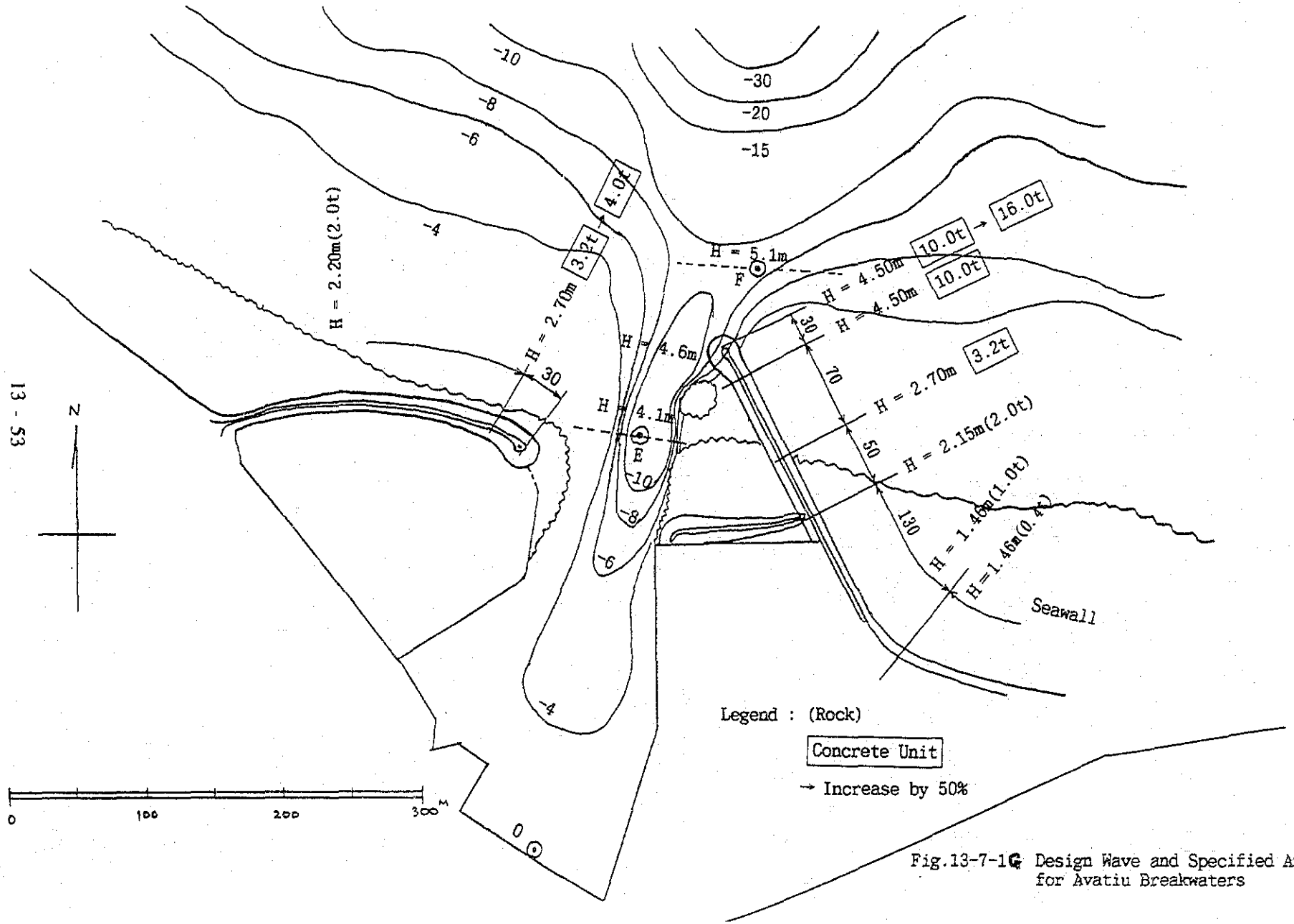


Fig.13-7-16 Design Wave and Specified Armour Size for Avatiu Breakwaters

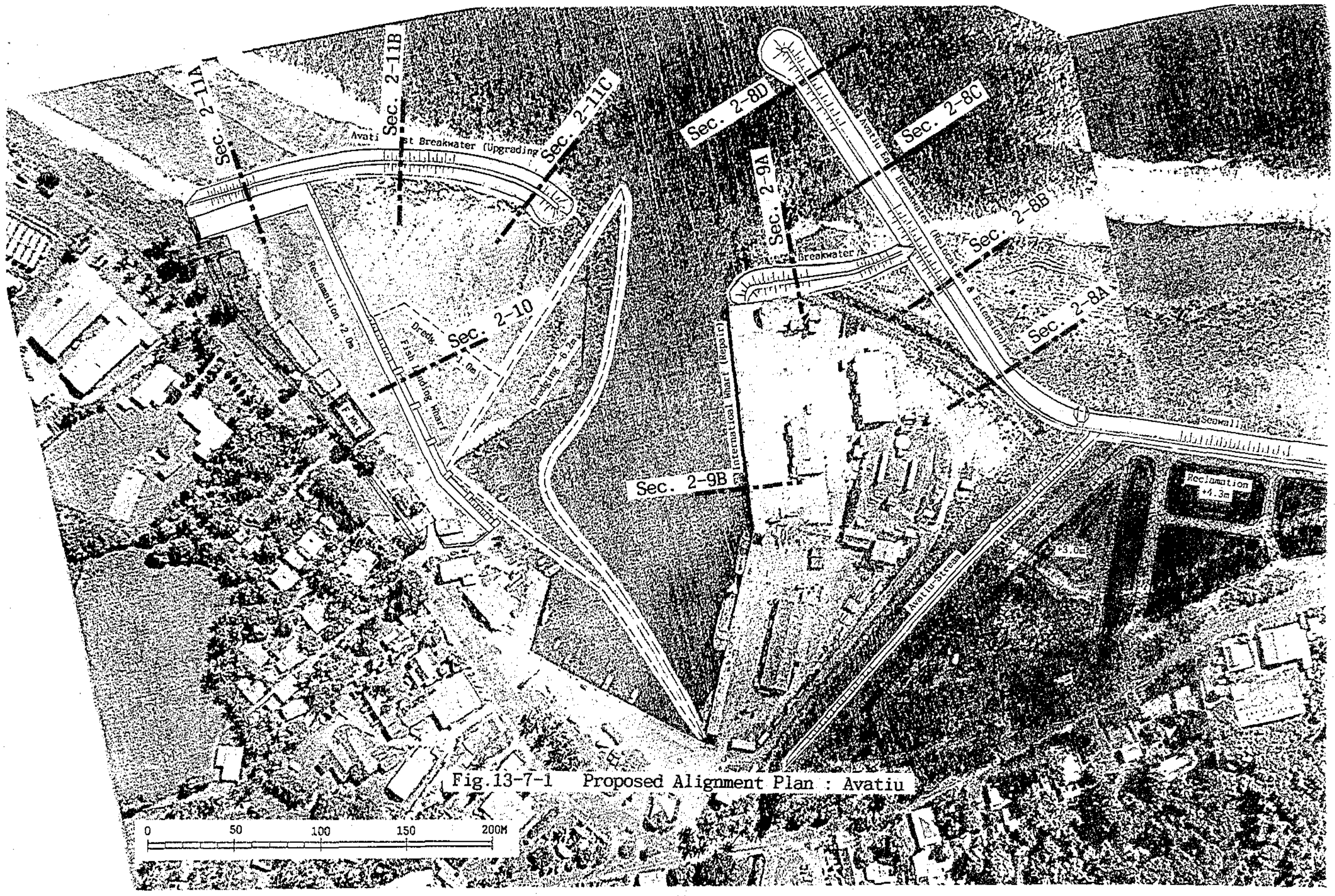
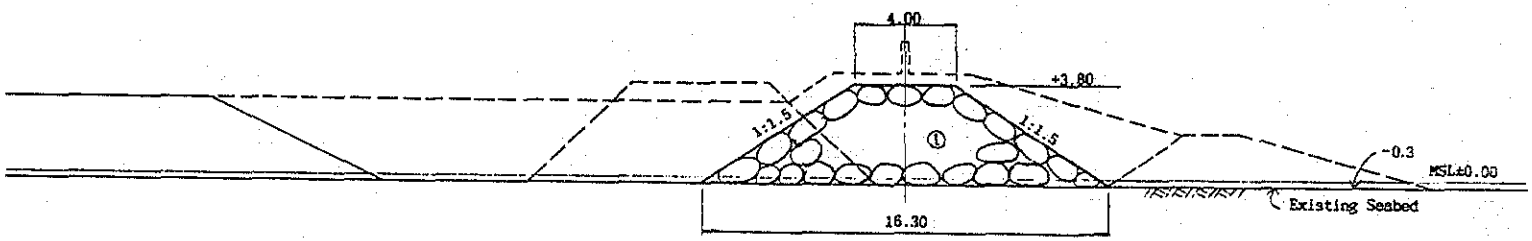


Fig.13-7-1 Proposed Alignment Plan : Avatiu

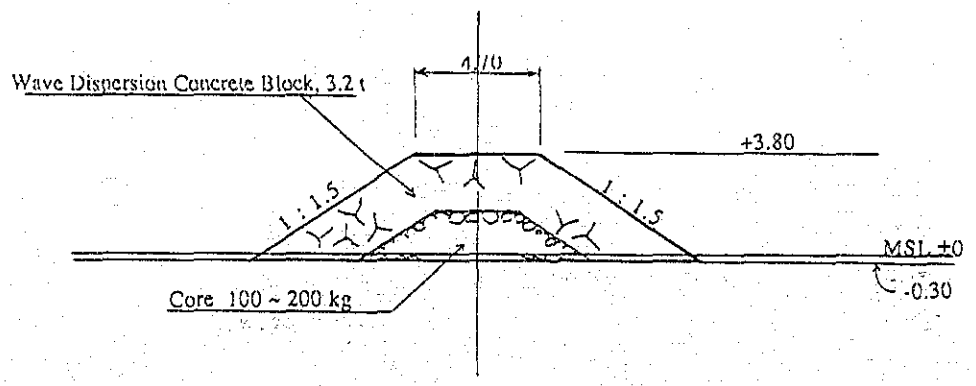
SECTION 2-8A L=130.0m

AVATIU EAST BREAKWATER



SECTION 2-8B, L = 50.0M

AVATIU EAST BREAKWATER



Legend (General Materials)

①	Armour Rock	1~2	ton/pc
②	〃	400~700	kg/pc
③	Core Rock	100~200	kg/pc
④	〃	10~100	kg/pc
⑤	〃	<10	kg/pc
⑥	Gravel		
⑦	Reclamation : General Earth		
⑧	Filter Sheet		
⑨	Parapet Wall		
⑩	Apron		

EXCV : Excavation

Fig. 13.7.2 Typical Section : Avatiu Harbour (1/5)

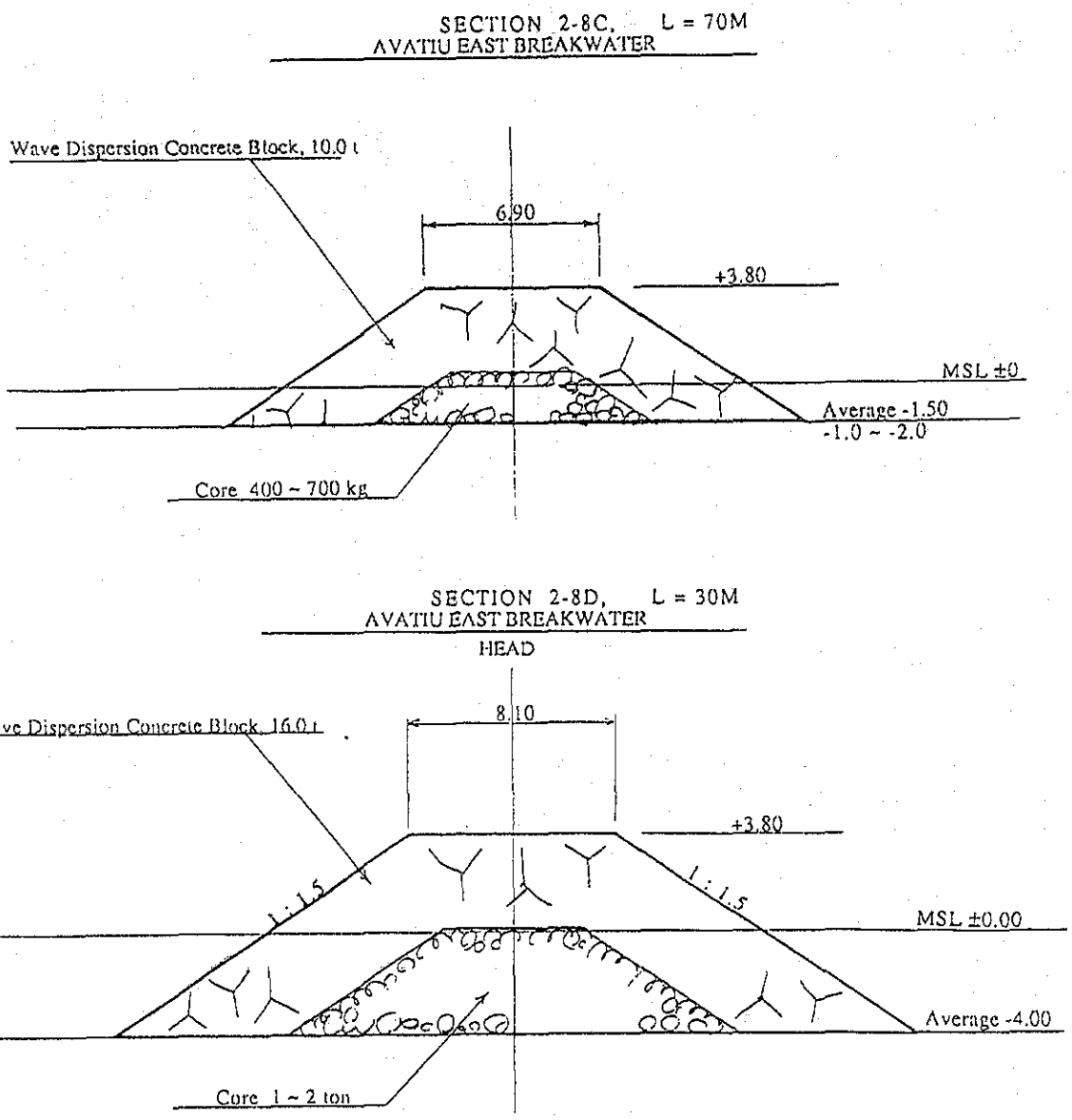


Fig. 13.7.2 Typical Section : Avatiu Harbour (2/5)

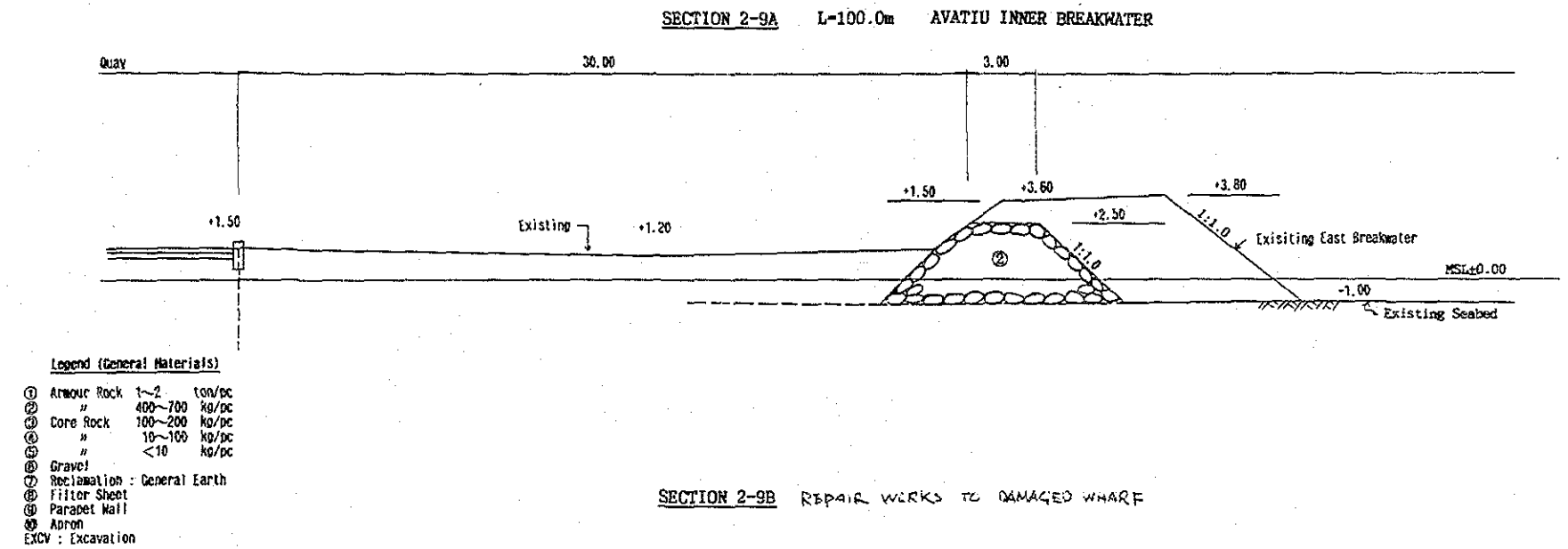
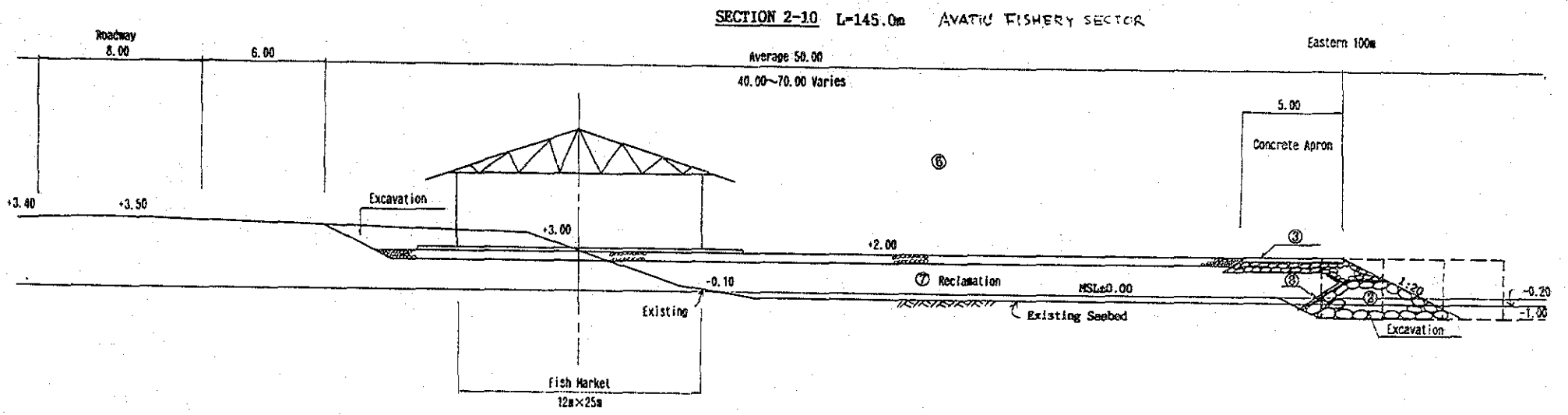
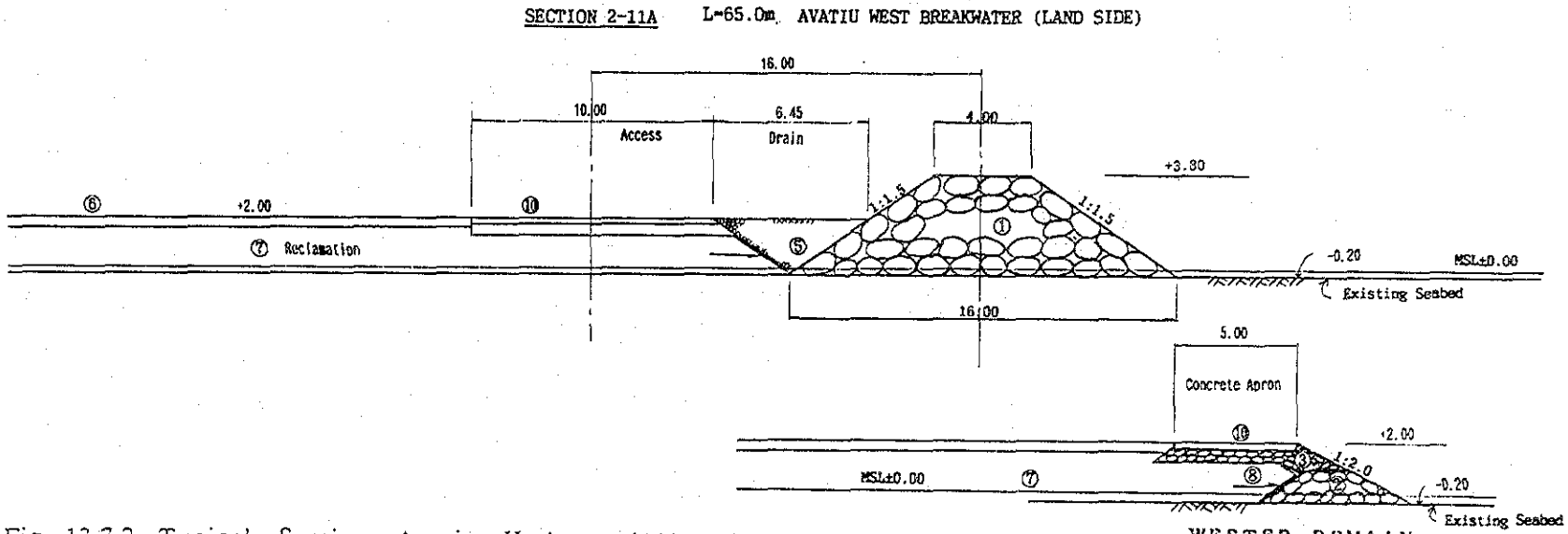


Fig. 13.7.2 Typical Section : Avatiu Harbour (3/5)



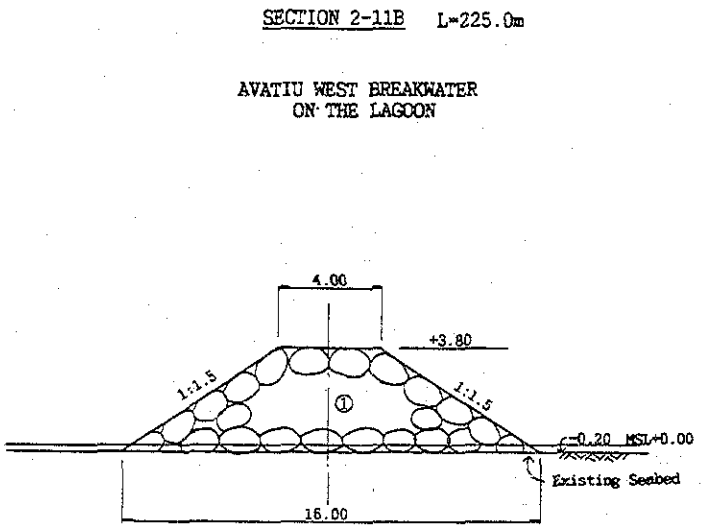


Legend (General Materials)

①	Armour Rock	1~2	ton/pc
②	〃	400~700	kg/pc
③	Core Rock	100~200	kg/pc
④	〃	10~100	kg/pc
⑤	〃	<10	kg/pc
⑥	Gravel		
⑦	Reclamation : General Earth		
⑧	Filter Sheet		
⑨	Parapet Wall		
⑩	Apron		

EXCV : Excavation

Fig. 13.7.2 Typical Section : Avatiu Harbour (4/5)



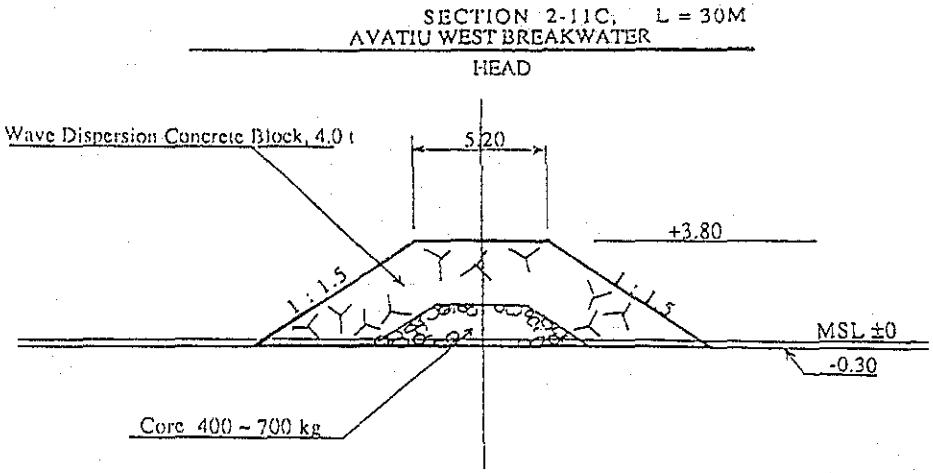


Fig. 13.7.2 Typical Section : Avatiu Harbour (5/5)

Chapter 14: Construction Program

Chapter 14 Construction Program

This chapter deals with the construction method of major work and the implementation schedule.

14.1 Construction Program

14.1.1 Quantity of Works

Table 14-1 shows both major works and quantities for the construction of the Short-term Development Plan. According to this, reclamation volume and dredging volume are 150,000 m^3 and 40,000 m^3 respectively. Thus, 110,000 m^3 of general earth should be collected from the borrow areas. Total rock materials for proposed seawall and breakwaters amounts to 95,000 m^3.

Total rock materials	95,000 m^3
- Reuse of the existing breakwaters	16,000 m^3
- New rock materials	79,000 m^3

Total concrete volume amounts to 9,300 m^3 breakdown of which is as follows.

Total concrete volume	9,300 m^3
- Pavement and apron	1,700 m^3
- Parapet wall	900 m^3
- Wave dispersion units	5,700 m^3
- Others	1,000 m^3

Concrete volume is much less than rock materials, since unit cost of the former is about 15 times of the latter. Structures proposed are mainly rock works in order to implement the project by minimum cost.

Table 14-1 Quantity of Major Works (1/4)

Materials	Spec.	Unit	Site-1 Health Dept.		Site-2 (Avarua Harbour)										
			Seawall L=300 m	Sub Total	East Seawall L=125 m	East Breakwater L=60 m	East Breakwater L=30 m	West Breakwater L=30 m	Marina Wall L=850 m	Marina Jetty	Stream Wall L=70 m	Quay Repair L=155 m	Dredging -2.5 m	Temp. Quay L=120 m	Berthing Jetty
Armour Rock	1 ~ 2 ton	m³	4,857	4,857	3,133	(Replace) 2,212									
Armour Rock	400 ~ 700 kg	m³		-			390				(Replace) 368				
Core Rock	100 ~ 200 kg	m³	2,736	2,736	783				2,975		(Replace) 254	1,547		1,198	
Core Rock	10 ~ 100 kg	m³		-					538			986		756	
Core Rock	~ 10 kg	m³		-											(Block Filling 103
Gravel		m³		-					519	500	270	492		732	
Reclamation	General Earth	m³		-	20,880										
Reclamation	Dredged Material	m³	8,360	8,360								5,425		6,732	
Filter Sheet		m²		-	1,338				595		455	543		420	
Parapet Concrete	Reinforced	m³	240	240	110						48	135			
Pavement Concrete	Reinforced	m³		-	281				128		116	233		180	
Drainage Concrete	Reinforced	m³		-											
Jetty Concrete	Precast Block	m³		-						300					99
Dredging	Blasting	m³		-									5,888		
Dredging	Clam shell	m³		-									4,050		
Planting/Lawn		Ls or m²	1	1	2,500 m²						350 m²				
Repair Works	Concrete	m³		-											
Repair Works	Pavement	m²		-											
Utilities		Ls		-											
Others		Ls	1	1						Piggings					(Fittings) 1
Concrete Block	3.2t ~ 4.0t Wave Dispersion	m³		-			699	890						1,198	
Concrete Block	8.0t ~ 10t Wave Dispersion	m³		-										1,198	
Concrete Block	16t Wave Dispersion	m³		-										1,198	

Table 14-1 Quantity of Major Works (2/4)

Materials	Spec.	Unit	Site-2 (Pon Park C)		Site-2 (Pon Park Complex)		Site-2 (Avatiu Harbour)							
			Add. to Wal L=130 m	Seawall/Recl. L=195 m	Seawall/Recl. L=220m	Reclamation L=260 m	East B/W L=130m	East B/W L=50m	East B/W L=70m	East B/W L=30m	Inner B/W L=100m	Quay Repair L=130m	Slipway L=30m	Fish. Quay L=145m
Armour Rock	1 ~ 2 ton	m³	2,652	5,823	6,569		(Replace) 4,940			1,452				
Armour Rock	400 ~ 700 kg	m³	2,652	5,823	6,569				1,170		2,360			1,407
Core Rock	100 ~ 200 kg	m³		2,933	3,309	(Replace) 520		575						676
Core Rock	10 ~ 100 kg	m³												
Core Rock	~ 10 kg	m³												
Gravel		m³												3,035
Reclamation	General Earth	m³		24,398	38,053									11,093
Reclamation	Dredged Material	m³			17,000	13,000								
Filter Sheet		m²		2,691	3,036									435
Parapet Concrete	Reinforced	m³	144	181	205									
Pavement Concrete	Reinforced	m³		176	198									
Drainage Concrete	Reinforced	m³	78	105	119									
Jetty Concrete	Precast Block	m³												354
Dredging	Blasting	m³												
Dredging	Clam shell	m³												
Planting/Lawn		Ls or m²			LS. 1	LS. 1								
Repair Works	Concrete	m³										33		
Repair Works	Pavement	m²										900	150	
Utilities		Ls												
Others		Ls	1	1	1	1	Incl. str'm. March 20m 1					1	Incl. Dike 30m 1	Fitting 120m
Concrete Block	3.2t ~ 4.0t Wave Dispersion	m³		2,933	3,309	(Replace) 520		823						
Concrete Block	8.0t ~ 10t Wave Dispersion	m³		2,933	3,309	(Replace) 520			1,673					
Concrete Block	16t Wave Dispersion	m³		2,933	3,309	(Replace) 520				1,550				

Table 14-1 Quantity of Major Works (3/4)

Materials	Spec.	Unit	West B/W			Site-2 (Avaiku Harbour)			Sub Total
			L=65m	L=195m (Replace)	L=30m	Fish Market	Utilities	Dredging	
Armour Rock	1 ~ 2 ton	m³		7,800					34,581
Armour Rock	400 ~ 700 kg	m³			315				6,013
Core Rock	100 ~ 200 kg	m³							14,250
Core Rock	10 ~ 100 kg	m³							2,278
Core Rock	~ 10 kg	m³	533						533
Gravel	-	m³	273						5,914
Reclamation	General Earth	m³							94,424
Reclamation	Dredged Material	m³							42,157
Filter Sheet		m²							9,513
Parapet Concrete	Reinforced	m³		56					878
Pavement Concrete	Reinforced	m³	98						1,410
Drainage Concrete	Reinforced	m³							302
Jetty Concrete	Precast Block	m³							713
Dredging	Blasting	m³						22,000	27,888
Dredging	Clam shell	m³						6,000	12,050
Planting/Lawn		Ls or m²							2,850
Repair Works	Concrete	m³							33
Repair Works	Pavement	m²							1,050
Utilities		Ls					Water, Lighting		-
Others		Ls				Shelter 300m²			-
Concrete Block	3.2t ~ 4.0t Wave Dispersion	m³							2,454
Concrete Block	8.0t ~ 10.0t Wave Dispersion	m³			240				1,673
Concrete Block	16t Wave Dispersion	m³							1,590

Table 14-1 Quantity of Major Works (4/4)

Materials	Spec.	Unit	Site-3 (Airport East)					Site-4 (Airport Western End)						Grand Total
			Aux. Dike L=120 m	Seawall L=130 m	Seawall L=90 m	Seawall L=80 m	Sub Total	Seawall L=80 m	Breakwater L=150 m	Groin L=20 m	Seawall L=65.0 m	Seawall L=50.0 m	Sub Total	
Armour Rock	1 ~ 2 ton	m³		4,458	2,855	3,102	10,415	2,052	3,234		1,901	1,464	8,651	58,514
Armour Rock	400 ~ 700 kg	m³	1,800				1,800			289			289	8,102
Core Rock	100 ~ 200 kg	m³		1,355	1,246	1,106	3,717	554	2,295		332	256	3,437	24,140
Core Rock	10 ~ 100 kg	m³					-						-	2,278
Core Rock	~ 10 kg	m³					-						-	533
Gravel		m³					-	290			407	313	1,010	6,924
Reclamation	General Earth	m³					-	364			2,096	1,614	4,074	98,498
Reclamation	Dredged Material	m³			2,141		2,141						-	50,658
Filter Sheet		m²					-	1,040			845	650	2,535	12,048
Parapet Concrete	Reinforced	m³		104	72	64	240	64			52	40	156	1,514
Pavement Concrete	Reinforced	m³					-	60			49	38	147	1,557
Drainage Concrete	Reinforced	m³					-						-	302
Jetty Concrete	Precast Block	m³					-						-	713
Dredging	Blasting	m³					-						-	27,888
Dredging	Clam shell	m³					-						-	12,050
Planting/Lawn		Ls or m²					-	1 LS			1 LS	1 LS	-	2,850
Repair Works	Concrete	m³					-						-	33
Repair Works	Pavement	m²					-						-	1,050
Utilities		Ls					-						-	-
Others		Ls					-						-	-
Concrete Block	3.2t ~ 4.0t Wave Dispersion	m³		-			-						-	2,454
Concrete Block	8.0t ~ 10.0t Wave Dispersion	m³		-			-						-	1,673
Concrete Block	16t Wave Dispersion	m³		-			-						-	1,590

14.1.2 Construction Method

The construction program for major construction items is studied for cost estimation and schedule preparation.

Major work items for the Short-term Development Plan includes:

In Coastal Protection Work

a. Seawall (rock riprapping)
b. Concrete apron
c. Concrete U-shaped drainage
d. Asphalt pavement
e. Temporary berthing jetty (concrete)
f. Detached breakwater (rock dike)
g. Leading jetty (rock dike)
h. Plantation and Landscaping
i. Car parking (Asphalt pavement)
j. Dredging of ordinary soil, sand and silty soil
k. Dredging of coral bed (blasting)
l. Stream outlet relocation
m. Others

In Port Improvement Work

a. Breakwater (rock mound)
b. Breakwater (relocate)
c. Breakwater (wave dispersion concrete unit)
d. Concrete apron
e. Asphalt pavement
f. Building and office, fish market and ice plant
g. Dredging of ordinary soil, sand and silty soil
h. Dredging of coral bed
i. Repairs to the existing quay and wharf (concrete sheet piles)
j. Repairs to the existing concrete pavement
k. Navigation aids (a marker buoy)
l. Ice plant (0.5 t/day)
m. Cargo handling equipment
   - Forklift, 1 unit 32 tons

- Forklift, 1 unit 5 ton
- Forklift, 1 unit 2.5 ton
- Tractor-trailers, 1 unit

n. 350 HP tugboat

o. Others

There are no particular work items here.

It can be said that the work should be executed under the following conditions:

(i) Marine work should be implemented during calm climatic seasons

(ii) As much as possible, work should be executed landwards. It is recommended to minimize the utilization of floating construction plants.

Most of breakwater construction can be carried out using temporary rock dike extending from the beach. Height of dike will be 1.2 ~ 1.5 m since the average lagoon depth and High Water level are MSL -0.3 m and MSL +0.3 m respectively.

Geotechnical condition here are ideal and all the proposed structures are located where soil condition is good. Therefore no soil improvement work, one of the most expensive work items for marine construction, will be required.

The preparation of the rock material stockpiles should start as early as possible, since the newly required rock volume amount to 79,000 m^3.

Accessibility to the construction sites is generally good since they face directly to the existing beach road.

14.2 Preliminary Construction Schedule

The required construction period is estimated to be about three years including one year for design and contract document preparation. The required period of preparation work before the first year will depend upon financial arrangements. Table 14-2 shows a typical schedule in the most speedy arrangement.

Table 14-2 Master Construction Schedule

Items	Year				
	1992	① 1993	② 1994	③ 1995	1996
Financial Arrangement	—				
Detailed Design		—			
Contract		—			
Construction			—	—	
Operation					→●

Table 14-2 shows the schedule when actual construction effort commences at the beginning of 1994. The detailed schedule is shown in Fig. 14-1.

It is assumed that the required minimum time for making the financial arrangement is six months.

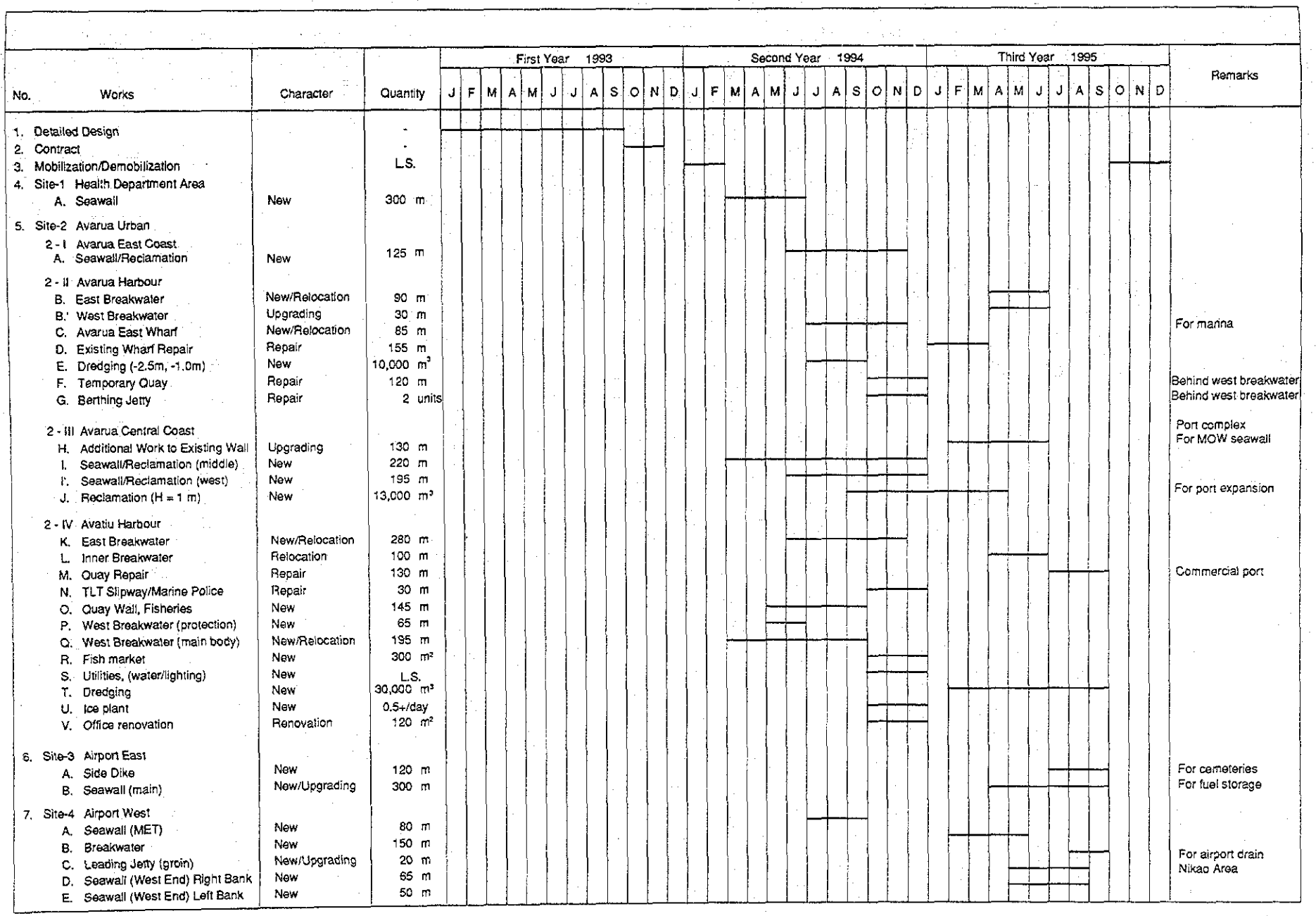
After executing the construction contract, the Contractor will deliver their first team to the site within one month. Mobilization will be completed within two months.

It is assumed that assuring enough rock production rate and undertaking marine works during the calm season are extremely important factors. In the proposed schedule, it is anticipated that enough rock material can be supplied by government quarries. Thus, it is recommended that MOW arrange rock stockpiles to meet the requirement.

MOW's Avarua coast rock mound seawall was constructed in rock laying speed of 1,000 m^3 per month. In the proposed schedule, rock material of 79,000 m^3 should be collected with 20 months. In this case, a new quarry like a Black Rock one should be prepared. Otherwise rock stockpiling should be commenced long before the start of construction.

It is strongly recommended to use rock material which is locally available and to use concrete material in limit purpose because concrete work in the island is expensive.

Fig. 14-1 Construction Schedule, Coastal Protection and Port Improvement: Cook Islands/Rarotonga Island
Short-term Development



No.	Works	Character	Quantity	Remarks
1.	Detailed Design		-	
2.	Contract		-	
3.	Mobilization/Demobilization		L.S.	
4.	Site-1 Health Department Area			
	A. Seawall	New	300 m	
5.	Site-2 Avarua Urban			
	2 - I Avarua East Coast			
	A. Seawall/Reclamation	New	125 m	
	2 - II Avarua Harbour			
	B. East Breakwater	New/Relocation	90 m	
	B.' West Breakwater	Upgrading	30 m	
	C. Avarua East Wharf	New/Relocation	85 m	For marina
	D. Existing Wharf Repair	Repair	155 m	
	E. Dredging (-2.5m, -1.0m)	New	10,000 m^3	
	F. Temporary Quay	Repair	120 m	Behind west breakwater
	G. Berthing Jetty	Repair	2 units	Behind west breakwater
	2 - III Avarua Central Coast			Port complex
	H. Additional Work to Existing Wall	Upgrading	130 m	For MOW seawall
	I. Seawall/Reclamation (middle)	New	220 m	
	I'. Seawall/Reclamation (west)	New	195 m	
	J. Reclamation (H = 1 m)	New	13,000 m^3	For port expansion
	2 - IV Avatiu Harbour			
	K. East Breakwater	New/Relocation	280 m	
	L. Inner Breakwater	Relocation	100 m	
	M. Quay Repair	Repair	130 m	Commercial port
	N. TLT Slipway/Marine Police	Repair	30 m	
	O. Quay Wall, Fisheries	New	145 m	
	P. West Breakwater (protection)	New	65 m	
	Q. West Breakwater (main body)	New/Relocation	195 m	
	R. Fish market	New	300 m^2	
	S. Utilities, (water/lighting)	New	L.S.	
	T. Dredging	New	30,000 m^3	
	U. Ice plant	New	0.5+/day	
	V. Office renovation	Renovation	120 m^2	
6.	Site-3 Airport East			
	A. Side Dike	New	120 m	For cemeteries
	B. Seawall (main)	New/Upgrading	300 m	For fuel storage
7.	Site-4 Airport West			
	A. Seawall (MET)	New	80 m	
	B. Breakwater	New	150 m	
	C. Leading Jetty (groin)	New/Upgrading	20 m	For airport drain
	D. Seawall (West End) Right Bank	New	65 m	Nikao Area
	E. Seawall (West End) Left Bank	New	50 m	

Chapter 15: Project Cost Estimates

Chapter 15 Project Cost Estimates

This chapter deals with the cost estimation required for the Short-term Development Plan, which includes work components urgently required among the Master Plan. Year 1997 is the target year for this work. All the cost is shown by Cook Dollars.

15.1 Summary of Project Cost

Total project cost for thirty years operation is 29.32 million Cook dollars; 10.37 and 18.95 million dollars for coastal protection work and port improvement work respectively.

Table 15-1 Project Cost Summary

Unit : million Cook Dollars

Cost Items	Coastal Protection	Port Improvement	Total
Initial Cost	8.46	12.80	21.26
Operation/ Management Cost	-	2.31	2.31
Maintenance Cost	1.91	3.84	5.75
Total	10.37	18.95	29.32

Notes 1. Operation and maintenance costs are for thirty years.
2. Annual maintenance cost
Coastal protection works--------0.75% of initial cost
Port Improvement works--------1.0% of initial cost

Of these costs, local currency and foreign currency components are 10.01 million dollars and 19.31 million dollars respectively; thus, the local components share only 34 %. Table 15-2 shows the currency components.

Table 15-2 Currency Components

Unit : million Cook Dollars

Cost Items	Coastal Protection			Port Improvement			Total		
	L.C	F.C	T.C	L.C	F.C	T.C	L.C	F.C	T.C
Initial Cost	3.36	5.10	8.45	3.98	8.82	12.80	7.34	13.92	21.26
Operation Cost	-	-	-	1.19	2.65	3.84	1.19	2.65	3.84
Maintenance Cost	0.76	1.15	1.91	0.72	1.59	2.31	1.48	2.74	4.22
Total	4.12	6.25	10.37	5.89	13.06	18.95	10.01	14.31	29.32

Notes
1. Local and foreign currency ratio in the initial cost is applied those for operation and maintenance costs.
2. Foreign cost includes direct and indirect foreign costs. Indirect foreign costs are for work items that are available on the island, but were originally imported. For example, fuel can be purchased on the island, yet it was originally imported.
3. L.C: Local Currency, FC :Foreign Currency, TC: Total Cost

Basic cost estimate condition is shown in subsection 7.9.2 of Chapter 7.

15.2 Coastal Protection Work

This section deals with the required costs for the proposed coastal protection work including the initial cost and the maintenance costs.

15.2.1 Summary Costs

Total project cost for thirty year operations is 10.37 million dollars; 8.46 million dollars and 1.91 million dollars for the initial cost and maintenance cost respectively. The initial cost represents 81.7 % of the total project cost. Operation costs are not estimated because of the character of the work.

Local and foreign currency components are 39.7 % and 60.3 % of the total project cost respectively.

Table 15-3 Project Cost Summary : Coastal Projection Work

Unit : million Cook Dollars

Cost Items	L.C	F.C	T.C
Initial Cost	3.36 (39.7%)	5.10 (60.3%)	8.46 (81.7%)
Operation Cost	-	-	-
Maintenance Cost	0.76	1.15	1.91 (18.3%)
Total	4.12 (39.7%)	6.54 (60.3%)	10.37 (100%)

15.2.2 Initial Investment Cost

This subsection deals with the initial investment cost required for construction for coastal protection.

The total initial investment cost for the coastal protection work amounts to 8.46 million dollars; 7.02 million dollars and 1.44 million dollars for the basic cost (or direct construction cost) and contingency respectively.

Note. The contingency is for allowance amount including:

a. Twelve percent of basic cost for the physical contingency which is the allowance cost to cover any additional cost to the basis cost due to unknown physical factors.

b. Eight percent of the basic cost for engineering.

c. One half percent of the basic cost for overseas training of government officers.

Of the 7.02 million dollar, basic cost 4.01 million dollars (57.2 %) will be spent for the coastal protection work around the Avarua urbanized area.

Table 15-4 Initial Investment Cost : Coastal Protection Work

Unit : 1,000 Cook Dollars

Sites	Basic Cost	Contingency*	Total Initial Cost after Contingency
Site-1 Health Department	747	153	900
Site-2 Avarua Urban			
(1) Avarua East Coast	833	171	1,004
(2) Avarua Central Coast	3,179	652	3,831
Subtotal	4,012	823	4,835
Site-3 Airport East	1,157	237	1,394
Site-4 Airport West	1,102	226	1,328
Total	7,018	1,439	8,457

Table 15-5 Currency Components : Coastal Protection Work

Unit : 1,000 Cook Dollars

Site	Basic Cost			Contingency			Total Initial Cost		
	L.C	F.C	T.C	L.C	F.C	T.C	L.C	F.C	T.C
A. Site-1 Health Department									
(1) Rock Mound Wall	(299)	(448)	(747)	(61)	(92)	(153)	(360)	(540)	(900)
B. Site-2 Avarua Urban									
B-1 Avarua East Coast									
(1) Seawall/Recla	333	500	833	68	103	171	401	603	1,004
B-2 Avarua Central Coast									
(1) Upgrading of MOW Wall	166	226	392	32	48	80	198	274	472
(2) Seawall/Recla (East)	681	1,022	1,703	140	209	349	821	1,231	2,052
(3) Seawall/Recla (West)	425	659	1,084	68	155	223	493	814	1,307
Subtotal	1,272	1,907	3,179	240	412	652	1,512	2,319	3,831
Subtotal of B.	(1,605)	(2,407)	(4,012)	(308)	(515)	(823)	(1,913)	(2,922)	(4,835)
C. Site-3 Airport East									
(1) Auxiliary Works	36	61	97	8	12	20	44	73	117
(2) Main Seawall (East)	122	183	305	25	38	63	147	221	368
(3) Main Seawall (Mid)	129	193	322	26	40	66	155	233	388
(4) Main Seawall (West)	173	260	433	36	52	88	209	312	521
Subtotal	(460)	(697)	(1,157)	(95)	(142)	(237)	(555)	(839)	(1,394)
D. Site-4 Airport West									
(1) Seawall (MET)	123	185	308	25	38	63	148	223	371
(2) Lagoon Breakwater	121	183	304	25	37	62	146	220	366
(3) Loading Jetty	6	10	16	1	2	3	7	12	19
(4) Seawall (Right bank)	107	161	268	22	33	55	129	194	323
(5) Seawall (Left bank)	84	122	206	17	26	43	101	148	249
Subtotal	(441)	(661)	(1,102)	(90)	(136)	(226)	(531)	(797)	(1,328)
Total (A, B, C, D)	(2,805)	(4,213)	(7,018)	(553)	(885)	(1,439)	(3,359)	(5,098)	(8,457)

15.2.3 Maintenance Cost

For the future repair work, required maintenance cost should be included in the project cost. This is for costs accrued after the completion of construction. As there are no service facilities such as a wharf or transit shed here, operation costs have not been taken into consideration.

Based on similar project experience, 0.75% of the initial cost is allocated for the annual maintenance cost.

15.3 Port Improvement Work

This section deals with the required costs for the proposed port improvement work including initial cost and operation/maintenance costs.

15.3.1 Summary of Costs

Total project cost for thirty year operation is 18.95 million dollars; 12.80 million dollars and 6.15 million dollars for the initial cost and operation/maintenance costs respectively.

Local and foreign cost components are 31.1 % and 68.9 % of the total project cost respectively.

The initial cost shares 67.6 % of the total project cost.

Table 15-6 Project Cost Summary: Port Improvement Work

Unit: million Cook Dollars

Costs Items	L.C		F.C		T.C	
Initial Cost	3.98		8.82		12.80	(67.6%)
Operation/Management Cost	0.72		1.59		2.31	(12.1%)
Maintenance Cost	1.19		2.65		3.84	(20.3%)
Total	5.89	(31.1%)	13.06	(68.9%)	18.95	(100%)

15.3.2 Initial Investment Cost

This subsection deals with the initial investment cost required for construction and mechanical supplies. The total initial investment cost for port improvement work amounts to 12.80 million dollars; 10.62 million dollars and 2.18 million dollars for the basic cost and contingency respectively.

Table 15-7 Initial Investment Cost: Port Improvement Work

Unit: 1,000 Cook Dollars

	Harbour and Sectors	Basic Cost	Contingency	Total Cost after Contingency
A.	Avarua Harbour			
A-1	Common Works	5,498	1,127	6,625
A-2	TLL Sectors	1,602	329	1,931
A-3	Fisheries Sectors	884	181	1,065
	Subtotal	7,984	1,637	9,621
B.	Avarua Harbour			
B-1	Common Works	1,299	266	1,565
B-2	Marina	845	173	1,018
B-3	Repairing Work	495	101	596
	Subtotal	2,639	540	3,179
	Total	10,623	2,177	12,800

Table 15-8 Currency Components: Port Improvement Work

Unit: 1,000 Cook Dollars

	Harbour and Sectors	Basic Cost			Contingency			Total Cost		
		L.C	F.L	T.C	L.C	F.L	T.C	L.C	F.L	T.C
A.	Avatiu Harbour									
A-1	Common Works									
(1)	East Breakwater	1,300	1,950	3,250	-	-	-	-	-	-
(2)	Inner Breakwater	23	34	57	-	-	-	-	-	-
(3)	West Breakwater (main body)	215	323	538	-	-	-	-	-	-
(4)	West Breakwater (protection)	40	59	99	-	-	-	-	-	-
(5)	Dredging	280	1,120	1,400	-	-	-	-	-	-
(6)	Reclamation	62	92	154	-	-	-	-	-	-
	Subtotal	(1,920)	(3,578)	(5,498)	(394)	(733)	(1,127)	(2,314)	(4,311)	(6,625)

A-2 TLT Sectors (Commercial)									
(1) Quay Repair	90	128	218	-	-	-	-	-	-
(2) Repair (TLT Slipway/ Marine Police)	20	31	51	-	-	-	-	-	-
(3) Utilities	11	42	53	-	-	-	-	-	-
(4) Tugboat	5	1,095	1,100	-	-	-	-	-	-
(5) Equipment/Buoy	5	175	180	-	-	-	-	-	-
Subtotal	(131)	(1,471)	(1,602)	(26)	(303)	(329)	(157)	(1,774)	(1,931)
A-3 Fisheries Sector									
(1) Quay Wall	175	262	437	-	-	-	-	-	-
(2) Fish Market Shed	45	105	150	-	-	-	-	-	-
(3) Utilities	59	238	297	-	-	-	-	-	-
Subtotal	279	605	884	45	136	181	324	741	1,065
Avatiu Total	(2,330)	(5,645)	(7,984)	(465)	(1,172)	(1,637)	(2,795)	(6,826)	(9,621)
B. Avarua Harbour									
B-1 Common Works									
(1) East Breakwater	-	-	-	-	-	-	-	-	-
(2) West Breakwater	-	-	-	-	-	-	-	-	-
(3) Dredging	70	280	350	-	-	-	-	-	-
Subtotal	(450)	(849)	(1,299)	(92)	(174)	(266)	(542)	(1,023)	(1,565)
B-2 Marina									
(1) Avarua East Wharf	190	284	474	-	-	-	-	-	-
(2) Temporary Quay	124	187	311	-	-	-	-	-	-
(3) Berthing Jetty	24	36	60	-	-	-	-	-	-
Subtotal	(338)	(507)	(845)	(69)	(104)	(173)	(407)	(611)	(1,018)
B-3 Repairing Work									
(1) Repair Work for Existing Wharf	(198)	(297)	(495)	(40)	(61)	(101)	(238)	(358)	(596)
Avarua Total	(986)	(1,653)	(2,639)	(201)	(339)	(540)	(1,187)	(1,972)	(3,179)
Grand Total	(3,316)	(7,307)	(10,623)	(666)	(1,511)	(2,177)	(3,982)	(8,818)	(12,800)

15.3.3 Operation and Maintenance Cost

For the future port operations and repair work, the operation and maintenance cost should be included in the project cost. These are costs for accured after the completion of construction.

Based on similar project experience, the annual operation and management cost and maintenance cost are allocated as 0.60% and 1.00% of the initial cost respectively.

15.4 Disbursement Schedule

The initial cost of the project is 21.26 million Cook dollars. An expenditure schedule is prepared based on the following conditions:

(a) The total construction period is three years including design and contract document preparation.
(b) An advance payment of thirty percent of the initial cost is considered.

Table 15-9 Disbursement Schedule

unit: million Cook Dollars

	First Year	Second Year	Third Year	Total
Disbursement	8.50	6.38	6.38	21.26
Ratio	40%	30%	30%	100%

15.5 Detail of Cost Estimation

The unit prices for the cost estimation is based on the 1992 current prices at the site and for similar projects.

Basic cost estimation condition is given in subsection 7.9.2.

Major unit prices are shown in Table 15-10.

Local and foreign currency components are also assumed by the characteristics of the work. It is reported that most of construction material, and all of the construction equipment and fuel are imported. Thus, the net local component is labour cost. Table 15-11 shows samples of currency breakdown.
Detailed cost estimation is provided in Appendix B-1.

Table 15-10 Unit Prices of Major Work (1992 Price)

Works	Specification		Raw Price	Addition*	Unit Price			Adjustment
A. Rock								
1. Armour Rock	1 ~ 2 ton		50.0 $/m³	x 1.20*	= 60.0 $/m³			60.0 $/m³
2. Armour Rock	1 ~ 2 ton	Replace	50.0 $/m³	x 1.20	= 60.0 $/m³	x 0.40	=	24.0 $/m³
3. Armour Rock	400 ~ 700 kg		45.0 $/m³	x 1.20	= 54.0 $/m³			54.0 $/m³
4. Armour Rock	400 ~ 700 kg	Replace	45.0 $/m³	x 1.20	= 54.0 $/m³	x 0.40	=	22.0 $/m³
5. Core Rock	100 ~ 200 kg		40.0 $/m³	x 1.20	= 48.0 $/m³			
6. Core Rock	10 ~ 100 kg		40.0 $/m³	x 1.20	= 48.0 $/m³			
7. Core Rock	<10 kg		40.0 $/m³	x 1.20	= 48.0 $/m³			
B. Reclamation								
1. Gravel	Dredged				10.0 $/m³			
2. Run of Quarry					10.0 $/m³			
3. General Earth					10.0 $/m³			
4. Excavation and filling	at site				10.0 $/m³			
5. Excavation and dispose	to other site				10.0 $/m³			
C. Dredging								
1. Dredging	Clamshell		22.0 $/m³	x 1.20	= 25.0 $/m³			
2. Dredging	Blasting		41.0 $/m³	x 1.20	= 50.0 $/m³			
3. Dredging	Mixed		1/2 (25.0 + 50.0)		= 37.5 $/m³			
D. Concrete Works								
1. Reinforced Concrete	Type I	Wall	800.0 $/m³	x 1.20	= 960.0 $/m³			
2. Reinforced Concrete	Type II	Pave	600.0 $/m³	x 1.20	= 720.0 $/m³			
3. Plain Concrete	Type III	Wall	500.0 $/m³	x 1.20	= 600.0 $/m³			
4. Plain Concrete	Type IV	Flat	400.0 $/m³	x 1.20	= 480.0 $/m³			
E. Filter sheet			25.0 $/m²	x 1.20	= 30.0 $/m²			
F. Wave dispersion Block	Concrete unit							
1. Works on lagoon			500.0 $/m³	x 1.20	= 600.0 $/m³			
2. Works by floating plant			600.0 $/m³	x 1.20	= 720.0 $/m³			

* 20% increase for allowance and overhead is given to local unit price.
Since most of raw price is taken from the government construction sectors.

Table 15-11 Currency Breakdown Samples

Armour Rock, 1 ~ 2 ton

Work Component	Labour (Local)	Machine (Foreign)	Fuel (Foreign)	Material (Foreign)	Total
Quarry	10	10	4	1	25
Transport	2	2	1	0	5
Execution	12	14	3	1	30
	24	23	11	2	60
	40%	38%	18%	4%	100.0%

Local contents, 40 %.

Concrete (Reinforced), Wall work

Work Component	Labour (Local)	Machine (Foreign)	Fuel (Foreign)	Material (Local)		Material (Foreign)	Total
Preparation	50	25	5	80	+	120	280
Reinforcement	62	15	3	0	+	220	300
Form	40	12	3	25	+	100	180
Mix/Placing	113	42	5	10	+	30	200
	265	94	16	115	+	470	960
	28%	10%	1%	12%		49%	100.0%

Local contents
(265 + 115) ÷ 960 = 40 %

Chapter 16: Project Evaluation

Chapter 16 Evaluation of the Project

The purpose of the Feasibility Study is to appraise the viability of the project itself.

First of all, the necessity of the project (Policy objectives) and the concrete measures adopted in the project have been described in Chapter 11. Then the coordination and urgency of these measures have been examined in Chapter 11. Secondly, the validity concerning the investment scale and the implementation program of the project have been examined in Chapter 15. Thirdly, the effects of the project will be divided into two phases. One is implementation phase consisting of plan, survey and works. The other phase is utilization after the construction.

Fourthly, the measurement of the quantifiable benefit, which were identified in third procedure, will be carried out. Then the economic analysis will be conducted comparing the benefits and costs generated during the project life.

The third and fourth items will be done in this chapter.

16.1 Investment Scale and Implementation Plan

The total initial investment cost of the project is approximately NZ$21.2 million. Total costs for coastal protection works amount to about NZ$8.5 million and the total cost for port improvement is about NZ$12.8 million. Items of the initial investment cost are shown in Table 15-1 in Chapter 15. The construction schedule is shown in Fig. 14-1 in Chapter 14. The total cost will be paid out over the first three years.

16.2 Examination of the Positive Effects of the Project

In this section, the effects generated by the project will be described.

16.2.1 Business Effect

The effects generated by the implementation of the project can be divided into two phases: the planning phase consisting of plans, and surveys; and the construction phase.

1) Planning Phase

In the planning phase, the demonstration effect, which means effectiveness of advertising, employment effect and training effect are included.

In this study, counterpart training can be regarded as one of the effects.

2) Construction Phase

In the construction phase, demand for construction materials, increase in production by inter-industry relations, increase in plant investment and progress in production technology can be considered to be the effects.

Additionally, needless to way, employment opportunities will increase and training will be given to the works.

Accordingly, the impact on environment caused by the construction work will require sufficient consideration.

Table 16-1 shows the summary of the business effect.

Table 16-1 Summary of Business Effect

	Summary of Effects		Effects generated by this project
Business Effect	Planning Phase	Demonstration Economic and Educational Effect	Counterpart training in F/S Planning D/D Design Employment of staffs during the survey
	Construction Phase	Effect of increased demand for materials	Rocks, Stones, Sand about 200,000m³ Concrete about 10,000m³
		Effect of increaseed employment opportunities	Labour 7,500/man*days (One day 30)
		Educational effect	On the job training at work site
		Effect of developing resources	Development of Quarry Site and Secondary effect on employment
		Impact on environment	Water Pollution
		Other impact (Inflow of foreign labor)	

16.2.2 Utilization Effect

Effects generated after the construction work are called "Utilization effect".

This effect can be divided into three categories.

1) Existing Effect

The "Existing effect" refers to the positive impact on the existing facility itself, for example, protection of national land, the creation of a city monument, security of the nation and the peoples' resultant peace of mind.

2) Users' Effect

The "Users' effect" indicates the benefits of users of the facilities; for example, the consignees or shippers can receive benefits such as savings in time, savings in cost and the decrease in the ratio of damaged cargo, decrease in accidents, increased comfort and others.

3) Suppliers' Effect

The "Suppliers' effect" refers to positive impacts such as a decreases in operating/maintenance cost.

4) Multiplier Effect

The "Multiplier effect" can be divided into economic effects and socio-cultural effects.

The economic effect includes improved productivity, increased income, decrease in price of staple products prices and higher land values. Concerning the socio-cultural effect, an increase in employment opportunities and a higher quality of life can be cited; however, a negative impact on the environment must be considered.

Table 16-2 shows the summary of the utilization effect.

Table 16-3 shows the summary of benefit items.

Table 16-2 Utilization Effects

Summary of Effects	Benefits
Utilization Effect	
Existing Effect	
·Protection of national land	·Decrease in land-loss by coastal protection
·Safety of nation	·Safety of residents ·Maintaining of economic activities
·Security of facilities	·Protection of residential and public buildings ·Security of transport system such as airport, port, road ·Decrease in maintenance cost of the above facilities ·Seculity of life-line such as gas pipe-line, water supply and electric cable
·Symbol of city (formation of growth core in the city)	·Formation of growth core by the implementation of Port-Park Complex and Avarua Harbour Project
Users' Effect	
·Time and cost savings	·Savings in waiting time by improvement of breakwater at Avarva Habour ·Saving in ship cost due to the decrease in the delay of ship arrival ·Savings in damage of containers and increase in cargo handling efficiency
·Decrease in fatigue	·Decline in fatigue by the decrease in waiting off-shore: port entry is much easier
·Improvement of landscape	·Enhanced scenic beauty by green zone in Port Park Complex: also increase in tourists
Suppliers' Effect	
·Savings in operating cost	·Improvement of cargo handling efficiency by the expansion of yards and procurement of required equipment ·Decrease in working time of laborers by decrease in delay of ship arrival
·Savings in maintenance cost	·Decrease in maintenance cost of breakwaters and wharves ·Decrease in off-shore unloading
Multiplier Effect (Economic Benefits)	
·Improvement of land-use efficiency	·Land in urban areas will be utilized efficiently
·Increase in income	·People engaged in tourism, fishery, agriculture, commerce can raise their incomes
·Increase in land value	·Government will receive higher rental charges because of increasing land values
·Input of foreign currency (Socio-Economic)	·Increase in the number of tourists generates foreign currency
·Increase in employment opportunities	·Promotion of industries creates employment opportunities
·Improvement of quality of life	·Economic growth of the nation, and establishment of infrastructure make life-levels improve
·Impact on society and culture	·Increase in tourism
·Impact on environment	

Table 16-3 Type of Benefits

Items	Coast or Port	Direct	Indirect	Scale of Eff. H — M — S	Quantifiable or Unquantifiable	NO.
·Decrease in land-loss by coastal protection	C	O		▲	Q	
·Safety of residents	C	O		▲	U	
·Maintaining of economic activities	C		O	▲	Q	
·Protection of residential and public buildings	C	O		▲	Q	
·Security of transport system such as airport, port, road	C・P	O		▲	U	
·Decrease in maintenance cost of the above facilities	C・P	O		▲	Q	
·Seculity of life-line such as gas pipe-line, water supply and electric cable	C	O		▲	U	
·Formation of growth core by the implementation of Port-Park complex and Avarua Harbour Project	C		O	▲	U	
·Savings in waiting time by improvement of breakwater at Avarua Habour	P	O		▲	Q	
·Saving in ship cost due to the decrease in the delay of ship arrival	P	O		▲	Q	
·Savings in interest by improvement of cargo handling efficiency	P	O		▲	Q	
·Decline in fatigue by the decrease in waiting off-shore: port entry is much easier	P		O	▲	U	
·Enhanced scenic beauty by green zone in Port Park Complex: also, increase in tourists	C		O	▲	U	
·Improvement of cargo handling efficiency by the expansion of yards and procurement of required equipment	P	O		▲	Q	
·Decrease in working time of laborers by decrease in delay of ship arrival	P	O		▲	Q	
·Decrease in Maintenance Cost of Breakwaters and Wharves	P	O		▲	Q	
·Decrease in off-shore unloading	P	O		▲	Q	
·Land in urban areas will be utilized efficiently	C		O	▲	U	
·People engaged in tourism, fishery, agriculture,Commerce can raise their incomes	C・P		O	▲	U	
·Government will receive higher rental charges because of increasing land values	C		O	▲	Q	
·Increase in the number of tourists generates foreign currency	C・P		O	▲	U	
·Promotion of Industries creates employment opportunities	C・P		O	▲	U	
·Economic grouth of the nation, and establishment of infrastructure improve quality of life	C・P		O	▲	U	
·Imoact on landscape			O	▲	U	
·Increase in tourism			O	▲	U	

16.3 Purpose and Methodology of the Economic Analysis

16.3.1 Purpose

The purpose of the economic analysis is to appraise the economic feasibility of the Short-term Plan for coastal protection and port improvement from the viewpoint of the national economy. For this purpose, after investigating the economic benefits and costs that will arise from the project, it is examined whether the net benefits of this project will exceed those that could be obtained from other investment opportunities (the opportunity cost of capital) in the Cook Islands.

16.3.2 Methodology

(1) EIRR

The economic internal rate of return (EIRR) based upon a cost-benefit analysis is used to appraise the feasibility of the project.

(2) "With" and "Without" Analysis

The EIRR value is obtained from the yearly economic benefit-cost value. The economic benefits are obtained from the difference between the "with" case and the "without" case.

As for the detailed method used for calculating cost and benefits, please refer to Section 16.5.

NOTE) The economic analysis of projects must be based on incremental benefits and costs. This requires comparison of the situation that would prevail without the project and the situation with the project. This "with and without" comparison may not be the same as a "before and after" comparison. For example, it could be that the availability of the relevant inputs and outputs to the rest of the economy would change even without the project. Such expected changes should be taken into account in defining the "without project" situation.

(3) Measurement of Costs and Benefits

In estimating the costs and benefits of the project, it should be noted that the value of goods quoted at a market price does not always represent the true value of those goods from the viewpoint of the national economy. The local currency portion of the goods and materials at market prices often includes customs duties. The labour cost at market prices is often influenced by a minimum wage system and other regulations. Therefore, "economic pricing" should be conducted for the economic analysis. Economic pricing here means the appraisal of costs and benefits in terms of international prices (border prices). In the calculation of the costs and benefits, transfer items such as import duties, other taxes and subsidies should be excluded. The market prices are changed to border prices by various conversion factors mentioned below.

16.3.3 Conversion into Economic Prices

In general, all costs and benefits are divided into traded goods, non-traded goods, labour and transfer items. Labour is further divided into skilled and unskilled labour.

Transfer items such as tax and subsidies can be eliminated because they do not cross the national border.

(1) Traded Goods

Traded goods are expressed at CIF (cost, insurance and freight) prices for imports and at FOB (free on board) prices for exports, which are border prices themselves.

(2) Non-traded goods

The local currency portion, after deducting traded goods, labour costs and transfer items, is considered as non-tradable goods, of which the economic price is calculated by multiplying the Standard Conversion Factor (SCF). The SCF is used to determine the economic prices of certain non-traded goods and services that cannot be directly valued at border prices. By using the SCF, we are able to void the price differential between the domestic market and the international market, a differential caused by import duties and export subsidies.

SCF is expressed by the following equation:

$$SCF = \frac{I + E}{(I + D_i) + (E - D_e)} = 0.86$$

Where, I : Total Amount of Import
E : Total Amount of Export
D_i : Total Amount of Import Duties
D_e : Total Amount of Export Duties

In this Study, SCF = 0.86 is adopted.

(3) Labour

a) Skilled Labour

The economic cost of skilled labour is obtained by multiplying its market price by the Conversion Factor for Consumption (CFC), assuming that the market mechanism is functioning properly. The CFC is used for converting the prices of consumer goods from domestic market prices to border prices.

CFC is expressed by the following equation:

$$CFC = \frac{(IC+EC)}{(IC+D_{ic})+(EC-D_{ec})} = 0.92$$

Where, IC : Total Imports of Consumer Goods
E C : Total Exports of Consumer Goods
D_{ic} : Total Import duties of Consumer Goods
D_{ec} : Total Export duties of Consumer Goods

In this Study, CFC = 0.92 is adopted.

b) Unskilled Labour

For the economic analysis, costs for unskilled labour should be measured in terms of their opportunity cost; that is, the value of lost marginal production that the employment of laborers for a given project would create for other purposes.

It is common that the inflow of unskilled labour to the project is mainly from the agricultural sector which is relatively elastic in its use of labour and where wages are normally lowest. So, it is often assumed in a simplified manner that the economic cost of unskilled labour is equal to the per capita income of the agricultural sector. The general wage level for agricultural workers, according to the data prepared by MOPED, is NZ$ 27 a day. Consequently, we can consider wages for agricultural workers as a reliable indicator of marginal productivity, that is, the economic cost of unskilled labour.

Therefore, it can be considered that the economic cost is NZ$ 27 a day. Multiplying this figure with the market price of unskilled labour for construction (estimated NZ$ 36 a day) and CFC, the conversion factor for unskilled labour is calculated as below.

Conversion Factor for Unskilled Labour	=	Workers' Opportunity Cost	/	General Workers' Construction Cost	x CFC

= 27/36 x 0.92

= 0.69

16.4 Prerequisites of the Economic Analysis

16.4.1 Period of Calculation

Taking into consideration the depreciation period of the main facilities and the construction schedule, the period of calculation for the economic analysis is assumed to be 30 years.

16.4.2 "With" Case

According to the Short-term Plans shown in Chapters 12 and 13, the projects comprise:

1) Coastal Protection for:

a. Seawall at the airport, West end,
b. Coast at the fuel tank yard, airport East,
c. Area between Avatiu Harbour and Avarua, (Port Park Complex)