MINISTRY OF INFRASTRUCTURE (MOI)
THE GOVERNMENT OF THE KINGDOM OF TONGA

PREPARATORY SURVEY REPORT
ON
THE PROJECT
FOR
UPGRADE OF WHARF FOR DOMESTIC TRANSPORT
IN
THE KINGDOM OF TONGA

MARCH 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
IDES INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Joint Venture of Oriental Consultants Global Co., Ltd. (consist of Ides Co., Ltd.).

The survey Team held a series of discussions with the officials concerned of the Government of the Kingdom of Tonga, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Tonga for their close cooperation etended to the survey team.

March 2015

Akira Nakamura
Director General,
Infrastructure and Peacebuilding Department
Japan International Cooperation Agency

Summary

1. Background and Outline of the Proposal for Official Grant Aid

(1) Outline of Nuku'alofa Port

The Kingdom of Tonga is in the South Pacific Ocean with an archipelago of 170 islands and has only 36 islands that are inhabited. Tonga's total land area is 718 km^2 and it has 419 km of total coastline and lies on a volcanic ridge known as the Pacific Ring of Fire. Sea transportation is a critical component in the development process of the country as a whole. More than 90 percent of the volume of the foreign trade is carried by sea. The islands of Tonga are scattered in an Exclusive Economic Zone (EEZ) area of approximately 700,000 km^2, so inter-island shipping plays a crucial role in providing the fundamental means of transportation for the people as air transportation is either expensive or very limited in both capacity and availability.

Nuku'alofa Port is situated on Tongatapu island (the largest island at 257 km^2 and with approx. 70,000 inhabitants). Nuku'alofa Port consists of three wharfs; Queen Salote Wharf for international cargoes and inter-island shipping, Vuna Wharf for international cruise ships and Faua Wharf. Faua Wharf was built to cater for the domestic cargo and passenger ferries and fishing vessels. Currently, the domestic ferries provide daily sea transport services to Eua Island except for Sunday. More than 30,000 passengers are traveling each year between Nuku'alofa Port and Eua Island.

Inter-island transport has no sole use berth and presently it has to use a part of Queen Salote Wharf tentatively. As for the demand trend of inter-island passengers and cargo, the number of passengers is about 40,000 persons per year and cargo volume is about 20,000 tons per year. Both figures have not changed much during the past 10 years. The main route of domestic transport is Nuku'alofa ~ Ha'apai ~ Vava'u and two domestic ships operate on the route. MV Otouanga'ofa is the main ship, 400 pax with 563 tons of cargo capacity. Another ship is MV Pulupaki, 250 pax with 120 tons of cargo. The former is operated by the Friendly Island Shipping Agency (FISA: a Public company in Tonga) and the latter is by a private company. The operation frequency of the two ships is on the same timing, once a week departing from Nuku'alofa every Tuesday evening. In the view point of effective use of the berths, it would be better if each ship used the berth on different timing. However, both ships give a demand basis for operation priority over keeping a periodic operation due to small demand and financial reasons.

(2) Current Problems of Inter-island Transportation

Since both passengers and cargo volumes of inter-island ferries are constantly full or over capacity, the present terminal is always overcrowded every Tuesday. Furthermore, the present ferry terminal is an awkward shape, as a result, these two elements bring chaos to passenger and cargo flows and an unsafe situation caused by the turbulent flows occur everywhere in the present terminal. Besides, waiting passengers have to stand outside due to the lack of a waiting hall and they are suffering from sand and dust pollution because there is no paving in the present terminal area, so, the environment while waiting

for boarding is very poor. Therefore, passengers are strongly wishing for a terminal building and pavement in the whole terminal area.

Another problem of the existing two berths is that the berths cannot function as a shelter port due to the lack of a breakwater. Mainly North or North-West winds are remarkable at Nuku'alofa especially when a cyclone strikes. Although the existing port mouth opens to the East, strong waves diffract and come into the existing domestic transport berths so ships cannot stay alongside of the berths in bad weather. As a result, they have to evacuate to offshore during rough sea conditions.

Also, the berths can be used for another two ships, MV Nuivakai and MV Sitka. The former has an important role in carrying logs from Eua Island. Basically ships for Eua Island should use Faua Wharf but big logs need wide and long berth so she has to use the domestic berth when it is available. The latter carries mainly construction materials for Ha'apai and Vava'u and her body is relatively smaller so usually she can use the same berth with MV Otuanga'ofa, although the gap between the two ships is quite narrow and it is not recommendable by International Standards.

As a wrap up of the discussions, the items to be solved are as follows.

i. To secure passenger and cargo flows and ensure the safety of both flows.
ii. To expand the cargo yard and acquire an appropriate number of car parking spaces.
iii. Necessity to function as a shelter port.
iv. To secure safe manoeuvring space in the port basin area and access channel. Necessity of berth development to realize safe cargo handling operations.
v. To improve the environment of waiting passengers by building a terminal building and pavement in the terminal.

(3) Request by the Tongan Side

The primary application from the Tongan side was for the rehabilitation of the existing Faua Wharf to accommodate MV Otuanga'ofa. (refer to Table 1)

Table 1 Primary Request by Tongan Side

No	Description	Size	Quantity
1	Wharf Extension (by sheet piling)	W=10 m x L=134 m	1 Lot
2	2-Story Domestic Ferry Passenger Terminal Building	W=17 m x L=50 m	1 No.
3	Solar Panel Roof for Terminal Building	-	1 Lot
4	Access road, Walkway & Car Passenger loading & unloading area	-	1 Lot
5	Concrete Parapet Wall	H=1.5 m x L=134 m	1 Lot
6	Dredging Wharf Basin	To depth of 5.5 m	1 Lot

After discussions with the participants such as MOI, PAT, FISA, Captains, ship owners, etc. through the Preparatory Survey, it was found that it would be difficult to construct the required components in the existing Faua Wharf due to the following reasons;

- There is not enough sea area to manoeuvre M.V. Otuanga'ofa safely.
- Wave conditions in Faua Wharf will become worse by widening the port mouth

Therefore, the location of a new wharf for the inter-island ferries was studied along with several options. The western side the sea area of Faua Wharf is selected as the most optimal location for a new wharf.

Although the original application from the Government of Tonga requested an upgrade of Nafanua Wharf on Eua Island, both Japan and the Tonga side agreed that it would not be included in the Project due to the limited budget.

2. Outline of the Study Results and Contents of the Project

(1) Survey Period

The Japan International Cooperation Agency (JICA) dispatched the Survey Team to Tonga from August 22, 2014 to October 4, 2014. The Survey Team conducted a series of site inspections including topographic and bathymetric surveys, soil investigations and an environmental survey, held discussions with MOI to confirm the requests and the involved organizations and budget allocations. After the team returned to Japan, discussions with the Japanese side were undertaken and an outline design study was prepared that compiled with the draft outline design report. From February 9 to February 19, 2015, the draft outline design report explanation team was dispatched to Tonga to explain the draft outline design report and the contents of the Project.

(2) Upper Goal of the Project

According to the "Tonga Strategic Development Framework (TSDF) 2011-2014", presented by the Government of Tonga, to ensure safe and reliable transport infrastructure is one of the key outcomes in the infrastructure sector. The Government of Tonga has prioritized increasing competition, with responsible supervision, to increase the quality of sea transport services both domestically and internationally.

This project is for the upgrade of inter-island transportation in response to the strategies of the TSDF and improvement of the maritime transport sector as follows;

i. To ensure safe and reliable transport infrastructure and facilities,
ii. To promote high quality competition in sea transport services,
iii. To improve inter-island transport easing the socio-economic condition of Tonga,
iv. To address the issue of climate change and risk disaster management.

(3) Objective and Scope of the Project

1) Objective of the Project

The objective of the Project is to improve handling efficiency in order to ensure the safety of Nuku'alofa Port through separating domestic and international cargoes.

2) Input by the Project (Scope of Assistance)

i) Project Components

Based on the original request by the Tongan side, a pre-preparatory survey was conducted in 2014, and the discussions in this Preparatory Survey and scope of the assistance are concluded as shown in Table 2.

Table 2 Basic Components of the Project

No	Facilities	Descriptions	Remarks
1	Breakwater	Rubble mound type sloping breakwater with concrete parapet walls	L=approx. 250 m
2	Berth	2 nos. for large domestic ferries	L=90 m/berth
3	Loading Ramp	2 nos.	
4	Accessories	Mooring bits, fenders, curbs, etc.	
5	Channel & Basin	Dredging works	Designed depth: -4.0 m
6	Cargo handling yard	Concrete pavement	CDL+3.0 m
7	Passenger Terminal Building	3 story RC structure w/solar panel on top	
8	Access road, Car parking	Asphalt pavement	
9	Ancillary	Sidewalk, Passenger walkway, Drainage, Fences	
10	Guard house, Waste station	One-story, 2 nos. each	
11	Navigation Aids	2 marine lights, Sector light	

ii) Allocation of the project components from the objectives of the Project

The relationship between the objectives and project components are summarized below;

① To secure navigation safety for vessels
   a) Upgrading of the navigational channel and basin
   b) Installation of navigation aids (beacons and sector light)

② To secure the berthing and mooring operations
   a) Securing harbour calmness with a breakwater
   b) Installation of fenders and bollards

③ To secure the safety for passengers and cargo handling operations
   a) Upgrading the cargo yard and loading ramps
   b) Separating the traffic lines of cargo and passenger
   c) Installation of vehicle entrance gates and guard houses
   d) Installation of guard fences
   e) Upgrading the car parking area

④ To secure the safety and amenities in the passenger waiting area
   a) Upgrading the waiting hall in the terminal building
   b) Upgrading the pavement to prevent sand and dust
   c) Installation of the covered passenger walkway

⑤ Others (earnings and landscape, etc.)

a) Preparing attractive facilities such as a restaurant and viewing deck

b) Construction of a greenbelt along Vuna road

c) Installation of a monument to the friendly intercourse between Japan and Tonga

d) Terminal building as an evacuation facility

e) Adoption of LED lights for yard lighting and building

(4) Basic Plan

Based on the above-mentioned matters, the planned concept for upgrade of domestic transportation are as summarized in Table 3.

Table 3 Planned Concepts for Upgrade of Domestic Transportation

No	Port Facilities	Planned Concepts	Remarks
1	Breakwater	Breakwater (250 m length) will be built on the north side of the wharf. The structural type will be a rubble mound sloping type with concrete parapet walls.	The harbour calmness alongside the wharf shall be secured to provide a cargo handling operation rate of at least 97.5% considering that the critical wave height for cargo handling works is 0.5 m of $H_{1/3}$.
2	Berths	Two berths (90 m length) will be planned. The structural type of the quay wall will be a sheet pile type and the crown height will be +3.0 m.	Two inter-island ferries shall be able to be alongside and handle their cargoes simultaneously.
3	Loading Ramps	Two loading ramps (20 m width) will be planned.	Safe cargo handling operations shall be secured corresponding to the tidal changes.
4	Accessories	Accessories for the mooring facilities such as bollards (250 kN), V-shaped fenders, curbing, corner plates, etc. will be planned.	The safety of berthing and mooring of domestic ferries shall be secured.
5	Channel and basin	Channel (-4.0 m water depth and 60 m width) and basin (120 m diameter) will be planned by dredging works.	The safe navigation and ship manoeuvring for domestic ferries shall be secured.
6	Cargo handling yard	The cargo handling yard will be paved with concrete pavement and eight LED lighting poles will be installed for night time operation.	The pavement shall prevent the sand and dusts and secure the safety of cargo handling operations. Concrete paving shall be selected due to its durability and easy maintenance.
7	Passenger Terminal Building	3 story RC structure building (25 m width and 50 m length) with solar panels on top will be planned.	Safe and attractive spaces shall be provided for not only passengers but also tourists and the Tongan people.
8	Access road and car parking	Access road and car parking (approx. 100 parking spaces) with asphalt paving will be planned.	The passenger pickup cars and cargo trucks shall be able to access the port easily and smoothly.
9	Ancillary	Ancillaries such as sidewalk, passenger walkway, drainage, fences, etc. will be planned.	Ferry passengers shall be able to board and exit safely and comfortably. Port security shall be secured to prevent third parties from entering the port area.
10	Guard houses and waste stations	1 story buildings for a guard house and waste station will be planned at each gate.	The security guards shall be arranged at each gate to check the cargo trucks and secure the safety of passengers. The waste stations shall be provided for environmental reasons.
11	Navigation aids	Two marine lights at the port entrance and one sector light on land will be planned.	Domestic ferries shall be operated safely year-round.

3. Implementation Schedule and Project Cost

The implementation schedule of the Project is about 28.5 months for detailed designs, tender process and construction. The cost of the Project provided by the Tongan Government is roughly estimated at about $TOP 291,000 (about JPY 16.1 million).

4. Project Evaluation

The Project will generate the following benefits.

(1) Relevance

Pacific Islands Leaders Meeting: PALM is a summit-level meeting which has been held every three years since 1997. Leaders openly discuss various issues that Pacific island countries are facing in order to build close cooperative relationships and forge a bond of friendship between Pacific island countries and Japan.

The Sixth Pacific Island Leaders Meeting (PALM 6) took place at the Bankoku Shinryokan, Nago City, Okinawa, on May 25 and 26, 2012, in the summit, Japan committed to make maximum efforts to provide up to 500 million US dollars of assistance over the next three years in order to push forward cooperation and at the end of the summit, the Okinawa "Kizuna (“Bonds” in English)" Declaration was adopted.

This Project coincides with the policy of Japanese aid to Pacific island counties just like the Okinawa “Kizuna” Declaration.

(2) Effectiveness

1) Quantitative Effects

Table 4 Project Outcome (Quantitative Effects)

Indices	Basis (at 2014)	Target (at 2021, three years after completion of the Project)
Wharf / Mooring Facilities Number of ship calls for the 1,500 G.T. vessels (times per year)	0	45 times per year
Wharf / Mooring Facilities Cargo Volume (tons per year)	0	45,000 tons per year
Wharf / Mooring Facilities Passenger Traffic (persons per year)	0	45,000 persons per year

2) Qualitative Effects

a) Reduction of berthing and leaving time for inter-island ferry
b) Improvement of cargo handling efficiency by the upgrade of cargo yard and the separation of traffic flows of cargoes and passengers
c) Improvement of the amenities for passengers by the upgrade of the waiting hall
d) Security for passengers by the upgrade of the passenger walks way
e) Revitalizing the economy in Tonga with the increased revenue and job development by the upgrade of the new terminal building

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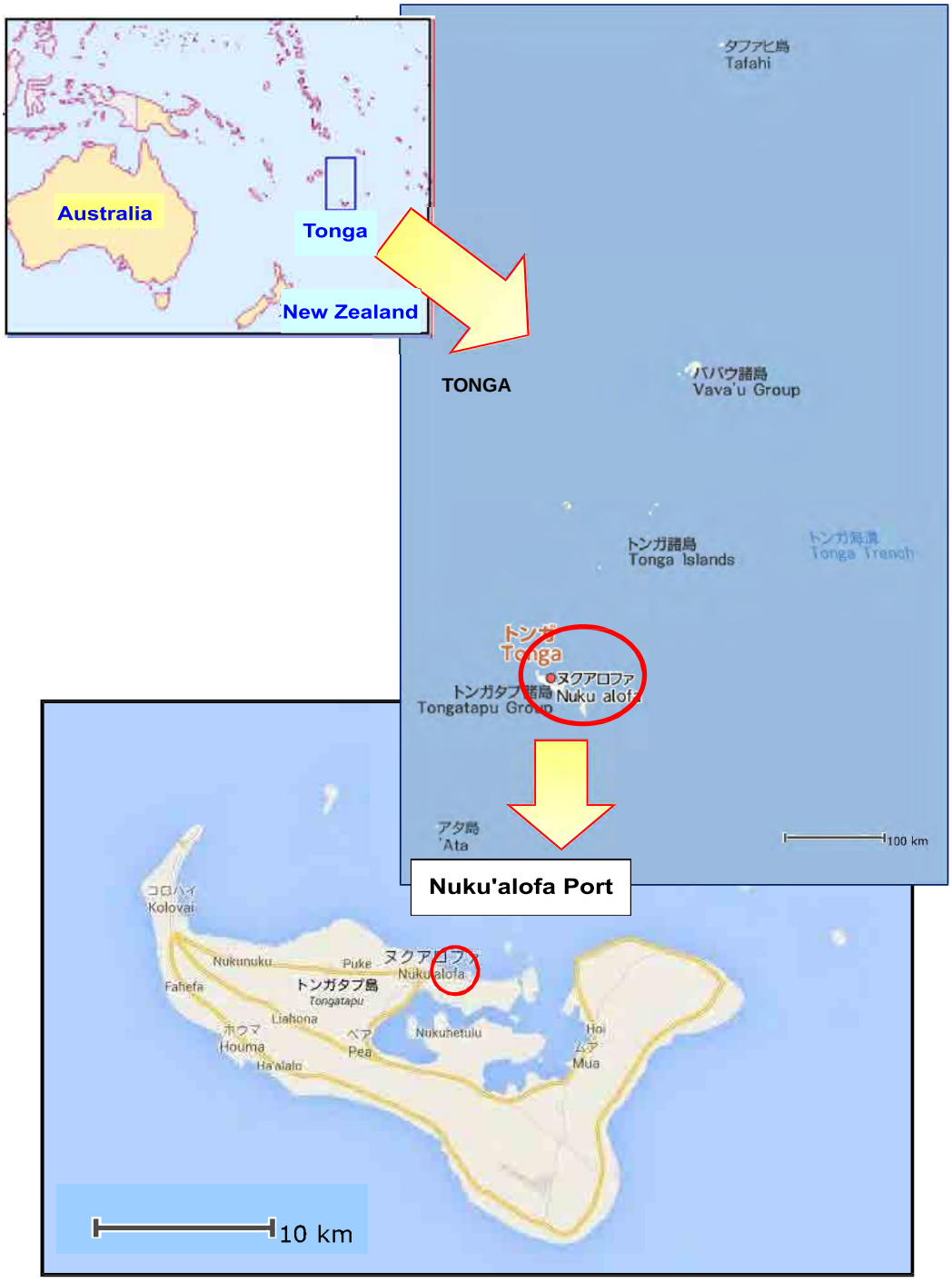
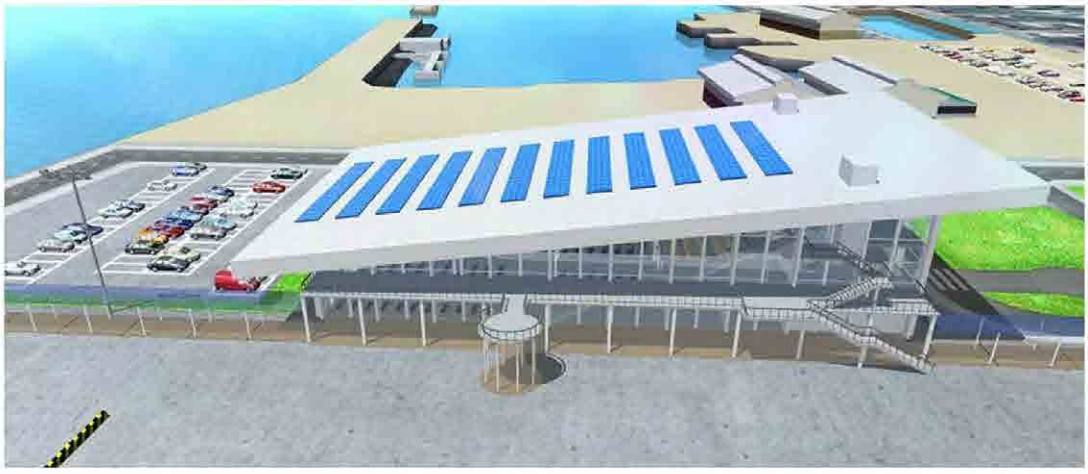


Location Map



Perspective

Photo 1 : Queen Salote Wharf (Berth No.3 & 4)

Photo 1-1: Full View of Berth for Inter-island Ferry

Berth No. 3 & 4 in Queen Salote Wharf

No paving behind the apron area

Photo 1-2: Passenger Waiting Shed and Toilet

There is no wall for waiting shed, so it is windswept and passengers are suffering from sand dust.

Photo 1-3: Loading Ramps

Two ferries are berthing side by side.

Photo 1-4: Inside of the Waiting Shed

There are not enough chairs, and winds and rains blow in. Passengers are suffering severely from sand dust pollution by the strong winds

Photo 1-5: Boarding into ferry (MV Otuanga'ofa)

Passengers are boarding through the landing step at portside.

Photo 1-6: Car Parking

Overcrowding and congestions in car parking are caused by the lack of spaces and compartment lines.

Photo 1 : Queen Salote Wharf (Berth No.3 & 4)

Photo 1-7: Cargo Loading into MV Otuanga'ofa

Containers and bulk cargoes are loading by forklift.

Photo 1-8: Forklift (8 tons weight) for cargo handling

Photo 1-9: Cargo Loading by Ship Crane

MV Otuanga'ofa has two ship cranes.

Photo 1-10: Boarding onto MV Pulupaki

After finish cargo loading, MV Pulupaki is shifted to be alongside and passengers are boarding from portside.

Photo 1-11: MV Otuanga'ofa is mooring at Berth No.3 in Queen Salote Wharf.

Photo 2: Faua Wharf

Photo 2-1: Full View of Faua Wharf

Photo 2-2: Port Entrance at Faua Wharf

Photo 2-3: Existing Breakwater at Faua Wharf

Rubble mounds are made of coral stones in Tonga. Waves are overtopping during rough sea conditions due to the low crown height.

Photo 2-4: East Area of Faua Wharf

Photo is taken toward south direction from North-West corner. Warehouses are in the back.

Photo 2-5: Revetment on west side of Faua Wharf

Photo 2-6: Sea area on west side of Faua Wharf

Planned Project Site

Photo 2: Faua Wharf

Photo 2-7: Sea area on west side of Faua Wharf

Proposed Project Site

Revetments along Vuna road can be seen in the back.

Photo 2-8: Revetment on the west side of Faua Wharf

Taken from South toward North.

Photo 2-9: Walking Path alongside Vuna Road

Photo 2-10: West side of Faua Wharf

There are containers and materials for maintenance of MV Pulupaki.

Photo 2-11: West side of Faua Wharf

Maintenance materials for MV Pulupaki

Photo 2-12: West side of Faua Wharf

Miscellaneous materials and waste for MV Pulupaki

Photo 2: Faua Wharf

Photo 2-13: West side of Faua Wharf

Moored abandoned vessels

Photo 2-14: Ferry Berth bound for Eua Island

MV Onemato is moored.

Photo 2-15: Boarding to MV Onemato

Passengers board MV Onemato from the ramp on the bow. She makes one round trip to Eua Island every day except Sunday.

Photo 3: Inter-island Large Ferries

Photo 3-1: MV Otuanga'ofa

Ship Owner: FISA

Gross Tonnage: 1,534 G.T.

Dead Weight: 563 ton

Passengers: 400 persons

Photo 3-2: MV Pulupaki

Ship Owner: UATA, Gross Tonnage: 500 G.T.

Dead Weight: 120 ton, Passengers: 250 persons

Photo 3-3: MV Sitoka

Ship Owner: South Sea Shipping,

Gross Tonnage: 289 G.T., Dead Weight: 133 t

Main transport item is construction materials.

Photo 3-4: MV Nuivakai

Ship Owner: FISA, Gross Tonnage: 591 G.T.

Main transport item is logs from Eua Island.

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Abbreviations

	Abbreviation	Meaning
A	ADB	Asia Development Bank
B	BOD	Biological Oxygen Demand
C	COD	Chemical Oxygen Demand
D	DO	Dissolved Oxygen
	DWT	Dead Weight Tonnage
E	EBIT	Earnings Before Interests and Taxes
	EBITDA	Earnings Before Interest, Tax, Depreciation and Amortization
	EIA	Environmental Impact Assessment
F	FISA	Friendly Island Shipping Agency Limited
G	GT	Gross Tonnage
H	HAT	Highest Astronomical Tide
I	IFC	International Finance Corporation
	IUCN	International Union for Conservation of Nature and Natural Resources
J	JICA	Japan International Cooperation Agency
L	LAT	Lowest Astronomical Tide
M	M/D	Minutes of Discussions
	MEC	Ministry of Environment and Communication
	MHWS	Mean High Water Spring
	MLWS	Mean Low Water Spring
	MOFNP	Ministry of Finance and National Planning
	MOI	Ministry of Infrastructure
	MOPE	Ministry of Public Enterprise
	MSL	Mean Sea Level
N	NEMO	National Emergency Management Organisation
	NIIP	National Infrastructure Investment Plan
	NPA	National Planning Authority Office
	NPBT	Net Profit Before Tax
	NPAT	Net Profit After Tax
O	ODA	Official Development Assistance
	OHCA	Office for Coordination of Humanitarian Affairs
P	PAT	Ports Authority Tonga
S	SS	Suspended Solids
T	TEU	Twenty-foot Equivalent Unit
	TFP	Tonga Forest Products
	T-N	Total Nitrogen
	TOP	Tonga Pa'anga
	TOR	Terms of Reference
	T-P	Total Phosphorus
	TPH	Total Petroleum Hydrocarbon
	TPL	Tonga Power Limited
	TDSL	Tonga Strategic Development Framework

Chapter 1 Background of the Project

1. Background of the Project

1-1 General

The Kingdom of Tonga is in the South Pacific Ocean with an archipelago of 170 islands and has only 36 islands being inhabited. Tonga's total land area is 718 km^2 and has 419 km coastline lying on a volcanic ridge known the Pacific Ring of Fire. Sea transportation is a critical component in the development process of the country as a whole. More than 90 percent of the volume of the foreign trade is carried by sea. The island of Tonga are sparely located in an Exclusive Economic Zone (EEZ) area of approximately 700,000 km^2, so inter-island shipping plays a crucial role in providing the fundamental means of transportation for the people as air transportation is either expensive or very limited in both capacity and availability.

Nuku'alofa Port is situated in Tongatapu island (the largest island 257 km^2 and approx. 70,000 inhabitants). Nuku'alofa Port consists of three wharfs; Queen Salote Wharf for international cargoes and inter-island shipping, Vuna Wharf for international cruise ship and Faua Wharf. Faua Wharf was built to cater for the domestic cargo and passenger ferries and fishing vessels. Currently, the domestic ferries provide daily sea transport services to Eua Island except Sunday. More than 30,000 passengers travel each year between Nuku'alofa Port and Eua Island, and the demand for transport of passengers and cargoes in inter-island ferry services is increasing.

The challenges of Faua Wharf are as follows:

i. The wharf cannot cater for the operations of bigger ferries more than 300 GT,
ii. The waterway and basin are shallow for the draught of the M.V.'Otuanga'ofa (1500 GT),
iii. There are no proper facilities for loading and unloading of cargoes,
iv. There are no safety facilities for passengers and port operators, and
v. There is not sufficient shelter for all domestic ferries during the tropical cyclones.

For the above reasons, the domestic inter-island ferries such as the M.V.'Otuanga'ofa, M.V. Pulupaki and M.V. Sitka are berthing at the Queen Salote Wharf for their operations. The operations of these ferries during embarking and disembarking of passengers are crowded and the loading and unloading of general and hazardous cargoes are dangerous due to the lack of proper facilities.

According to the "Tonga Strategic Development Framework (TSDF) 2011-2014", presented by the Government of Tonga, to ensure safe and reliable transport infrastructure is one of the key outcomes in the infrastructure sector. The Government of Tonga has prioritized the increasing competition, with responsible supervision, to increase the quality of sea transport services both domestically and internationally.

This project will upgrade Faua Wharf in order to implement the following strategies of the TSDF and improve the maritime transport sector:

i. To ensure safe and reliable transport infrastructure and facilities,
ii. To promote competition with high quality in sea transport services,
iii. To improve inter-island transport easing the socio-economic condition of the Tonga,

iv. To address the issue of climate change and risk disaster management.

According to the above-mentioned background, the Government of Tonga requested Japan's Grant Aid for the project for upgrade of Faua Wharf.
Based on the request from the Government of Tonga, the preliminary survey was conducted in February 2014. In this survey, it was agreed between the Tongan side and the Japanese side that the project components will be studied to upgrade Faua Wharf. The purpose of this JICA Preparatory Survey (hereinafter referred to as "the Survey") is to determine the project components based on the discussions, survey and study regarding the requirements.

This inception report is prepared to confirm the mutual understandings regarding basic items of the required project (hereinafter referred to as "the Project"), the characteristics of the Survey, the objectives and methods of the Survey and to explain Japan's Grant Aid scheme.

1-2 Main Goals

The JICA Survey Team (hereinafter referred to as "the Team") understands that the following two items make up the main goals of the Government of Tonga and agreement with the Japanese side in the preliminary survey conducted in February, 2014:

- Upgrading Faua Wharf to provide a safe and reliable terminal for all domestic ferries in order to increase high quality competition in providing sea transport services,
- Securing a sustainable shelter to address issues of climate change and disaster risk reduction.

The objective of the project is to improve handling efficiency in order to ensure the safety of Nuku'alofa Port through separating domestic and international cargoes.

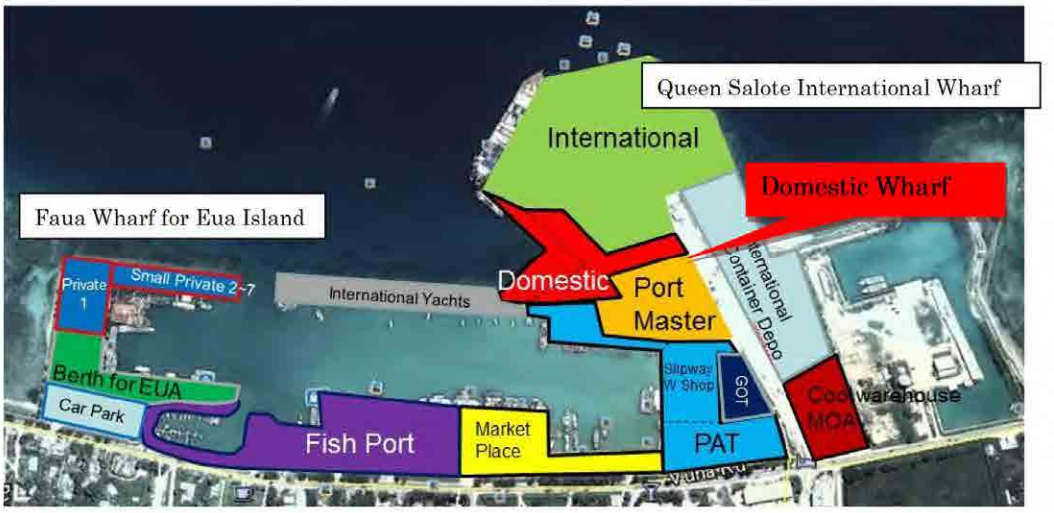
1-3 Objectives

The aim of the Survey is to provide the basic documents necessary for the appraisal of the Project by the Japanese Government. It is important for both sides to understand that at this stage of the Survey no commitment is made from the Japanese side concerning the realization of the Project. The final report will be used by the Japanese Government to decide whether or not some components of the Project will be executed under the Grant Aid scheme. The basic concept, size, contents and the related Grant Aid items (if it is executed) are also to be decided from the results of the Survey by both sides.
Based on the above, the objectives of the Survey are summarized as follows:

i. To confirm the objectives and contents of the requested project,
ii. To confirm the necessity and justification of the implementation of Japan's Grant Aid project,
iii. To identify the most suitable scope and components of the Project,
iv. To implement an outline of the design and cost estimation,
v. To propose the implementation plan and obligations of the recipient country for the Project.

1-4 Present Conditions of Nuku'alofa Port and Tasks to be solved

Nukualofa Port has several important roles in marine transport in Tonga. The roles are; International wharf called Queen Salote Wharf, central wharf which handles agricultural products and general cargos, fishing port area, and ferry wharf for Eua Island named Faua Wharf. Additionally, international yachts are berthing along the central breakwater. During a busy period or under a variety of circumstances, the domestic cargo/ passenger berthing, one of important roles of Nuku'alofa Port, is allocated in a part of Queen Salote Wharf as shown in the red colour of the following Figure.

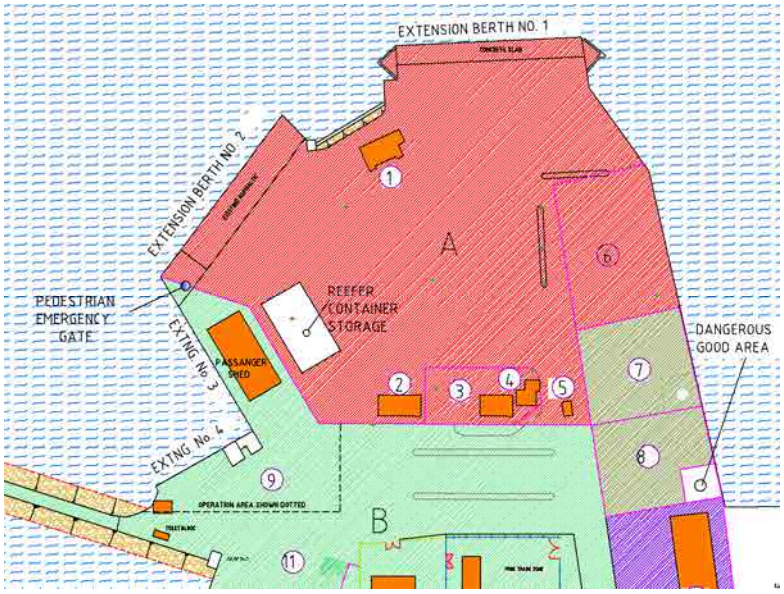


Source: Google Earth, JICA Study Team

Figure 1-1 Present Nuku'alofa Port

1-4-1 Queen Salote Wharf

The following is a plan-view drawing of Queen Salote International Wharf.



Source: PAT

Figure 1-2 Queen Salote Wharf

Table 1-1 Facilities of Queen Salote Wharf

Berth Name	Length (m)	Depth (m)	Purpose
No.1 (North)	93	11.6	Container, General cargo
No.2 (North-West)	110	12.0	Container, Tanker, Ro-Ro, General cargo
No.3 (West)	100	8.0	Domestic transport (passenger cargo & Ro-Ro)
No.4 (West)	60	8.0	Domestic transport (passenger cargo)

Source: PAT

Cargo handling volume of Queen Salote International Wharf is about 220,000 ton/ year of which about 200,000 ton is import cargo and the balance of 20,000 ton is for export. These volumes have been almost the same during the past 10 years. The main import cargos are from New Zealand and the feeder ships visit Nuku'alofa port basically once a week. Japanese break bulk/ Ro-Ro ships also visit once a month by way of Asian countries. Considering the scale/ size of the berthing facilities, Queen Salote Wharf has enough capacity compared to present cargo handling volume.

On the other hand, domestic transport, which is another key transport mode in Tonga, has no sole use berth and presently it tentatively has to use a part of Queen Salote Wharf.

As for the demand trend of domestic passenger/ cargo, the number of domestic passengers is about 40,000 persons/ year and domestic cargo volume is about 20,000 ton/ year. Neither figure has changed during the past 10 years. The main route of domestic transport is Nuku'alofa ~ Ha'apai ~ Vava'u and two domestic ships operate on the route. MV Otouanga'ofa is the main ship, 400pax with 563 ton of cargo capacity. Another is MV Pulupaki, 250 pax with 120 ton cargo. The former is operated by Friendly Island Shipping Agency (FISA: a Public company in Tonga) and the latter is by a private company.

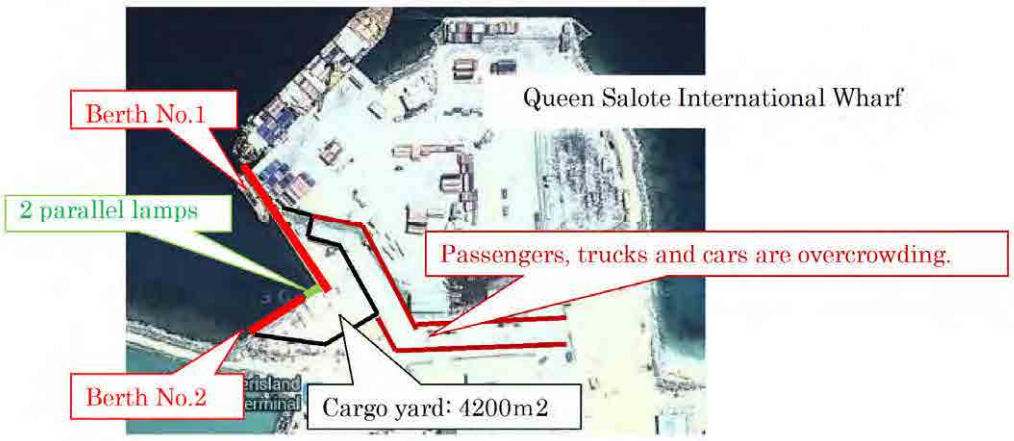
The operation frequency of the two ships is the same timing, once a week departing from Nuku'alofa every Tuesday evening. On the view point of effective use of the berth, it is better that each ship use the berth in different timing however, both ships give demand basis operation priority over keeping periodical operation due to the small demand and financial reasons, therefore, the present situation will be continued.

As the result of site investigations on passenger numbers, it is confirmed that both ships together carry 700 passengers/ trip in total and it can be said that over capacity operation (total passenger capacity: 650 =Otuanga'ofa 400 + Pulupaki 250) goes on constantly.

As for cargo handling volume, 250 ton/ trip in total is confirmed. Although the weight per trip is within the total capacity (total cargo capacity: 683 = Otuanga'ofa 563 + Pulupaki 120), cargo space (m^3 basis) is always full.

Since both passenger numbers and cargo volume are constantly full or over capacity, the present terminal is always overcrowded every Tuesday. Furthermore, the present domestic terminal is an awkward shape, as a result, these two elements bring chaos to passenger/ cargo flows and unsafe situations caused by congestion of the flow everywhere in the present terminal. Besides, waiting passengers have to stand up outside due to lack of a waiting hall and they are suffering from dust pollution because there is no pavement in the present

terminal area, so, the environment for waiting to board is very poor. Therefore, passengers are strongly wishing for a better terminal building and pavement in the whole terminal area.

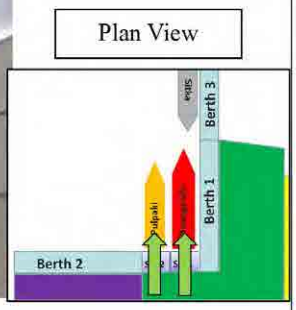


Source: Google Earth, JICA Study Team

Figure 1-3 Present Situation of Domestic Wharf

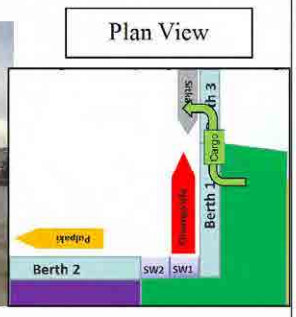
There are two berths allocated for domestic transport. The following table shows the steps of the present berthing procedures. Present berthing procedures are complicated and dangerous due to the awkward shape of the berths and limitation of available area.

① Cargo loading of 2 ships has to be done with parallel berthing.



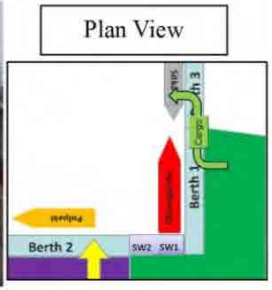
Both ships hit and make scratches on each ship body, due to parallel lamp.

② After cargo loading, passengers can go on board to MV Otuanga'ofa as it is but MV Pulpaki has to turn left to come alongside berth No.2 to start boarding because passenger can go on board only from her body side. MV Sitka is still continuing cargo loading in front of MV Otuanga'ofa.



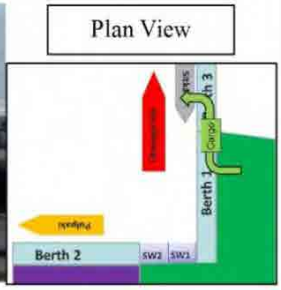
When MV Pulpaki turns, the left side of ship end is hitting corner of berth concrete because the turn is done with keeping left end painter, so both ship and concrete are damaged.

③ Passenger can go on board to MV Pulpaki. At the same time MV Otuanga'ofa cut the painters and starts to sail in the ocean.



Although MV Otuanga'ofa has very limited space (that is, Pulpaki is still her left side with only 3m clearance and MV Sitka is just in front of her), MV Otuanga'ofa dare to sail.

④ MV Otuanga'ofa sails in ocean but MV Pulpaki is still under receiving passengers.



Above picture shows very narrow clearance.

Source: JICA Study Team

Figure 1-4 Present Condition of berthing Procedures

Another problem of the existing two berths is that the two berths have no shelter due to lack of a breakwater. As explained in another chapter, mainly North/ North West winds are predominant at Nuku'alofa especially when cyclones strike. Although the existing port mouth opens to the East, strong waves diffract and come into the existing domestic transport berths so two ships cannot stay inside of the berths under bad weather. As the result, they have to evacuate offshore during rough sea conditions.

Also, the berths are sometimes used for another two ships, MV Nuvakai and MV Sitka. The former has an important role to carry logs from Eua Island. Basically ships/ ferries for Eua Island should use Faua wharf but big logs need a wide and long berth so she has to use the domestic berth when it is available. The latter carries mainly construction materials for Ha'apai and Vava'u and her body is relatively smaller so usually she can use berth No.1 together with MV Otuanga'ofa, although the gap between the two ships is quite narrow and it is not recommendable by International Standards.

As a wrap up of discussions, the items to be solved are the following.

i. To secure passenger and cargo flow separately and ensure the safety of both flows.
ii. To expand the cargo yard and acquire appropriate car parking space.
iii. Make necessary upgrades so that it will function as a shelter port.
iv. Secure safe manoeuvring space in the port basin area and access channel. Also, berth development is necessary to realize safe cargo handling operations.
v. Improve the environment for waiting passengers by building a terminal building and paving the terminal.

1-4-2 Central Wharf and Breakwater

The Central Wharf has functions mainly as a fishing port and a general cargo handling space. Additionally, the Central wharf has another role as an open free market every Saturday. The scale of the free market is quite large and almost all of the space of Central Wharf: 18,000 m^2 (450 m x 40 m) is used for the market. PAT collects fees for land use from each market owner and it is an important income source for PAT.


Source: JICA Study Team

Figure 1-5 Free Market at Central Wharf (every Saturday)

There are many yachts and pleasure boats inside of the Central Breakwater. The place is used as a platform for whale watching and its high season is every September.

1-4-3 Faua Wharf

The major boat using Faua Wharf is MV Onemato and she is in operation every day except Sunday. MV Onemato is an essential lifeline between Tongatapu and Eua Island and about 150 persons/ trip are using it.

Usually MV Onemato leaves Tongatapu at 10am and come back to Faua Wharf at 6pm. Before the boat leaves or arrives, Faua Wharf is cwowded by not only passengers but also people who have come to see someone off and usually over 300 persons are in and around the Wharf, however, there is no proper shed/ building so these people have to stay outside during the entire time. Therefore, if a proper terminal building is constructed, the environment of these people will be improved, and if the building has a good restaurant/ gift shop and so on, it will contribute to enhance the local economy.

Also MV Onemato carries small timbers produced by Tonga Forest Products (TFP: a Public Company in Tonga) and the frequency is once a week or less, depending on demand. Due to the smaller ship size, MV Onemato can carry only small timbers and therefore, larger logs are carried by MV Nuvakai.

Source: JICA Study Team

Figure 1-6 MV Onemato at Faua Wharf

A problem of Faua Wharf is that sunken ships are disturbing the manoeuvring of MV Onemato. As shown in the following picture (left side), there are three sunken ships located inside of the northern breakwater. If these sunken ships are removed, this space can be effectively become the sole use port for Eua Island, that is, MV Onemoto will have easier manoeuvring and middle size ships like MV Nuvakai and MV Sitoka can berth at the Faua Wharf. PAT deeply recognizes this and they are trying to arrange it.

Sunken ships
(unfortunately precious berth space is lost)

MV Onemato has to turn within a very limited area
(She is almost tatching to berth to avoid sunken ship)

Source: JICA Study Team

Figure 1-7 Sunken Ships are Disturbing Safe Manoeuvring of MV Onemato

1-5 Natural Conditions

1-5-1 Meteorological and Oceanographic Conditions

Tonga has a tropical climate throughout the year which reflects its location within the trade wind zone. Winter winds between May and August are mostly weak and summer winds between December and April are basically strong.

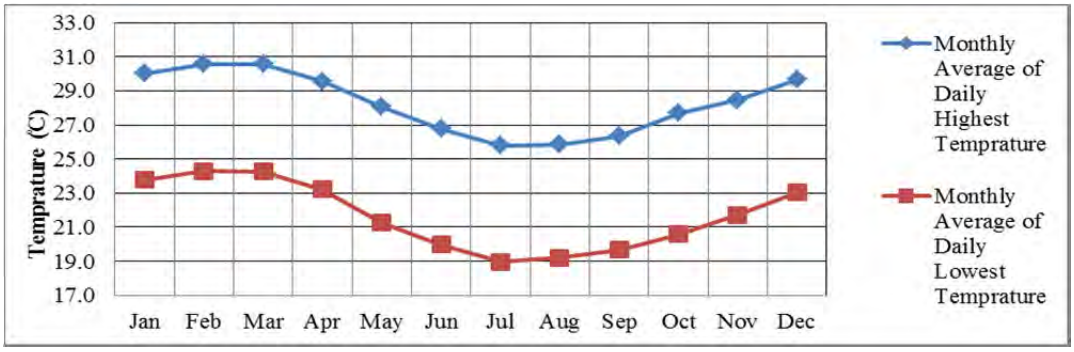
The most frequent wind directions (approximately 70%) are south-east and east-southeast in Nuku'alofa. The hot and humid season is between December and April with an average mean temperature of 27℃. Rainfall is highest in the summer season, and especially, the rainfall is more than 200 mm/month and the humidity is approx. 77% between January and March. On the other hand, June to October is cooler and a relatively dry season, with an average mean temperature of 22℃ to 24℃ per month. Rainfall is quite light at 130mm/month, and humidity is approximately 73%. Yearly mean average temperature is 25℃. Yearly mean rainfall is approx. 1,800mm/year. January to March usually has high-temperature and humidity and it is the Cyclone Season. Most cyclones form near the equator and gain strength as they move towards the south.

Cyclone"Ian" (6th -12th January 2014) passed directly over the northeast islands of Ha'apai, impacting housing, infrastructure and agricultural products.

The outline of the meteorological condition in Tonga is as follows.

(1) Temperature

There are no significant differences in temperature. Monthly average highest temperatures are from 25℃ to 31℃ and monthly average lowest temperatures are from 19℃ to 24℃. Figure 1-8 and Table 1-2 show the monthly average highest temperature and the monthly average lowest between 2004 and 2014.



Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-8 Monthly Temperature (2004-2013)

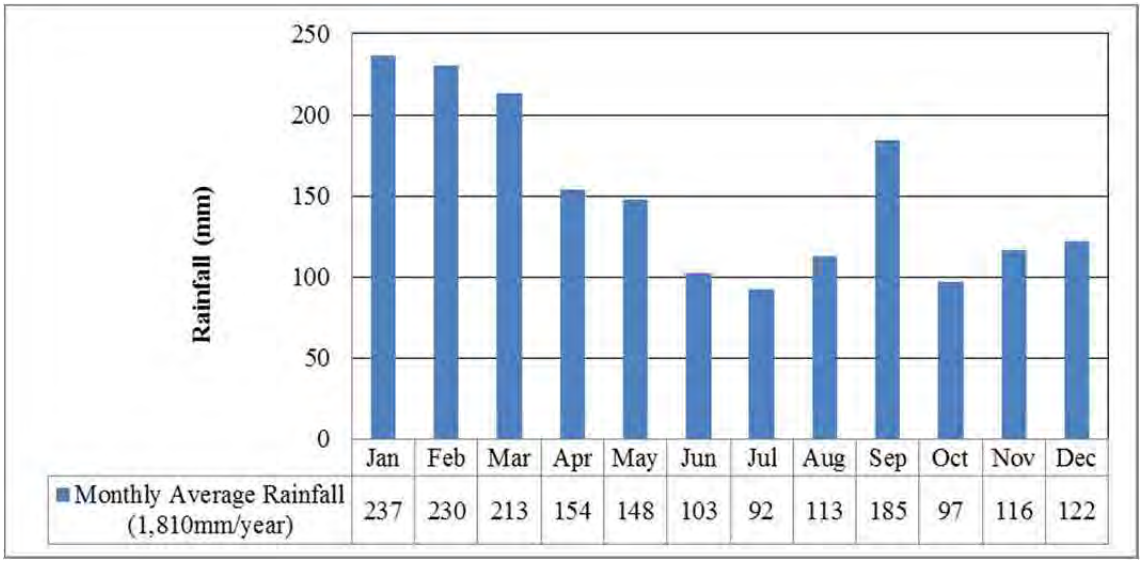
Table 1-2 Monthly Temperature (2004-2013)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Monthly Average of Daily Highest Temperature.	30.0	30.6	30.6	29.6	28.1	26.8	25.8	25.9	26.3	27.7	28.5	29.6	**28.3 °C**
Monthly Average of Daily Lowest Temperature.	23.8	24.3	24.3	23.2	21.3	20.0	19.0	19.2	19.7	20.6	21.7	23.0	**21.7 °C**

Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

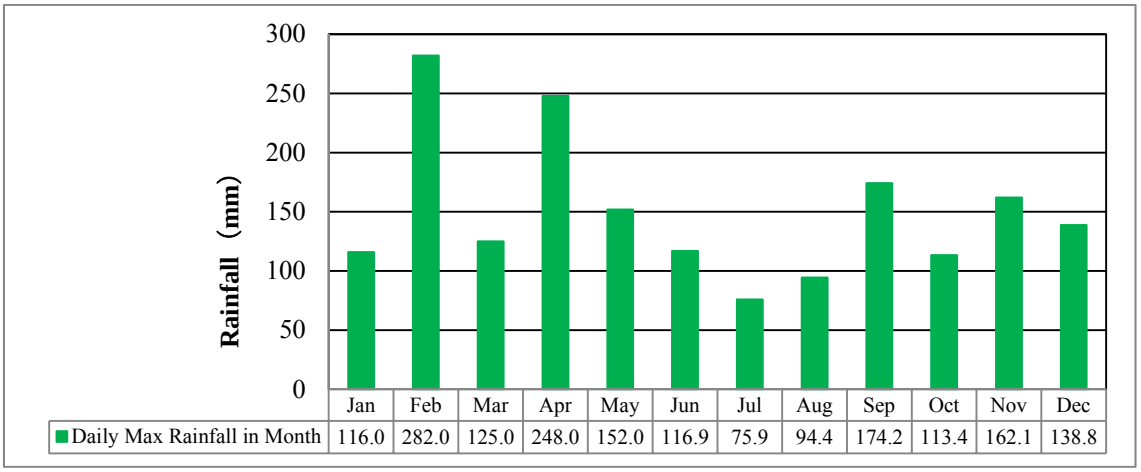
(2) Rainfall

Based on the weather data of the Meteorology & Coast Radio Services in Tonga, the annual rainfall in Nuku'alofa from 2004 to 2013 is shown in Figure 1-9 and maximum daily rainfall in each month between 2004 and 2013 is shown in Figure 1-10. Annual rainfall is approx. 1,800mm/year, with more than 200mm/month from January to March. The driest month is July and the wettest month is January. Moreover, February has the record of more than 250mm/day in the daily highest rainfall.



Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-9 Monthly Average Rainfall (2004-2013)

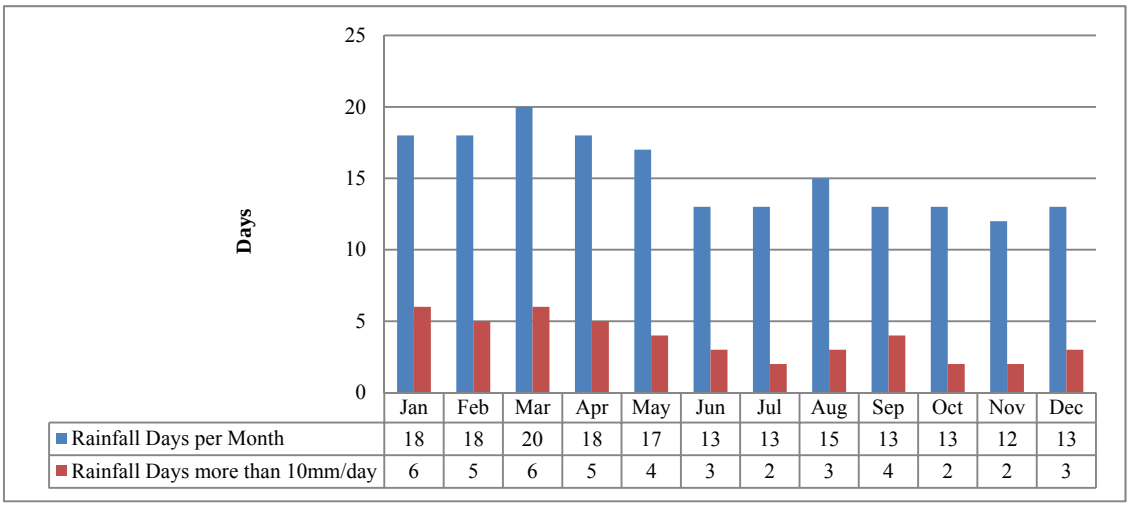


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Max Rainfall in Month	116.0	282.0	125.0	248.0	152.0	116.9	75.9	94.4	174.2	113.4	162.1	138.8

Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-10 Daily Max Rainfall per Month (2004-2013)

Figure 1-11 shows the rainfall days per month in Nuku'alofa. Rainfall days with more than 10mm/day are 2 to 6 days per month and 45 days per year



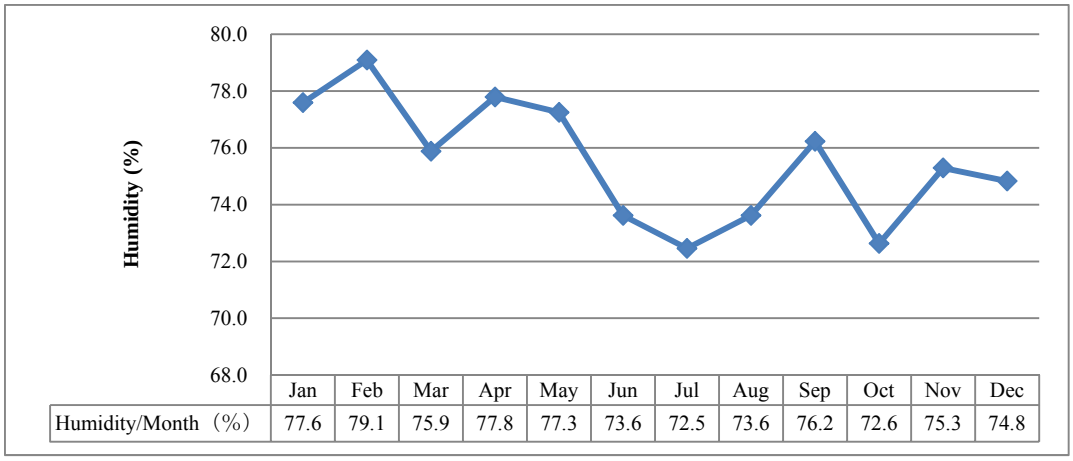
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall Days per Month	18	18	20	18	17	13	13	15	13	13	12	13
Rainfall Days more than 10mm/day	6	5	6	5	4	3	2	3	4	2	2	3

Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-11 Rainfall Days per Month (2004-2013)

(3) Humidity

Monthly average minimum relative humidity (2004-2013) in Nuku'alofa is shown in Figure 1-12. The humidity fluctuates between approximately 72 and 79%. The lowest is 72.5% in July and the highest is 79.1%,



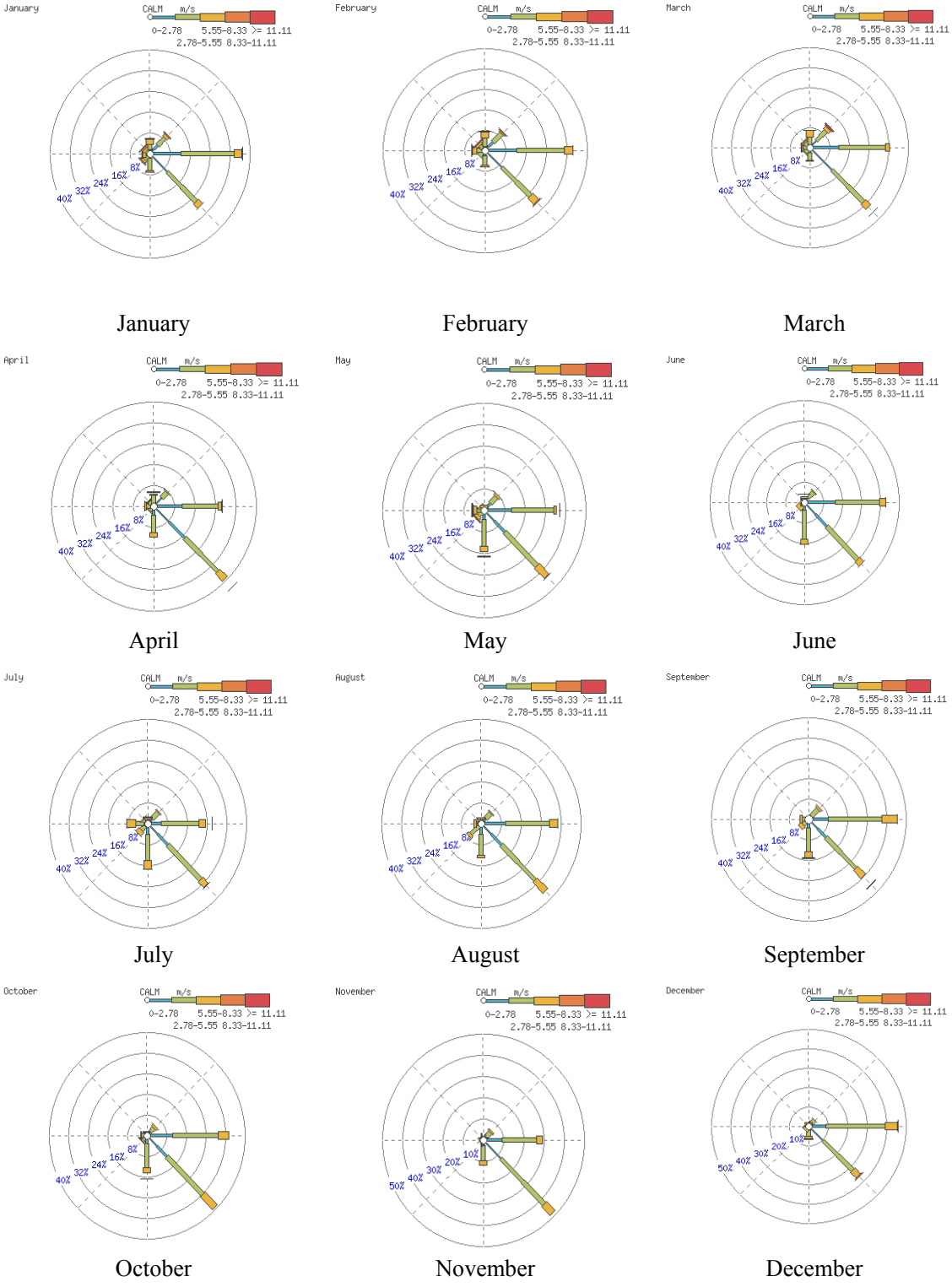
Humidity/Month （%）	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	77.6	79.1	75.9	77.8	77.3	73.6	72.5	73.6	76.2	72.6	75.3	74.8

Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-12 Monthly Average Humidity (2004-2013)

(4) Wind Condition

Winds over Tongatapu Island are dominated by the east and south-east trades all year round. Wind velocity is less than 10 m/s normally, however, strong winds of more than 10m/sec occur in December, January and February (cyclone season).



Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

Figure 1-13 Monthly Wind Rose (2009-2014)

(5) Sea Condition

1) Tide and Tidal Level

There are two tides per day and approximately 1.5 m of yearly tidal differences in Nuku'alofa Port. Tidal observations in Nukualofa Port have been conducted since 1993 by the Meteorology & Coast Radio Services and a monthly tidal table is published. The main tidal levels are as follows.

- Highest level (1/ Mar/2014) +2.146 m
- Average Highest Level in past 20 years (1993-2013) +1.854 m
- Average Level (Mean Sea Level) +1.000 m
- Average Lowest Level in past 20 years (1993-2013) +0.275 m
- Lowest Level (17/May/1995) +0.071 m

Elevation 0.00 m of the tidal observation instrument is 2.069 m below Bench Mark "TON1". Based on the published tidal table, the highest tidal level was 1.880 m and the lowest tidal level was 0.13 m in 2014.

2) Wave Condition

Based on the previous report (Basic Design Study Report on The Project for Extension of Nuku' Alofa Foreshore Protection in the Kingdom of Tonga), the structure design cyclone applied was Cyclone "Issac", and the following wave heights were calculated in front of the Queen Salote Wharf by the Wilson's Wave Development Curves method.

Table 1-3 Wave Conditions

	Wave Height	Period	Wind Direction
Deepwater Wave	11.6m	12.6sec	NE
Wave in front of Queen Salote Wharf	3.0m	-	-

Source: JICA Study Team

1-5-2 Natural Disaster

The eastern side of the Tonga Islands runs parallel to the Tonga Trench (1,200 km total distance and 10.85 km deep at deepest point) and the Pacific Plate is being sub-ducted below the Indo-Australian Plate and the convergence is taking place at a rate estimated at approximately 20 cm per year. The Tonga slab area is best known as the world's premier earthquake region and it is located on the circum-Pacific volcanic belt where a large number of volcanic eruptions occur in the basin of the Pacific Ocean. The volcanic belt in the South Pacific is the most active plume rise point (South Pacific super plume) in the world and it is expected that there will be an extremely large volcanic eruption several hundred thousand years in the future. Moreover, based on the past records, Tonga Islands was affected by tropical cyclones approximately 1.9 times/year in El Nino and approximately 1.6 times/year in La Nina.

According to the 2014 World Risk Report (WRR 2014) published by the United Nations University, Tonga

is ranked 2nd highest in probability to encounter a natural disaster (earthquake, cyclone, flood, etc.) in the world. Japan also is high risk ranking 4th highest in probability to encounter a natural disaster.

(1) Earthquake

The record for earthquakes of more than magnitude 6.0 in and around Tonga is shown in the following table.

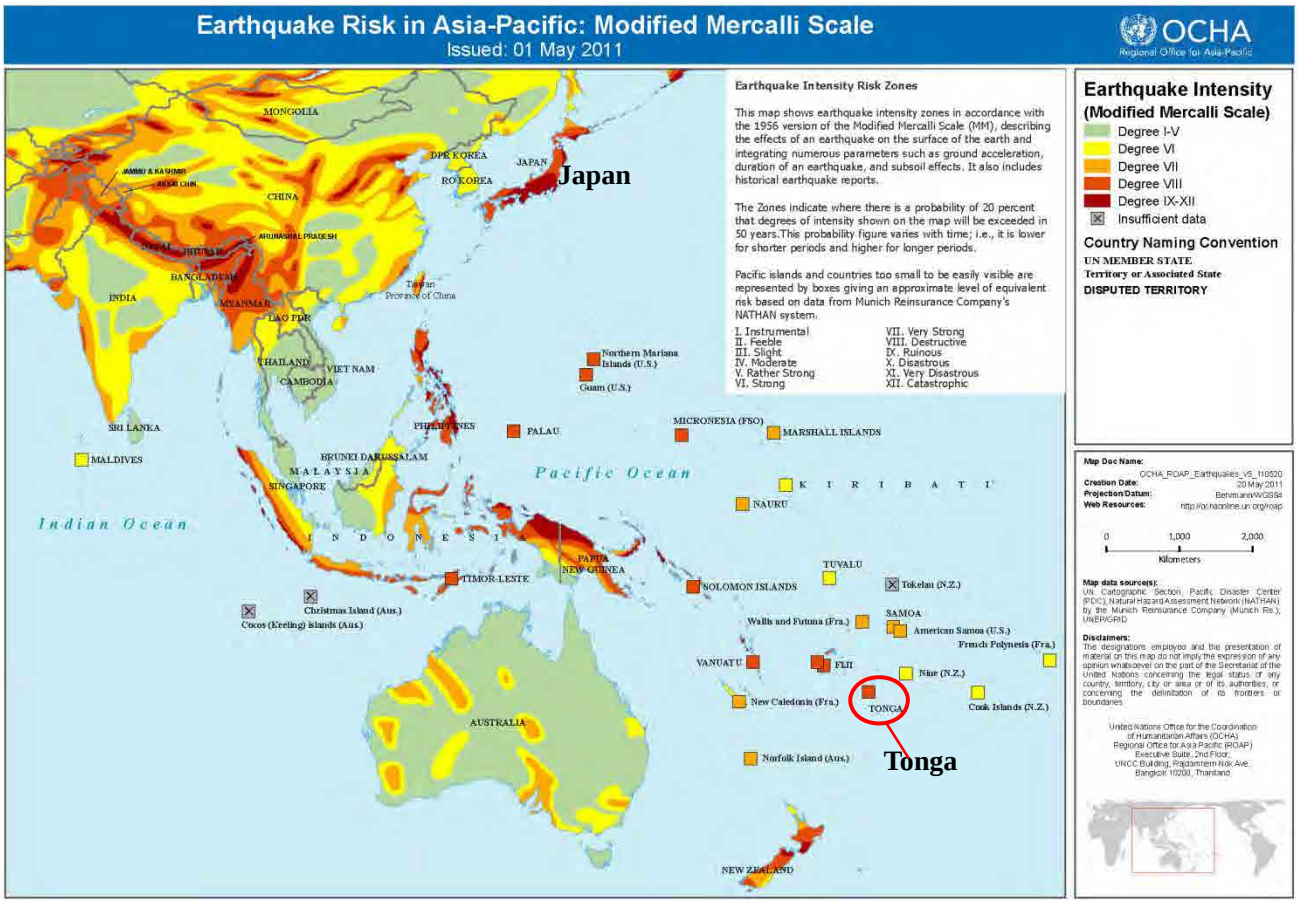
The most active seismic activity area in the world is the area around Tonga and earthquakes of more than magnitude 6.0 were generated around Tonga 174 times in 52 years.

According to the earthquake intensity risk zone map in the Asia-Pacific area published by the UN Office for Coordination of Humanitarian Affairs (OHCA), the Tonga area is Degree VII (Destructive). Japan is in the range between Degree VII and Degree XII, and the middle part of Hokkaido, Sea of Japan side of the Tohoku area, Kyusyu and Okinawa area are in the range of Degree VIII. (See Figure 1-14)

Table 1-4 Main Earthquake Records in and around Tonga

NO	Earthquake Origin Time			Hypocenter of Earthquake					NO	Earthquake Origin Time			Hypocenter of Earthquake				
	Year	Month	Day	Latitude	Longitude	Depth (km)	Magnitude	Place		Year	Month	Day	Latitude	Longitude	Depth (km)	Magnitude	Place
1	1962	4	30	-18.33	-175.84	7.2	6.5	Tonga	88	1994	2	24	-17.46	-174.18	125.5	6.0	Tonga
2	1965	1	5	-20.51	-173.91	4.3	6.8	Tonga	89	1994	4	27	-21.52	-173.56	40.3	6.2	Tonga
3	1965	3	18	-19.92	-175.94	225.2	6.3	Tonga	90	1995	4	7	-15.34	-173.43	32.5	7.4	Tonga
4	1965	3	22	-15.34	-173.18	32.2	6.5	Tonga	91	1995	4	8	-15.36	-173.32	32.9	6.1	Tonga
5	1965	3	23	-15.35	-173.09	34.0	6.5	Tonga	92	1995	7	28	-21.27	-175.24	99.3	6.3	Tonga
6	1965	7	21	-20.77	-175.62	5.0	6.0	Tonga	93	1995	8	29	-21.14	-174.22	20.1	6.0	Tonga
7	1965	8	20	-22.84	-176.10	79.7	6.0	South of the Fiji Islands	94	1995	10	6	-20.04	-175.84	201.3	6.3	Tonga
8	1967	1	1	-15.27	-173.56	33.1	6.6	Tonga	95	1996	2	25	-22.34	-175.70	13.2	6.0	Tonga region
9	1968	3	11	-16.19	-173.87	111.3	6.3	Tonga	96	1996	11	14	-21.33	-176.44	189.7	6.0	Fiji region
10	1968	7	29	-22.50	-174.90	57.2	6.0	Tonga region	97	1997	2	7	-19.89	-173.11	28.0	6.4	Tonga
11	1968	9	26	-20.96	-176.85	249.9	6.0	Fiji region	98	1997	5	27	-15.37	-173.09	20.5	6.3	Tonga
12	1968	10	6	-15.06	-175.31	21.9	6.0	Tonga	99	1997	8	29	-15.24	-175.41	7.8	6.4	Tonga
13	1968	10	6	-14.85	-175.35	10.3	6.0	Samoa Islands region	100	1997	10	14	-22.26	-176.63	163.4	7.7	south of the Fiji Islands
14	1970	7	16	-19.21	-173.30	15.0	6.0	Tonga	101	1998	11	15	-21.63	-176.38	152.6	6.2	Fiji region
15	1970	7	17	-21.93	-174.63	11.6	6.2	Tonga	102	1998	12	27	-21.77	-176.20	146.5	6.8	Fiji region
16	1972	5	22	-17.83	-175.01	224.6	7.2	Tonga	103	1999	1	24	-21.14	-174.45	13.0	6.0	Tonga
17	1972	8	28	-21.34	-174.24	1.5	6.0	Tonga	104	1999	2	3	-20.32	-174.16	9.0	6.2	Tonga
18	1972	9	9	-15.36	-175.57	15.0	6.1	Tonga	105	1999	4	13	-21.51	-176.32	161.6	6.8	Fiji region
19	1974	6	4	-15.95	-174.99	275.4	6.1	Tonga	106	1999	12	7	-15.95	-173.92	140.1	6.3	Tonga
20	1974	6	7	-15.45	-175.28	45.3	6.0	Tonga	107	2000	1	8	-16.94	-174.09	155.0	7.2	Tonga
21	1974	12	21	-14.57	-174.93	15.0	6.1	Samoa Islands region	108	2000	1	26	-17.32	-173.86	55.0	6.2	Tonga
22	1975	5	18	-20.91	-173.88	3.9	6.0	Tonga	109	2000	9	11	-15.91	-173.57	118.0	6.3	Tonga
23	1975	9	24	-20.49	-173.96	27.8	6.5	Tonga	110	2000	9	26	-17.27	-173.78	56.0	6.3	Tonga
24	1977	6	22	-22.91	-175.75	64.2	8.1	Tonga region	111	2000	10	21	-17.37	-175.05	287.5	6.2	Tonga
25	1977	7	24	-15.31	-173.06	15.0	6.3	Tonga	112	2000	10	31	-18.04	-175.17	15.5	6.2	Tonga
26	1977	8	11	-17.67	-174.29	118.6	6.7	Tonga	113	2001	4	28	-18.10	-176.90	361.0	6.8	Fiji region
27	1977	9	13	-15.47	-173.21	12.5	6.0	Tonga	114	2001	7	4	-21.79	-176.59	180.0	6.5	Fiji region
28	1978	3	3	-15.28	-173.46	54.5	6.2	Tonga	115	2001	10	2	-16.20	-173.69	98.0	6.1	Tonga
29	1978	3	4	-21.86	-174.70	12.8	6.0	Tonga	116	2002	1	28	-15.40	-173.07	27.4	6.2	Tonga
30	1978	6	11	-15.23	-173.52	48.8	6.0	Tonga	117	2002	5	8	-18.01	-174.48	132.9	6.2	Tonga
31	1978	7	2	-15.29	-175.40	15.0	6.5	Tonga	118	2002	8	9	-16.38	-176.06	364.0	6.1	Fiji region
32	1978	7	17	-14.96	-175.78	297.7	6.5	Samoa Islands region	119	2002	10	13	-14.57	-175.28	18.7	6.0	Samoa Islands region
33	1979	7	24	-20.45	-174.13	18.1	6.1	Tonga	120	2003	3	14	-17.45	-175.07	275.0	6.3	Tonga
34	1979	11	24	-18.90	-176.56	4.4	6.3	Fiji region	121	2003	3	28	-15.32	-173.42	41.0	6.1	Tonga
35	1980	3	31	-20.41	-173.68	4.3	6.0	Tonga	122	2003	5	3	-15.24	-173.56	34.0	6.2	Tonga
36	1980	6	18	-15.26	-173.51	36.4	6.3	Tonga	123	2003	7	27	-21.11	-176.44	213.0	6.6	Fiji region
37	1980	8	24	-15.22	-173.44	35.2	6.2	Tonga	124	2003	9	2	-15.30	-173.10	19.0	6.4	Tonga
38	1980	10	9	-15.43	-173.29	52.1	6.1	Tonga	125	2004	1	25	-16.87	-174.09	135.0	6.6	Tonga
39	1980	11	30	-19.49	-175.79	238.0	6.3	Tonga	126	2004	2	23	-14.84	-175.46	31.0	6.1	Samoa Islands region
40	1980	12	19	-21.21	-174.36	18.5	6.1	Tonga	127	2004	4	24	-21.90	-174.82	8.0	6.1	Tonga
41	1981	6	1	-16.13	-173.56	33.0	6.0	Tonga	128	2004	9	3	-15.23	-173.27	12.0	6.0	Tonga
42	1981	9	1	-15.11	-173.02	17.1	7.5	Tonga	129	2005	3	19	-20.49	-174.19	26.4	6.1	Tonga
43	1981	11	4	-20.02	-174.20	35.7	6.5	Tonga	130	2005	5	18	-15.34	-173.17	4.3	6.2	Tonga
44	1982	6	11	-17.64	-174.32	125.8	6.8	Tonga	131	2005	8	6	-19.61	-175.79	202.4	6.0	Tonga
45	1983	1	8	-15.41	-173.22	43.7	6.2	Tonga	132	2005	10	5	-20.55	-174.20	11.6	6.0	Tonga
46	1983	3	21	-21.53	-175.28	61.6	6.7	Tonga	133	2006	2	26	-15.28	-176.19	32.5	6.0	Fiji region
47	1983	5	15	-18.93	-175.51	15.0	6.7	Tonga	134	2006	3	5	-20.10	-175.62	205.8	6.1	Tonga
48	1983	6	1	-17.08	-174.52	182.4	6.5	Tonga	135	2006	4	30	-15.54	-173.03	10.0	6.0	Tonga
49	1983	10	17	-20.54	-173.85	0.6	6.0	Tonga	136	2006	5	3	-20.15	-174.10	55.0	8.0	Tonga
50	1984	4	18	-15.94	-174.30	150.8	6.4	Tonga	137	2006	7	7	-15.27	-173.55	35.0	6.0	Tonga
51	1984	6	15	-15.86	-174.75	257.2	6.6	Tonga	138	2006	8	15	-21.17	-176.17	154.0	6.1	Fiji region
52	1984	10	15	-15.87	-173.56	127.0	7.1	Tonga	139	2006	11	30	-21.39	-174.52	12.5	6.0	Tonga
53	1984	10	30	-17.08	-174.00	142.3	6.6	Tonga	140	2007	8	26	-17.42	-174.32	127.4	6.0	Tonga
54	1984	11	17	-18.33	-175.62	25.1	6.2	Tonga	141	2008	1	22	-15.28	-175.35	6.0	6.0	Tonga
55	1985	6	3	-15.35	-173.39	46.4	6.6	Tonga	142	2008	1	22	-15.42	-175.59	10.0	6.1	Tonga
56	1985	10	12	-21.65	-176.31	157.8	6.1	Fiji region	143	2008	4	16	-18.61	-175.70	10.0	6.3	Tonga
57	1986	6	28	-20.06	-175.95	223.1	6.5	Tonga	144	2008	6	26	-20.77	-173.34	38.0	6.2	Tonga
58	1986	8	18	-20.48	-174.13	25.8	6.0	Tonga	145	2008	8	19	-15.09	-173.48	8.0	6.1	Tonga
59	1986	10	30	-21.67	-176.55	189.5	7.2	Fiji region	146	2008	10	19	-21.86	-173.82	29.0	6.9	Tonga
60	1987	1	9	-19.43	-176.43	5.7	6.5	Fiji region	147	2008	10	22	-18.41	-175.35	233.4	6.4	Tonga
61	1987	3	19	-20.36	-176.09	212.5	6.5	Fiji region	148	2008	11	8	-15.22	-174.23	121.0	6.0	Tonga
62	1987	10	8	-19.61	-173.03	15.6	6.2	Tonga	149	2009	9	29	-15.36	-173.16	10.0	6.0	Tonga
63	1987	11	3	-17.15	-173.73	98.7	6.1	Tonga	150	2009	10	2	-16.34	-173.47	8.0	6.1	Tonga
64	1988	1	15	-20.77	-175.98	218.6	6.4	Tonga	151	2009	10	14	-14.91	-174.82	10.0	6.3	Samoa Islands region
65	1988	2	6	-16.19	-173.77	121.5	6.1	Tonga	152	2009	11	24	-20.71	-174.04	18.0	6.8	Tonga
66	1988	4	2	-15.39	-173.02	20.3	6.2	Tonga	153	2010	2	9	-15.05	-173.49	10.0	6.1	Tonga
67	1988	6	11	-15.14	-173.42	42.6	6.0	Tonga	154	2010	2	13	-21.90	-174.77	11.0	6.1	Tonga
68	1988	7	19	-19.55	-174.99	144.2	6.3	Tonga	155	2010	4	10	-20.11	-176.22	273.2	6.0	Fiji region
69	1988	12	5	-15.30	-173.42	42.8	6.2	Tonga	156	2010	4	21	-15.27	-173.22	35.0	6.1	Tonga
70	1989	1	2	-18.62	-174.51	116.7	6.1	Tonga	157	2010	9	4	-17.37	-174.00	69.0	6.1	Tonga
71	1989	3	11	-17.79	-174.73	234.8	6.9	Tonga	158	2010	11	3	-20.47	-174.28	18.0	6.1	Tonga
72	1990	2	24	-15.39	-175.16	1.3	6.0	Tonga	159	2011	1	31	-22.01	-175.62	76.0	6.0	Tonga region
73	1990	5	20	-18.16	-175.16	231.6	6.2	Tonga	160	2011	2	12	-20.88	-175.67	85.0	6.1	Tonga
74	1990	6	23	-21.50	-176.46	185.2	6.9	Fiji region	161	2011	9	5	-15.30	-173.62	37.0	6.2	Tonga
75	1990	12	11	-15.38	-173.09	18.3	6.1	Tonga	162	2011	9	22	-15.44	-175.31	10.0	6.4	Tonga
76	1990	12	21	-20.54	-173.94	15.3	6.0	Tonga	163	2011	12	26	-16.20	-173.86	90.0	6.0	Tonga
77	1991	1	8	-18.07	-173.45	33.7	6.1	Tonga	164	2012	4	28	-18.69	-174.71	134.7	6.6	Tonga
78	1991	3	3	-21.87	-175.00	14.9	6.1	Tonga	165	2013	5	11	-17.95	-175.10	212.2	6.4	140km WNW of Neiafu, Tonga
79	1991	4	6	-15.03	-175.45	21.3	6.7	Tonga	166	2013	5	23	-20.56	-175.77	149.1	6.3	86km NW of Nuku`alofa, Tonga
80	1991	4	19	-15.04	-174.96	24.7	6.0	Tonga	167	2013	8	1	-15.24	-173.50	31.7	6.0	82km NNE of Hihifo, Tonga
81	1991	5	10	-16.21	-174.07	134.0	6.2	Tonga	168	2013	11	23	-17.12	-176.54	371.0	6.5	Fiji region
82	1991	6	9	-20.24	-176.15	277.8	7.0	Fiji region	169	2014	1	21	-15.14	-174.68	6.1	6.1	133km NW of Hihifo, Tonga
83	1991	10	30	-15.30	-173.08	13.9	6.1	Tonga	170	2014	4	26	-20.75	-174.71	45.0	6.1	66km NE of Nuku`alofa, Tonga
84	1992	12	24	-15.31	-173.01	19.6	6.2	Tonga	171	2014	6	29	-14.78	-175.26	9.0	6.4	193km SSE of Mata-Utu, Wallis and Futuna
85	1993	2	13	-14.93	-176.83	20.0	6.0	Fiji region	172	2014	6	29	-14.98	-175.51	18.0	6.7	201km SSE of Mata-Utu, Wallis and Futuna
86	1993	5	16	-15.32	-173.22	18.6	6.6	Tonga	173	2014	7	19	-15.82	-174.45	227.3	6.2	76km W of Hihifo, Tonga
87	1993	10	4	-21.44	-174.30	34.2	6.0	Tonga	174	2014	9	4	-21.40	-173.26	11.8	6.0	175km E of `Ohonua, Tonga

Source: Geology Unit, Natural Resources Division in Nuku'alofa, Ministry of Lands and Natural Resources



Source: UN Office for Coordination of Humanitarian Affairs (OCHA)

Figure 1-14 Earthquake Intensity Risk Zones Map in Asia-Pacific (May, 2011)

Table 1-5 lists the record of tsunami disasters caused by earthquake or volcanic eruption. After issuing a tsunami warning, evacuation to higher ground (Evacuation Center) is formulated in the National Tsunami Plan 2012.

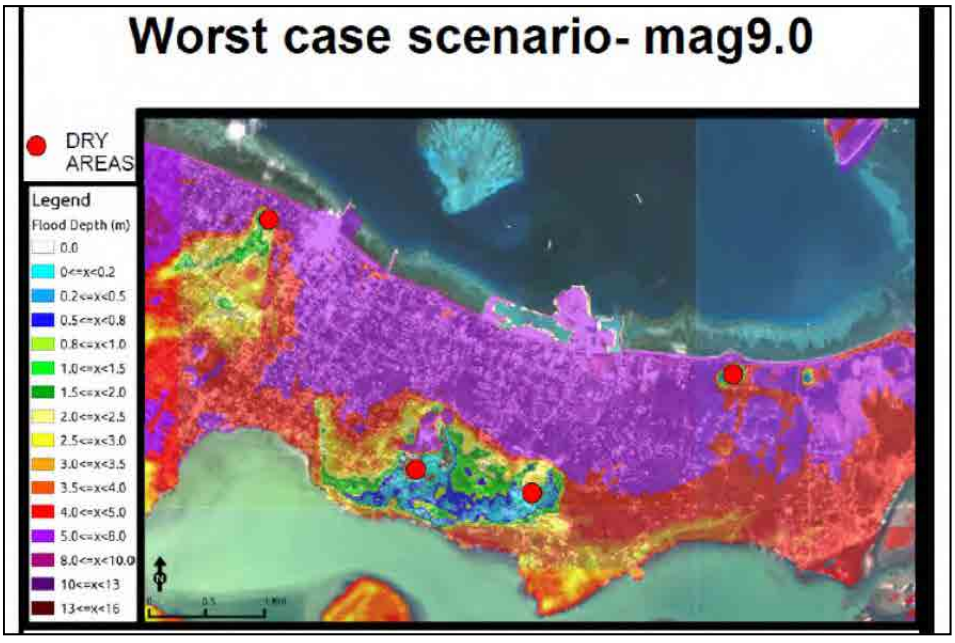
Recently, on 30 September 2009, a tsunami with a height of 17 m, arising from the seismic centre of the Samoan Islands region was generated which caused substantial damage to the residential buildings and 9 people were reported dead in Niuatoputapu and Tafahi Island in the northern part of Tonga.

Figure 1-15 describes the result of a simulation conducted by NEMO (National Emergency Management Office). Based on the result, the estimated maximum Tsunami height would be approximately 8 m in the design project area.

Table 1-5 Main Tsunami Records

Year	Date	Cause	Source	Comments
1853	24 Dec	Tech-tonic	Tongatapu Island	Changes in land level and flooding
1855	17 Nov	Tech-tonic	Tonga Islands	1 meter wave height at reported Tau near Tongatapu
1881	24 Nov	Tech-tonic	Tonga Islands	Land subsided but no tsunami reported
1901	9 Aug	Tech-tonic	Tonga Islands	No information on extent of damage
1908	1 Jan	Volcanic	Tonga Islands	Submarine volcano eruption but extent of damage not known
1919	30 Apr	Tech-tonic	Tonga Islands	2.5m wave height in Ha'apai and no information of damage from other islands
1928	19 May	Volcanic	Ha'apai Islands	Earthquake felt, tsunami wave appeared and pumice littered the shores
1948	16 Sep	Tech-tonic	Tonga Islands	Small Pacific wide tsunami recorded
1963	10 Dec	Tech-tonic	Tonga Islands	Strong swell reported in Tahiti
1968	25 Jul	Tech-tonic	Kermadecs Is	0.1 m tsunami recorded in Suva
1977	2 Apr	Tech-tonic	Tonga Trench	3 tsunami waves observed
2009	30 Sep	Tech-tonic	Niuatoputapu	17 meter waves washed up in Niuatoputapu and Tafahi Islands in Northern Tonga killing 9 people

Source: National Tsunami Plan(2012), National Tsunami Working Group, NEMC



Source: National Emergency Management Office

Figure 1-15 Result of Tsunami Simulation

(2) Cyclone

Table 1-6 lists the record of cyclones, storms and strong winds generated from and around Tonga from 1960 to the present.

Regarding cyclones during recent years, Tropical Cyclone “Ian” (Category 5) struck and caused extensive damage to the Ha'apai Islands in January 2014 and in February 2012, Cyclone “Jasmine” and Cyclone “Cyril” brought heavy rains and flooding to Tonga. Moreover, in 2010, Cyclone “Rene” (Category 4) pounded Tonga and damaged the agricultural products.

The worst cyclone in the history of Tonga, Cyclone “Issac” took place in 1982, killing six people, impacting 45,000 people and flooding 23 km^2 in Tongatapu Island.

Table 1-6 Cyclone Record in and around Tonga (1960- January 2014)

Name	Active Date	Min P	Area	Extreme Wind	Name	Active Date	Min P	Area	Extreme Wind
Nil	17-19 Jan 1960		NTT/VV	Est. 60kt gust 90kt(Storm)	**1989-1990**				
Nil	14-19 Mar 1961		VV/HP/TBU	100kt gust 150kt(Severe)	'Ofa	30Jan- 10Feb	987	Tonga(Ntt), Niue, Samoa	Est. gust 140kts (Hurricane)
Nil	22-23 Nov 1964		S/Tonga	40kt gust 55kt(Minor)					
Nil	25/26 Feb 1969		S/Tonga	N/A	**1990-1991**				
1969-1970 (El-Nino)					Sina	24-Nov -4Dec	960	Tonga(TBU/ HP), Niue, Fiji,	65kt gust 100kt(Hurricane)
Nil	11-12 Jan 1970	990(NZ)	Tonga	Gale					
Dolly	11-25 Feb 1970	965(NZ)	Tonga, Niue, Samoa	Gale	**1991-1992 (El-Nino)**				
Gillian	8-11 Apr 1970	980(NZ)	Tonga	Hurricane	Val	4-13 Dec	940	Tonga(NTT), Samoa, Tokelau	Est. 50kt(Hurricane)
Helen	13-16 Apr 1970	990(NZ)	Tonga, Wallis & Futuna	Storm					
1970-1971					**1992-1993**				
Nil					Joni	6-13 Dec	940	Tongatapu, Fiji, Tuvalu	Hurricane
1971-1972					Nina	23Dec-5Jan	955	Nfo/Ntt/Vv, Fiji (Rotuma)	Hurricane
Nil	18-24 Jan	990	Tonga, Niue	Storm	Kina	26Dec-5Jan	955	Tongatapu, Fiji	gust 120kt(Hurricane)
					Mick	5-9 Feb	987	Vv/Hp, Fiji	Storm
1972-1973 (El Nino)									
Bebe	19-28 Oct	945	S/Tonga, Fiji,Tuvalu	Hurricane	**1993-1994 (El-Nino)**				
Collete	2-3 Nov	990	N/Tonga, W & Futuna	Storm	**1994-1995 (El-Nino)**				
Elenore	31Jan-7Feb	980	N/Tonga, Niue ,Smoa, S/Cooks	Hurricane	**1996-1997**				
Juliette	3-4 April	980	S/Tonga(Ha'apai), Fiji	50kt gust 75kt(Hurricane)	Hina	12 -21Mar	970	TBU/'Eua	50kt gust 90kt (Hurricane),
					Keli	10-15 Jun	955	Nfo, Ntt, Fiji, Tuvalu	Est. gust 100kt (Hurricane)
1973/1974									
Lottie	5-12Dec	960(NZ) , 963(NC)	S/Tonga, New C, Fiji	Hurricane	**1997-1998 (El-Nino)**				
1974-1975					Ron	1-8 Jan	900	Niuafo'ou,Samoa,Wallis	Est. gust 125kt (Hurricane),
Val	29Jan-5Feb	945	Tonga, Samoa, Fiji, W&Futuna	Hurricane	**1998-1999**				
1975-1976					Cora	23-30Dec	960	Tt/Hp/'Eua, Fiji,Wallis	47kt gust 73kt (Hurricane)
Nil					**1999-2000**				
1976-1977					Mona	8-10 Mar 2000	960	Tt/Hp/'Eua	44kt gust 65kt (Hurricane)
UN-Named	3-9 Feb	990	S/Tonga, Fiji	Storm	**2000-2001**				
Pat	15-18Mar	980	Tonga, NIue	Hurricane	Paula	26Feb-8 Mar	930	Tt/Hp/'Eua, Fiji, Vanuatu,	40kt gust 60kt (Hurricane)
1977-1978 (El-Nino)					2001-**2001-2002**				
Anne	25-31Dec	980	Tonga, Niue, Fiji Futuna	Hurricane	Waka	29Dec01-1Jan(	930	Nfo/ Ntt/ Vv,	100kt gust 140kt (Hurricane)
Ernie	16-23Feb	980	Tonga, Fiji	Hurricne					
					2002-2003 (El-Nino)				
1978-1979					Yolande	5-Dec-02		Tonga waters, no land areas	gale
Leslie	21-23Feb	980	Southern Tonga	Hurricane	Ami	110-15 Jan200	950(FJ), 994(TBU)	TT/EUA, Fiji	40kt gust 60kt (Hurricane)
Meli	24-23Mar	920(FJ)	Northern Tonga	Hurricane	Cilla	27-28 Jan2003	993(Hp)	Tonga(Ha'apai)	28kt gust 58kt (Gale)
					Eseta	13-14 March03	994(TBU)	TT/Hp	40kt gust 60kt (Gale)
1979-1780					Fili	16-Apr-03		Tonga Waters,	Gale
'Ofa	10-15Dec	980	Northern Tonga	Hurricane					
					2003-2004				
1980-1981					Heta	5-6 Jan2004		Nfo/Ntt,Niue, Samoa	Est 80kt gust 100kt
Betsy	30 Jan-3 Feb 198	990	Tonga, Niue	40kt gust 52kt(Storm)					
Cliff	8-15 Feb	970	Tonga,Niue,Vanuatu, N/Caledon	Hurricane	**2004-2005**				
Un-named	16-20 Feb	990	Tonga, Fiji, Niue, S/Cooks	Storm	Lola	30Jan05-1Feb0	997(Tbu)	Tbu & 'Eua	26kts gust 47kts
Daman	20-24 Feb	980	Northern Tonga	Hurricane					
					2005-2006				
					Tam	12-13 Jan2006	991(Nfo)	Niuafo'ou	40-45kts gust 50kts
1981-1982					Urmil	14-15 Jan2006	994(Ntt)	Niuatoputapu	40-45kts gust 60kts
Issac	27Feb-5Mar	930	Hp/ TBU	90kt gust 130kt (Hurricane	Vaianu	11-15 Feb2006		All of Tonga	35kts gust 54kts
1982-1983 (El-Nino)					**2009-2010 (El Nino)**				
NIL					Mick (Cat 2)	Dec 3–15, 200	975	Fiji, Tonga	
1983-1984									
Lance	3-8Apr	985	Tonga, Wallis	Hurricane	Rene (Cat 4)	Feb 9-17, 2010		Samoa, Tonga (Most damage to vegetation, fruit trees etc, rain)	
Un-named	22-30 Mar		Tonga	40kt gust 53kt					
1984-1985					Tomas (Cat 4)	Mar 9-18, 201(	930	(Fiji most affected, Tonga only strong winds mainly affects	
Drena	11-14 Jan	987	Niuatoputapu	Est. 50kt gust 70kt (Storm)				vegetation, few buildings)	
Eric	14-20Jan	955			**2010-2011**				
1985-1986					Wilma (Cat 4)	Jan 19-28, 201	930	(Samoa, Fiji , Tonga)	185km/hr
Keli	8–12Feb	987	Tonga, Fiji,Vanuatu	50kt gust 70kt (Storm)					
Lusi	2-10Mar	990	Tonga, Vanuatu,N/C	Storm	**2011-2012**				
Martin	10-14 Apr	970	Ha'apai, Fiji	40kt gust 60kt (Hurricane),	Cyrill	6 – 7 Feb, 2012		Vv, Hp, TBU, 'Eua	50kts gust to 60kts
					Jasmine (Cat 1)	13-16 Feb, 2012		Vv, Hp, TBU, 'Eua	Gust up to 50kts,
1987-1988 (El-Nino)					(recorded at Fua'amotu on the 14th Feb)				
					2012-2013				
1988-1989					Evan	13-16 Dec 2012		North of Niuafoóu	
Un-named	7-14 Feb	987	Tonga,Fiji	35kt gust 50kt (Storm),					
Kerry	29 Mar-3Apr	985	Tonga, Fiji	50kt gust 65kt (Hurricane)	**2013-2014**				
					Ian (Cat 5)	6-9 Jan 2014		Haápai	

Source: Meteorology & Coast Radio Services, Fua'amotu Airport (HQ)

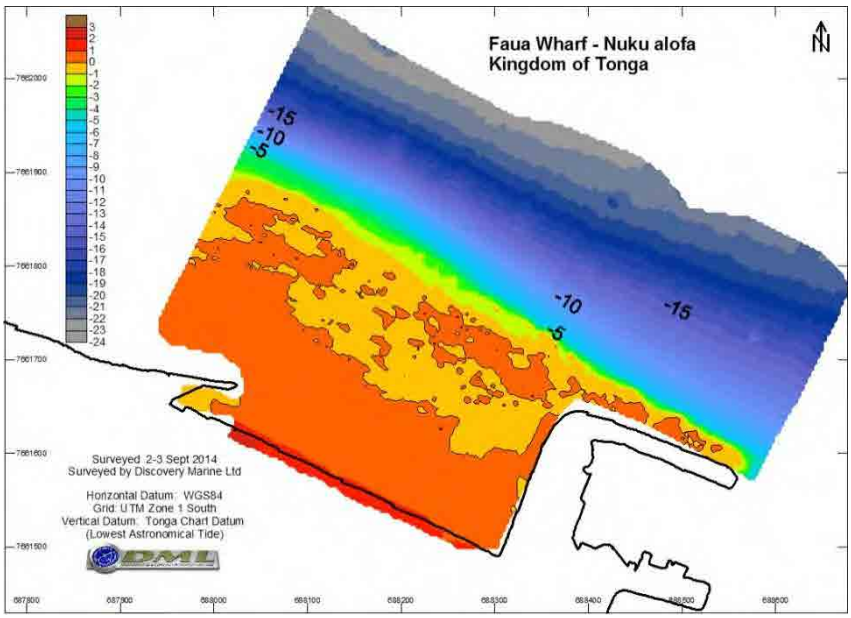
1-5-3 Topographic and Hydrographic Surveys

Topographic and Hydrographic Surveys in the project area were conducted by a local contractor from 1st September to 6th September. The topographic and hydrographic survey areas are described in Figure 1-16.

Source: JICA Study Team

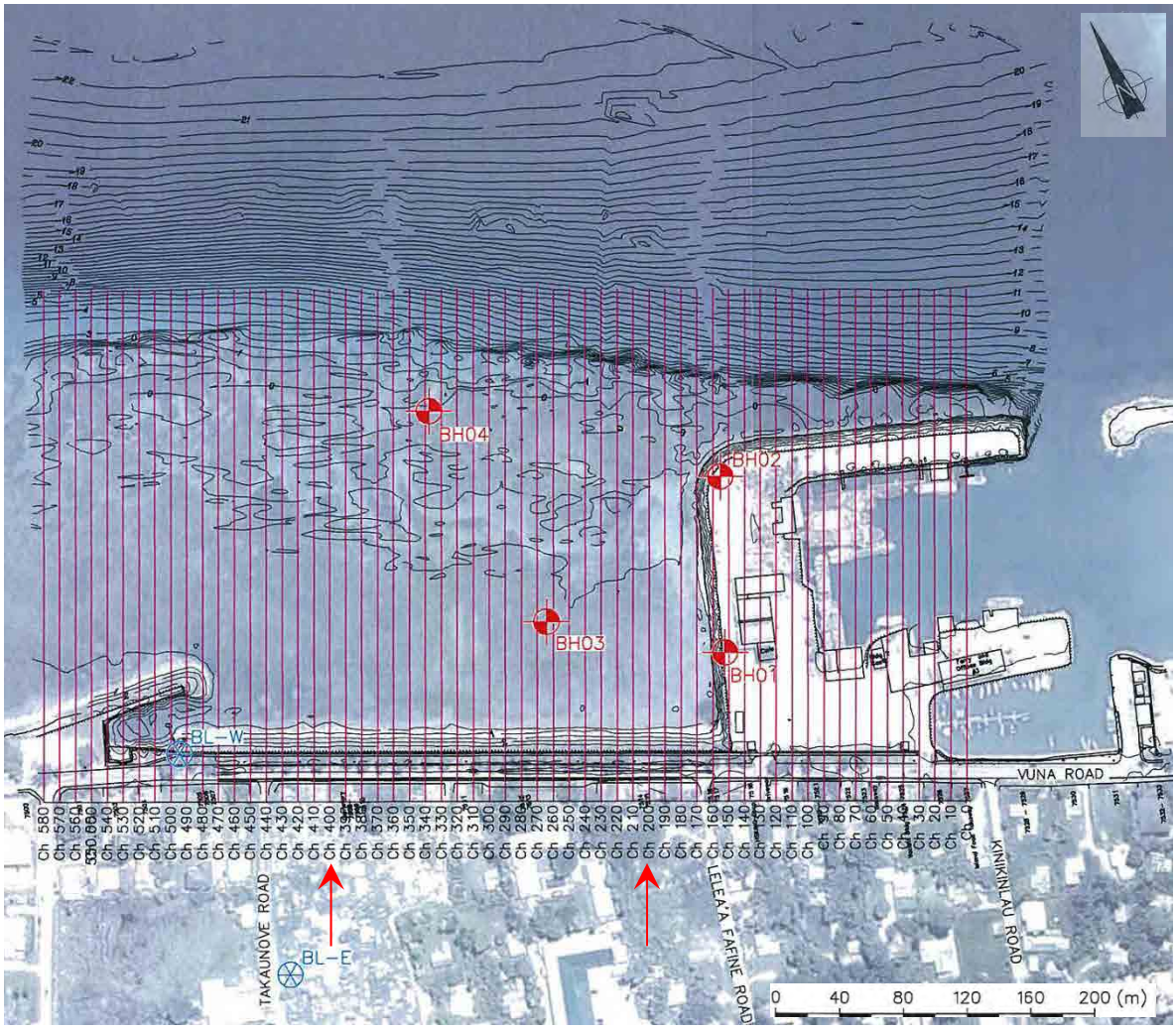
Figure 1-16 Topographic and Hydrographic Survey Area

Figure 1-17, Figure 1-18 & Figure 1-19 show the depth contours of the hydrographic survey, sounding map, and cross sections, respectively. The flat width of the fringing reef is approximately 220 m to 270 m from the shoreline, at the end of the flat area, at the seaward edge of the reef, the seabed falls away steeply to approx. 20 m in depth.



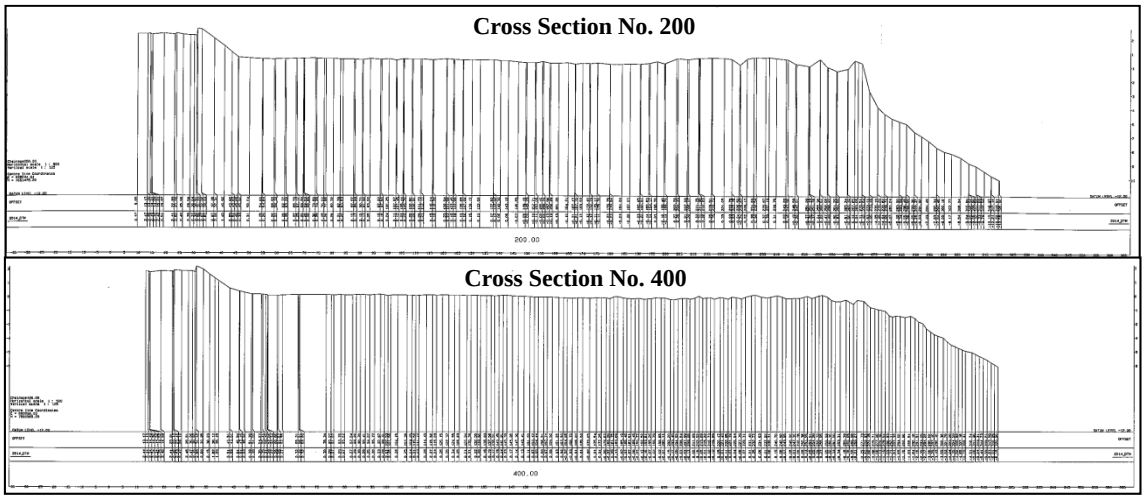
Source: JICA Study Team

Figure 1-17 Depth Contour Image of the Hydrographic Survey



Source: JICA Study Team

Figure 1-18 Sounding Map

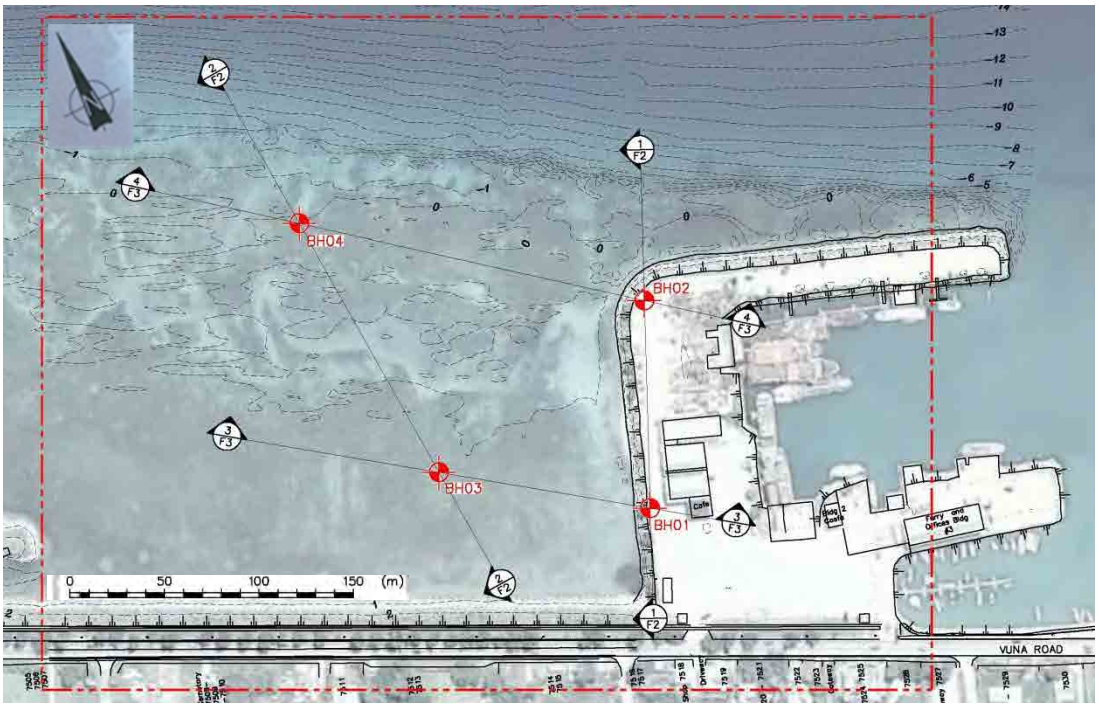


Source: JICA Study Team

Figure 1-19 Cross Section of No. 200 & No. 400

1-5-4 Soil Investigation

The geography of Tongatapu Island is that of a gradually upthrusted coral island, it's rather flat, and is covered with volcanic ash. The soil investigation was conducted in 2 boreholes on the land that is a candidate for the Ferry Wharf and another 2 boreholes in the sea area that were drilled from the 2nd to 20th September by a local contractor. Figure 1-20 describes the locations of the Soil borings.



Source: JICA Study Team

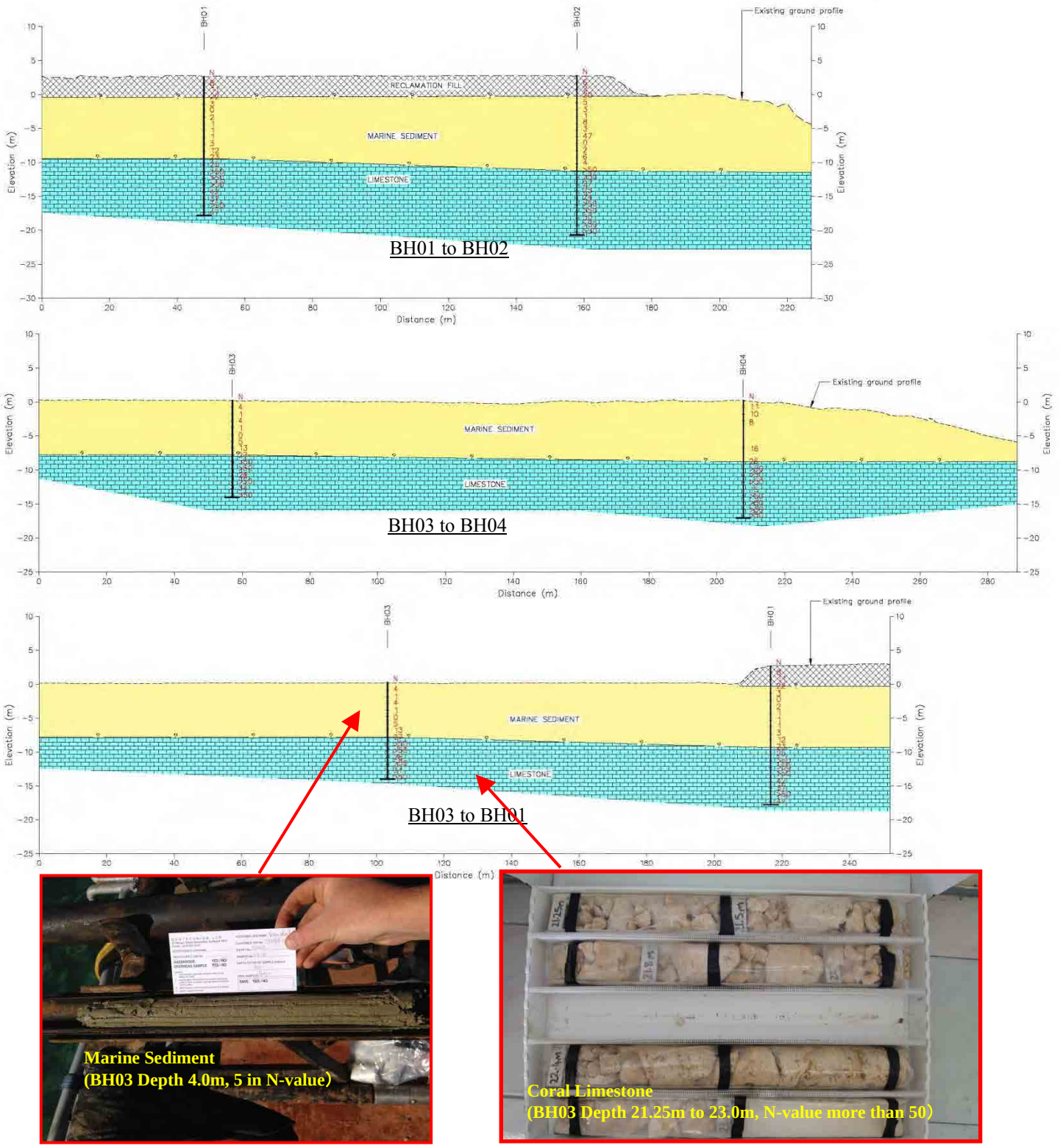
Figure 1-20 Soil Boring Locations

Based on the characteristic soil condition from each boring log, the soil was divided into 3 layers, reclamation fill (BH01 & BH02), marine sediment and coral limestone.

Marine sediments were encountered in each borehole from 0m to -12 m in elevation and were mostly silt and the materials were generally soft to firm. Typical N-values for marine sediments ranged 0 to 17.

Coral limestone more than 50 in N-value exists in the elevations from -9 m to -11 m and the coral limestone has a void space layer in a sandwich arrangement with an overall estimated porosity of approximately 30%.

Figure 1-21 lists the subsoil profile and soil samples



Source: JICA Study Team

Figure 1-21 Subsoil Profile and Soil Samples

Table 1-7 lists the summary of the 4 borings' result.

Table 1-7 Summary of Boring Result (September 2014)

Boring No.	Elevation	N-value	Soil Condition
BH 01 (Land Boring)	Ground Level+2.7m ~ -0.3m	8 < N < 22	Reclamation Fill
	-0.3m～-6.3m	0 < N < 3	Marine Sediment (Soft Silt)
	-6.3m～-8.3m	3 < N < 12	Interbedded Ash and Sand
	-8.3m～-10.3m	23 < N < 25	Coral Gravels
	-10.3m～-17.3m	37 < N < 50	Coral Limestone
BH 02 (Land Boring)	Ground Level+2.8m ~ -0.2m	8 < N < 22	Reclamation Fill
	-0.2m～-10.2m	0 < N < 3	Marine Sediment (Soft Silt)
	-10.2m～-12.2m	50 ≤ N	Coral Limestone
	-12.2m～-16.2m	24 < N ≤ 27	
	-16.2m～-20.2m	50 ≤ N	
BH 03 (Sea Boring)	Sea Botttom-0.6m ~ -1.6m	N = 4	Sand
	-1.6m ~ -6.6m	0 < N < 5	Marine Sediment (Soft Silt)
	-6.6m ~ -7.6m	N = 13	Coral Gravels
	-7.6m ~ -8.6m	N = 27	Extremely Weak, "Voided", Coral Limestone
	-8.6m ~ -17.6m	N = 28, 50 ≤ N	Coral Limestone
BH 04 (Sea Boring)	Sea Bottom-0.6m ~ -1.6m	N = 11	Sand
	-1.6m ~ -8.6m	0 < N < 22	Marine Sediment
	-8.6m ~ -9.6m	N = 26	Coral Gravels
	-9.6m ~ -12.6m	50 ≤ N	Coral Limestone
	-12.6m ~ -13.6m	N = 15	Weaker Coral Limestone
	-13.6m ~ -17.6m	50 ≤ N	Coral Limestone

Source: JICA Study Team

Table 1-8 lists the result of grain size analysis in laboratory tests, and Table 1-9 lists the results of the physical tests without grain size tests (unit weight, natural moisture content, liquid limit, plastic limit, etc.), mechanical tests and consolidation tests.

Borehole logs for each boring are shown in Appendix-8.

Table 1-8 Result of Laboratory Tests (Part 1)

No.	Borehole No.	Depth of Sample		Particle Size Distribution - (% passing)																											
				Gravel										Sand								Silt									Clay
		From	To	37.5000	26.5000	19.0000	13.2000	9.5000	6.7000	4.7500	3.3500	2.0000	1.1800	0.6000	0.4250	0.3000	0.2120	0.1500	0.0900	0.0630	0.0468	0.0342	0.0250	0.0180	0.0134	0.0095	0.0068	0.0049	0.004	< 0.0014
		m	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1		1.00	1.45																												
2		2.00	2.45	100	64	41	34	30	24	21	19	16	13	10	8	7	6	5	3	3											
3		3.00	3.45																												
4		4.00	4.45	-	-	100	86	64	60	56	54	50	46	41	39	36	34	31	25	23	20	16	13	10	8	7	5	4	3	2	
5		5.00	5.45																												
6		6.00	6.45	-	-	100	98	93	87	82	79	75	70	65	63	60	58	54	46	41	35	30	25	19	15	12	9	7	6	3	
7		7.00	7.45																												
8		7.50	7.62																												
9		7.62	7.76	-	-	100	83	75	69	63	60	57	53	49	46	44	41	37	30	25	21	17	13	10	8	6	4	3	2	1	
10		8.00	8.45	-	100	97	84	73	67	64	61	57	53	47	45	43	40	36	31	24	20	17	13	10	8	6	4	3	2	1	
11		9.00	9.45																												
12	BH01	10.00	10.45	-	-	-	-	-	100	99	98	96	95	93	92	90	87	82	72	65	58	52	44	38	31	25	18	12	9	3	
13		10.50	10.70																												
14		10.72	10.85																												
15		10.86	10.99																												
16		11.00	11.45																												
17		12.00	12.45	-	100	93	83	76	62	51	42	28	18	11	9	7	6	5	4	4											
18		13.00	13.45																												
19		17.00	17.45	-	-	100	95	79	68	58	49	39	30	21	17	13	11	9	7	6											
20		17.50	17.60																												
21		18.00	18.45																												
22		19.00	19.34	100	76	67	62	59	51	41	35	27	21	15	12	10	8	7	6	5											
23		20.00	20.45																												
24		1.00	1.45	-	100	77	71	66	55	47	42	37	32	25	22	20	17	15	12	10											
25		3.00	3.45																												
26		6.00	6.45																												
27		7.00	7.45	100	94	82	63	53	46	41	37	34	31	29	28	26	25	20	15	13											
28		8.00	8.45		100	95	92	80	74	71	68	63	60	56	53	50	44	36	26	19	15	13	11	9	7	5	4	3	2	1	
29		9.00	9.45																												
30	BH02	10.00	10.45	-	100	97	94	87	84	82	79	76	73	69	67	62	57	48	36	30	25	22	19	16	13	11	9	7	6	3	
31		10.50	10.70																												
32		11.00	11.45																												
33		12.00	12.45	100	77	77	68	59	57	56	55	54	52	48	43	37	15	13	11	9	8										
34		13.00	13.45																												
35		14.00	14.45	-	100	90	82	70	57	49	41	32	26	19	17	15	13	11	9	8											
36		16.83	16.80																												
37		18.70	18.80																												
38		1.00	1.45																												
39		1.50	1.95	-	-	100	93	83	76	72	69	65	61	55	52	47	41	36	28	24	19	17	14	11	9	7	5	3	2	1	
40		2.00	2.45																												
41		2.50	2.95	-	100	90	71	64	53	47	43	39	36	33	30	28	24	20	14	13											
42		3.00	3.45																												
43	BH03	4.00	4.45	-	-	100	85	75	71	69	67	64	61	54	50	45	39	32	23	21	18	15	12	10	8	6	5	4	3	1	
44		4.50	4.70																												
45		5.00	5.45	-	-	100	97	88	78	74	72	70	66	58	53	48	41	33	23	21	18	14	11	9	7	5	4	3	2	1	
46		6.00	6.45																												
47		7.00	7.95	100	77	77	66	55	48	40	33	28	24	19	17	14	12	9	6	5											
48		0.50	0.95																												
49		1.00	1.45	100	78	61	52	42	36	29	25	21	17	15	13	12	11	10	8	7											
50		1.50	1.95																												
51		2.00	2.45	100	85	85	73	54	44	38	31	27	23	19	17	16	14	13	10	9											
52		2.50	2.95																												
53		3.00	3.45																												
54		3.50	3.95	-	100	89	81	75	71	69	69	64	59	55	52	49	44	39	31	26	20	18	16	13	11	9	7	5	3	1	
55	BH04	4.10	4.30																												
56		4.50	4.95	-	100	98	89	73	65	59	57	55	51	46	43	40	34	27	20	19	16	13	10	8	6	4	3	2	2	1	
57		5.50	5.95	-	-	100	96	93	91	90	89	84	77	68	63	58	52	45	38	34	27	23	20	17	15	12	10	8	6	3	
58		6.50	6.95																												
59		7.50	7.95	-	-	100	92	87	82	79	76	72	67	60	56	50	43	35	26	23	18	15	12	10	8	6	5	4	3	1	
60		8.50	8.95																												
61		9.00	9.45	100	93	86	73	59	49	41	34	27	23	19	18	16	13	10	6	5											
62		14.00	14.15																												
Total No. of Tests				27																											

Source: JICA Study Team

Table 1-9 Result of Laboratory Tests (Part 2)

No.	Borehole No.	Depth of Sample		Natural Moisture Content	Specific Gravity	Unit Weight		Liquid limit	Plastic limit	Plasticity Index	Unconfined Compressive Test			Consolidation Test		Unconsolidated-Unconfined Compression Test Peformed	Consolidation Test Performed
		From	To			Natural	Dry				U.C.S	Modulus of Elasticity	Axial Strain	Effective Friction Angle	Effective Cohesion		
				W		r_W	r_d	W_L	Wp	Ip	q_u	E	e_f	f	C'		
		m	m	%		g/cm^3	g/cm^3	%	%	%	kPa	kG/cm^2	%	°	kPa		
1	BH01	1.00	1.45	23.3	2.82												
2		2.00	2.45														
3		3.00	3.45	30.9	2.82												
4		4.00	4.45		2.80			75	34	41							
5		5.00	5.45	50.1	2.83												
6		6.00	6.45		2.80			59	25	34							
7		7.00	7.45	49.9	2.85												
8		7.50	7.62					73	27	46							◎
9		7.62	7.76	50.0	2.91									45	0		
10		8.00	8.45		2.80			42	22	20						◎	
11		9.00	9.45	65.5	2.84												
12		10.00	10.45		2.80			136	48	88							
13		10.50	10.70	109.0	3.04			156	62	94							
14		10.72	10.85	119.0										37	3		
15		10.86	10.99														
16		11.00	11.45	62.4	2.82												
17		12.00	12.45														
18		13.00	13.45	15.1	2.72												
19		17.00	17.45														
20		17.50	17.60	10.1		2.80	2.55			14,452	1,728	0.87					
21		18.00	18.45	16.9	2.72												
22		19.00	19.34														
23		20.00	20.45	20.1	2.73												
24	BH02	1.00	1.45	42.2													
25		3.00	3.45	26.6	2.81												
26		6.00	6.45	51.0	2.83												
27		7.00	7.45	43.6													
28		8.00	8.45		2.80			81	25	56							
29		9.00	9.45	47.9	2.84												
30		10.00	10.45		2.80			100	31	69							
31		10.50	10.70														◎
32		11.00	11.45	67.0	2.88												
33		12.00	12.45														
34		13.00	13.45	79.4	2.91			142	43	99							
35		14.00	14.45	21.3													
36		16.83	16.80	5.5		2.00	1.90				8,269	938	1.14				
37		18.70	18.80	9.4		1.98	1.81				6,255	1,101	0.84				
38	BH03	1.00	1.45	44.4	2.84												
39		1.50	1.95		2.85												
40		2.00	2.45	60.1	2.89												
41		2.50	2.95														
42		3.00	3.45	52.8	2.91												
43		4.00	4.45		2.85			111	27	84							
44		4.50	4.70														◎
45		5.00	5.45	72.5	2.93												
46		6.00	6.45	76.8	2.94												
47		7.00	7.95	32.0	2.79												
48	BH04	0.50	0.95	26.0	2.87												
49		1.00	1.45	29.8													
50		1.50	1.95	35.2	2.88												
51		2.00	2.45														
52		2.50	2.95	27.2	2.88												
53		3.00	3.45	36.6	2.89												
54		3.50	3.95	48.9	2.90												
55		4.10	4.30														◎
56		4.50	4.95	64.7	2.94												
57		5.50	5.95	63.2				91	27	64							
58		6.50	6.95	59.1	2.94												
59		7.50	7.95	57.2	2.94												
60		8.50	8.95	52.6	2.94												
61		9.00	9.45														
62		14.00	14.15	6.1		2.17	2.05				15,846	2,570	0.8				
Total No. of Tests				41	39	4		11			4			2		1	4

Source: JICA Study Team

1-6 Environmental and Social Consideration

1-6-1 Environmental Impact Assessment

Development of the new domestic wharf is categorized as a "major project" under Tonga's Environmental Impact Assessment Act, 2003, and hence submission of an Environmental Impact Assessment (EIA) report is required in order to obtain an environmental approval from the Ministry of Environment and Communications (MEC).

The JICA Study Team conducted an environmental impact assessment of the proposed new domestic wharf, based on the requirements stipulated under Tonga's national EIA law/regulation (Environmental Impact Assessment Act, 2003 and Environmental Impact Assessment Regulations, 2010) and JICA's "Guidelines for Environmental and Social Considerations (2010)". The main results of the environmental impact assessment are summarized in the ensuing Sections. For more details see the full EIA report attached as Appendix-7.

1-6-2 Status of Existing Environment

The new domestic wharf will be constructed on top of a shallow fringing coral reef of approximately 200 m width. Corals and sea-grass are distributed along the reef, providing habitats to various marine organisms. The natural environment is in relatively pristine condition, with no significant pollution identified through a field survey.

The new domestic wharf is located relatively close to a residential/commercial area, only separated by Vuna road. Also around 20 Taovala producers work in the shallow waters of the project area for soaking materials used for Taovala. Relocation of their activity will be required due to the project.

1-6-3 Potential Environmental Impacts and Environmental Management Plan

Table 1-10 shows the potential environmental impacts and proposed mitigation measures for the construction phase, including the timing of implementation and responsible entities.

Table 1-10 Proposed Mitigation Measures for the Identified Environmental Impacts (Construction Phase)

Category		Environmental Impacts	Proposed Mitigation Measures	Timing of Implementation	Responsible Entities
Physical	Air quality	Dust dispersion from construction site	• Water spraying	Throughout construction period	Construction contractor
		Exhaust emission from construction machines and vehicles	• Regular inspection and maintenance • Avoiding sensitive areas during transportation of construction materials	Throughout construction period	Construction contractor
	Noise	Noise from pile-driving works	• Use of low-noise pile driver (vibratory pile driver) • Noise monitoring	During pile-driving works	Construction contractor
		Noise from construction machines and vehicles	• Regular inspection and maintenance • Avoiding sensitive areas during transportation of construction materials	Throughout construction period	Construction contractor
	Vibration	Vibration from pile-driving works	• Vibration monitoring	During pile-driving works	Construction contractor
	Water quality	Dispersion of suspended sediments through dredging and reclamation works	• Installation of silt curtain • Monitoring of turbidity levels	During dredging and reclamation works	Construction contractor
	Odours	Decomposition odours from dredged material	• Drying of dredged material far from residential area (north side of Faua wharf)	During dredging works	Construction contractor
	Waste	Construction wastes	• All waste will be temporarily stored at a designated location inside the construction site. • Non-hazardous solid waste: disposal at Tonga Waste Authority landfill site. • Hazardous waste: send to a local company for treatment or recycling. Hazardous wastes that are not accepted in Tonga will be transported overseas for treatment or disposal. • Metal scraps: send to a local recycling company. • Human waste: Installation of temporary toilets. Generated sludge will be disposed of at the Tonga Waste Authority landfill site	Throughout construction period	Construction contractor
Natural	Ecosystem	Impact on corals due to dispersion of suspended sediments	• Installation of silt curtain • Monitoring of coral health	During dredging and reclamation works	Construction contractor and local expert
Social	Livelihood	Relocation of Taovala soaking area	• Monitoring of relocated Taovala producers	Throughout the construction period	MOI

Source: JICA Study Team

Table 1-11 shows the potential environmental impacts and proposed mitigation measures for the operation phase, including the timing of implementation and responsible entities.

Table 1-11 Proposed Mitigation Measures for the Identified Environmental Impacts (Operation Phase)

Category		Environmental impacts	Proposed mitigation measures	Timing of implementation	Responsible entities
Physical	Water quality	Wastewater discharge from ships	• Prohibition of wastewater discharge from ships	Throughout operation	MOI and port operator
		Wastewater discharge from terminal building	• Installation of septic tank and discharge under BOD concentration of 30 mg/l • Regular inspection and maintenance of septic tank	Throughout operation	MOI and port operator
	Sediment quality	Contamination by use of harmful anti-fouling paint	• Request ship owners to voluntarily refrain from the use of harmful anti-fouling paint	Throughout operation	MOI and port operator
	Waste	Waste from ships and terminal building	• All waste will be temporarily stored at a waste reception facility inside the wharf. • Non-hazardous solid waste: disposal at Tonga Waste Authority landfill site. • Hazardous waste: send to a local company for treatment or recycling. • Food waste: send to local farms as a feed for domestic animals. • Human waste: treatment through septic tank. Generated sludge will be disposed of at the Tonga Waste Authority landfill site	Throughout operation	MOI and port operator

Source: JICA Study Team

1-6-4 Environmental Monitoring Plan

The following monitoring programs will be conducted during the construction phase to confirm the environmental status and the effectiveness of the proposed mitigation measures:

- Monitoring of noise
- Monitoring of vibration
- Monitoring of water quality
- Monitoring of coral health
- Monitoring of Taovala producers

Depending on the monitoring results, the mitigation measures may be revised until impacts are reduced to satisfactory levels.

1-6-5 Public Consultation

A public consultation meeting was held on November 6th, 2014, to inform and obtain the opinions of the

public about the planned project, its potential environmental impacts and mitigation measures. Over 30 people participated in the meeting including local residents of Maufanga, shop owners, relevant government agencies and so on.

The main concerns raised were related to the project location, traffic congestion, usage of dredged material and so on. No participants expressed opposition to the project once their concerns were answered through the meeting.

Since MOI had limited experience in holding of such public consultation meetings, there was some inefficiency in its preparation. The JICA Study Team has therefore prepared a "Manual for the preparation of public consultation meetings" based on the lessons learnt through this meeting. The manual can be referred to when holding such meetings in the future (see Appendix-6 for the manual).

1-6-6 Conclusions

Development of the new domestic wharf will contribute significantly in improving the safety and quality of domestic inter-island shipping, which is the fundamental means of transportation for the Tongan people. The construction works and the new terminal building will also create new employment opportunities, alleviating to some extent the high domestic unemployment rate.

There will inevitably be moderate environmental impacts, in particular during construction works, such as noise, water quality degradation and coral reduction. These impacts will be minimized by implementing mitigation measures and strict monitoring programs. Impacts in the operation phase will be minimized by implementing strict pollution control measures and proper waste management.

Chapter 2 Contents of the Project

2. Contents of the Project

2-1 Basic Concept of the Project

2-1-1 General

In Nuku'alofa Port in Tongatapu Island of the Kingdom of Tonga, there are three principal wharves, which are Queen Salote Wharf for the international traffic and large inter-island ferries, Vuna Wharf for international cruise ships and Faua Wharf for small ferries to Eua Island and fishing vessels. The inter-island ferries provide sea transport services for passengers and cargoes such as daily necessities, construction materials, fuels etc. Inter-island shipping plays a crucial role in providing the fundamental means of transportation for the people since air transportation is either expensive or very limited in both capacity and availability.

The government-owned cargo and passenger ferry "M.V. Otuanga'ofa" which was donated by the Government of Japan plays the crucial role of inter-island transportation. This ferry was built in 2010 to carry 400 passengers and 560 tons of cargo and operates a weekly service to Ha'pai and Vava'u. Not only M.V. Otuanga'ofa but also M.V. Pulupaki, M.V. Sitka and M.V. Nuivakai are berthing at the west side of Queen Salote Wharf that is planned for the international porting wharf for their operations. The operations of these ferries during embarking and disembarking of passengers are congested, and the loading and unloading of general cargoes and hazardous cargoes are dangerous due to lack of space and proper facilities for safety. The current utilization of domestic and international berths at Queen Salote Wharf does not satisfy the International Security Regulations. In addition, there is no shelter port for these ferries in Nuku'alofa Port. Therefore, they must leave the port and anchor offshore during rough sea conditions such as tropical cyclone season.

The objectives of the project are to improve handling efficiency and to contribute to the economic growth by ensuring the safety of Nuku'alofa Port through separating domestic and international cargoes at Queen Salote Wharf. In order to attain these objectives, a new wharf for these domestic ferries is planned in Faua Wharf area. The basic components of the project to achieve those objectives are as follows;

- To upgrade Faua Wharf to provide a safe and reliable terminal for large inter-island ferries in order to increase high quality competition in providing sea transport services,
- To secure sustainable shelters for vessels and port users to address issues of climate change and disaster risk reduction,
- To provide attractive and friendly port facilities in order to generate revenues for maintenance and repair of the port.

2-1-2 Basic Components

These basic concepts meet the precepts of the "Development and Maintenance of Infrastructure" in "Tonga Strategic Development Framework (TSDF) 2011-2014" and the "National Infrastructure Investment Plan (NIIP) 2013-2033" established in 2013 under the "Pacific Region Infrastructure Facility (PRIF)".

The main components of this project are ①the Breakwater with concrete parapet walls, ②Berths for large inter-island ferries, ③Navigational channel and basin, ④Domestic ferry passenger terminal building, etc. as shown in Table 2-1.

Table 2-1 Basic Components of the Project

No	Facilities	Descriptions	Remarks
1	Breakwater	Rubble mound type sloping breakwater with concrete parapet walls	L=approx. 250 m
2	Berth	2 nos. for large domestic ferries	L=90 m/berth
3	Loading Ramp	2 nos.	
4	Accessories	Mooring bits, fenders, curbs, etc.	
5	Channel & Basin	Dredging works	Designed depth: -4.0 m
6	Cargo handling yard	Concrete pavement	CDL+3.0 m
7	Passenger Terminal Building	3 story RC structure w/solar panel on top	
8	Access road, Car parking	Asphalt pavement	
9	Ancillary	Sidewalk, Passenger walkway, Drainage, Fences	
10	Guard house, Waste station	One-story, one each	
11	Navigation Aids	2 marine lights, Sector light	

Source: JICA Study Team

Although the original application from the Government of Tonga requested the upgrading of Nafanua Wharf in Eua Island, both Japan and the Tonga side agreed that it would not be included in the Project due to the limited budget.

2-2 Outline Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

The primary application from Tonga was for the rehabilitation of the existing Faua Wharf to accommodate M.V. Otuanga'ofa. After discussions with the participants, MOI, PAT, FISA, Captains, ship owner, etc. through the Preparatory Survey, it is difficult to construct the required components in the existing Faua Wharf due to the following reasons;

- There is not enough sea area to manoeuvre M.V. Otuanga'ofa safely.
- Wave conditions in Faua Wharf will become worse by widening the port mouth

Therefore, new locations for the inter-island ferries were studied and four candidates were compared as shown in Table 2-2. The western side sea area of Faua Wharf is selected as the most optimal location for a new wharf.

The target vessel for the basic design is M.V. Otuanga'ofa and two berths and ramps for the large domestic ferries are planned in this project. The reasons why the port facilities for two large ferries are required are as follows;

- The large ferries in Tonga are regularly maintained and repaired every two years at the dry dock in Fiji since no dry dock is available for them in Tonga.
- During busy seasons such as Christmas Day, New Year holidays, Christian Assembly, etc., it is not adequate for only one ferry to cope with the demands of passengers and cargoes.

The future possibilities to enlarge the vessel size are low because the trends of population, economic growth, cargoes and passengers in Tonga have been almost flat during the past 10 years. Even if the volume of cargo and passenger numbers increase in the future, M.V. Otuanga'ofa can deal with this by increasing the weekly trips from once to twice and/or three times a week.

The relationship between objectives and project components are summarized below;

① To secure the navigational safety for all vessels
   a) Upgrading of navigational channel and basin
   b) Installation of navigation aids (beacons and sector light)

② To secure the berthing and mooring operations
   a) Securing harbour calmness through building a breakwater
   b) Installation of fenders and bollards

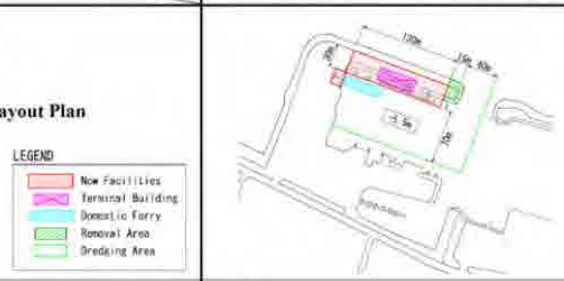
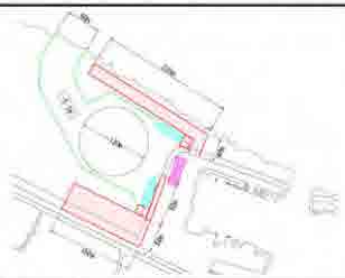
③ To secure the safety for passengers and cargo handling operation
   a) Upgrading cargo yard and loading ramps
   b) Separating the traffic lines of cargo and passengers
   c) Installation of vehicle entrance gates and guard houses

d) Installation of guard fences
e) Upgrading car parking area

④ To secure the safety and amenities in the passenger waiting area
a) Upgrading the waiting lounge in the terminal building
b) Upgrading the pavement to prevent blowing sand and dust
c) Upgrading the covered passenger walkway

⑤ Others (earnings and landscape, etc.)
a) Preparing attractive facilities such as a restaurant and viewing deck
b) Construction of greenbelt along Vuna road
c) Installation of a monument to the friendly intercourse between Japan and Tonga
d) Terminal building that can serve as an evacuation facility
e) Adoption of LED lights for yard lighting and buildings

Table 2-2 Comparison Table for Port Layout Plan in Faua Wharf

	Case-1: Original Plan (Seaward-berth)	Case-2: Revised Plan (Landward-berth)	Case-3: Proposed Plan (West-side sea area)	Case-4: Developed Plan
Layout Plan				
Outline of the Plan	15 m of west side breakwater is removed and the port mouth is widened up to 55 m to enter the M.V.'Otuanga'ofa. The berth (30 m width and 130 m length) is planned behind the west breakwater to moor the domestic ferries. The retaining walls are placed on the existing breakwater to protect the wharf during tropical cyclones.	The port mouth is widened as same as Case-1. The berth for domestic ferries is planned on the land side of the wharf considering the safety and easiness of the ship maneuvering.	The new wharf is planned on the western side sea area of Faua Wharf: - Breakwater: 270 m length - Berth: 2 nos. x 80 m length - Landing ramp: 2 nos. - Dredging: V=110,000 cu. m - Reclamation area: 50 m width x 150 m length	The widening port mouth and the berth location are as same as Case-1. The port facilities on the land side are removed to secure the required basin are (120 m as two times of ship length). Approx. 200 m extension of the east side of breakwater will be required to secure the harbor calmness inside the wharf.
Effects on Harbor Calmness	●The north sea swells during cyclone seasons will affect more extensively than the present conditions due to the widened port mouth. Score: 5 of 20	●Same as on the left Score: 5 of 20	○The waves inside wharf will be calm year-round due to the breakwater. Score: 20 of 20	○The waves inside wharf will be calm year-round due to the extension of the existing breakwater. Score: 20 of 20
Features of Port Facilities	●It is difficult for domestic ferries to maneuver by themselves due to the lack of basin area in case of strong wind and high waves. ●Harbor calmness will not be secured during tropical cyclone. ●The performance criteria for the shelter port for all domestic ferries will not be satisfied. ●The existing mooring facilities behind the west breakwater will be dismantled. ●Abandoned ships and utilities will be removed. Score: 5 of 20	●Same as on the left; although, safer and better ship operability than Case-1. ●Same as on the left ●Same as on the left ●The existing port facilities on the land side of the wharf will be dismantled. ●Same as on the left Score: 10 of 20	○The performance criteria for the shelter port for all domestic ferries will be satisfied during tropical cyclones. ○The future expansion of port facilities will be available. ●The dredging volume will be largest among all cases. Score: 20 of 20	○Same as on the left ●The expanded breakwater will be a costly and bigger structure because of the deep water location. ●The large scale of port layout plan is to be reconsidered due to removal of the existing port facilities on the land side. ●Abandoned ships and utilities will be removed. ●Additional soil investigations will be required. Score: 15 of 20
Effects on Other Ship during construction	●Some operational and safety problems for other ship will be occurred, but they can be managed. Score: 10 of 20	●Same as on the left Score: 10 of 20	○No impacts will be happened since the project is located outside of Faua Wharf. Score: 20 of 20	●Profound effects will be considered due to the large scale of rebuilding. Score: 5 of 20
Environmental Issues	○ The environmental and social conditions is categorized as "Category B". ●The disposal area for dredged materials shall be provided. Score: 15 of 20	○Same as on the left ●Same as on the left Score: 15 of 20	●The Category might be changed B to A due to the JICA Guideline. ●Same as on the left Score: 5 of 20	○ The environmental and social conditions is categorized as "Category B". ●Same as on the left Score: 15 of 20
Project Cost	**12 million US$** Score: 20 of 20	**15 million US$** Score: 15 of 20	**30.5 million US$** Score: 10 of 20	**55 million US$** Score: 5 of 20
Evaluation	GOOD (Total score: 55 of 100)	GOOD (Total score: 55 of 100)	**BEST (Total score: 75 of 100)**	BETTER (Total score: 60 of 100)

Note: ○: Advantage, ●: Disadvantage

Source: JICA Study Team

2-2-1-2 Natural Environmental Conditions

The basic design and construction plan are executed considering the natural environmental conditions which are distinctive in Tonga. In Tonga the eastern trade wind blows throughout the year, and especially it becomes stronger in summer season (December – April). It is hot and humid from January to March and the tropical cyclones pass through in this season. The design wind speed complies with the design codes in Tonga. The design waves for the breakwater and harbour calmness is fixed by the results of the wave analysis in this study since no design wave is defined for Nuku'alofa Port. Tsunami height and seismic coefficient are also fixed adequately with consideration of Tongan design standards and similar design studies in this area. The subsoil conditions in the project area are composed of complicated layers which are characteristic of atoll islands. Therefore, based on the soil investigation carried out in the Preparatory Survey, the calculation of dredging and reclamation volumes and basic design for marine facilities and building structures are studied properly.

2-2-1-3 Socio Economic Conditions

The main industries in Tonga are agriculture and fishery. The domestic cargo volume is roughly flat in the last ten years. The project area is located at the city centre of Nuku'alofa and adjacent to the Eua Ferry Terminal and Vuna road which is one of the main roads in Tongatapu Island. Due to the favourable location, it is easy for domestic cargoes and passengers to access the new ferry terminal. Moreover, as for designing of a passenger terminal building, one of the goals is to be a friendly facility which everybody, not only ferry passengers but also all guests such as inhabitants, tourists, and Eua ferry passengers, can access without any constraints. Also, port facilities are to be designed as a kind of symbol that show the amicable relationship between Japan and Tonga since Tonga is historically a nation that has been friendly with Japan. In 2019 the South Pacific Games will be held in Tonga for the first time. This new wharf will be a gateway for the domestic ferries in Tonga. Therefore, the basic design should be executed considering that the terminal building will be a kind of monument which is symbolic of the "Entrance Port" in Tonga.

2-2-1-4 Construction/Procurement Conditions

The designs of the port facilities in Tonga comply with the design criteria of the donating countries such as New Zealand and Australia because Tonga has no specific standard for port facilities. Basically, Japanese standards are applied to the port facilities in this project, and the design conditions are determined referring to the design reports of the existing port facilities in Nuku'alofa Port. Regarding the building structures, the building codes in Tonga are mainly applied, but if they do not cover enough, Japanese codes are adopted complementarily.

Considering the peculiar conditions of construction and procurement on the island country, proper designs that meet the local conditions are executed. Based on the machinery and construction materials lists of items that can be procured in Tonga and interviews with the local contractors and suppliers, reasonable and easy constructing plans for local contractors have been prepared.

2-2-1-5 Operation and Maintenance

The operation and maintenance for the port facilities prepared in this project will be carried out by PAT. PAT has adequate capability to maintain these port facilities due to the sufficient budget for operation and maintenance, organization, personnel and technical level. The facilities are designed to be maintenance-free as far as possible. The structure of the breakwater is selected as "gravel mound sloping type" which is made of local procured stones and is easily repaired by PAT themselves. As for the lighting system, LED lights are adopted as for many as possible. Although the initial costs of LED are higher than the normal lights, the maintenance costs over 50 years are lower and they are more cost effective. The terminal building will have a restaurant and a cafeteria with potentially high profitability, and PAT can apply the profits from the tenant income to the maintenance costs of the port facilities.

2-2-1-6 Environmental and Social Considerations

The Environmental Impact Assessment (EIA) report was prepared by the Ministry of Infrastructure (MOI) with technical assistance from the JICA Preparatory Survey Team, and approved by the Ministry of Environment and Communications (MEC). The basic designs and construction plans of the new wharf are to be conducted with consideration for the environmental management plan of the EIA report. The environmental management plan provides information on the proposed mitigation measures and environmental monitoring plan for physical, natural and social environmental impacts.

2-2-1-7 Facility Grades

On the basis of the above mentioned project objectives and concepts, the grades for each facility are described below.

(1) Breakwaters

The strength and arrangement of breakwaters are studied to secure the cargo handling operating rate at least 97.5 % for each berth against the wave with 50-year return period.

(2) Navigational Channel

The width and depth of the navigational channel have enough space for the mutual navigations by target vessels. The navigation aids are also to be installed to secure safe navigation.

(3) Basins

The basin has adequate water area and depth for ship manoeuvring by the target vessel.

(4) Berths

Two target vessels can be alongside at the same time all the year. An additional three cargo ships also can berth in the port during rough sea conditions.

(5) Terminal Building

The terminal building can accommodate the passengers of the two target vessels and Eua ferry, and it provides a restaurant, ticket counters, offices, etc. Solar panels are installed on the roof to partially supply the daytime electricity. This building also can be available as a shelter in case of disasters.

(6) Cargo Yards

In order to secure the safety of passengers and cargo handling activities and enhance the cargo handling efficiency, a passenger walkway and yard lights are to be prepared, and the cargo yard will have enough space for cargo handling operations. The cargo yard is designed to have concrete paving that is durable and easy to maintain.

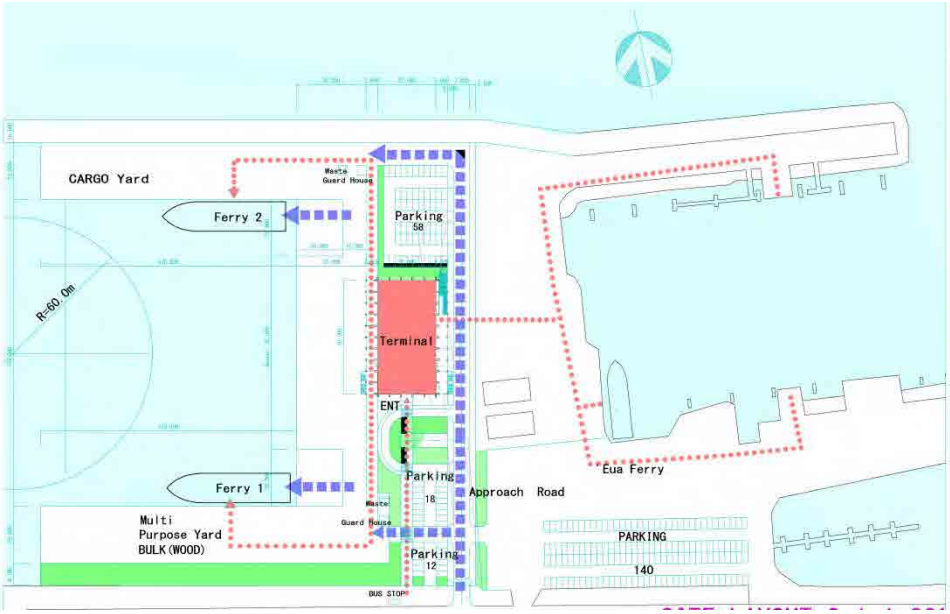
2-2-1-8 Work Procedure, Procurement and Work Schedule

During construction, procedures that are well-known and common work methods considering the past similar projects in Tonga will be employed. The local construction materials are also selected preferentially to reduce the amount of imported materials. The construction equipment which is available in Tonga is also prioritized for use, and the procurement of equipment from foreign countries is minimized as much as possible. In this regards, the construction procedures are planned without using bigger machines. Work schedule is planned within 24 months to complete by the beginning of 2018 considering the South Pacific Games in autumn 2019.

2-2-2 Basic Plan (Construction Plan/Equipment Plan)

2-2-2-1 Port Layout Plan

Several port layout plans as shown in Table 2-3 were studied based on the discussions with MOI, PAT, FISA and port related persons during the Preparatory Survey. The following plan as shown in Figure 2-1 is selected comparing the port safety, ship manoeuvrability, and usability of port facilities.



Source: JICA Study Team

Figure 2-1 Port Layout Plan

Table 2-3 Comparison Table for Port Layout Plan

Comparative Study on New Port Layout

	Case A	Case B	Case C
Port Layout (Plan)			
Features	・ Each ferry is able to have a sole use berth respectively. ・ As the above result, cargo/ passenger of each ferry can be free from mutual interferences. ・ Inner berth can be used for another ship in case of emergency. ・ Sufficient turning area can be acquired for the objective ship.	・ Terminal building is closer to the ships and it contributes less walking distance for the passengers. ・ Each cargo handling yard can be isolated respectively. ・ Breakwater doesn't have berth structure as the result there is no concern to get splash to ship under bad weather. ・ There is waste space (dead space) due to berthing direction.	・ Terminal building is closer to the ships and it contributes less walking distance for the passengers. ・ Each cargo handling yard can be isolated respectively. ・ This layout can't get extra berth. (No emergency berth)
Port Safety	・ Port safety is higher compared to other cases due to a sufficient distance in between 2 berths. ・ Remarkable wind direction is east side at the site. This layout can realize ship berthing with the wind direction and it will bring less damage to the ship berthing ・ and smooth cargo on/ offloading under the strong wind condition.	・ Simultaneous sailing of both ships can't be possible. ・ Ferry 1 has to berth worst direction toward remarkable east wind and it will bring heavy ship rolling. ・ Separate cargo yard secures safety cargo handling respectively.	・ Both ships have to berth face to face and it is not allowed by the Japanese Standards on the point of maneuvering safety. ・ Remarkable East wind affect to both ships directly and not safe against ship rolling. ・ Separate cargo yard secures safety cargo handling respectively.
Ship Maneuvering	・ Sufficient tuning space in the port. ・ Ship bow is sailing direction when berthing and it contributes easiness of maneuvering. ・ Ship can turn even in the bad weather due to wide calmness port area.	・ The position relation of 2 ships berthing makes more difficulty on ship maneuvering. ・ Remarkable wind from east side disturbs ship maneuvering compared to Case 1.	・ Most difficult ship maneuvering due to face to face berthing. ・ Remarkable wind from east side disturbs ship maneuvering compared to other cases.
Usability of Port	・ Longer walking distance from Terminal to both ships. ・ Sufficient cargo space for both ships. ・ There is no waste space in the port. ・ There is crossing points between cargo and passenger flows therefore both flows can not be simultaneously.	・ Shorter walking distance makes easier to the passengers. ・ Congestion points of each ship closer to Case A. ・ As the result of above mentioned, accident frequency is higher.	・ Shorter walking distance makes easier to the passengers. ・ Congestion points of each ship closer to Case A. ・ As the result of above mentioned, accident frequency is higher.
Evaluation	**Most Recommendable ◎** **(Excellent as shelter port with functions of port safety and smooth ship maneuvering)**	**Acceptable but Not Recommendable ○** **(Not smooth ship maneuvering and there is dead water space in the Port.)**	**Not Recommendable Δ** **(Impossible to realize safety maneuvering)**

Source: JICA Study Team

2-2-2-2 Port Facilities (Civil Works)

(1) Design Standard

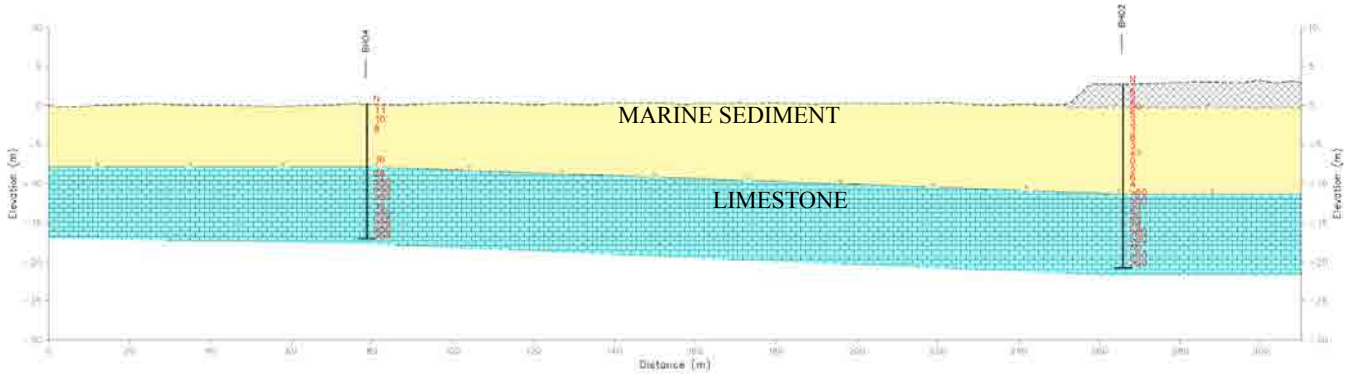
The design standard for the port facilities basically complies with the "Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI, 2009" since Tonga has no specific standard for port facilities. The design period for the main port structures is 50 years.

(2) Breakwaters

1) Structural Type of Breakwater

The existing breakwater at Faua Wharf is a rubble mound sloping type and covered with armour stones (2.0 tons apiece). It has been stable and durable on a long-term basis and not been seriously damaged by tropical cyclones. The selected structural type of the breakwater in this basic design stage is almost the same as the existing rubble mound type.

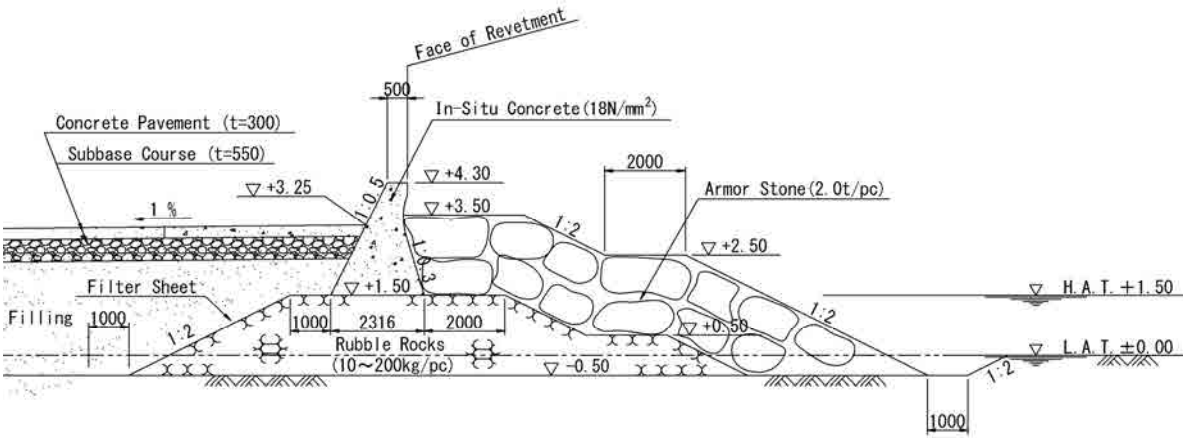
According to the soil investigation results conducted during the Preparatory Survey, the soft marine sediments are found down to around -10 m from sea bed level as shown in Figure 2-2.



Source: JICA Study Team

Figure 2-2 Geological Section

If the gravity type (i.e. caisson and block type) was selected, it would be necessary for the foundation of the breakwater to have countermeasures applied for strengthening the bearing capacity, such as replacement or soil improvement due to the soft layer underneath the breakwater. Therefore, a rubble mound sloping type is optimal for this project because rubble stones can be procured easily in Tonga and the ground contact pressure is smaller than others. The typical cross section of the breakwater is shown in Figure 2-3.



Source: JICA Study Team

Figure 2-3 Typical Cross Section of Breakwater

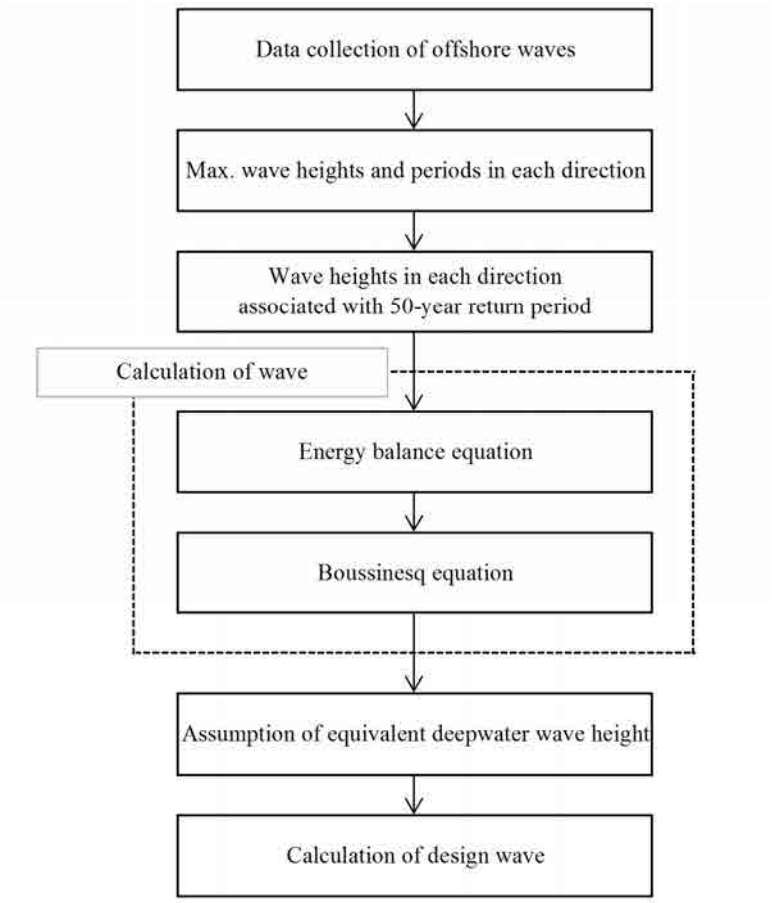
The design concepts of the breakwater are as follows;

- Breakwater gains greater toughness and ductility by forming a small step in the armour layer,
- Armour stone is placed on a shallow-slope (gradient 1:2) to cope with rough sea conditions,
- Concrete parapet walls are installed to reduce the rate of wave overtopping onto the cargo yard,
- Rubble rocks are placed up to the elevation of H.A.T. +1.5 m to reduce the ground contact pressure of the parapet walls and be able to carry out construction works on land.

2) Design Waves

The JICA Study Team purchased the wave prediction records (one every hour, 24 times per day) for the 30 years (1984 – 2013), which were prepared by the offshore wave database (hereinafter GPV: Grid Point Value) observed by the Japan Meteorological Agency, because Tonga has no longstanding wave observation data for around the country. The maximum wave heights and periods for each year and each direction were selected from the GPV, and the offshore wave heights associated with a 50-year return period were calculated based on the extreme value statistics. The wave period with a 50-year return period was calculated using a correlating equation incorporating the method of least squares for the periods corresponding to the maximum wave height in every direction. The calculation for the wave transformation at the area from offshore points to the front points of Nuku'alofa Port employs the energy balance equation, and the Boussinesq equation is employed at the area from the front points of Nuku'alofa Port to the designed breakwater. The wave heights calculated by the Boussinesq equation are the significant wave heights. Therefore, the equivalent deep-water wave heights are calculated by the ratio of significant wave heights to the waves affected by shoaling and breaking. The design wave in front of the breakwater was calculated considering the transformation of the wave due to shoaling and breaking.

Figure 2-4 shows the calculation procedure for design waves.



Source: JICA Study Team

Figure 2-4 Calculation Procedure for Design Waves

The design waves at the breakwater are calculated by the above mentioned procedures. The design wave heights employed for computing the crown height and mass of armour stones are selected from the maximum values in each direction and water depth. The water elevation for each calculation is C.D.L.+1.50 m at the highest astronomical tide. The calculation results for the design waves and the waves adopted for the structure of the breakwater are shown in Table 2-4.

Table 2-4 Calculation Results of Waves in front of Breakwater

Item		Values				Remarks
Wave direction		NW	NNW	N	NNE	
Equivalent deepwater wave height H0' (m)		0.69	0.93	1.24	0.72	
Wave period T0 (sec)		16.3	14.7	14.2	13.7	
Wavelength L0 (m)		414.48	337.10	314.56	292.80	
Wave steepness H0'/L0		0.0017	0.0028	0.0039	0.0025	
Principal direction of wave α (N° E)		33	32	33	34	
Bottom slope tan θ		1/10	1/10	1/10	1/10	
High Water Level (m)		1.50	1.50	1.50	1.50	
Wave in front of upright wall	Seabed elevation	0.30	0.30	0.30	0.30	
	Water depth h (m)	1.80	1.80	1.80	1.80	
	h/H0'	2.609	1.935	1.452	2.500	
	H1/3/H0'	2.490	2.043	1.610	2.390	
	H1/3 (m)	1.72	1.90	2.00	1.72	Significant wave height
	Seabed elevation	0.30	0.30	0.30	0.30	
	Water depth (h)max (m)	1.80	1.80	1.80	1.80	
	(h)max/H0'	2.609	1.935	1.452	2.500	
	Hmax/H0'	3.499	2.739	2.171	3.330	
	Hmax (m)	2.41	2.55	2.69	2.40	Maximum wave height
Wave at distance of 5 times wave height	Seabed elevation	0.45	1.00	1.30	0.45	
	Water depth (h)5 (m)	1.95	2.50	2.80	1.95	
	(h)5/H0'	2.826	2.688	2.258	2.708	
	(H1/3)5/H0'	2.529	2.370	2.102	2.432	
	(H1/3)5 (m)	1.75	2.20	2.61	1.75	Significant wave height
	Seabed elevation	0.30	0.95	1.30	0.40	
	Water depth (h)max.5 (m)	1.80	2.45	2.80	1.90	
	(h)max,5/H0'	2.609	2.634	2.258	2.639	
	(Hmax)5/H0'	3.499	3.384	2.954	3.424	
	(Hmax)5 (m)	2.41	3.15	3.66	2.47	Maximum wave height

: Input values for calculation of crown height of breakwater

: Input value for calculation of required mass of armor stones

Source: JICA Study Team

3) Crown Height of Breakwater

The breakwater must serve as a revetment for the cargo yard and passenger walk way. From that point of view, the crown height of the breakwater must comply with the design requirements of a revetment. Generally, the following two methods are employed for the calculation of crown height depending on the installation location.

- "Wave Overtopping Quantity" : in case the location is seaward from the coast line
- "Wave Runup Height": in case the location is landward from the coast line

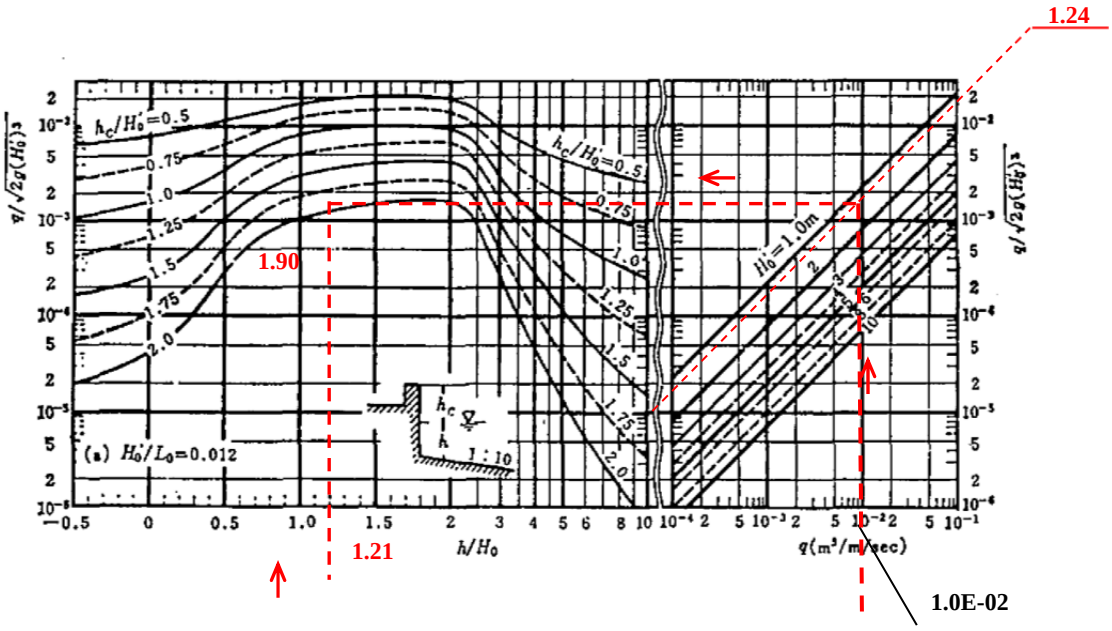
Therefore, the wave overtopping method is employed since the breakwater is located seaward from the coast line.

Design conditions are as follows;

Equivalent deep water wave height: H_0'=1.24 m
Wave period: T=14.2 sec
Wave length: L_0=314.56 m (=1.56xT^2)
Tidal water level: C.D.L.+1.50 m (H.W.L.)
Seabed slope: 1/10
Bottom elevation of revetment: C.D.L.±0.00 m
Allowable overtopping quantity: q=0.01 m^3/m/s

Therefore,

H_0'/L_0=1.24/314.56=0.004 ==>Diagram H_0'/L_0=0.012
h/Ho'＝1.50/1.24＝1.21



Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.111

Figure 2-5 Diagram for Estimating Wave Overtopping Rate

From above diagram, the value of hc/H_0' is 1.90, and hc=1.90 x 1.24 =2.356 m
Hence, the required crown height shall be no less than C.D.L.+3.856 m (=1.50 + 2.356).

However, there are many things that could happen including water spray and overtopping due to the force of the strong winds that are difficult to predict by means of ordinary calculations. The safety and relief of all port users are to be secured because many passengers and workers utilize the cargo yard behind the breakwater all year around. Therefore, concrete parapet walls around 1.0 m in height (C.D.L.+4.30 m) are required to protect against unexpected overtopping.

4) Breakwater Length

The length of the breakwater should be fixed by evaluating the harbour calmness, but it should not be less than the berth length (L=90 m) because the land just inside the breakwater is used for the apron of the berth. The harbour calmness can be calculated for the probability of the occurrence of a wave height that does not exceed the critical wave height for cargo handling work. The cargo handling operating rate is the percentage of time that the harbour is calm enough to load and unload cargo, and in general the acceptable harbour calmness is assessed as the cargo handling operating rate of at least 97.5 %. The critical wave height for cargo handling works is 0.5 m of $H_{1/3}$ referring to Table 2-5.

Table 2-5 Reference Values for Threshold Wave Height for Cargo Handling Works

Ship type	Threshold wave height for cargo handling works ($H_{1/3}$)
Small craft	0.3m
Medium/large ship	0.5m
Very large ship	0.7–1.5m

Note) Here, the small craft means ships of roughly <500GT class which mainly use the small craft basin, the very large ship means ships of roughly ≥50,000GT class which mainly use large-scale dolphins or offshore berths, and the medium/large ship means ships other than the small craft and the very large ships.

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.581

The following two alternatives are studied to determine the breakwater length;

- Plan 1: Berth length + 50 m
- Plan 2: Same length of berth

The calculation results for the cargo handling operating rate for each alternative are shown in Table 2-6.

Table 2-6 Cargo Handling Operating Rate of Alternatives

Alternative	Location	Cargo handling operating rate (%)	Remarks
Plan 1 (Berth length + 50 m)	North berth	100	Critical wave height = 0.5 m
	South berth	100	
Plan 2 (Same length of berth)	North berth	100	
	South berth	100	

Source: JICA Study Team

Plan 2 can secure the cargo handling operating rate more than 97.5 %, and the length of the breakwater is 90 m, which is the same as the berth length. The calculation results for cargo handling operating rate for Plan 2 at each berth location are as shown in Tables 2-7 and 2-8.

Table 2-7 Cargo Handling Operating Rate of Plan 2 at North Berth

CARGO Yard		W	WNW	NW	NNW	N	NNE	NE	ENE	E	Calm	frequency		Cumulative	
H1/3 RANK(m)												Num.	Rate(%)	Num.	Rate(%)
Calm										61	195,908	195,969	74.5	263,024	100.0
0.00 ～ 0.05										61		61	0.0	67,055	25.5
0.06 ～ 0.10		741	220	33	15	30	196	1,164	7,471	27,219		37,089	14.1	66,994	25.5
0.11 ～ 0.15		184	470	797	793	1,468	2,693	4,465	5,630	7,565		24,065	9.2	29,905	11.4
0.16 ～ 0.20		17	50	373	509	1,058	967	696	336	573		4,579	1.7	5,840	2.2
0.21 ～ 0.25				132	207	219	104	100	28	48		838	0.3	1,261	0.5
0.26 ～ 0.30				25	100	83	41	5	8	10		272	0.1	423	0.2
0.31 ～ 0.35				12	47	20	14					93	0.0	151	0.1
0.36 ～ 0.40				8	21	22						51	0.0	58	0.0
0.41 ～ 0.45				7								7	0.0	7	0.0
0.46 ～ 0.50												0	0.0	0	0.0
0.51 ～ 0.55												0	0.0	0	0.0
0.61 ～ 0.60												0	0.0	0	0.0
0.71 ～												0	0.0	0	0.0
TOTAL		942	745	1,387	1,692	2,900	4,015	6,430	13,473	35,476	195,908	262,968			
	Num.	0	0	0	0	0	0	0	0	0	0		0	Operation rate(%)	
Excess	Rate(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	100.0	

Source: JICA Study Team

Table 2-8 Cargo Handling Operating Rate of Plan 2 at South Berth

Multi Purpose Yard		W	WNW	NW	NNW	N	NNE	NE	ENE	E	Calm	frequency		Cumulative	
H1/3 RANK(m)												Num.	Rate(%)	Num.	Rate(%)
Calm											195,908	195,908	74.5	262,968	100.0
0.00 ～ 0.05												0	0.0	67,060	25.5
0.06 ～ 0.10		487	38				8	11	1,463	17,275		19,282	7.3	67,060	25.5
0.11 ～ 0.15		403	519	476	224	466	1,327	3,465	9,745	15,898		32,523	12.4	47,778	18.2
0.16 ～ 0.20		42	158	629	785	1,292	1,785	2,400	2,051	2,071		11,213	4.3	15,255	5.8
0.21 ～ 0.25		10	28	128	343	821	729	413	178	198		2,848	1.1	4,042	1.5
0.26 ～ 0.30			2	110	172	176	97	129	30	25		741	0.3	1,194	0.5
0.31 ～ 0.35				22	97	71	46	12	6	9		263	0.1	453	0.2
0.36 ～ 0.40				8	40	52	20					120	0.0	190	0.1
0.41 ～ 0.45				4	28	3	3					38	0.0	70	0.0
0.46 ～ 0.50				10	3	19						32	0.0	32	0.0
0.51 ～ 0.55												0	0.0	0	0.0
0.61 ～ 0.60												0	0.0	0	0.0
0.71 ～												0	0.0	0	0.0
TOTAL		942	745	1,387	1,692	2,900	4,015	6,430	13,473	35,476	195,908	262,968			
	Num.	0	0	0	0	0	0	0	0	0	0		0	Operation rate(%)	
Excess	Rate(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	100.0	

Source: JICA Study Team

5) Mass of Armour Stones

The armour stones for a sloping breakwater are placed to protect the rubble stones inside; it is necessary to ensure that an armour stone has a mass sufficient to be stable so that it does not shift position. This stable mass, the required mass, can be obtained by calculation using the following Hudson's formula. The required mass of armour stones is no less than 2.0 tons per piece.

<Input Data>

ρr:	2.6	t/m3
ρw:	1.03	t/m3
H:	2.61	m
KD:	3.5	<= Rubble Stone (angular)
α:	26.6	° 1 : 2.0

<Output>

Ns^3:	6.99	
M:	1.87	ton

$$M_d = \frac{\rho_r H_d^{\,3}}{N_{Sd}^{\,3}(S_r - 1)^3} \qquad (1.7.1)$$

where

M : required mass of rubble stones or concrete blocks (t)
ρ_r : density of rubble stones or concrete blocks (t/m3)
H : wave height used in stability calculation (m)
N_S : stability number determined primarily by the shape, slope, damage rate of the armor, etc.
S_r : specific gravity of rubble stones or concrete blocks relative to water

$$N_S^{\,3} = K_D \cot\alpha \qquad (1.7.3)$$

where

α : angle of the slope from the horizontal line(°)
K_D : constant determined primarily by the shape of the armor units and the damage ratio

Type of armor	Number of layers	Placement method	K_D		cotα
			Breaking waves	Non-breaking waves	
Rubble stones (rounded)	2	Random	(1.2)	2.4	1.5–5.0
	3 or more	〃	(1.6)	(3.2)	〃
Rubble stones (angular)	2	〃	2.0	4.0	〃
	3 or more	〃	(2.2)	(4.5)	〃

( ) shows estimated values.

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.411

(3) Berth

1) Water Depth of Berth

According to the Japanese standard for port facilities, the water depth of berth can be calculated using the following equation.

Berth water depth = Maximum draft + Under Keel Clearance

The maximum draft is the full loaded draft which is 3.0 m for M.V. Otuanga'ofa. For the keel clearance, it is preferable to use a value equal to 10 % of the maximum draft. Additionally in mooring facilities where sheltering by ships that are moored in abnormal weather, the addition of a keel clearance which considers wave factors is necessary. Therefore, the required berth water depth is calculated as follows.

Required berth water depth = 3.0 (draft) + 0.3 (10 %) + 0.5 (wave height) = 3.8 m => **C.D.L.-4.0 m**

The design berth depth for evaluating quay walls is C.D.L.-4.5 m considering 0.5 m depth due to the over-dredging value of sandy materials.

2) Berth Length

The required berth length for M.V. Otuanga'ofa (1,534 G.T.) is 90 m complying with Table 2-9. Regarding the loading ramp, the length and width are both 20 m considering the existing ramp dimensions.

Table 2-9 Intermediate and short-Distance Ferries

Gross tonnage GT (t)	Case of bow and stern side docking type		
	Length of berth (m)	Length of bow and stern side docking type quaywall (m)	Water depth of berth (m)
400	60	20	3.5
700	80	20	4.0
1,000	90	25	4.5
3,000	140	25	5.5
7,000	160	30	7.0
10,000	190	30	7.5
13,000	220	35	8.0

(In all cases, domestic gross tonnage.)

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.689

3) Crown Height of Quay Wall

The crown height of the quay wall is calculated by the following equation considering the values in Table 2-10 and the existing berth elevation.

H.W.L.+1.50 m + 1.5 m = C.D.L.+3.0 m

Table 2-10 Standard Crown Heights of Wharves

	Tidal range 3.0m or more	Tidal range less than 3.0m
Wharf for large vessels (water depth of 4.5m or more)	+0.5–1.5m	+1.0–2.0m
Wharf for small vessels (water depth of less than 4.5m)	+0.3–1.0m	+0.5–1.5m

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.689

4) Apron Width

The apron width is 10 m as shown in Table 2-11, and the slope of the apron concrete is 1.0% flowing toward seawards.

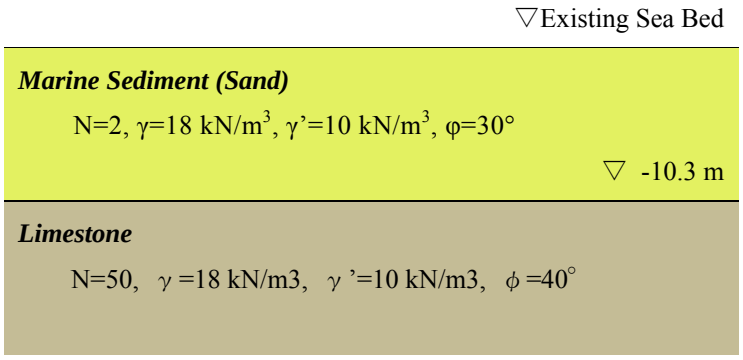
Table 2-11 Apron Widths

Berth water depth (m)	Apron width (m)
Less than 4.5	10
4.5 or more and less than 7.5	15
7.5 or more	20

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.889

5) Subsoil Conditions

The subsoil conditions for the quay wall design are based on the field survey results conducted in the Preparatory Survey. The subsoil conditions are shown in Figure 2-6.



Source: JICA Study Team

Figure 2-6 Subsoil Condition for Quay Wall

6) Seismic Coefficient

The quay wall structures are to be evaluated for seismic impact by using the seismic coefficient method. The seismic coefficient is 0.15 the same as the existing quay walls (sheet pile type, -12 m water depth) at Queen Salote International Container Wharf.

7) Loading Conditions

The maximum loading condition caused by heavy equipment is that of a forklift (TCM-80) with a fully loaded container. According to the brochure for the forklift, the loading specifications are as follows;

Unloaded Weight: 11.55 tons

Full Container: 6.0 tons

Load Area: 5.23 m x 1.80 m = 9.414 m^2

Ground Pressure: (11.55 + 6.0)/9.414 = 1.86 t/m^2 ==> **2.0 t/m^2**

8) Corrosion Rates of Steel

The corrosion rate of steel should be determined based on the environmental conditions of the site because the corrosion rate is determined by the corrosive environmental conditions. The corrosion rate of steel below LWL -1.0 m is 0.15 mm/year as shown in the standard values listed in Table 2-12.

Table 2-12 Standard Values of Corrosion Rates for Steel

Corrosive environment		Corrosion rate (mm/year)
Seaside	HWL or higher	0.3
	HWL – LWL -1 m	0.1–0.3
	LWL -1 m – seabed	0.1–0.2
	Under seabed	0.03
Land side	Above ground and exposed to air	0.1
	Underground (residual water level and above)	0.03
	Underground (residual water level and below)	0.02

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.333

No special corrosion protection methods, such as cathodic protection, for steel are to be undertaken for the quay wall. The severest corrosion zone above LWL -1.0 m is protected by covering with concrete.

9) Structural Type of Quay Wall

The following three alternatives of structural type for the quay wall were compared based on the results of the Preparatory Survey.

i) Case 1: Sheet Pile Quay Walls

The front sheet piles are driven down to sufficient depth, one after another. The horizontal anchor force is transmitted from the wales by the way of a tie wire to an anchorage. In Nuku'alofa Port, most of the existing quay walls are sheet pile type. The contractor in Tonga are familiar with this type.

ii) Case 2: Concrete Block Wall Type

A concrete block wall is one of the gravity-type quay walls and belongs to the oldest type of berth structures. They consist of large blocks placed one upon the other in a masonry wall pattern. This type of quay wall has a long life and requires only modest maintenance. The concrete blocks can be considered economical for projects, but this structure has to be built on rock or firm ground and a large stock yard to construct concrete blocks would need to be prepared.

iii) Case 3: L-shaped Block Wall Type

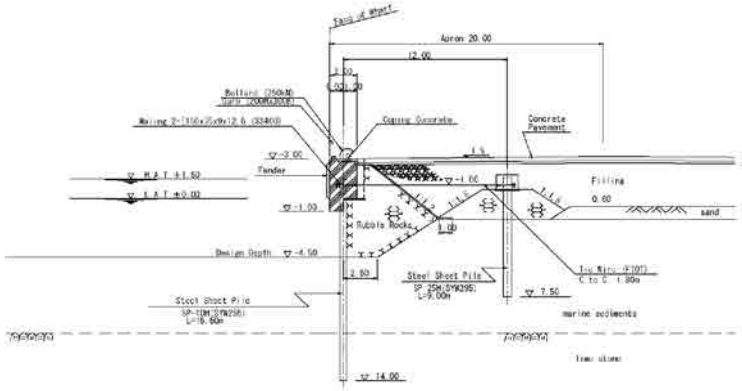
This type is also one of the gravity-type quay walls. The L-shaped blocks are made of reinforced concrete retaining wall elements. The quay wall is made by installing the L-shaped elements side by side in position on a prepared rubble mound base at the sea bottom and the elements are placed using a heavy floating crane.

iv) Comparison of Alternatives

The comparison table is shown in Tables 2-13 to 2-15. Alternatives are compared based on their workability, viability, construction costs, etc. In conclusion, the Sheet pile type is selected as the most optimal type of quay wall for this project.

Table 2-13 Case 1: Sheet Pile Quay Wall

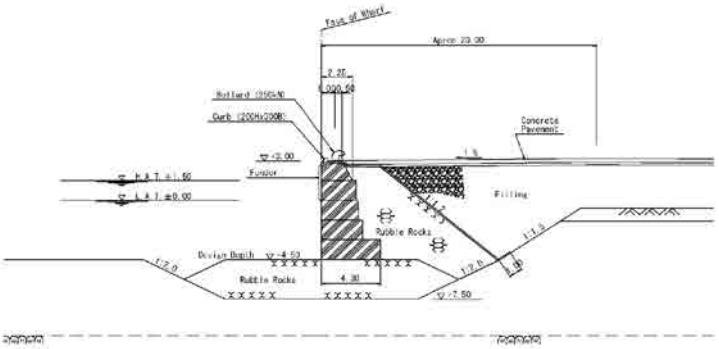
Evaluation Factor: ◎Superior (3 points), ○Norma (2 points) △Inferior (only 1 point)

	Case 1: Sheet Pile	
Standard Section		
Feature of Structural Design	・ This is a stable structure due to displacement reduction by support of back side piles. ・ This design does not require a stone foundation and extra dredging like other 2 ideas. ・ Pile toe reaches to the bearing layer and it is securely countermeasure toward bad influence of soft layer	
Workability	・ This design makes consecutiveness work and it brings high workability. ・ This design does not require a large temporary yard like other 2 types. ・ Due to simple work component, work time is shorter than others.	◎ (3points)
Related to dredging work/ reuse of dredged material	・ Pile toe reaches to bearing layer and it does not require further foundation works with small scale dredging only. ・ In case of adopt this design, dredging volume and reclamation volume can be almost balanced so not many waste material can be produced.	◎ (3点)
Reliability	・ Tonga has past experiences of this method and it has high reliability. ・ Pile toe reaches to bearing layer and it contribute higher stability. ・ This design has less impact of earthquake compared to other 2 designs.	◎ (3points)
Cost per m	￥1,396,000 /m （Direct cost only）	◎ (3points)
Evaluation	**1st (Recommendable)** (Total points; 12 points)	

Source: JICA Study Team

Table 2-14 Case 2: Concrete Block Wall Type

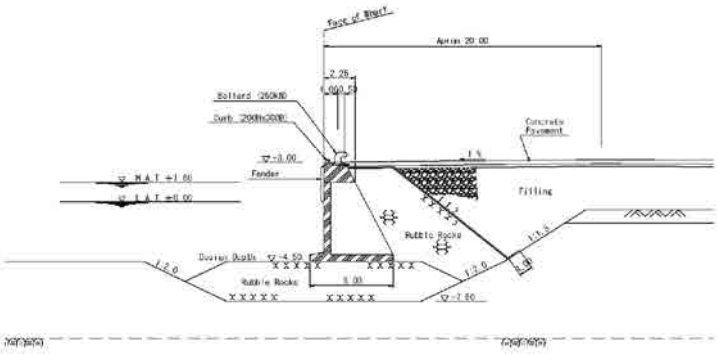
Evaluation Factor: ◎Superior (3 points), ○Norma (2 points) ΔInferior (only 1 point)

	Case 2: Concrete Block Wall (Gravity type)	
Standard Section		
Feature of Structural Design	・ Multiple con. blocks acquires the required height and those weight hold structural ・ stability. A certain scale of rubble stone foundation is needed but it contributes reduction of ・ influence from ground. ・ This design has less work items and structurally simple. Soft layer management can be realized by increase thickness of rubble mound.	
Workability	・ A certain large space is essential to manufacture many conc. Blocks. ・ Block size has to be bigger and heavier in accordance with lower layer, and related to this, larger lifting crane is needed.	○ (2points)
Related to dredging work/ reuse of dredged material	・ Larger scale of dredging is needed to acquire a certain thickness of rubble ・ mound. Related to the above, bigger volume of dredging is needed.	Δ (1point)
Reliability	・ There is no past experience of this design in Tonga. ・ This design is relatively weak against influence of earthquake. In case that unexpected bigger quake is attacked, it might have a concern that block is out of alignment.	Δ (1point)
Cost per m	￥1,649,000/ m （Direct cost only）	Δ (1point)
Evaluation	**3rd (NOT recommendable)** (Total points; 5 points)	

Source: JICA Study Team

Table 2-15 Case 3: L-shaped Block Wall Type

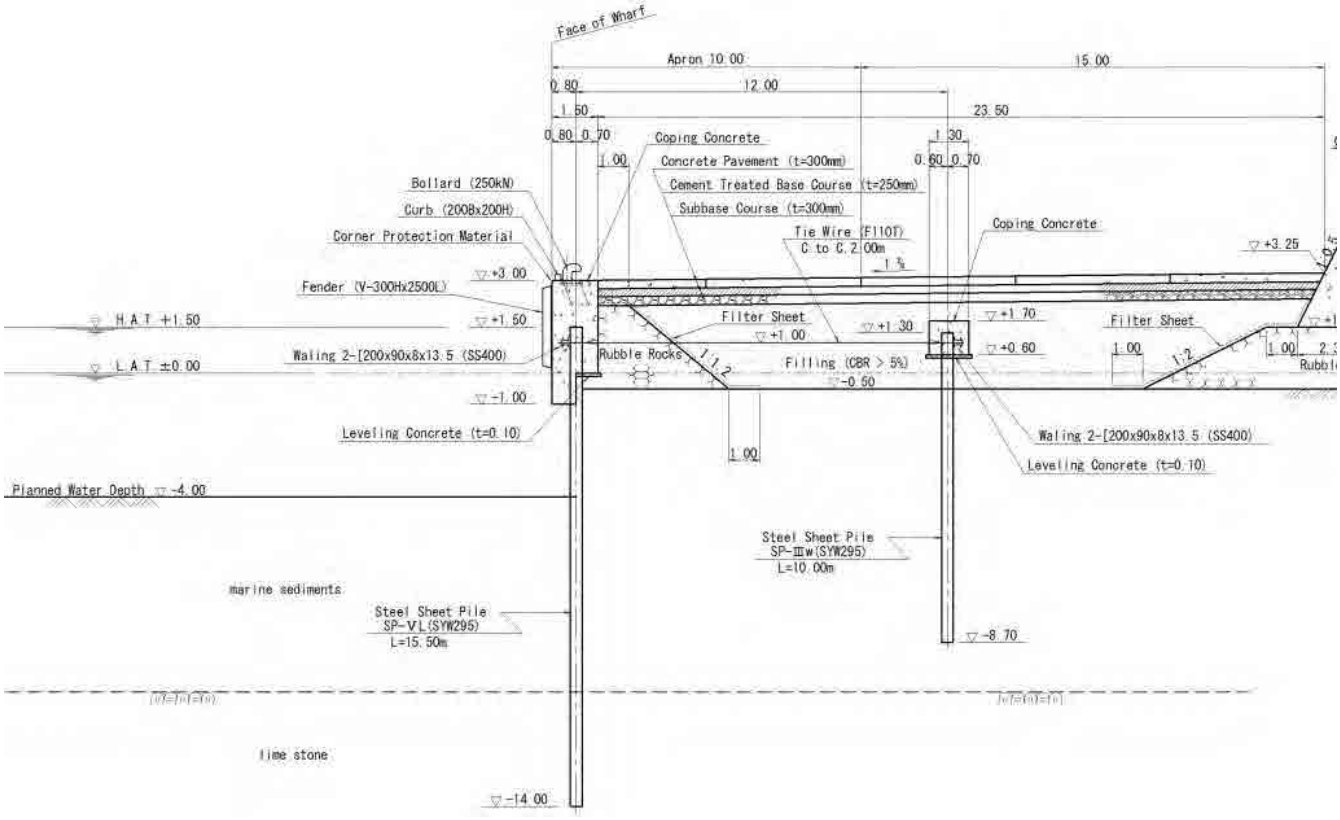
Evaluation Factor: ◎Superior (3 points), ○Norma (2 points) ΔInferior (only 1 point)

	Case 3: L type Block (Gravity-type)	
Standard Section		
Feature of Structural Design	・ Both weight of L type block and soil loaded on the block can be a gravity of structure. ・ Above gravity makes stability of the whole structure. ・ A certain scale of rubble stone foundation is needed but it contributes reduction of influence from ground. ・ This design has less work items and structurally simple. ・ Soft layer management can be realized by increase thickness of rubble mound.	
Workability	・ A certain large space is essential to manufacture many conc. Blocks. ・ Larger lifting crane is needed due to heavier weight of the block. ・ About 6m of such a high block is needed in this project and it forces to do a danger work in high place.	○ (2points)
Related to dredging work/ reuse of dredged material	・ Larger scale of dredging is needed to acquire a certain thickness of ・ rubble mound. Related to the above, bigger volume of dredging is needed.	Δ (1点)
Reliability	・ There is no past experience of this design in Tonga. ・ This design is relatively weak against influence of earthquake. In case that unexpected bigger quake is attacked, it might have a concern that block is out of alignment.	Δ (1point)
Cost per m	￥1,401,000[円]/ m （Direct cost only）	○ (2points)
Evaluation	**2nd (NOT recommendable)** (Total points; 6 points)	

Source: JICA Study Team

10) Performance Verification of Quay Wall

The standard cross section and performance verification results for the sheet pile quay walls are as shown in Figure 2-7.



Source: JICA Study Team

Figure 2-7 Standard Cross Section of Quay Walls

<Calculation Results for Sheet Pile Quaywalls>

Sheet pile: Type-VL

	Permanent situation	Variable situation (Earthquake)
Bending Stress (N/mm2)	104.5 ≦ 295.0 OK	143.5 ≦ 295.0 OK
Required Embetment depgth (m)	-12.834	-13.051
Designed Embetment depgth (m)	-14.000	

Tie wire: F110T

	Permanent situation	Variable situation (Earthquake)	Variable situation (Tractive force)
Yield load (kN)	297.95 ≦ 485.2 OK	525.06 ≦ 746.6 OK	494.19 ≦ 746.6 OK
Required Tie length (m)	9.719	11.954	9.713
Designed Tie length (m)	12.000		

Wales: 2[200x90x8.0x13.5

	Permanent situation	Variable situation (Earthquake)	Variable situation (Tractive force)
Bending Stress (N/mm2)	167.5 ≦ 235.0 OK	141.4 ≦ 235.0 OK	133.1 ≦ 235.0 OK

Anchorage: Sheet pile Type-Ⅲw

	Permanent situation	Variable situation (Earthquake)	Variable situation (Tractive force)
Bending Stress (N/mm2)	110.5 ≦ 295.0 OK	97.8 ≦ 295.0 OK	90.9 ≦ 295.0 OK
Deformation (cm)	1.523 ≦ 5.0 OK	1.660 ≦ 3.0 OK	1.506 ≦ 5.0 OK
Required Embetment depgth (m)	-7.997	-8.094	-7.985
Designed Embetment depgth (m)	-8.700		

Source: JICA Study Team

(4) Ancillary Mooring Facilities

1) Fenders

V-shaped rubber fenders (2.5 m in length and 0.3 m in height) are installed on the quay walls at intervals of 10 m.

2) Mooring Posts and Bollards

The values given in the following Table 2-16 are generally used for the standard values of the tractive forces caused by ships on mooring posts and bollards. Therefore, the mooring posts of 350 kN and 250 kN bollards are to be installed in this project.

Table 2-16 Standard Values of Tractive Forces by Ships

Gross tonnage of ship (t)	Tractive force acting on mooring post (kN)	Tractive force acting on bollard (kN)
Over 200 and not more than 500	150	150
Over 500 and not more than 1,000	250	250
Over 1,000 and not more than 2,000	350	250
Over 2,000 and not more than 3,000	350	350
Over 3,000 and not more than 5,000	500	350
Over 5,000 and not more than 10,000	700	500
Over 10,000 and not more than 20,000	1,000	700
Over 20,000 and not more than 50,000	1,500	1,000
Over 50,000 and not more than 100,000	2,000	1,000

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.308

The distance of the intervals between bollards and their minimum number of installations per berth refer to the values given in Table 2-17, and the bollards are installed at intervals of 15 m on the berth.

Table 2-17 Placement of Bollards

Gross tonnage of design ship (t)	Maximum interval between bollards (m)	Minimum number of installation per berth (unit)
Less than 2,000	10-15	4
2,000 or more and less than 5,000	20	6
5,000 or more and less than 20,000	25	6
20,000 or more and less than 50,000	35	8
50,000 or more and less than 100,000	45	8

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.871

The two mooring posts are to be installed at the top side of each ramp to fix the stern lines.

3) Curbing

The size of the curbs is 200 mm height and 200 mm width, the same as the existing facilities. The distance between curb needs to be less than the wheel treads of the cargo handling equipment and vehicles. They are set at about 30 cm in general to drain rainwater from the apron.

4) Lifesaving Facilities

Four ladders made of rubber are to be installed on both sides of each berth in order to rescue any persons who drop into the sea.

5) Corner Plates

Corner plates made of plastic are installed at the corners of the coping concrete since the existing coping concrete has been damaged by the mooring ropes and cargo handling operations.

(5) Aprons and Cargo Yards

1) Concrete Pavement

Concrete pavement is selected for the aprons and cargo yards in consideration of durability, minimizing maintenance and availability in Tonga. Concrete slab thickness is 30 cm as shown in Table 2-18 and 2-19.

Table 2-18 Action Classification for Concrete Pavement

Action classification	Type of action		Action (kN)	Ground contact radius (cm)
CP_1	Fork lift truck	2t	25	10.6
	Tractor trailer	for 20ft, 40ft	50	17.8
	Fork lift truck	3.5t	45	13.8
CP_2	Fork lift truck	6t	75	17.8
CP_3	Truck	25 ton class	100	17.8
	Fork lift truck	10t	125	22.2
	Straddle carrier		125	22.2
	Fork lift truck	15t	185	26.8
CP_4	Mobile crane (truck crane, rough terrain crane, all terrain crane)	Type 20	220	19.9
	Fork lift truck	20t	245	30.7
	Mobile crane (truck crane, rough terrain crane, all terrain crane)	Type 25	260	20.3

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.894

Table 2-19 Reference Values for Concrete Slab Thickness

Action classification	Concrete slab thickness (cm)
CP_1	20
CP_2	25
CP_3	30
CP_4	35
Applied to piled pier slab	10

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.897

2) Lighting Facilities

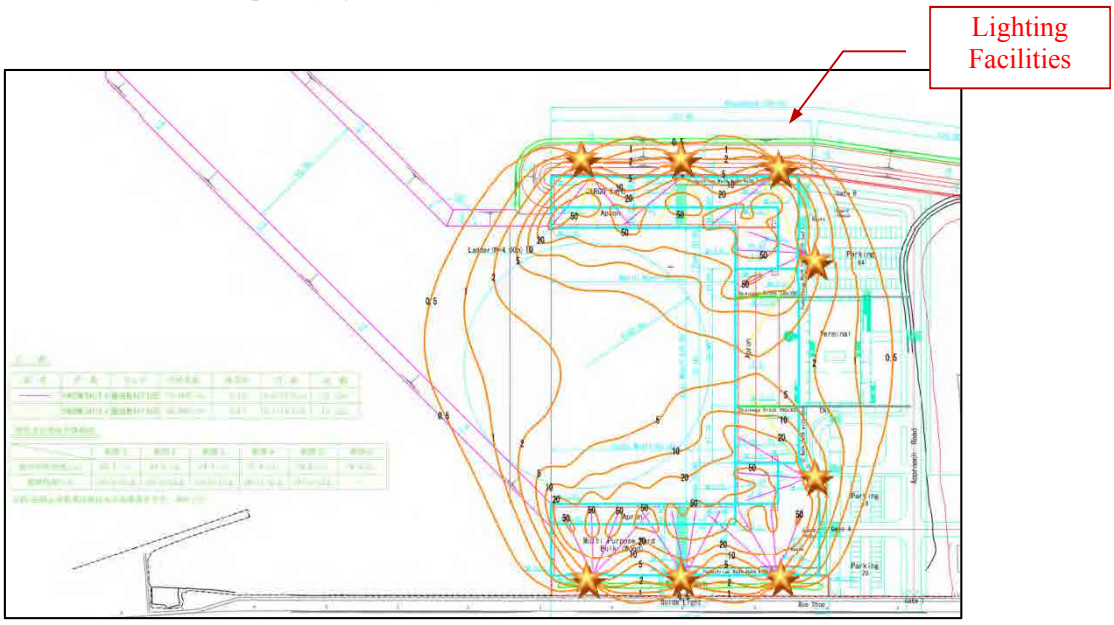
The lighting facilities for the cargo handling yard are installed preparing for the incoming and outgoing passengers and cargo handling works after sunset. The values shown in Table 2-20 are used for the standard intensity of illumination of each type of outdoor facility. The required intensity of illumination for the apron and walk way are 50 lx and 20 lx respectively.

Table 2-20 Standard Intensity of Illumination for Outdoor Lighting

Facility			Standard intensity of illumination (lx)
Wharf	Apron	Passenger facilities, vehicle facilities, mooring facilities for pleasure boats, general cargo berths, container berths	50
		Slipways for pleasure boats, aprons for handling dangerous goods using pipelines	30
		Simple work aprons using pipelines and belt conveyors	20
	Yard	Container storage spaces, general cargo storage spaces, cargo handling yards, cargo transfer yards	20
	Path	Passenger gates, vehicle gates	75
		Passenger paths, vehicle paths	50
		Other paths	20
	Security	All facilities	1–5
Road and Park	Road	Main roads	20
		Other roads	10
	Parking lot	For ferries	20
		Others	10
	Park Green space	Garden paths	3

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan p.882

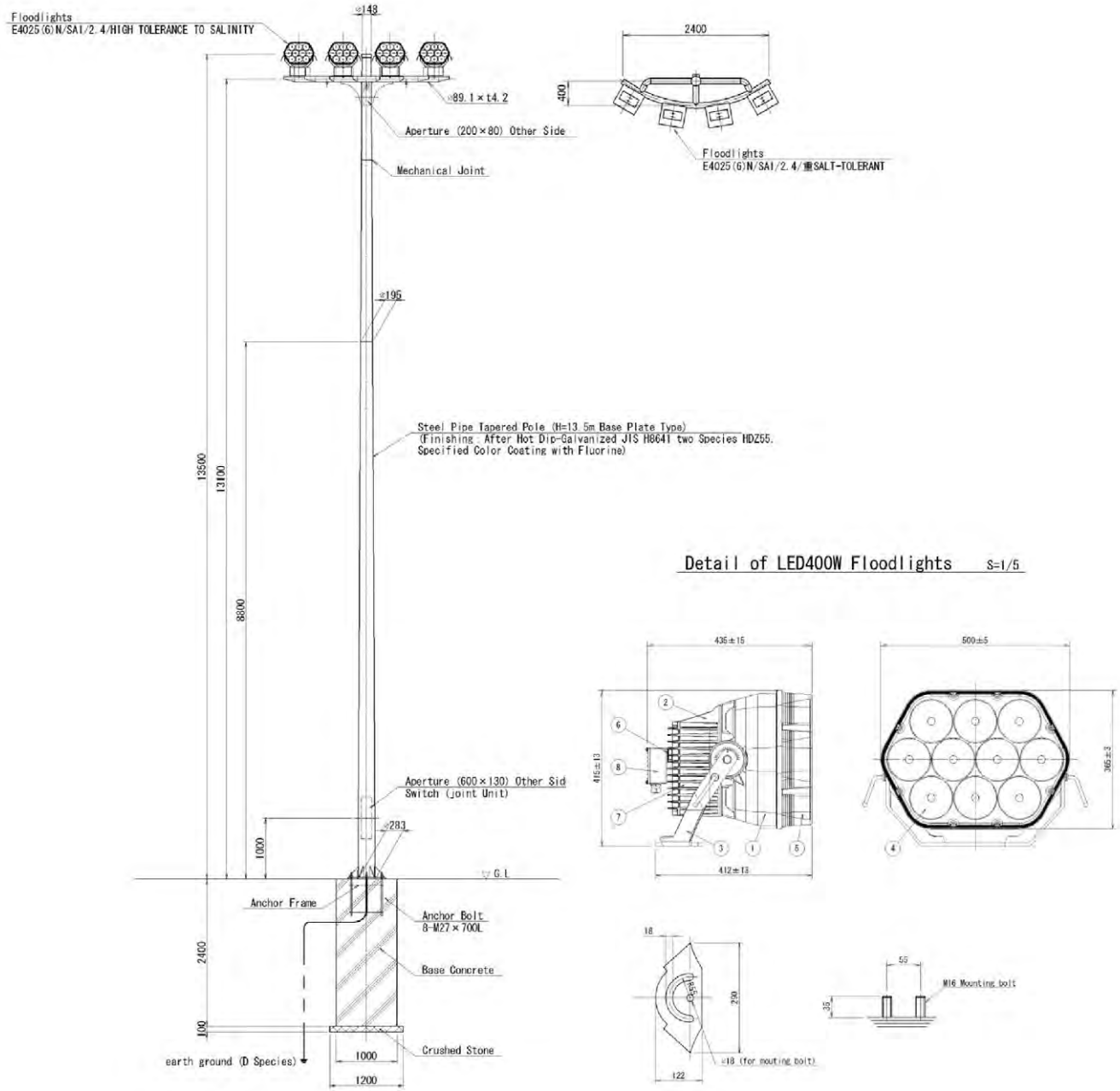
An adequate arrangement plan for yard lighting facilities is studied to deal with the required intensity of illumination for each facility. The eight lighting units are installed as shown in the following illumination distribution plan (Figure 2-8).



Source: JICA Study Team

Figure 2-8 Illumination Distribution Plan

The drawing of lighting facilities is shown in Figure 2-9.

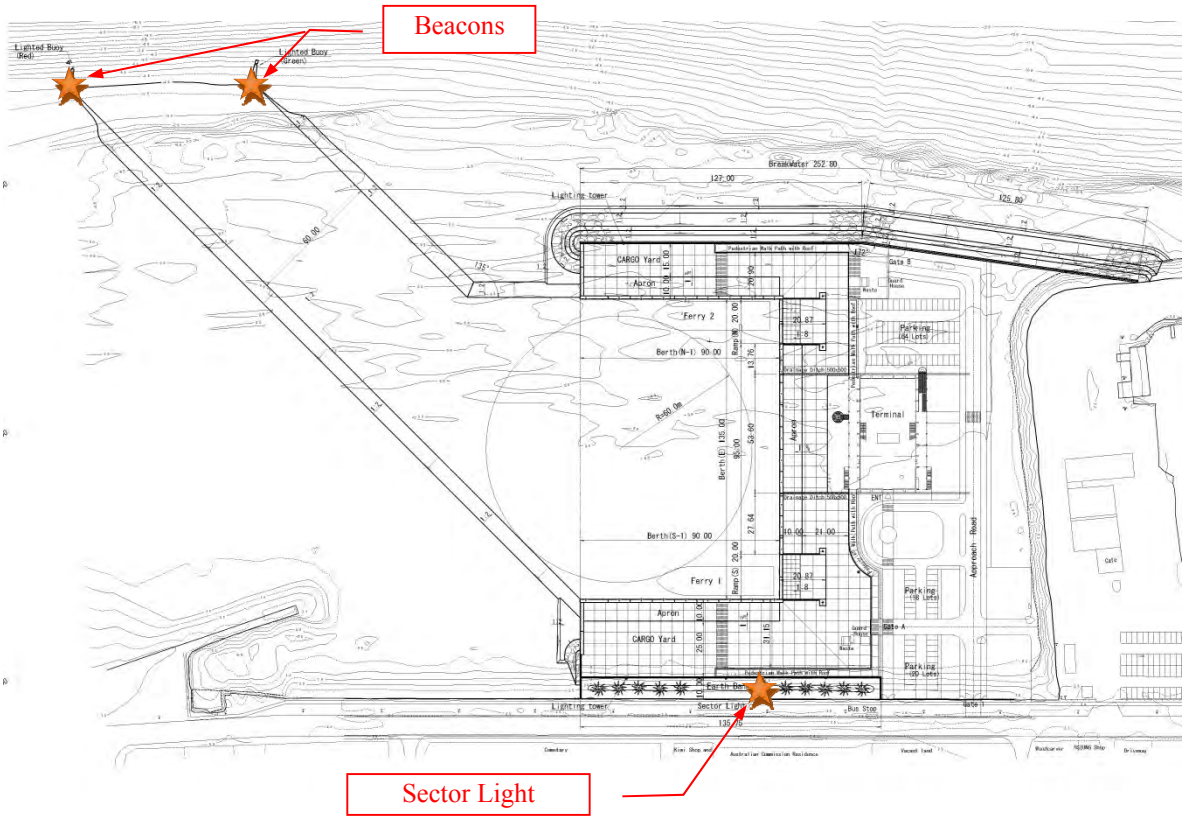


Source: JICA Study Team

Figure 2-9 Lighting Facilities for Cargo Yard

(6) Navigation Aids

The navigation aids, such as two light beacons and a sector light, to secure ship safety are to be installed because both sides of the navigational channel are shallow and the width of the port entrance is only 60 m. A pair of red and green light beacons is to be set at each side of the port entrance. A steel pipe pile is to be driven into the sea bed as the foundation for each beacon. A sector light is to be installed on land on the centreline of the navigational channel. The arrangement plan for the navigation aids is shown in Figure 2-10.

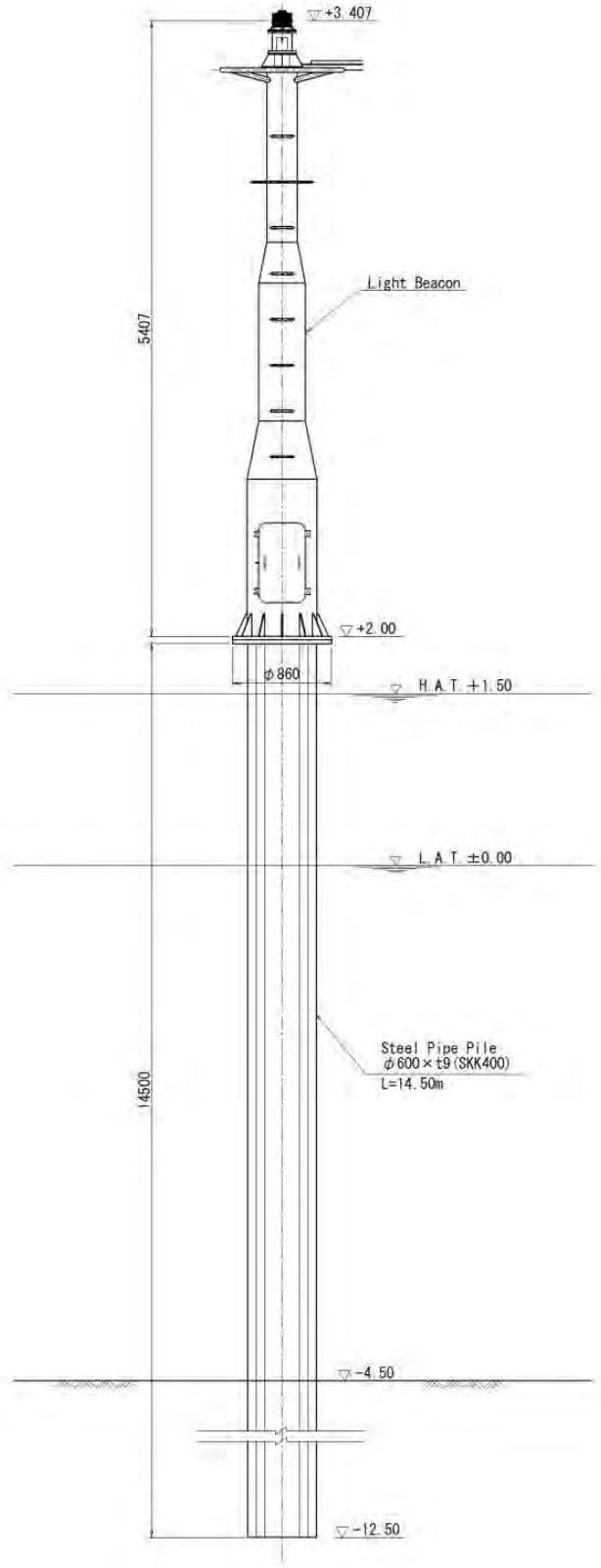


Source: JICA Study Team

Figure 2-10 Arrangement Plan for the Navigation Aids

1) Light Beacons

The cross section of a light beacon with its foundation is shown in Figure 2-11.

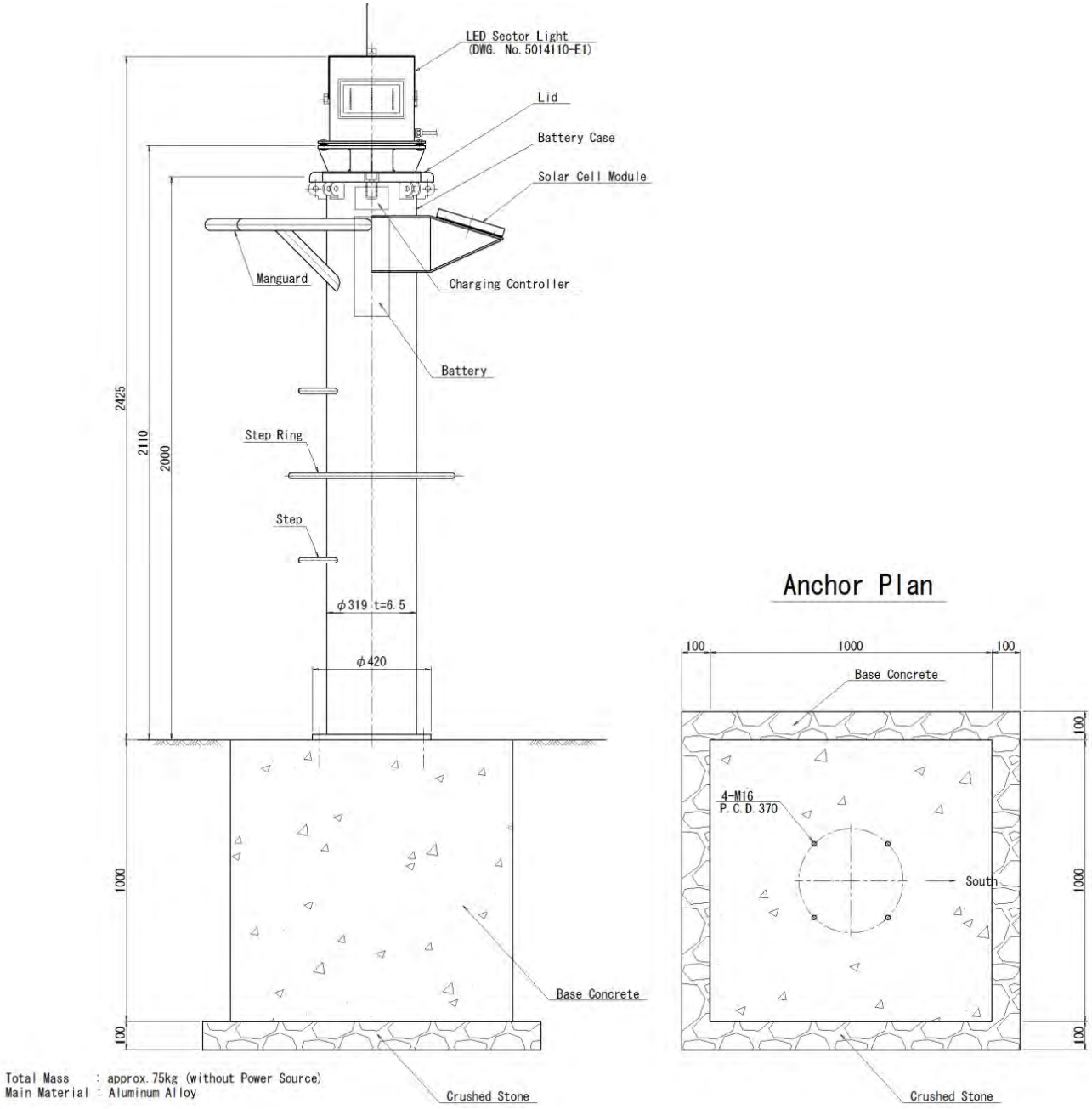


Source: JICA Study Team

Figure 2-11 Cross Section of Light Beacon

2) Sector Light

The drawing of the sector light and foundation is shown in Figure 2-12.



Source: JICA Study Team

Figure 2-12 Cross Section of Sector Light and Foundation

2-2-2-3 Buildings

(1) Outlines of the Building Facilities

Outlines of the building facilities are described as Table 2-21.

Table 2-21 Outlines of Building Facilities

No	Name of Facility	Outline of Facility		
1	Ferry Terminal	1 block	Reinforced Concrete 3 story building, Steel Truss Roof, Steel Pile	
		Floor Area	1F	1,610.74 m^2
			2F	926.23 m^2
			3F	342.31 m^2
			Total	2,879.28 m^2
		Finish	Roof	Steel Sheet Folded Roof H = 165 mm Felt t = 4 mm, Glass wool insulation = 100 mm
			Exterior wall	Colum, Girder: Exposed concrete + Exterior Paint Wall: Concrete Block Mortar Trowel + Exterior Paint
			Floor	3F Office, Corridor: Ceramic Tile
				2F Restaurant: Ceramic Tile
				2F Kitchen: Non-slip Ceramic Tile, Urethane Membrane Waterproofing
				2,3F Toilet: Non-slip Ceramic Tile, Urethane Membrane Waterproofing
				1F Entrance Hall, Waiting: Ceramic Tile 600×600
				1F Toilet: Non-slip Ceramic Tile
				1F Office, Ticket Counter: Ceramic Tile
				Staircase: Non-slip Ceramic Tile
				Mechanical room: Concrete Non-slip paint
			Wall	Concrete Block Mortar Trowel + Interior Paint
			Ceiling	General: Plaster board t = 12 mm + Interior Paint
				Toilet: Cement Board t = 6 mm
				Waiting Hall: Wooden Louver
				Stair step: Concrete Mortal Trowel + Exterior Paint
		Electrical	Equipment	LED lighting, Fire Alarm System, Communication System, Transformer, Generator, Garden lighting
		Mechanical	Equipment	Air-conditioner, Ventilation, Water supply, Sanitary, Drainage, Water tank, Water Reservoir, Pump, Septic Tank
		Solar Cell System	Equipment	Solar Module, Power conditioner, Control Panel
2	Connection Corridor (1),(2),(3),(4)	4 block	Steel Structure with Poly-carbonate Folded Roof	
		Floor Area	1F	195.0+186.95+105.0+264.0 m^2
			Total	795.95 m^2
		Finish	Floor	Inter-locking Block Pavement
			Column	H-shaped Steel
			Roof	Poly-carbonate Folded Roof
3	Guard House (1), (2)	2 block	Reinforced Concrete one story building, Steel Roof	
		Floor Area	1F	48.00 m^2 × 2 ＝ 96.00 m^2
			Total	96.00 m^2
		Finish	Roof	Steel Sheet Folded Roof h=60
			Wall	Concrete Block Mortar Trowel + Exterior Paint
			Floor	Ceramic Tile
			Wall	Concrete Block Mortar Trowel + Interior Paint
			Ceiling	Plaster Board t=9mm
		Electrical	Equipment	Ventilation, Lighting, Toilet

No	Name of Facility	Outline of Facility		
4	Entrance Canopy	1 block	Steel Structure with Glass Roof	
		Floor Area	1F	75.00 m^2
			Total	75.00 m^2
		Finish	Roof	Glass t ＝ 6
			Floor	Inter-locking Block Pavement
			Ceiling	Glass
5	Landscaping	Concrete Pavement		t ＝ 300
		Asphalt Pavement		Road, Parking Area
		Inter-locking Block Pavement		Connecting Corridor
		Drainage Ditch		Road Drainage, Site Drainage
		Gate 1 W = 12.0 m		Main Entrance
		Gate 1 W = 4.0 m		Pedestrian Entrance
		Gate A W = 7.0 m		Wharf Entrance
		Gate B W = 7.0 m		Wharf Entrance
		Japanese Garden		Sand Garden (Sekitei), Memorable Rock (Kageishi)
6	Tonga Side Work	Removal of Debris		
		Planting of Green area, Power Line, Telephone line, Water Supply, Kitchen Refrigerators		

Total Floor Area ＝ 3,846.23 m^2

Source: JICA Study Team

(2) Design Policy

1) Basic Policy

① Considering the Function of the facility first according to the discussion with the client.
② Low Maintenance cost, Low Energy for sustainable facilities.
③ Tight Schedule under ODA Scheme
④ Quality Control through Implementation stage

2) Natural Conditions

Natural conditions can be described as below.

① Temperature : Average Temperature 25°C, Maximum 35°C
② Wind Velocity : Maximum Wind Velocity 70.0m/sec
③ Rain fall : Maximum 400mm/month
④ Seismic : 0.25 G (Using Allowable Stress Method)

3) Terrain

The planned site will be landfilled with materials dredged from the channel and basin area.

4) Subsoil Conditions

According to the results of the subsoil investigation conducted during the Preparatory Survey in September 2014, a lime stone layer (N≧50) is encountered at the elevation of C.D.L. -11.0 m.

5) Socio Economic Conditions

The area surrounding the site is residential area with a good environment including the Australian Ambassador's House. So it will be necessary to consider the construction method that will only produce low noise, low vibration and low emission of dust through the construction stage. Public information should be released to the residents before starting construction in order to have good public relations with the residents based on their recognition of the Project.

A memorial plate will be set on the promenade deck on the 1st floor of the terminal building.

6) Material Supply

Almost all construction products procured in Tonga are imported from New Zealand except concrete and stone materials.

7) Apply Local Products and Local Contractor

Ready-mixed concrete, sand, aggregates, cements, paints, mortars, boards, tiles and aluminium sash are to be procured from the local suppliers. But steel pipe piles, steel structures, steel folded roofs, solar cell system, sewage treatment plant, transformer, generators, LED lighting fixtures, furniture, etc. will be exported from Japan.

Utilizing local contractors is an important issue for the Project. Through construction works the technical transfer should be achieved, especially for the solar cell, transformer, sewage treatment plant, etc.

8) Maintenance and Operation

The building facilities in the Project are not different than others in Tonga, and only ordinary maintenance and operation are required. LED lights are to be provided in all facilities to minimize the running costs. Underground reservoir tanks to collect rainwater are to be installed to minimize the water volume taken from the piped system. Solar cells on the roof are provided to produce electric power. A sewerage treatment plant is set to minimize the environmental impacts. These facilities need daily or periodical maintenance. Therefore, on-the-job training will be very important through the construction period. For these reasons, using the local contractors will be really important and it will be helpful for the Tongan side to utilize these contractors as the maintenance providers after completion of the Project.

9) Grade of the Facilities

Technical policies for the terminal building are as follows;

- Natural ventilation and natural lighting are the first priority,
- Air-conditioned area is limited to office area only,
- Lighting fixtures are to be LED in principle. They will give more light and last longer,
- Solar cells of 80 kW will be set on the roof top. They will provide power for pumping rainwater

from the underground reservoir tank and for the aeration blower sending air to the aeration tank of the sewerage treatment system.

10) Construction Method and Implementation Schedule

Planned construction duration will be the 12 months from February 2017 to January 2018.

(3) Outline of the Facility

1) Passenger Terminal Building

i) Function

There are three categories of buildings, a terminal building, connecting corridors and guard houses. The ferry terminal is the main building of the Project. The main function of the terminal building can be described as ticketing for domestic ferry passengers and waiting space for the passengers in safety and ambiance. Connecting corridors can serve as a systematic and safe route for the passengers going from the terminal building to the domestic ferry even in the rainy season or at night time. The guard house can serve for watch keeping and safety with measuring space for luggage and waste managing. In the terminal building there are three major areas as mentioned below.

- Space for passengers including a waiting hall, entrance hall and restaurant
- Space for operations like a ticket counter, offices and kitchen
- Supporting space like toilets, pump rooms, electrical rooms and workshop

ii) Scale

The main target ferries of the Project are M.V. Otofanga'ofa (400 passenger) and M.V. Pulupaki (250 passenger), and a sub-target ferry would be M.V. Sitoka (120 passenger), M.V. Onemato (120 passenger) and M.V. Araimoana (80 passenger) according to PAG requirements.

2) Waiting Hall

Waiting space calculated based on the largest ferry (M.V. Otuanga'ofa) among the target ferries. 400 passengers $\times$ 1.5 m^2/person = 600 m^2 required for seating space. Additionally, space for walking like stair cases and aisles require 150 m^2. Totally 750 m^2 will be given for the waiting hall. But M.V. Otuanga'ofa and Pulupaki are operated two times per week on the same day, so additional space for 250 passengers would be required. Therefore, 250 $\times$ 1.5 m^2 = 375 m^2 for the additional space is prepared as the restaurant (250 m^2) and entrance hall (120 m^2). Those spaces will be equipped with furniture (benches, chairs and tables are included in the Project) for passenger use.

3) Toilets

Based on our research for daily operations of M.V. Otuanga'ofa and Pulupaki, there are over 100 vehicles arriving to pick up and let off passengers and luggage each day. So the number of the toilets will be calculated using the 100 vehicles. According to the standard for the number of toilets by the

Japanese Highway Authority (calculation table prepared by Japan Institute of Architecture: Architectural Data Volume 8), the required female toilet booths are 20 and male toilet booths are 5 and the number of urinals is 15. The main toilets are designed using these numbers on the ground floor. And two toilet units for disabled people will be prepared.

4) Restaurant

There are two approaches to the restaurant. The first one is a direct approach for passengers coming from the waiting hall. And second one is using a slope or stairs from outside to attract non-passenger guests. Kitchen space will be 1/3 of the restaurant space and is to be equipped with kitchen equipment and utensils like stainless sinks, gas tables, kitchen tables, shelves and etc. But refrigerators, freezers and wash machines will be not included in the Project.

All guests can use the exterior deck, called the "Promenade Deck", where exterior restaurant space will be prepared with tables, chairs and umbrellas or awnings by the project.

5) Entrance Hall

The entrance hall with check in counter is designed for 100 people waiting in this area. There are benches for waiting persons prepared by the project.

6) Ticket Counter

Length of the ticket counter is 10 m. Several ferry companies can use the same counter at the same time. In back of this counter area there is office space and there are small staircases directly connected to the second floor where more office space is prepared.

7) Offices

There are 200 m^2 office spaces and two toilets and a corridor on the second floor for operating the whole terminal building and ferry operation.

8) Cyclone Shelter

The terminal building is designed strong enough to withstand cyclones and earthquakes and can serve as a shelter during disasters. The first floor, including the restaurant and promenade deck, are raised 6.5 m above the sea level and direct access is possible for passengers through a staircase and slope. The second floor is reserved for office spaces but in case of emergency it would be used as an evacuation space, and it is raised 10.1 m above the sea level.

In this aspect, important equipment like the transformer, distribution boards, and the power-conditioner for the solar cells are set on the first floor. Even if the ground floor of the building were flooded completely, the basic functions of the building infrastructure would not be lost.

9) Solar Cells

The terminal building has large roof of over 2,000 m^2 inclining 7 degrees towards north which will be

suitable for setting solar cells. So 312 solar modules will be set, totally 80 kW of solar power can be produced in the daytime. Normal lights, water-supply pumps, blowers and pumps for the sewage treatment plant can be operated on the solar power. Surplus solar power might be sent to the Tong Power Limited (TPL) through normal cable.

10) Landscape

Main specifications landscaping are as follows;

- Parking: around 100 apaces
- Pedestrian walk path: 2.5 ~ 4.0 m width
- Approach road: 12.0 m width of asphalt pavement include walk way 2.5 m width on both sides
- Connecting Corridor (1), (2), (3), (4): 3.5 m width with transparent roofs
- Guard House (1), (2): Office, Waste storage, Measurement space
- Japanese garden
- Fence: 2.5 m height
- Green belt and area: Retaining wall and curb stone

(4) Outlines of Architecture

1) Terminal Building

Passenger Terminal Building: 3-story building with reinforced concrete structure & steel truss roof

Building Area: 2,100 m^2, Total floor area: 2,879.28 m^2

Exterior finishing of terminal building is as shown in Table 2-22.

Table 2-22 Terminal Building Exterior Finishing Schedule

Facility	Place	Specification
Terminal Building	Roof (1)	Steel Sheet Folded Roof H=160, t=0.8mm Insulation: Glass Felt t=5mm, Glass wool t=100
	Roof (2)	Concrete with Urethane Membrane Waterproof
	Eaves	Wooden Louver with XYLADECOR (Exterior)
	Exterior Wall	Exposed Concrete/Mortar Trowel with Exterior Paint
	Promenade Deck	Non-slip Ceramic Tile 300×300
	Restaurant Deck	Wooden Plastic Deck Floor (EW0001)
	Connecting Corridor	Non-slip Ceramic Tile 300×300
	Exterior Stair Case	Non-slip Ceramic Tile 300×300
	Exterior Window	Aluminium Readymade sash
	Entrance Door	Stainless Door
	Exterior Door	Stainless Door
	Rain Drainage Pipe	Aluminium Pipe150φ
	Roof Drain	Aluminium Roof Drain
	Waste	Light weight steel shutter

Source: JICA Study Team

Interior finishing and electrical/mechanical specifications of the main building are as Table 2-23.

Table 2-23 Terminal Building Interior Finishing Schedule

F	Room	Floor	Wall	Ceiling	Light	Fire alarm	Air-con	Vent
GF	Waiting Hall	Ceramic Tile 600×600	Mortar trowel EP	Wooden Louver with XYLADECOR (Exterior)	○	○		
	Entrance Hall	Ceramic Tile 600×600	Mortar trowel EP	LGS PB12mmEP	○	○		
	Ticket Counter (1)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	
	Ticket Counter (2)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	
	Office (1)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	○
	Office (2)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	○
	Pump Room (1)	Ceramic Tile 300×300	Mortar trowel EP	LGS Cement Acoustic Board 6mm EP, Glass wool t=100	○	○		○
	Pump Room (2)	Ceramic Tile 300×300	Mortar trowel EP	Same as above	○	○		○
	Male Toilet (1)	Ceramic Tile 300×300 Urethane Membrane Waterproof with Concrete t=80	Ceramic Tile 300×300	Exposed Concrete EP	○	○		
	Female Toilet (1)	Same as above	Same as above	Same as above	○	○		
1F	Restaurant	Ceramic Tile 600×600	Mortar trowel EP	Wooden Louver with XYLADECOR (Exterior)	○	○		
	Kitchen	Non-slip Ceramic Tile 300×300	Mortar trowel EP	LGS Cement Board 6mm EP	○	○		○
	Male Toilet (2)	3 Ceramic Tile 300×300 Urethane Membrane Waterproof with Concrete t=80	Ceramic Tile 300×300	LGS Cement Board 6mm EP	○	○		○
	Female Toilet (2)	Same as above	Ceramic Tile 300×300	LGS Cement Board 6mm EP	○	○		○
	Workshop	Mortar Trowel with Urethane floor paint	Mortar trowel EP	LGS Cement Acoustic Board 6mm EP, Glass wool t=100	○	○		○
	Generator room	Mortar Trowel with Urethane floor paint	Mortar trowel EP	Same as above	○	○		○
	TR room	Mortar Trowel with Urethane floor paint	Mortar trowel EP	Same as above	○	○		○
	Panel room	Mortar Trowel with Urethane floor paint	Mortar trowel EP	Same as above	○	○		○
	Stair Step (1), (2)	Non-slip Ceramic Tile 300×300	Mortar trowel EP		○	○		
2F	Office (3)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	
	Office (4)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○	○	
	Male Toilet (3)	Ceramic Tile 300×300	Mortar trowel EP	LGS PB12mmEP	○	○		○
	Female Toilet (3)	Ceramic Tile 300×300	Mortar trowel EP	LGS Cement Board 6mm EP	○	○		○
	Corridor	Ceramic Tile 300×300	Mortar trowel EP	LGS Cement Board 6mm EP	○	○		
	Stair Step (3), (4)	Non-slip Ceramic Tile 300×300	Mortar trowel EP		○	○		

Source: JICA Study Team

Electrical and Mechanical Specifications of the main facilities are as below,

Outline of the main equipment

Transformer: 200 kVA
Generator: Diesel Generator 35 kW
Solar Cell: 80 kW, 400 m^2, 312 units, 8 Power conditioners
Emergency Light: 10 lux, 10 minutes
Evacuation Light: Battery type
Fire Alarm System: Smoke Detector, Heat Detector with Alarm System
Exterior Lighting: Street lights, Garden lights
Water Tank: 15ton for Supply water, 15 ton for Rain harvesting with Pressure pump
Rainwater Reservoir: Underground tank 240 ton, with water treatment system
Sewage Treatment Plant: Aeration system with Contact Media, BOD level 30 ppm
Lighting System: Office 180 lux, Hall 100 lux

2) Landscaping and Parking

Main specifications for landscaping and parking are as follows;

- Approach Road: Asphalt Concrete Paving 40 mm + 50 mm, Crasher-run 300 mm
- Parking area: Asphalt Concrete Paving 50 mm, Crasher-run 150 mm
- Loading Area: Concrete Paving 300 mm, Crusher-run 150 mm
- Curb stone: Concrete Curb stone 150/200×400 mm, length = 600 mm
- Pedestrian Walk Path: Interlocking Block 50 mm, Sand 50 mm, Crusher-run 100 mm
- Connecting Corridor: Steel Structure with Transparent roof
- Guard House: Reinforced Concrete with Steel Roof Structure
- Green Area: Plantation (Tongan side works)

3) Furniture

Main specifications for furniture are as follows;

- Entrance Hall: 12 sets of Benches
- Waiting Hall: 450 sets of Benches
- Restaurant: 16 sets of Table & Chairs, a set of Counter table with Counter Chair
- Outside Restaurant: 8 sets of Tables & Chairs with Umbrellas

4) Kitchen Equipment

The kitchen equipment to be prepared is stainless sink, gas table, stainless table, stainless shelves, etc.

5) Others

- Memorial Plate
- Model of Wharf and Terminal Building

(5) Design Standard

1) Sewage Treatment Plant

According to the standard for sewage treatment plants in Japan (JIS A3302 - 2000), the target number of people using toilets of this type in a terminal building is calculated as a public hall or highway rest stop.

Public Hall

n = 0.08 A = 0.08×2,100＝168 ➔ Target number 168 persons

where,

n: number of people

A: Total Floor Area = 2,092 m^2

Highway rest stop

n=2.55 P = 2.55×84 = 214.2 ➔ Target number 214 persons

where,

n: number of people

P: Parking spaces = 84

Therefore, 215 persons per day for sewage treatment plant capacity are selected.

2) Sprinkler and Fire Hydrants

According to the Fire Fighting Regulations in Japan, the terminal building (Area = 2,070 m^2) is not required to have a sprinkler system due to its having less than 6,000 m^2 floor area, also it does not require a fire hydrant system because the floor area is less than 2,100 m^2.

3) Fire Alarm System

According to the Fire Fighting Regulation in Japan, this type of building is required to have a Fire Alarm System because it has over 1,000 m^2 of floor area and its capacity is over 400 people. Therefore, the terminal building is to be equipped with a Japanese Type Fire Alarm System the same as the Vaiola Hospital Tonga.

4) Emergency Lights

According to the Building Regulations in Japan, this type of building with a floor area over 500 m^2 and/or over 3 story building shall be equipped with emergency lights. Therefore, emergency lights (battery type) for the terminal building are to be installed.

5) Evacuation Lights

According to the Fire Fighting Regulations in Japan, the terminal building is a special building and should be equipped with evacuation lights at each emergency exit.

6) Roof Drainage

The standards for drainages are described in the following Table 2-24.

Table 2-24 Effective Drain Pipe Diameter with Roof Drainage Area

Drain Pipe	Drainage effective Area (m^2)	Drainage Capacity (l/s)	Roof Area (m^2) by Rainfall Strength				
			100 mm/h	120 mm/h	140 mm/h	160 mm/h	180 mm/h
Diameter 50φ	0.00204	2.9	106	88	76	66	59
Diameter 75φ	0.00465	6.7	241	201	172	150	134
Diameter 100φ	0.0785	11.4	410	342	293	256	228
Diameter 125φ	0.01227	17.8	640	534	457	400	356
Diameter 150φ	0.01227	24.36	876	734	626	548	487
Square 100×100	0.00465	6.7	241	201	172	150	134
Square 125×125	0.00785	11.4	410	342	293	256	228

Source: JICA Study Team

The area of the roof is 2,100 m^2. Six roof drain pipes (150φ) are to be provided for the rainfall drains. There will be one drain pipe for each 350 m^2 area. According to the above table, this will handle a rainfall intensity of over 180 mm/h. This is far more than enough capacity to drain the strongest-ever rainfall recorded in this area. But it is important to provide overflow pipes considering the possibility of clogging with leaves. The overflow pipes will be studied in the detail design stage.

7) Examination of Gutter Capacity

In the case of 180mm/h rainfall, the following equations are applied;

Total rainfall per hour: 0.18 m/h × 2,100 m^2 = 378 m^3 ①
Drainage Capacity of Pipe 150φ: 0.024 m^3×3,600 = 86.4 m^3
Total Drainage Capacity of 6 pipes: 86.4 m^3×6 pipes = 518.4 m^3 ≥ ① 378 m^3

Therefore, the capacity of the drain pipe is sufficient.

Capacity of Gutter: 0.1 × 1.1 m = 0.11 m^3/m and 35 m × 0.11 m^3 = 3.85 m^3

This value is considered as a buffer for 40 seconds.

Overflow pipes (100φ) are prepared for each drainage pipe.

8) Glass Thickness

According to the standard of Japan Institute of Disaster Management for Architecture, the following equations for glass selection by the Committee of Function of Glass are employed.

Height of building: Maximum height is 15.6 m and Minimum height is 7.9 m.

Standard Height = (15.6 + 7.9) / 2 = 11.75 m → 11.0 m

Largest Glass Size: Area = 1.9 m × 1.8 m = 3.42 m^2 (A)

According to the records in Tonga, Maximum Wind Velocity is 70 m/sec.

This is almost equal to the Okinawa area (Maximum wind in Okinawa is 80 m/sec).

This means that a suitable standard wind velocity is 70/1.5 = 46 m/sec. (same as Okinawa)

In the case of Largest Glass-(A) thickness is 8.0 mm

$$P = 300 \times k1 \times k2/A \times (t+t^2/A) = 300 \times 1.0 \times 1.0/3.42 \times (8+8\times8/3.42) = \underline{2{,}352.94\ N/m^2}$$

where,

P: allowable glass stress

k1: coefficient of glass 1.0

k2: coefficient 1.0

t: thickness 8.0 mm

According to Table for Glass Selection by the Committee of Function of Glass, standard wind pressure is W = 1,758 N/m^2.

1,758 × 1.53 m^2 = 2,695 $N/m^2 \geq \underline{2{,}352.94\ N/m^2}$, in the case of Okinawa=Tonga,

Therefore, 8 mm thickness is not enough for the height over 10m.

The required glass thickness under G.L. +6 m height is suitable for 8 mm, and over G.L. +7 m height is 10 mm.

9) Building Structure Calculation Standard

The building structure calculations have been done using seismic coefficient 0.25 G, which is in accord with Japanese Regulations. Japanese structure design will be done based on the Allowable Stress Method not the Ultimate Stress Method like in the USA. The Allowable Stress Method uses the allowable stress of the materials that is 1/3 of the ultimate strength of its materials. So generally speaking, three times higher structural strength will be given to the structure.

(6) Load Condition

Base on the condition below, detail design will be conducted.

1) Facility Durability

Planned Facility durability is 30 years.

2) Design Live Loads

Design will be done based on Table 2-25.

Table 2-25 Live Loads

Live Load	Japanese Regulation
Waiting Hall	500 kg/m^2 (In Japan 360 kg)
Entrance Hall	500 kg/m^2 (In Japan 360 kg)
Office, Restaurant	300 kg/m^2
Mechanical Rooms	500 kg/m^2 (Equipment Weight)

Source: JICA Study Team

(7) Structure Design

1) Structure Type

A reinforced concrete rahmen structure with steel truss roof structure is selected for the basic design.

The large roof structure is suitable for a "Vierendeel Steel Truss" to provide maintenance space and natural ventilation space for the large volume waiting hall and restaurant space. The connecting corridor is a steel structure and the guard house has concrete walls.

2) Foundation Type

A pile foundation is suitable for the terminal building because of subsoil conditions. According to the soil investigation, the length of foundation piles will be 11.0 m.

Foundations of the connecting corridor and guard house are continuous footings and isolated footing types.

Piling Method

The "Rotating Penetration of Steel Finned Pile" will be selected due to the following reasons.

a) "Earth drill Method" is not suitable because of high water level and the high volume of waste soil.
b) "Precast Concrete Method" is not suitable because of lack of resistance to pull-out stress in case of an earthquake and Tsunami.
c) "Normal Steel Pipe Piling Method" is not suitable for the same reasons as above.

Table 2-26 Summary of Piling Method

Method	Rotating Penetration of Steel Finned Pile
Outline	Finned Steel Pile rotated by Construction Machine penetrating into soil to the subsoil
Maker	JFE, Asahi Kasei, Sansei
Waste Soil	No waste soil <Very Good Point>
Cement	No use <Very Good Point>
Noise & Vibration	Noiseless and less vibration <Good Point>
Environment	No dump trucks <Very Good Point>
Pile Joint	Automatic welding <Good Point>
Pile Diameter	318.5φ、267.4φ
Subsoil Confirmation	PR-value confirmation <Good Point>
Pull out	Resistance to pull out is certified <Very Good Point>
Footing	Small <Very Good Point>
Accuracy	Using guide leader <Good Point>
Construction Machine	Smaller <Good Point>
Construction of Duration	25 days

Source: JICA Study Team

3) Materials

① Concrete

Classification : Normal Ready Mixed Concrete

Design Strength : Main fc = 25 N/mm^2

Slab on the ground fc = 18 N/mm^2

Blind fc = 15 N/mm^2

② Re-bar

Classification : SD295A and SD345 by Japanese Standard

(8) Electrical and Mechanical Works

1) Electrical Works

Transformer, generator, main feeder, distribution board, lighting and consent, communication system, fire alarm system and emergency light system are designed according to the Japanese Standards.

2) Mechanical Works

Plumbing system, water supply system combined with rain water harvesting system and air-conditioner with ventilation are designed according to the Japanese Standards.

2-2-3 Outline Design Drawings

Outline design drawings are as follows.

Figure 2-13 General Layout Plan
Figure 2-14 General Layout of Breakwater
Figure 2-15 Layout of Berth (E)
Figure 2-16 Layout of Berth (N-1)
Figure 2-17 Layout of Berth (S-1)
Figure 2-18 Typical Cross Section of Berth (N-1)
Figure 2-19 Typical Cross Section of Berth (E)
Figure 2-20 Typical Cross Section of Ramp
Figure 2-21 Typical Cross Section of Berth (S-1)
Figure 2-22 Layout of Pavement
Figure 2-23 Layout of Ramp Section
Figure 2-24 Site Layout Plan of Building Works
Figure 2-25 Terminal Building GF Plan
Figure 2-26 Terminal Building 1F Plan
Figure 2-27 Terminal Building 2F Plan
Figure 2-28 Terminal Building Roof Plan
Figure 2-29 Terminal Building Section (1), (2)
Figure 2-30 Terminal Building Elevation 1
Figure 2-31 Terminal Building Elevation 2

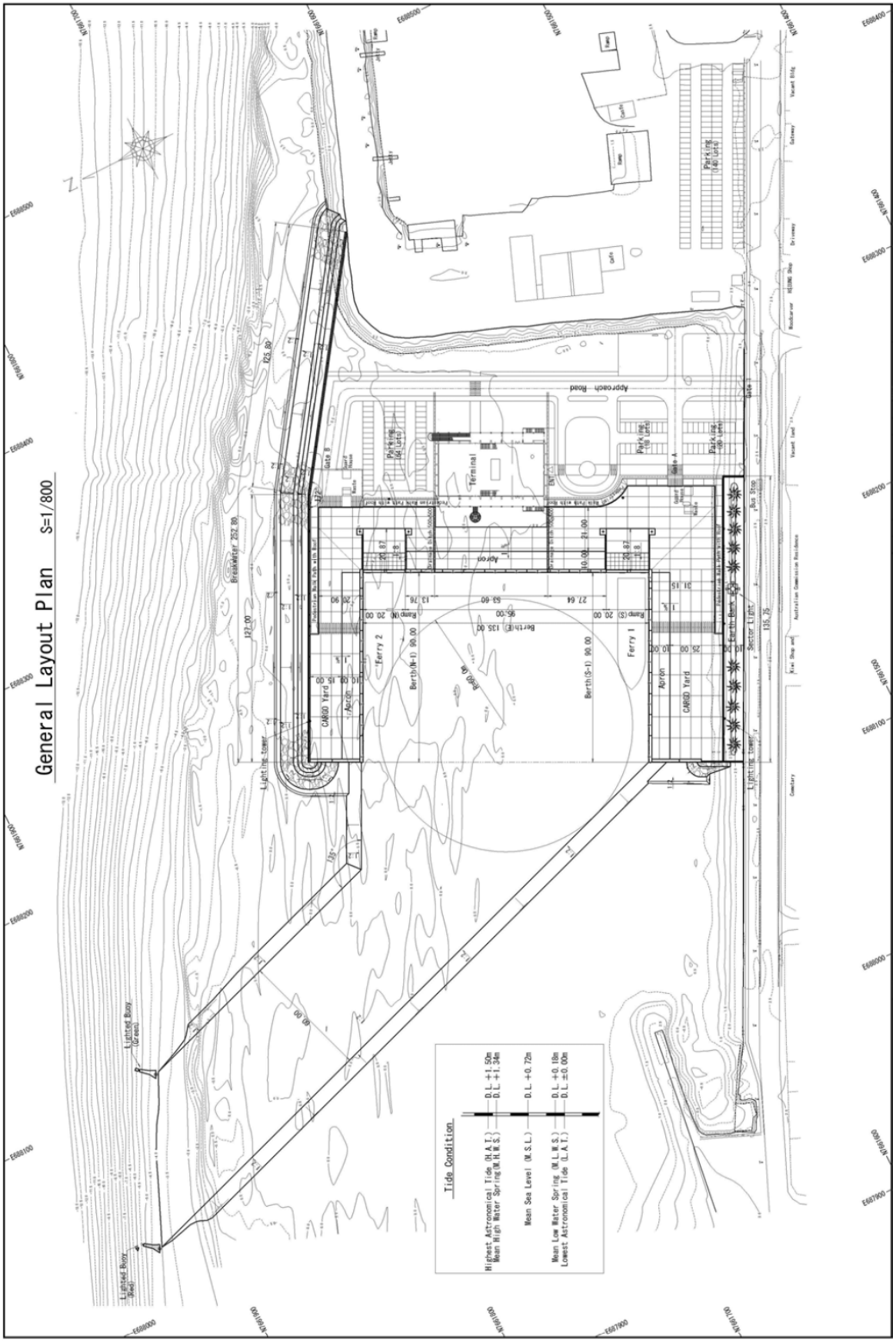


Figure 2-13 General Layout Plan

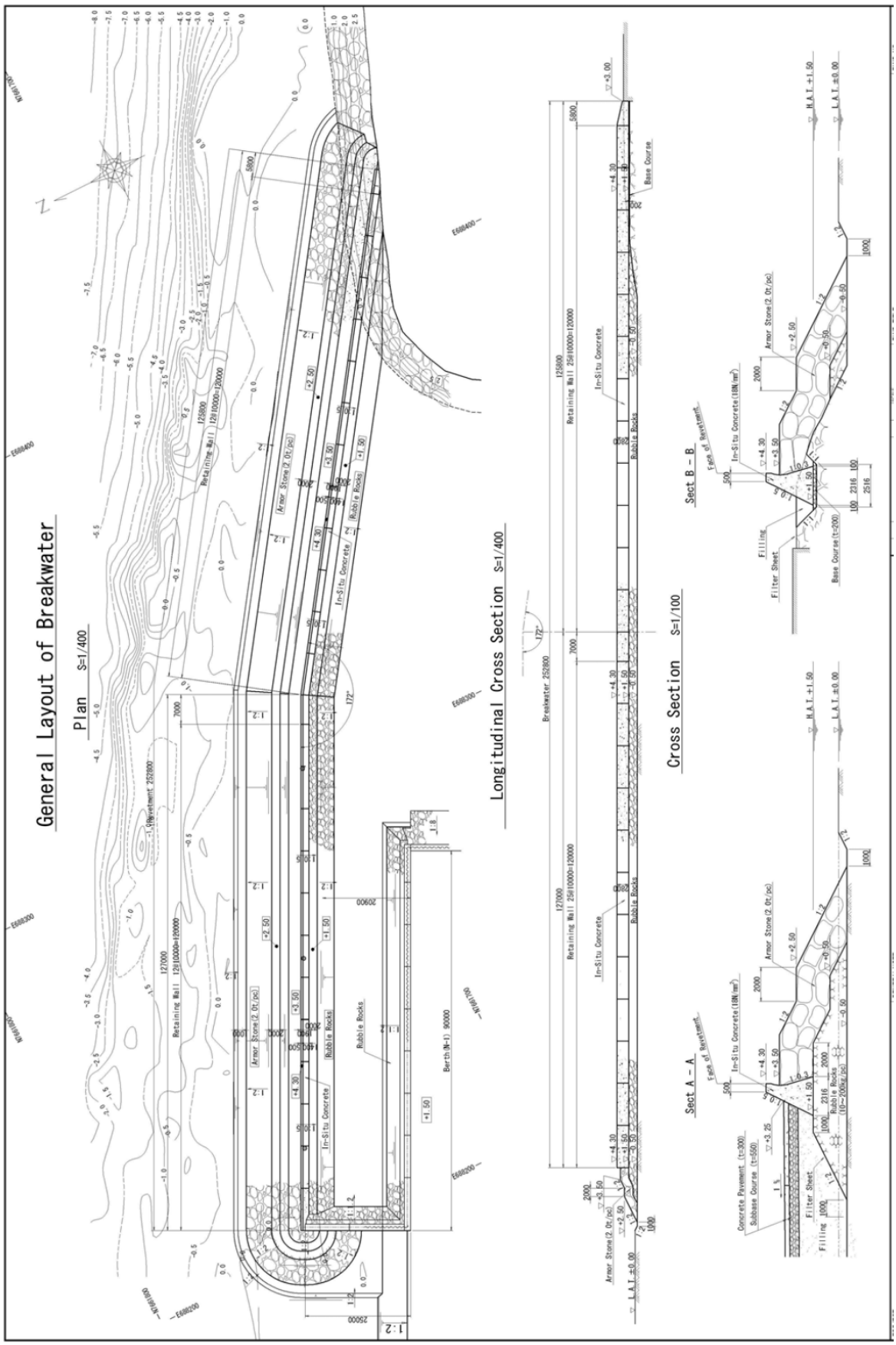


Figure 2-14 General Layout of Breakwater

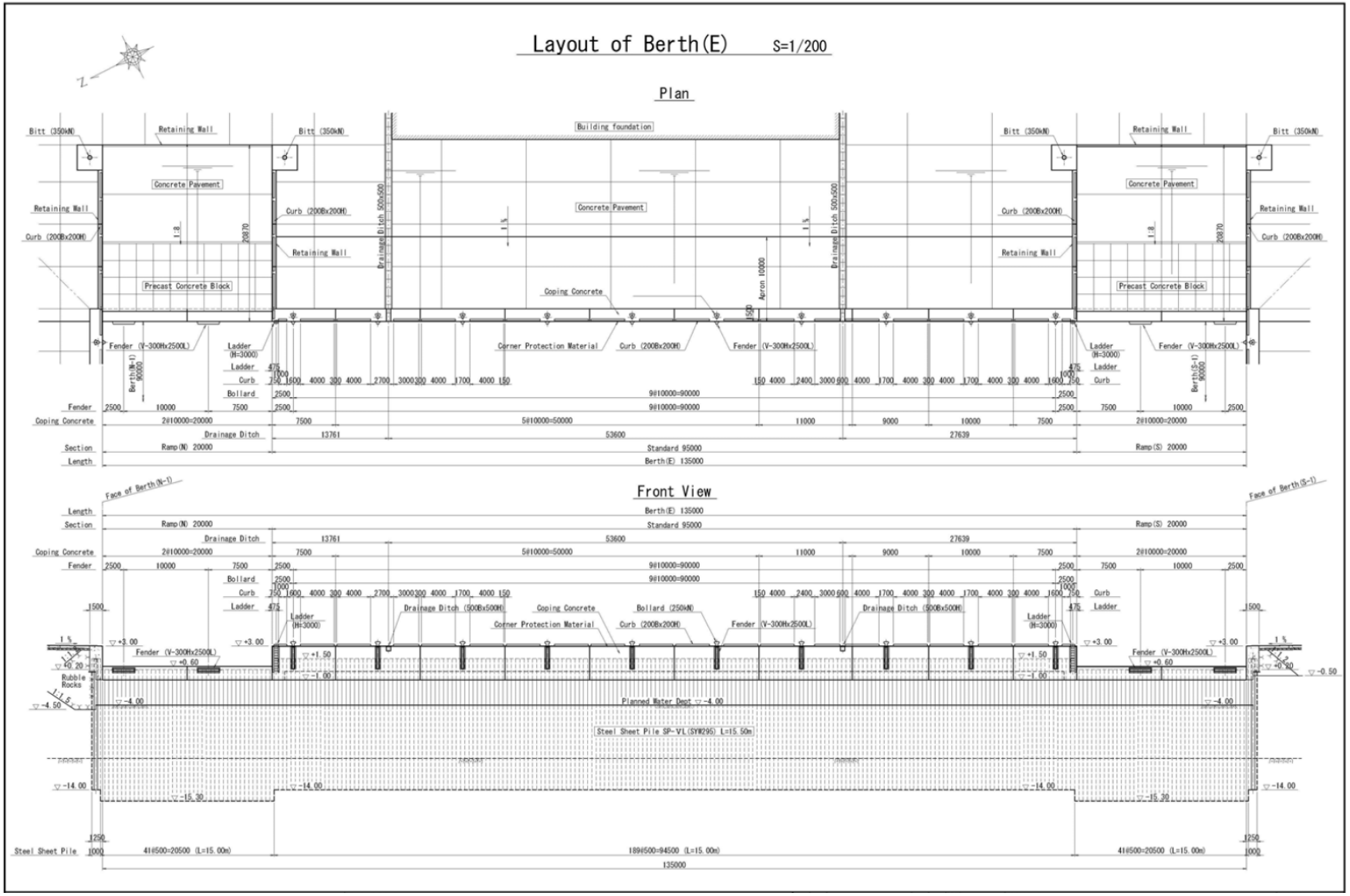


Figure 2-15 Layout of Berth (E)

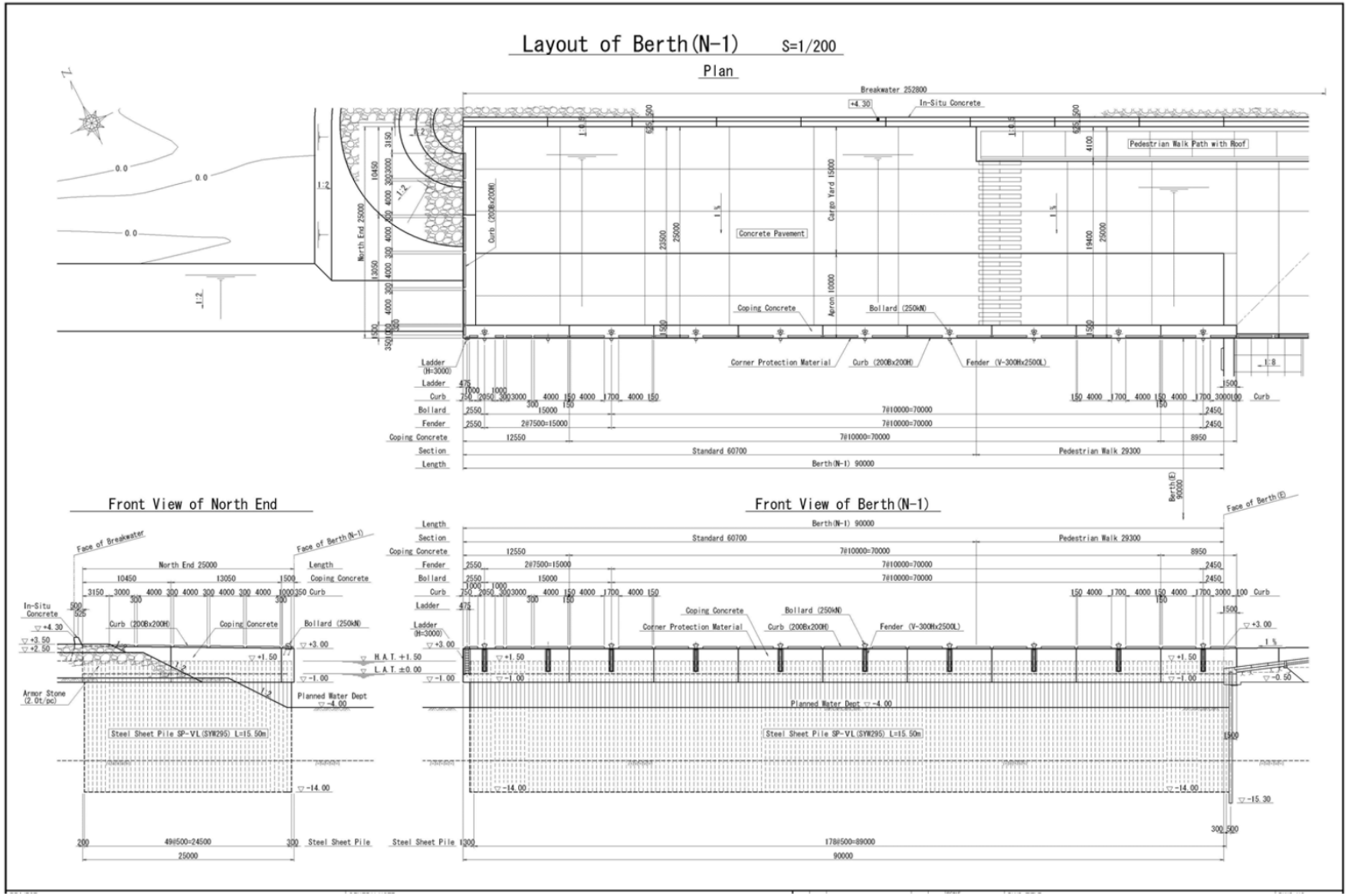


Figure 2-16 Layout of Berth (N-1)

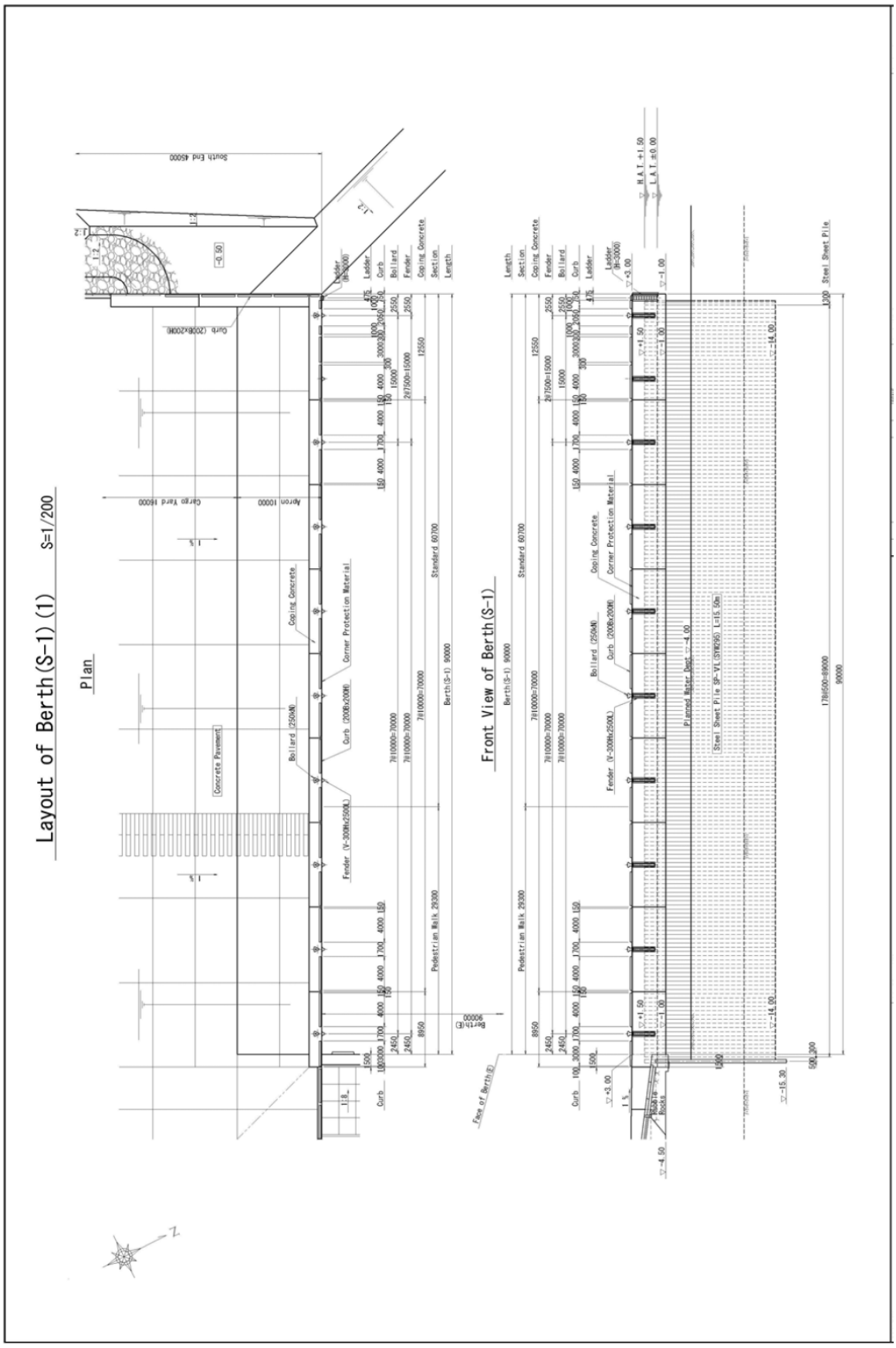


Figure 2-17 Layout of Berth (S-1)

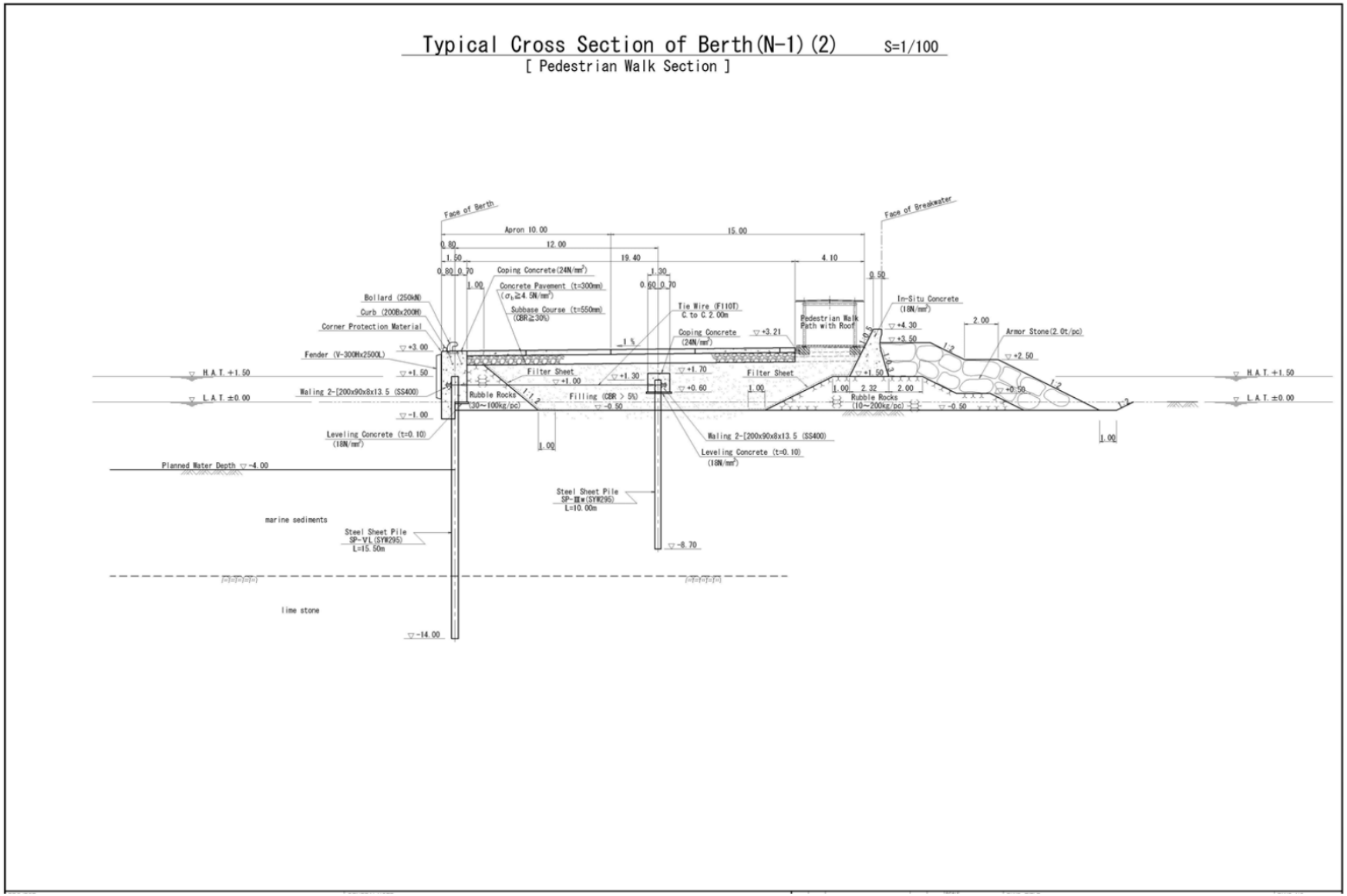


Figure 2-18 Typical Cross Section of Berth (N-1)

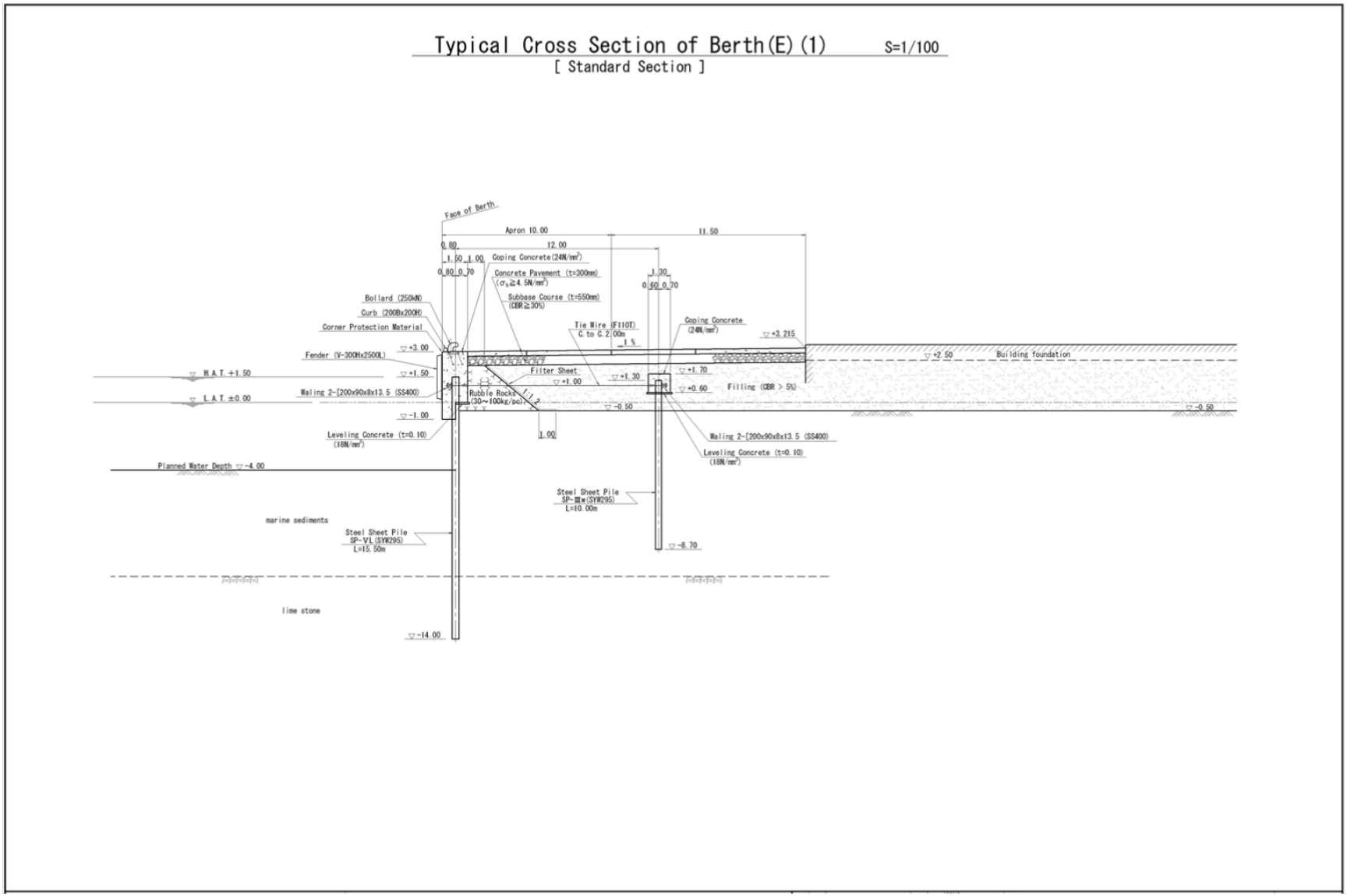


Figure 2-19 Typical Cross Section of Berth (E)

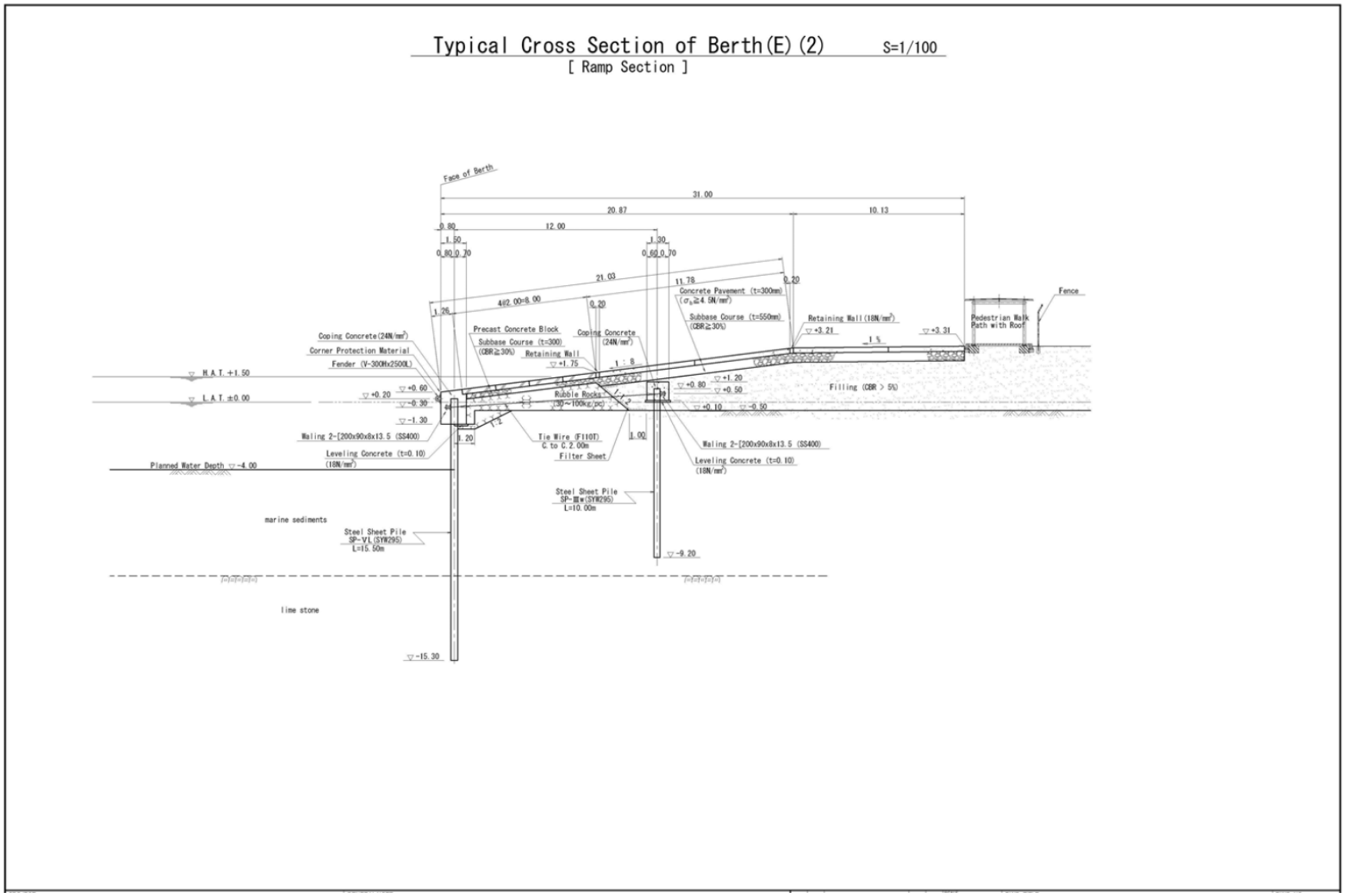


Figure 2-20 Typical Cross Section of Ramp

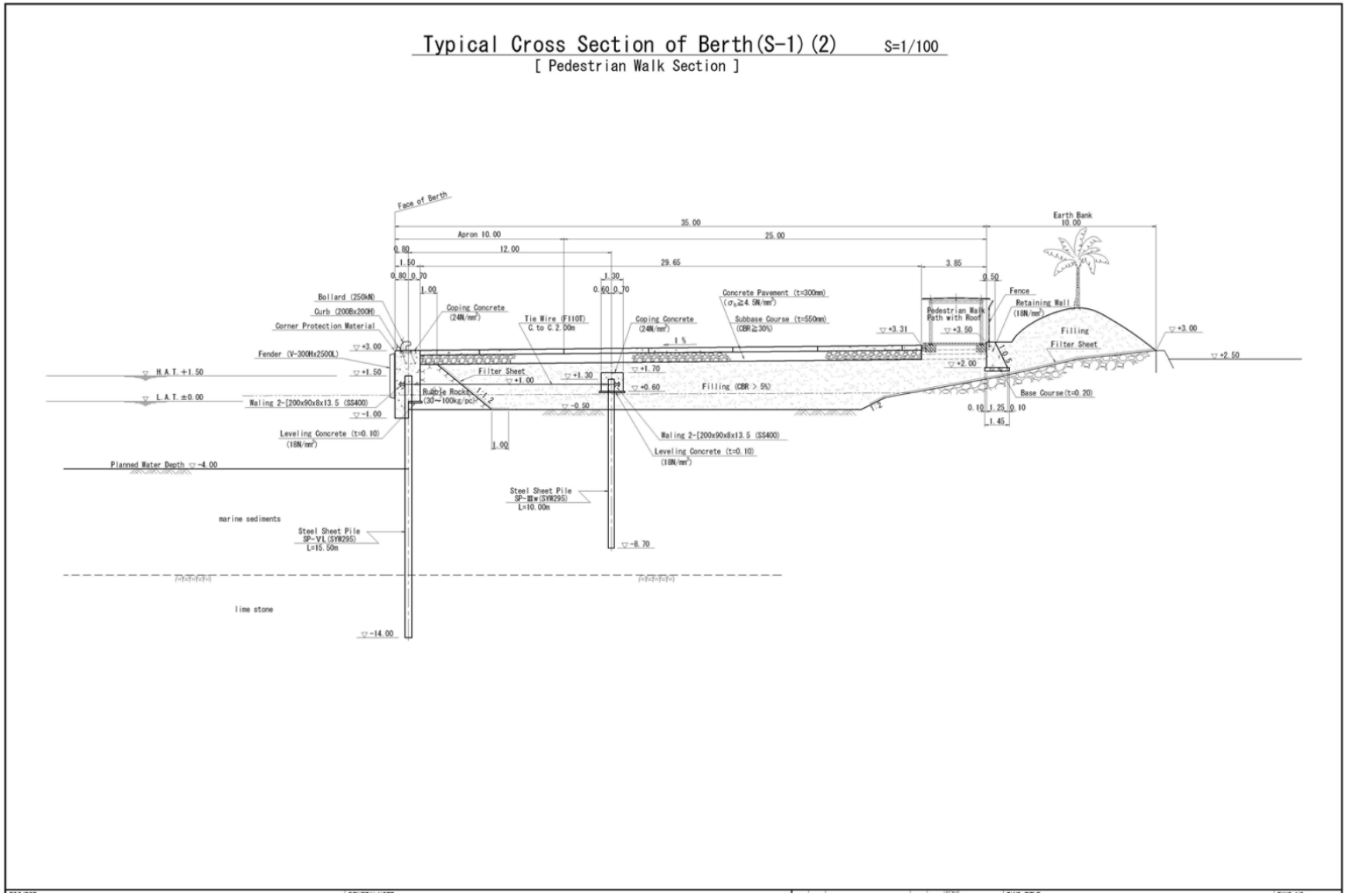


Figure 2-21 Typical Cross Section of Berth (S-1)

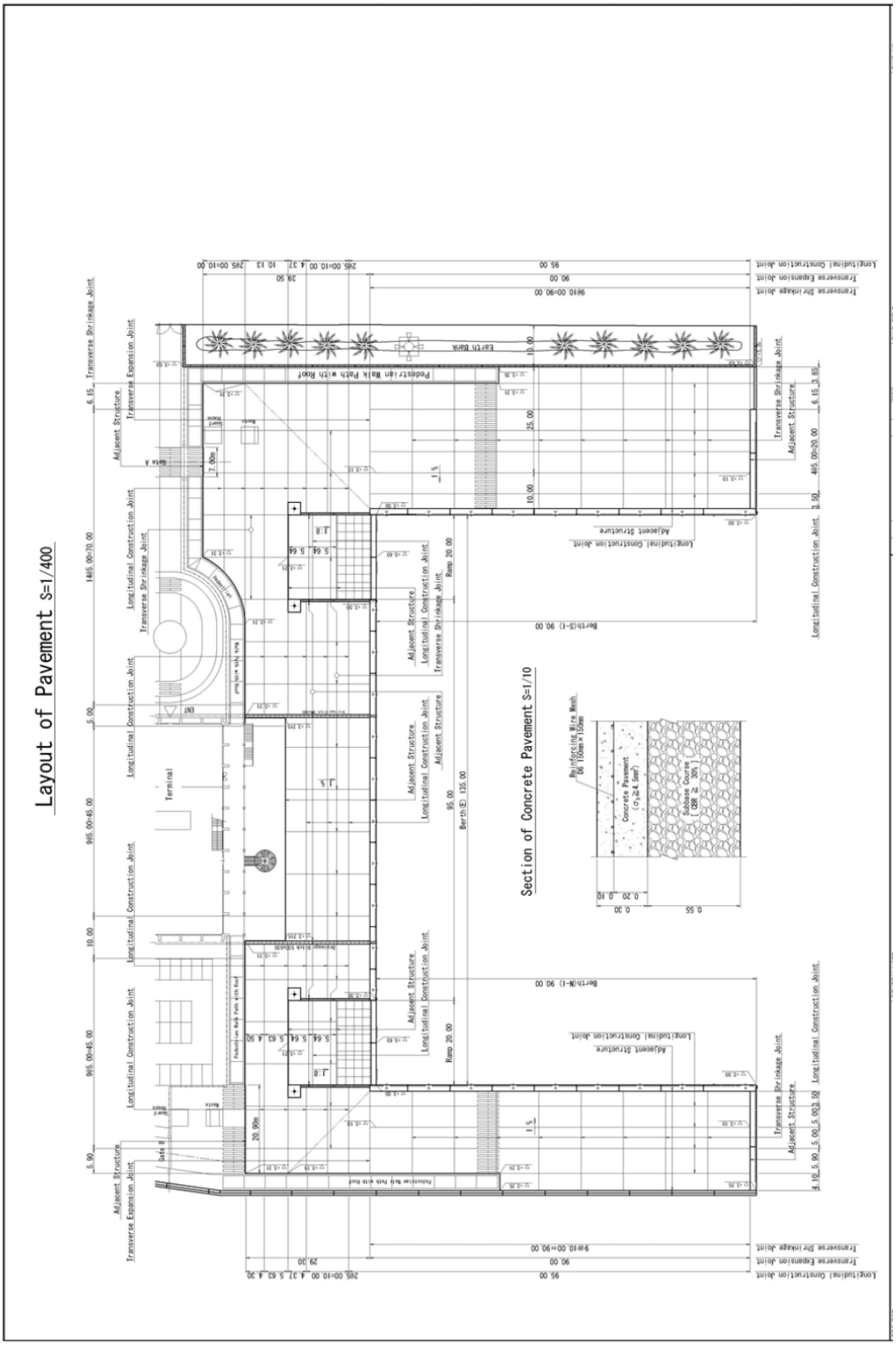


Figure 2-22 Layout of Pavement

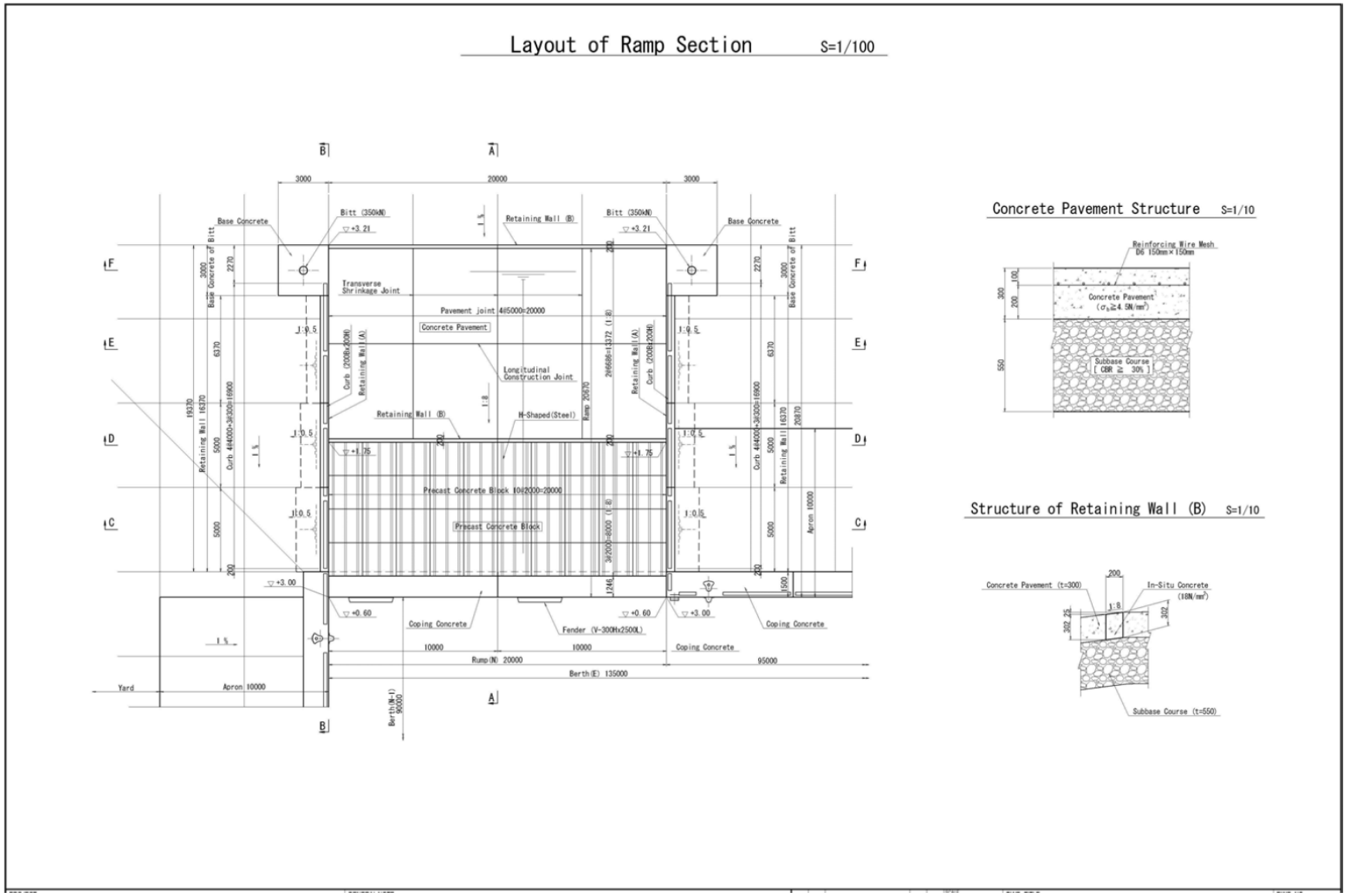


Figure 2-23 Layout of Ramp Section

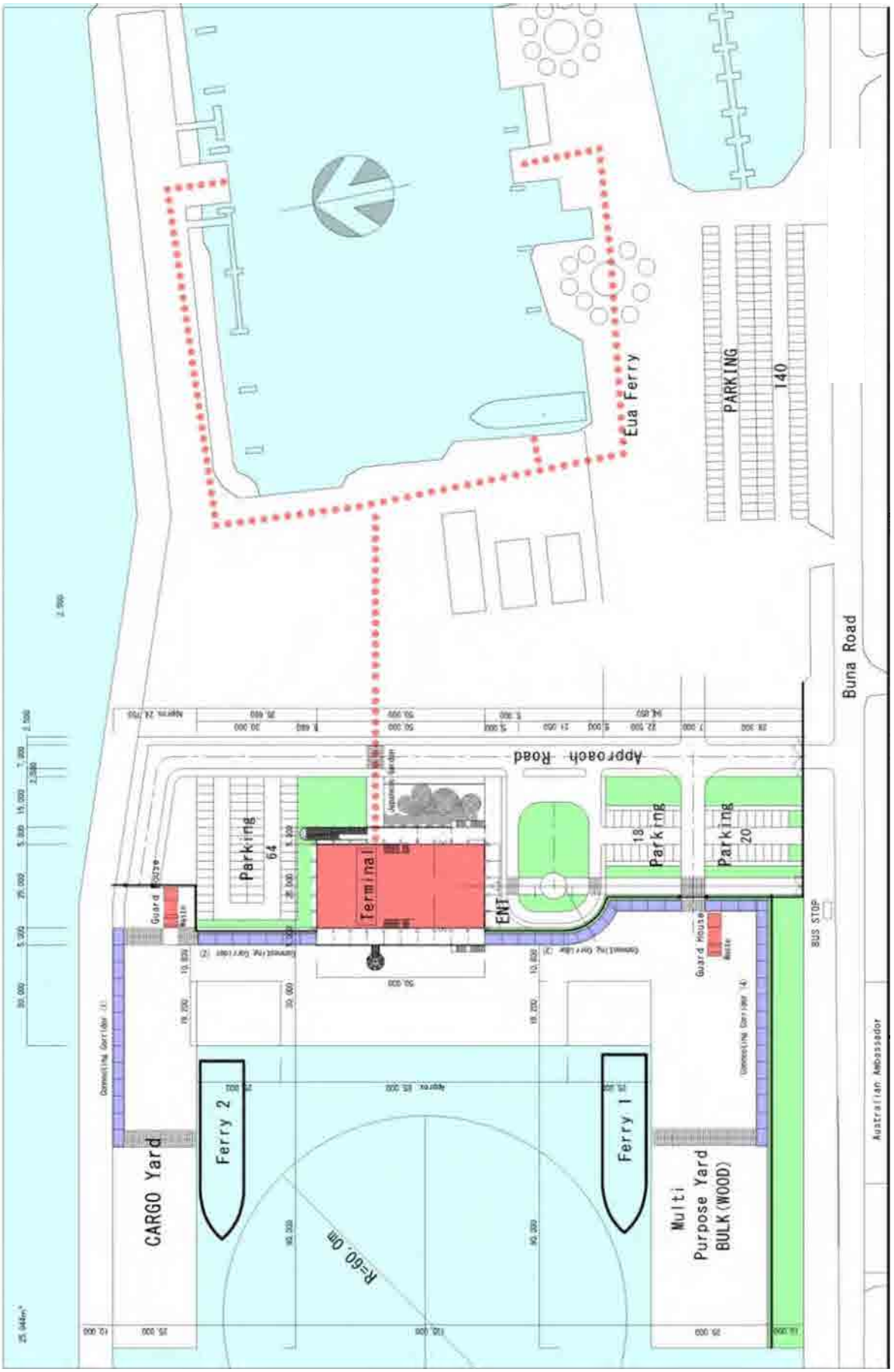


Figure 2-24 Site Layout Plan of Building Works

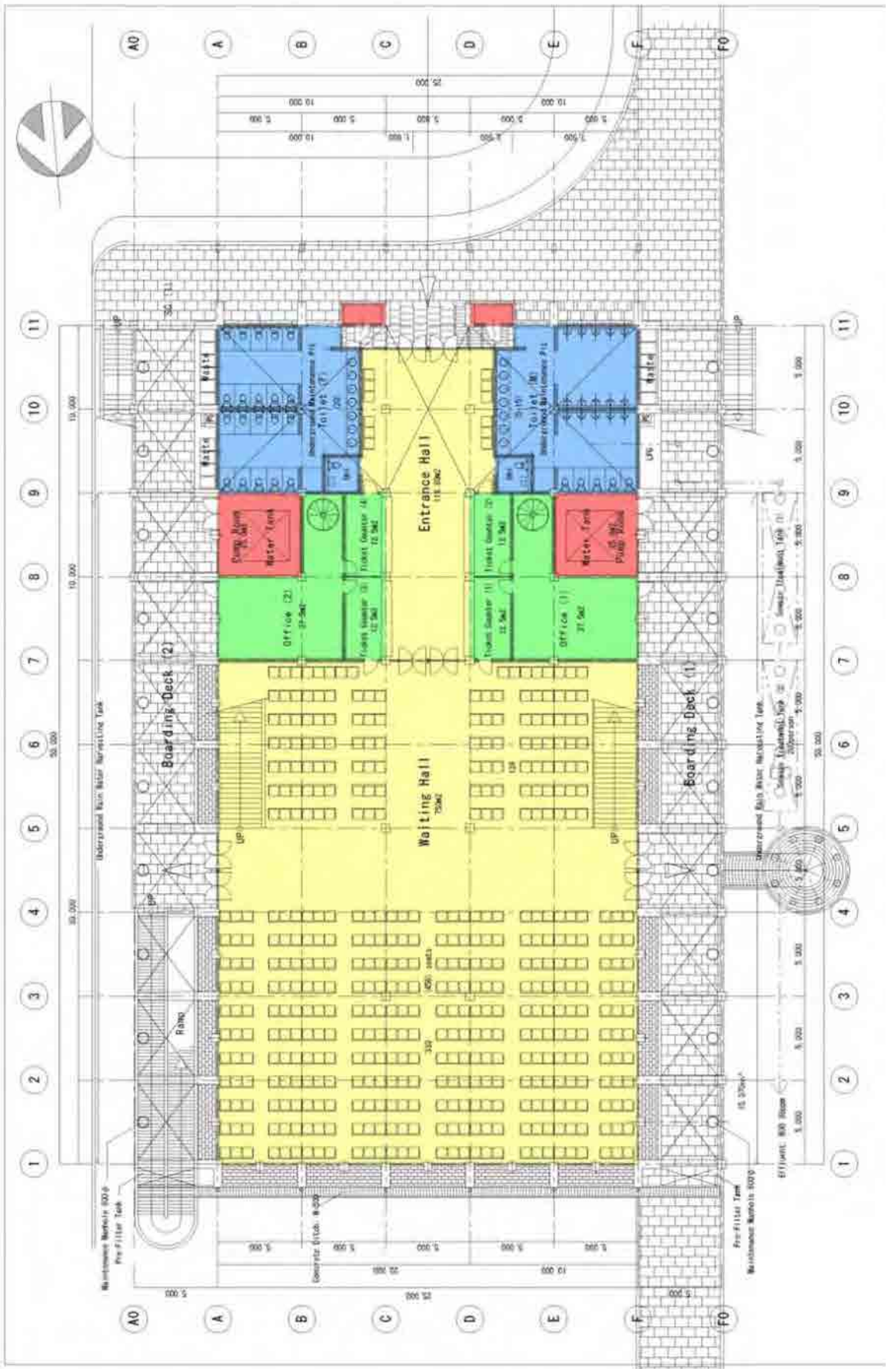


Figure 2-25 Terminal Building GF Plan

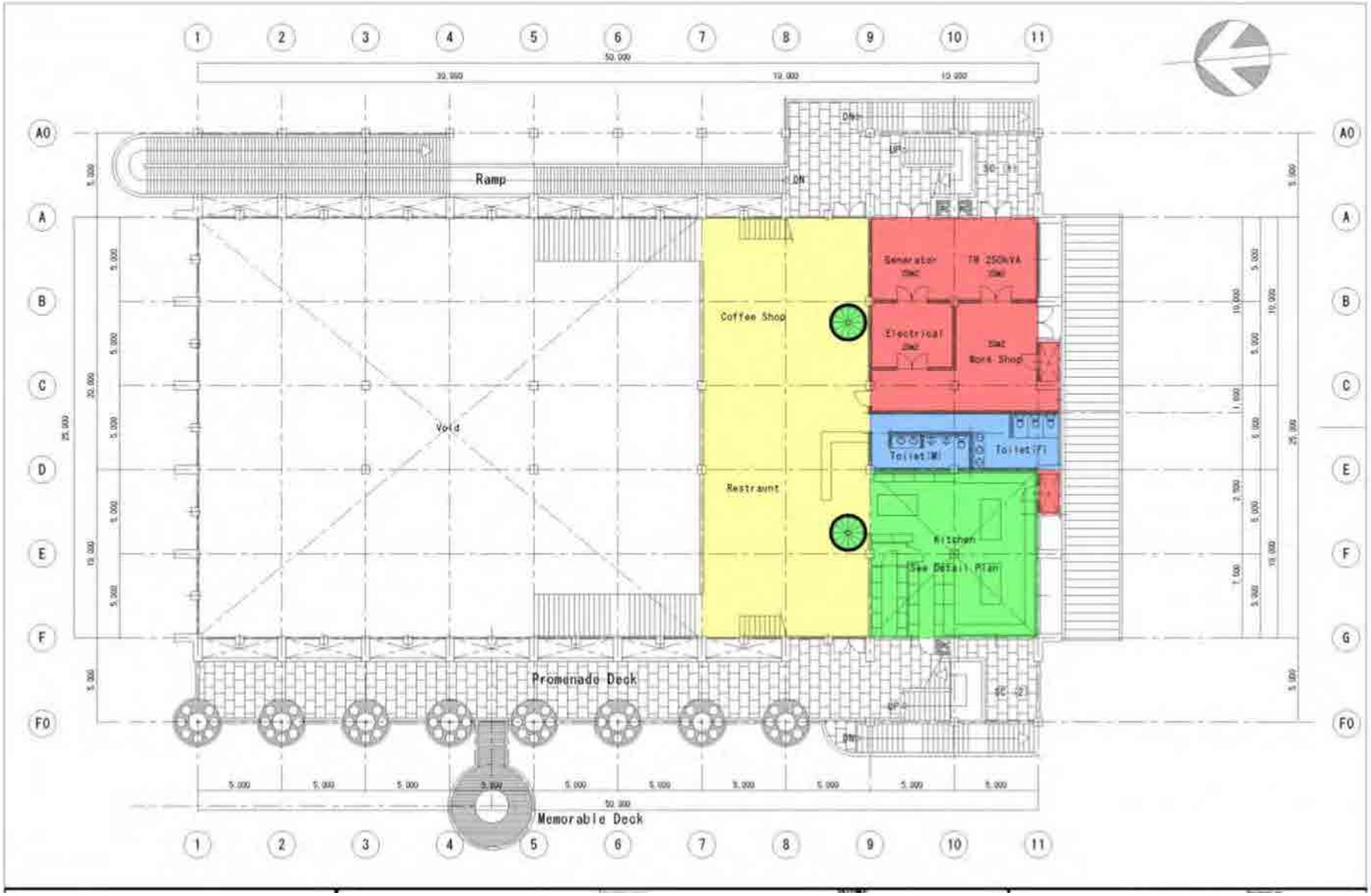


Figure 2-26 Terminal Building 1F Plan

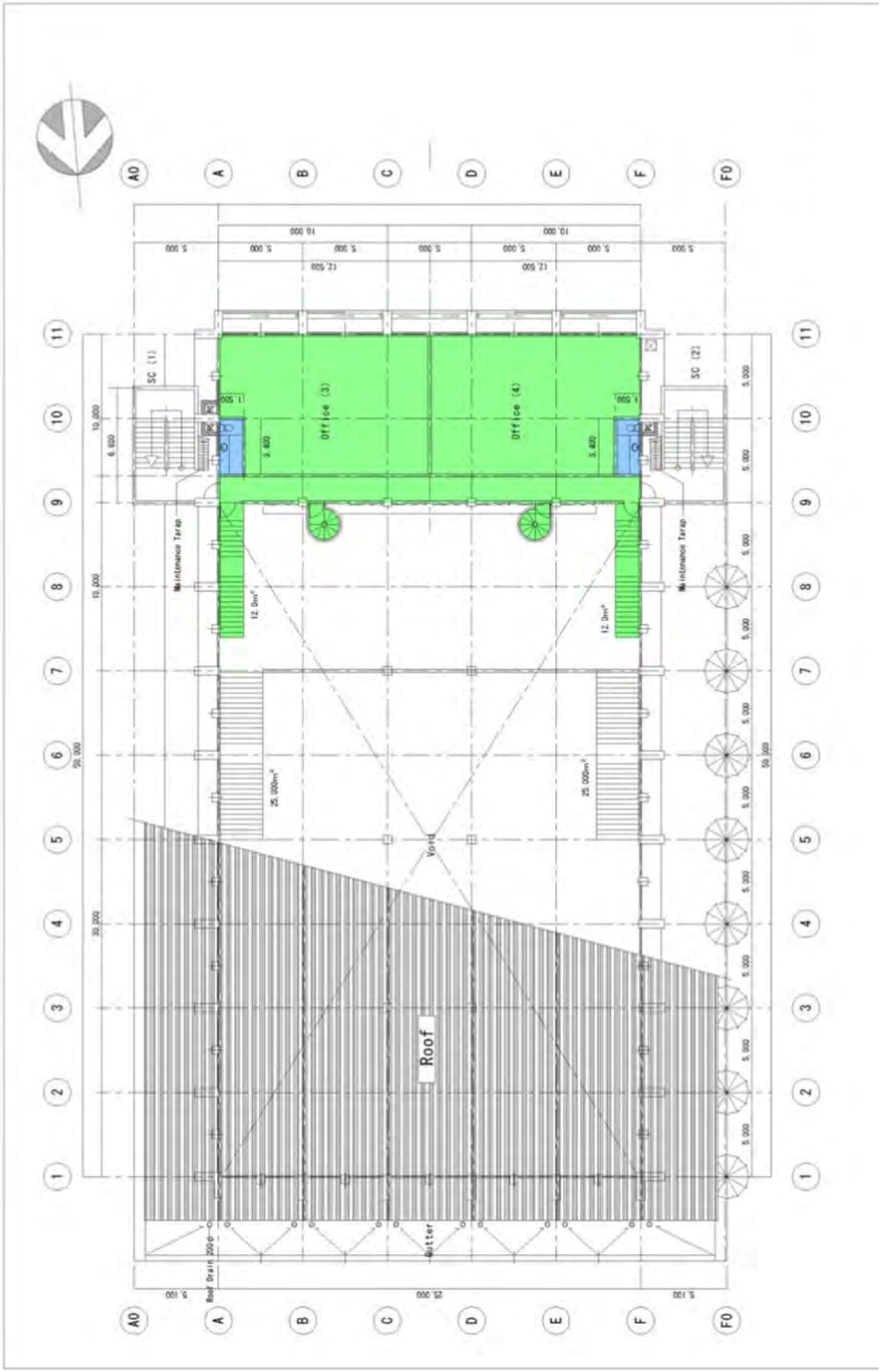


Figure 2-27 Terminal Building 2F Plan

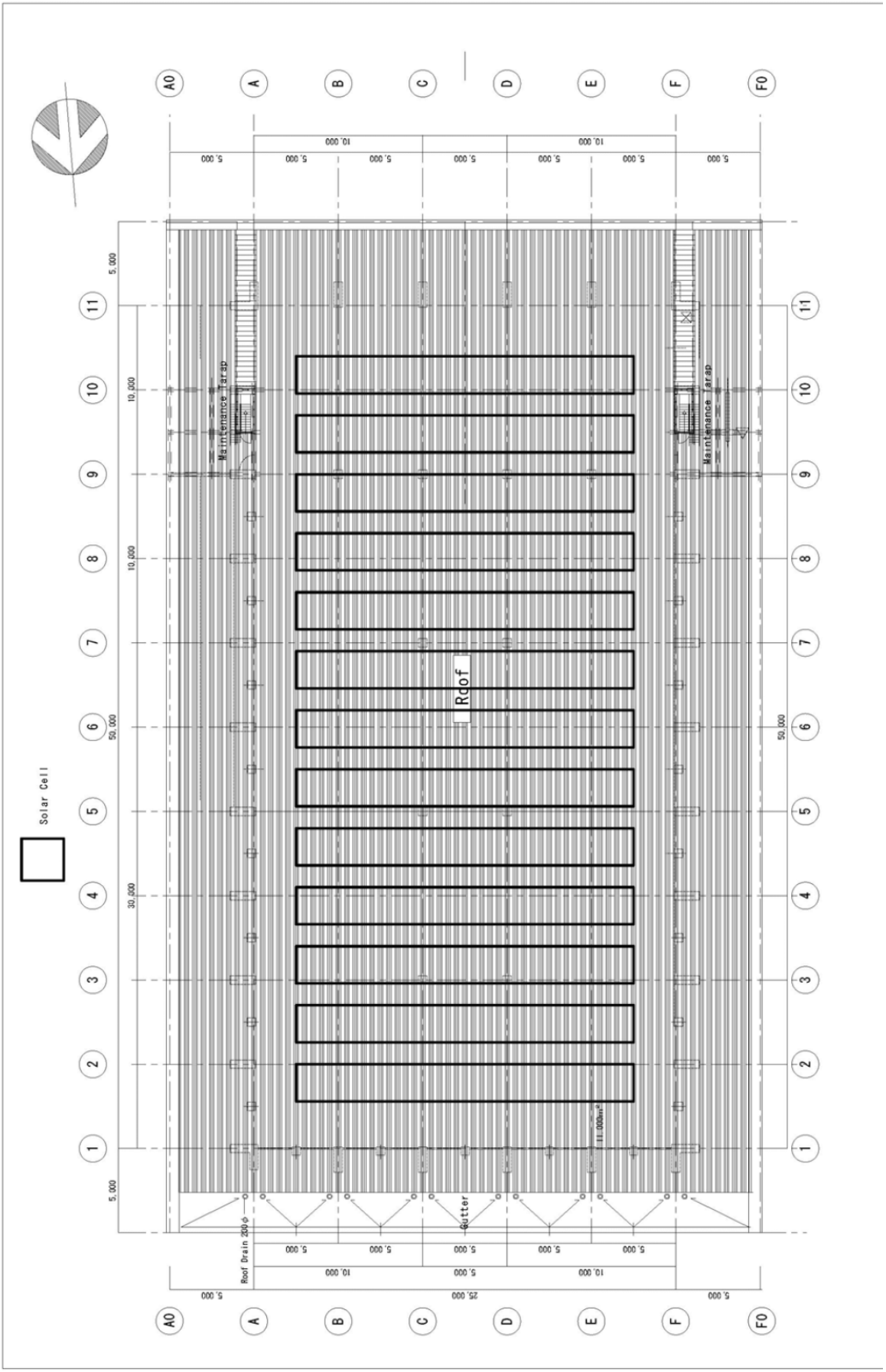


Figure 2-28 Terminal Building Roof Plan

Figure 2-29 Terminal Building Section (1), (2)

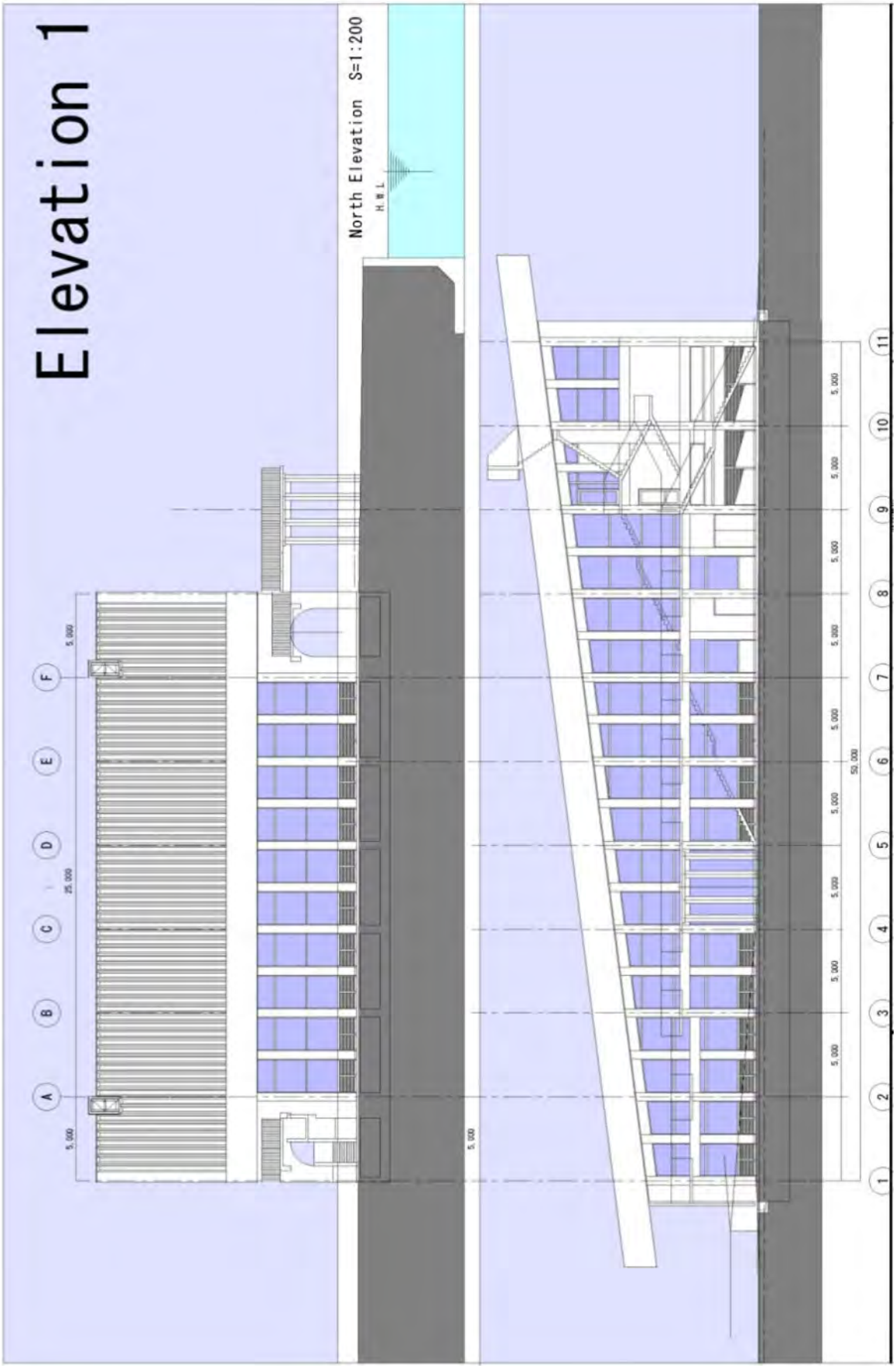


Figure 2-30 Terminal Building Elevation 1

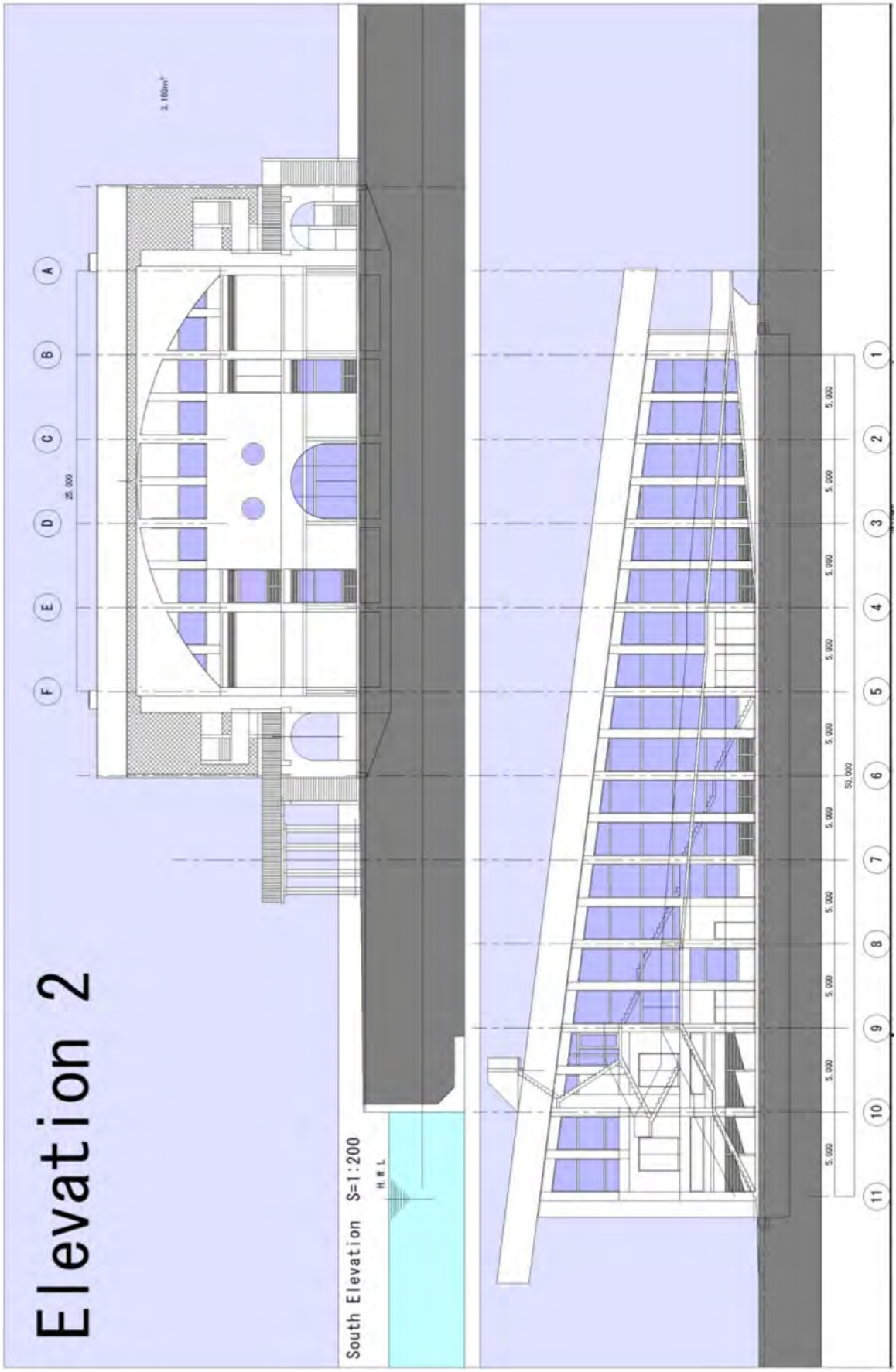


Figure 2-31 Terminal Building Elevation 2

2-2-4 Implementation Plan

2-2-4-1 Policy of Construction Plan and Procurement Materials

Although the amount of new building construction has been increasing recently in Tonga, almost all are technically at a basic level. On the other hand, the major work of this Project is marine civil works, which requires special skills, equipment and experiences, and there are not many past experiences in Tonga. The following discussions should continue keeping that fact in mind.

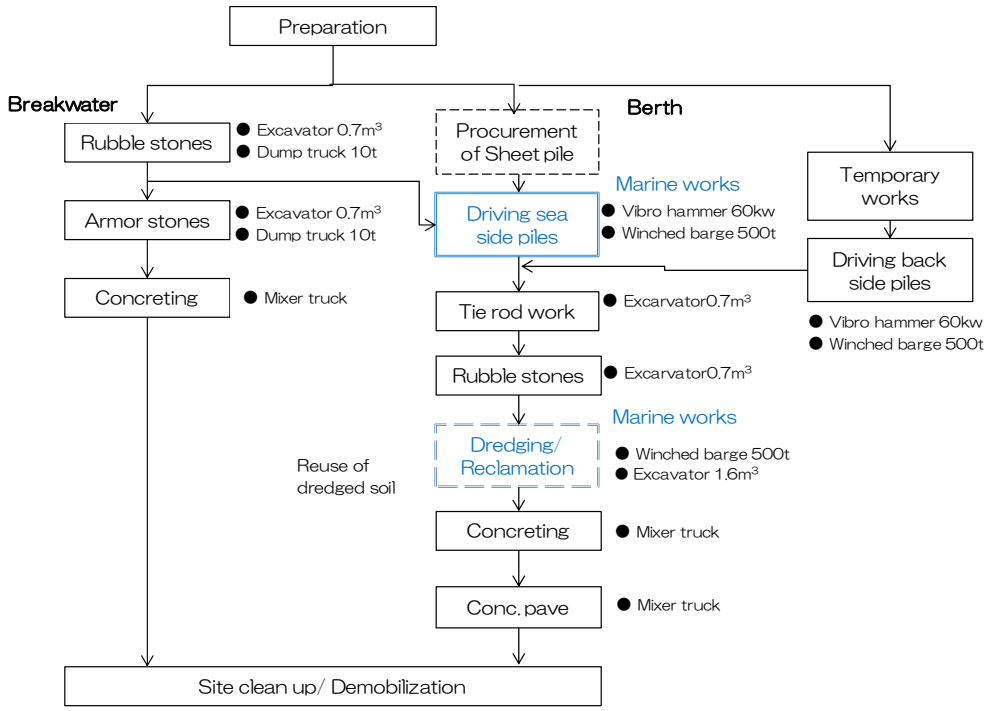
(1) Policy of Construction Plan

This project is the biggest scale of port & harbour project in Tonga planned by Japanese ODA under the scheme of grant aid, and the people of Tonga expects good things from this Project largely. Concretely, an increase of employment and beneficial contributions to the local economy.

Seeing the issues from the view point of the construction plan, the most important thing is that the structural design should be similar to the construction trend in Tonga, that is, it can be possible to maximally utilize local forces, in other words, local material, equipment and manpower.

The JICA Study Team have been deeply aware of this since the beginning stage of conceptual design and as it proceeded to the Study.

The construction work flow for the marine civil works is introduced in Figure 2-32.



Source: JICA Study Team

Figure 2-32 Work Flow of Marine Civil Works

(2) Policy of Procurement of Materials

Although building construction is increasing in Tonga, the construction labour force is very small and suppliers of construction material are very small scale and struggling, so, at present in Tonga, procurement of construction materials has to depend on importing from nearby countries, especially from New Zealand. As a result, basically each contractor imports the required materials on a demand basis.

There are regular feeder ships from New Zealand to Tonga arriving about twice a week. To make the material procurement plan, the confirmation of the availability of stock in consideration of this transportation interval is essential.

In this Project, many Japanese materials are to be used e.g. sheet piles with the related materials, port miscellaneous accessories like fenders, bollards, curbing, roofing materials for the main terminal building, solar system and so on. A regular liner from Tokyo visits Tonga usually once a month and traveling time of the liner is 30 days each way according to the shipping company. So these Japanese procurements need a plan with a longer lead time.

Considering these surroundings, earlier material procurement is required to secure on time completion of the Project by eliminating delay of material arrival, and this requires a larger stock yard due to the necessity of earlier/ longer material storage.

As for procurement of construction equipment in Tonga, the situation is similar to material procurement and only basic equipment like a 0.7 m^3 excavator, 10 ton dump truck, 25 ton truck crane and so on, can be hired locally. Besides, the number of usable machines seems to be limited so pre-confirmation of availability of each piece of equipment is important prior to making the equipment procurement plan.

This project has a certain scale of marine civil work and it requires procuring special equipment, a 500 ton barge equipped with winches that can load a 50 ton crane for piling work and a larger excavator 1.6 m^3 class for port dredging work. This barge is special and can't be procured from New Zealand and/or other nearby countries but it is possible from Japan, therefore, it is planned to hire it from Japan.

With regard to labour procurement, presently the government of Tonga is editing the labour act and there are no effective labour regulations or labour act so the local labour environment operates on a contract basis in each construction project. Therefore, to realize a reasonable contract for on time completion of the project with safety considerations, Japanese contractors shall examine present trend of the labour environment in Tonga carefully under supervision of the Consultant and instruct local labourers based on Japanese safety regulations. A concern is the day of rest in Tonga. Usually construction projects require working on Sunday to recover from any delays but the day of rest in Tonga is more strictly observed compared to other countries, so the Japanese contractor shall consider the custom/ culture of Tonga carefully when proposing work conditions.

The demarcation of material procurement is shown in the following Table 2-27.

Table 2-27 Basic Procurement Policy

Tonga	New Zealand/ Other countries	Japan
Materials		
Sand	Building fixtures	Steel sheet pile, Tie rod
Rubble/ Armour stone	Toilet/ sink	Fender, Bollard, Navigation light (LED)
Concrete	Tile, Bond, and finishing materials for building	Solar and septic tank system
Timber	Sealing	Roofing
Equipment		
Excavator (0.4 – 0.7 m^3)	Excavator (1.6 m^3)	500t barge with winches
Small bulldozer(2 t)	Crawler crane (50 t)	
Dump truck(4 - 10 t)	Jib tower crane（50 t）	
Trailer (20 - 40 ft)	Vibro-hammer（60 kW）	
Truck crane 25 t		
Labour		
Common labour	Skilled labour	Special Technician
Team leader	Supervisor	

Source: JICA Study Team

2-2-4-2 Key Issues on Construction/ Procurement for the Project

(1) Key Issues regarding Construction Works

Minimization of Marine Civil Works

Key work on the Project is marine civil work which requires a work-ship for dredging and piling works on the sea. However, the works on the sea are largely affected by weather conditions compared to normal works on land and they often cause delays. Also, marine works impose higher costs due to the need to procure a special work barge which has to be brought in from overseas.

On the other hand, the planned site has a certain space, approximately 4 ha: 200 m in the east west direction and 200 m in the north south direction, and parallel works can be undertaken if a combination of simultaneous work is appropriate. Also, a good combination of the works make the construction period shorter.

So, the JICA Study Team examined the construction plan for possible parallel combination work with a minimum of marine works. As a result, basically only two work items, dredging and piling for the sea side sheet piles, are selected as marine civil works with only one special work ship, a 500 ton winched barge, which is a versatile work vessel and can be used not only for dredging when an excavator is loaded on board but also for piling when a 50 ton crane with vibro-hammer is mounted. Consequently, this examination contributes to minimize project costs as well.

Table 2-28 shows the work demarcation plan for the Project.

Table 2-28 Work Demarcation Plan

	Work on Land	Marine Civil Work
1	Preparation/ Temporary works except installation/ removal of silt fence	Piling for front side piles
2	Breakwater except trimming of stone slope	Dredging and reclamation
3	Piling for back side pile and installation of tie wires	
4	Cooping concrete for berth	
5	Ramp concrete	
6	Levelling/compaction of reclaimed yard	
7	Building works	
8	Solar/ septic tank system and external works	

Source: JICA Study Team

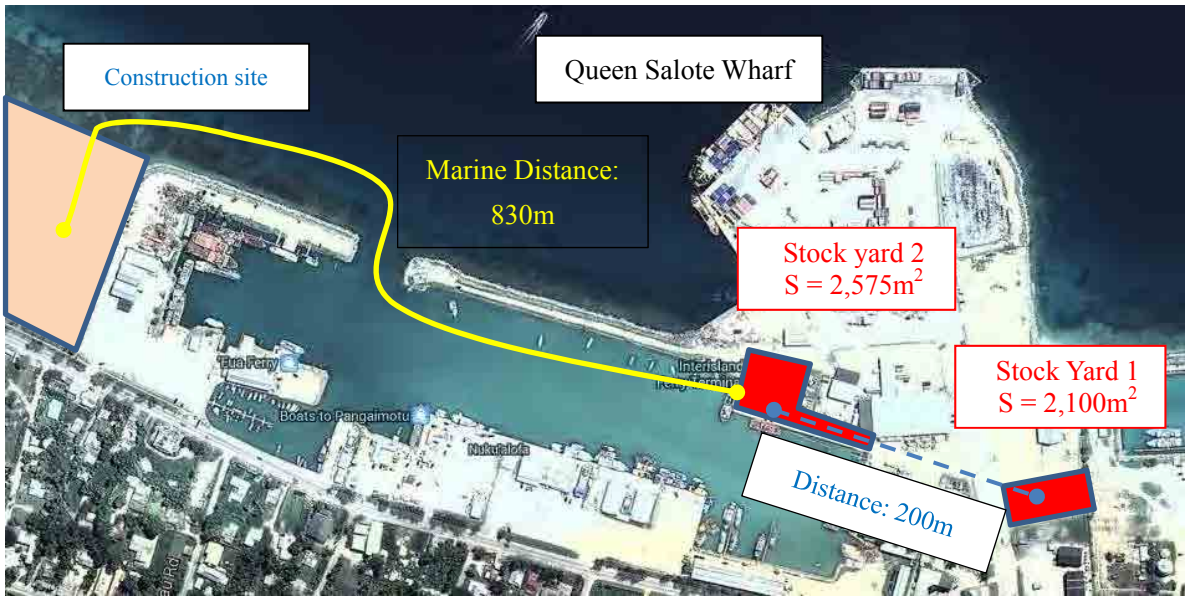
(2) Key for Material Procurement

Stock Yards

To avoid wasting time waiting for material, earlier material procurements from overseas are essential so relatively larger stock yards are planned within the Nukualofa Port. Sometimes loss and/or theft of material from a stock yard has happened and it leads to a delay of the Project and increase in project costs, but in this project, the yards can be acquired in the port area with a good security system so such risks of material loss might be much lower.

The major material which requires the largest stock space is the sheet pile from Japan. Necessary time to store the piles is in the early stage of the project commencement and the stock period is only for a few months so this big space will not need to be kept during the entire construction period. However, the necessity of earlier material procurement for all construction items is quite high. Therefore, such a big area for the stock yard shall be kept until the completion of the Project.

Considering these surroundings, two stock yards are planned as shown in Figure 2-33.



Source: JICA Study Team

Figure 2-33 Planned Stock Yards

2-2-4-3 Demarcation of Responsibility between Tonga and Japan

Based on the principle of Japanese ODA scheme and several discussions in this Study, each government has the responsibilities for the Project as shown in Table 2-29.

Table 2-29 Demarcation of Responsibility for the Project

No.	Item	Japan	Tonga
1	Land Acquisition		●
2	Land clean up to be able to commence the Project including planned temporary yard		●
3	1) Temporary power/ water supply for the construction	●	
	2) To bring in primary main power for the Project		●
	3) Setting up secondary power system	●	
	4) Maintain all port facilities		●
4	Procedures for Material/ Equipment procurement for the Project		
	1) Cost for international transport	●	
	2) Necessary Procedures for Tax/ duty exemption		●
	3) Cost for domestic transport after custom clearance	●	
5	Procedures for Tax/ duty exemptions		●
6	To provide entry permits necessary for the members to engage in the Project		●
7	Appropriate operation & maintenance of all facilities after completion of the Project		●
8	To remove or relocate ships that are not being used and existing utilities and waste within the Project Site to a designated area or Project affected area, before Pre-Qualification (PQ) of this Project.		●
9	EIA Procedures in compliance with the regulations of TONGA	support	●
10	To arrange issuance of licenses, permission and other necessary procedures (including acquisition of the permits and licenses for disposal of dredged materials) for the Project		●
11	Cost for bank commissions		
	1) Authority to Pay (A/P)		●
	2) Commission fee for payment		●

Source: JICA Study Team

(1) Responsibility of the Government of Japan

Based on the grant aid scheme of Japanese ODA, basically all costs for the construction of the Project are carried by the Japanese Government.

(2) Responsibility of the Government of Tonga

The items that the Government of Tonga are responsible for will be confirmed by M/D during the Study and one of the important issues for the commencement of the Project is the above mentioned item No. 8.

2-2-4-4 Policy of Supervision of Work Execution/ Material Procurement

(1) Policy of Supervision of Work Execution

The whole Project needs 24 months for the construction, which is comprised of marine civil works and building works. Marine civil works needs 18 months and building structures including solar/ septic tank systems & external works requires 12 months, this means both works are overlapped for 6 months. Concretely, after the completion of the berth reclamation in the building area is when almost half of the

whole reclamation area is completed, then building works shall be commenced to achieve on time completion.

One item of great importance in the management of the work is to complete the Project before the South Pacific Games which are scheduled in September 2019. The JICA Study Team consider this as vital and set the commencement of the Project in January 2016, which means the completion will be by the end of 2018, and this will give enough margin for the Games.

Supervision of the construction is scheduled to consider civil works and building works and each work is controlled by a senior Japanese Engineer. Additionally, at each key point in the construction, e.g. time to commence the Project, time to start marine works & building works and so on, each specialist from Japan shall be at the site to achieve appropriate quality and on time construction with site safety.

(2) Policy of Supervision of Material Procurement

This project has to relay on many imported materials and it requires secured material procurement, that is, earlier procurement.

Key items for supervision of material procurement are the following.

1) Approval of Shop Drawings

Prior to manufacture/procurement of materials, The Consultant shall approve the shop drawings.

An item on the critical path is to procure sheet pile. According to the survey result, manufacturing of the piles needs 1.5 months, the international transport needs a month, so the total is 2.5 months. However, the time to start the piling on site is from the beginning of the 4th month, that means there is only 0.5 month for making and approval of the shop drawings after the signing of the contract. Therefore, the Consultant has to instruct the Contractor to commence the shop drawing works immediately after the contract signing so as not to cause any delay of the works.

2) Interim/Final Inspections of Material Manufacturing

To reduce the risks of a mistaken/mismatched order, an interim inspection will be done. After completion of the manufacturing, the final inspection will be done in the presence of the Consultant at the manufacturer's yard.

3) Inspections at Embarking Port

After approval of final inspection at the manufacturer's facilities, the pre-shipping inspection is done at the Yokohama Port to confirm the required material is loaded and secured to prevent shifting or damage during the sea transportation.

4) Inspections on Site

After arrival of the materials at Queen Salote International Wharf, it shall be stocked in temporary stock yards. At that time, inspections shall be done to confirm whether or not there are any damages and/or losses.

2-2-4-5 Quality Control Plan

An important theme in the construction is to utilize local materials, equipment and labour forces. A large contribution to the local economy is expected but there is a concern regarding quality control based on the Japanese Standards. Therefore, a sensitive quality control plan shall be needed.
The keys for the quality control plan are shown following.

(1) Rubble and Armour Stones for the Breakwater

There are three active quarries on Tongatapu Island and their total capacities are quite enough for the Project but all mined stones are coral and the unit weight is relatively light, so the quality control of those stones, especially on the weight, is important in order to construct the required quality breakwater.

(2) Concrete

Two major ready mix concrete plants are in Tongatupu Island and each plant has 100 m^3 per day capacity. Since the Project has no large scale casting of concrete, the total capacity is sufficient to provide concrete for the demand of the Project. Also, each plant has been tested on the chloride content periodically and there seems to be little reason for concern regarding alkali-aggregate reaction according to their past records. However, each plant system is quite simple and the quality management is at a preliminary level, which can often be seen in the developing countries, so the inspection of fresh concrete is usually done when the concrete arrives at the site, and X bar management on the strength of the concrete (7 days and 28 days strength records) shall be tracked in order to maintain the structural quality.

2-2-4-6 Procurement Plan (Solar Cell System)

A Japanese maker who had completed a solar power project by Japanese ODA in March 2015 will be selected for the procurement of the Solar Cell System.
The reasons are as follows;

- ✓ Supplier achievements are verified in Tonga,
- ✓ Same local contractor who has the experience of the similar works can be employed,
- ✓ Same local contractor can take over the maintenance works,
- ✓ The solar cell system has higher quality and longer durability.

2-2-4-7 Soft Component (Technical Assistance) Plan

(1) Solar Cell System

The solar cell system is composed of 312 sets of solar modules, a support system, connecting cables, eight (8) units of power-conditioners, data measurement unit, interface panel, CPU, sundial, thermometer and etc. The electricity generated by the solar cell system is changed from direct current (DC) to alternating current (AC) through power-conditioners and sent to the transformer. All systems

are operated automatically. However, the cleaning of the surface glass of the solar modules is important maintenance works to keep the power generation capacity at a high level. Therefore, there are water tap on the roof top to provide water for washing the panels.

Another required maintenance item is to keep the solar system in good condition. The technical transfer of the operation and maintenance is so important for the people in Tonga that the Japanese mentor of this system will instruct the local contractor through on-the-job training during the construction and installation works.

The maintenance points are described as follows.

- Cleaning the glass of the solar modules regularly
- Fans and filters of the power-conditioner are also cleaned periodically, and the condenser should be replaced every ten years.
- Inspection of the data measurement instrument and interface panel

The useful life of a power-conditioner is around 17 years and the condenser in the power-conditioner will need to be replaced every 10 years. The replacement costs for the eight condensers will be $TOP24,000 (= $TOP3,000×8). Therefore, $TOP2,400 must be set aside every year for funding the replacement of the power-conditioner condensers. A maintenance contract with a local contractor that has adequate knowledge and experience will be recommended to keep the solar system in heathy condition.

(2) Sewage Treatment Plant

The sewage treatment plant (STP) in the Project is designed as a “contact aeration system”, and the underground tanks are separated into two tanks. The first tank is for preparation of the waste water and the second tank is for aeration. In the aeration tank there are the contact media made of plastic and the aeration pipes are set underneath the media. The blowers send air to the bottom of the aeration tank, and the air washes over the contact media and this activates aerobic bacteria to treat the waste water. The produced activated sludge finally settles to the bottom of the tank. This sludge is vacuumed out by a vacuum car twice a year. Normally all STP processes are operated automatically. But a daily inspection and checking are important for it to operate constantly.

The maintenance points are described as follows.

- Checking water quality and flow
- Checking sound and smell of pumps and blowers
- Vacuuming out the sludge twice a year

The actual useful life of the pumps and blowers is around 10 years, and will need to be replaced every 10 years. A pump costs $TOP3,000 and a blower costs $TOP5,500 to replace with new machines. The replacement costs will be $TOP24,000 for eight (8) pumps and $TOP11,000 for two (2) blowers. The total $TOP35,000 will be required to replace pumps and blowers every 10 years. Therefore, yearly

$TOP3,500 savings for the replacement will be needed. And a maintenance contract with a local contractor that has adequate knowledge and experience will be important to keep the STP in heathy condition.

2-2-4-8 Implementation Schedule

The implementation schedule is as shown in Figure 2-34.

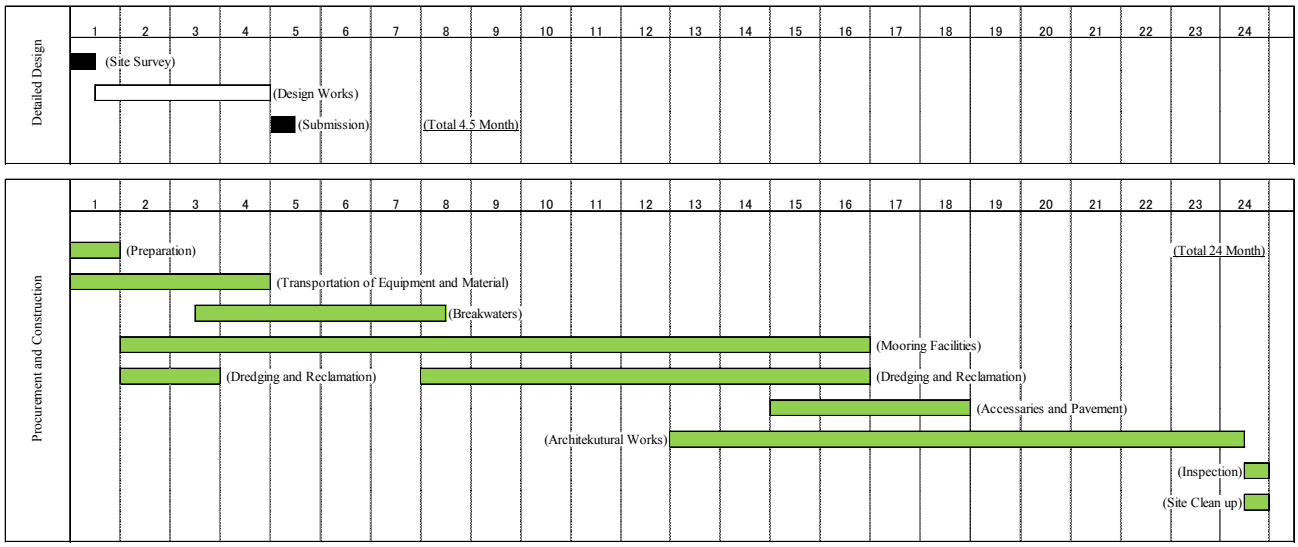


Figure 2-34 Implementation Schedule

2-3 Obligations of Recipient Country

In the Preparatory Survey for the Project, the Tongan side and the Japanese side confirmed that the following matters are Tongan side obligations under the Project.

1) To obtain the Development Consent including EIA report

2) To provide tax exemption for construction materials and equipment for the Project

3) To obtain necessary permits for the Project implementation such as construction permit for the port facilities and execution permit for starting the construction works and others as necessary

4) To remove or relocate the abandoned ships or existing utilities or waste in the existing Faua Wharf to a designated area or Project unaffected area before Pre-Qualification (PQ) of the Project

5) To secure sites for a material storing yard, temporary construction yard and waste disposal

6) To secure enough budget and personnel necessary for the operation and maintenance of the facilities implemented by the Project including the periodical maintenance works after the completion of the Project

7) Cost for commission to the bank, such as Authority to Pay (A/P) and commission fee for payment

Assumed Costs: $TOP72, 000

8) To conduct the following miscellaneous works;

- ✓ Planting Works along the Vuna road ($TOP140,000 by MOI)
- ✓ Relocation of electrical poles for receiving power ($TOP9, 000 by Tonga Power Ltd.)
- ✓ Installation of watt-hour meter for the terminal building ($TOP4,000 by Tonga Power Ltd.)
- ✓ Installation of telephone and internet cables ($TOP15,000)
- ✓ Procurement of office furniture and equipment ($TOP27,000 by Ferry Company)
- ✓ Procurement of refrigerator and freezer ($TOP24,000 by Restaurant Owner)

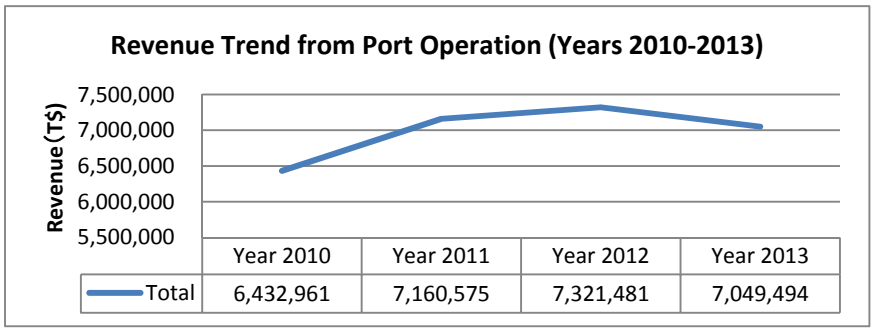
2-4 Project Operation Plan

PAT is expected to be the organization responsible for the operation of the new domestic wharf. The operational capacity of PAT for the new domestic wharf was evaluated by assessing PAT's current operation and technical capacities, and the effect on PAT's future payment balance.

2-4-1 Status of Operation and Management

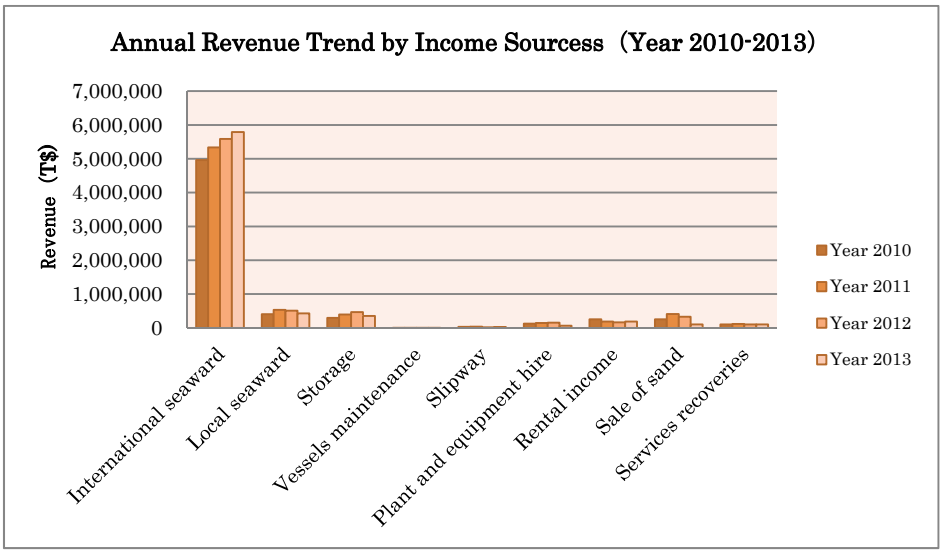
2-4-1-1 Status of Revenue

As shown in Figure 2-35, revenue from the port operation in fiscal year 2013 has fallen slightly compared with the years 2011 and 2012. The main reason was due to the decrease of inter-island cargo shipping demand for construction materials, which was caused by the completion of improvement works at the central area of Nuku'alofa. However, the main revenue of PAT (over 80 %) is generated by the international wharf as shown in Figure 2-36, which has been increasing steadily over recent years. Therefore, the revenue of PAT is also increasing steadily.



Source: JICA Study Team

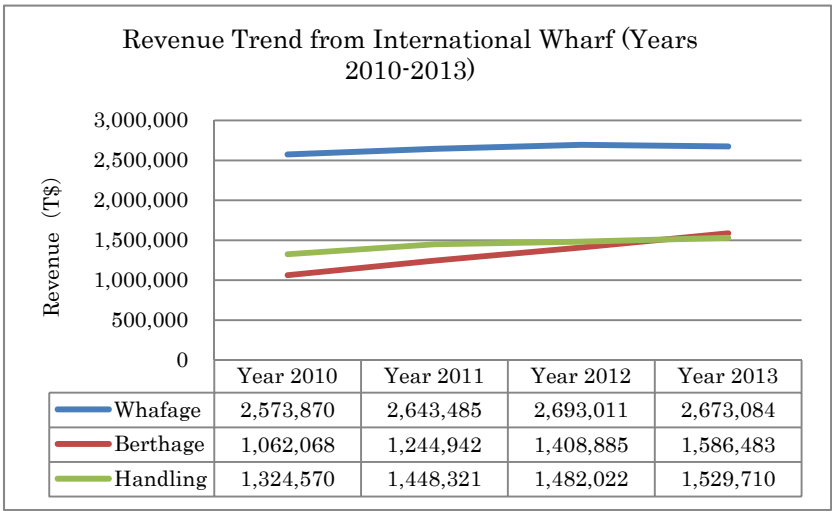
Figure 2-35 Revenue Trend from Port Operation by PAT (Year 2010-2013)



Source: JICA Study Team

Figure 2-36 Annual Revenue Trend by Income Source (Years 2010-2013)

Figure 2-37 indicates the annual revenue trend from the international wharf. The revenue from the international wharf is generally high for the wharfage fee, berthage fee and cargo handling fee. Revenue from the domestic wharf and other port activities should be increased.



	Year 2010	Year 2011	Year 2012	Year 2013
Whafage	2,573,870	2,643,485	2,693,011	2,673,084
Berthage	1,062,068	1,244,942	1,408,885	1,586,483
Handling	1,324,570	1,448,321	1,482,022	1,529,710

Source: JICA Study Team

Figure 2-37 Revenue Trend from International Wharf (Years 2010-2013)

2-4-1-2 Status of Annual Payment Balance

Table 2-30 indicates the status of the annual revenue/expenditure of PAT for years 2010 to 2013. Profit was obtained each year. The rate of profitability was 48 % in 2013, 55 % in 2012, 49.9 % in 2011 and 34.4 % in 2010.

Table 2-30 Annual Revenue/Expenditure of PAT (Years 2010 – 2013)

(Unit: $TOP)

		Year 2013	Year 2012	Year 2011	Year 2010
(a)	**Revenue**				
	International seaward				
	Whafage	2,673,084	2,693,011	2,643,485	2,573,870
	Berthage	1,586,483	1,408,885	1,244,942	1,062,068
	Handling	1,529,710	1,482,022	1,448,321	1,324,570
	Local seaward	430,216	507,868	534,889	405,288
	Storage	354,807	464,963	393,944	294,937
	Vessels maintenance	622	467	450	3,352
	Slipway	24,332	19,420	35,095	31,220
	Plant and equipment hire	63,751	152,411	145,139	125,213
	Rental income	185,514	162,844	187,449	254,655
	Sale of sand	100,017	328,068	408,304	254,390
	Services recoveries	100,958	101,522	118,557	103,398
	Total	7,049,494	7,321,481	7,160,575	6,432,961
(b)	**Administrative and other operating expenses**				
	Allowance for uncollectability	86,876	174,254	147,140	51,774
	Auditor's remuneration				
	Prior year		12,000	27,059	2,132
	Current year	23,500	23,500	18,500	19,399
	Consultants fees	6,364	14,595	59,045	126,008
	Costof goods sold	78,204	229,772	211,540	220,298
	Director's fees	88,231	73,000	91,943	36,159
	Donation	1,357	8,420	8,700	3,008
	Board honorarium	37,990	30,687	46,194	17,454
	Fuel	165,679	80,732	274,893	260,950
	Insurance	506,238	320,840	296,644	241,313
	Legal fees	20,244	34,738	58,860	135,687
	Loss on disposal of property, plant and equipment		74,987	2,549	369,782
	Repairs and maintenance	439,913	344,087	370,533	332,049
	Total	1,454,596	1,421,612	1,613,600	1,816,013
(c)	**Personnel Expenses**				
	Wages and salaries	1,585,330	1,459,221	1,430,467	1,630,211
	Superannuation contributions to National Retirement Fu	108,599	61,111	109,561	115,728
	Key management compensation- short term benefits	266,200	169,015	267,505	271,461
	Overtime and annual leaves	182,657	177,662	164,951	386,676
	Total	2,142,786	1,867,009	1,972,484	2,404,076
(d)	**Balance of Revenue and Expenses**	3,452,112	4,032,860	3,574,491	2,212,872

Source: Port Authority Tonga Annual Report, Year 2010-2013

Table 2-31 shows the financial report of PAT for years 2012 and 2013. Table 2-32 shows the return on assets, operating efficiency and working ratio of PAT in 2012 and 2013, which were calculated based on the results of the financial report.

Table 2-31 Financial Report of PAT in 2012 and 2013

Unit: $TOP

	Actual 2012	Actual 2013	Business plan 2013
Statement of financial performance			
Total Revenue	7,400,164	7,272,356	6,873,000
Total Expendeture	5,768,814	6,549,052	6,423,000
EBITDA	3,307,191	2,737,456	2,311,000
Depreciation	1,361,167	1,583,764	1,528,000
EBIT	1,884,228	1,153,692	783,000
Interest Income	61,721	78,496	60,000
Interest Expenses	274,496	256,006	182,000
NPBT	1,671,453	976,182	600,000
Income Tax	431,047	252,878	150,000
NPAT	1,240,406	723,304	450,000
Statement of financial position			
Total Assets	22,740,724	22,412,546	20,878,000
Total Liabilities	6,065,011	5,633,732	4,047,000
Equity (Net assets)	16,675,713	16,778,814	16,831,000
Return to Shareholders （%）			
Return on Assets	5%	3%	2%
Return on Equity	7%	4%	3%
Profit margin	17%	10%	7%
Current ratio	$2.14: $1.00	$2.08: $1.00	$2.89: $1.00
Capital Structure (%)			
Debt ratio (Debit/Equity)	36%	34%	24%
Interest cover ratio			
Times cover (EBIT/Interest)	7	5	4

Source: JICA Study Team

Table 2-32 Evaluation Results of PAT's Operation in Years 2012 and 2013

Evaluation items	Year 2012	Year 2013	Criteria of health of operation
Return on assets	5 %	3 %	
Operating efficiency (Operating Expenses/ Operating Revenue)	78 %	90 %	≤ 70 % ~ 75 %
Working ratio (EBITDA/Total Revenue)	44.7 %	37.6 %	≥ 50 % ~ 60 %

Source: JICA Study Team

Although operating efficiency satisfied the evaluation criteria, working ratio did not satisfy the evaluation criteria. However, it could be said that PAT is generally in a healthy operating status, except for the slow revenue in year 2013.

2-4-2 Effects of this Project on PAT's Operation

The revenue structure of PAT will basically not change through this project because the operation of inter-island passenger/cargo handling at Queen Salote Wharf will be transferred to the new domestic wharf. PAT will not require to borrow money for this project because it will be donated by Japanese Grand Aid. However, it is necessary to know the effect on PAT's payment balance in the circumstance of adding the depreciation costs of this project. The effects on PAT's payment balance in the case of adding depreciation and annual maintenance costs was simulated based on the years 2010-2013. Additional revenue expected from the market and restaurant facilities of the new terminal building was not incorporated in the simulation.

2-4-2-1 Depreciation Cost Added by this Project

Table 2-33 shows the booking cost of each facility in the new domestic wharf and the accumulating depreciation cost at the 1st operation year. The total added booking cost of this project is $TOP 51,588,787. Table 2-33 also indicates the 1st year accumulating depreciation cost ($TOP 68,322) in the bottom of the right column. The residual value was set as 10 % of the booking depreciation costs.

Table 2-33 Booking Cost and Accumulating Depreciation Cost at 1st Operation Year by this Project

2015 0104 Estimation		Booking Cost $TOP	Life age	Ratio of Dep. (%)	Accumurating Dep. Cost 1st year
Cost of Harbour Facilities	1. Breakwater	4,862,001	40	2.50	3038.75
	2. Berth	20,031,448	40	2.50	12519.66
	3. Dredging and reclamation	2,144,535	40	2.50	1340.33
	4. Accessories				
	4-1 Mooring posts	500,605	40	2.50	312.88
	4-2 Fender	1,191,491	15	6.67	5298.16
	4-3 Ladder	66,028	15	6.67	293.60
	4-4 Edging cover	110,850	15	6.67	492.91
	4-5 Car stopper	475,493	15	6.67	2114.36
	4-6 Floating Light beacon	274,494	40	2.50	171.56
	5. External works & Pavement				
	5-1 Concrete pavement	3,367,606	20	5.00	8419.02
	5-2 Filling works	438,720	20	5.00	1096.80
	5-3 Drainage works	47,352	20	5.00	118.38
	5-4 Lighting poles	2,722	15	6.67	12.10
	5-5 Removal works	398,684	20	6.67	1329.61
Cost of Terminal buildings	1. Terminal building	10,449,703	30	3.33	11599.17
	2. Fixing works				
	2-1 Electrical facilities	1,940,005	15	6.67	8626.56
	2-2 Water supply, Drainage & Swage plants	784,614	15	6.67	3488.92
	2-3 Air conditioner & Ventilation facilities	102,003	15	6.67	453.57
	3. Others				
	3-1 Solar panel	866,438	30	3.33	961.75
	3-2 Security hat	332,717	15	6.67	1479.48
	3-3 Boarding bridge waay	425,333	30	3.33	472.12
	3-4 Outdoor facilities	2,296,109	30	3.33	2548.68
	4. Furniture	384,721	15	6.67	1710.73
	5. Others	95,115	15	6.67	422.94
Total		51,588,787			68322.04

Source: JICA Study Team

2-4-2-2 Change of Payment Balance of PAT by this Project

Table 2-34 shows the change of PAT's payment balance due to this project. The change of PAT's payment balance was simulated for three scenarios (Project 1, Project 2 and Project 3). Project 1 was set as the moderate-case scenario based on the status of year 2013. Project 2 was set as the lowest-case scenario based on year 2010. Project 3 was set as the most prosperous condition based on year 2012. The right end three columns of Table 4-8 indicate the prediction results of three project scenarios with the added cost of depreciation and the annual maintenance required by this project. The results indicate the necessity of achieving the revenue level of the year 2013. The annual maintenance cost of this project is shown in Table 2-37.

Table 2-34 Predicted Change of PAT's Payment Balance by this Project

Income Statement (Year 2010-2013)	Year 2013	Year 2012	Year 2011	Year 2010	Income Projection By 2013 Project 1	By 2010 Project 2	By 2012 Project 3
Revenue	7,049,494	7,321,481	7,160,575	6,432,961	7,049,494	6,432,961	7,321,481
Other income	222,862	78,683	104,865	643,367	222,862	643,367	78,683
Total income	7,272,356	7,400,164	7,265,440	7,076,328	7,272,356	7,076,328	7,400,164
Depreciation	1,583,764	1,361,167	1,422,856	1,370,210	1,652,086	1,652,086	1,652,086
Administrative and other operating expenses	2,392,114	2,246,475	2,150,968	2,256,733	2,392,114	2,256,733	2,246,475
Personel expenses	2,142,786	1,867,009	1,972,484	2,404,076	2,142,786	2,404,076	1,867,009
Impairment loss on property, plant and equipment	0	41,285	202,123	0	860,464	860,464	860,464
Profit from operations	1,153,692	1,884,228	1,517,009	1,045,309	224,906	-97,031	774,130
Finance income	78,496	61,721	26,142	4,577	78,496	4,577	61,721
Finance cost	256,006	274,496	274,532	335,697	256,006	335,697	274,496
Finance cost-net	177,510	212,775	248,390	331,120	177,510	331,120	212,775
Profit from operations before tax	976,182	1,671,453	1,268,619	714,189	47,396	-428,151	561,355
Income tax expense	252,878	431,047	438,663	178,547	11,849	0	140,339
Profit after tax	723,304	1,240,406	829,956	535,642	35,547	-428,151	421,016
Other comprehensive income	0	0	0	0	0	0	0
Total comprehensive income for the year	723,304	1,240,406	829,956	535,642	35,547	-428,151	421,016
					%	%	%
Profit from operations			運営収支		3.2	-1.5	10.6
Profit from operations before tax			税引き前利益		0.7	-6.7	7.7
Profit after tax			税引き後利益		0.5	-6.7	5.8

Source: JICA Study Team

The new terminal building will have space for selling island goods and a restaurant, in addition to its function as a passenger terminal. Therefore, additional income sources will be available from the terminal operation.

Moreover, berths No. 3 (100 m length) and No.4 (60 m length) of the Queen Salote Wharf can be used as a cargo handling berth after completion of this project. Table 2-35 shows the revenue from berths No.1 (93 m length) and No.2 (110 m length) of Queen Salote Wharf for years 2010 to 2013. The average annual revenue in the four years was $TOP 26, 724 per meter.

Due to the limited water depth (-8.0 m) and consequent limitation in acceptable vessel size of berths No. 3 and No.4, revenue from these berths are expected to be 1/6 of the revenue of berths No.1 and No.2. The revenue generated from berths No. 3 and 4 is predicted to be $TOP 712,640 per year ($TOP 26,724/m x 160 m x 1/6). Therefore, it is expected that PAT will be able to earn the revenue of the year 2013. Furthermore, additional revenue from commercial activities (e.g. restaurant) is expected to be generated. Therefore, it can be concluded that from a financial perspective, PAT has sufficient capacity to operate the new domestic wharf.

Table 2-35 Revenue from Berths No.1 and No.2

	Year 2010	Year 2011	Year 2012	Year 2013
Revenue ($TOP)	4,960,508	5,366,748	5,583,918	5,789,277
Revenue/m ($TOP/m)	24,436	26,437	27,507	28,519

Average/m: $TOP 26, 724/m

Source: JICA Study Team

2-4-3 Appraisal of PAT's Capacity as the Operational Organization of this Project

2-4-3-1 Appraisal of PAT's Port Operation Capacity from a Technical Perspective

The operation of the new domestic wharf will require the ability to manage wharf operation, maintenance of the terminal building, security in the parking area and operation of the cargo handling area. PAT will be able to handle and manage all facilities of the new wharf and terminal building because PAT already has sufficient technical staffs (except for civil engineers) within its architectural department. In the event of necessary maintenance works for the wharf and breakwater structures, MOI will be responsible. In the case of large scale maintenance works, MOI and PAT will work together for making the plan and corresponding technical matters and budget. Therefore, it can be concluded that PAT has sufficient technical capacity to operate the new domestic wharf.

2-4-3-2 Appraisal of PAT's Capacity as the Operational Organization

The JICA Study Team concludes that PAT has sufficient capacity as the operational organization of the new domestic wharf, both from the financial and technical perspectives.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) Cost to be borne by the Recipient Country

The scope of works of the Tongan side as a part of the project components are shown in Table 2-36. The necessary cost is estimated at about $TOP 291,000 (about ¥16.1 million Japanese Yen).

Table 2-36 Scope of Works and Costs of Tongan Side

Item	Party in charge	Amounts ($TOP)
1) Bank Commissions	MOFNP	72,000
1) Planting Works	MOI or PAT	140,000
2) Relocation of electrical poles	Tonga Power Ltd.	9,000
3) Installation of watt-hour meter	Tonga Power Ltd.	4,000
4) Installation of TEL & internet	Shipping Company	15,000
5) Office furniture & equipment	Shipping Company	27,000
6) Refrigerator & freezer	Restaurant owner	24,000
Total		291,000

Source: JICA Study Team

(2) Basis of the Cost Estimates

The basis of the cost estimates are listed below.

1) Base Data: October, 2014

2) Exchange Rates
   a) Tonga Pa'anga to Japanese Yen : 58.22 Yen/$TOP
   b) US Dollar to Japanese Yen : 104.83 Yen/USD

3) Procurement/Construction Period
   Detailed design and construction period and schedule are as shown in the implementation schedule in Figure 2-13.

4) Others
   The project will be implemented in accordance with the procedures of grant aid projects of the Japanese Government.

2-5-2 Operation and Maintenance Costs

The annual maintenance costs of this project are calculated as $TOP860, 464 as shown in Table 2-37.

Table 2-37 Annual Maintenance Costs of the Project

Annual Maintenace Cost	Cost($TOP)	Maintenace cost per year	Note
1. Supeerstructures (1.0% of Construction cost)	22,356,944	223,569	Exculde Breakwater & Dredging & External works & pavement
2. Terminal Buildings (3% of Construction cost)	15,190,419	455,713	Cost of Terminal Buildings(excluding outdoor facilities and others)
3. Pavement works (1.0% of construction cost)	6,646,308	66,463	External works & Pavement, Outdoor facilities, others
4. Navigational aids etc. (3.0% of Construction cost)	2,616,239	78,487	Port accessories & External works
5. Environmental monitoring fee	36,232	36,232	2 times per year
Total		860,464	

Source: JICA Study Team

Chapter 3 Project Evaluation

3. Project Evaluation

3-1 Preconditions

For the proper implementation of the Project, the following matters shall be ensured by the Tongan side.

i) EIA approval required for the commencement of the Project was secured in March, 2015 as confirmed in the M/D.

ii) The necessary permits for the Project implementation such as construction permit shall be obtained by the bit announcement.

iii) The sites for material storing yard, temporary construction yard and waste disposal shall be secured as agreed in the M/D.

iv) The tax exemption permit for custom clearance and the Project implementation shall be executed.

v) The abandoned ships or existing utilities or waste within the Project site shall be removed or relocated to a designated area or an area unaffected by the Project before Pre-Qualification (PQ) of the Project.

vi) Environmental monitoring programs that comply with the EIA procedure shall be conducted and reported to the JICA Tonga Office during the construction phase to confirm the environmental status and the effectiveness of the proposed mitigation measures. Depending on the monitoring results, proper mitigation measures shall be selected until impacts are reduced to satisfactory levels.

vii) The miscellaneous works regarding building and landscaping shall be carried out adequately.

3-2 Necessary Inputs by Recipient Country

The following matters shall be undertaken by the Tongan side to produce and sustain the effects of the Project.

i) The necessary budgets and management for the maintenance of the port facilities shall be secured properly.

ii) An adequately qualified local contractor shall be selected for the maintenance works of the solar cell system and sewerage treatment plant.

iii) The synergy effects with Eua ferries shall be enhanced by upgrading the port facilities in the existing Faua Wharf.

iv) A safe and reliable domestic transportation system shall be established by securing the maintenance and operation of the inter-island ferries.

v) The effective cargo handling and passenger's safety shall be secured by the arrangement of security guards, who manage the traffic lines of passengers and cargoes, at the port entrance.

vi) An increase in port profit and the activation of the regional economy shall be promoted by adding functions such as shops selling local products, services utilized in a restaurant, attractive events in the waiting hall, etc.

3-3 Important Assumptions

(1) Upgrade of Domestic Port Facilities

As for the inter-island transportation system, the required functions will be performed only after both the base port and domestic harbours connecting each other are maintained properly. Nuku'alofa Port as a base port will be developed by this Project, however, the port facilities of the domestic ports in Ha'apai, Vava'u and Niuas Island are not maintained in good condition. MOI is in charge of the maintenance works of domestic ports, but most of the port facilities are severely deteriorated due to the lack of maintenance budget of Marine & Port Division in MOI. Two domestic ferries are usually operated every week. At Ha'apai Island passengers and cargoes are to be transhipped onto small vessels and transported by shuttle because of the shallow water depth. In addition, the risks of grounding higher during night operation. Even Halaevalu Port on Vava'u Island, the second largest port in Tonga, has only one berth and a narrow basin for domestic ferries. Therefore, one ferry has to wait outside of the port area while another ferry is at the berth.

The upgrade of the domestic port facilities is necessary in order to exhibit and sustain the effects of the Project. Especially the upgrade of Halaevalu Port in Vava'u will have a high priority since many tourists, passengers and cargoes are using this port. The development plan as an international port might be also considered due to its high profitability.

(2) Procurement of a New Inter-island Ferry

The inter-island ferry, which a private company is operating at present, is approximately 25 years old, and she is getting older. Her maintenance condition is not good enough due to financial difficulties of the ship owner so that she will be decommissioned in the near future. Also she has a particularly high risk of serious accident at sea if this situation is continued. Not less than two ferries are required considering the present operational conditions and the regular inspection at Fiji dock every two years. Therefore, an alternative new ferry should be procured to secure the safe and sustainable inter-island transportation system.

(3) Preparation of Public Workshop

There is no public workshop where a private ferry can be repaired in Tonga. Preparing a large dock like in Fiji is not feasible since usage frequency is too low to operate lucratively in Tonga, which is located on the fringe of the South Pacific region. A workshop for ferry and cargo handling equipment is out of the scope of this Project. So, the workshop owned by FISA in Queen Salote Wharf will only be available for all shipping owners after completion of this Project. In the future, however, a public workshop should be prepared to maintain the good condition of all ships and cargo handling equipment.

3-4 Project Evaluation

3-4-1 Relevance

The Pacific Islands Leaders Meeting (PALM) is a summit-level meeting which has been held every three years since 1997. Leaders openly discuss various issues that Pacific island countries are facing in order to build close cooperative relationships and forge a bond of friendship between Pacific island countries and Japan.

The Sixth Pacific Island Leaders Meeting (PALM 6) took place at the Bankoku Shinryokan, Nago City, Okinawa, on May 25 and 26, 2012, in the summit, Japan committed to make a maximum effort to provide up to 500 million US dollars of assistance over the next three years in order to push forward cooperation, and at the end of the summit, the Okinawa "Kizuna (“Bonds” in English)" Declaration was adopted.
This Project coincides with the policy of Japanese aid to Pacific island counties just like the Okinawa “Kizuna” Declaration.

3-4-2 Effectiveness

(1) Quantitative Effects

A Project Outcome (Quantitative Effects) is shown in Table 3-1.

Table 3-1 Project Outcome (Quantitative Effects)

Indices	Basis (at 2014)	Target (at 2021, three years after completion of the Project)
Wharf / Mooring Facilities Number of ship calls for the 1,500 G.T. vessels (times per year)	0	45 times per year
Wharf / Mooring Facilities Cargo Volume (tons per year)	0	45,000 tons per year
Wharf / Mooring Facilities Passenger Traffic (persons per year)	0	45,000 persons per year

Source: JICA Study Team

(2) Qualitative Effects

a) Reduction of berthing and leaving time for inter-island ferry
b) Improvement of cargo handling efficiency by the upgrade of cargo yard and the separation of traffic flows of cargoes and passengers
c) Improvement of the amenities for passengers by the upgrade of the waiting hall
d) Security for passengers by the upgrade of the passenger walks way
e) Revitalizing the economy in Tonga with the increased revenue and job development by the upgrade of the new terminal building

(3) Project Design Matrix

A Project Design Matrix (PDM) to evaluate the project effect is summarized in Table 3-2. Overall Goal, Project Goal by the Project and expected effects and quantitative and qualitative indices are as shown in Table 3-2.

Table 3-2 Project Benefit - Project Outcome Indices

Project	Quantifiable Indices	Source of Indices	Qualitative (Indirect) Effects / Exterior Conditions
Overall Goal To upgrade the wharf for domestic transport in Nuku'alofa Port To revitalize the economic activities of Tonga	Revenue - Port fees - Port operation Economic Indices - Import and Export amount (increase) - GDP in current USD - GDP per capita in current USD	- Tonga Statistical Year Book - PAT Statistical Year Book - World Bank Data Base	The Project may contribute to; - Safety for port users, - Efficiency for cargo handling, - Amenities for passengers, tourists and Tongan people, - Revitalizing the economy in Tonga.
Project Goal To separate the international cargo and domestic cargo To improve the safety of berthing and mooring facilities for inter-island ferries To upgrade the efficiency of cargo handling and the safety for passengers	- Specialized for international cargo at Queen Salote Wharf - Congestion reducing of access road to Queen Salote Wharf - Number of safe berthings of ferry - Number of ships in shelter port - Number of cargo traffic - Number of passenger traffic	- Tonga Statistical Year Book - PAT Statistical Year Book - Study by JICA Study Team	- Port security as an international port will be secured in Queen Salote Wharf. - Port operation will be revitalized by securing the safety and amenities. - Traffic flows of passengers and cargoes will be separated and secure the safety and efficiency of cargo handling.
Direct Effects To increase the safety for port users in Queen Salote Wharf To increase the satisfaction and evaluation regarding the safety of port users	Evaluation for the safety of port users regarding the following items; - Berthing and mooring facilities - Cargo handling works - Incoming & outgoing passengers - Waiting hall - Navigation aids	- Interview with port users by JICA Study Team and PAT	- The safety and ship operability for navigation, berthing and mooring will be improved. - The safety and efficiency of cargo handling will be improved. - The amenity and safety for passengers will be upgraded.
Activities To provide the upgraded port facilities for inter-island ferries such as breakwater, quay walls, accessories, cargo yards, terminal building, etc.	**Input** **Japanese Side** To provide port facilities for the inter-island ferry wharf, To install navigation aids, To construct a terminal building.	**Pakistani Side** To conduct adequate maintenance for port facilities, ferries and cargo handling equipment To upgrade the existing Faua Wharf To arrange the security guards	The required budget for maintenance shall be prepared, and adequate repair and maintenance shall be executed steadily every year. Upgrade of domestic port facilities Preparation of alternative new inter-island ferry Preparation of a public workshop

Source: JICA Study Team

Appendices

Appendices

Appendix-1: Member List of the Survey Team A1-1

Appendix-2: Survey Schedule A2-1

Appendix-3: List of Parties Concerned in the Recipient Country A3-1

Appendix-4: Minutes of Discussions A4-1

Appendix-5: Minutes of the Public Consultation Meeting A5-1

Appendix-6: Manual for the Preparation of Public Consultation Meeting A6-1

Appendix-7: Draft EIA Report A7-1

Appendix-8: Borehole Log A8-1

Appendices

Appendix-1: Member List of the Survey Team

(1) First Field Survey

Name	Position	Organization
Mr. Ken Imai	Leader	JICA
Mr. Keisuke Yamagami	Co-Leader	JICA
Mr. Kenichi Iwama	Chief Consultant/ Port Planner 1	Oriental Consultants Co., Ltd.
Mr. Takaaki Muroi	Co-Chief Consultant/ Port Planner 2/ Construction Planner & Cost Estimator	Oriental Consultants Co., Ltd.
Mr. Eiichi Matsuura	Port Facility Designer 1	Oriental Consultants Co., Ltd. (Ides)
Mr. Makoto Kobayashi	Port Facility Designer 2	Oriental Consultants Co., Ltd.
Mr. Yasuo Horigome	Architectural Planner & Designer	Oriental Consultants Co., Ltd.
Mr. Yuji Nozaki	Natural Condition Survey	Oriental Consultants Co., Ltd.
Mr. Shingo Shiratori		Oriental Consultants Co., Ltd.
Mr. Takeshi Sato	Environmental Specialist	Oriental Consultants Co., Ltd. (Ides)

(2) Support for the Public Consultation

Name	Position	Organization
Mr. Takaaki Muroi	Co-Chief Consultant/ Port Planner 2/ Construction Planner & Cost Estimator	Oriental Consultants Co., Ltd.
Mr. Takeshi Sato	Environmental Specialist	Oriental Consultants Co., Ltd. (Ides)

(3) Second Field Survey

Name	Position	Organization
Mr. Satoru Matsuyama	Leader	JICA
Mr. Shinji Sakurai	Senior Advisor	JICA
Mr. Kenichi Iwama	Chief Consultant/ Port Planner 1	Oriental Consultants Co., Ltd.
Mr. Takaaki Muroi	Co-Chief Consultant/ Port Planner 2/ Construction Planner & Cost Estimator	Oriental Consultants Co., Ltd.

Appendix-2: Survey Schedule

(1) 1st Field Survey (from August 22 to October 5, 2014)

Day	Date		Leader	Planning Coordinator	Cheef Consultant/Port Planner 1	Co-Cheef Consultant/Port Planner 2/Construction Planner/Cost Estimator	Port Facilities Designer 1	Port Facilities Designer 2	Architectural Planner/Designner	Natural Condition Survey	Environmental Specialist
			Mr. Ken IMAI	Mr. Keisuke YAMAGAMI	Mr. Kenichi IWAMA	Mr. Takaaki MUROI	Mr. Eiichi MATSUURA	Mr. Makoto KOBAYASHI	Mr. Yasuo HORIGOME	Mr. Yuji NOZAKI	Mr. Takeshi SATO
1	8/22	Fri	Move by Air NZ090 Tokyo-Auckland								Move by Air NZ090 Tokyo-Auckland
2	8/23	Sat	Arrive at Nuku'alofa by Air NZ270 13:25, 【6】Site Condition Survey								Arrive at Nuku'alofa by Air NZ270 13:25, 【6】Site Condition Survey
3	8/24	Sun	Internal Meeting								Internal Meeting
4	8/25	Mon	Meeting w/JICA, Courtesy Call on EOJ, Discussion with MOT & PAT/【9】Briefing on Grant Aid Scheme								【8】Environmental and Social Consideration/ 【6】Site Condition Survey
5	8/26	Tue	【6】Site Condition Survey/Minutes Discussion with MOI & PAT								Ditto
6	8/27	Wed	Minutes Discussions with MOI & PAT								Ditto
7	8/28	Thu	Minutes Discussions with MOI & PAT, Finalization of M/D								Ditto
8	8/29	Fri	Finalization and Signing on M/D, Report to JICA & EOJ					Move by Air NZ090 Tokyo-Auckland			Ditto
9	8/30	Sat	Move by Air from Nuku'alofa		Documentation			Arrive at Nuku'alofa by Air NZ270 13:25			Ditto
10	8/31	Sun			Internal Meeting			Internal Meeting			Internal Meeting
11	9/1	Mon			【5】Survey of other Donors Projects/【6】Site Condition Survey			【6】Site Condition Survey			【8】Environmental and Social Consideration/ 【6】Site Condition Survey
12	9/2	Tue			Ditto	【5】Survey of other Donors Projects/【6】Site Condition Survey/【7】Natural Condition Survey		Ditto			Ditto
13	9/3	Wed			Ditto	Ditto		Ditto			Ditto
14	9/4	Thu			Ditto	Ditto		Ditto			Ditto
15	9/5	Fri			Ditto	Ditto	Move by Air NZ090 Tokyo-Auckland	Ditto	Move by Air NZ090 Tokyo-Auckland		Ditto
16	9/6	Sat			【6】Site Condition Survey	【6】Site Condition Survey 【7】Natural Condition Survey	Arrive at Nuku'alofa by Air NZ270 13:25	【6】Site Condition Survey	Arrive at Nuku'alofa by Air NZ270 13:25		【8】Preparation of Environmental Survey/【6】Field Survey
17	9/7	Sun			Internal Meeting & Documentation						Internal Meeting & Documentation
18	9/8	Mon			【6】Site Condition Survey	【10】Procurement Survey 【7】Natural Condition Survey	【6】Site Condition Survey	【6】Site Condition Survey	【6】Site Condition Survey 【7】Natural Condition Survey	Move by Air NZ090 Tokyo-Auckland	【8】Preparation of Environmental Survey/【6】Field Survey
19	9/9	Tue			Ditto	Ditto	Ditto	Ditto	Ditto	Arrive at Nuku'alofa by Air NZ974 22:10	Ditto
20	9/10	Wed			Ditto	Ditto	Ditto	Ditto	Ditto	【7】Natural Condition Survey/ 【6】Site Condition Survey	Ditto
21	9/11	Thu			Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
22	9/12	Fri			【9】Study of Basic Plan	【9】Basic Plan/ 【11】Construction Survey	【9】Study of Basic Plan			Ditto	Ditto
23	9/13	Sat			Ditto	Ditto	Ditto			Ditto	Ditto
24	9/14	Sun			Internal Meeting						
25	9/15	Mon			【9】Study of Basic Plan	【9】Basic Plan/ 【11】Construction Survey	【9】Study of Basic Plan, Preliminary Design			【7】Natural Condition Survey/ 【6】Site Condition Survey	【8】Preparation of Environmental Survey/【6】Field Survey
26	9/16	Tue			Ditto	Ditto	Ditto			Ditto	Ditto
27	9/17	Wed			Ditto	Ditto	Ditto			Ditto	Ditto
28	9/18	Thu			Ditto	Ditto	Ditto			Ditto	Ditto
29	9/19	Fri			Ditto	Ditto	Ditto			Ditto	Ditto
30	9/20	Sat			Documentation and Report Writing						
31	9/21	Sun			Internal Meeting						
32	9/22	Mon			【9】Basic Plan/【12】Management and Maintenance	【9】Basic Plan/ 【11】Construction Survey	【9】Basic Plan/【12】Management and Maintenance	【9】Basic Plan, Preliminary Design	【9】Basic Plan, Report Writing	【6】Natural Condition Survey, Report Writing	【8】Environmental and Social Consideration/ 【6】Site Condition Survey
33	9/23	Tue			Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
34	9/24	Wed			Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
35	9/25	Thu			Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
36	9/26	Fri			Ditto	Ditto	Ditto	Move by Air to Aucland	Ditto	Ditto	Ditto
37	9/27	Sat			Report Writing			Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50	Report Writing	Ditto	Ditto
38	9/28	Sun			Internal Meeting				Internal Meeting		
39	9/29	Mon			Compilation of the report / each Job Roles		【9】Basic Plan, Report Writing		【9】Basic Plan, Report Writing	【6】Natural Condition Survey, Report Writing	Report Writing
40	9/30	Tue			Discussion with PAT / Compilation of the report / each Job Roles		Ditto		Ditto	Move by Air to Aucland	Ditto
41	10/1	Wed			Discussion with PAT, Report to JICA and Embassy / Move by Air to Aucland		Ditto		Ditto	Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50	Move by Air to Aucland
42	10/2	Thu			Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50		Ditto		Ditto		Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50
43	10/3	Fri					Move by Air to Aucland		Move by Air to Aucland		
44	10/4	Sat					Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50		Move from Aucland to Tokyo by Air NZ099, Arrive at Tokyo 16:50		

(2) Field Survey (from November 2 to November 11, 2014)

Day	Date		Co-Cheef Consultant/Port Planner 2/Construction Planner/Cost Estimator	Environmental Specialist
			Mr. Takaaki Muroi	**Mr. Takeshi Sato**
1	11/2	Sun	Move by Air NZ090 Tokyo-Aukland	
2	11/3	Mon	Arrive at Nuku'alofa by Air NZ970 13:10	
3	11/4	Tue	JICA, Discussion with MOI and PAT	
4	11/5	Wed	Discussion with PAT, MOI and MOE	
5	11/6	Thu	Preparation and Attending Public Consultation	
6	11/7	Fri	Discussion with Ministry of Fisheries and PAT	
7	11/8	Sat	Internal Meeting	
8	11/9	Sun	Documentations	
9	11/10	Mon	Move by Air NZ973 Nuku'alofa-Aukland	
10	11/11	Tue	Arrive at Tokyo by Air NZ099 16:55	

(3) 2nd Field Survey (from February 9 to February 19, 2015)

Day	Date		Leader	Senior Advisor	Cheef Consultant/Port Planner 1	Co-Cheef Consultant/Port Planner 2/Construction Planner/Cost Estimator
			Satoru Matsuyama	**Shinji Sakurai**	**Kenichi Iwama**	**Takaaki Muroi**
1	2/9	Mon			Move by Air KE706 Tokyo-Aukland	
2	2/10	Tue	Move by Air Tokyo-Aukland		Move by Air VA167 Aukland-Nuku'alofa	
3	2/11	Wed	Move by Air VA167 Aukland-Nuku'alofa		Discussion with JICA and PAT	
4	2/12	Thu	Discussion with JICA, MOI and PAT, Site Visit			
5	2/13	Fri	Minutes of Discussions with MOI			
6	2/14	Sat	Meeting with FISA, Inspection of Otuanga'ofa, Site Visit			
7	2/15	Sun	Internal Meeting and Documentations			
8	2/16	Mon	Report to JICA and Embassy / Move by Air to Aucland		Report to JICA and Embassy	
9	2/17	Tue	Arrive at Tokyo by Air		Meeting with FISA, JICA and MOI	
10	2/18	Wed			Meeting with MOE, Move by Air to Aukland	
11	2/19	Thu			Arrive at Tokyo by Air KE130 20:45	

Appendix-3: List of Parties Concerned in the Recipient Country

MOI (Ministry of Infrastructure)

Lord Tu'i Vakano	Prime Minister
Mr. Ringo K Fa'oliu	Chief Exective Officer
Ms. Kelera Tonga	Director of Marine & Ports Division
Mr. Tevita Lavemai	Acting Director for Land Transport Division

MOFNP (Ministry of Finance and National Planning)

Dr. 'Aisalce Eke	Minister
Mr. Tatafu Moeaki	Chief Exective Officer

PAT (Ports Authority Tonga)

Mr. Mossese Lavemai	General Manager
Mr. Iketau Kaufusi	Infrastructure & Technical Manager
Mrs. Mele Havea Lavemaau	Human Resources Manager
Capt. Hakaumotu Fakapelea	Port Master
Capt. Potesio Tu'angalu	Assistant Pilot

MOPE (Ministry of Public Enterprise)

Hon. Fe'ao Vakata	Minister
Mr. Siaosi Sovaleni	Chief Exective Officer

MEC (Ministry of Environment and Communications)

Hon. Samiu Vaipulu	Minister
Ms. Paula Mau	Chief Exective Officer
Mr. Sione Tukia Lepa	Chief Environment Officer

National Planning Authority Office

Lord Ma'afu	Minister of National Planning Authority
Mr. Tukua Tonga	Chief Operating Officer

FISA (Friendly Island Shipping Agency Limited)

Mr. Viliami Vakautapola VI	General Manager
Capt. Koli Loa'amanu	Capten of M.V.Otuanga'ofa

UATA Shipping Company

Mr. Etuate Uata	General Manager

Embassy of Japan

Dr. Kazuchika Hamuro	Ambassador
Mr. Tetsumi Murata	Counsellor
Mr. Takuya Kitahara	Researcher/Adviser
Ms. Eriko Oshimi	Chief of political & Economic Sec.

JICA Tonga Office

Mr. Hiroshi Kikawa	Resident Representative
Mr. Kaname Ishiguro	Program Formulation Advisor

Appendix-4: Minutes of Discussions

The following minutes are attached in this appendix.

1) M/D at 1st field survey dated August 29, 2014

2) Memorandum at 1st field survey dated September 26, 2014

3) M/D at 2nd field survey dated February 13, 2015

Minutes of Discussions
on the Preparatory Survey
for the Project for
Upgrade of Wharf for Domestic Transport

In response to the request from the Government of Kingdom of Tonga (hereinafter referred to as "Tonga"), the Government of Japan decided to conduct a Preparatory Survey on "The Project for Upgrade of Wharf for Domestic Transport" (hereinafter referred to as "the Project"), and entrusted the Survey to Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent the Preparatory Survey Team to Tonga for the Outline Design (hereinafter referred to as "the Team"). The Team is headed by Mr. Ken IMAI, Advisor, Infrastructure and Peace building Department, JICA, and is scheduled to stay in the country from 22nd August to 3rd October, 2014.

The Team held a series of discussions with the officials concerned of Tonga and conducted a field survey in the Project Site. In the course of the discussions, both sides have confirmed the main items described in the attached sheets. The Team will proceed to further works and prepare the Preparatory Survey Report.

Nuku'alofa, August 29th, 2014

Ken IMAI
Leader of Preparatory Survey Team
Japan International Cooperation
Agency
Japan

Tatafu Moeaki
Chief Executive Officer
Ministry of Finance and National
Planning
Tonga

Ringo K Fa'oliu
Chief Executive Officer
Ministry of Infrastructure
Tonga

ATTACHEMENTS

1. Objective of the Project

The objective of the Project is to improve handling efficiency in order to ensure safety of Nuku'alofa port through separating domestic and international cargos.

2. Project Site

The Project Site is Faua Wharf in Nuku'alofa, the capital city of Tonga (Annex-1).

3. Executing and Implementing Agencies

The Executing Agency for the Project is the Ministry of Finance and National Planning, and Implementing Agency for the Project is the Ministry of Infrastructure (hereinafter MOI).

The each Agency charts are shown in Annex-2.

4. Scope of the Project agreed by both sides

4-1. The Tonga side and the Team reconfirmed that the component of upgrade of Nafanua Wharf would not be included in the Project, and the Team would conduct the Preparatory Survey focusing on the component of upgrade of Faua Wharf(Annex-6).

4-2. Tonga side and the Team agreed to change the Project Site location to western side sea area of Faua Wharf.

As a result, Tonga side requested construction of a new wharf for a large size vessel at Project Site.

JICA will assess the appropriateness of the request through the Preparatory Survey and will report the findings to the Government of Japan. As a result of the Preparatory Survey, JICA will decide whether the Environmental Category needs to be changed or not.

The Tonga side understands the general rule of Japan's Grant Aid Scheme that final approval of the Project will be decided by the Government of Japan.

5. Japan's Grant Aid Scheme

5-1. The Team informed to the Tonga side about the Japan's Grant Aid Scheme and necessary measures to be taken by Tonga. The Team explained the procedures for

the Project described in Annex-3 and 4.

5-2. Tonga side will take the necessary measures, as described in Annex-5 for smooth implementation of the Project, as a condition for the Japan's Grant Aid to be implemented.

6. Environmental and Social Considerations

6-1. The Team explained that the Environmental Category of this project is categorized as "Category B" at this moment. However, there is a possibility that JICA will change the Category from B to A in future, if any major environmental impact is identified during the course of the Survey such as existence of large-scale and/or endangered coral species in the Project Site. Tonga side will take necessary measures in accordance to JICA Environmental and Social Consideration Guideline, and the Team will support Tonga side.

Tonga side agreed that the current project schedule would be delayed and the terms of the Survey extended if the Environmental Category changes from B to A, because of necessary additional procedure and surveys. JICA will inform the result of the Environmental Category decision on Tonga side as soon as possible after the completion of this field survey.

6-2. MOI is responsible for obtaining environmental permit of this Project, required under the Environmental Impact Assessment Act 2003. This includes preparation and submission of Proposal notification (Form 1), EIA report and other documents requested by the Ministry of Environment and Communication (hereinafter MEC). The Proposal notification should be submitted to MEC by the end of September 2014, and notify JICA the results of MEC's decision as soon as possible. MOI will also be responsible for organizing public involvement activities (e.g. public consultation meeting) required under the Environmental Impact Assessment Regulation 2010. The Team will provide MOI necessary technical assistance and all the environmental information collected during the course of the Survey. MOI should obtain environmental permit by February 2015 at the latest, unless there is any delay in the works and schedule of the Team, or the changing of the Environmental Category.

7. Schedule of the Survey

Assuming the Environmental Category for this project is "B", Tonga side and the Team agreed to the schedule below.

7-1. The Team will proceed with further field survey until 3rd October, 2014.

7-2. JICA will prepare the draft report and the draft specification and dispatch a mission in order to explain their contents around February, 2015.

7-3. If the contents of the draft final report are accepted in principle by the Tonga side, JICA will complete the final report and send it to Tonga around the late part of March, 2015.

8. Other Relevant Issues

8-1. Tonga side shall, at its own expense, provide the Team with the following items for the convenience of the Survey.

(1) Security-related information as well as measures to ensure the safety of the Team.
(2) Information as well as support in obtaining medical service.
(3) Data and information necessary for the Survey.
(4) Counterpart personnel.
(5) Entry permits necessary for the Survey team members to conduct field surveys.
(6) Work space and internet for the Team

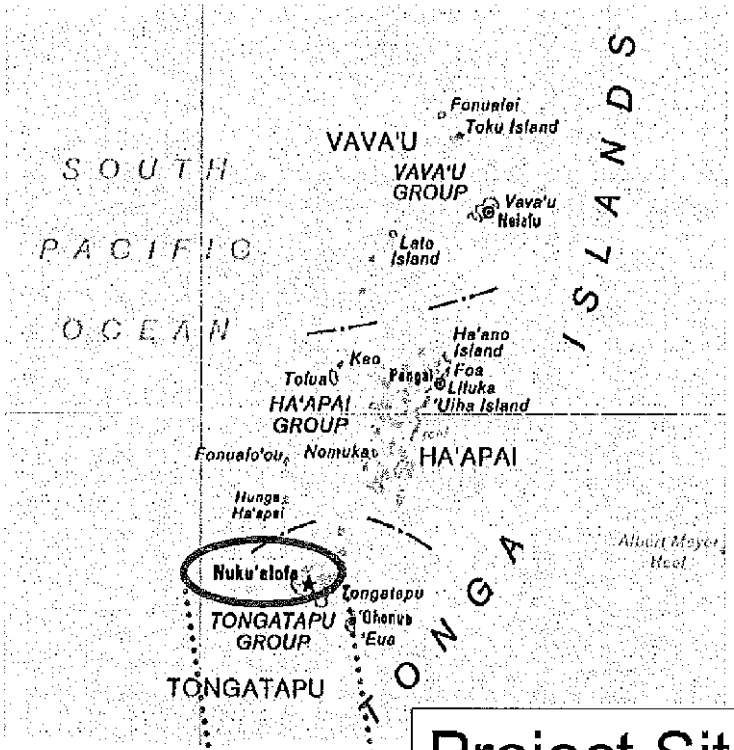
8-2. Tonga side accepted that the following undertakings should be taken by the Tonga side at the Tonga's expenses under the Project if implementation of the Project is approved by the Government of Japan.

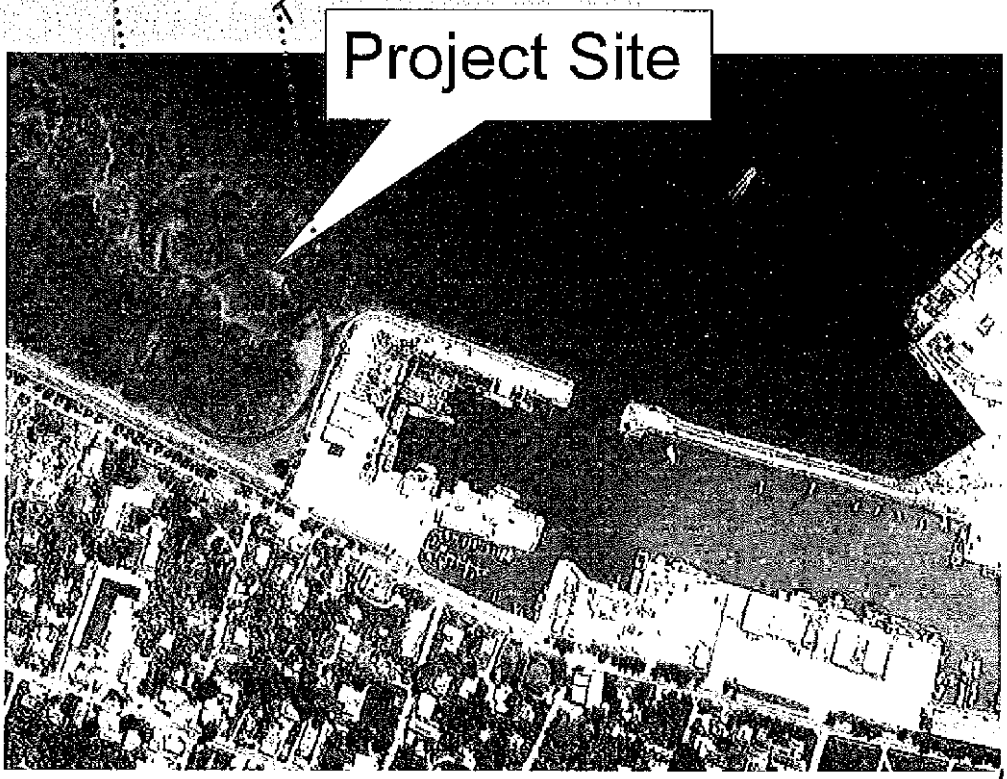
(1) To provide tax exemption for construction materials and equipment for the Project.
(2) To secure sites for material storing yard, temporary construction yard and waste disposal.
(3) To remove or relocate not abandoned ships or existing utilities or waste within the Project Site to designated area or Project affected area, before Pre-Qualification (PQ) of the Project.
(4) To implement coral relocation before PQ, if needed.
(5) To arrange issuance of license, permission and other necessary procedures (including acquisition of the permit and licenses for disposal of dredged materials) for the Project.
(6) To secure enough budget and personnel necessary for the operation maintenance of the facilities implemented by the Project, including the periodical maintenance work after the completion of the Project.

Annex-1 Project Site
Annex-2 Organization Chart
Annex-3 Japan's Grant Aid
Annex-4 Flow Chart of Japan's Grant Aid Procedures
Annex-5 Major Undertakings to be taken by Each Government
Annex-6 Summary of Preliminary Survey on the Project for Upgrade of Domestic Wharves

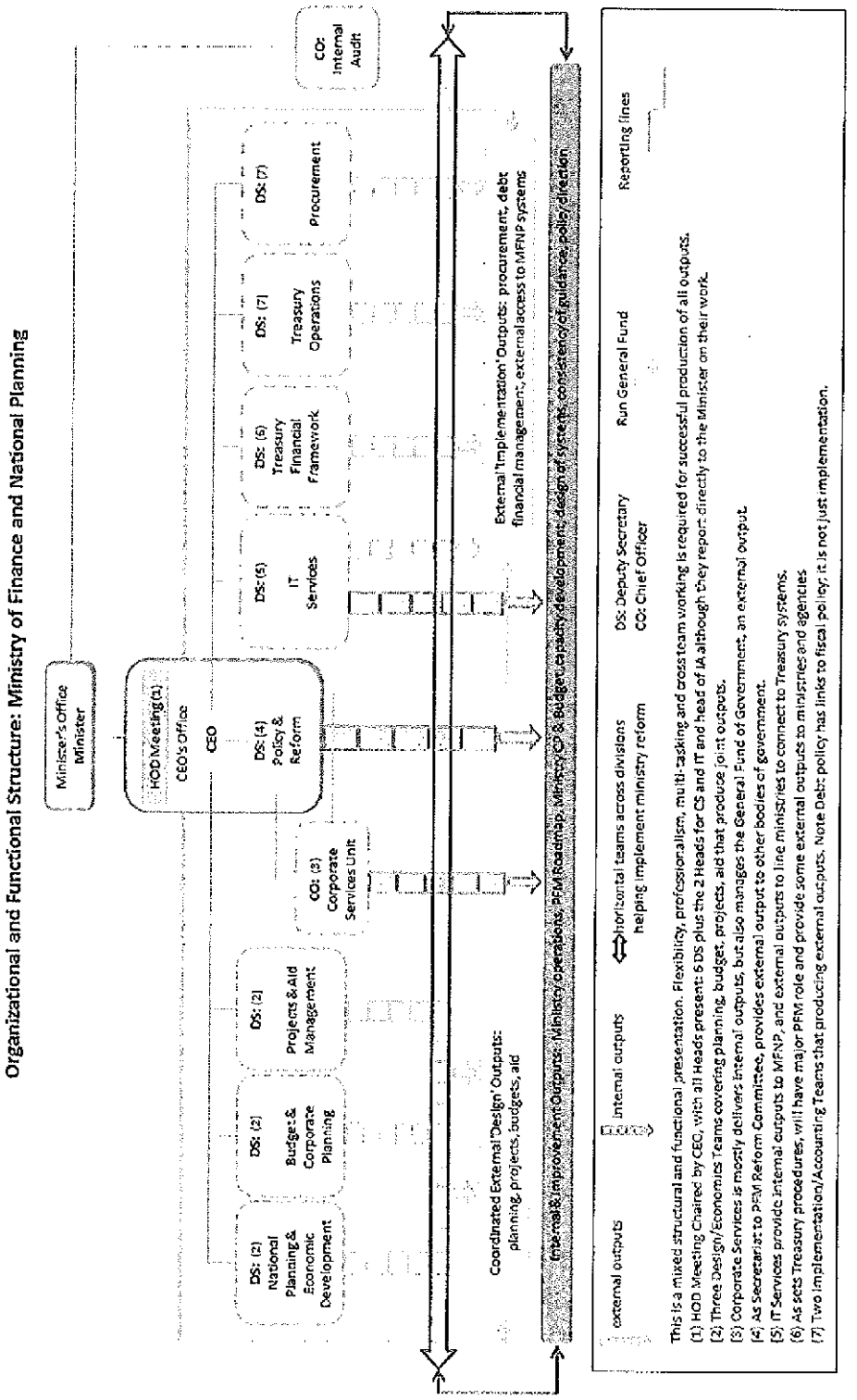
Annex-1

Project Site



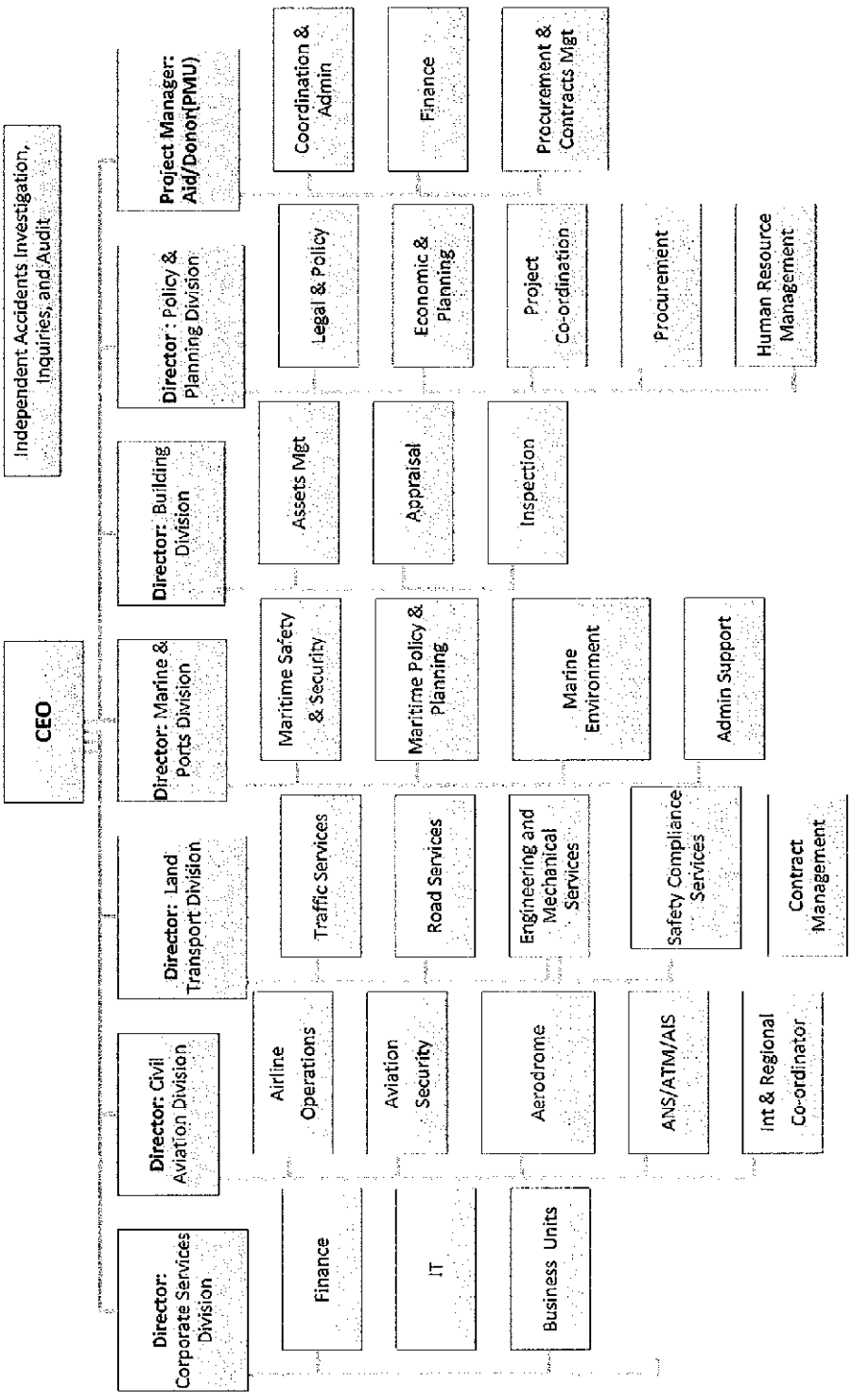


Annex2-1


Organizational and Functional Structure: Ministry of Finance and National Planning
Minister's Office
Minister
HOD Meeting (1)
CEO's Office
CEO
DS: (2) National Planning & Economic Development
DS: (2) Budget & Corporate Planning
DS: (2) Projects & Aid Management
CO: (3) Corporate Services Unit
DS: (4) Policy & Reform
DS: (5) IT Services
DS: (6) Treasury Financial Framework
DS: (7) Treasury Operations
DS: (7) Procurement
CO: Internal Audit
Coordinated External 'Design' Outputs: planning, projects, budgets, aid
External 'Implementation' Outputs: procurement, debt financial management, external access to MFNP systems
Internal Improvement Outputs: Ministry operations, PFM Roadmap, Ministry CB & Budget capacity development, design of systems, consistency of guidance, policy direction
external outputs
internal outputs
horizontal teams across divisions helping implement ministry reform
DS: Deputy Secretary
CO: Chief Officer
Run General Fund
Reporting lines
This is a mixed structural and functional presentation. Flexibility, professionalism, multi-tasking and cross team working is required for successful production of all outputs.
(1) HOD Meeting Chaired by CEO, with all Heads present: 6 DS plus the 2 Heads for CS and IT and head of IA although they report directly to the Minister on their work.
(2) Three Design/Economics Teams covering planning, budget, projects, aid that produce joint outputs.
(3) Corporate Services is mostly delivers internal outputs, but also manages the General Fund of Government, an external output
(4) As Secretariat to PFM Reform Committee, provides external output to other bodies of government.
(5) IT Services provide internal outputs to MFNP, and external outputs to line ministries to connect to Treasury systems.
(6) As sets Treasury procedures, will have major PFM role and provide some external outputs to ministries and agencies
(7) Two Implementation/Accounting Teams that producing external outputs. Note Debt policy has links to fiscal policy; it is not just implementation.

Annex 2-2

Organizational and Functional Structure: Ministry of Infrastructure



Annex-3

JAPAN'S GRANT AID

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund provided to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

・Preparatory Survey
- The Survey conducted by JICA

・Appraisal &Approval
-Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet

・Authority for Determining Implementation
-The Notes exchanged between the GOJ and a recipient country

・Grant Agreement (hereinafter referred to as "the G/A")
-Agreement concluded between JICA and a recipient country

・Implementation
-Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for

the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a outline design of the Project.
- Estimation of costs of the Project.

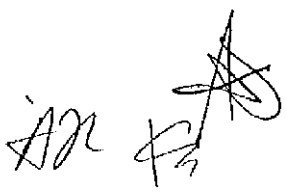
The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Outline Design of the Project is confirmed based on the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey



JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project's implementation after the E/N and G/A.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Annex.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

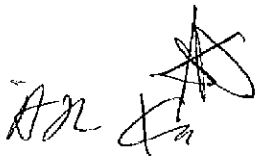
b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions paid to the Bank.

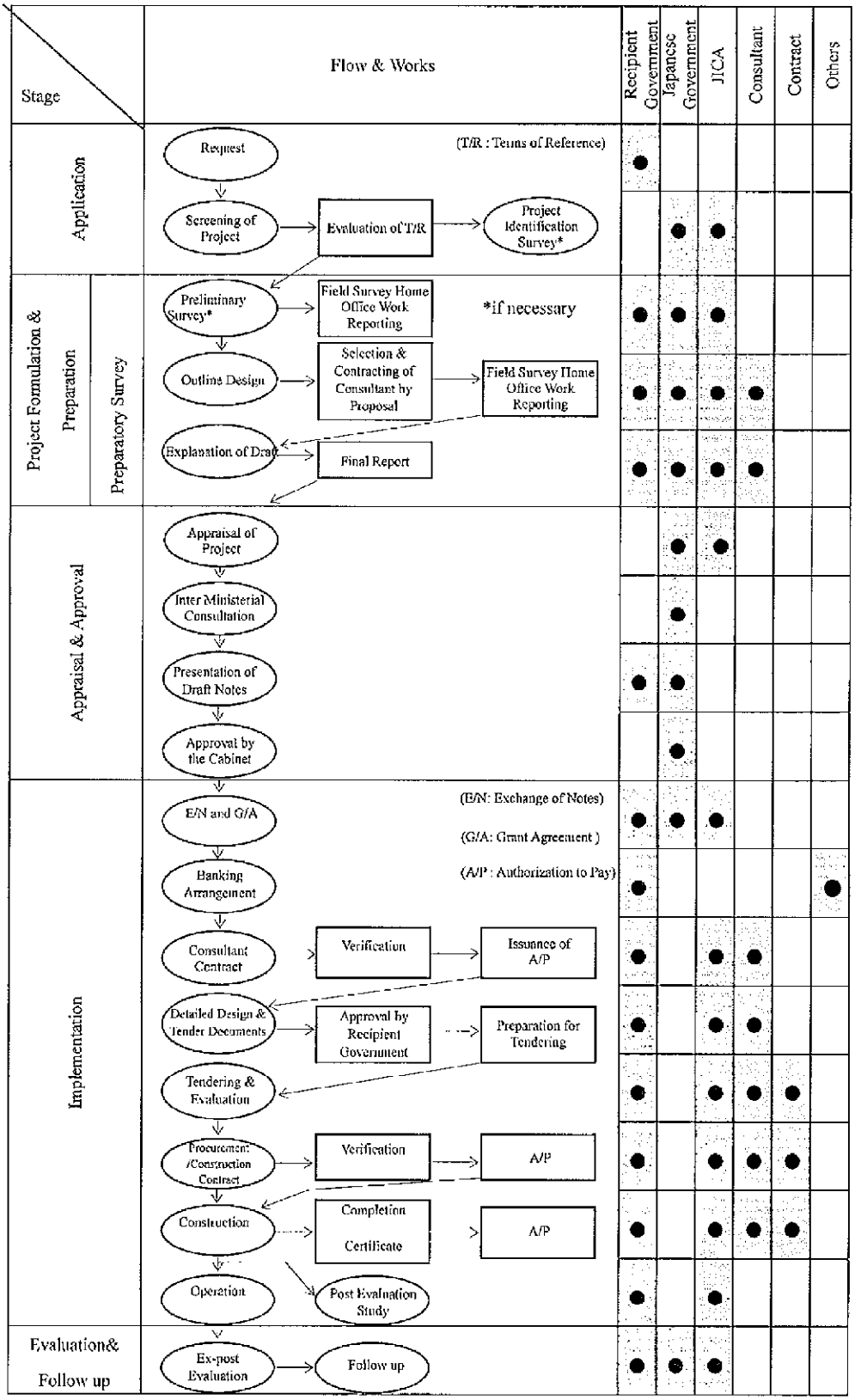
(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA socio-environmental guidelines.



Annex-4

FLOW CHART OF JAPAN's GRANT AID PROCEDURES



Annex-5

Major Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	to secure a lot of land and sea necessary for the implementation of the Project and to clear the site		●
2	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products		
	1) Marine (Air) transportation of the Products from Japan to the recipient country	●	
	2) Internal transportation from the port of disembarkation to the project site		●
3	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the products and the services be exempted		●
4	To accord Japanese physical persons and / or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
5	To ensure that the Facilities and the products be maintained and used properly and effectively for the implementation of the Project		●
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project		●
7	To bear the following commissions paid to the Japanese bank for banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
8	To give due environmental and social consideration in the implementation of the Project.		●
9	To remove or relocate not used ships or existing utilities or waste within the Project site to designated area or Project affected area, before PQ tender of this project		●
10	To take some measures against corals that lies in Project site (if necessary), before PQ tender of this project.		●

(B/A : Banking Arrangement, A/P : Authorization to pay)

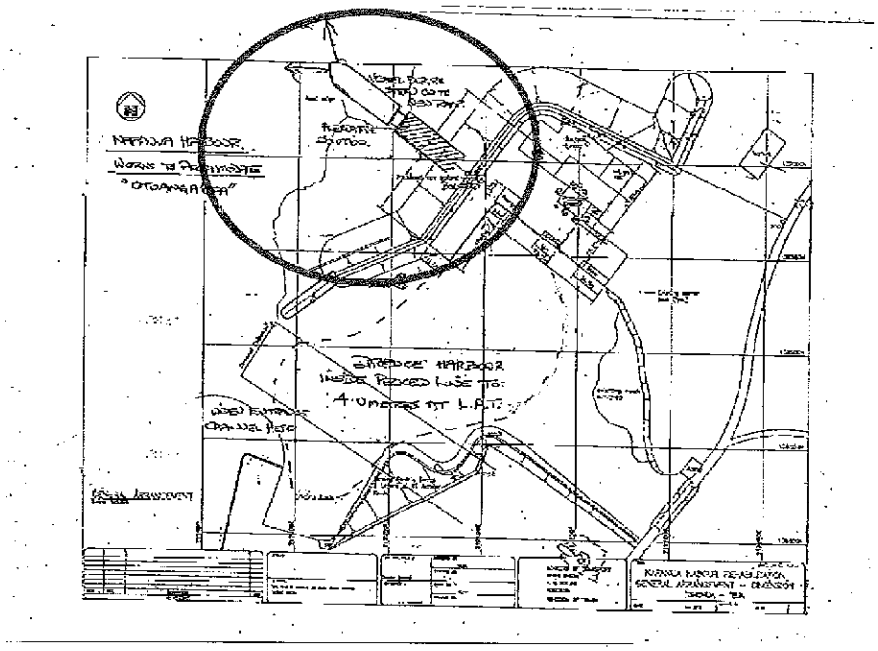
Annex-6

Summary of Preliminary Survey on the Project for Upgrade of Domestic Wharves

The result of the Preliminary Survey on the Project for Upgrade of Domestic Wharves on February 2014 is as follows;

1. The component of upgrade of Faua Wharf is crucial to ensure safety of domestic passengers and cargoes, and it is expected technically feasible. In this sense, the preparatory survey will cover this component.

2. However, under the constrain of the budget, the component of upgrade of Nafanua Wharf seems technically and economically difficult due to the following aspects, which simply consists of outer extension (shown below with red circle) of a new wharf to accommodate "Otuanga'ofa".
- Calmness of the ocean waters cannot be secured outside the harbor to safely accommodate "Otuanga'ofa" as well as "Onemoto".
- The new wharf is expected to be used only a few days a year to accommodate "Otuanga'ofa".



3. Therefore, the component of upgrade of Nafanua Wharf will not be included in the preparatory survey.

4. In short, Japan will conduct the preparatory survey focusing on the component of upgrade of Faua Wharf.

Memorandum of Discussions for the Outline Design
on the Preparatory Survey
for the Project for
Upgrade of Wharf for Domestic Transport

Ministry of Infrastructure (hereinafter referred to as "MOI") and the joint venture of the Oriental Consultants Co., Ltd and Ides Inc. on behalf of the JICA Preparatory Survey Team (hereinafter referred to as "the Team") are confirmed the following items to conduct a Preparatory Survey on "The Project for Upgrade of Wharf for Domestic Transport" (hereinafter referred to as "the Project").

1. Outline Design

The outline design of the Project will be conducted in Japan based on the Minutes of Discussions which was signed on August 29, 2014 between the JICA and the Tongan Government (hereinafter referred to as "the Minutes") and the survey results which was conducted by the Team during their stay in Tonga from August 22 to October 3, 2014.

The Team explained to MOI about their survey results and preliminary concept for the outline design of the Project as hereunder. However, contents, components, scale, dimensions and other details of the Project are subject to further study to be finalized based on the discussions in Japanese side.

(1) Port Layout Plan

The port layout was planned as shown in **Annex-1** as "General Concept of Port Layout Plan". The main facilities of the new wharf will be as follows.

a) Breakwater: Approx. 200 m
b) Approach Channel: Depth -4.0 m, Width 60 m
c) Turning Basin: Depth -4.0 m, Area Diameter 120 m
d) Wharf: L=110 m x B=45 m for M.V. Otuanga'ofa
   L=110 m x 25 m for Private Ferry
   L=145 m x 15 m for Other Cargo Ships
e) Terminal Building for Domestic Ferry Passengers: 1 No.
f) Parking Lots: 1 Lot
g) Access Road and Walkway: 1 Lot
h) Yard Lighting Facilities: 1 Lot
i) Fences and Gates: 1 Lot
j) Navigational Aids: 1 Lot

The structural type of wharf will be "Sheet Pile Quaywalls" as shown in **Annex-2** (Typical Cross -section of Wharf and Breakwater) by the results of the comparative examination. The structural type of breakwater will be a rubble mound breakwater with armor stones. The length and detailed structures of breakwater will be reviewed by the results of the wave analysis which are conducted in Japan.

(2) Terminal Building Plan

The architectural design for Terminal Building is planned as shown in **Annex-3**. Outline of the main functions of the building will be as follows.

a) Ground Floor: Waiting Hall for the Passenger, Entrance Hall, Ticket Counter and Office, Toilet (20 booths for female, 5 booths and 15 urinals for male), Pump room.
b) 1st Floor: Restaurant, Kitchen, Toilet, Electrical and Machinery rooms. Restaurant will contribute to the regional activation by its ability to pull in more customers. This floor will be connected to Promenade Deck served as Tsunami Evacuation Deck for the people.
c) 2nd Floor: Offices for Terminal Operation.
d) Total floor area will be approx. 2,060m^2, and 3-story building.
e) Big Roof can be utilized for Solar Photo Panel and maintenance route.
f) Waiting Hall, Restaurant and Entrance Hall can accommodate approx. 700 passengers, which are decided by the results of field survey and the study of the traffic data evaluation.
g) Evacuation Deck for the people on the 1st Floor approx.165m^2 equipped with Evacuation Slope and exterior, interior stair ways, those facilities combined with restaurant can accommodate more than 700 people in the time of tsunami disaster.
h) Natural ventilation system will be completely adapted for waiting hall and restaurant.
i) Emergency Generator and Transformer will be set on 1st Floor to avoid intrusion.
j) Rain-water harvesting system will be introduced using underground water tank.

2. Major Undertakings by Tongan Side

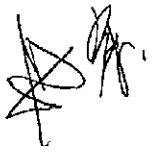
MOI accepted that the following undertakings should be taken by the Tongan side at the Tonga's expenses under the Project if implementation of the Project is approved by the Government of Japan.

(1) To remove or relocate the abandoned ships, existing utilities and wastes within the Project Site as shown in **Annex-4** before Pre-Qualification (PQ) of the Project.
(2) To secure and clear the sites for material storing yard and temporary construction yard as shown in **Annex-5**.
(3) To secure and clear the waste disposal yard for the dredged materials as shown in **Annex-5**.
(4) The following items for the terminal building should be excluded from the Project.
   - Kitchen instrument
   - Electric appliance except lighting equipment, outlets, air-conditioners, fire-alarm boxes, air fans, telephone outlet
   - Movable furniture

   The fixed furniture will be finalized within the project budget based on the discussions in Japanese side.

Above items were confirmed and agreed between MOI and the Team.

Nuku'alofa, September 26, 2014



Ringo K Fa'oliu
Chief Executive Officer
Ministry of Infrastructure
Tonga

Kenichi Iwama
Chief Consultants
Oriental Consultants Co., Ltd.
on behalf of JICA Study Team

< Attachment >

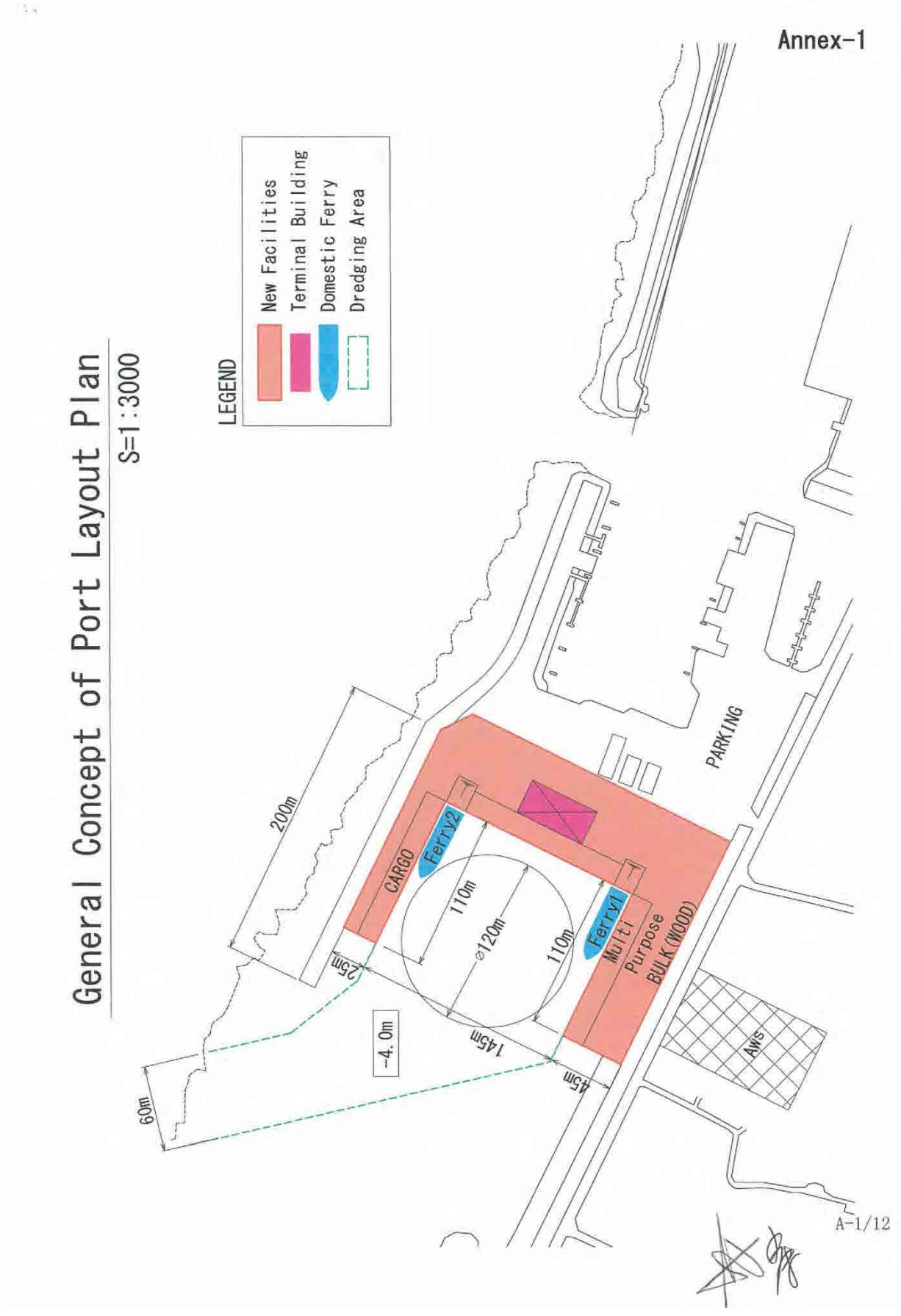
Annex-1: General Concept of Port Layout Plan

Annex-2: Typical Cross Section of Wharf and Breakwater

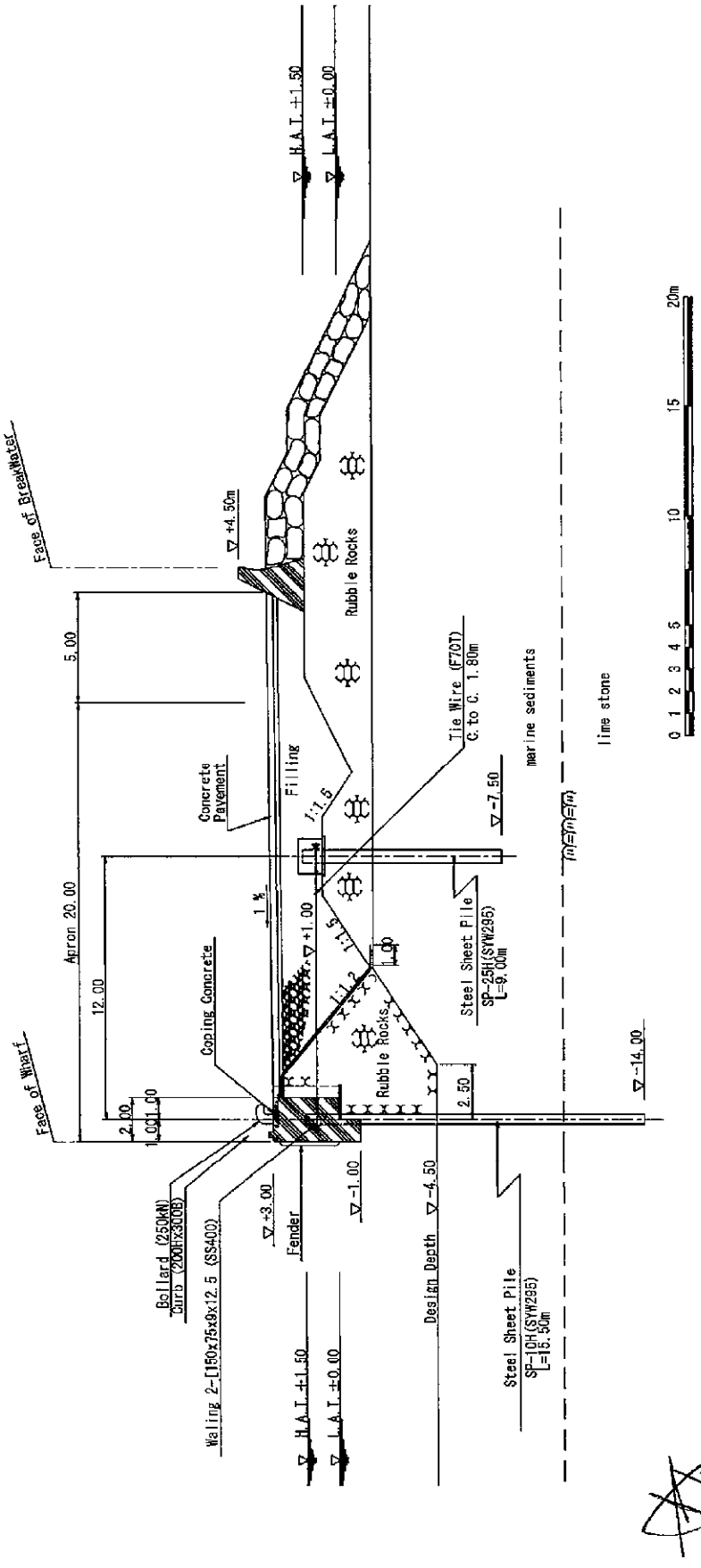
Annex-3: Terminal Building Plan

Annex-4: Ships, Utilities and Wastes to be removed in Faua Wharf

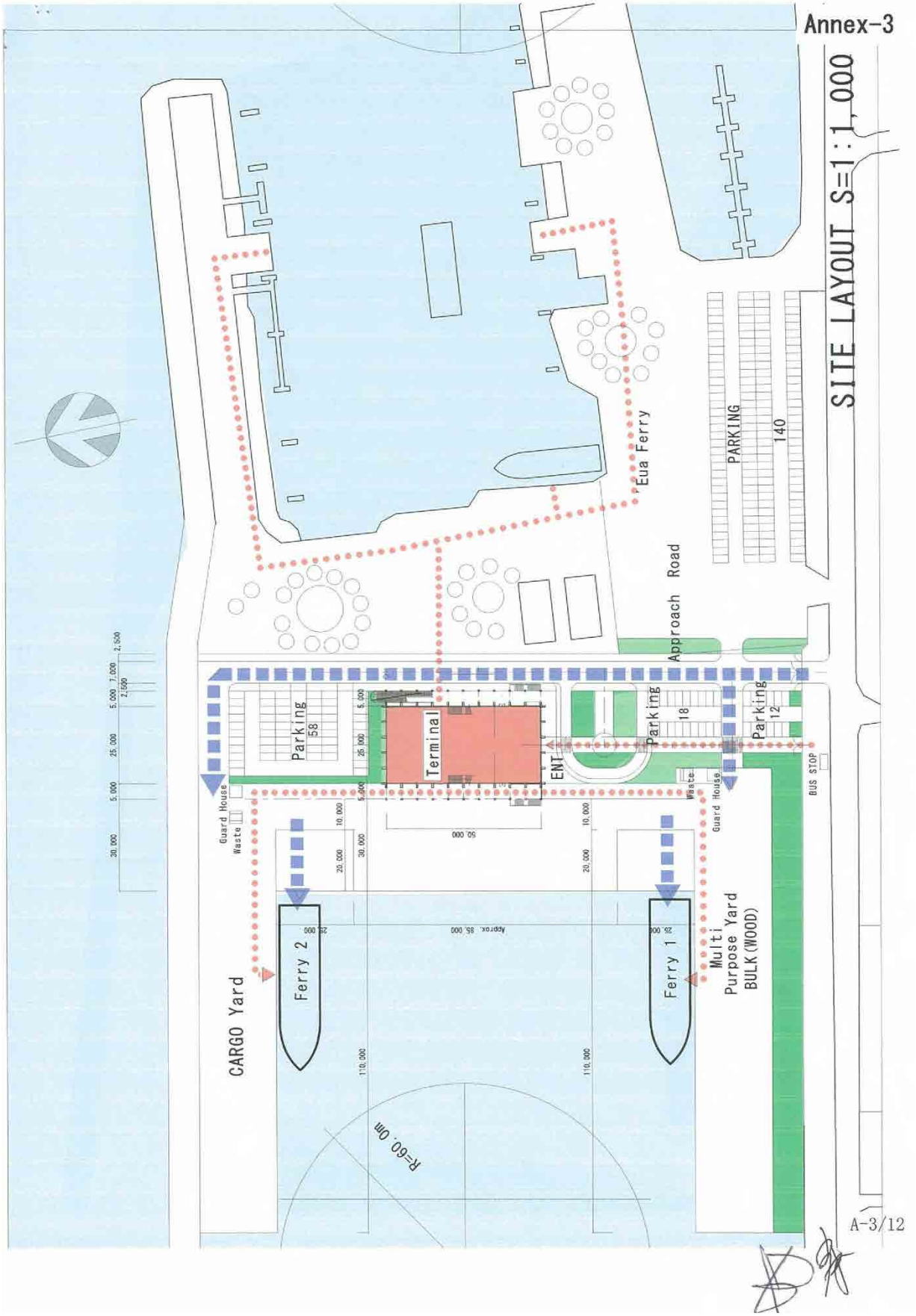
Annex-5: Location of Material Storage Yard, Temporary Construction Yard and Waste Disposal Yard

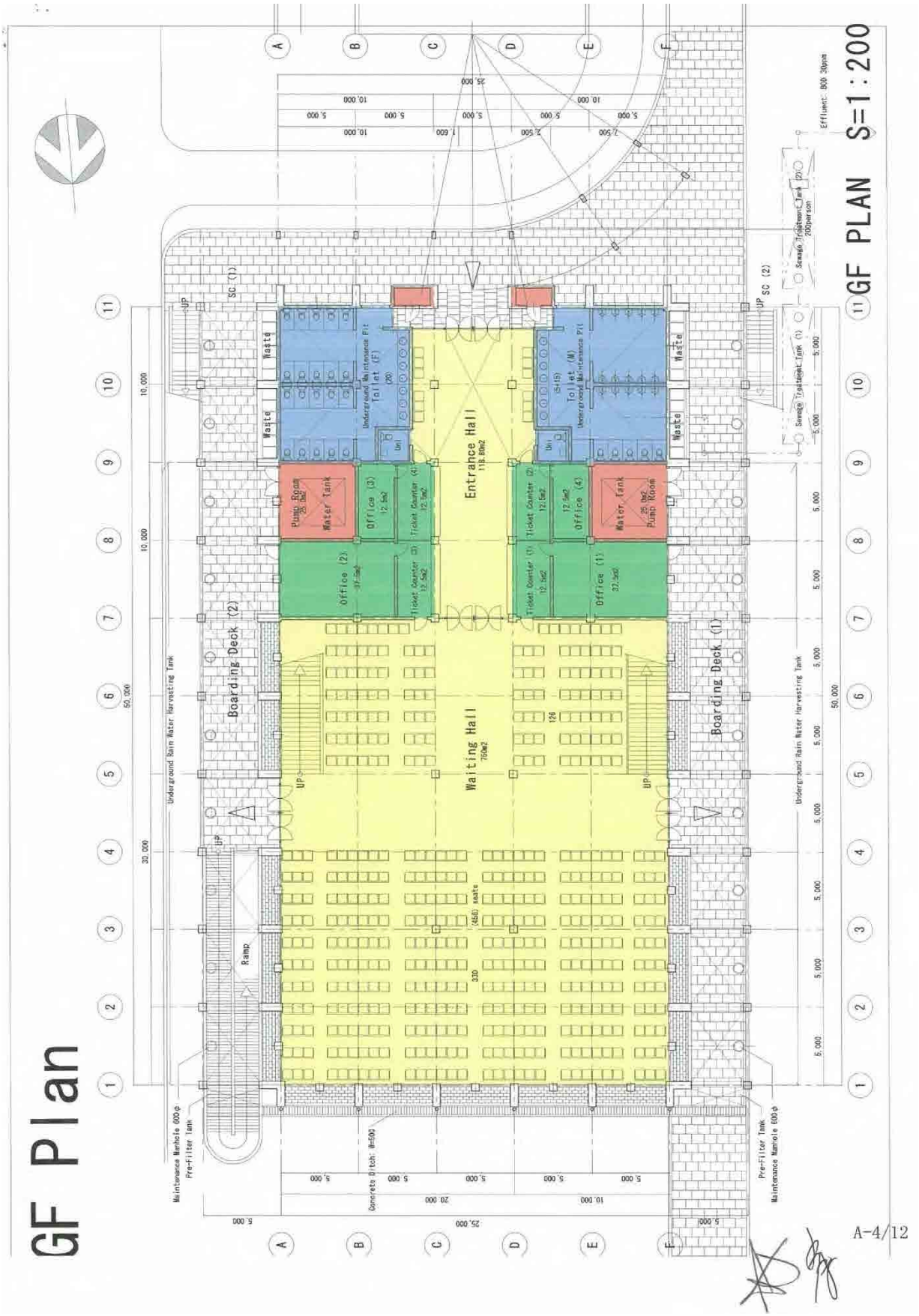

Annex-1
General Concept of Port Layout Plan
S=1:3000
LEGEND
New Facilities
Terminal Building
Domestic Ferry
Dredging Area
PARKING
200m
CARGO
Ferry2
110m
ø120m
110m
Ferry1
Multi
Purpose
BULK(WOOD)
25m
-4.0m
145m
45m
60m
AWS
A-1/12

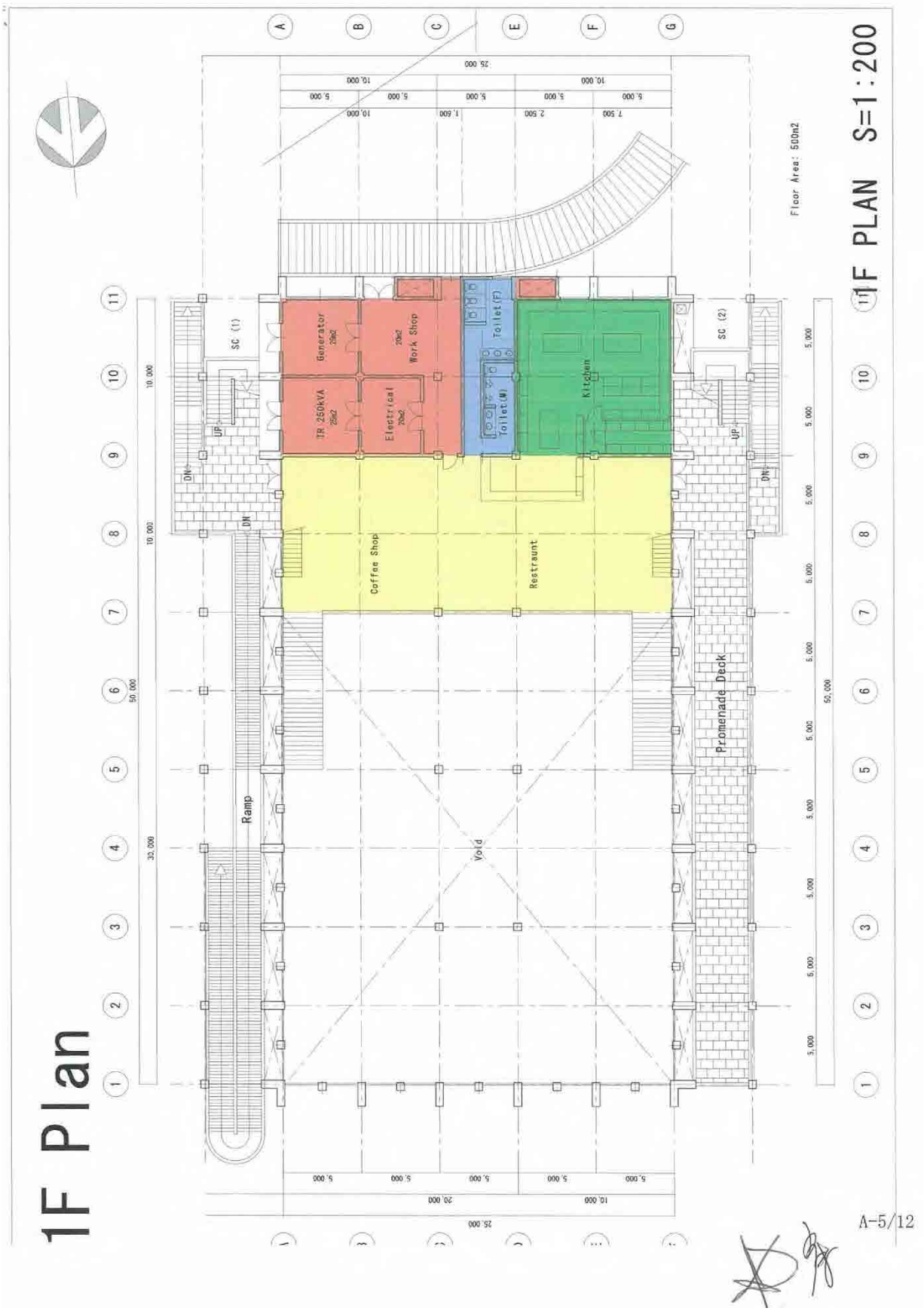
Annex-2

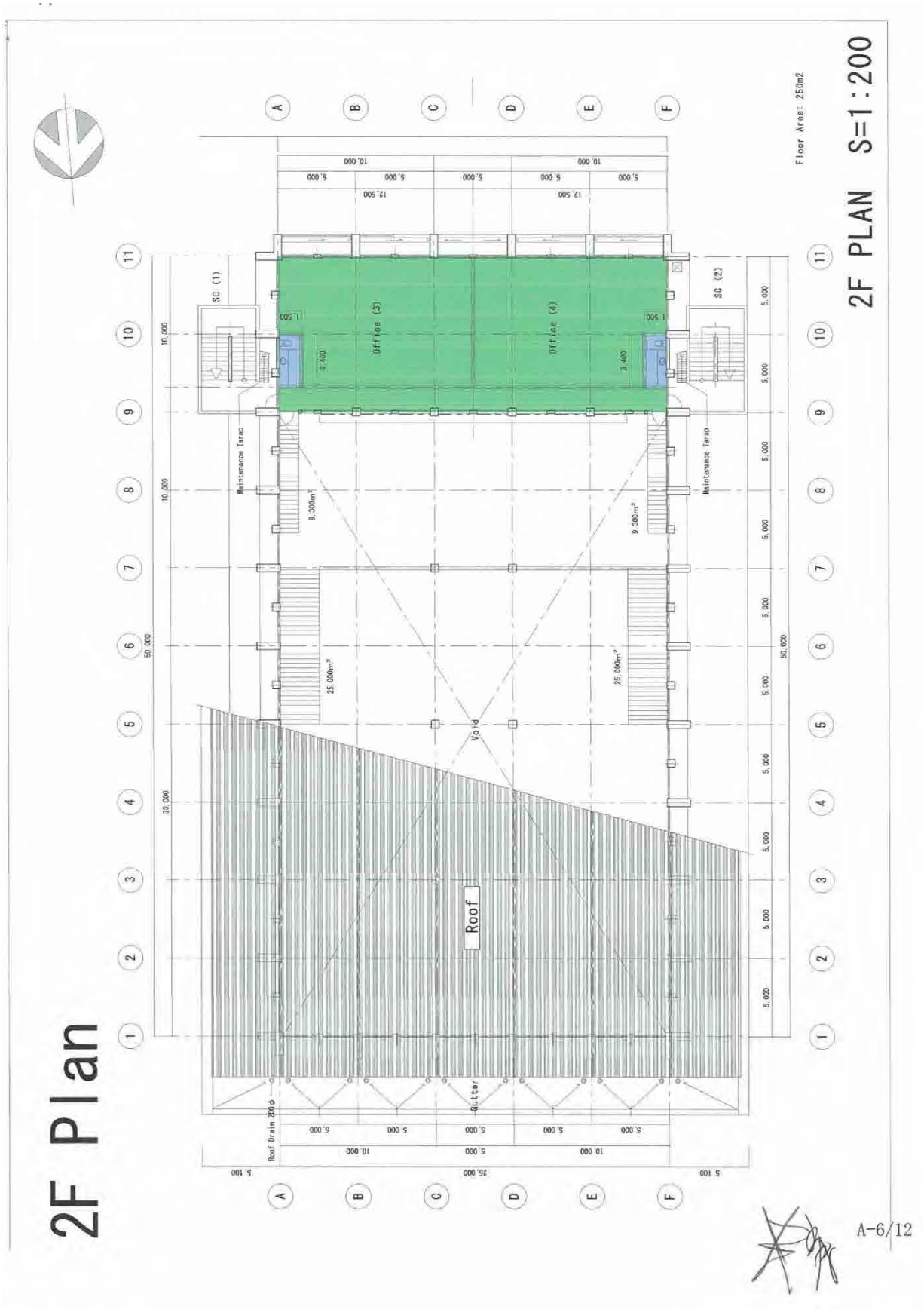

H.A.T.+1.50
L.A.T.±0.00
Face of BreakWater
▽+4.50m
Rubble Rocks
5.00
Concrete Pavement
Filling
1:1.5
Tie Wire (F70T)
C. to C. 1.80m
marine sediments
lime stone
▽-7.50
Apron 20.00
12.00
1%
▽+1.00
1:1.5
1:1.2
Coping Concrete
Steel Sheet Pile
SP-25H(SYW295)
L=9.00m
Rubble Rocks
2.50
2.00
1.00
1.00
Face of Wharf
▽-14.00
▽-1.00
▽-4.50
Design Depth
Bollard (250kN)
Curb (200Hx300B)
Waling 2-[180x75x9x12.5 (SS400)
▽+3.00
Fender
Steel Sheet Pile
SP-10H(SYW295)
L=15.50m
H.A.T.+1.50
L.A.T.±0.00
0 1 2 3 4 5 10 15 20m

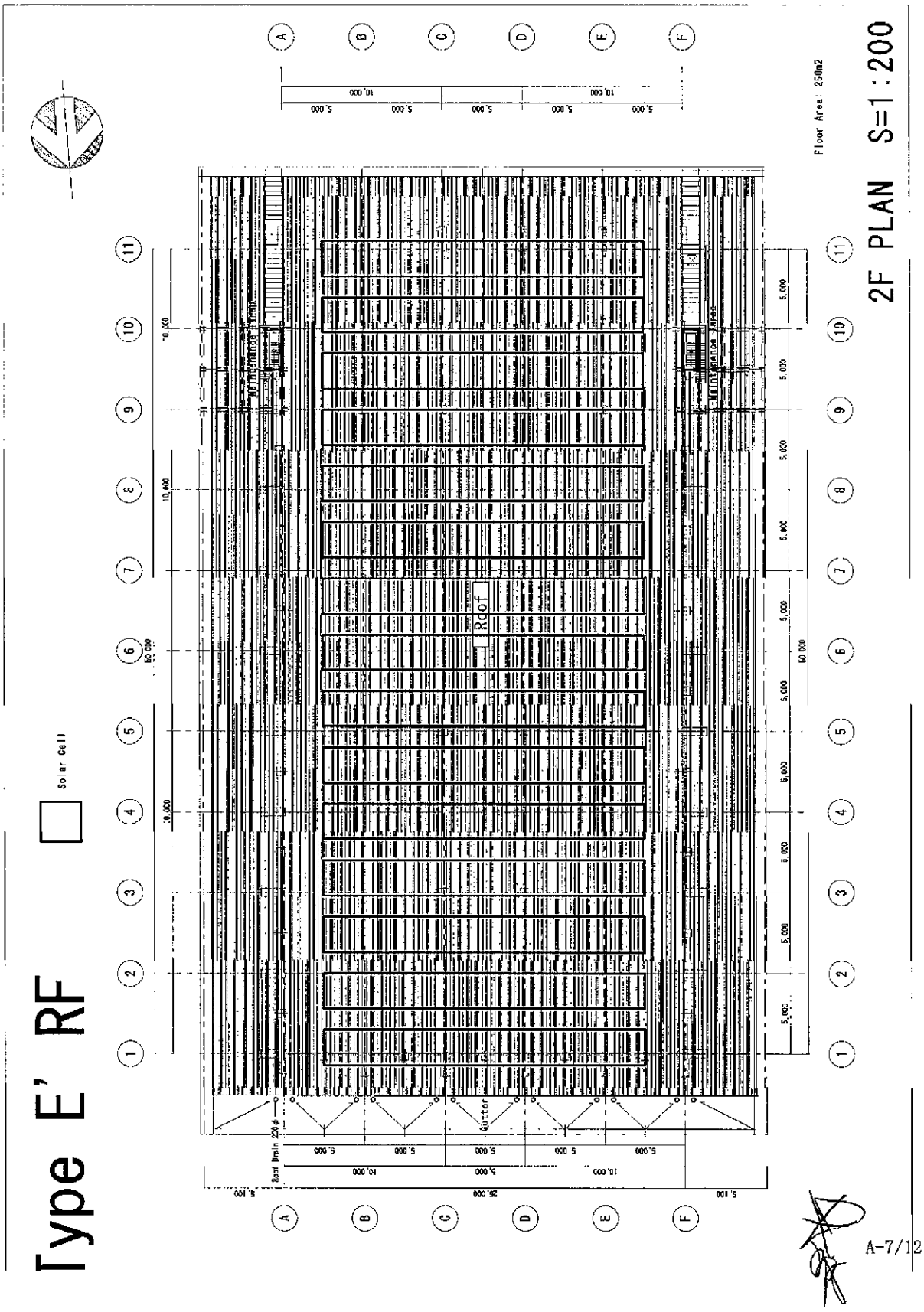
A-2/12

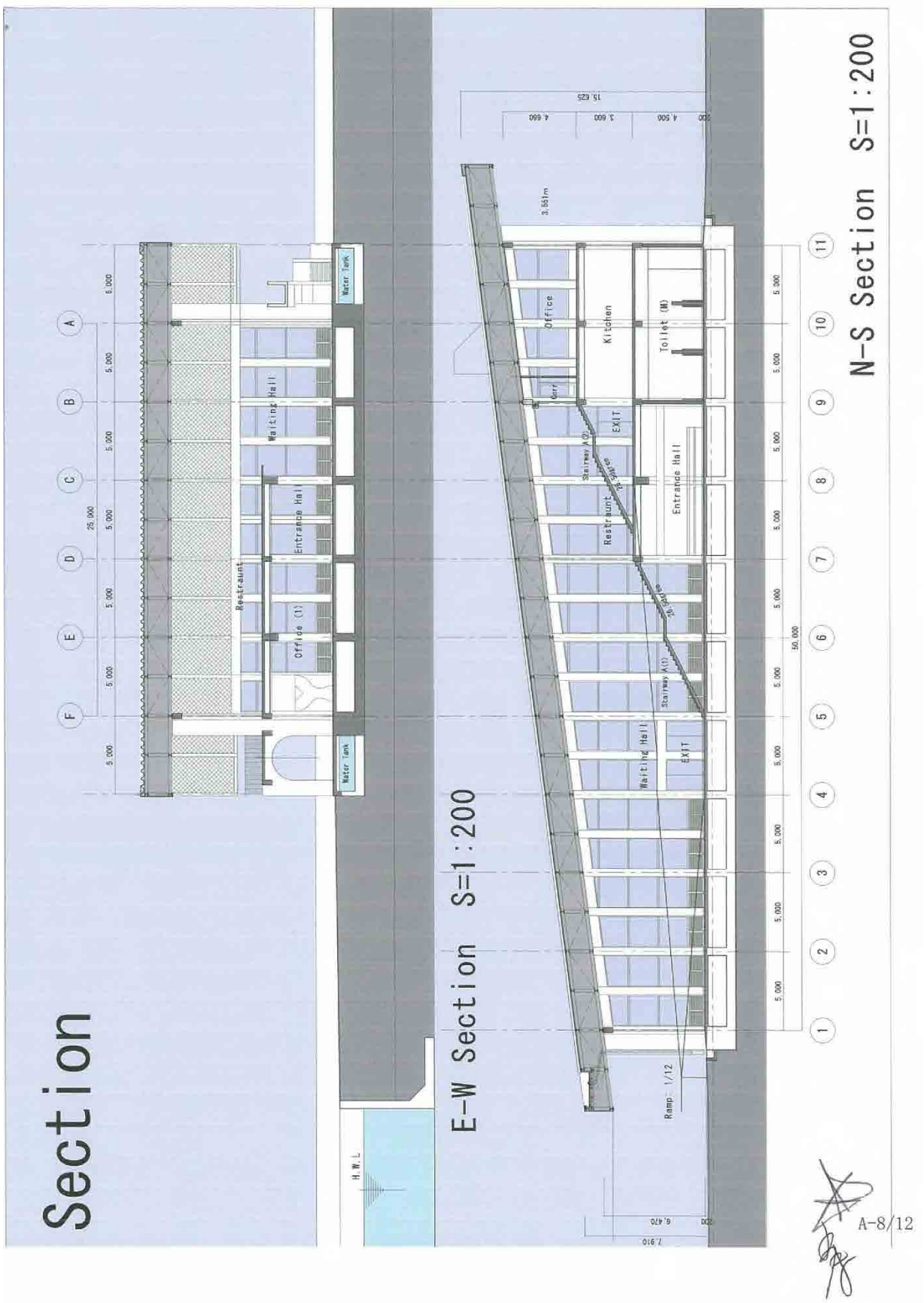

Annex-3
SITE LAYOUT S=1:1,000
Eua Ferry
PARKING
140
Approach Road
Parking
58
Terminal
ENT
Parking
18
Parking
12
Guard House
Waste
Guard House
Waste
BUS STOP
50,000
10,000
20,000
30,000
CARGO Yard
Ferry 2
Ferry 1
Multi
Purpose Yard
BULK(WOOD)
110,000
R=60.0m
A-3/12

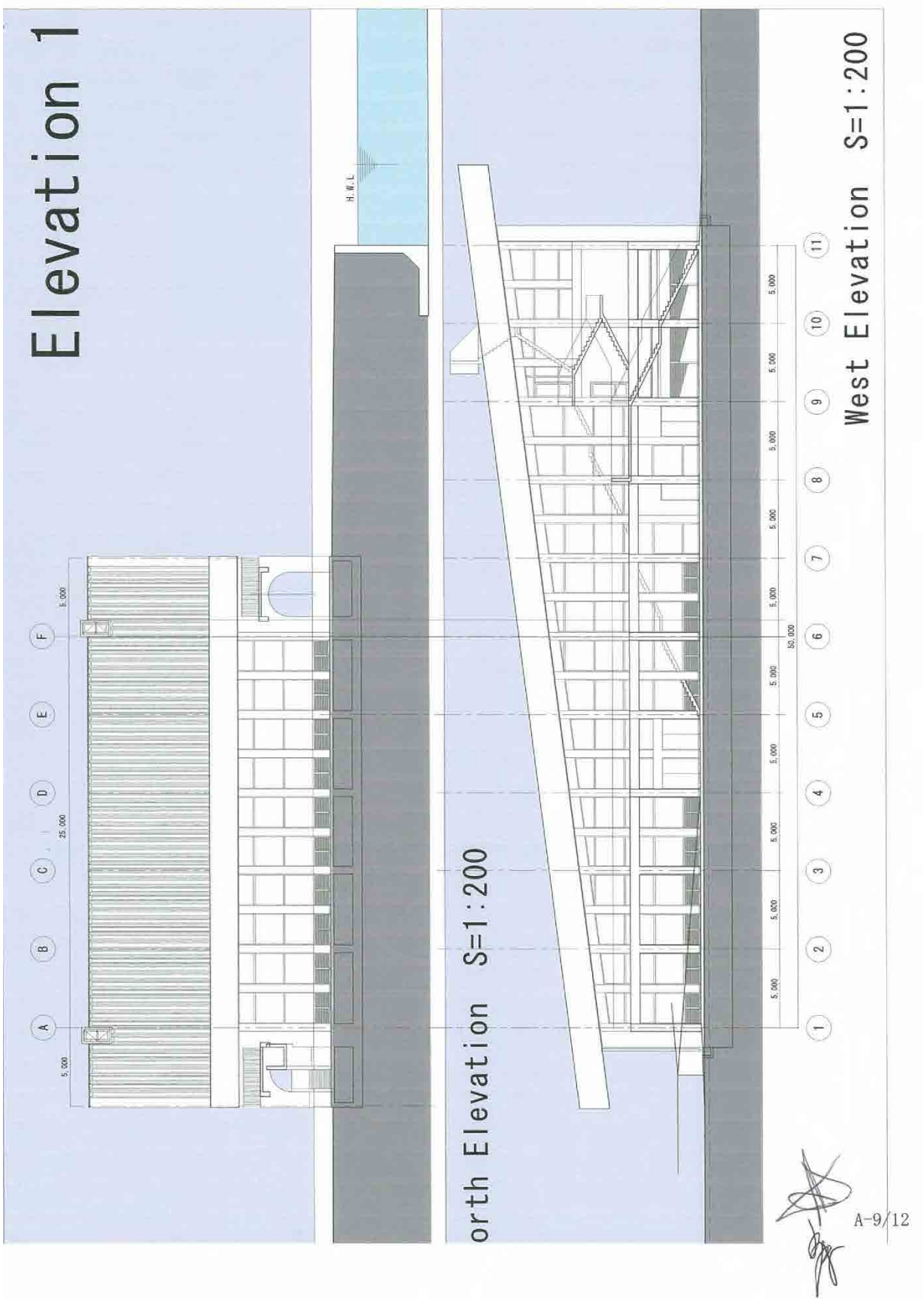

GF Plan
GF PLAN S=1:200
Entrance Hall
118.80m2
Waiting Hall
750m2
Boarding Deck (1)
Boarding Deck (2)
Office (1)
Office (2)
Office (3)
Office (4)
Ticket Counter (1)
Ticket Counter (2)
Ticket Counter (3)
Ticket Counter (4)
Pump Room
Water Tank
Toilet (F)
Toilet (M)
Waste
Ramp
Underground Rain Water Harvesting Tank
Pre-filter Tank
Maintenance Manhole ϕ60
Concrete Ditch: W=500
Sewage Treatment Tank (1)
Sewage Treatment Tank (2)
200person
Effluent: BOD 30ppm
SC (1)
SC (2)
A-4/12

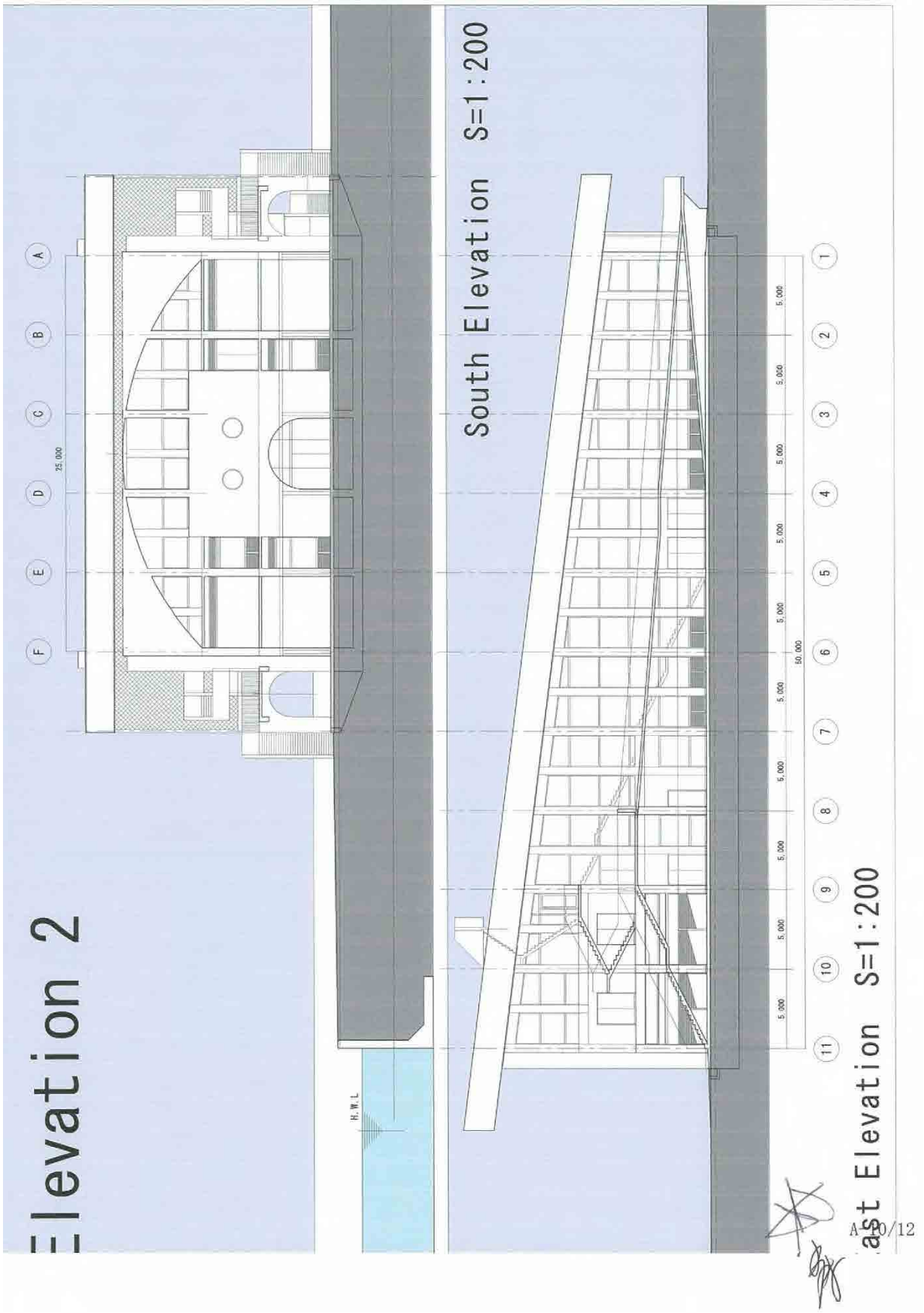

1F PLAN S=1:200
Floor Area: 500m2
1F Plan
Generator
20m2
Work Shop
20m2
Toilet(F)
ITR 250kVA
20m2
Electrical
20m2
Toilet(M)
Kitchen
SC (1)
SC (2)
UP
DN
Coffee Shop
Restraunt
Promenade Deck
Ramp
Void
A-5/12


2F PLAN S=1:200
Floor Area: 250m2
2F Plan
Office (3)
Office (4)
Void
Roof
Gutter
Maintenance Tarap
SG (1)
SG (2)
A-6/12


Type E' RF
Solar Cell
2F PLAN S=1:200
Floor Area: 250m2
Roof
Gutter
Maintenance Area
A-7/12


Section
E-W Section S=1:200
N-S Section S=1:200
A-8/12
Water Tank
Waiting Hall
Entrance Hall
Restraunt
Office (1)
Water Tank
Office
Kitchen
Toilet (M)
Corr.
EXIT
Stairway A(1)
Restraunt
Entrance Hall
Stairway A(1)
Waiting Hall
EXIT
Ramp 1/12
H.W.L
25,000
50,000
15,625
3,560m
7,910
6,470


Elevation 1
H.W.L
orth Elevation S=1:200
West Elevation S=1:200
A-9/12

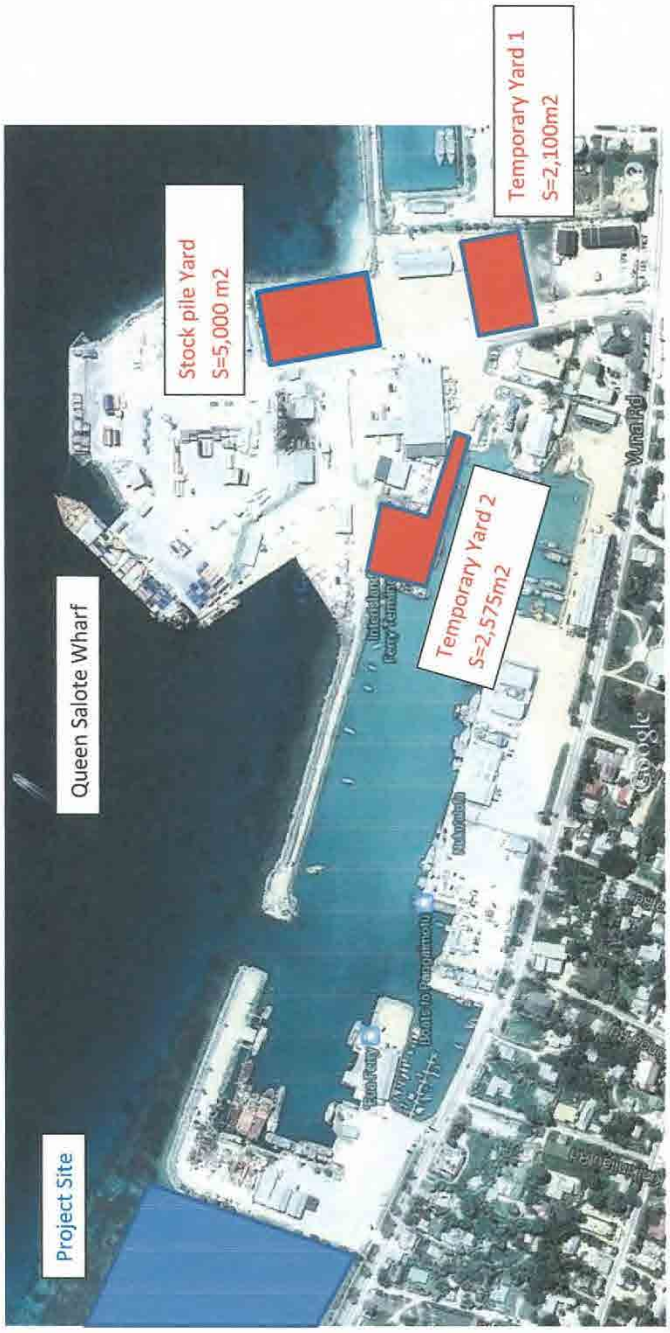

Elevation 2
South Elevation S=1:200
East Elevation S=1:200
H.W.L
A
B
C
D
E
F
1
2
3
4
5
6
7
8
9
10
11
25.000
50.000
5.000
A-10/12

Annex-4

Abandoned ships, warehouse and wastes to be removed or relocated

A-11/12

Annex-5



Source: JICA Study team based on Google Earth

Figure: Temporary Yard and Stock Pile Yard Plan

A-12/12

Minutes of Discussions
on the Preparatory Survey
for the Project for
Upgrade of Wharf for Domestic Transport
in the Kingdom of Tonga
(Explanation of the Draft Outline Design Report)

On the basis of the discussions and field survey in the Kingdom of Tonga (hereinafter referred to as "Tonga") in August and September, 2014, and the subsequent technical examination of the results in Japan, Japan International Cooperation Agency (hereinafter referred to as "JICA") prepared a draft Preparatory Survey Report on the Project for Upgrade of Wharf for Domestic Transport (hereinafter referred to as "the Draft Report").

In order to explain and discuss with the Tonga side on the contents of the draft report, JICA sent to Tonga the draft report explanation team (hereinafter referred to as "the Team"), which is headed by Mr. Satoru Matsuyama, Advisor, Grant Aid Project Management Division 1, Financial Cooperation Implementation Department, JICA, from February 10 to 17, 2015.

As a result of the discussion, both sides confirmed the main items described in the attached sheets.

Nuku'alofa, February 13, 2015

Satoru Matsuyama
Leader of the draft report explanation team
Japan International Cooperation Agency

Tatafu Moeaki
Chief Executive Officer
Ministry of Finance and National Planning
Kingdom of Tonga

Ringo K Fa'oliu
Chief Executive Officer
Ministry of Infrastructure
Kingdom of Tonga

ATTACHMENT

1. Components of the Draft Outline Design Report

   The Tonga side agreed and accepted in principle the contents of the Draft Report explained by the Team.

2. Japan's Grant Aid Scheme

   The Tonga side reconfirmed the Japan's Grant Aid scheme. The Tonga side reassured to take necessary measures as described in Annex-4 and Annex-5 of the Minutes of Discussions (M/D) signed by both sides on August 29, 2014.

3. Schedule of the Study

   JICA will complete the Final Outline Design Report of the Preparatory Survey in accordance with the confirmed items and send it to the Tonga side around April, 2015.

4. Cost Estimation

4-1. The Japanese side explained to the Tonga side the rough estimate of the Project Cost described in Annex-1; however, the final Project Cost described in the Exchange of Notes (hereinafter referred to as "E/N") would be appraised by the Government of Japan.

4-2. The both sides agreed that in order to secure a fair and equitable procurement, the Project Cost Estimation attached in Annex-1 should never be duplicated or released to any third party before the signing of all the Contract(s) for the Project.

5. Undertakings by the Tonga side

5-1. The Tonga side will undertake the necessary arrangement/work for the Project listed in Annex-1 at its own expenses based on the contents of the Draft Report.

5-2. The Tonga side agreed to obtain the required environmental permit of the Project from the Ministry of Environment and inform JICA Tonga Office by written by the end of March, 2015.

5-3. The Tonga side agreed to obtain the construction permit including execution permit from relevant authority before Pre-Qualification (PQ) of the Project.

5-4. The Tonga side agreed to secure and prepare the temporary yard before PQ of the Project .

5-5. The Tonga side agreed to remove or relocate abandoned ships and existing utilities/waste within the area of current Faua Wharf before PQ of the Project.

5-6. The Tonga side agreed to conduct the following works/procurements in timely

manner mentioned below.

Works/Procurement	Timing of the conduction
Planting Works	21st month after start of construction
Removal Works of Power Pole for Distribution Line	23rd month after start of construction
Works for Electric Register	23rd month after start of construction
Works for Internet Line	23rd month after start of construction
Procurement of equipment for Ferry Operation Office	23rd month after start of construction
Procurement of equipment for Restaurant and Coffee shop	23rd month after start of construction

6. Operation and Maintenance of the Facilities and Equipment

6-1. The Tonga side will secure enough staff and budget necessary for operation and maintenance of the facilities and equipment to be provided by the Project. The annual operation and maintenance costs are estimated as Annex-2, and details are mentioned in the Draft Report.

7. Environmental and Social Considerations

7-1. The both sides agreed to the contents of the Environmental Checklist as shown in Annex-3.

7-2. The Tonga side agreed that monitoring for environmental and social considerations will be conducted by the responsibility of Ministry of Infrastructure and Tonga Port Authority in accordance with the Environmental Monitoring Plan described in the draft report. The results of monitoring will be provided to JICA Tonga Office by filling in the Monitoring Form attached as Annex-4, during construction phase and after completion of the Project.

7-3. The Tonga side agreed that JICA may disclose the monitoring results and may disclose further information as well on demand from the third parties.

8. Disclosure of Information

Both sides confirmed that the study results excluding the Project cost will be disclosed to the public after completion of the Preparatory Survey. All the study results including the Project cost will be disclosed to the public after all the contracts for the Project are concluded.

Annex-1 Project Cost Estimation
Annex-2 Annual Maintenance Cost
Annex-3 Environmental Checklist
Annex-4 Environmental Monitoring Form

CONFIDENTIAL

Annex-1

Project Cost Estimation

(2) Cost Borne by the Government of Tonga

Description	Estimated Cost (Tonga Pa'anga)	Converted to JPY (million Yen)
Planting Works	140,000	7.83
Removal Works of Power Pole for Distribution Line	9,000	0.5
Works for Electric Register	4,000	0.2
Works for Internet Line	15,000	0.8
Equipment for Ferry Operation Office	27,000	1.5
Equipment for Restaurant and Coffee shop	24,000	1.3
Bank Commissions	72,000	4.0
TOTAL	**291,000**	**16.13**

Notes:

(1) The cost estimates in the above table are provisional and will be further examined by the Government of Japan for the approval of the Grant.

Annex-2

Annual Maintenance Cost

Maintenance Items	Tonga Pa'anga
1. Outlying facilities	223,569
2. Terminal building	455,713
3. Paving and outdoor facility	66,463
4. Facility and equipment for navigation	78,487
5. Environmental monitoring	36,232
Total	860,464

Environmental Checklist

Annex-3

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a)Y (b)N (c)N (d)N	(a) MOI submitted EIA report to MEC in January 2015. (b) The EIA report is currently under review by MEC. (need to check review status and schedule with MEC) (c) The EIA report is currently under review by MEC. (d) There are no other environmental permits required.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a)Y (b)Y	(a) Public consultation meeting was held on November 2014 by MOI. Around 30 people participated including local residents from Maufanga. There was no objections raised towards the project once the concerns raised by the participants were answered. The project's EIA report is also been posted on MOI and MECs' website for public comment since January. (need to check if any comments were received) MOI has also conducted interviews with several Taovala producers as they will be required to relocate their activity. Some interviewees were reluctant about moving from the current soaking area. MOI will continue to correspond with the Taovala producers and work towards obtaining mutual agreement. (need to check the agreement status with Taovala producers) (b) The stakeholders had no objection on the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a)Y	(a) The location of the project was initially considered inside Faua wharf but was concluded unfeasible and the remain option was west side of Faua wharf. Once the location was decided three port layout options were considered.
2 Pollution Control	(1) Air Quality	(a) Do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust emitted from ships, vehicles and project equipment comply with the country's emission standards? Are any mitigating measures taken?	(a)Y	(a) Tonga has no emission standards. Nevertheless, the amount of air pollutant emission will be similar to the current situation as there will be no major additional air pollutant sources. Dust dispersion from the port area is currently an issue especially from unpaved areas. Dust dispersion from the new wharf will be prevented through concrete pavement.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Do effluents from the project facilities comply with the country's effluent and environmental standards? (b) Do effluents from the ships and other project equipment comply with the country's effluent and environmental standards? (c) Does the project prepare any measures to prevent leakages of oils and toxicants? (d) Does the project cause any alterations in coastal lines and disappearance/appearance of surface water to change water temperature or quality by decrease of water exchange or changes in flow regimes? (e) Does the project prepare any measures to prevent polluting surface, sea or underground water by the penetration from reclaimed lands?	(a)Y (b)Y (c)Y (d)Y (e)Y	(a) Wastewater from the terminal building will be treated through septic treatment system, which is designed to discharge under World Bank standard (BOD: <30 mg/l).(no discharge standard in Tonga) (b) Ships will be prohibited to discharge any wastewater inside the port area and near land in accordance to Tonga's Marine Pollution Prevention Act 2002. (c) The port will be equipped with a waste reception facility to prevent any leakages of pollutants. (d) There will be slight alteration to the flow regime due to the presence of breakwater but its impact on water quality is considered to be limited to in and around the port area due to its limited length and configuration. (e) Reclamation works will inevitably cause turbidity but its dispersion will be minimized by installing silt curtain.
2 Pollution Control	(3) Wastes	(a) Are wastes generated from the ships and other project facilities properly treated and disposed of in accordance with the country's regulations? (b) Is offshore dumping of dredged soil properly disposed in accordance with the country's regulations? (c) Does the project prepare any measures to avoid dumping or discharge toxicants?	(a)Y (b)Y (c)Y	(a) The port will be equipped with a waste reception facility where all wastes will be temporary stored. The wastes will then be disposed at the local waste disposal facility or taken to local recycling companies. (b) Dredged soil will be used as reclamation material. Excessive dredged soil will be stored inside the existing port area for later beneficial use. (c) Any toxic waste will be contained in specialized containers and temporary stored at the waste reception facility. The wastes will then be treated/disposed/recycled in accordance to local regulations and norms.
	(4) Noise and Vibration	(a) Do noise and vibrations from the vehicle and train traffic comply with the country's standards?	(a)Y	(a) While there are no noise/vibration standards in Tonga, the project will implement the following measures to minimize noise/vibration impacts: - Use of low-noise pile driver (vibratory pile driver) - Noise and vibration monitoring (comparison with Japanese environmental standard) - Regular inspection and maintenance of equipment and vehicles - Avoidance of sensitive areas during transportation of construction materials
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a)N	(a) There will be no extraction of groundwater.
	(6) Odor	(a) Are there any odor sources? Are adequate odor control measures taken?	(a)Y	(a) The dredged material are possible odor source due to decomposition of organic material. Odor impacts will be minimized by drying it as far as possible from the residential area (i.e. north side of Faua wharf).

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(7) Sediment	(a) Are adequate measures taken to prevent contamination of sediments by discharges or dumping of hazardous materials from the ships and related facilities?	(a)Y	(a) Dumping of hazardous wastes into the sea will be strictly prohibited in accordance to the Marine Pollution Prevention Act 2002. The port will be equipped with a waste reception facility to prevent any accidental discharge of hazardous wastes.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)N	(a) No impact is expected as the nearest protected area is located more than 3 km away from the project site.
3 Natural Environment	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic organisms? Are adequate measures taken to reduce negative impacts on aquatic organisms? (e) Is there a possibility that the project will adversely affect vegetation or wildlife of coastal zones? If any negative impacts are anticipated, are adequate measures taken to reduce the impacts on vegetation and wildlife?	(a)Y (b)N (c)Y (d)Y (e)N	(a) The project site is located over a coral reef. (b) Five endangered coral species under IUCN Red List have been identified in the reefs near the project site. No endangered coral species were found inside the project site. (c) Although around 300 m of coral habitat will be lost through the port construction, such loss is considered to be of moderate significance due to the following: - The affected coral habitat is small in proportion to the overall coral habitat area of Tongatapu north coast which extends over 30 km. - The affected coral habitat can be considered to have limited ecological value due to the relatively low coral diversity, absence of endangered species and presence of many dead corals. The project will minimize impacts on the surrounding coral ecosystem by installing silt curtain and by conducting water quality and coral monitoring. (d) Refer to (c). (e) There are no terrestrial vegetation or wildlife of any significance in the coastal zone.
	(3) Hydrology	(a) Do the project facilities affect adversely flow regimes, waves, tides, currents of rivers and etc if the project facilities are constructed on/by the seas?	(a)N	(a) The breakwater will inevitably alter the local water circulation but will be limited to around the port area due to its limited length and configuration.
	(4) Topography and Geology	(a) Does the project require any large scale changes of topographic/geographic features or cause disappearance of the natural seashore?	(a)N	(a) The project is located in a developed area where the natural shoreline is already artificially altered by the existing port and seawalls.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a)N (b)N (c)N (d)N (e)N (f)N (g)N (h)N (i)N (j)N	(a)-(J) No resettlement is required.
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that changes in water uses (including fisheries and recreational uses) in the surrounding areas due to project will adversely affect the livelihoods of inhabitants? (c) Is there a possibility that port and harbor facilities will adversely affect the existing water traffic and road traffic in the surrounding areas? (d) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are considerations given to public health, if necessary?	(a)Y (b)N (c)N (d)N	(a) There are around 20 people that work in the shallow inner reef flat of the project site, where they soak materials used for making traditional mat/cloth (Taovala). Due to the project, these people will be required to relocate their activity to another nearby site. Since there are sufficient spaces available that are close to the current site, relocation should not be of any major significance. Nevertheless, MOI will continue to correspond with Taovala producers to ensure that the project will have minimum impact on their livelihood. MOI will also monitor the Taovala producers to see if any adverse impacts are experienced due to relocation. (b) Refer to (a). (c) There will be no major alteration to the existing water and road traffic. (d) The risk of infectious diseases spreading is low as the majority of the work force will be from the local area.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)N	(a) There are no archeological, historical, cultural and religious heritage sites around the project site.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)Y	(a) The current sea view from Vuna road will change to a port dominant view. To mitigate such impacts, trees will be planted along the boundary of the wharf facing Vuna road, which is expected to create a more pleasant view and atmosphere.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a)N (b)N	(a) (b) There are no ethnic minorities and indigenous peoples around the project site.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a)N (b)Y (c)Y (d)Y	(a) No (b) Construction will be implemented under strict safety measures and rules. Furthermore, a safety fence will be installed around the project site during the construction period. Security guards will also be placed at the entrance of the project site. (c) Safety training including traffic safety and public health for workers will be implemented for individuals involved in the project. (d) The project will ensure that such violations do not occur.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a)Y (b)Y (c)Y	(a) **Measures to reduce noise/vibration impacts:** - Use of low-noise pile driver (i.e. vibratory pile driver) - Noise/vibration monitoring - Regular inspection and maintenance of equipment and vehicles - Avoidance of sensitive areas during transportation of construction materials **Measures to reduce dust impacts:** - Water spraying at dusty areas **Measures to reduce turbidity impacts:** - Installation of silt curtain - Water quality monitoring **Measures to reduce waste impacts:** - Storage of waste in designated area to prevent spills and dispersion (b) Silt curtain will be installed to minimize turbidity dispersion towards the surrounding coral ecosystem. Additional mitigation measures will be considered if significant impacts are identified through coral monitoring. (c) The Taovala producers will be monitored to see if any impacts are experienced through relocation.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a)Y (b)Y (c)Y (d)N	(a)(b) - Monitoring of noise: Daily at two locations - Monitoring of vibration: Daily at two locations - Monitoring of water quality: Daily at six locations - Monitoring of coral health: Monthly at six locations - Monitoring of Taovala producers: Once every six months through interview survey (c) Implementation of the above monitoring (except Taovala producers which will be the responsibility of MOI) will be a requirement under the contract between the construction contractor. (d) Reporting will be conducted in accordance to the conditions stipulated in the EIA approval. The construction contractor will nevertheless be required to report regularly to the construction supervisor and MOI.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
6 Note	Note on Using Environmental Checklist	(a) Where necessary, impacts on groundwater hydrology (groundwater level drawdown and salinization) that may be caused by alteration of topography, such as land reclamation and canal excavation should be considered, and impacts, such as land subsidence that may be caused by groundwater uses should be considered. If significant impacts are anticipated, adequate mitigation measures should be taken. (b) If necessary, the impacts to trans boundary or global issues should be confirmed, if necessary (e.g., the project includes factors that may cause problems, such as trans boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)N (b)N	(a) Although dredging may cause seawater intrusion into the underground freshwater lens, the risk of such occurrence is low for the following reason: - The dredging area is most likely to be outside of the underground freshwater and seawater boundary as dredging is conducted only over the reef flat where groundwater is usually seawater. - The seabed of the dredging area is primarily comprised of impermeable material, which will prevent seawater intrusion towards the underground freshwater lens.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Annex-4

Environmental Monitoring Form

1. Pre-construction phase

(1) Comments from the public and MEC regarding the EIA

Monitoring item	Comments	Response of MOI
Contents of formal comments from the public on the EIA		
Contents of formal comments from MEC on the EIA		

2. Construction phase

(1) Noise (L_{Aeq})

Week	Location	Reference standard (dB)	Weekly Ave. (dB)	Weekly Max. (dB)	Compliance status (e.g. no. of days that exceeded reference standard)	Measures implemented in case of non-compliance
	Boundary of construction site	85*1				
	Boundary of nearest residential area	65*2				

*1: Based on Noise Regulation Law of Japan
*2: Based on Basic Environment Law of Japan

(2) Vibration (Lv_{10})

Week	Location	Reference standard (dB)	Weekly ave. (dB)	Weekly max. (dB)	Compliance status (e.g. no. of days that exceeded reference standard)	Measures implemented in case of non-compliance
	Boundary of construction site	75*1				
	Boundary of nearest residential area	-				

*1: Based on Vibration Regulation Law of Japan

(3) Seawater quality (Turbidity)

Week	Location	Reference standard (NTU)*	Weekly ave. (NTU)	Weekly max. (NTU)	Compliance status (e.g. no. of days that exceeded reference standard)	Measures implemented in case of non-compliance
	Coral site 1	2				
	Coral site 2	2				
	Coral site 3	2				
	Construction site boundary 1	-				
	Construction site boundary 2	-				
	Reference site	-				

*: Standard established for this project based on the results of the water quality survey and the following scientific literature: P.L.A. Erftemeijer et al., (2012), Environmental impacts of dredging and other sediment disturbances on corals, Marine Pollution Bulletin 64. The threshold level may be adjusted during the construction phase if it is deemed too high or low, based on the results of the coral health monitoring.

(4) Coral health

Month	Location	Percent live coral coverage (%)	Percent bleaching (%)	Coral stress indicators (e.g. excessive mucus production, discoloration, sedimentation)	Measures implemented in case of adverse impacts identified
	Coral site 1				
	Coral site 2				
	Coral site 3				
	Coral site 4				
	Coral site 5				
	Coral site 6				

(5) Taovala producers

Month	Name	Comments of interviewee	Measures implemented in case of complaint