Ministry of Environment and Communications

The Project for Upgrade of Wharf for Domestic Transport

Environmental Impact Assessment Report

January 2015

Ministry of Infrastructure

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List of abbreviations

ADB	Asian Development Bank
AIMS	Australian Institute of Marine Science
EIA	Environmental Impact Assessment
GoJ	Government of Japan
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
MEC	Ministry of Environment and Communications
MOI	Ministry of Infrastructure
SOPAC	Pacific Islands Applied GeoScience Commission
TBT	Tributyltin
TSDF	Tonga Strategic Development Framework

1. Introduction

The Kingdom of Tonga is in the South Pacific Ocean with an archipelago of 169 islands with only 36 islands being inhabited. Domestic inter-island shipping plays a crucial role in providing the fundamental means of transportation for the Tongan people, and it is Ministry of Infrastructure (MOI) responsibility to ensure its safe and secure operation.

Currently, in Nukualofa Port, the domestic inter-island ships berth at Faua wharf and Queen Salote wharf. Faua wharf can only accommodate ships under 300 gross tonnage mainly due to the shallow depth and lack of basin space. Larger domestic ships are therefore now berthing at Queen Salote wharf, at berths 3 and 4. However, due to the lack of space in the berthing, cargo handling and passenger waiting areas, allocation of an alternative berthing area for large domestic ships has been become an urgent necessity. Furthermore, for safety and security reasons, the port plans to allocate Queen Salote wharf solely of international ships, which was the original plan.

Initially, Faua wharf was considered as the alternative berthing area by upgrading its infrastructure, and MOI requested the Government of Japan (GoJ) for Grant Aid assistance. The request was duly accepted by GoJ, and experts were dispatched through Japan International Cooperation Agency (JICA) to study in detail the proposed plan under the project titled "Preparatory Survey for the Project for Upgrade of Wharf for Domestic Transport in the Kingdom of Tonga (hereinafter abbreviated as "JICA Preparatory Survey")", commencing in August 2014. However, after initial studies, the proposed plan was concluded unfeasible as sufficient space cannot be secured inside Faua wharf for large domestic ships despite upgrade works. As an alternative option, the JICA Preparatory Survey proposed a plan to develop a new domestic wharf on the west side of Faua wharf, and was duly approved by MOI. Since then, the basic plan and design of the new wharf has been devised by the JICA Preparatory Survey.

Since the development of the new domestic wharf is categorized as a "major project" under the Environmental Impact Assessment Act, 2003, submission of an Environmental Impact Assessment (EIA) report is required for obtainment of environmental approval from the Ministry of Environment and Communications (MEC). This EIA report has thus been prepared by MOI with technical assistance from the JICA Preparatory Survey. The requirements stipulated in the Environmental Impact Assessment Regulations, 2010, and JICA's "Guidelines for Environmental and Social Considerations (2010)" were referred in the process.

2. National development policy

The Tonga Strategic Development Framework (TSDF) 2011-2014, emphasizes the need for the government to ensure safe and reliable transport infrastructure, and increase the quality of sea transport services both domestically and between the Kingdom and overseas. Construction of the new domestic wharf will contribute significantly in realizing these strategies, and therefore of significant importance to MOI.

3. Project description

3.1. Location

The new domestic wharf is located in Tongatapu Island, Nukualofa, the capital of Tonga. It is in front of Maufanga, one of the coastal villages in Nukualofa. Figure 3-1 shows the location of the new domestic wharf.

Source: prepared with Google Earth

Figure 3-1 Location of the new domestic wharf (red-dotted line)

3.2. Layout and facilities

The new domestic wharf will have two ship berthing areas with each having a length of 90 m. The space behind the berths will be used as a cargo yard. Ships will enter the wharf through a new access channel and turning basin with a depth of -4 m, which will require dredging of approximately 153,000 m^3 of seabed. Most of the dredged material will be used for reclamation of the wharf. The wharf will be protected from waves by a breakwater of approximately 250 m in length.

A three story terminal building will be built in the east side of the wharf to accommodate passengers up to around 700 people. The 1st floor is allocated as a ticket booth and waiting area, the 2nd floor for restaurants, and 3rd floor for office space of shipping companies. The building will be partly powered by the solar panel that will be installed on the roof. Parking space will be available on the north and south side of the terminal building, which can accommodate a total of around 100 cars. Figure 3-2 shows the layout of the new domestic wharf. Figure 3-3 shows the

design of the terminal building. Table 3-1 shows the specification of the main wharf facilities.

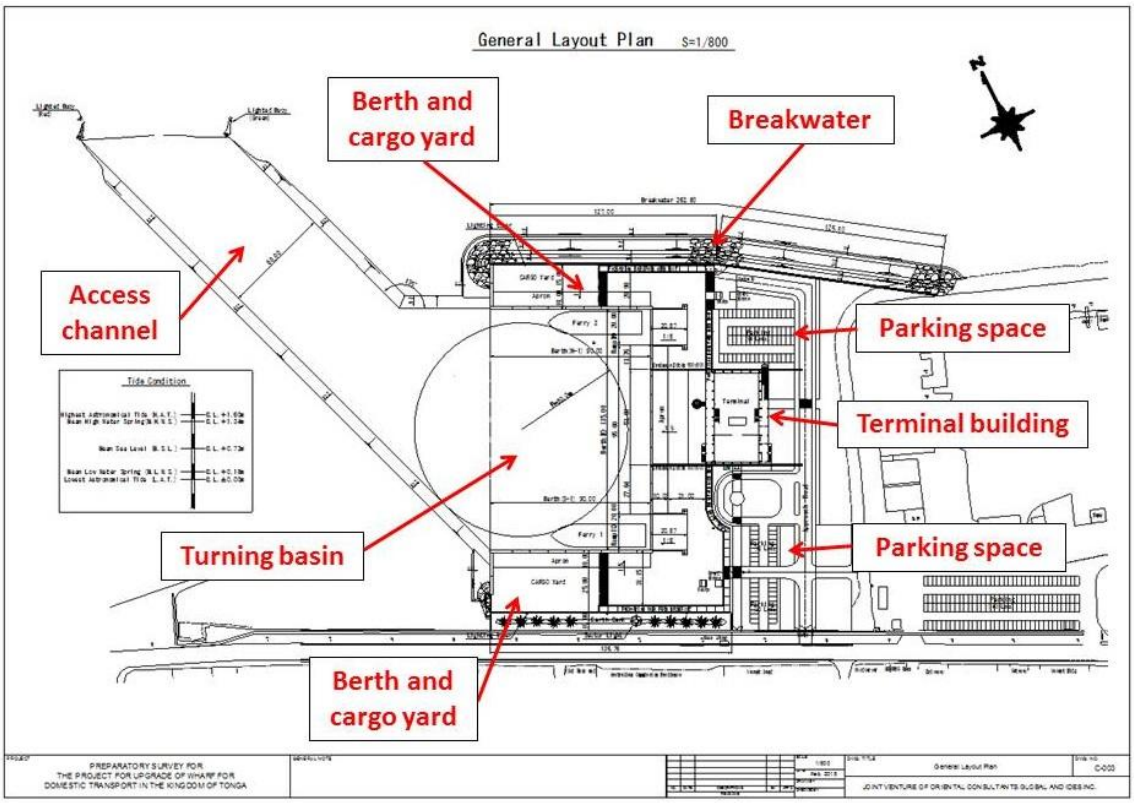


Figure 3-2 Layout of the new domestic wharf

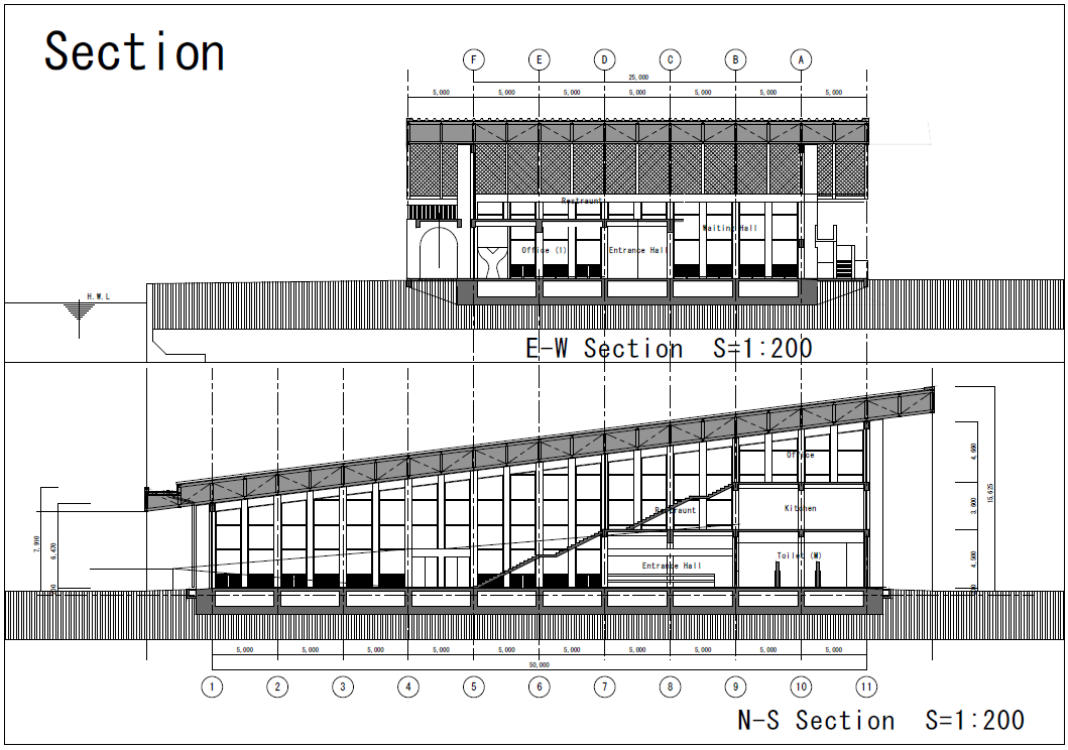


Figure 3-3 Design of the terminal building

Table 3-1 Specification of the main wharf facilities

Main facilities	Specification
2 berths (north and south side)	Length: 90 m
2 cargo yards (north and south side)	Surface area (north side): approx. 90 m x 25 m Surface area (south side): approx. 90 m x 35 m
Breakwater	Length: approx. 250 m
Access channel and turning basin	Depth: - 4 m
Terminal building (3 story)	Surface area: 50 x 25 m Height: approx. 150 m

3.3. Construction method and materials

3.3.1. Berth and cargo yard

Table 3-2 shows the construction procedure of the berth/cargo yard. Figure 3-4 shows a cross-section of the berth/cargo yard of the breakwater side. Apart from the steel sheet pile, all materials (e.g. rocks, concrete) will be procured locally.

Table 3-2 Construction procedure of the berth/cargo yard

	Type of construction work	Construction machine
Step 1	Pile driving of steel sheet pile (approx. 800 sheets)	Vibratory hammer, crane barge
Step 2	Backfill with rubble rocks (approx. 2,700 m^3)	Excavator, dump truck
Step 3	Backfill with dredged material (approx. 77,000 m^3)	Excavator, barge
Step 4	Concrete coping	Concrete truck
Step 5	Concrete pavement	Concrete truck

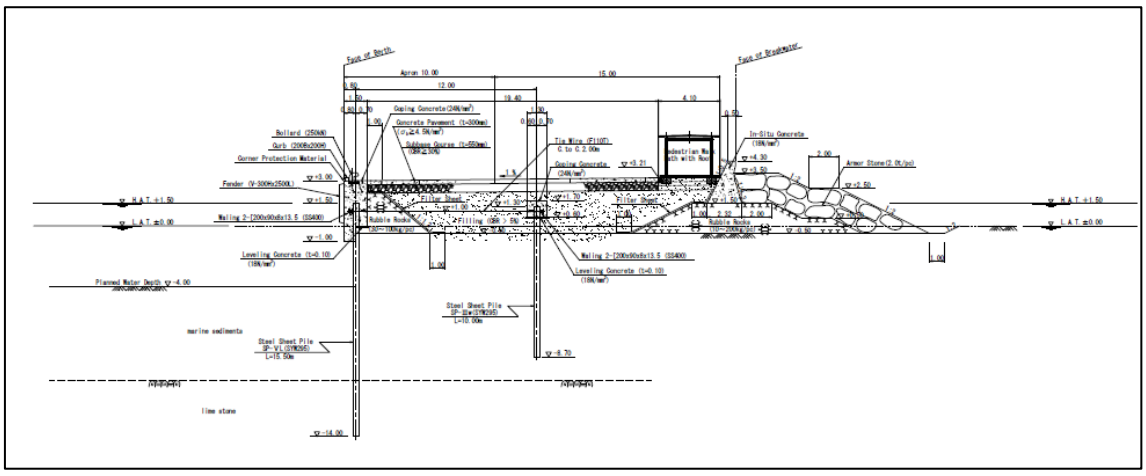


Figure 3-4 Cross-section of the berth/cargo yard (breakwater side)

3.3.2. Breakwater

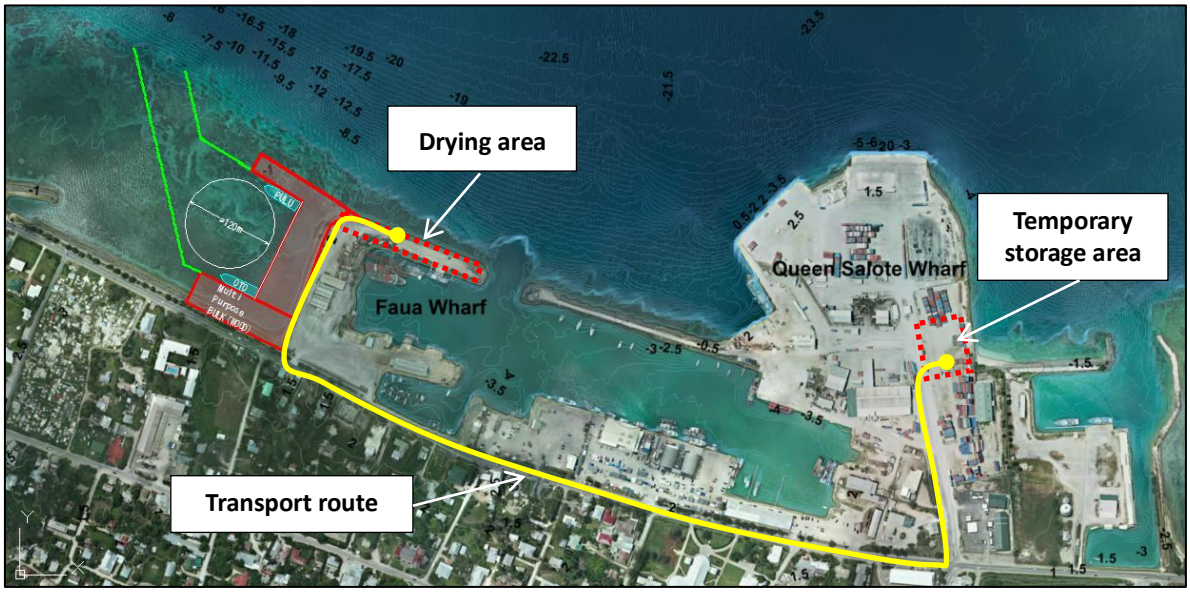
Table 3-3 shows the construction procedure of the breakwater (see Figure 3-4 for the cross-section of the breakwater). All materials (e.g. rocks, concrete) will be procured locally.

Table 3-3 Construction procedure of the breakwater

	Type of construction work	Construction machine
Step 1	Placement of rubble rocks (approx. 8,200 m^3)	Excavator, dump truck
Step 2	Placement of armor rocks (approx. 6,200 m^3)	Excavator, dump truck
Step 3	Installation of concrete seawall (approx. 900 m^3)	-

3.3.3. Access channel and turning basin

The access channel and turning basin will be dredged with an excavator placed on a barge. The dredged material will be used for reclaiming the wharf. Around 30,000 m^3 of excessive dredged material will be generated, which will be temporary stored in the empty space available south of Queen Salote wharf for later beneficial use. The excessive dredged material will be transported to the storage area with dump trucks after drying them at north side of Faua wharf. Figure 3-5 shows the handling process of the excessive dredged material.



Source: prepared with Google Earth

Figure 3-5 Handling process of the excessive dredged material

3.3.4. Terminal building

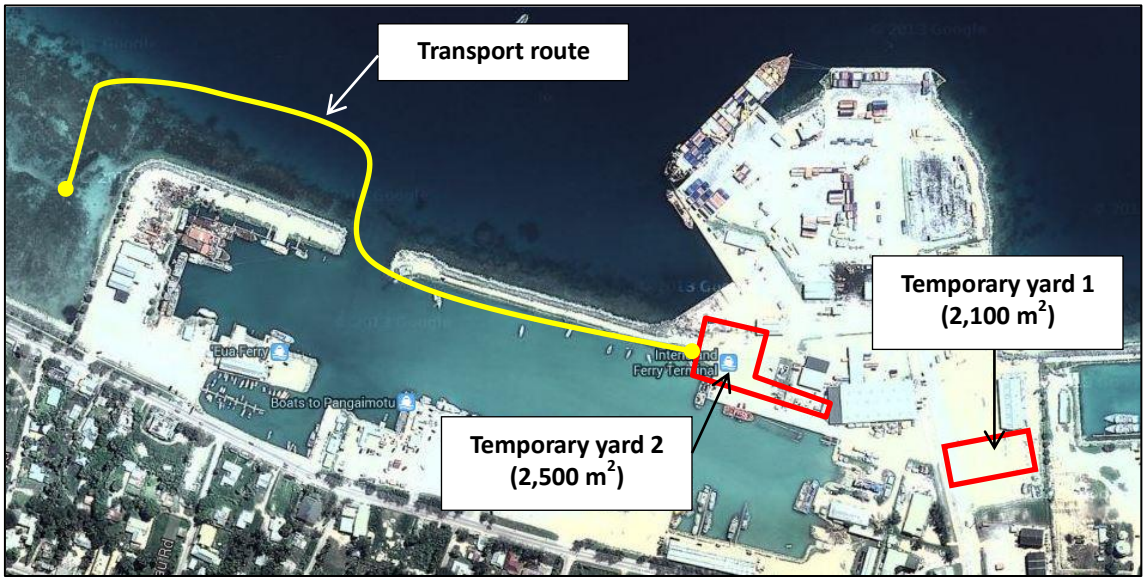
Construction of the terminal building will commence once the reclamation works is completed. It will take approximately 1 year to complete. Table 3-4 shows the main materials required and supply source.

Table 3-4 Construction materials required for the terminal building and supply source

Material	Volume	Source
Steel bar	350 t	Oversea supplier
Steel frame	300 t	Oversea supplier
Concrete	2,100 m^3	Local supplier
Concrete pile	120 t	Oversea supplier
Aluminum door & window	1,000 m^2	Oversea supplier
Steel roof	2,100 m^2	Oversea supplier

3.3.5. Temporary yard

A temporary yard will be required mainly to store construction materials (e.g. sheet piles) and bending/cutting works. Two temporary yards will be established inside the existing port area as shown in Figure 3-6. The construction materials will be transported to the construction site via sea using a barge.



Source: prepared with Google Earth

Figure 3-6 Location of the temporary yard and transport route of construction materials

3.4. Construction schedule

Construction is expected to commence from 2016, and take around two years to complete. Table 3-5 shows the construction schedule for the main works.

Table 3-5 Construction schedule of the main works

No		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Preparation works																								
2	Breakwater																								
3	Berth																								
4	Dredging & Reclamation																								
5	Port accessories																								
6	Terminal building																								
7	External works																								
8	Site clean up																								

4. Status of existing environment

4.1. Physical environment

4.1.1. Climate

Nuku'alofa has a subtropical weather, with a wet and hot season from December to April, and a dry and cool season from May to November. Rainfalls on Nuku'alofa have an average of around 1,800 mm per year. Wind is predominantly from the east and south-east direction. Typhoons occur in the wet season occasionally causing damage.

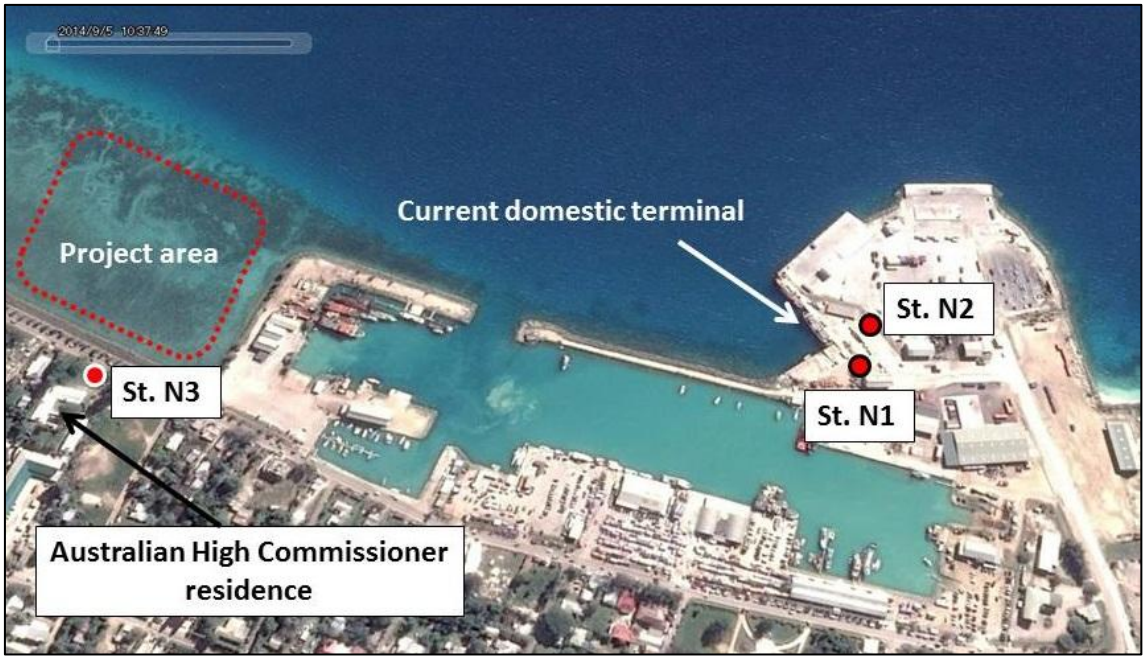
4.1.2. Air quality

While there are no air quality data available around the project area, air quality should be relatively good due to limited air pollution sources. However, since some areas of the port are unpaved, dust dispersion can sometimes be an issue inside the port especially during windy conditions. Ship passengers have also complained of such dust problem when interviewed.

4.1.3. Noise

Noise levels (equivalent sound level: L_{Aeq}) were measured at the current domestic terminal at Queen Salote wharf and at the roadside in front of the Australian High Commissioner residence. Figure 4-1 shows the location of the noise survey sites.

Stations N1 and N2 were surveyed on November 4th, 2014 (Tuesday), prior to the departure of Otuangaofa, one of the domestic ships. Station N3 was surveyed on November 4th and 8th, 2014 (Saturday). Traffic volume was also counted during the survey of Station N3. Each measurement was conducted for 10 minutes, using IEC-compliant sound level meter (RION NL-27). Table 4-1 shows the results of the noise survey.



Note: Stations N1 and N2 was located approximately 40 m from the berthing ship.
Source: prepared with Google Earth

Figure 4-1 Location of the noise survey site

Table 4-1 Results of the noise survey

Station	Date/time	L_{Aeq} (dB)	Main noise source
N1	2014/11/4 (17:20-17:30)	69.1	Ship generator, forklift, car
N2	2014/11/4 (17:40-17:50)	65.9	Ship generator, forklift, car
N3	2014/11/4 (18:00-18:10)	63.4	Car (10/min.)
	2014/11/8 (10:20-10:30)	63.8	Car (15-20/min.)
	2014/11/8 (10:40-10:50)	66.8	Car (15-25/min.)

Noise levels in the domestic terminal area (Stations N1 and N2) ranged between 65-69 dB, with the main noise source being ships, forklift and cars. Noise levels in front of the Australian High Commissioner residence (Station N3) ranged between 63-67 dB, with the main noise source being the cars passing through Vuna road.

Since Tonga has no noise standard, the noise levels at Station N3 were compared with the ambient noise standard set by the Ministry of Environment, Japan. The Japanese noise standard is set depending on the characteristics of the receiving environment, and the standard set for roadside residential/commercial area was considered appropriate for comparison, which is 65 dB (daytime). The current noise levels at Station N3 are more or less in compliance to the Japanese standard, although it may exceed during high traffic.

4.1.4. Water quality

Water quality survey was conducted on September 4th, 2014 to understand the water quality status around Nukualofa port and project area. Table 4-2 shows the survey parameters and

analysis method. Water temperature, pH and DO were measured *in situ* with portable water quality meter. Other parameters were analyzed in New Zealand (Hill Laboratories accredited by International Accreditation NZ) by air freighting water samples in a chilled container. Figure 4-2 shows the location of the survey sites. Measurements were made for surface and bottom layers, but only for surface layer where water depth was less than 1 m (sites W8 and W9).

Table 4-2 Parameters and analysis method of water quality

	Parameter	Method	Detection limit
1	Water temperature	*In situ* measurement with portable meter (YSI ProDO)	-
2	Salinity	Laboratory analysis (APHA 2520B)	0.2
3	Turbidity	Laboratory analysis (APHA 2130B)	0.10 NTU
4	Suspended solids (SS)	Laboratory analysis (APHA 2540D)	3 mg/l
5	pH	*In situ* measurement with portable meter (Eutech 35)	-
6	Dissolved oxygen (DO)	*In situ* measurement with portable meter (YSI ProDO)	-
7	Chemical oxygen demand (COD)	Laboratory analysis (APHA 5520D)	6 mg O_2/l
8	Total nitrogen (T-N)	Laboratory analysis (APHA 4500)	0.05 mg/l
9	Total phosphorus (T-P)	Laboratory analysis (APHA 4500)	0.004 mg/l
10	Total petroleum hydrocarbon (TPH)	Laboratory analysis (US EPA 8015B)	0.10-0.7 mg/l
11	*Escherichia coli*	Laboratory analysis (APHA 9222)	1 cfu/100 ml

Source: prepared with Google Earth

Figure 4-2 Location of the water quality survey sites

Table 4-3 shows the results of the water quality survey (the laboratory analysis report is

attached as Appendix 1). Since there are no water quality standards in Tonga, the results are compared with relevant oversea standards. Following are the main findings of the survey:

- Water temperature and salinity were more or less uniform between all the sites and layers, indicating lack of any water stratification.
- Surface turbidity levels at the offshore areas (sites W1-W7 and W11) ranged between 0.11-0.22 NTU (average value: approx. 0.15 NTU). Turbidity levels at the bottom layers were in general similar or slightly higher than the surface layer (abnormally high values were recorded at W2, which was probably due to the disturbance of bottom sediment caused during sampling). Turbidity levels at the inshore area (sites W8 and W9) and inside Faua wharf (W10) were generally higher than the offshore areas, probably due to less water exchange or sediment re-suspension.
- Surface SS levels at the offshore areas (sites W1-W7 and W11) ranged between 3-6 mg/l. There was a relatively good correlation between turbidity and SS levels.
- DO concentration ranged generally between 8-9 mg/l. Relatively low concentration was recorded at sites W8 (6.61 mg/l) and W9 (5.62 mg/l). This was probably be due to the nighttime consumption of oxygen by seagrass and is of no major concern (measurement at sites W8 and W9 were conducted at dawn).
- Although nutrient levels (T-N and T-P) at the bottom layer of site W3 was slightly high, in general, all the sites were below detection limit or below reference standard. Hence there were no signs of eutrophication.
- TPH levels were below detection limit at all the sites. Hence there were no signs of oil pollution.
- *E. coli* levels were significantly lower than the reference standard. Hence there were no signs of sewage pollution.
- Based on the survey results, no significant pollution was found, and the water quality around the Nukualofa port and project area can be considered to be under relatively good condition.

Table 4-3 Results of the water quality survey

	Layer	Depth (m)	Temp. (˚C)	Salinity (‰)	Turbidity (NTU)	SS (mg/l)	pH	DO conc. (mg/l)	DO sat. (%)	COD (mg/l)	T-N (mg/l)	T-P (mg/l)	TPH (mg/l)	*E. Coli* (cfu/100 ml)
W1	S	-	23.1	36	0.11	3	8.2	9.67	112.9	< 300	< 0.3	0.005	< 0.7	< 1
	B	20	23.0	36	0.24	9	8.1	9.60	112.0	< 300	< 0.3	0.006	< 0.7	< 1
W2	S	-	23.3	36	0.11	< 3	8.2	9.52	111.6	< 300	< 0.3	0.006	< 0.7	< 1
	B	15	22.9	36	9.0	10	8.2	9.55	111.0	< 300	< 0.3	0.074	< 0.7	< 1
W3	S	-	23.1	36	0.17	6	8.2	9.51	112.9	320	< 0.3	0.007	< 0.7	< 1
	B	25	23.3	36	0.22	8	8.1	9.55	112.5	< 300	< 0.3	0.010	< 0.7	< 1
W4	S	-	23.0	36	0.12	5	8.2	9.62	112.0	< 300	< 0.3	0.009	< 0.7	1
	B	12	22.9	36	0.29	11	8.1	9.60	111.7	< 300	< 0.3	0.006	< 0.7	< 1
W5	S	-	23.2	36	0.16	4	8.0	8.81	103.2	< 300	< 0.3	0.005	< 0.7	< 1
	B	7	22.9	36	0.27	9	8.1	9.50	110.8	< 300	< 0.3	0.006	< 0.7	1
W6	S	-	23.2	36	0.19	6	8.1	7.96	93.1	< 300	< 0.3	0.004	< 0.7	< 1
	B	7	22.9	36	0.42	9	8.2	9.50	110.8	< 300	< 0.3	0.008	< 0.7	< 1
W7	S	-	23.1	36	0.18	5	8.2	9.40	109.7	< 300	< 0.3	0.005	< 0.7	< 1
	B	15	23.1	36	0.17	< 3	8.2	9.53	112.6	< 300	< 0.3	0.005	< 0.7	< 1
W8	S	< 1	23.1	36	0.64	10	7.9	6.61	77.3	< 300	< 0.3	0.009	< 0.7	5
W9	S	< 1	23.3	36	0.71	13	7.8	5.62	66.4	< 300	< 0.3	0.007	< 0.7	1
W10	S	-	23.2	36	0.41	10	8.1	8.84	106.6	< 300	< 0.3	0.007	< 0.7	9
	B	5	23.0	36	14.3	47	8.1	9.01	106.1	< 300	< 0.3	0.020	< 0.7	15
W11	S	-	23.3	36	0.22	7	8.2	9.52	112.7	< 300	< 0.3	0.005	< 0.7	< 1
	B	10	23.4	36	0.16	7	8.1	9.49	112.8	< 300	< 0.3	0.005	< 0.7	< 1
ANZECC 2000*1			-	-	-	-	8.0-8.4	-	> 90	-	0.1	0.015	-	-
Japan Fisheries Standard*2			-	-	-	-	7.8-8.4	> 6.0	-	-	0.3	0.03	-	-
EU 2006*3			-	-	-	-	-	-	-	-	-	-	-	250

S: surface, B: bottom

*1: Australian and New Zealand Environment and Conservation Council (ANZECC), 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality - Aquatic Ecosystems (Tropical waters)

*2: Water quality standard for fisheries (2005), Japan Fisheries Resource Conservation Association

*3: European Union Bathing Water Directive (2006/7/EC)－Good quality coastal waters

Note: Results not in compliance with all the reference standards are highlighted in grey.

4.1.5. Sediment quality

Sediment quality survey was conducted on September 3rd, 2014 to understand the sediment quality status of the planned dredging area and around Nukualofa port. Table 4-4 shows the survey parameters and analysis method. All chemical parameters were analyzed in New Zealand at Hill Laboratories Ltd., which is a laboratory accredited by International Accreditation NZ. Particle size analysis was conducted at Geotechnics Ltd., laboratory. Figure 4-3 shows the location of the survey sites. Sediment samples were collected by a diver from the surface layer only.

Table 4-4 Parameters and analysis method of sediment quality

	Parameter	Analysis method	Detection limit
1	Water content	NZS 4402:1986	-
2	Particle size	NZS 4402:1986	-
3	Total organic carbon (TOC)	Elementar Combustion Analyser	0.05 g/100 g dry wt
4	Arsenic (Ar)	ICP-MS analysis	0.010-0.4 mg/kg dry wt
5	Cadmium (Cd)	ICP-MS analysis	
6	Chromium (Cr)	ICP-MS analysis	
7	Copper (Cu)	ICP-MS analysis	
8	Lead (Pb)	ICP-MS analysis	
9	Mercury (Hg)	ICP-MS analysis	
10	Nickel (Ni)	ICP-MS analysis	
11	Zinc (Zn)	ICP-MS analysis	
12	Total PCBs	GC-MS analysis	0.0010-0.02 mg/kg dry wt
13	Total petroleum hydrocarbon (TPH)	GC-FID analysis (US EPA 8015B)	8-60 mg/kg dry wt
14	Tributyltin (TBT)	GC-MS SIM analysis	0.003-0.007 mg/kg dry wt

Source: prepared with Google Earth

Figure 4-3 Location of the sediment quality survey sites

Table 4-5 shows the results of the sediment quality survey (the laboratory analysis report is attached as Appendix 1). Since there are no sediment quality standards in Tonga, the results are compared with Australian National Assessment Guidelines for Dredging 2009.

Table 4-5 Results of the sediment quality survey

	Unit	S1	S2	S3	S4	S5	S6	Ref.*
Water cont.	%	41.1	37.3	136.0	51.2	37.7	40.8	-
Grain size	% silt	6	5	67	4	7	2	-
	% sand	85	86	32	91	56	86	-
	% gravel	9	9	1	5	37	12	-
TOC	g/100 g	1.8	1.6	1.8	1.5	1.3	0.9	-
Ar	mg/kg	15.7	15.1	33	10.8	15.4	8.7	20
Cd	mg/kg	< 0.02	< 0.02	0.04	0.02	0.03	< 0.03	1.5
Cr	mg/kg	6.6	7	20	17.9	14	4.5	80
Cu	mg/kg	1.3	1.8	26	33	24	0.6	65
Pb	mg/kg	1.48	1.61	8.1	31	29	1.23	50
Hg	mg/kg	< 0.02	< 0.02	0.04	< 0.02	0.03	< 0.03	0.15
Ni	mg/kg	4.5	4.4	8.2	6.6	6.0	4.2	21
Zn	mg/kg	4.6	5.5	57	64	59	3.7	200
PCBs	mg/kg	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	23
TPH	mg/kg	< 70	< 70	< 90	< 70	< 70	< 70	550
TBT	mg/kg	< 0.004	< 0.004	< 0.004	0.007	0.079	< 0.004	0.009

Ref.*: Screening values of National Assessment Guidelines for Dredging 2009
Note: Results above screening level is highlighted in grey.

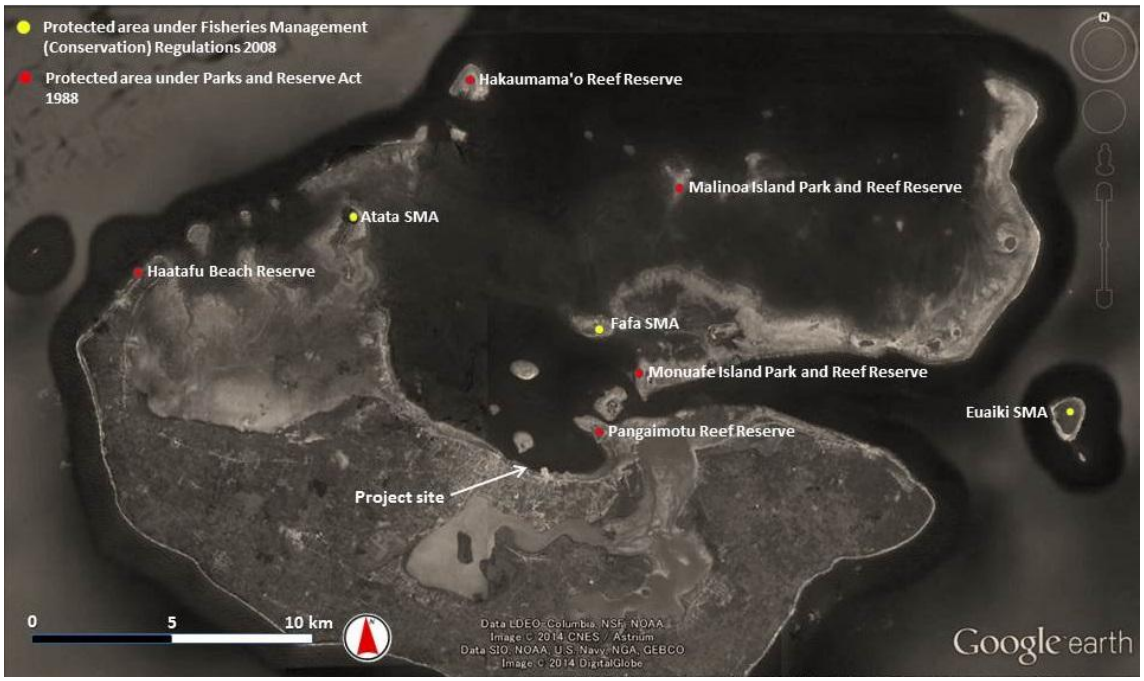
Following are the main findings of the survey:

- No sediment pollution was detected at the planned dredging site (sites S1 and S2).
- Elevated level of arsenic (Ar) was detected inside Faua wharf (site S3). The reason of such elevation is uncertain.
- Elevated level of TBT was detected at the international terminal of Queen Salote wharf (site S5). This is probably due to the use of TBT containing anti-fouling paint by some ships.

4.2. Natural environment

4.2.1. Protected area

Marine protected areas in Tonga are designated through Parks and Reserve Act 1988 and Fisheries Management (Conservation) Regulations 2008. Figure 4-4 shows the location of the marine protected areas around Tongatapu Island. The marine protected area closest to the project area is Panagaimotu Reef Reserve, which lies around 3 km northeast from the project area.



Source: Parks and Reserve Act 1988 and Fisheries Management (Conservation) Regulations 2008. Prepared with Google Earth.

Figure 4-4 Marine protected areas around Tongatapu Island

4.2.2. Protected species

Eleven species of birds and one sea turtle (*Dermochelys coriacea*) are protected under the Birds and Fish Preservation Act 1988. These species were not found around the project area.

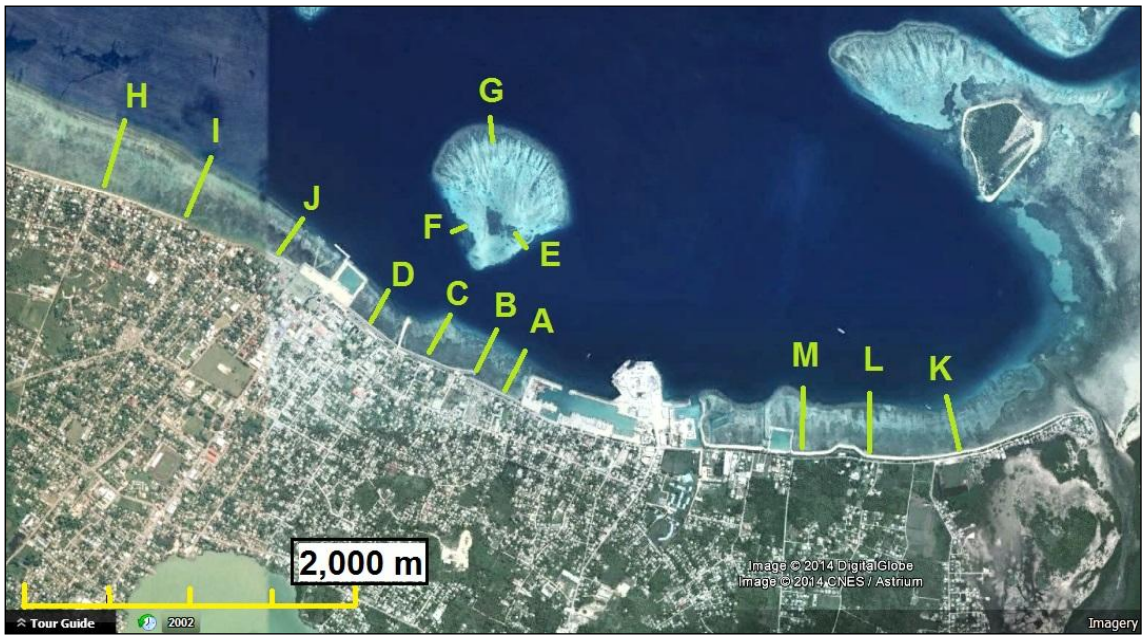
4.2.3. Coastal ecosystem

The new wharf will be constructed on top of a shallow fringing coral reef of approximately 200 m width. Most of the north coast of Tongatapu Island is fringed by such fringing coral reef. An ecosystem survey was conducted along the coral reef around the project site during September 15-18th, 2014, to understand mainly the following:

- Coral and seagrass distribution
- Percent coverage and diversity of corals
- Presence of endangered species

(1) Survey method

Survey was conducted by scuba diving (snorkeling in shallow areas) along 13 transects set along the coral reef, extending from the shallow inner reef flat, outer reef flat and to the reef slope up to around 3-4 m depth. The offshore reef lying approximately 800 m north from the project site was also surveyed. Figure 4-5 shows the location of the survey transects.



Source: prepared with Google Earth

Figure 4-5 Location of the survey transects

Six transects (A, B, C, D, E, G) near the project site were studied in detail by recording quantitatively the substrate type and coral lifeform along 20 m horizontal transects set at the inner reef flat, outer reef flat and reef slope. The type of coral species were also identified where possible on site or later by photograph. Fish and macro-invertebrates species were also recorded. The other transects (F, H, I, J, M, L, K) were studied in less detail and qualitatively, focusing mainly to understand roughly the coral and seagrass distribution.

(2) Survey results

1) Coral and seagrass distribution

The pattern of coral and seagrass distribution was similar throughout the surveyed area. Corals were mainly distributed along the outer reef flat and reef slope. Coral distribution became sparse once the reef slope gives way to a gradual sandy slope. Seagrass was distributed along the inner reef flat where the seabed is sandy. Brown algae and rubble were found in-between the coral and seagrass area. Figure 4-6 shows a typical cross-section profile of the surveyed coral reefs.

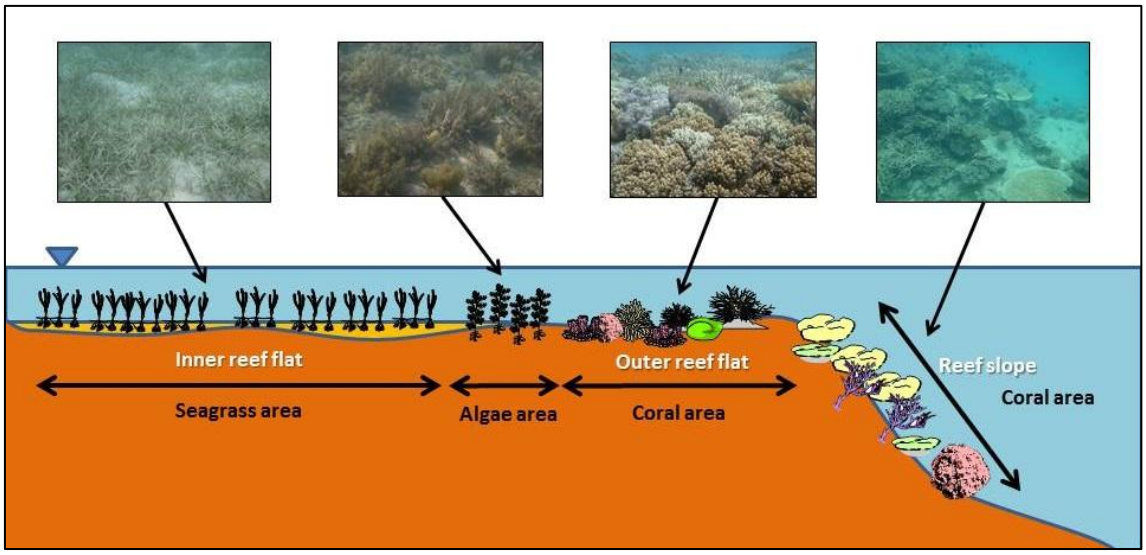
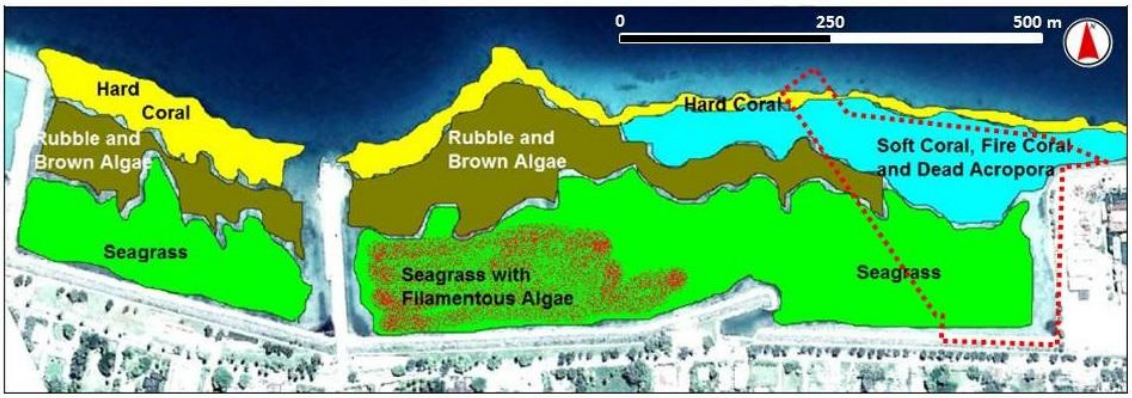


Figure 4-6 Typical cross-section profile of the surveyed coral reefs

Figure 4-7 shows the coral and seagrass distribution around the project area, which was developed based on the transect survey and Google Earth image. Note that corals inside the project area (red-dotted line) are mainly comprised of soft corals and fire corals. Dead *Acropora* corals are also common. These facts indicate that the project area is unsuitable for hard coral growth. Seagrass was densely distributed from the shore and up to around halfway of the reef.



Red-dotted line: project area

Figure 4-7 Coral and seagrass distribution around the project area

Figure 4-8 shows the coral and seagrass distribution at the offshore reef. Corals were mainly distributed in the outer reef flat and reef slope of the north side of the reef. Seagrass were mainly distributed in the west and east side of the reef.

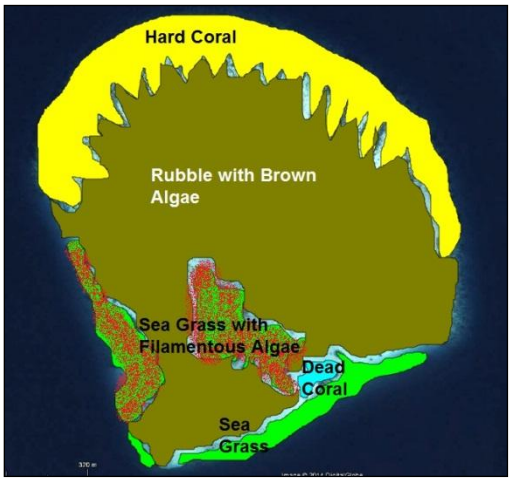


Figure 4-8 Coral and seagrass distribution at the offshore reef

2) Percent coral coverage

Figure 4-9 shows the percent substrate type in the coral reefs in the project site (transects A and B) and along the reef lying west (transects C and D). Substrate type was divided into the following categories: 1) Hard coral (including fire coral), 2) Soft coral, 3) Dead coral (corals died recently), 4) Algae, 5) Seagrass, 6) Sponge, 7) Rock (including long-dead corals), 8) Rubble, 9) Sand, 10) Silt and 11) Others.

In the outer reef flat, hard coral coverage (orange) ranged between 7-85%, but tended to be significantly higher at transects C (27%) and D (85%). Although hard coral coverage at transect A was relatively high (29%), this was mainly due to the high coverage of fire corals. In contrary, soft

coral coverage (yellow) was significantly higher in the project area (around 30%) compared to transects C (2%) and D (1%).

In the reef slope, hard coral coverage was more or less uniform between transects, ranging between around 40-50%. Soft coral coverage was less than 10% at all transects.

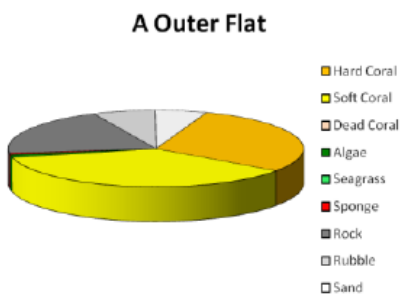
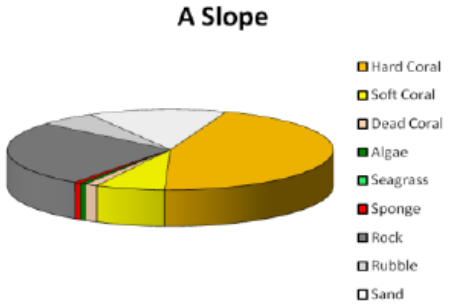
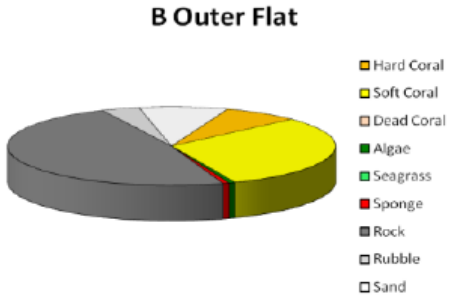
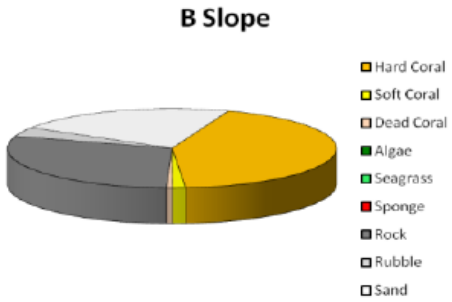
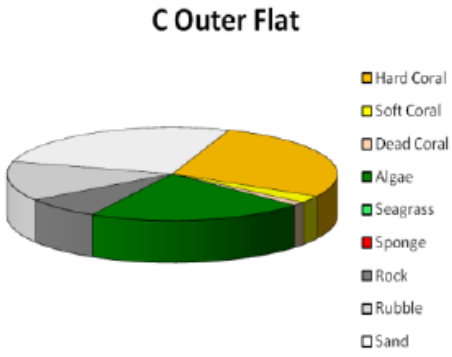
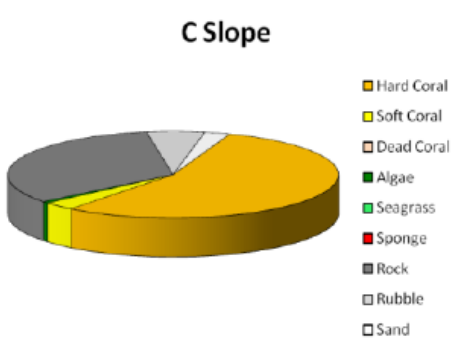
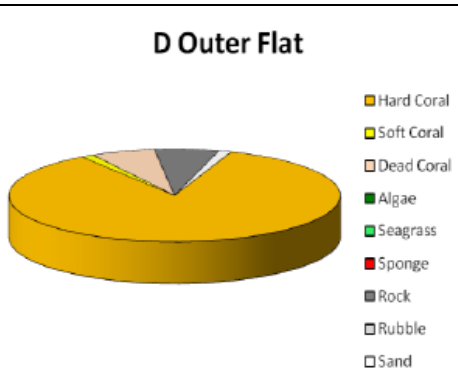
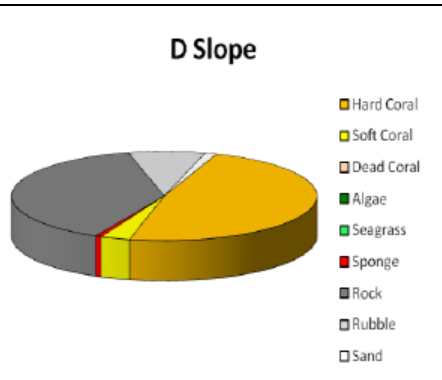
Transect	Outer reef flat	Reef slope
A		
B		
C		
D		

Figure 4-9 Percent substrate type in the coral reef around the project site

Figure 4-10 shows the percent substrate type in the offshore reef (transects E and G). Hard coral coverage at transect E was limited in both the outer reef flat (20%) and reef slope (8%). On the other hand, hard coral coverage at transect G was high at both the outer reef flat (61%) and reef

slope (65%), the highest within the surveyed area. Soft coral coverage was limited at both the outer reef flat (1%) and reef slope (12%).

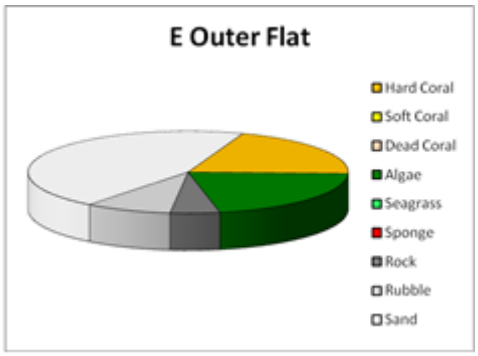
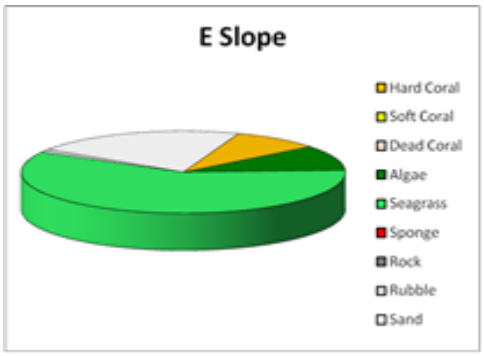
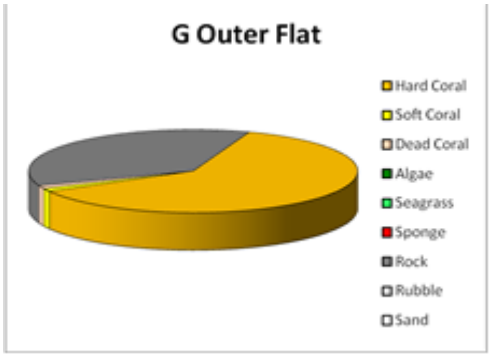
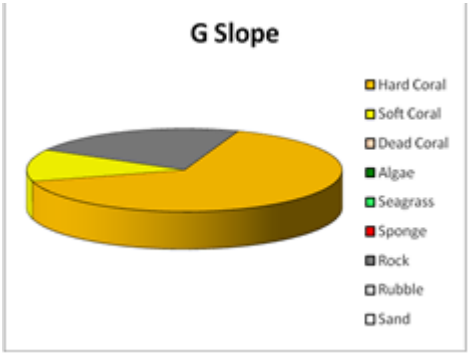
Transect	Outer reef flat	Reef slope
E		
G		

Figure 4-10 Percent substrate type in the offshore reef

3) Coral diversity based on lifeform

The diversity of hard corals was surveyed by classifying them by lifeforms, as set by the Australian Institute of Marine Science (AIMS). In general, a coral habitat can be considered as in good condition with increasing diversity of lifeforms. Table 4-6 shows the lifeform categories of hard corals.

Table 4-6 Lifeform categories of hard corals as set by AIMS

	AIMS lifeform categories	Code
1	*Acropora* branching coral	ACB
2	*Acropora* digitate coral	ACD
3	*Acropora* tabular coral	ACT
4	*Acropora* encrusting coral	ACE
5	*Acropora* submassive coral	ACS
6	Non-*Acropora* coral branching	CB
7	Non-*Acropora* coral massive	CM
8	Non-*Acropora* coral encrusting	CE
9	Non-*Acropora* coral foliose	CF
10	Non-*Acropora* coral submassive	CS
11	Non-*Acropora* coral fungoid (mushroom)	CMR
12	Non-*Acropora* coral *Millipora* (fire)	CME
13	Non-*Acropora* coral *Heliopora* (blue)	CHE

Figure 4-11 shows the lifeform diversity of hard corals in and around the project area (transects A-D) and the offshore reef (transects E and G). (Transect E will not be discussed further as it is primarily a seagrass area)

In the outer reef flat, lifeform diversity of hard corals at transects A and B were lower compared to the other transects. Transects A and B were dominated by soft (purple bar) and fire (green bar) corals, whereas the other transects were comprised of diverse lifeforms of hard corals, most notably various forms of *Acropora* corals (yellow-orange bars).

In the reef slope, lifeform diversity of hard corals were more or less uniform between transects. In addition to *Acropora* corals, there were diverse ranges of non-*Acropora* corals, most notably encrusting and massive corals (bluish bars).

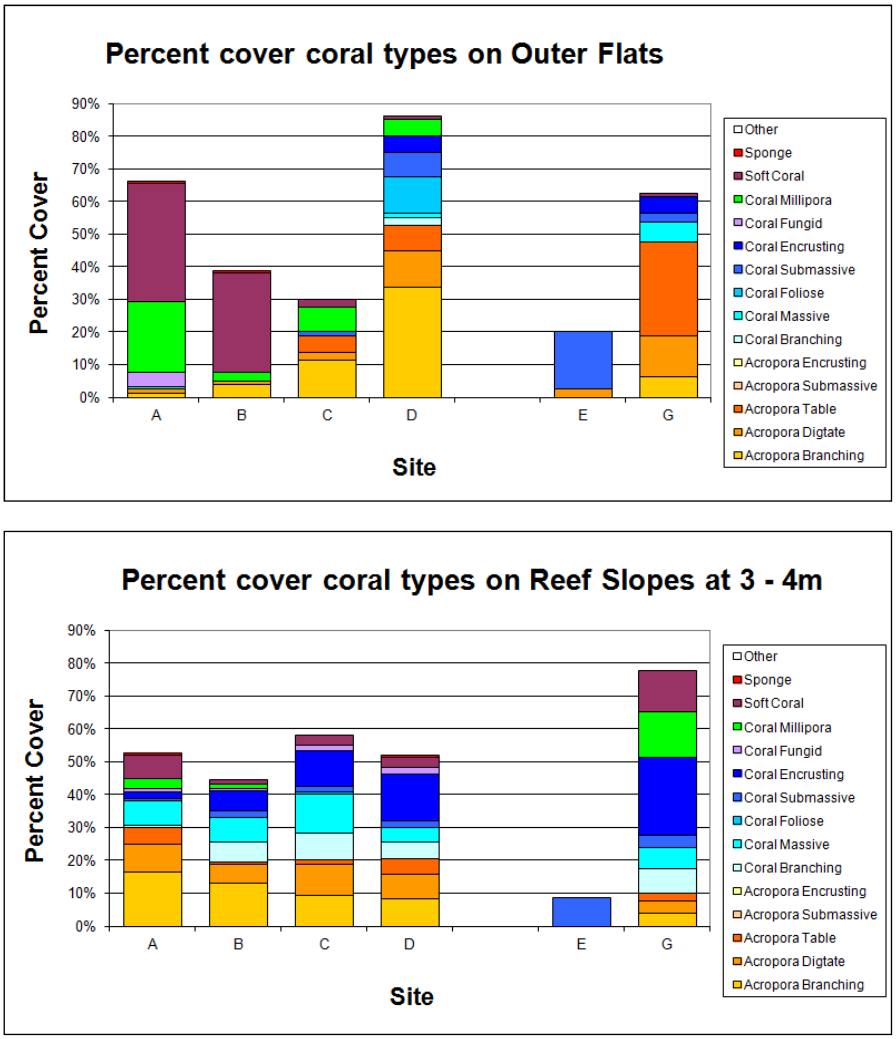


Figure 4-11 Lifeform diversity of hard corals in the project area and offshore reef

4) Endangered coral species

Table 4-7 shows the coral species identified through the survey (note that the list does not cover all the coral species in the transects and the actual numbers will be higher). Over 60 species were identified, in which 5 species (high-lighted in grey) are classified as Vulnerable under the IUCN Red List. None of these endangered species were found at the project site. Figure 4-12 shows photos of the endangered corals species identified through the survey.

Table 4-7 A list of coral species identified through the survey

	Genus	Species	Red list	Transect												
				A	B	C	D	E	F	G	H	I	J	K	L	M
1	*Acropora*	*abrotanoides*	LC			X										
2	*Acropora*	*exquisita*	DD	X												
3	*Acropora*	*florida*	NT			X										
4	*Acropora*	*formosa*	NT	X						X	X	X				
5	*Acropora*	*longicyathus*	LC	X			X									
6	*Acropora*	*loripes*	NT	X			X			X						
7	*Acropora*	*microphthalma*	LC	X											X	
8	*Acropora*	*nobilis*	LC	X	X	X										
9	*Acropora*	*secale*	NT							X						
10	*Acropora*	*digitifera*	NT	X				X		X	X					
11	*Acropora*	*gemmifera*	LC	X	X					X						X
12	*Acropora*	*humilis*	NT							X						
13	*Acropora*	*millipora*	NT							X						X
14	*Acropora*	*prostrata*	DD	X			X			X	X					
15	*Acropora*	*rosaria*	DD	X	X		X									
16	*Acropora*	*sarmentosa*	LC	X		X										
17	*Acropora*	*secale*	NT							X						
18	*Acropora*	*tenuis*	NT							X						
19	***Acropora***	***willisae***	**VU**							X						
20	*Acropora*	*hyacinthus*	NT	X	X	X	X			X	X	X	X			
21	*Acropora*	*latisella*	LC	X	X		X			X	X	X				X
22	*Montipora*	*digitata*	LC								X					
23	*Montipora*	*stellata*	LC													X
24	***Pachyseris***	***rugosa***	**VU**			X										
25	*Porites*	*cylindrica*	NT	X	X	X	X			X	X					
26	*Tubastrea*	*micrantha*	-	X						X						
27	*Astreopora*	*listeri*	LC		X											
28	*Echinophyllia*	*echinata*	LC		X		X									
29	*Echinophyllia*	*hirsutissimus*	LC	X	X											
30	*Favia*	*routumana*	LC		X		X				X					
31	*Favites*	*abdita* or *complanata*	-	X		X			X							
32	*Favites*	*flexuosa*	NT				X									
33	*Galaxea*	*fascicularis*	NT							X						
34	*Goniastrea*	*U/I Species*	-							X						
35	*Goniastrea*	*reliformis*	LC	X	X					X						x
36	*Goniastrea*	*pectinata*	LC	X		X	X									
37	*Lobophyllia*	*corymbosa*	LC			X										
38	*Merulina*	*ampliata*	LC			X				X						
39	*Montastrea*	*magnistellata*	NT			X	X			X						
40	*Mycedium*	*elephantotus*	LC	X						X						
41	*Oxypora*	*lacera*	LC							X						
42	*Pachyseries*	*speciosa*	LC				X									
43	*Pavona*	*varians*	LC	X						X						
44	*Psammocora*	*superficialis*	LC								X					
45	***Pavona***	***decussata***	**VU**												X	
46	*Podabacia*	*crustacea*	LC				X									
47	***Turbinaria***	***peltata***	**VU**							X						
48	***Turbinaria***	***reniformis***	**VU**			X				X						
49	*Diaseris*	*distorta*	-												X	

	Genus	Species	Red list	Transect												
				A	B	C	D	E	F	G	H	I	J	K	L	M
50	*Fungia*	*concinna*	LC	X		X										
51	*Fungia*	*fungites*	-	X	X										X	
52	*Fungia*	*horrida*	LC	X										X	X	
53	*Polyphyllia*	*novaehiberniae*	NT													
54	*Echinopora*	*hirsutissima*	LC												X	
55	*Gonipora*	*columnella*	NT		X											
56	*Montipora*	*spumosa*	LC	X						X						
57	***Pavona***	***decussata***	**VU**								X	X		X		
58	*Pocillopora*	*damicornis*	LC	X			X	X								
59	*Pocillopora*	*verruscosa*	LC										X			
60	*Lobophytum*	sp.	-							X					X	X
61	*Sarcophyton*	sp.	-											X	X	
62	*Sinulaira*	*flexibilis*	-											X		
63	*Sinularia*	sp.	-	X	X	X				X				X	X	X

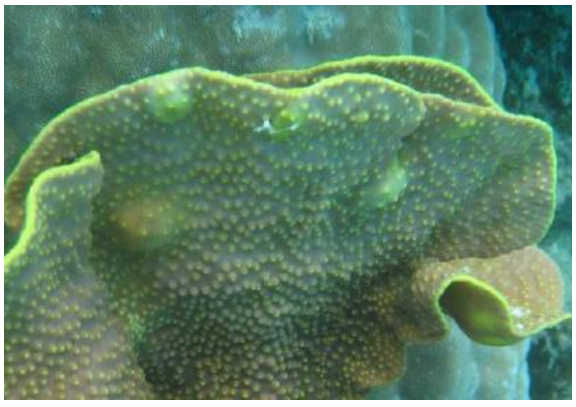
Note: *Pavona decussate* was found in two different lifeforms hence the duplication.

Acropora willisae (G)

Pachyseris rugosa (C)

Pavona decussate (H, I, K, L)*

Turbinaria peltata (G)



Turbinaria reniformis (C, G)

*: *Pavona decussate* was found in two different lifeforms.

Figure 4-12 Photos of endangered coral species identified through the survey

5) Seagrass and macro-algae

Table 4-8 shows the seagrass and macro-algae species identified through the survey. Seagrass were comprised of 4 species, with *Halodule uninervis* most prominent. None of the identified species are classified as endangered under the IUCN Red List.

Table 4-8 Seagrass and macro-algae species identified through the survey

	Genus	species	Transect												
			A	B	C	D	E	F	G	H	I	J	K	L	M
Seagrass	*Halophila*	*ovalis*											X		
	Halophila	*ovalis bullosa*	X	X	X	X	X								
	Halodule	*uninervis*	X	X	X	X	X	X		X	X	X	X	X	X
	Syringodium	*isoetifolium*	X												
Red algae	*Hypnea*	*esperi*	X	X	X	X				X	X	X	X	X	X
	Colpomenia	*sinuosa*		X											
	Galaxaura	*cohaerens*									X	X			
Brown algae	*Hydroclathrus*	*clathrus*	X												
	Lyengaria	*stellata*		X	X	X									X
	Padina	*santae-crucis*		X	X	X				X	X	X	X	X	X
	Turbinaria	*spicifera*		X		X				X	X	X	X	X	X
	Sargassum	*odontocarpum*								X	X	X			
	Sargassum	sp.			X	X				X	X	X	X	X	X
Green algae	*Codium*	*bulbopilium*								X	X	X			
	Halimeda	*borneensis*		X			X								

6) Benthic macro-invertebrates

Common benthic macro-invertebrates were sea cucumber, starfish, sea urchin and gastropods.

7) Fish

A total of 95 fish species were identified through the survey. Most of the species recorded were of the families Damselfish (Pomacanthidae), Butterflyfish (Chaetodontidae), Surgeonfish (Acanthuridae) and small Wrasse (Labridae). Very few species of fisheries importance such as Groupers (Serranidae), Sweetlips (Haemullidae), Jacks (Carrandidae) or Mackerels (Scombridae) were seen. None of the identified species are classified as endangered under the IUCN Red List.

4.2.4. Coastal hydrology

According to SOPAC (2008)[1], water circulation in the north-side of Tongatapu Island is influenced by the interaction of tide, wave and wind-induced currents. During spring tide, tidal currents dominate. During neap tides, tidal current decreases and current is mainly influenced by wind. Influence of wave-induced currents is limited to the areas facing the outer seas. Around the port area, current movement is likely to be driven by tide and wind currents, as wave action is limited.

[1] SOPAC (2008), Tonga Technical Report, Hydrodynamic Model of Fanga'uta lagoon: Water Circulation and Applications

4.3. Social environment

4.3.1. Population

According to ADB (2011) report, the population of Nukualofa is around 35,000 people, which is around one-third of the national population. The population is expected to grow to around 45,000 people by 2030.

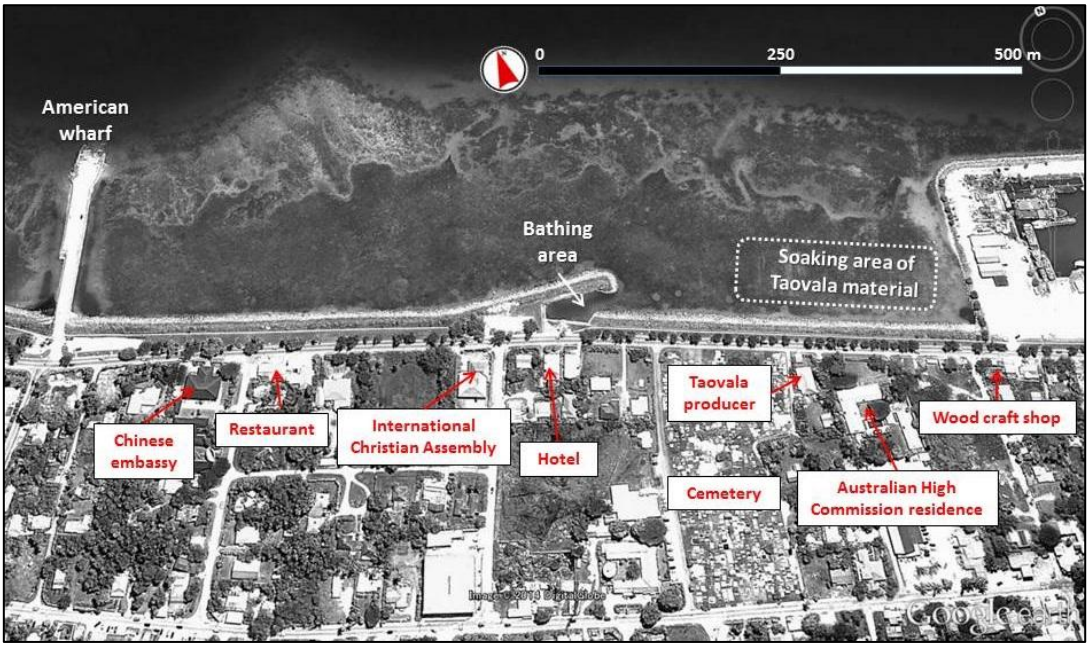
4.3.2. Land and water use

The land area adjacent to the Project site crossing Vuna road consists of residential houses (including Australian High Commission residence), shops, cemetery, hotel/lodges, restaurants, religious building, Chinese embassy and so on. Along the sea side of Vuna road lies a narrow stretch of promenade where people stroll and relax. Street vendors also sell food along the promenade (recently a new selling area for the street vendors was developed in the empty space next to the Australian High Commission residence).

The shallow waters in and around the project site is used by locals to soak materials (e.g. Pandanus leaves) used for making Taovala (Tongan traditional mat). There are around 20 people that work in the project area.

Children often bathe inside the jetty built between the port and American wharf. The offshore reef lying northwest of the project site is used as a diving spot by local tour operators.

Figure 4-13 shows the main land and water uses adjacent to the project site.



Source: prepared with Google Earth

Figure 4-13 Main land and water uses around the project site

5. Analysis of alternatives

In the initial planning phase, the berthing area for the domestic inter-island ships was planned to be relocated to Faua wharf, through extension and upgrade works. However, this plan was concluded as unfeasible, as sufficient space cannot be secured despite such works, in particular for the larger vessels. The remaining option was to develop a new wharf on the west side of Faua wharf. Development of the east side of the existing port was not possible as the area is reserved for the Tongan navy.

Once the development site was selected, three port layout options were considered mainly from the perspective of port usability. Figure 5-1 shows the considered port layout options and the advantages and disadvantages of each option. After careful analysis of each option, Option 1 was selected mainly as it enables to secure the longest ship berthing area and largest cargo yard. Although the cargo and passenger route cross-over with Option 1, the safety of passengers will be secured by allowing embarkation only after cargo loading is completed and also via a designated pathway.

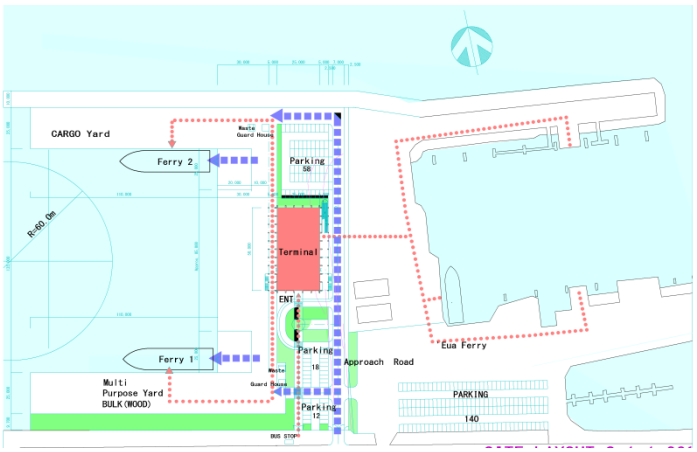
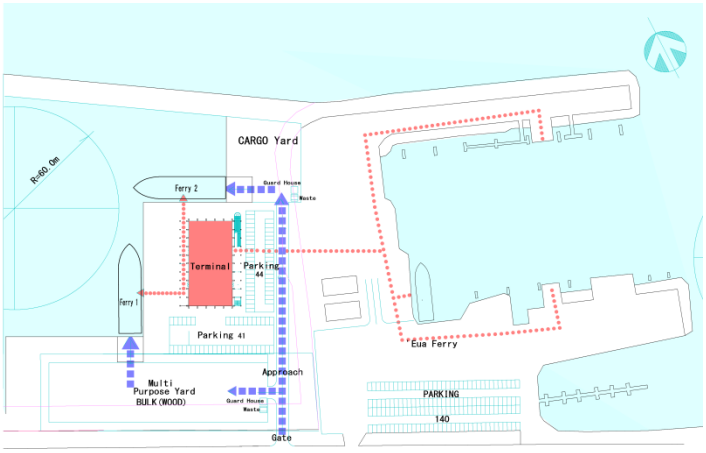
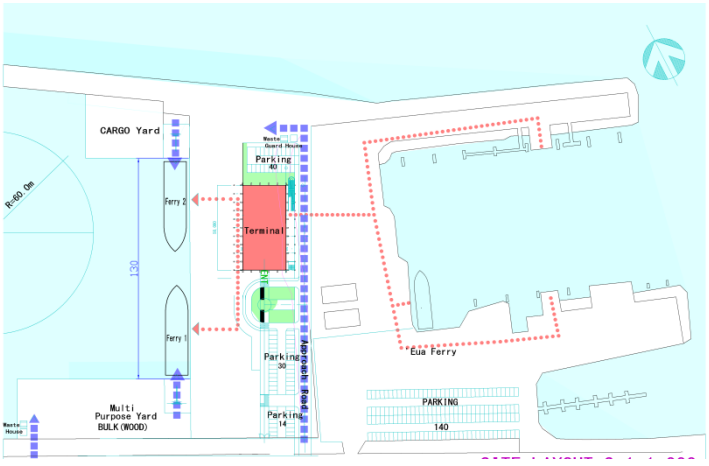
Option 1 [Advantages] ・ Possible to secure long berthing space and large cargo yard [Disadvantages] ・ Crossing of cargo and passenger route ・ Long walk to ship	
Option 2 [Advantages] ・ No crossing of cargo and passenger route ・ Short walk to ship [Disadvantages] ・ Small berthing space and cargo yard	
Option 3 [Advantages] ・ No crossing of cargo and passenger route ・ Short walk to ship ・ Longer berthing space than Option 2 [Disadvantages] ・ Shorter berthing space and smaller cargo yard compared to Option 1	

Figure 5-1 Considered port layout options

6. Potential environmental impacts and proposed mitigation measures

6.1. Scoping of potential environmental impacts

This Section will assess the potential environmental impacts for the construction and operation phases, covering physical, biological and social environmental aspects. The potential environmental impacts have been identified through a scoping exercise based on JICA's "Guidelines for environmental and social considerations (2010)", which provides a list of items to be considered in the scoping process. Scoping was conducted based on preliminary information collected through field surveys, interview surveys, field reconnaissance and so on.

Table 6-1 shows the results of the scoping including the rationale behind the rating. Items rated as having potential negative/positive impacts (e.g. A-, B-, C-) are assessed in detail in the ensuing sections.

Table 6-1 Results of scoping

	Item	Rating		Rationale
		Construc-tion	Operation	
Physical environment	Air quality	B-	B-/B+	**[Construction]** · Exhaust emission from construction machines and vehicles. · Dust emission from construction site. **[Operation]** · Exhaust emission from cargo and passenger vehicles. · Reduced dust emission due to concrete paving of the wharf. (positive impact)
	Noise/vibration	B-	B-	**[Construction]** · Noise and vibration emitted from pile-driving work. **[Operation]** · Noise from ships, cargo handling and vehicles.
	Water quality	B-	B-	**[Construction]** · Dispersion of suspended sediments due to dredging works. **[Operation]** · Discharge of wastewater from ships and terminal building.
	Soil quality	D	D	**[Construction]** · There are no activities that may affect soil quality. **[Operation]** · There are no activities that may affect soil quality.
	Sediment quality	D	B-	**[Construction]** · There are no major sources of sediment pollution. **[Operation]** · Anti-fouling paint of ships may pollute the sediment.
	Odor	B-	D	**[Construction]** · Dredged material may emit offensive odor due to organic decomposition. **[Operation]** · There are no significant odor sources.
	Waste	B-	B-	**[Construction]** · Generation of construction wastes. **[Operation]** · Generation of wastes from ships and terminal building.
	Land subsidence	D	D	**[Construction]** · There are no activities that may cause land subsidence. **[Operation]** · There are no activities that may cause land subsidence.
Natural environment	Protected area	D	D	**[Construction]** · No impacts expected due to distant location (> 3 km) of the protected area. **[Operation]** · No impacts expected due to distant location (> 3 km) of the protected area.
	Ecosystem	A-	B-	**[Construction]** · Direct loss of corals and seagrass. · Possible impacts on corals and seagrass through dispersion of sediments from construction works (e.g. dredging). **[Operation]** · Possible impacts through water pollution from ships and terminal building.

	Hydrology	C-	D	**[Construction]** · Dredging may cause seawater intrusion into the underground freshwater. **[Operation]** · The breakwater will inevitably alter the local water circulation but will be limited to around the port area.
	Topography	D	D	**[Construction]** · There is no significant alteration of topography except the dredging area. **[Operation]** · There will be no alteration of topography.
Social environment	Resettlement	D	D	Resettlement is not required.
	Indigenous people	D	D	There are no indigenous people around the project area.
	Livelihood	B-/B+	B+	**[Construction]** · Taovala producers will be required to relocate their activity. · Employment of local work force (positive impact). **[Operation]** · The terminal building will provide opportunities for local businesses (e.g. restaurant) and employment (positive impact).
	Land use	D	D	There will be no impact on current land use.
	Water use	B-	D	**[Construction]** · Taovala producers will be required to relocate their activity. · Possible restriction of using the bathing area. **[Operation]** · There will be no major alteration on current water use.
	Social infrastructure and service	D	D	No impacts are expected on social infrastructure and service.
	Cultural heritage	D	D	There are no cultural heritages around the project site.
	Landscape	B-	B-	**[Construction]** · Current sea view will be obstructed by construction works. **[Operation]** · Current sea view will be obstructed by the new wharf.
	Infectious diseases	D	D	The risk of infectious diseases spreading is low as the majority of the work force will be from the local area.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown.
D: No impact is expected.

6.2. Method of impact assessment

The degree of the environmental impacts was rated into four levels (major, moderate, minor and no impact) by considering factors such as magnitude, spatial extent and duration of the impacts. The positive effects of mitigation measures were also taken into account in the assessment. Assessment was conducted quantitatively whenever possible. Table 6-2 shows the assessment criteria applied for the impact rating. Note that some impacts are not rated due to the uncertainties involved in the assessment.

Table 6-2 Assessment criteria applied for impact rating

Impact rating	Assessment criteria		
	Physical environment	**Natural environment**	**Social environment**
Major	High likelihood of human health impacts with very little potential for improvement.	Permanent alteration of ecosystem, and major loss of biodiversity with very little potential for recovery.	Permanent change in livelihood with significant financial loss with very little potential for improvement.
Moderate	Possible impacts on human health but good potential for improvement.	Possible impacts on ecosystem and biodiversity but with good recovery potential.	Possible change in livelihood and financial loss but good potential for improvement.
Minor	Possible impacts on human health but likelihood very low.	Possible impacts on ecosystem and biodiversity but likelihood very low.	Possible change in livelihood and financial loss but likelihood very low.
No impact	No change from present status	No change from present status	No change from present status

6.3. Construction phase

6.3.1. Physical environment

6.3.1.1. Air quality

Exhaust emissions from construction machines and vehicles may deteriorate the local air quality. To minimize air pollution, these machines and vehicles will be regularly inspected and maintained so to prevent/minimize emission of excessive air pollutants. There will also be regular flow of dump trucks carrying rock material from the local quarry. While the traffic volume of these dump trucks is expected to be low (2 per hour), these trucks will be required to avoid sensitive areas as far as possible so to minimize impacts to the local people.

Dusts may be generated from the reclamation areas especially during dry and windy days. To minimize dust dispersion, the surface will be sprayed with water whenever necessary. The construction site will also be surrounded by a fence, which should block dust to a certain extent.

Providing that the above measures are implemented effectively, impact on air quality should be minor.

6.3.1.2. Noise

Noise from construction machines and vehicles may become nuisance to the local people. To minimize noise pollution, these machines and vehicles will be regularly inspected and maintained to minimize noise emission. There will also be regular flow of dump trucks carrying rock material from the local quarry. While the traffic volume of these dump trucks is expected to be low (2 per hour), these trucks will be required to avoid sensitive areas as far as possible so to minimize impacts to the local people.

The most significant noise source will be pile-driving works, which is required for installing sheet piles along the berths. To minimize noise from pile-driving works, a vibratory pile driver will be used, which emits less noise compared to other conventional battering-type pile drivers.

However, since the construction site is close to the residential area, noise impact of pile-driving work was predicted using the following standard sound attenuation formula:

$$L_{Aeq} = L_{Aw} - 8 - 20 \times \log_{10} r$$

L_{Aeq}: Equivalent sound level (dB)

L_{Aw}: Sound power level of noise source (dB)

r: Distance from noise source (m)

The sound power level (L_{Aw}) of vibratory pile driver was set as 112 dB, based on the technical manual[2] published by Highway Environment Research Institute (now Research Institute of Road and Street), Japan. The results of the prediction is shown in Table 6-3.

Table 6-3 Predicted noise attenuation from vibratory pile driver

Distance from source (m)	10	20	30	40	50	60	70	80	90	100
Equivalent sound level (dB)	84.0	78.0	74.5	72.0	70.0	68.4	67.1	65.9	64.9	64.0

Since Tonga has no noise standard, the Japanese noise standards were referred for assessing the impacts of pile-driving works. Two types of noise standards were referred: one is standard applied for construction works and the other ambient noise standard. Table 6-4 shows the Japanese noise standard for construction works and ambient noise standard.

Table 6-4 Japanese noise standard for construction works and ambient noise standard

Type of standard	Standard (dB)	Note
Construction work	85 (daytime)	Noise level to be met at construction site boundary. (Source: Noise Regulation Law)
Ambient noise standard	65 (daytime) 60 (nighttime)	Standard for residential/commercial area located adjacent to road. (Source: The Basic Environment Law)

The worst-case scenario will be when pile-driving works are conducted along the south side of the wharf, as it will be closest to the residential area. In such case, distance to the boundary of the construction site and residential area will be approximately 40 m and 60 m respectively. Figure 6-1 shows the distance between pile-driving works and the boundary of construction site and residential area, under worst-case scenario.

[2] Technical Manual on Road Environmental Impact Assessment (2007)

Source: prepared with Google Earth

Figure 6-1 Distance between pile-driving works and the boundary of construction site and residential area (under worst-case scenario)

According to the prediction of noise attenuation (Table 6-3), noise levels at the boundary of construction site and residential area were 72.0 dB and 68.4 dB respectively. However, since these values consider only contribution from pile-driving works, it is necessary to consider the accumulative effects of background noise level, which was around 65 dB according to the field survey. Table 6-5 shows the predicted noise level at the boundary of construction site and residential area when background noise level is incorporated.

Table 6-5 Predicted noise level at the boundary of construction site and residential area when background noise level is incorporated

Location	Noise level without background (dB)	Noise level with background (dB)
Construction site boundary	72.0	72.8
Residential area boundary	68.4	70.1

Note: Background noise level set as 65 dB. Noise level predicted by using standard noise accumulation formula.

The above result shows that noise level at the construction site boundary (72.8 dB) will be under the Japanese standard for construction works (85 dB). However, noise levels at the residential area boundary (70.1 dB) will exceed the Japanese standard for residential/commercial area (65 dB) by around 5 dB.

In conclusion, noise levels around the residential area may be relatively high during pile-driving works. However, since pile-driving works will be limited to around 5 months and

daytime, noise impacts from pile-driving works will be temporary and therefore remain within moderate levels. Noise levels will also be monitored during pile-driving works (see Section 7.2.1 for details).

6.3.1.3. Vibration

Pile-driving works will generate vibration which may affect the nearby residential area. Hence impact of pile-driving works was predicted using the following standard vibration attenuation formula:

$$L(r) = L(r_0) - 15 \log_{10}(r/r_0) - 8.68\,\alpha\,(r - r_0)$$

L(r): Vibration level at distance r (dB)

$L(r_0)$: Vibration level at reference point (dB)

r: Distance from pile driver (m)

r_0: Distance from pile driver to reference point (5 m)

α : Attenuation coefficient

The vibration level at reference point (L(r)) was set as 77 dB, which is the level set for vibratory pile driver under the technical manual[3] published by Highway Environment Research Institute (now Research Institute of Road and Street), Japan. The attenuation coefficient was set as 0.01, also based on the above manual. The results of the prediction is shown in Table 6-6.

Table 6-6 Predicted noise attenuation from vibratory pile driver

Distance from source (m)	10	20	30	40	50	60	70	80	90	100
Vibration level (dB)	72.1	66.7	63.2	60.4	58.1	56.0	54.2	52.4	50.8	49.2

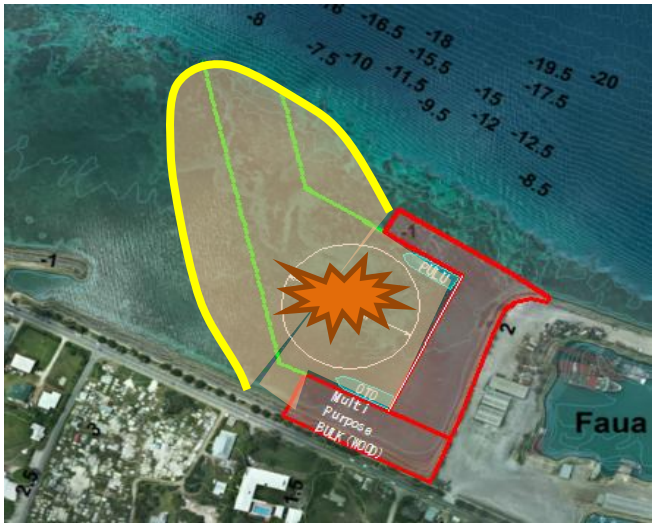
Since Tonga has no vibration standard, the Japanese vibration standard (Vibration Regulation Law) was referred for assessing the impacts of pile-driving works. Under the Japanese standard vibration levels should be under 75 dB at the boundary of the construction site.

The worst-case scenario will be when pile-driving works are conducted along the south side of the wharf, as it will be closest to the residential area. In such case, distance to the construction site boundary will be approximately 40 m. The prediction shows that vibration levels at 40 m from source to be around 60 dB, which is 15 dB lower than the Japanese standard. Therefore, it is likely that vibration levels from pile-driving works will comply with the Japanese standard and impacts remain within minor levels. Nevertheless, due to the proximity of the residential area to the construction site, vibration levels will be monitored during pile-driving works (see Section 7.2.2 for details).

[3] Technical Manual on Road Environmental Impact Assessment (2007)

6.3.1.4. Water quality

Dredging works will degrade the water quality, as it will suspend/disperse significant amount of seabed sediments into the surrounding waters. Such dispersion of sediments may affect the surrounding ecosystem through increasing water turbidity. To minimize sediment dispersion, silt curtain will be installed around the construction site, which will block the sediments to a certain extent. Figure 6-2 shows an image of how silt curtain will be installed.



Note: The yellow line is the silt curtain

Figure 6-2 Image of silt curtain installation

In addition, turbidity levels will be monitored in the adjacent waters as sediments can leak out through the silt curtain. Additional measures will be implemented if turbidity levels exceed the set threshold value (see Section 7.2.3 for details).

In conclusion, impacts on water quality should remain within moderate levels providing that silt curtain and turbidity monitoring is effectively employed.

6.3.1.5. Odor

While most of the dredged material will be used for reclamation, there will likely to be some excessive dredged material, which will be temporary stocked in the empty space south of Queen Salote wharf. Since these dredged materials may contain organic substances, it may emit offensive odor from the decomposition process, and become a nuisance to the local residents. To avoid such impacts, the excessive dredged material will be first dried at the north side of Faua wharf, where it should be far enough from the residential area. Once dried and odorless, the dredged material will be transported to the designated stocking area via Vuna road.

In conclusion, odor impacts should remain within minor level providing that dredged materials are initially dried at the north side of Faua wharf.

6.3.1.6. Waste

Construction works will generate various types of waste including hazardous waste. Wastes will be managed in manner so that it does not cause any pollution. Reuse and recycling will also be promoted to minimize waste generation. Table 6-7 shows the waste management plan for each waste type.

Table 6-7 Waste management plan of construction waste

Waste type	Management method
Non-hazardous solid waste (e.g. plastics, wrappings, paper, wood debris)	Non-hazardous solid waste will be temporary stored at a designated location inside the construction site. These wastes will be stored in a manner to prevent dispersal by wind. Eventually, the wastes will be disposed at the Tonga Waste Authority landfill site.
Hazardous waste (e.g. waste oil, waste battery)	Hazardous wastes will be temporary stored at a designated location inside the construction site. Measures will be taken to prevent spills and leakages into the surrounding environment. Eventually, the wastes will be transported to a local company for treatment or recycle. Hazardous wastes that are not accepted in Tonga will be transported to overseas for treatment or disposal.
Metal scraps	Metal scraps will be taken to a local recycling company.
Human waste	Temporary toilet will be installed at the construction site. The generated sludge will be disposed at the Tonga Waste Authority landfill site.

Providing that wastes are managed in accordance to the waste management plan, there should be no impacts from construction waste.

6.3.2. Natural environment

6.3.2.1. Ecosystem

The new wharf is located over a coral reef, providing habitat to various marine organisms. Around 300 m of coral habitat distributed along the outer reef flat and reef slope would be lost through construction works (e.g. breakwater construction, dredging and reclamation). While it is not possible to accurately predict the consequence of such loss, it is considered to be of moderate significance for the following reasons:

- The area of the affected coral habitat is small in proportion to the overall coral habitat area of the north coast of Tongatapu Island, which extends over 30 km.
- The coral habitat in the construction site can be considered to have limited ecological value compared to the other coral habitats along the coast, due to the relatively low coral diversity, absence of endangered species and abundance of dead corals.

Although the loss of coral habitat is considered to be of moderate significance, it is important that impacts to the coral habitat outside the construction area are minimized. One of the main concerns is the impact caused by sediment dispersion, in particular by dredging works. Corals are

vulnerable to high turbidity and if it persists for long duration there is a high risk that these corals will be significantly affected. To minimize such risk, silt curtain will be installed around the construction site to minimize sediment dispersion. Coral health will also be regularly monitored and additional measures will be considered if any significant coral health degradation are identified (see Section 7.2.4 for details).

Apart from corals, seagrass is also extensively distributed along the shallow inner reef, which is also important habitat for marine organisms. Approximately 2 ha of seagrass bed will be lost due to construction works. However, since seagrass distribution is extensive along the coastline of northern Tongatapu, such loss in seagrass area is considered to have limited impact. Further loss will be avoided as much as possible by minimizing sediment dispersion through silt curtain.

In conclusion, impacts on ecosystem (coral and seagrass) should remain within moderate levels providing that silt curtain and monitoring is effectively employed.

6.3.2.2. Hydrology

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.

6.3.3. Social environment

6.3.3.1. Livelihood

(1) Taovala production

There are around 20 people that work in the shallow inner reef flat of the construction site, where they soak materials (usually Pandanus leaves) used for making Taovala, a traditional Tongan mat/cloth. The materials are soaked in seawater by tying them on a rope stretched along wooden posts. They are soaked for around 1 week to make them soft. Soaking is conducted all-year round. Figure 6-3 shows photos of how Taovala material is soaked.

Figure 6-3 Photos of Taovala soaking works

Due to the new wharf construction, people working in the construction site will be required to relocate their activity to another nearby site. MOI conducted interview in November 2014 with four Taovala producers to hear their opinions regarding the relocation. All of them lived in Maufanga village, and Taovala production was their main livelihood. While none of the interviewees expressed any objection towards the project, some were concerned that relocation will affect their work. The main concerns were as follows:

- It will take time to find another soaking site.
- It will take more time to travel and complete work.
- The current location is suitable for soaking work.

Despite the concerns raised by some people, there are sufficient spaces available that are close to the current site, and relocation to such nearby area should not incur much additional effort. 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 (see Section 7.2.5 for details).

(2) Employment

Around 140 workers will be required for the construction including skilled and unskilled works. The project's policy is to take precedence in employing the local work force for these works. However, oversea workers may be employed for certain skilled works if local resource is unavailable.

6.3.3.2. Water use

As mentioned in the previous section, Taovala producers are using the construction site for soaking Taovala materials.

The calm water created by the small breakwater west to the construction site is also used by the

local people for bathing. Such use may be temporary restricted during construction for safety reasons.

6.3.3.3. Landscape

The current sea view from Vuna road will be obstructed by the construction works, as a fence will be installed along the construction site for safety reason. However, since the length of the fence will be around 200 m, such obstruction of sea view will be limited to a small area of Vuna road. The obstructed area is also considered as having relatively low landscape value as there are no tourist facilities (e.g. hotels) in front of the construction site. Hence landscape impacts should remain within minor levels.

6.4. Operation phase

6.4.1. Physical environment

6.4.1.1. Air quality

(1) Exhaust emission

Exhaust emission from ships, cargo handling equipment and cargo/passenger vehicles may deteriorate the local air quality, especially on the day of ship departure and arrival. However, impact on air quality is considered to be minor for the following reasons:

- Ship departure and arrival occur only around 2 times a week.
- Cargo handling will be done by forklift, which has limited exhaust emission.
- No significant increase in traffic volume is expected, as the number of passengers and cargo volume will be more or less same as present.
- Most of the time air pollutants will quickly disperse through the persistent trade wind.

(2) Dust

The current domestic terminal is unpaved. Hence, passengers are often affected by dust raised through wind and vehicles. The new wharf will solve such issues as it will be concrete paved.

6.4.1.2. Noise

Noise from ships, cargo handling and cargo/passenger vehicles may become a nuisance to the local residents, especially on the day of ship departure and arrival. However, noise impacts are considered to be minor for the following reasons:

- Ship departure and arrival occur only around 2 times a week.
- No significant increase in traffic volume is expected, as the number of passengers and cargo volume will be more or less same as present.
- Cargo handling will be done by forklift, which has limited noise emission.

6.4.1.3. Water quality

Water quality around the new wharf may deteriorate due to discharge of wastewater from ships and terminal building. To avoid such as impacts the following measures will be enforced/implemented:

- Wastewater discharge (e.g. bilge water, sewage water) from ships will be prohibited in the port in accordance to the Marine Pollution Prevention Act, 2002 and MARPOL 73/78.
- Wastewater from the terminal building (e.g. sewage water, kitchen wastewater) will be treated through septic tank with aeration system. The treated wastewater will then be discharged to the sea from the breakwater area via a soak pit under BOD concentration of 30 mg/l, which is the standard set by World Bank. The septic tank will also be inspected and maintained regularly to ensure it is functioning properly and effectively.
- The new wharf will be equipped with an oil spill response kit to respond in case of accidental oil spills.

Providing that the above measures are implemented effectively, impact on water quality should remain within minor levels.

6.4.1.4. Sediment quality

Ships coat the bottoms of its hull with anti-fouling paint to prevent marine organisms attaching to the hull. However, anti-fouling paint often contains harmful substances such as tributyltin (TBT), which slowly dissolve into seawater and then accumulate in bottom sediments. Marine organisms may then be contaminated by TBT, which is known to cause deformations and sex changes, for example on whelks. According to the sediment quality survey, TBT levels in the Queen Salote wharf area were high and there is a risk that sediments in the new wharf area will be similarly contaminated.

While the Marine Pollution Prevention Act, 2002 prohibits the use of TBT for vessels under 30 m in length, it does not apply to the domestic ships of the new wharf as most are larger than 30 m. Nevertheless, MOI will request to the ship owners to voluntarily refrain the use of TBT containing anti-fouling paint.

6.4.1.5. Waste

Various types of wastes will be generated from ships and terminal building. The new wharf and terminal building will have a waste reception facility for temporary storage of these wastes. Sufficient number of dust bins will also be placed along the wharf so to prevent passengers throwing away their rubbish. Special dust bins will also be placed for recyclable wastes such as drinking cans. Table 6-8 shows the waste management plan for each waste type.

Table 6-8 Waste management plan of operation phase

Waste type	Management method
Non-hazardous solid waste from ships and terminal building (e.g. food wrappings, drinking cans, paper)	Non-hazardous solid waste will be temporary stored at the waste reception facility and eventually disposed at the Tonga Waste Authority landfill site. Recyclable waste such as drinking cans will be stored in a special dust bin and taken to a local recycling company.
Hazardous waste from ships and cargo handling equipment (e.g. waste oil, waste battery)	Hazardous wastes will be temporary stored at the waste reception facility and eventually transported to a local company for treatment or recycle.
Food waste from ships and terminal building	Food waste will be stored in a special bin and eventually taken to local farms as a feed for domestic animals.
Human waste from terminal building	Human waste will be treated through septic tank. The generated sludge will be disposed at the Tonga Waste Authority landfill site.

Providing that wastes are managed in accordance to the waste management plan, there should be no impacts from construction waste.

6.4.2. Natural environment

6.4.2.1. Ecosystem

The coral and seagrass habitat around the new wharf could be affected if port activities cause water pollution. However, providing that the port will implement strict pollution control measures and waste management as explained in the previous section, impact on ecosystem should remain within minor levels.

6.4.3. Social environment

6.4.3.1. Livelihood

The terminal building will provide new business opportunities for the local service sector as it is planned to provide food and drink services for passengers and visitors. This will also create new employment opportunities for the local people as there will be demand for restaurant workers.

6.4.3.2. Landscape

Once the wharf is constructed, the current sea view from Vuna road will change to a port dominant view, which may be unpleasant for the pedestrians and nearby residents. 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. Hence landscape impacts should remain within minor levels.

7. Environmental management and monitoring plan

Based on the results of the environmental impact assessment, an environmental management plan has been prepared to ensure that the project proponent and other related entities implement the project efficiently with minimal environmental impacts. The environmental management plan provides information on the proposed mitigation measures and environmental monitoring plan.

7.1. Mitigation measures

Table 7-1 shows the proposed mitigation measures of the identified environmental impacts for the construction phase, including the timing of implementation and responsible entities.

Table 7-1 Proposed mitigation measures of 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
	Odor	Decomposition smell from dredged material	• Drying of dredged material far from residential area (north side of Faua wharf)	During dredging works	Construction contractor
	Waste	Construction wastes	• See Section 6.3.1.6. for waste management plan.	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

Category		Environmental impacts	Proposed mitigation measures	Timing of implementation	Responsible entities
Social	Livelihood	Relocation of Taovala soaking area	• Monitoring of relocated Taovala producers	Throughout the construction period	MOI

Table 7-2 shows the proposed mitigation measures of the identified environmental impacts for the operation phase, including the timing of implementation and responsible entities.

Table 7-2 Proposed mitigation measures of 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 the use of harmful anti-fouling paint	Throughout operation	MOI and port operator
	Waste	Waste from ships and terminal building	• See Section 6.4.1.5. for waste management plan.	Throughout operation	MOI and port operator

7.2. 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

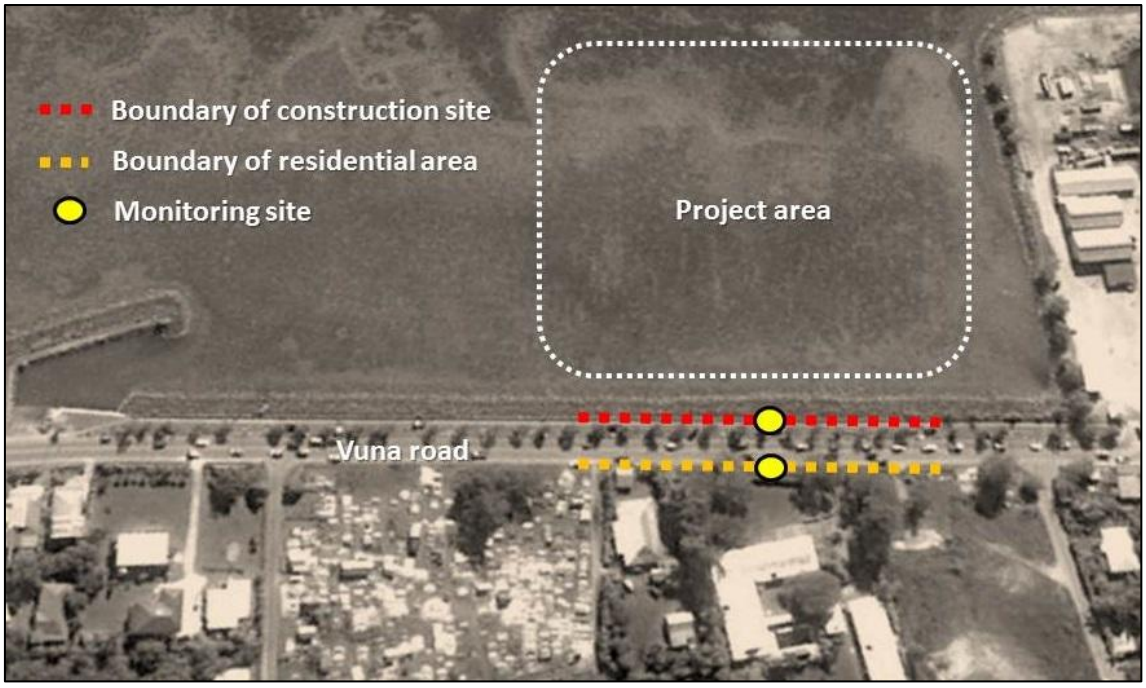
Depending on the monitoring results, the mitigation measures may be revised until impacts are reduced to satisfactory levels. The proposed environmental monitoring programs are described below.

7.2.1. Monitoring of noise

Aim: To monitor whether pile-driving works are not having any adverse impacts on the surrounding residential areas.

Location: The following two (2) sites (see Figure 7-1 for the location)

- One (1) site at the boundary of construction site facing Vuna road
- One (1) site along the boundary of the residential area facing Vuna road



Source: prepared with Google Earth

Figure 7-1 Location of noise monitoring sites

Frequency: Daily (once each during the morning and afternoon) during pile-driving works and whenever considered necessary by the supervising consultant.

Parameter: Equivalent Sound Level (L_{Aeq})

Method: Noise levels will be measured based on method stipulated in the Basic Environment Law of Japan.

Threshold level: Additional measures will be implemented if noise caused from construction works exceeds the following levels:

- Boundary of construction site: 85 dB (based on Noise Regulation Law of Japan)
- Boundary of residential area: 65 dB (based on Basic Environment Law of Japan)

Responsible entity: Construction contractor

Reporting requirements: The monitoring results will be reported 1/week to the supervising consultant and MOI, and to MEC whenever required.

Monitoring cost: approximately US$ 5,000

7.2.2. Monitoring of vibration

Aim: To monitor whether pile-driving works are not having any adverse impacts on the surrounding residential areas.

Location: The following two (2) sites. The location is same as noise monitoring.

- One (1) site at the boundary of construction site facing Vuna road
- One (1) site along the boundary of the residential area facing Vuna road

Frequency: Daily (once each during the morning and afternoon) during pile-driving works and whenever considered necessary by the supervising consultant.

Parameter: Vibration level (Lv_{10})

Method: Vibration levels will be measured based on method stipulated in the Vibration Regulation Law of Japan.

Threshold level: Additional measures will be implemented if vibration caused from construction works exceeds the following levels:

- Boundary of construction site: 75 dB (based on Vibration Regulation Law of Japan)

Responsible entity: Construction contractor

Reporting requirements: The monitoring results will be reported 1/week to the supervising consultant and MOI, and to MEC whenever required.

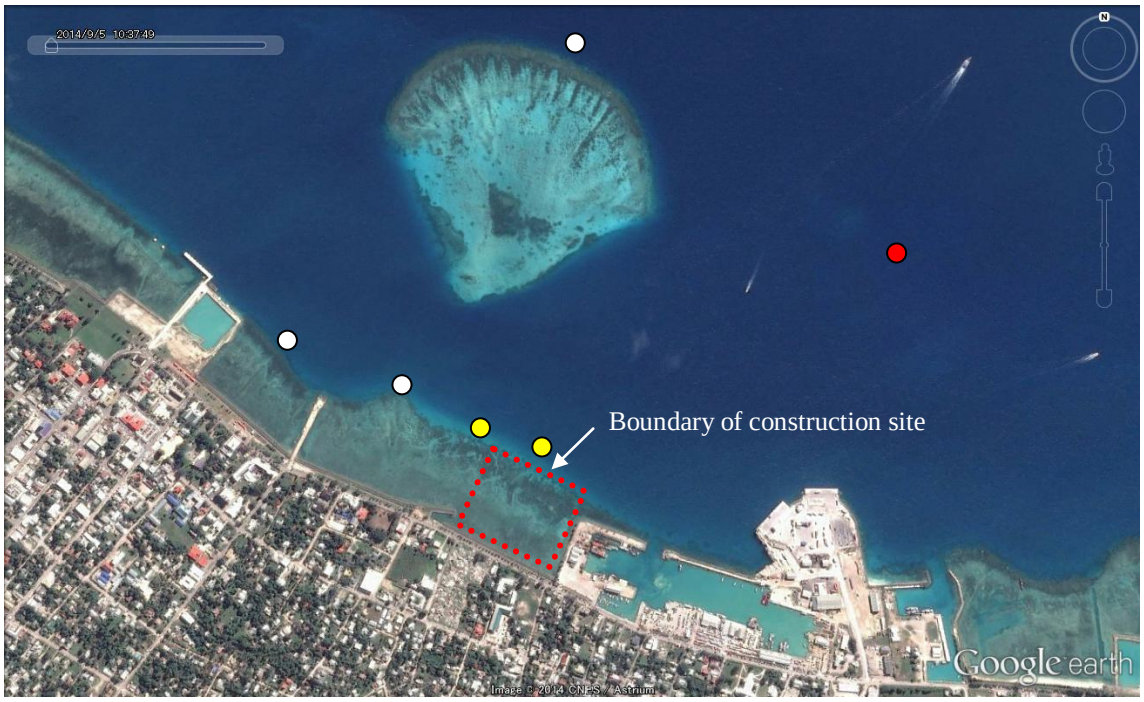
Monitoring cost: approximately US$ 5,000

7.2.3. Monitoring of water quality

Aim: To monitor whether construction works are not elevating the turbidity levels around the surrounding coral reefs.

Location: A total of six (6) sites (see Figure 7-2 for approximate location)

- 3 sites: coral reef area (white circle)
- 2 sites: boundary of construction site (yellow circle)
- 1 site: reference site (red circle)



Source: prepared with Google Earth

Figure 7-2 Approximate location of water quality monitoring sites

Frequency: Daily during dredging and reclamation works and whenever considered necessary by the supervising consultant.

Method: Turbidity levels will be measured at the surface layer using a turbidity meter.

Threshold level: Additional measures will be implemented if turbidity caused from construction works exceeds 2 NTU[4] at the coral reef area for 3 days within 6 days:

Responsible entity: Construction contractor

Reporting requirements: The monitoring results will be reported 1/week to the supervising consultant and MOI, and to MEC whenever required.

Monitoring cost: approximately US$ 20,000

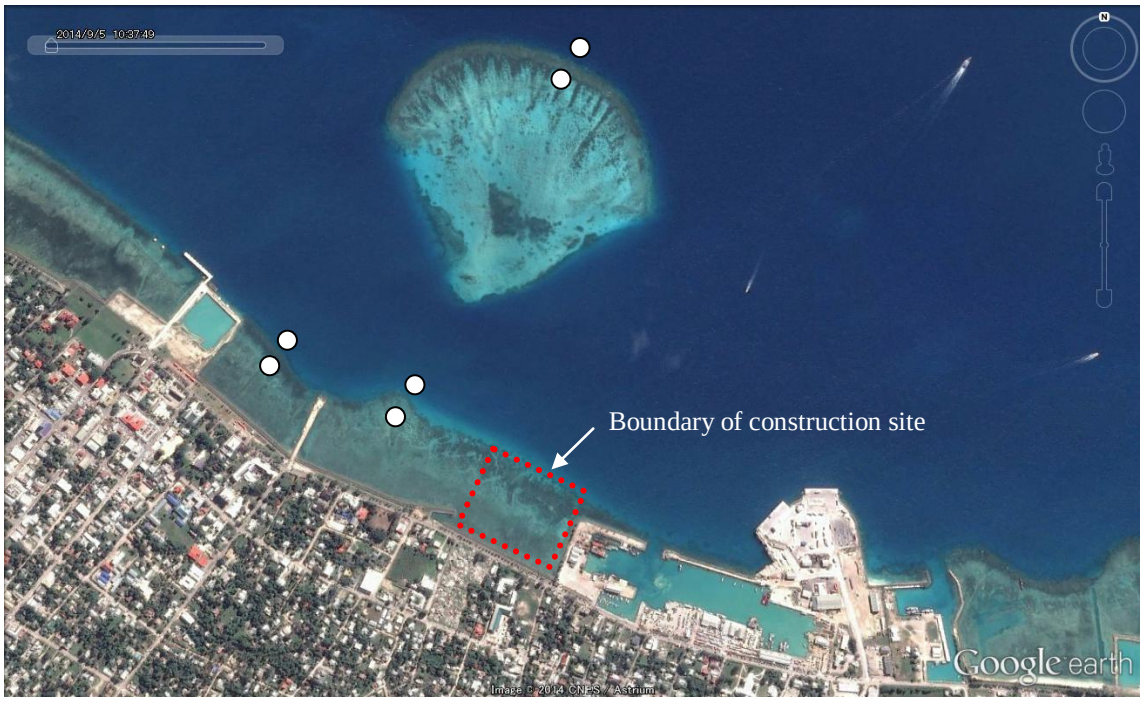
7.2.4. Monitoring of coral health

Aim: To monitor whether construction works are not causing adverse impacts on the health of corals outside the construction site.

Location: A total of six (6) sites (see Figure 7-3 for approximate location)

- 3 sites in the outer reef flat and 3 sites in the reef slope area

[4] The threshold level of 2 NTU was set 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.



Source: prepared with Google Earth

Figure 7-3 Approximate location of coral health monitoring sites

Frequency: Once a month during dredging and reclamation works and whenever considered necessary by the supervising consultant.

Method:

(1) Pre-survey

Prior to the start of construction, a permanent monitoring quadrat (e.g. 2 m x 2 m) will be set at the coral reef areas shown in Figure 7-3. The quadrats will be set by targeting coral species that are vulnerable to turbidity and species listed under IUCN red list. The target coral species will be determined together with a local or overseas coral expert. At each quadrat, baseline information such as percent live-coral coverage, percent bleaching and coral health status will be recorded. Underwater photographs will also be taken for record.

(2) Monitoring survey

The following impact indicators will be observed at the set monitoring quadrats:

- Percent live-coral coverage
- Percent bleaching
- Coral stress indicators such as excess mucus production, change in color, sediment accumulation

Additional measures will be implemented if there is reduction in live coral coverage or if signs of coral stress are identified. The health status will be evaluated by a local or overseas coral expert.

(3) Post-survey

Within two weeks after the completion of the dredging and reclamation works, the status of the corals will be surveyed and compared with the pre-survey.

Responsible entity: Construction contractor
Reporting requirements: The monitoring results will be reported 1/month to the supervising consultant and MOI, and to MEC whenever required.
Monitoring cost: approximately US$ 10,000

7.2.5. Monitoring of Taovala producers

Aim: To monitor whether the relocation are not having any adverse impacts on their activities and livelihood.
Frequency: Once every 6 month
Method: Interview survey
Responsible entity: MOI
Reporting requirements: The monitoring results will be reported to MEC whenever required.
Monitoring cost: Negligible

8. Public consultation

Public consultation meeting was held on November 6th, 2014, to inform and obtain opinions of the public about the planned project, its potential environmental impacts and mitigation measures. The stakeholders and public were invited by sending invitation letters. The local community (Maufanga and Fasimoeafi) were also informed via the local town officer and announcement through public radio on November 4th, 5th and 6th. Over 30 people participated in the meeting including, local residents of Maufanga, shop owners, relevant government agencies and so on. Tonga TV also came to cover the meeting.

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. The minutes of the meeting is attached as Appendix 2.

9. Conclusion

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.