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GEOCARE & Petroleum Consult Ltd

ENVIRONMENTAL IMPACT ASSESSMENT

PROPOSED REPLACEMENT CAUSEWAY FOR FOA ISLAND, KINGDOM OF TONGA

by

Talanoa Fuka Kitekei'aho and Poasi Ngaluafe

This report has been prepared to analyze potential significant effects associated with the construction of a replacement causeway between Lifuka and Foa Islands, Kingdom of Tonga. Mitigation measures are suggested on potentially significant impacts together with discussions on alternative design of the structure in order to reduce its impacts on coastal processes and coastal erosion witnessed on islands of Foa and Lifuka.

SUMMARY

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FOR

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Type of Action

Proposed rehabilitation works on Foa Causeway

Description of the Proposed Action

The purpose of the action is to improve transportation and reduce maintenance cost by upgrading causeway between Foa and Lifuka Islands, to become more resilient and less vulnerable to impacts of high energy waves. Built in the period 1978-1979, the raised coral structure has served the people of Foa and Lifuka well despite increasing maintenance cost. The replacement structure is similar to the existing one but with rock armoring to reduce the energy of waves impacting on the structure and culverts in the middle to encourage water flows to the western side of the Causeway. The estimated cost of construction is about TOP4.67 million

Environmental Effects

Environmental effects requiring specific analysis are limited to the followings;

- possible effect of the structure on coastal erosion
- dispersion of fine sediment from the construction site and its possible effects on fauna and flora in the nearby areas.

Other effects considered in the analysis include social issues on fisheries and tourism, health issues on fish poisoning and on biological communities of the areas.

Mitigation and Monitoring

The effect of fine sediment plume is unavoidable but can be minimized by avoiding transportation of fine sediment to site during loading and deliveries of large coral boulders from the quarries. The sediment plume would affect mostly the marine ecosystem to west of the site. The effect on coastal erosion can be mitigated by having two channels of appropriate lengths at two ends of the causeway

to isolate the two littoral currents operating on the coastline of Foa and Lifuka and another large channel in the middle for improved water and nutrients circulation on the western side of the causeway. The improved circulation would mitigate most of the social, health and biological issues raised by the community of Foa Island.

Alternatives to the Proposed Action

The alternative 2 of **having a bridge or open piling structure** is ideal for it will free up all coastal processes, mitigate all social and health issues and reduce coastal erosion. However, the capital cost for a bridge is likely to be 10 times the cost for upgrading the Causeway and would not be feasible with funds available at the moment. Alternative 3 of building **concrete driveway on the reef** flat is considered a health risk and too much inconvenience as people will have to only travel during low tide. Alternative 4 of **do nothing** is considered too expensive on maintenance cost and causing too much negative effects on the environment.

Public Hearing

A public scoping meeting was held on December 16, 2010 at Foa. Oral and written comments are incorporated in this report and recorded in Appendix B.

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ACKNOWLEDGEMENT

I would like to thank the proponent, Mr Leveni ‘Aho, CEO of Ministry of Works, Mr Sione Taumoepeau, Head of the PMU, for having confidence in our company in conducting this Environmental Impact Assessment. I am also grateful to Ministry of Fisheries for accommodating the survey team while at Ha’apai, especially Mr Sailosi ‘Alofi and his dear wife ‘Ana who continuously provided us with fresh raw fish every morning for breakfast. Finally, to Lotele and the Fofo’anga buys for providing assistance during fieldworks.

ENVIRONMENTAL IMPACT ASSESSMENT

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PROPOSED REPLACEMENT CAUSEWAY FOR FOA ISLAND, KINGDOM OF TONGA

BACKGROUND

For many years the people of Foa Island used boats to access important services such as colleges, hospital, wharf and the administrative centre, Pangai, which are all situated on the island of Lifuka. The building of the airport in early 1980s, at the northern end of Lifuka Island, further adds to the significance of the causeway as a mean for transportation and economic developments of the two islands.

The Foa Causeway was first built in 1978-79. Today the causeway serves approximately 7,600 people of the Ha'apai Group. The Causeway was built simply as a continuous raised road made entirely of coral boulders and a concrete slab for pedestrians and vehicles to travel to and from the two islands. It is a one lane structure with an average height just above mean sea level, exposing the structure to wave overtopping and devastating impacts of high energy waves during spring tides, storms and cyclones. These wave actions have caused frequent damages to the causeway leading to high maintenance cost and inconveniences, to users of this important route. Recent inspection of the structure by engineers from Ministry of Works revealed that it is inadequate and requires major rehabilitation works.

The funding for this rehabilitation works is made available by the Government of Germany in agreeing to swap part of a loan still owed by the Tonga Government to any it project may choose. The Foa Causeway was chosen as the project. Prior to the construction, the Tonga Government through the Ministry of Works, and in accordance with the EIA Act of 2003, wishes to examine potential for environmental impacts, associated with this rehabilitation works. This study is to be completed by an independent contractor in conformance with the agreed Terms of Reference (Appendix A). The tender for this study was won by Geocare & Petroleum Consultants.

Contractor's Specific Proposal

In response to this requirement the contractor proposed the following:

1. The contractor will carry out the work according to the agreed Terms of Reference and will deliver an appropriate environmental report to specification.

2. The contractor will be responsible for synthesis and analysis of existing data, for all travel and for preparation of the final document. It is estimated that the final documents can be delivered within 22 days of commencement of the study.

3. The Government of Tonga, through Ministry of Works will arrange for a scoping meeting, inviting appropriate officials and members of the general public, to be held on Wednesday 15 December, 2010.

4. The concerns received from this meeting will be prioritized and add to the scope of this study.

The proposal was accepted and arrangement was made to commence the study on 13 December 2010. The contractor spent two days in the field, determining and determined current regime in the channel, littoral current directions along the coastlines of Foa and Lifuka and recording baseline data on the reef flats, east and west of the proposed replacement causeway. The latter data would form part of a monitoring program to be instigated during and after the construction of the causeway.

The Scoping Meeting (15 December 2010)

This is an important part of developing an Environmental Assessment. The inputs from this meeting were prioritized and added to the initial scope of this study if there is a need.

The meeting was held on 16 December 2010 after the town officers of six villages and District Officer was advised on Monday 13 December 2010. The meeting was attended by 12 representatives, including all town officers, District officers and representatives from Fisheries and Ministry of Works. The minute of the meeting is presented in APPENDIX B. The participants' inputs were prioritized and classed under 4 main categories listed below.

Table 1: Categorization of Issues during the Scoping Meeting

CONCERNS	**NO. OF INPUTS**
PHYSICAL EFFECTS OF CAUSEWAY (sand transportation, coastal erosion, ocean mixing)	3
EFFECTS ON FISHERIES (fish migration, fish poisoning, lack of marine life)	3
COASTAL EROSION	1
POLLUTION (dead reef, lack of marine abundance and variety)	2
ALTERNATIVE STRUCTURES (improve ocean mixing, coastal erosion, isolate coastal processes)	3

Specific questions arising from the discussions are listed below (in italics) and responses are addressed here and some will be brought out later for discussion in appropriate sections of this report.

Physical Effects of the Causeway

1. *Since the building of the causeway, we witnessed coastal erosion, lack of marine species in the causeway area.*

   It appears from the data collected on the current that the causeway contributes significantly to the coastal erosion on the western coastlines of Foa and Lifuka. Prior to the construction the coastal processes acting on Lifuka and Foa islands were separated by the channel. The construction of the causeway joined the two processes into one which increased distance of transportation, disrupting supply of sediment along the two coastlines resulting in coastal erosion.

   The lack of marine life is likely due to lack of ocean mixing and pollution from sediment plume as a result of continuous maintenance works on the causeway.

Effects on Fisheries

2. *Fisheries in area of the causeway is affected badly, why was the EIA not done before the causeway was built in the beginning?*

   Firstly, in 1978-79 there was not much awareness about the environment. Secondly, Tonga Environment Impact Assessment Act was passed only in 2003 with its Regulation recently passed in November 2010. The Regulations is now enforcing the Act and all proponents of major projects must conduct an EIA to be approved by Ministry of Environment and Climate Change (MECC) before commencement of any construction.

Coastal Erosion

3. *The channel between Foa and Nukunamo used to be smaller than today (approx. 100m) with land extended further to sea. There used to be lots of coconut trees on the coastline but now all gone and the channel is becoming bigger than before. Is this related to the causeway?*

   We think so. As we have seen on the currents acting on the channels between Nukunamo-Foa, Lifuka - Uoleva, the water flows is towards the west during both low and high tides. We think that the causeway in the Foa-Lifuka channel is stopping water from getting through to the west, resulting in a change in water changed in water flow as it heads out towards Foa-Nukunamo and Lifuka-Uoleva channels. In the case of Foa, the large volume of water and intensity of flow may have been responsible for the coastal erosion at this end of the Island.

Pollution

4. *Fish in the area of the causeway, especially the pone (surgeon fish) is becoming poisonous, no one is fishing them. Is this related to the causeway?*

   Fish poisoning could be related to two things. Firstly, lack of ocean mixing may result in anoxic environment leading to growth of certain poisonous seaweeds that fishes feed upon and become poisonous. Secondly, contaminats in the sea can get into the food chain and make fishes poisonous.

Alternative Structures

5. *Is there money for this project and who is funding it?*

   The money is made available from funds owed to the Government of Germany which they have agreed to redirect towards Foa's causeway.

6. *Is there any final design for the causeway?*

   There is a preliminary design but the final design would be based on the EIA findings

7. *Can we have a causeway with an open piling structure to allow for free flow of water and sand distribution?*

   The final structure is dependent on the amount of money available to us. At the moment, it is a little over 4 million pa'anga. There are three options recommended by the EIA Consultants but perhaps a fourth option should be considered of a pavement built directly over the reef flat, allowing for free flow of water, no coral boulders to be thrown around by waves, little maintenance cost, cheaper but may restrict travelling to low tides only. Proper planning of trips to Lifuka will make this option viable.

8. *The causeway is very important for us and all we need is a structure that will allow us to travel to Lifuka. Maybe one channel in the middle will do.*

   We don't want to ignore the environmental impacts. We are now required by the EIA Act, 2003 to identify environmental impacts and suggest ways to minimize these effects. If we disregard the negative process operating at the moment coastal erosion will continue at both Foa and Lifuka islands, fisheries will still be affected and fish poisoning will continue. Furthermore, having one channel in the middle will cause a funneling effect which may later on clog up the channel with sediment or may offer an attacking point for waves.

Further Consultation

After conducting the Scoping Meeting, the Head of the Project Management Unit and the Consultants agreed that the current scope of the study has covered most of the concern`s and there is no need to search for more data. The team returns to Tonga on Friday 17th December 2010 to prepare the Final Report, after spending one week at Ha'apai.

ALTERNATIVES INCLUDING THE PROPOSED ACTION

This section defines the proposed course of action and examines four other alternatives brought out during the Scoping Meeting, on the structure of the proposed replacement causeway.

Alternative 1: Proposed Action

The purpose of the proposed action is to minimize the detrimental effects of waves on the structure, reduce maintenance cost and allowing for continuous utilization of the causeway by the people of Foa and Lifuka.

The proposed structure is a raised road similar to the existing one with the following variations;

1. The new structure will be wider with a pedestrian lane and 3 places for passing lanes.
2. The average height is only a few centimeters above the existing one.
3. Ten culverts evenly distributed to allow free flow of water and species migration
4. The core of the structure consists of precast concrete slab driven into the reef to form a large rectangular box, which would be filled with sand and sealed with 8 inches concrete slabs for pedestrians and vehicular usages.
5. Either side of the box would be strengthened and bordered by large coral boulders arranged to slope downward from top of the structure at 3:1 and 1.5:1, to dissipate wave energy.

The cost of construction of this structure is estimated at 4.67 million pa'anga. See Figure 1 below for the conceptual design of this structure.

Figure 1A`: Bird's Eye View and General Layout.

[redacted]

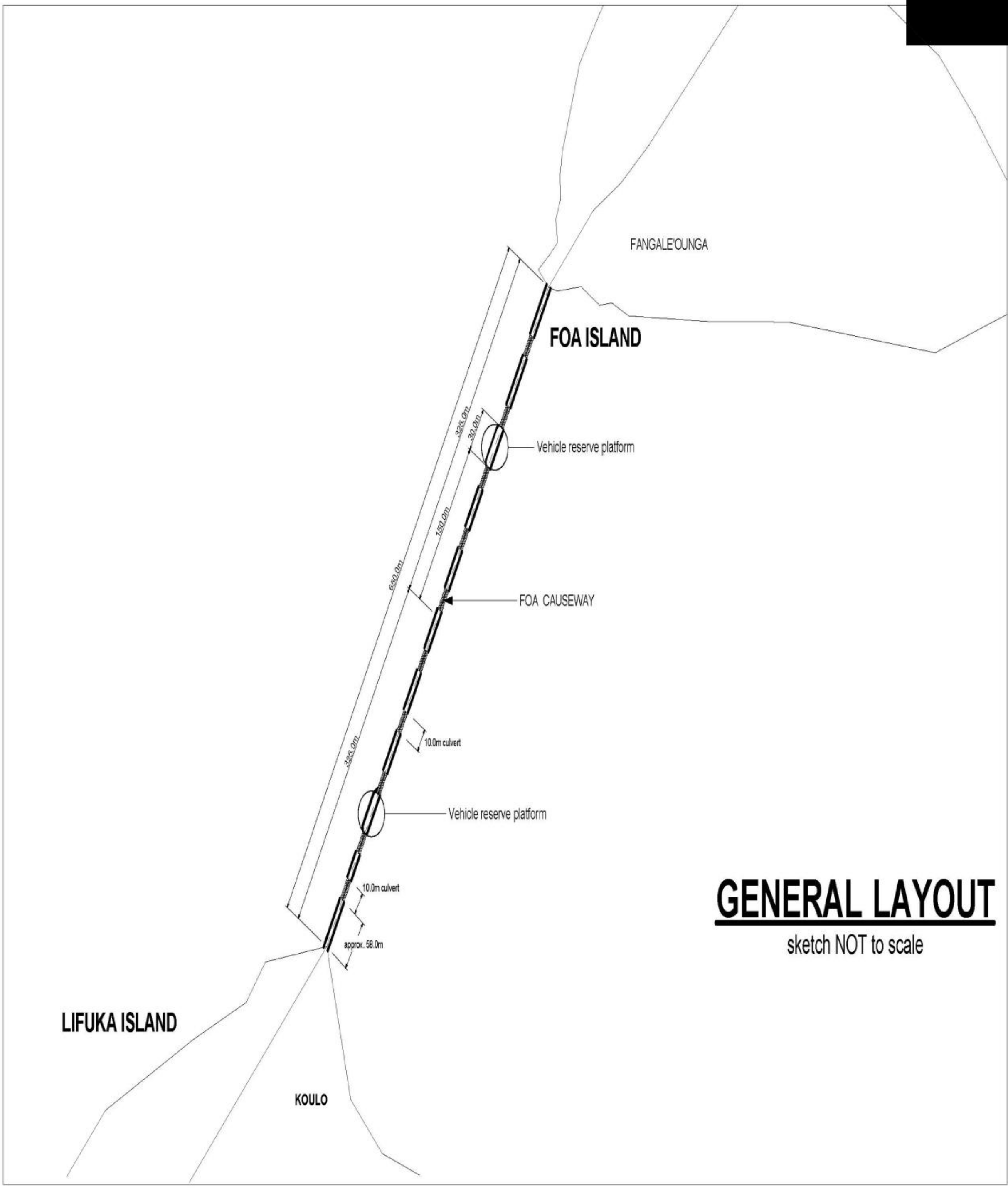
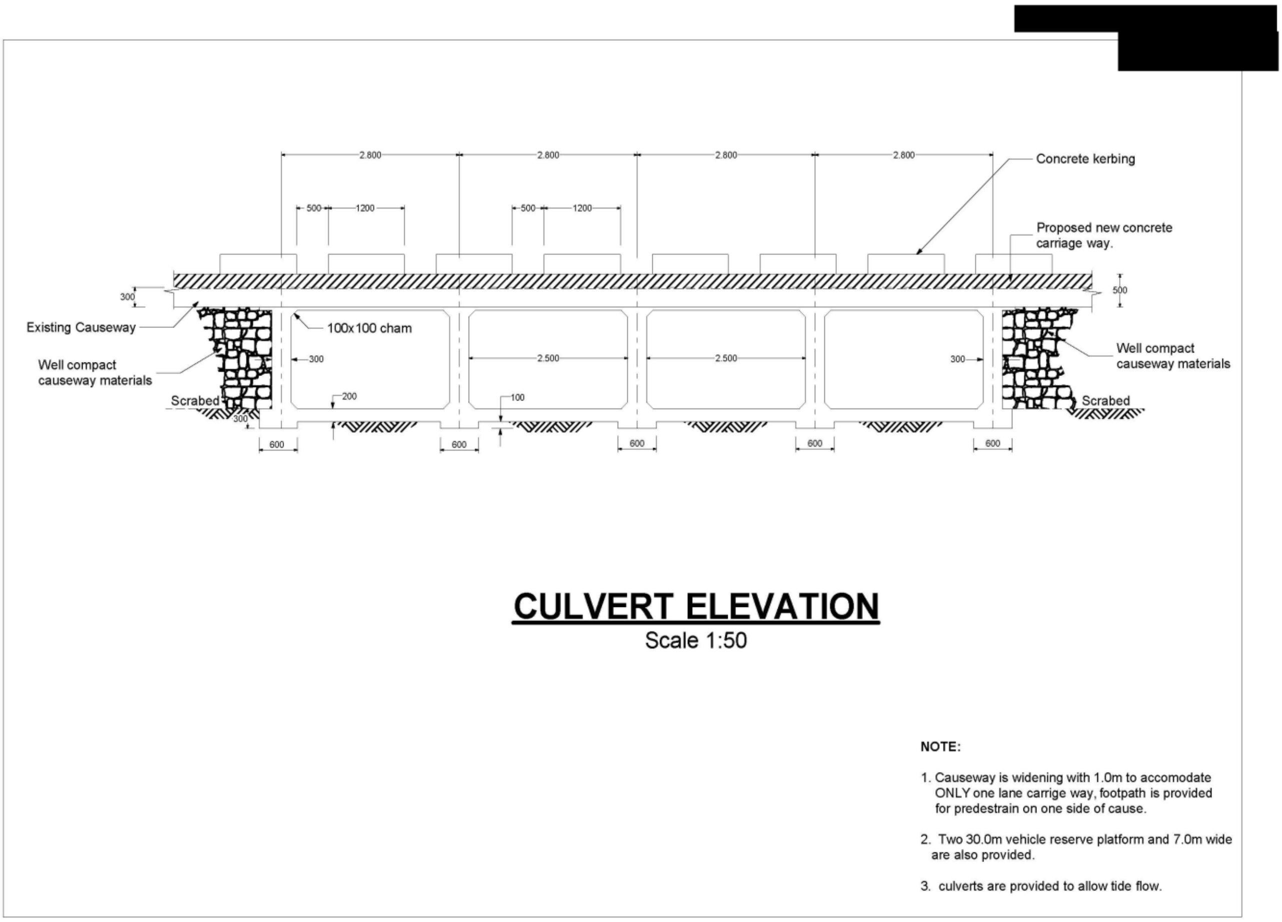

FANGALE'OUNGA
FOA ISLAND
325.0m
30.0m
Vehicle reserve platform
150.0m
650.0m
FOA CAUSEWAY
10.0m culvert
325.0m
Vehicle reserve platform
10.0m culvert
approx. 58.0m
LIFUKA ISLAND
KOULO
GENERAL LAYOUT
sketch NOT to scale

Figure 1B: Cross Sectional View



ALTERNATIVE 2: Open piling Structure

This alternative is considered in response to concerns regarding fisheries, free flow of water, species migration and coastal erosion, raised during the Scoping Meeting of 15 December 2010. The structure considered for this alternative can be regarded as a bridge, raised to a level that would be higher than highest wave recorded in the area, and supported by concrete piling to allow for free flow of water underneath the bridge and marine species migration to occur. The structure rises gently toward the middle and fall with same amount to the other end to allow for a road drainage system to be put in place to get rid of road pollutants (diesel and oil). This alternative is regarded as ideal for coastal processes to re-establish itself but likely to cost much more than that of the proposed action.

ALTERNATIVE 3: Reef Flat Concrete Pavement.

This alternative is focused on allowing for ocean mixing and re-establishment of littoral currents on Lifuka and Foa coastlines. It is proposed that a concrete pavement is built directly on the reef flat without any coral boulders on either side. This will allow for ocean mixing and no barrier against coastal processes. This would be cheaper but the only inconvenience is that travelling will be restricted to low tide only. This option is considered to causing inconveniences, restricting economic developments and would affect human health during a delay due to tides. This option is therefore rejected at this point.

ALTERNATIVE 4: Do Nothing

In this case no action would be taken and the present system of continuous maintenance works would continue unless replaced by some other action. Observations made by the consultants on the structure showed lots of areas with serious damages indicating that rising maintenance cost would be a great concern in the future. Furthermore its effect on coastal erosion, fisheries and health considerations will continue.

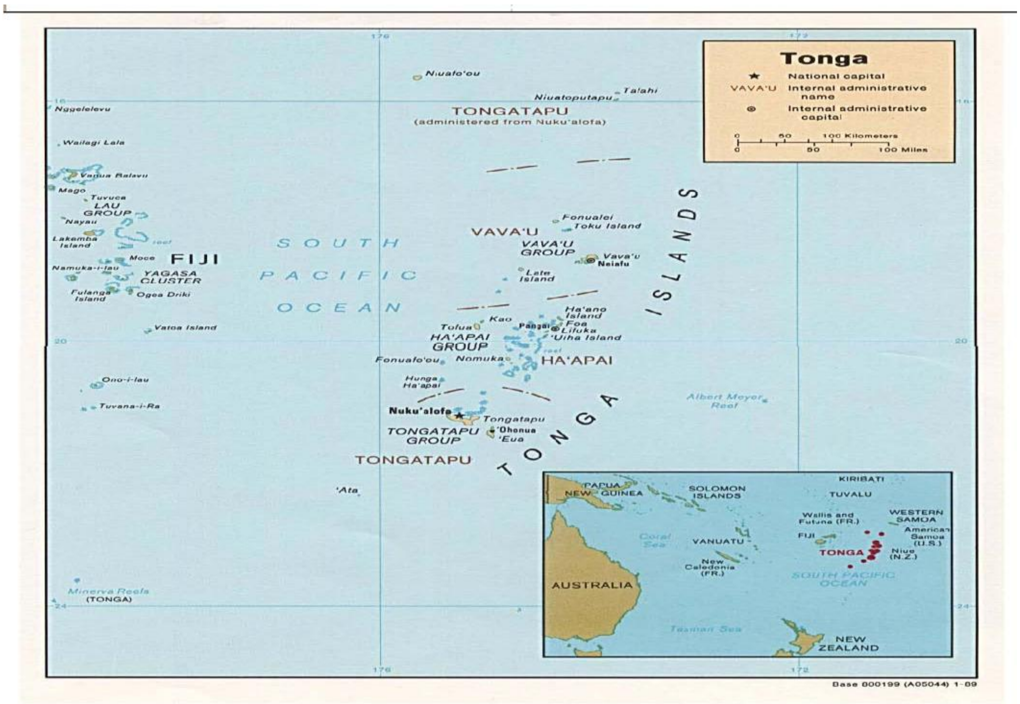
DESCRIPTION OF THE AFFECTED ENVIRONMENT

The following passages describe the most important aspects about the winds, ocean currents and waves, geological and bathymetric setting, coastline geomorphology, biological communities and social systems as they relate to the potential for environmental impacts. Detail description is given only to those aspects that relate directly to potential environmental impacts.

PHYSICAL CONSIDERATIONS

The Kingdom of Tonga lies between 15° - 23° 30´ S and 173° - 177° W (Figure 1). The Kingdom is an archipelago of about 150 islands of which 36 are inhabited within an exclusive Economic Zone of over 700,000 square kilometers. There are four main groups of islands that formed the Tonga Group. Arranged in a north to south direction, are the two Niuas, followed by the Vava'u Group, the Ha'apai Group and further south still is the Tongatapu Group of islands (Figure 1). Tongatapu is the largest of these islands and contains about 60% of its 120,000 population *(World Bank and CIA Factbook).* The capital Nuku'alofa lies on the northern leeward coast of Tongatapu island.

Figure 1: Tonga Group of Islands



Study Area

The study area is situated at the Ha'apai Group, at a shallow channel between the islands of Foa and Lifuka. See figure 2a & 2b below.

Figure 2a: Study area.

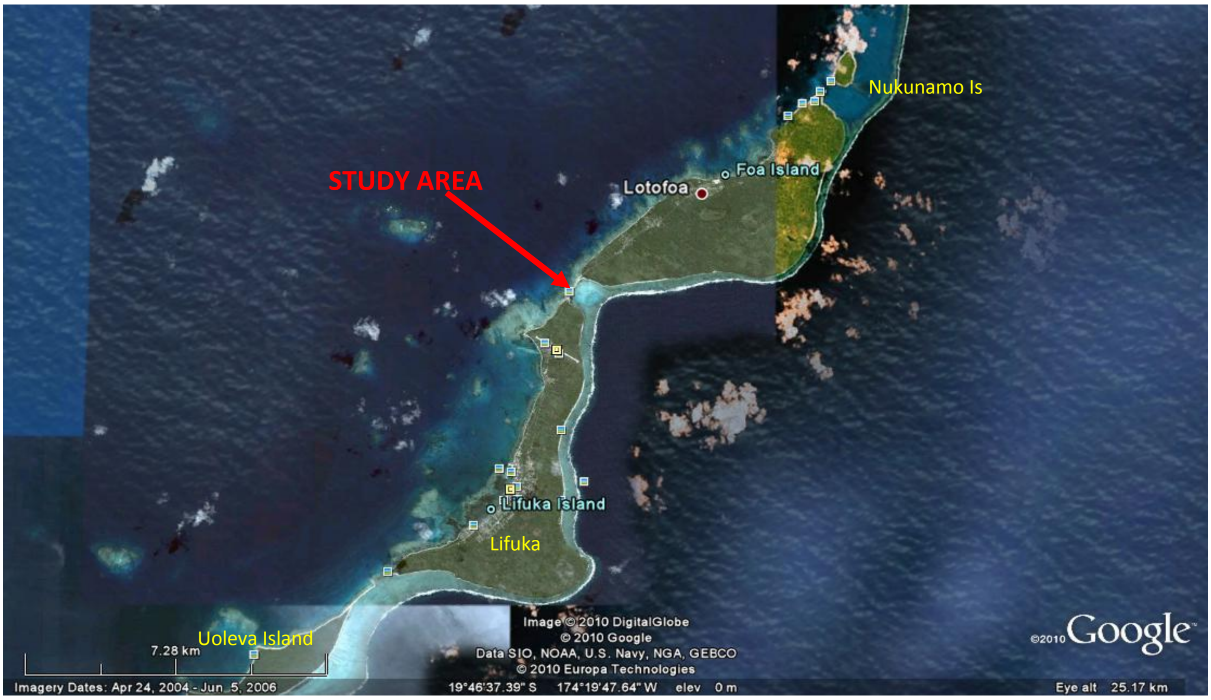


Figure 2b: Study area (close up).

The Ha'apai Group resembles a chain of barrier islands. The existing causeway is built on a reef flat of a barrier reef system that extends both north and south along the eastern coastline, as fringing reef then become barrier reefs where channels exist. The fringing reefs of the eastern coastlines face the dominant southeasterly wind and waves it generated, making it the main source for sand on beaches along the eastern coastlines of the two islands, Foa and Lifuka.

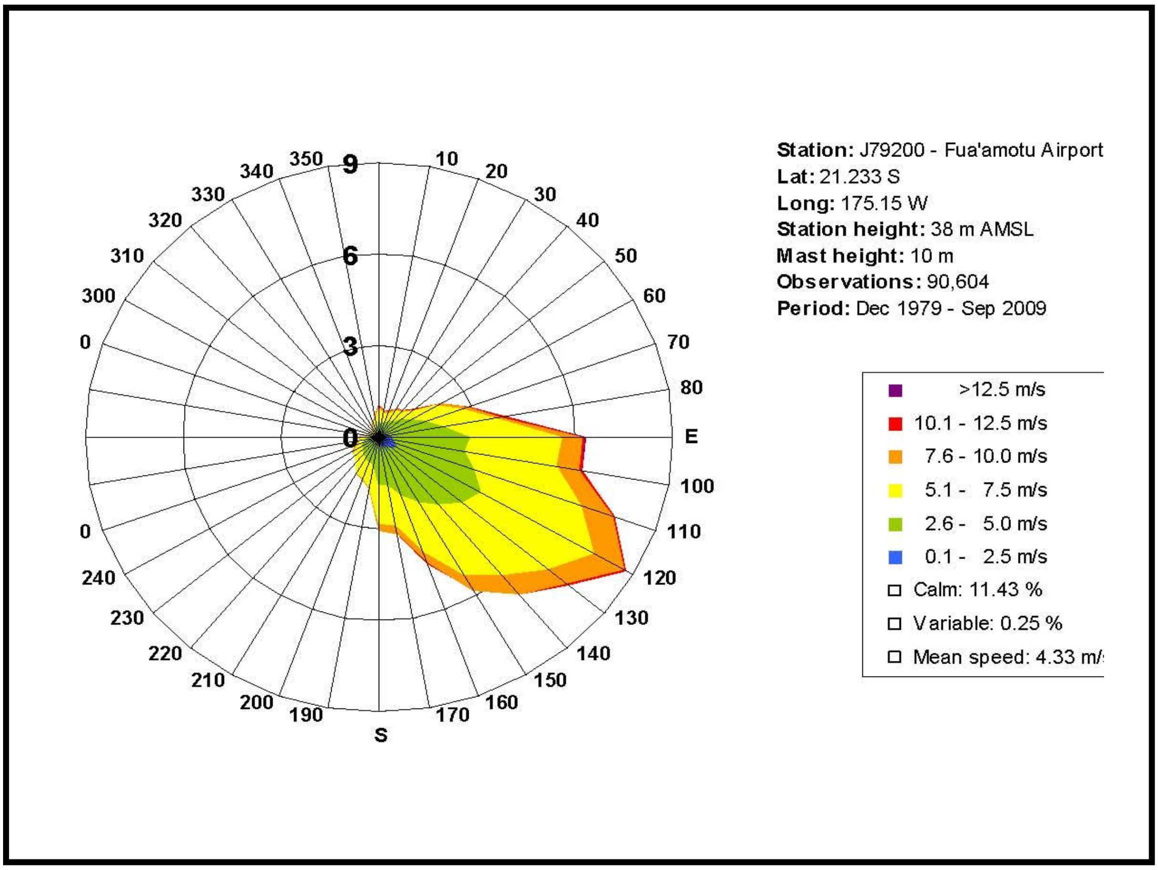
WIND & WAVES

The prevailing winds in Tonga consist mainly of the southeasterly winds, but cyclones pass through the area, generally from the northeast. Under ambient condition the wind speed is between 2.6/s and 7.5m/s (Figure 3). In extreme wind condition the wind has been recorded to reach 26.3m/s from the northeast direction in previous cyclones.

Tropical cyclones are seasonal phenomenon (November to April in the SW Pacific) with a frequency of 1 cyclone per season for Tonga. The average number of tropical cyclone that affected the SW

Pacific per season varies between 8 and 10. The Ha'apai Group tends to suffer the most as some of these cyclones passed through the Tonga Group.

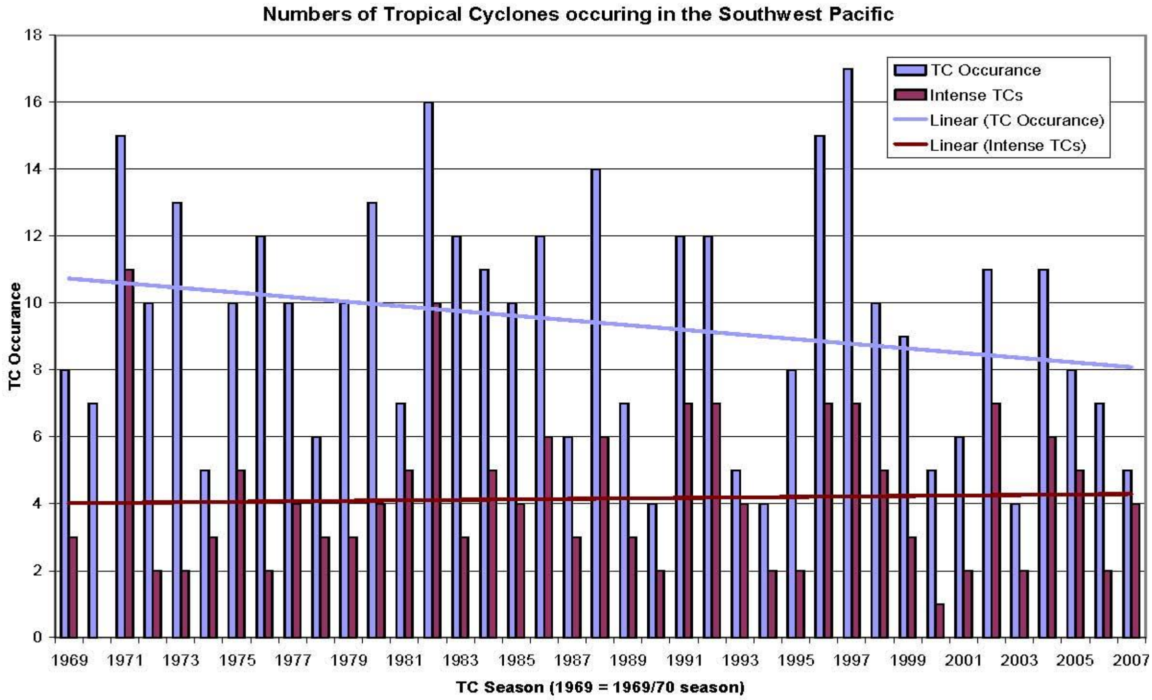
Figure 3: Wind Speed by return period. Source: NIWA, New Zealand



The study area would be doubly exposed to the prevailing SE winds and occasional cyclone that comes from the northerlies direction (NE-NW). High velocity cyclone and other storm winds do occasionally impact the islands from the north, along with associated large breaking waves. These waves have been recorded to cause large damages to the causeway.

Figure 4 shows the number of cyclone occurred in the Southwest Pacific, in the period 1969 - 2007. The graph is suggesting decrease in frequency of tropical cyclone and a corresponding increase in intensity.

Figure 4: Number of Tropical Cyclones occurred in the Southwest Pacific (1969-2007)



According to NIWA, we are in a moderate to strong La Nina condition and South Pacific countries should expect 9-12 cyclones for this season, for islands west of the dateline. Tonga should be expecting to be affected by at least 2 cyclones this season (Nov-April).

GEOLOGICAL AND BATHYMETRIC SETTING

The Tonga Group of islands is formed at the edge of the Australian Plate which is currently overriding the Pacific Plate to the east in a process known as subduction. It also has been classed by Packham (1978) as a classic simple arc. The subduction zone or where the two plates meet is marked with the Tonga-Kermadec Trench which is the second deepest in the world.

The Ha'apai Group is sandwiched between the Vava'u Group to the north and Tongatapu Group to the south. It is consisted of two chain of islands aligned in a NE-SW direction, separated by the deep Tofua trough. The western islands are volcanic in origin, including the active volcanic islands of Kao and Tofua. East of the Tofua Trough, are the low coral islands of the Ha'apai Group, composed mostly of Pliocene and Holocene limestones overlying older volcanic rocks. The Ha'apai Group contains the largest area of coral reefs in Tonga, and amongst the largest in the South Pacific (Zann, 1994).

The island of Foa is higher than Lifuka Island with few coral reef outcrops seen on the island. The distinct differences in coastal geomorphology and topography between the two islands suggest the possibility of a fault line running in an east-west direction through the channel, with Foa sitting on the uplifted block. However, time did not allow us to confirm this theory. The highest point in Foa is about 20 meter above mean sea level while the highest point in Lifuka is known to be 15m.

The existing causeway is bordered on its east and west sides with reef. The edge of the reef on the western side is about 200 m from the causeway while it is about a kilometer on the eastern side. At low tides the reef is partly exposed and crossing this lagoon can be done with little trouble on foot. However, water depth drops off very rapidly to more than 20m at edges of the two reefs.

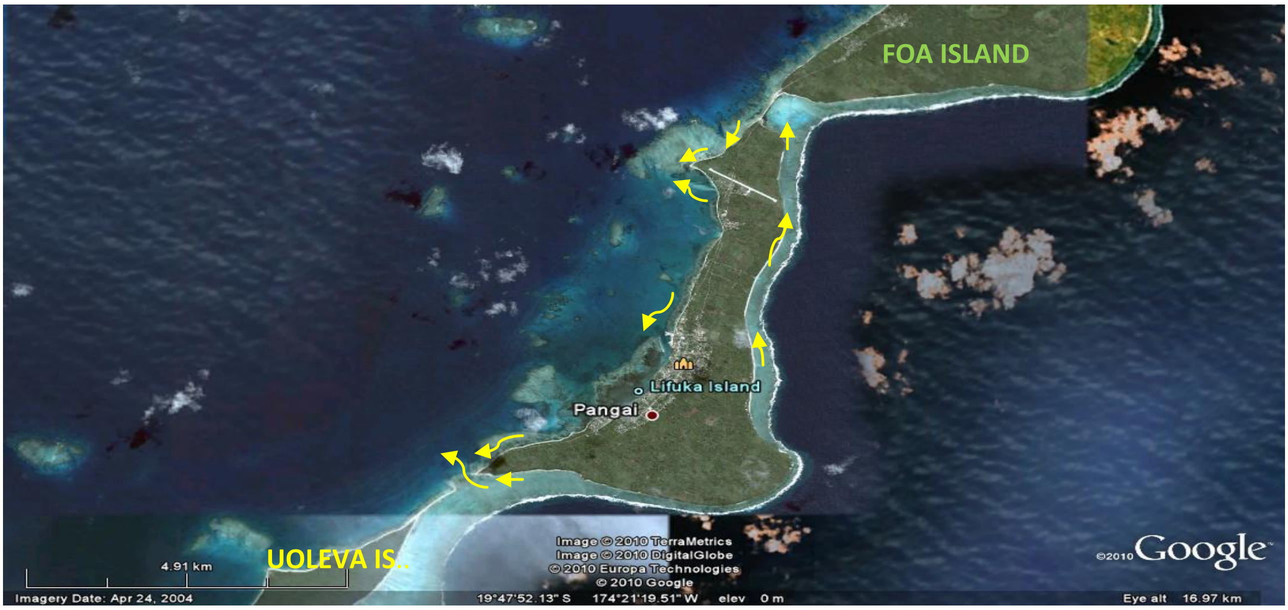
Coastal Morphology and Processes

Examination of the coastal morphologies and processes acting on the coastlines of Foa and Lifuka suggested a delicate balance between east facing beaches and those on the western side. The eastern coastlines of Foa and Lifuka face the dominant SE wind direction and waves it generated. Current determinations along the coasts of the two islands islands of Foa and Lifuka suggest strongly that the beaches on the western coastlines are being fed from sediment derived at the eastern coastline (Figures 5 & 6). Observations of littoral current acting in the channel areas (Nukunamo-Foa; Lifuka- Uoleva), showed a dominant east to west flow at both low and high tides.

Figure 5: Current pattern determined for along Foa, the Foa-Nukunamo and Lifuka-Foa channels.

The above pattern suggests that the channels act as a link in balancing sediment generated at the eastern coastline and the beaches on the western coastline. Refer to Appendix C for GPS locations of sites for current determinations.

Figure 6: Current flow regime around Lifuka's coastline.



With wind from the easterly direction, the pattern of currents at Lifuka –Uoleva channel was determined to be similar to that at Foa-Nukunamo channel. The flow of water in the channel remained at east to west at both low and high tides. At the SW corner of Lifuka Island, the flow converged to build a sand spit. The overall flow pattern on Lifuka suggests an anticlockwise pattern of sediment distribution which is also similar to that determined for Foa Island. The distribution pattern also demonstrates the influence of coastal geomorphology on wave pattern and final littoral current flow directions.

The two current patterns recorded on Foa and Lifuka have acted independently of each other for centuries. The building of the causeway in 1978-1979 connected these two processes, leading to a shift in the current pattern and distribution pathway of sediment along the shore of the two islands.

Coastal Erosion

The western coastlines of Foa and Lifuka islands are showing sign of severe coastal erosion (Figure 7 & 8) in some areas. On Lifuka, coastal erosion and sea water transgression is ruining the coastline of the village of Hihifo, while Foa Island is experiencing thinning of sand on its western beaches and totally removed in some areas towards the southern end of the island near the causeway (Figure 8).

Figure 7: Coastal erosion at village of Hihifo, Lifuka Island.

Figure 8: Severe coastal erosion at southwestern end of Foa Island, near the Causeway.

More photos taken on Foa and Hihifo village to show severe coastal erosion are shown in Appendix D.

The cause for coastal erosion is depicted from the current regime determined on the coastlines of the two islands. Current determination in channels of Foa-Nukunamo and Lifuka-Uoleva are east-west at both high and low tides suggesting that same applied to Foa-Lifuka channel prior to the construction of the Causeway. It is therefore concluded that prior to the causeway, the system was in equilibrium and the sand of Foa and Lifuka were supplied and driven by an anticlockwise current regime. The building of the causeway between the two islands joined the two processes together, leading to Lifuka's sand to be piled up at the Foa end of the causeway and Foa's sand lost to Lifuka along the western side of the Causeway, during NW winds. The longer route created a lag in sand supply (state of disequilibrium) resulting in accelerated coastal erosion on the two western coastlines of Foa and Lifuka (Figure 7 & 8).

BIOLOGICAL RESOURCES

The main biological resources considered in this analysis include the coral reefs and the reef organisms that live in them.

Coral Reef Habitats

Coral reef serves at least three major functions to island communities. First they form physical barrier to protect islands from rapid erosion due to ocean waves, secondly they provide habitat for large biological communities and thirdly they provide tourist attraction for island economies.

In order to fulfill the above roles reefs need to be healthy. The status of the reef was determined using transect lines and underwater photography (APPENDIX E). Epiphytes coverage is used to indicate level of sedimentation.

Transect lines taken on the reef flat to the east of the causeway showed lots of seagrasses at two ends of the causeway with very little in the middle (Site 2). There is very little *acropora sp* identified on this side with only fire corals *(stylophora sp*) and *Favid* hard coral (refer Appendix E, Plates 5, 6 & 8). The epiphytes coverage was found to concentrate on the two ends of the islands indicating much sheltered environment on this side. However, very little epiphytes coverage is noted in the middle part, perhaps due to returning current (rip current).

The coral on the western side looked degraded and mostly dead (Appendix E, Sites 4,5,6). The area is dominated by brown seaweed *(Sargassum sp.)* which is totally absent in the eastern side. The seagrass was found to increase towards edge of reef, scattered around the middle area and more abundant again near the causeway.

The epiphyte coverage is more prevalent on this side than the eastern side of the causeway (Figure 2). Epiphytes were found to cover seaweeds, seagrasses and even rubbles and substrates. Branching Coral *(Acropora sp)* was found in areas towards the edge of the reef but very scarce.

There appears to be a buildup of sediment on the western side of the Causeway which is probably due to frequent maintenance works carried out on the causeway. Dead coral and rubbles were extensive. Sea weeds that are indicative of high sedimentation were also prevalent in this area. Lack of ocean mixing due to barrier provided by the causeway allows for fine sediment to accumulate in the area and acts to suffocate coral reefs, sessile and slow moving marine organisms (brachiopod and Mollusca). Marine organisms were noted to lack in the area which is likely due to lack of ocean mixing and nutrients necessary for the survival of marine organisms and coral on this side.

In the Scoping Meeting, concerns were raised regarding lack in abundance and variety of marine species in the causeway area compared to years before the construction of the causeway. We think the Causeway caused low ocean mixing, changed water circulation pattern, increasing sediment plume generated by maintenance works have killed the coral habitats and create a toxic environment for marine organism in the area.

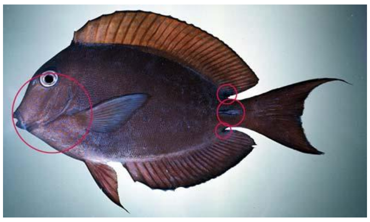
Reef Inhabitants

The lists of marine organisms were prepared with assistance from the participants of the Scoping Meeting. The flora was prepared from diving and photographs taken during the field studies on 13-15 December 2010.

Reef Fish

Reef fish is one of the major inhabitants of the coral reef ecosystem in Tonga. In the Ha'apai Group, the following species can be found;

Table 1: Finfish of Ha'apai Group

Common Names	**Local names**	**Scientific names**
Surgeon fish (5 species) 	'Ume Pone Manini	*Acanthurus sp*

Parrotfish (3 species) 	Hohomo, Lalafi	*Scarus sp*
Goatfish (2 species) 	Vete	
Rabbit fish (3 species) 	Oo	*Siganus sp*
Mullet (3 species)	Fua Kavakava Te’efo	Mugil sp

Table 2: Molluscs of Ha'apai Group

Common Names	Local Names	Scientific names
Bivalves • Giant clams (4 species) • Oysters	Vasuva Ufu	*Tridacna sp* *Atrina vexillum*
Gastropods • Trochus shell (2 species) • Greensnail (2 species) • Turbinella shell	Takaniko 'Elili Pule / Kele'a	Trochus sp Turbo sp Thais sp / Vasum sp
Octobus	Feke	*Octobus sp*

Table 3: Crustaceans of Ha'apai Group

Common Names	Local names	Scientific names
Lobsters • Banded lobster • Painted rock lobster • Coral lobster • Slipper lobster	• 'Uo Tonga • 'Uo Fisi • 'Uo Tavake • Tapatapa	*Panulirus penicillatus* *P.versicolor* *P.longipes* *Parribacus sp*
Crabs • Seven eleven crab	Pakatea	*Arpilius maculatus*

Table 4: Echinoderms of Ha'apai Group

These slow moving species are vulnerable to sediment plume. They are exclusively bottom dwellers

Common Names	Local names	Scientific names
Sea stars • Blue star • Featerstar	Mangamanga-'a-tai	Linckia laevigata
Sea urchin • Banded urchin	Vanamea	*Echinothrix calamaris*

Sea cucumbers • Lollyfish • Greenfish • Tigerfish • Surf redfish • Deepwater surf redfish • White teatfish • Black teatfish • Stonefish	Loli Holomumu Matamata Telehea kula Pulukalia Huhuvalu hinehina Huhuvalu ‘ui’uli Mokohunu maka	*Holothuria atra* *Stichopus chloronotus* *Bohadschia argus* *Actinopyga mauritiana* *Thelenota ananas* *H. fuscogilva* *H. nobilis* *Actinopyga miliaris*

Aside from reef fishes and the class cephalopods which have high mobility, the rest of the phyla are bottom dwelling and less mobile. These invertebrates are most vulnerable to sudden change in their living environment and significant increase in sedimentation could be detrimental to some of them.

Table 5: Marine Plants and algae of Ha’apai Group

Common Names	Local names	Scientific names
Seaweeds • Brown seaweed • Fan-leaf seaweed • Green turf-algae	Limu Limu Limu	*Sargassum echinocarpum* *Padina japonicus* *Halimeda sp*
Seagrasses • Turtle seagrass • Spoon seagrass	Limu-‘ae-fonu Limu	*Halodule sp/Thalassia sp* *Halophila ovalis*

SOCIAL SYSTEM

The primary social systems of concern in this assessment include fisheries, Tourism, transportation and economic development and Human Health.

Fisheries

Reef fishery is very common in Ha'apai which includes activities at commercial and subsistence level although the authors think there is a trend towards eating more meat than fish., after observing the reef flat for a few days while conducting fieldwork in Ha'apai. Most of the fish sold at the wharf come from day or night spear diving. The variety includes parrot fish species, leather jacket, groupers and snappers.

Ha'apai inshore fishery methods include lobster diving, night or day spear diving, giant clam diving, net fishing and hand lines fishing. According to discussion during the Scoping Meeting most inshore fishery methods used in the reef prior to the construction of the causeway included day or night spear diving, net fishing, hand lining and other forms of local fisheries including fakahe lomu, tufi loli (collecting sea cucumber), tuki hulihuli, a'a feke, moe kaloa'a, paki kuku, giant clam diving and so on. Today very little fishing is done in the causeway area due to sharp drop in number of catches on fishes and other marine organisms near the causeway. Fisheries are now done elsewhere in other parts of the coastline.

Tourism

The causeway offers transportation route to boost tourism in Foa where there are beautiful sandy beaches, two international resorts and a diving centre.

According to an official in the Ministry of Tourism in Tonga, it is estimated that more than 3,500 tourists arrived at Ha'apai each year (Kepreen Ve'etutu, pers com). The number of yachts visitors is listed on Table 6 below.

Table 6: Total number of yacht visitors from January to December (2007-2009).

NUMBER OF YACHTS				NUMBER OF YACHTS VISITORS		
	2007	2008	2009	2007	2008	2009
Tongatapu	181	259	239	508	665	516
Vava'u	416	551	458	1173	1577	1251
Ha'apai	36	91	67	112	186	202
TOTAL	633	901	764	1793	2428	1969

Transportation and Economic Development

The causeway provides positive impacts to people of Foa and Lifuka as a mean of transportation and opportunity for economic developments. By joining the two islands, the size of the market is increased to the benefits of the two islands in terms of trading. Fish catches in Foa can be sold at Lifuka and vice versa. Socially, the causeway creates an opportunity for outside marriages between the two islands. Ultimately, the causeway provides lots of benefits to the people of Foa because it provides access to most of the social services offered by the Tonga Government and private sectors at Lifuka island. These services are: hospital, secondary schools, police and fire stations, banks, wharfs, water, electricity, government department offices and shops.

Human Health

There is no major endemic in Tonga and the Ha'apai group that this causeway would assist in its spreading. However, fish related diseases such as ciguatera was reported by participants in the Scoping Meeting to have occurred in the surgeon fish species (pone). The likely causes of this disease are discussed below.

ENVIRONMENTAL CONSEQUENCES AND MITIGATION

This section evaluates the possible impacts of the alternative courses of action and possible mitigation measures which could reduce adverse impacts.

ALTERNATIVE 1: Proposed Action for Rehabilitation

This alternative is similar to existing structure with about ten culverts inserted in the middle of the structure to decrease pressure on the structure and allow for ocean mixing. The structure has two lanes with a walking lane. Potential impact of this structure on the environment and human resources of the area are evaluated in this section. Key elements of impacts generated by the existing structures have been described under the affected environment. It was evident from discussion during the Scoping Meeting that certain areas of concerns must be evaluated for impacts. These are:

1. The direct impact of the structure on coastal erosion on the eastern coastlines of Foa and Lifuka Islands
2. The dispersion of fine grained sediments suspended in the water column from construction
3. Improved water circulation and mixing
4. Economic and social systems

Physical Considerations

The existing structure has been proven to contribute significantly to coastal erosion on the western coastlines of Foa and Lifuka. The proposed alternative is similar to the existing structure with about ten culverts positioned evenly along it to alleviate pressure on the structure and allow for ocean mixing.

The positioning of about ten culverts in the middle will improve circulation but they are in the way of sand transportation along the causeway and are likely to get clogged up. As a result, the proposed alternative will continue to contribute significantly to coastal erosion on the two islands. Furthermore, the culverts would create a funnel effect focusing flow and wave impact into this zone.

Mitigation Measures:

- **Consider revising this proposed action to include channels at two ends of the causeway to ease wave impacts on the structure and isolate the two coastal processes (littoral currents) that move sand along the coastlines**
- **Strengthening of the structure at these three zones may be necessary.**

Biological Resources

The biological resources of main concern include the coral reefs and its inhabitants in the immediate area of the causeway. It is well established that enhanced concentration of suspended sediment in the water column can seriously affected growing corals and its inhabitants (Van Katwijk, 1993). Because it is not possible to avoid generating sediment plume in the re-habilitation works, this aspect of the assessment is an important component of this study.

The dispersion of fine sediment from construction would be mostly to the west as indicated by the current direction determined in the three channels. The width and distance of the sediment plume is approximated from mathematical model used by Cruickshank and Morgan (1996) to predict fine sediment dispersal in a sand mining area in Nuku'alofa lagoon.

According to this model the dispersion is limited to about 3 kilometers before fine sediment will settle out. Sediment plume from this construction will head out west of the causeway and finally towards open sea. The immediate areas around the construction side would also be affected because of lack of ocean mixing. This sediment plume would affect reef and marine organisms on its way. However, since reef on this side is mostly dead and marine organisms are scarce, impact is envisaged to be at minimum. There are no marine parks and diving areas identified within 3 kilometers to the west, hence the effects beyond the edge of the fringing reef, is also likely to be insignificant.

Mitigation Measures:

Avoid bringing fine sediment to site when loading big coral boulders to trucks.

Social System

Concerns were raised during the Scoping Meeting regarding the effect of the proposed action on the social systems of Ha'apai.

Fisheries

The analysis of sediment plume indicates a southerly pathway towards Lifuka affecting reef and marine organisms in this direction. Because the reef on the western side is narrow some of the sediment plume may head out to open seas and offer minimum impacts on immediate reef habitat. There is no important fishing areas identified nearby and in the direction of the plume except reef fisheries, which is likely to be affected. Therefore fishery is not expected to improve until the construction is over and the reef habitat is allowed to recover through ocean mixing and a "no fishing period" is enforced in this area.

Monitoring Activities:

1. **Continue to monitor this issue 3-6 months after construction using six transect lines already established, and every six months after that for a total period of 18 months after construction to detect signs of recovery.**
2. **Seek assistance from Department of Fishery on applying a curfew period on any type of fisheries within 2kms southward from Foa end of the Causeway.**

Transportation and Economic Developments

The causeway would provide numerous benefits to people of Foa and Lifuka in terms of transportation and economic developments. These benefits will include access to most social services based on Lifuka and increase in size of the market will boost economic development between the two islands. This option will offer employment and hired machineries to people of Foa Island.

Traffic counts on the causeway gave an average of about 50 to 60 trips which may offer an opportunity to revise the proposed design.

Mitigation Measures:

Consider reducing the two vehicle lanes into one with a passing lane in middle.

Tourism

Foa Island has two resorts, beautiful sandy beaches and one internationally recognized diving centre. The causeway would undoubtedly benefit these facilities from tourists and visitors from Tongatapu. However, coastal erosion would affect beaches and this may have some negative impacts on tourism.

Mitigation Measure:

Consider opening the two ends of the causeway to allow for isolation of the two littoral currents in order to minimize coastal erosion.

Human Health

According to participants of the Scoping Meeting, fish poisoning occurred after the construction of the causeway.

There are two ways that fishes in the area can become poisonous. Firstly, the western side of the Causeway has limited amount of ocean mixing which may lead to a development of an environment conducive to growth of certain poisonous algae that fishes may feed upon and become poisonous. Secondly, contaminants such as oil and diesel that leaked from vehicles using the Causeway could enter the food chain and become a source of poisoning. Fish poisoning would continue unless this issue is addressed.

Mitigation Measure:

1. **Create another opening of reasonable length to slow down water flows (60-80m) in the middle of the Causeway to allow for ocean mixing.**
2. **Ensure vehicles that leak oil and diesel NOT to use the Causeway by erecting signpost at two ends of the Causeway to this effect and let vehicle owners aware of this through village meeting.**
3. **Make it illegal for such vehicles to use Causeway through legislation. May need to seek MECC assistance.**

ALTERNATIVE 2: Open Piling Structure

This alternative provides the ideal structure but is not viable due to restriction on the amount of money made available for this project.

The structure is envisaged to be a single lane wide enough for a walking lane with a passing lane in the middle. The structure needs to be higher than any large waves that have reached the site to avoid waves overtopping. Arching the structure towards the middle will allow for a drainage system to work effectively in removing pollutants from vehicles using the causeway.

The effect of an open piling structure on the physical environment and social systems is analyzed according to concerns raised in the Scoping Meeting and used to analyze Alternative 1.

Physical Considerations

This structure will free up all coastal processes along the coastlines of the two islands and also inside the channel resulting in reduction in coastal erosion on the western coastlines of Lifuka and Foa.

Biological Resources
The improvement in ocean mixing and transfer of nutrients right across the channel will allow coral reef habitats to recover and inhabitants to return. It could also offer a cure for fish poisoning.

Social Systems
Fishery and human health were two areas of concerns and references were made towards them in the Scoping Meeting.

Fisheries
Drop in catches was the main concern in the Scoping meeting. However, a recovered ecosystem will improve the catches and health of the local community.

Transportation and Economic Developments
The structure is likely to have less maintenance cost in its early life. As in Alternative 1 it would contribute positively to an improved transportation system and economic development of the two islands.

Tourism
As in Alternative 1, the structure will have a positive impact to tourism at Foa Island

Human Health
As mentioned under fishery and biological resources, an improved ecosystem may reduce fish poisoning leading to a healthy life for the community of Foa.

ALTERNATIVE 3: Do Nothing

In the event that this Alternative is taken, it is assumed that present system of maintenance works would be continued.

Physical Considerations
The effect of the current structure on coastal erosion will continue and maintenance cost will remain as high. The cost would be too high when cost of eroded land and impact on the social systems are factored in making this alternative very expensive.

Biological Resources
Lack of ocean mixing and delivery of much needed nutrients to the western side of the causeway will continue. Reef habitats are deteriorating and marine organisms and fishes are either dead or migrated to other habitats.

Social System
The proposed structure will NOT address concerns raised in the Scoping meeting as effectively as that offers by Alternative 2 above.

Fisheries

The deteriorating status of reef ecosystem will ensure that fisheries will be affected into the future.

Transport and Economic developments

Transportation and economic development will be affected by continuing maintenance of the causeway.

Tourism

Continuing maintenance works may affect travel to and from the two resorts in Foa island.

Human Health

Fish poisoning will continue. While people are more cautious about the locally fish known as “Pone” other fishes may become poisonous and that would be dangerous for the community.

Monitoring Program

Appendix E was prepared as the baseline data for future monitoring studies of the effect of the causeway on ocean mixing and health of the reef ecosystem. It is recommended that monitoring of the reef flat must be carried out within 3-6 months after construction and 6 months thereafter for a period of 18 months when the reef is expected to show signs of recovery.

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APPENDIX A:

TERM OF REFERENCE

The FOA CAUSEWAY is located at the sea entrance between Lifuka Island and Foa Island in the North East of the Ha'apai Group. Built in 1978-79, the 665 m long Causeway serves the approximately 7,600 inhabitants of the Ha'api Group. The Causeway experienced severe damages in the past years caused by tropical cyclones, storm surges, tidal currents etc. A recent inspection indicated that upgrading works are urgently required. The project is classified as a major project and therefore requires a full environmental assessment, according to the EIA Act, 2003. The result of this study will be relevant to the final design of the project.

SCOPE OF WORKS

The Consultants is expected to undertake the following duties and responsibilities and be guided by requirements of the Ministry of Environment and Climate Change.

A. Establish physical, biological and social benchmarks in the project area
B. Determine the current regime in the channel
C. In association with Ministry of Works and Governor of Ha'apai, conduct a Scoping Meeting with all stakeholders to determine main concerns regarding the project
D. Prioritise issues and incorporate in the study as part of the scope for the purpose of:

    - Areas where significant impacts are likely to occur
    - Addressing any significant concerns

E. Production of EIA Document which address, among other things, the followings;

F. Assessment of environmental effects of the Foa Causeway Upgrading
    - Propose appropriate mitigations for any environmental issues
    - Recommendation on appropriate monitoring activities

APPENDIX B:

MINUTE OF SCOPING MEETING ON: FOA'S CAUSEWAY REHABILITATION WORKS

Date: Thursday, 16^{th} of December, 2010

Time: 10.30am.

Opening speech: Sione Taumoepeau (Project Manager).

Mr Taumoepeau explained the proponent, as Ministry of Works, and that he is the Project Manager. In term of funding for the project, he explained that the Government of Germany has agreed that money Tonga Government still owed to them on loan for the MV Olovaha, to be made available for this project. He also mentioned that all labors and machineries required will be hired locally, unless not available. The work will be conducted early next year.

Presentation:

The presentation of the preliminary results of the EIA was given by Mr Kitekei'aho supported by his colleague, Mr Poasi Ngaluafe (Marine Consultant).

The presentation focused on current determination exercises conducted at Foa/Ha'ano channel, Lifuka/Uoleva Channel and at the existing causeway at Foa/Lifuka channel. Twelve other points were taken around the east and west coastlines of Foa and Lifuka to determine general transportation pathways for sediment. Other studies were aimed at establishing baseline data on marine organisms on the causeway area, using Transect lines and underwater photography.

The results indicated a south to north transportation pathway on the east coast of the two islands, during the dominant SE wind. The transportation direction reversed to north –south during NW winds, which are usually cyclone winds. Prior to the building of the causeway, these two processes were operating independently of each other for the two islands. The building of the causeway joined these two processes into one, allowing sand transported from Lifuka on the east coast, to build up at Foa end of the causeway. On the other hand, Foa's sands are transported southward along the west side of the causeway to Lifuka Island. The delay in supply of sediment will cause a disequilibrium situation, initiating coastal erosion to occur. The transect line recorded dead corals, lack of marine abundance and variety, and huge build up of sub bottom mud on either sides of the causeway.

In conclusion, it is suggested that the causeway, in its current form, contribute significantly to the coastal erosion witnessed along west coastlines of Foa and Lifuka. Furthermore, it does not allow for ocean mixing and transportation of nutrients, from the eastern side to long awaited reefs and marine organisms on the west side of the causeway, which are now dead and no longer exist. Fish poisoning may be related to two scenarios; firstly, lack of ocean mixing may encouraged growth of poisonous seaweeds for fishes to feed upon, secondly washed off diesel and oil leaks from vehicles using the causeway may enter the food chain and cause fish poisoning.

Preliminary Recommendations:

In order to mitigate the physical and social issues caused by the current structure, the rehabilitation works should consider the following options;

1. Open piling structure with one lane and a passing lane (100m) in the middle- can be costly

2. An upgraded structure with proper rock armoring, with appropriate openings at the end of the causeway to isolate the coastal processes and openings in the middle for ocean mixing..

Participants:

There were about 12 people participating in this scoping meeting. The fact that all town officers and the District officer attended was encouraging because they were representing their respective communities and will communicate the results of the meeting.

Viliami Tukutau	-	Lotofoa, Town Officer
‘Alani Kavakiholeva	-	Fotua, Town Officer
‘Ulukilangi	-	Fangale’ounga, Town Officer
Kula	-	Faleloa, Town Officer
Polotu	-	Ha’afakahenga, Town Officer
Veivosa Taka	-	District Officer of Foa Island

In addition, four other community members participated.

Other Government Officers:

Sailosi ‘Alofi -	(Fisheries Division, Ha’apai)
Manase -	(Ministry of Works, Ha’apai)
Malakai -	(Ministry of Works , Ha’apai)

<u>Questions *(in italics)* and answers.</u>

There were only few questions asked by the participants but they offered lots of information and concerns on fisheries, coastal erosion and structure for the causeway. The questions are summarized to four main ones.

9. *Is the money available already for this project?*

The money is made available from funds owe to Government of Germany which they have agreed to redirect it to Foa's causeway. The fund will be released after acceptance of the EIA report.

10. *Is there any final design for the causeway?*

    There is a preliminary design but final design would be based on the EIA findings

11. *Why was the EIA not done before the causeway was built in the beginning?*

    Firstly, in 1978-79 there was not much awareness about the environment. Secondly, Tonga Environment Impact Assessment was passed in 2003 with its Regulation recently passed in November 2010. The Regulations is now enforcing the Act and all proponents of major projects must conduct an EIA prior to be passed by Ministry of Environment before commencement of construction.

12. *Can we have a causeway with an open piling structure to allow for free flow of water and sand distribution?*

    The final structure is dependent on the amount of money available to us. At the moment, it is a little over 4 million pa'anga. There are three options recommended by the EIA Consultants but perhaps a fourth option should be considered of a pavement built directly over the reef flat, allowing for free flow of water, no coral boulders to be thrown around by waves, little maintenance cost, cheaper but may restrict travelling to low tides only. Proper planning of trips to Lifuka will make this option viable.

13. *The causeway is very important for us and all we need is a structure that will allow us to travel to Lifuka. Maybe one channel in the middle will do.*

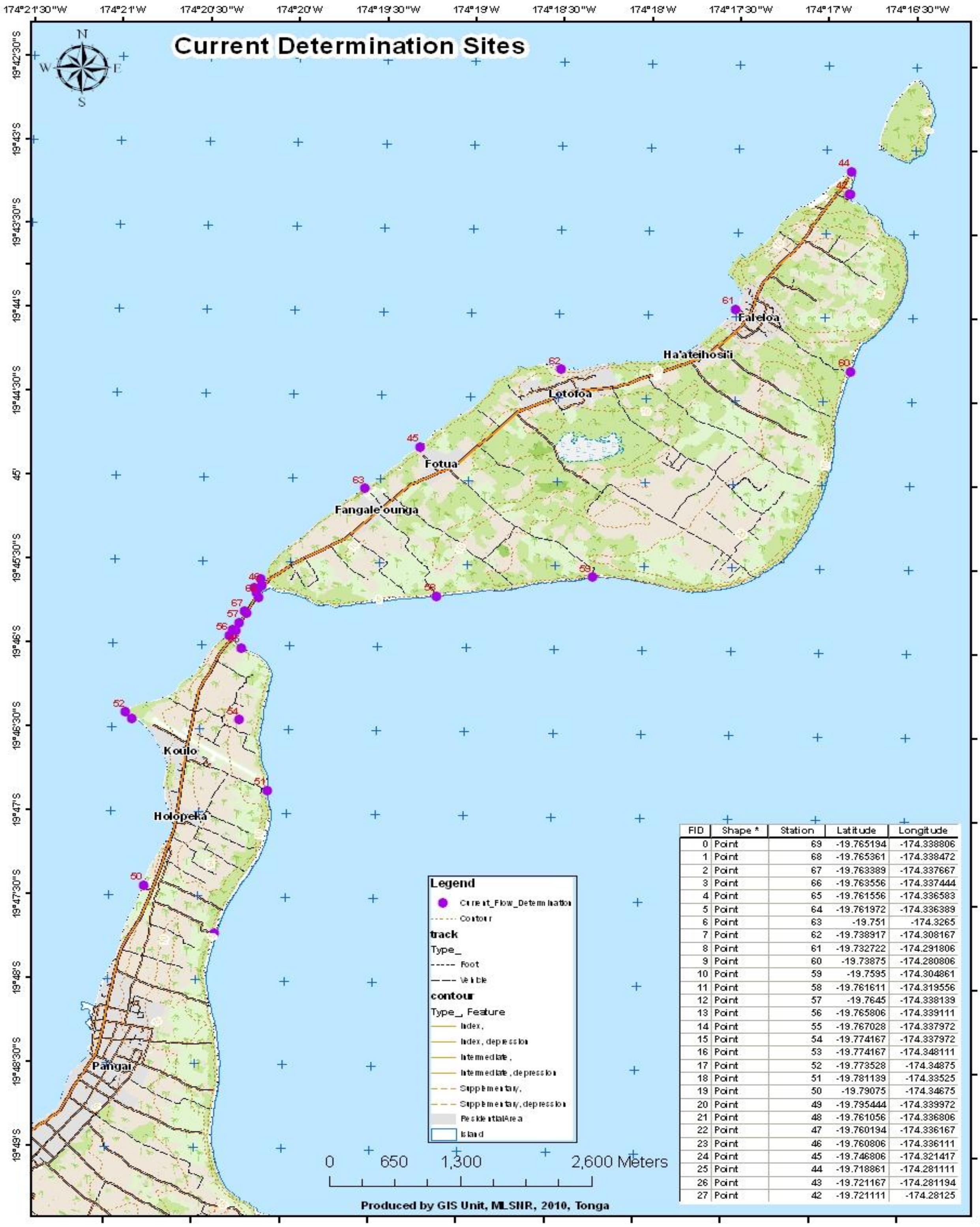
    We don't want to ignore the environmental impacts. We are now binded by the EIA Act, 2003 and must act to minimize these impacts. If we disregard the natural process, coastal erosion will continue at both Foa and Lifuka islands, fisheries will still be affected, fish poisoning will continue. Furthermore having one channel in the middle will cause a funneling effect which may later on clogged up the channel with sediment or may offer an attacking point for waves.

The meeting was closed by the District Officer of Foa Islands, Veivosa Taka at 12.30pm. In his speech he thanked the Consultants for the detailed study, the Ministry of Works for choosing the causeway as the project and the Project Management Unit for pushing for this study to be carried out. Lastly, he wished that an appropriate structure can be built to minimize effects on the environment.

Information supplied voluntary by participants:

- The causeway was initiated in 1950s but the structure was destroyed before completed.
- The Causeway was finally completed in 1978
- The channel used to have strong currents with a big rock outcrop in the middle of the channel. This rock is said to give a whistling sound indicating arrival of a 10m or so waves. The same waves have destroyed part of Uiha Island, south of Lifuka.
- Dead fish has been found in the area of the causeway
- Decline in marine variety and abundance, after construction of causeway.
- Fisheries were dominated by reef fishing in the area of the causeway in 60s and 70s, prior to the construction of the causeway. After the construction, reef fishing was tremendously affected and fish caught near the area were becoming poisonous (fish poisoning – pone (surgeon fish family) and decline sharply in abundance.
- The western side of the causeway is no longer dry at low tide after the last earthquake which carved breaks and possible vertical displacement in the ground
- The channel between Foa and Nukunamo used to be smaller than today (approx. 100m) with land extended further to sea. The town officer of Faleloa, Kula who is the owner of this piece of land and attended the meeting, planted plenty coconuts in this area but these have all gone, as the channel widen through coastal erosion, attributed to the construction of the Foa Causeway.

APPENDIX C: Current Determination Sites



FID	Shape *	Station	Latitude	Longitude
0	Point	69	-19.765194	-174.338806
1	Point	68	-19.765361	-174.338472
2	Point	67	-19.763389	-174.337667
3	Point	66	-19.763556	-174.337444
4	Point	65	-19.761556	-174.336583
5	Point	64	-19.761972	-174.336389
6	Point	63	-19.751	-174.3265
7	Point	62	-19.738917	-174.308167
8	Point	61	-19.732722	-174.291806
9	Point	60	-19.73875	-174.280806
10	Point	59	-19.7595	-174.304861
11	Point	58	-19.761611	-174.319556
12	Point	57	-19.7645	-174.338139
13	Point	56	-19.765806	-174.339111
14	Point	55	-19.767028	-174.337972
15	Point	54	-19.774167	-174.337972
16	Point	53	-19.774167	-174.348111
17	Point	52	-19.773528	-174.34875
18	Point	51	-19.781139	-174.33525
19	Point	50	-19.79075	-174.34675
20	Point	49	-19.795444	-174.339972
21	Point	48	-19.761056	-174.336806
22	Point	47	-19.760194	-174.336167
23	Point	46	-19.760806	-174.336111
24	Point	45	-19.746806	-174.321417
25	Point	44	-19.718861	-174.281111
26	Point	43	-19.721167	-174.281194
27	Point	42	-19.721111	-174.28125

APPENDIX D:

Photos showing coastal erosion at the western coastline of Lifuka island.

A failed foreshore structure built south of the Governor's Residence. The sea is seen to by-pass the

Structure.

Hihifo village. Coastal erosion is widespread.

Beach erosion, east coast of Foa island.

Coastal erosion west coast Foa Island, near the causeway.

APPENDIX E:

MONITORING REEF FLATS

Introduction

Foa causeway was built during 1978-1979 to improve travel between Foa and Lifuka islands. The causeway has been exposed to forces of nature all these years. Rough seas have caused lots of damages to the structure and recent observations by Ministry of Works (MOW), decided that the causeway requires extensive upgrading. However, prior to any major works and in accordance with the EIA Act 2003, MOW requires an Environmental Impact Assessment (EIA) to determine likely impacts this work may have on the environment and to propose mitigation measures to alleviate these impacts.

Objectives

This study is aimed at collecting baseline data on biological communities and reef ecosystem as a basis for monitoring of the site after the construction.

Equipments

The following equipments were used for the study.

- 20m tape
- 1 meter square quadrat
- Underwater Video Camera
- GPS and Note Book

Methods

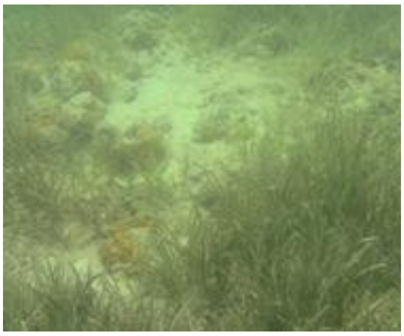
Three sites were selected along each side of the causeway. A 40m transect line was extended seaward towards the reef on each site. The starting point was recorded with a portable GPS. Each line is studied using a meter square quadrat, placed at every 5 meter interval, starting at the 0m point, to record types of substrates, fauna and flora inside the quadrat. Also inside the quadrat, the coverage of epiphytes on seaweeds, seagrasses and substrates are estimated as indicative of high sedimentation. The study was accompanied by underwater photography to record significant findings along each transect line.

RESULTS

Eastern Sites (Windward Side)

1

2



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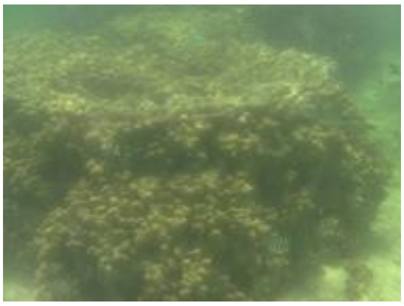

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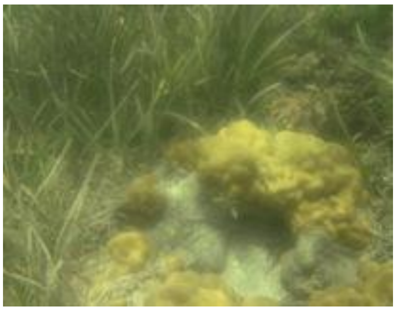

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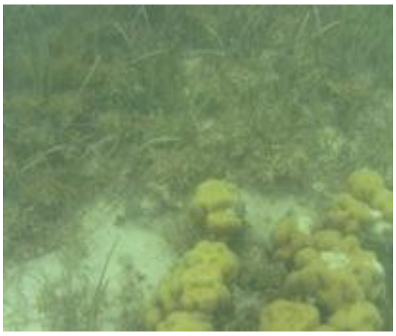

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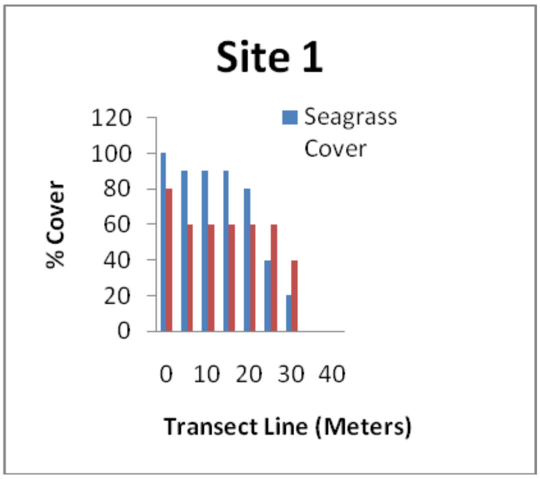
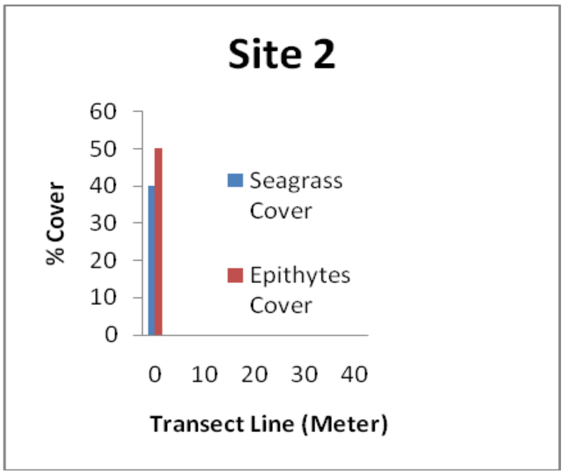
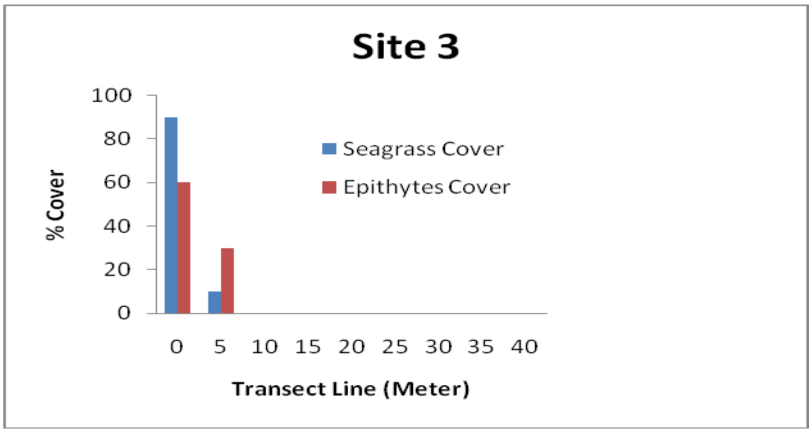
Plates 1 – 8 Indicate typical reef habitat, eastern side Foa Causeway.

The turtle seagrass (*Halodule sp), refer to plates 1,2 and 7,* is most dominant marine plant found in many areas around Lifuka Island but determined to be of low abundance at the Foa areas. At the centre of the causeway (Site 2), no seagrass was found near the shore but noted to be replaced by scattering hard corals (Plates 4,5,9), especially fire corals (***Stylophora*** *sp)* and *(Favid sp)*hard corals (Refer to Plate 5, 6, 8). In term of epithytes coverage, the coverage is higher at the site closer to Lifuka end. The middle line has very low abundance of seagrasses with 50% coverage with epiphytes which may indicate flushing. In Site 3, the seagrass coverage was found near shore with epiphyte coverage estimated at 60%. Graphs of epiphytes coverage is displayed in Figure 1 below.

Figure 1: Showing Seagrass distribution and epiphytes coverage, Eastern side of the causeway.







Western Side of the causeway.

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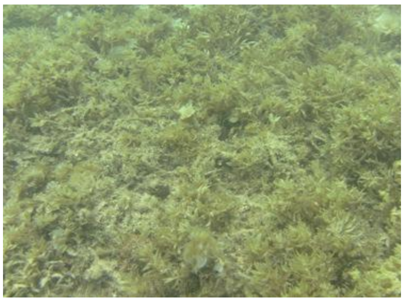

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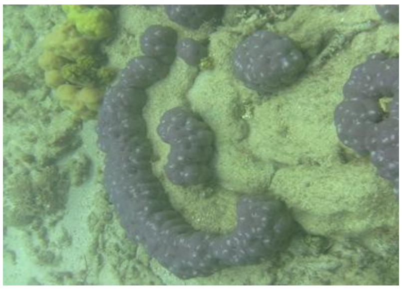

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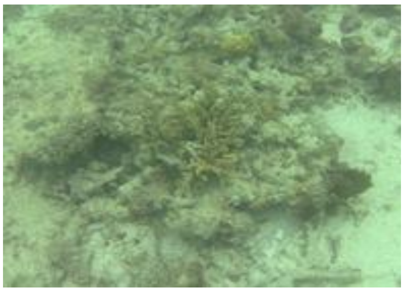

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Plate 9 – 17 Indicate typical habitat of the western side of Foa Causeway

The Sites on the western side of the causeway (Site 4, 5, 6) are dominated by brown seaweed (Sargassum sp.) which is totally absent in the eastern side. The seagrass was found to increase towards edge of reef, scattered around the middle and more abundant again near the causeway.

The epiphyte coverage is more prevalent on this side than the eastern side of the causeway (Figure 2). The epiphytes cover seaweeds, seagrasses and even rubbles and the pavement. Branching Coral (*Acropora sp*) was found in areas towards the edge of the reef but very scarce.

Figure 2: Percentage cover of seagrasses and epiphytes at the Western side areas of the Causeway