ENVIRONMENTAL IMPACT ASSESSMENT

For the proposed Harbour in Madidhoo Island

Shaviyani Atoll

MAY 2010

PREPARED BY CDE

CONSULTING

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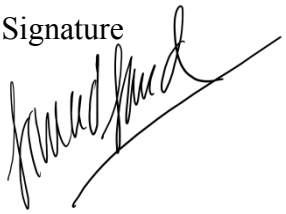
Consultant's Declaration

I certify that statements made in this Environment Impact Assessment are true, complete and correct to the best of my knowledge and available information.

Name:

Simad Saeed (EIA 06/2007)

Signature



Summary

This Environmental Impact Assessment (EIA) is an evaluation of the potential environmental, socio-economic and natural impacts of the proposed harbour dredging planned for Madidhoo Island, Shaviyani Atoll. The proponent of the project is Mr. Mohamed Waheed (Sh. Maroshi) and is being financed by by ADK Travels Pvt. Ltd under their Community Social Responsibility (CSR) Programme.

1.1 Introduction and key features of the project

Project Background

Madidhoo has been leased for commercial agricultural activities to Mr. Mohamed Waheed (Sh. Maroshi) for period of 20 years on April 1994. Since then, a number of agricultural investments have been undertaken on the island including, farm machinery, cleared farming plots, animal farming facilities and basic utilities.

The island does not have a natural harbour. At present produce form the island is loaded on to vessels using a smaller vessel. This process is time consuming and affects the efficiency of the investment, particularly during peak production times. Loading and unloading activities are also severely affected during peak northeast monsoon due to

strong wave activities. There have been occasions when the loading and unloading becomes dangerous for both the vessels and staff working on them.

Various options were discussed to remedy the transportation bottleneck in the past but were delayed due to funding shortages. The construction of Gaakoshibee Resort in close proximity had provided an opportunity to expand agricultural production on the island. Negotiations were held with the resort owners regarding business opportunities and they agreed to finance the construction of access infrastructure on the Madidhoo to improve the efficiency of the island operations.

Project Objectives

The main objective of this project is to provide a safer access to the island and a safe anchoring area.

Project Features

The key features of this project are:

1. Dredging an entrance channel and harbour basin.
2. Construction of a quaywall.
3. Replenishment of eroding beaches using dredge waste

1.2 Conformance to laws and regulations of Maldives and international conventions

The proposed developments require it to conform to a number of laws and regulations in the Maldives and other international protocols and conventions. Some of the key regulations include the Environmental Protection Act, Tourism Act and regulations, and the International Plant Protection Convention.

1.3 The Existing Environment

This project is being undertaken on an island already beinbg used for agricultural development.

The following outline the notable features related to this particular project:

- There is an existing reef entrance in the proposed site. The site has not been dredged but manually celared.
- The island is fairly large and the reef system is saturated with land. There is barely 80 m between the reef edge and island shoreline.
- The reef is not in pristine condition and large part of the reef system contains dead coral and sand.
- There is littering and debris on the reef system of the proposed site.
- The proposed site and surrounding areas have experienced severe erosion in the recent past.
- The water quality is in good condition.
- The eastern side experiences wave activity during NE monsoon and the western side experiences strong wave activity during SW monsoon. The number of unusable days for the eastern side is expected to be 10 days in a year but that of the western side is expected to be 30 days. The reef bedrock also appears to be stronger on the south side.

1.4 Environmental Impacts

The potential significant impacts from the project are summarized below:

Potential Adverse Impacts during the Construction Stage

- Potential damage to lagoon benthos and fish population due to turbidity and sedimentation from construction activities
- Potential water contamination (Marine Water and/or Ground Water)
- Noise and air pollution
- Changes to drainage
- Changes to hydrodynamics
- Impacts from waste

Potential Adverse Impacts during the Operations Stage

- Coastal erosion

Potential Adverse Impacts during the Operations Stage

- Increased efficiency of agricultural production process

1.5 Alternatives

No Development

The no development alternative was considered but even though all adverse impacts to the environment would be absent, the economic adverse impacts from not carrying out the project were found to be largely significant.

Dredging alternatives

Alternatives of excavator on a temporary sand bed, excavator on barge, Cutter Suction Dredger was considered and excavator on temporary sand bed was found to be the most cost effective for the scale of the project.

Quaywall Alternatives

Alternatives of geotextile bags filled with locally sourced sand, sheet pile, concrete structures and sand cement bags were evaluated and the latter option was found to be most cost effective for a small scale project.

Access infrastructure alternatives

Alternatives of developing a jetty which extends up to reef edge, a satellite harbor with a jetty extended to a basin and a harbour as proposed was considered and the latter was found to the most practical in the given conditions.

Alternative location

Two locations - eastern side (current Proposal) and western side – was considered and the current proposal was considered the most practical.

1.6 Environmental Monitoring Program

As this project, the proponent is advised to refer to and follow the monitoring program highlighted in the document. The monitoring aspects are summarised below:

- Water Contamination (Marine/Ground)
    - Water quality
- Marine Water Contamination Oil spills

- Oil leakage from machinery or vessels

- Coral reef health
  - Percent of live coral cover
  - Fish abundance
- Erosion and Coastal Changes
  - Beach profiles
  - beach line (at high tide & low tide)
  - Longshore currents
- Water Depth Water
  - Depth

The proponent is committed to undertake the monitoring programme.

1.7 Conclusions

The construction and operation of a harbour is justified based on economic grounds. The proposed development activities do have significant environmental impacts, particularly related to damage to coral reef, coastal erosion and potential contamination of sea water from accidental fuel and oil spills. These impacts are not specific to the project alone and are reminiscent of the impacts that would exist in a similar project in any island of the Maldives. To strike a balance between development needs and environmental preservation it is recommended that the mitigation measures proposed in this report be strictly enforced both by the developer and the regulatory authorities.

1 Introduction

This Environmental Impact Assessment (EIA) is an evaluation of the potential environmental, socio-economic and natural impacts of the proposed channel dredging at Madidhoo Island, Shaviyani Atoll.

Madidhoo is an island leased to Mr. Mohamed Waheed (Asseyri, Sh. Maroshi) for agricultural development. The proponent of the project is Mr. Mohamed Waheed and is being financed by ADK Travels Pvt. Ltd under their Community Social Responsibility (CSR) Programme.

The proposed harbour development will begin as soon as the Environmental Impact Assessment is approved and is expected to take 2 months to complete. The estimated cost for the project is Rf 600,000.

This EIA has been developed based on the Term of Reference (ToR) issued by the Ministry of Transport, Housing and Environment (MTHE) of the Maldives on 22 March 2010. This document is submitted by the proponent to the Ministry of Housing, Transport and Environment (MHTE) to fulfil the requirements for an EIA under Article 5 of the Environment Protection and Preservation Act (4/93). The *EIA Regulations 2007* have been used as the basis for developing this document.

1.1 Report Outline

This EIA is organised into nine sections. They are:

Chapter	Brief Description
Chapter 1	Introduction
Chapter 2	A description of the project including the project location, need for the project, information on the proponent, detailed description of project components including site conditions, site plans, implementation schedules, work methods, waste management and summary of inputs and outputs.
Chapter 3	A summary of the policy, planning and legal framework applicable to the project and a demonstration of how the project conforms to these aspects.

Chapter 4	Detailed description of the existing baseline environmental conditions.
Chapter 5	Information on the potential impacts and mitigation measures of the project.
Chapter 6	Environmental management plans for the construction and operation of the proposed project
Chapter 7	Assessment of best alternatives for the project or for certain project component.
Chapter 8	Details of the environmental monitoring program
Chapter 9	Information regarding stakeholder consultations
Chapter 10	Information regarding the potential gaps in existing data and limitations in the assessment

1.2 Project Background

Madidhoo has been leased for commercial agricultural activities to Mr. Mohamed Waheed (Sh. Maroshi) for period of 20 years on April 1994. Since then, a number of agricultural investments have been undertaken on the island including, farm machinery, cleared farming plots, animal farming facilities and basic utilities.

The island does not have a natural harbour. At present produce form the island is loaded on to vessels using a smaller vessel. This process is time consuming and affects the efficiency of the investment, particularly during peak production times. Loading and unloading activities are also severely affected during peak northeast monsoon due to strong wave activities. There have been occasions when the loading and unloading becomes dangerous for both the vessels and staff working on them.

Various options were discussed to remedy the transportation bottleneck in the past but were delayed due to funding shortages. The construction of Gaakoshibee Resort in close proximity had provided an opportunity to expand agricultural production on the island. Negotiations were held with the resort owners regarding business opportunities and they agreed to finance the construction of access infrastructure on the Madidhoo to improve the efficiency of the island operations.

1.3 Project Objectives

The main objective of this project is to provide a safer access to the island and a safe anchoring area.

1.4 Project Scope

The proposed project involves the following:

1. Dredging an entrance channel and harbour basin.
2. Construction of a quaywall.
3. Replenishment of eroding beaches using dredge waste

Details of the project description will be discussed in Chapter Two.

1.5 Terms of Reference

This EIA has been prepared to the requirements established by the Term of Reference (ToR) issued for this project on 22 March 2010 (See Appendix 2 for the ToR).

1.6 EIA Methodology

The process followed in the preparation of this environmental impact statement consists of five components: scoping consultations; literature review; field surveys; analysis of results; and output.

The first step of the process covered consultations with client and government agencies to determine the scope of the impact assessment. The scope was decided and the ToR was finalised on 22 March 2010 based on the information contained in the *EIA Regulations 2007*. During this stage the client clearly outlined their development needs and assessment was geared to match the development plan and environmental assessment needs.

During the second stage, a literature review was conducted to acquire background information on the site and its environment as well as to identify possible environmental impacts of the proposed developments in similar island settings. In this context, the *EIA Regulations 2007* and best practices from other harbour development activities were considered.

The third stage involved field assessment in areas covered by the EIA scope. Conditions of the existing environment were analysed using established appropriate scientific methods. Coastal and hydrographical conditions were studied through field surveys which involved using GPS and echo-sound meters. Data from regional studies, particularly climate and wave data were used to assess existing environment.

Marine water quality was assessed by laboratory analysis from the National Health Laboratory after collecting samples from different locations. Samples were collected in clean 500ml PET bottles after washing them with water to be sampled and also using sterilised glass bottles. Parameters tested for sea water quality assessment were Biological Oxygen Demand (BOD_5), Dissolved Oxygen (DO), Salinity, Total Dissolved Solids (TDS), pH, Nitrate, Nitrite, Phosphate and Faecal coliform.

The fourth stage involved in-house analysis using scientific analysis methods. These methods will be explained in detail in later sections.

The final stage involved compilation of individual consultant findings and consultations with the developer to adjust certain elements of the designs which were deemed to have significant affects on the project.

Field surveys were undertaken on 9 February 2010 and 23rd March 2010. The assessment and compilation of the EIA took 2 months.

1.7 The EIA Study Team

The team members of environment consultant team and their areas of contributions are listed in Table 1.2 below. Their CV's of are attached in Appendix 13.

Table 1.2: EIA study team and their areas of contribution

Consultant	Areas of Contribution
Dr. Simad Saeed	Team Leader, Social Scientist and Environmental Management and Planning
Ahmed Shaig	Terrestrial Environment, Atmospheric Environment and Risk Assessment
Hafeeza Abdulla	Environmental Management
Ali Moosa Didi	Surveyor
Ahmed Haiman Rasheed	Field Assistant (Marine)
Mohamed Shinaz Saeed	Marine Specialist

2 Project Description

2.1 Project Location

The project site is in Madidhoo. Madidhoo is located in Shaviyani atoll at approximately 06° 18' 55" N latitude and 73° 07' 49" E longitude (see Figure 2.1 & Plate 2.1). With a width of about 0.8 km and approximately 1.38 km in length, Madidhoo is among the large uninhabited islands of the Maldives with a total land area of approximately 105 ha. Madidhoo is located south east of Foakaidhoo and east of Gaakoshibee which is currently being developing as a tourist resort.

Figure 2.1: Location of Madidhoo (Marked in Red)

Source: Department of National Planning Website 2010

Figure 2.2: Madidhoo – Shaviyani Atoll

Source: Google Earth

2.1 Project Site Plan

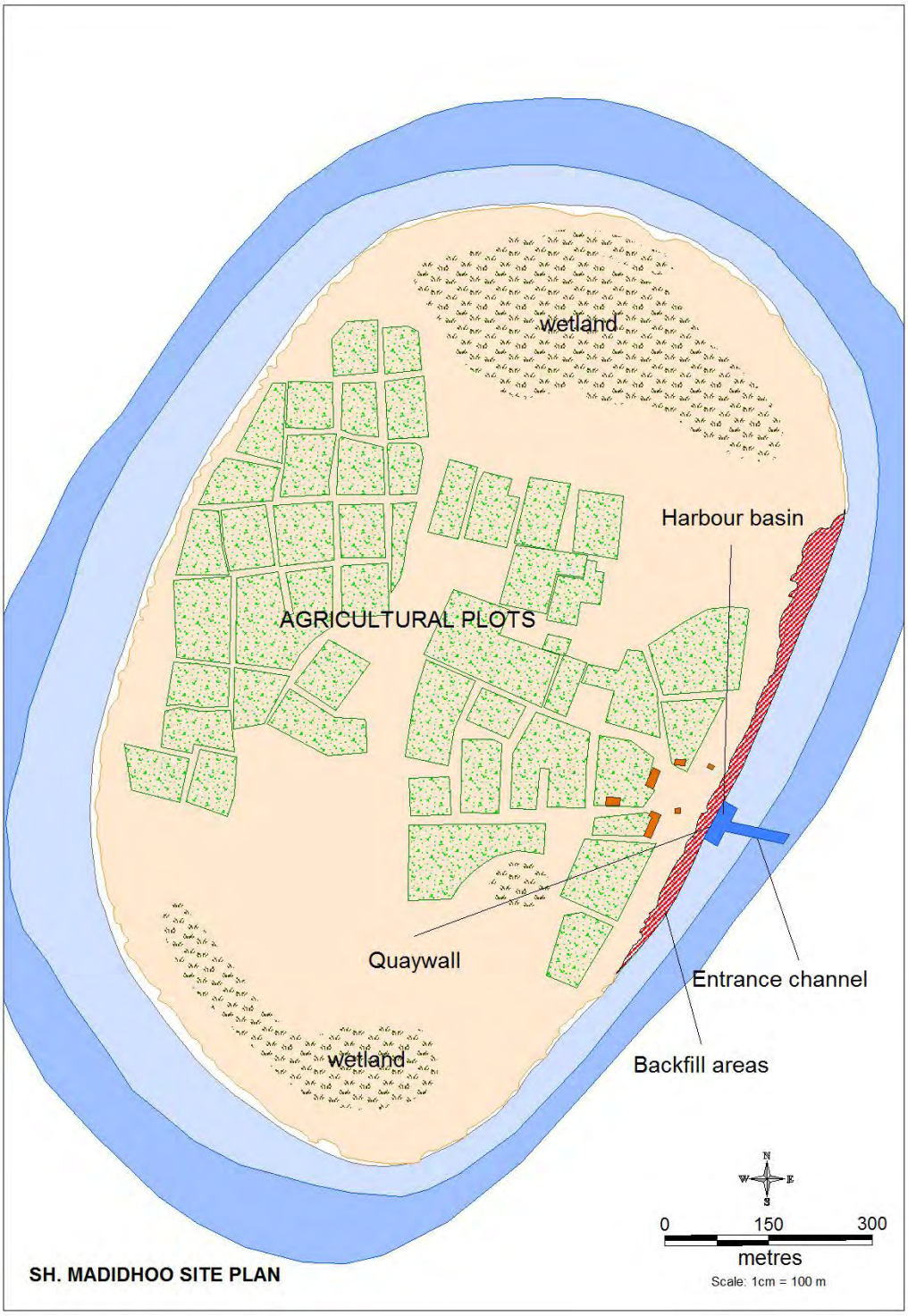


Figure 2.3: Site plan (reduced version)

A more detailed site plan is provided in Appendix 1.

2.2 Project Need and Justification

Madihoo has been using as an agricultural island for the last 17 years. Different types of vegetables and fruits such as pumpkin, cucumber, chilli, egg plant, papaya, water melon are grown commercially on this island. The products are directly supplied to 10 -12 resort islands and the remaining are sold through Madidhoo Mart shop located in Male'. These products are transported to resorts twice weekly and once a week to Male'. A 101 ft x 36ft is used to transport the goods from Madidhoo to other places. Due to the formation of the island, Madidhoo has a very narrow and shallow lagoon around the island which is not sheltered and hence access to the island is difficult. Therefore, the cargo vessel anchored in the channel outside the island reef while agricultural goods are loaded using a small boat (bohkura) with a capacity on one tonne. Due the small size of the bohkura, several trips are needed to load the goods which is not only inconvenient but also both time consuming and labour intense.

In addition, there are two other vessels that are used to bring fertilisers and other supplies to the island and transport goods to Male'. These vessels are normally anchored in the harbour of Maroshi which is approximately 45 minutes from Madidhoo. Therefore, a proper access to the island and a safe mooring area is required for the effective operation of the island.

2.3 Project Scope and Components

The project mainly involves the construction of access improvement infrastructure on Madidhoo. Project will involve the following activities:

1. Dredging an entrance channel and harbour basin.
2. Construction of a quaywall.
3. Replenishment of eroding beaches using dredge waste.

2.3.1 Dredging entrance channel and harbor basin

A small harbor has been proposed to improve the access and mooring facilities on the island. The harbour will be constructed on the eastern side of the island (see Appendix 1). The details of this component are as follows:

1. The reef entrance is approximately 90 m x 20 m with a dredged depth of 3 m from MSL. The dredge area is approximately 1800 m^2.
2. The harbour basin is approximately 60 m x 30 m with a dredged depth of 3.5 m MSL. The dredged area is approximately 1800 m^2.
3. The total dredge volume is estimated at 9,000 m^3, of which 75% or 6,750 m^3 is expected to be coarse to fine sediments suitable for construction and beach filling. Hence dredge waste will mainly be used for beach filling and quay wall construction. The rest of the larger material will be used as base material for construction of breakwater.
4. The side walls of the dredged areas (except quaywall) will be sloped at an angle to stabilse the face.

2.3.2 Beach Filling

Beach filling will be undertaken as proposed in Appendix B. The proposed replenishment width ranges from 10-15 m from the existing high tide line, fixed using a GPS survey on April 2010. The estimated total area covered with the available sand volume is 4000-5000 m^2.

2.3.3 Quay walls

Quay walls will be constructed parallel to the island shoreline using sand cement bags. The standard design for the quay walls are attached in Appendix C.

2.4 Mobilisation of equipment and materials and timing

- Site mobilisation involves the mobilisation of construction equipment, materials and workforce to the island and providing necessary storage for materials and site access and services for the workforce.
- Material will be transported via barges or landing crafts.
- Main subcomponents of constructions are given below. Table 2-1 provides the work programme and work schedule.
    - Mobilization, material download
    - Excavation of harbour basin
    - Excavation of entrance channel

- Disposal of dredged material
- Construction of retaining wall

Table 2.1: Construction Schedule for the proposed activities

		Month					
No	**Activity**	**1**	**2**	**3**	**4**	**5**	6
1	Mobilization and material download						
2	Vegetation clearance at the harbour front						
3	Excavation of harbour basin						
4	Excavation of entrance channel						
5	Backfilling and retaining wall construction						
6	Disposal of dredged material						

2.5 Workforce and Services

- There will be about 10 workers during the construction stage. These workers will be accommodated on the island and in temporary accommodations built on Gaakoshibee Island.
- Almost all workforce-related infrastructure and services will be provided on the Madidhoo..
- The Contractor is expected to provide workers with meals and appropriate entertainment facilities including radio and television. The proponent is partially responsible for services to be provided to the Contractor's staff or workers, since this activity is undertaken as CSR activity of Gaakoshibee Resort.

2.6 Utilities

- Water, electricity and sanitation facilities will be provided for construction workers from the island. a 2500-litre rainwater tank is kept on site for rainwater collection from the roofs of temporary accommodation blocks.
- Electricity will be provided using a 50kVA generator set on site.
- Sanitation facilities will be provided using existing toilets on the island.

2.7 Construction Waste management and disposal

- Construction waste is expected to be minimal since dredging is the main activity. Green waste is expected during landscaping and will be burnt onsite.
- Import of cement bags will form the bulk of packaging waste.
- Other wastes would be general domestic waste arising from material consumption by construction workforce. These will be managed using the waste management practices on the island and it would be the Contractor's responsibility to dispose of all construction-related waste during demobilisation along with any other waste. The Contractor will be required to clear all areas of work.
- See chapter 6 on the proposed construction stage waste disposal plan

2.8 Pollution control measures

The following measures will be taken to ensure minimal pollution during construction stage.

- Machinery will be properly tuned and maintained to reduce emissions and minimize risk of spills/leaks.
- All paints, lubricants, and other chemicals used on site will be stored in secure and bunded location to minimize risk of spill.

2.9 Health and safety Measures

- The contractor would ensure that Health and Safety procedures are complied with at all times.
- Construction activities would be carried out under the supervision of a suitably experienced person.
- All reasonable precautions will be taken for the safety of employees, and equipment will be operated by competent persons.
- Warning signs, barricades or warning devices will be provided and used. Necessary safety gear will be worn at all times.

2.10 Fire prevention

- Fire extinguishing equipment would be readily available and employees will be trained in its use. In general, water-based fire extinguishers would be used.
- Oxygen, acetylene or LPG bottles will not be left free-standing. All welding and cutting will be done in accordance to high safety regulations by experienced personnel.

2.11 Employment

- No new employment is envisaged as existing staff from Gaakoshibee Resort will be used,

2.12 Project inputs and outputs

- The types of materials that will go into the development and from where and how this will be obtained are given in Table 2.2. It includes the type of outputs (products and waste streams) and what is expected to happen to the outputs.

Table 2.2 Inputs and outputs for the construction and operation stage

Input resource(s)	Source/Type	How to obtain resources
	Construction Stage	
Construction workers	Local and foreign, mainly foreign	Gaakoshibee Resort
Construction material	light weight concrete blocks, reinforcement steel bars, sand, cement, aggregates, , etc	Import and purchase where locally available at competitive prices – Main Contractor's responsibility.
Maintenance material	Similar to above	Import or purchase locally where available
Water supply (during construction)	Rainwater and groundwater	Existing resources on the island
Electricity/Energy (during construction)	Diesel	Existing generator
Food and Beverage	Mainly imported sources except a few locally available products. Preference will be given to locally produced food items	Import and purchase locally
Fire fighting equipment	Fire Pumps, Fire Protection System, Smoke Detectors, Carbon Dioxide and Foam Fire Extinguishers, etc.	Local suppliers
Fuel, Kerosene and LPG	Light Diesel, Petrol, Lubricants	Local suppliers
Products and waste materials	**Anticipated quantities**	**Method of disposal**
	Outputs during construction stage	
Green waste from site clearance	small quantity	Burnt or mulched on site and used for nursery and landscaping needs.
Construction waste (general)	Small quantities	Combustibles: Burnt/incinerated Others: Sent to designated landfill

2.13 Work Methodology

2.13.1 Access Improvement & beach replenishment

Works for dredging and replenishment will be carried out using 1 excavators and 1 loader. Dredging offshore will be done using an excavator deployed within the lagoon. A temporary sand bed will be used for the operation of excavators. Dredged material will be transported to the beach areas using 1 truck where the sand material will be unloaded with the help of the excavator and loaders. Beach will be replenished using the loaders. Grading of beach material will take place prior to replenishment and will involve manual work.

Construction of quay walls will be undertaken on the site using small concreting machines and manual labour.

2.14 Alternatives

Alternatives for the following components of the project have been considered and addressed in the chapter 6.

- No project option
- Alternate sites
- Alternate designs
- Alternate Technologies

3 Policy, Planning and Legal Framework

3.1 Introduction

This Chapter will provide a summary of the legal instruments applicable to the project and demonstrate how the project conforms to these aspects.

The main legal instruments of concern are the Environmental Protection and Preservation Act (EPPA) 1993, the Environmental Impact Assessment Regulations 2007,.

3.2 The Environmental Protection and Preservation Act (EPPA) 1993

The Environmental Protection and Preservation Act (EPPA) of the Maldives (Law No. 4/93) is an umbrella law that provides wide statutory powers to the Environment Ministry regarding environmental regulation and enforcement.

The EPP Act 1993 states that the natural environment and its resources are a national heritage that needs to be protected and preserved for the benefit of future generations and that the protection and preservation of the country's land and water resources, flora and fauna as well as the beaches, reefs, lagoons and all natural habitats are important for the sustainable development of the country.

The primary components of the EPP Act 1993 are:

3.2.1 Environmental Guidance

Guidelines and advice on environmental protection shall be provided by the concerned government authorities in accordance with the prevailing conditions and needs of the country. Hence, all concerned parties shall take due consideration of the guidelines provided by the government authorities.

3.2.2 Environmental Protection and Conservation

Formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions shall be carried out by the Environment Ministry.

3.2.3 Protected Areas and Natural Reserves

The Environment Ministry shall be responsible for identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.

3.2.4 Environmental Impact Assessment

An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

3.2.5 Termination of Projects

Projects that have any undesirable impact on the environment can be terminated without compensation.

3.2.6 Waste Disposal Oil and Poisonous Substances

Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government. If such waste is to be incinerated, appropriate precaution should be undertaken to avoid any harm to the health of the population.

3.2.7 Hazardous/Toxic or Nuclear Waste

Hazardous / Toxic or Nuclear Wastes shall not be disposed anywhere within the territory of the country. Permission should be obtained for any trans-boundary movement of such wastes through the territory of Maldives.

3.2.8 The Penalty for Breaking the Law and Damaging the Environment

The penalty for minor offenses in breach of the EPP Act 1993 or any regulations made under this Act, shall be a fine ranging between Rf. 5.00 (Five Rufiyaa) and Rf. 500.00 (Five Hundred Rufiyaa) and for all major offences a fine not exceeding Rf. 100,000,000.00 (One Hundred Million Rufiyaa). The fine shall be levied by the Environment Ministry or by any other government authority designated by that ministry and shall depend on the seriousness of the offence.

3.2.9 Compensation

The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

3.2.10 Compliance of Sh. Madidhoo Project

The proposed harbour dredging activity at Sh. Madidhoo will fully abide to the Environmental Preservation and Protection Act. Disposal of oil, chemicals and other hazardous materials will be strictly controlled and managed. Such materials will not be disposed in to environment, but will be transported to designated waste disposal site.

This EIA report fulfils the legal requirement to submit an environmental impact assessment report for harbour dredging at Sh. Madidhoo to Ministry of Transport, Housing and Environment and will comply with the EPP Act 1993. This report was prepared after consultations with the Environment Ministry the Ministry of Fisheries and Agriculture.

3.3 Environmental Impact Assessment Regulation 2007

The Environment Ministry issued the EIA Regulation in May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Maldives. This Regulation provides a comprehensive outline of the EIA process, including the application to undertake an EIA, details on the contents, format of the IEE/EIA report, the roles and responsibilities of the consultants and the proponents as well as minimum requirements for consultants undertaking the EIA.

This EIA has been undertaken in accordance with the EIA Regulations 2007 of the Maldives.

3.3.1 Post EIA Monitoring, Auditing and Evaluation

The EIA Regulations 2007 provides a guideline of the environmental monitoring programme that should be included in EIA reports as monitoring is a crucial aspect of the EIA process.

Accordingly, the monitoring programme shall outline the objectives of monitoring, the specific information to be collected, the data collection program and managing the monitoring programme. Managing the monitoring programme requires assigning institutional responsibility, enforcement capability, requirements for reporting and ensuring that adequate resources are provided in terms of funds, skilled staff and the like.

The monitoring programme outlined in this report will comply with the EIA Regulations 2007.

3.4 National Environmental Action Plan II (NEAP II)

The aim of NEAP II is to protect and preserve the environment of the Maldives and to sustainably manage the country's natural resources for the collective benefit and enjoyment of present and future generations.

Accordingly, the key strategies of the NEAP II are:

- Continuous assessment of the state of the environment in the Maldives, including impacts of human activities on land, atmosphere, freshwater, lagoons, reefs and the ocean; and the effects of these activities on human well-being
- Development and implementation of management methods suitable for the natural and social environment of the Maldives and maintain or enhance environmental quality and protect human health, while at the same time using resources on a sustainable basis
- Ensure stakeholder participation in the decision making process by consultation and collaboration with all relevant sectors of society
- Preparation and implementation of comprehensive national environmental legislation in order to provide for responsible and effective management of the environment
- Adhering to international and regional environmental conventions and agreements and implementation of commitments embodied in such conventions.

Furthermore, NEAP II specifies priority actions in the following areas:

- Climate change and sea level rise; coastal zone management;
- biological diversity conservation; integrated reef resources management;
- integrated water resources management;
- management of solid waste and sewerage;
- Pollution control and management of hazardous waste;
- sustainable tourism development;
- land resources management and sustainable agriculture

- Human settlement and urbanization.

3.5 Waste Management Policy

The aim of the waste management policy is to formulate and implement guidelines and means for solid waste management in order to maintain a healthy environment. Accordingly, the key elements of the policy include:

- Ensure safe disposal of solid waste and encourage recycling and reduction of waste generated;
- Develop guidelines on waste management and disposal and advocate to enforce such guidelines through inter-sectoral collaboration;
- Ensure safe disposal of chemical, hazardous and industrial waste.

3.6 By Law on Cutting Down, Uprooting, Digging Out and Export of Trees and Palms from One Island to Another

In pursuant to the Environment Protection and Preservation Act of Maldives 1993, the Environment Ministry made a bylaw with the purpose of educating developers about the importance of trees including best management practices for maintaining trees and provide standards for preservation of trees in the Maldives and set down rules and regulations to be adhered to prior to commencing felling, uprooting, digging out and exporting of trees and palms from one island to another in Maldives.

The by law states that the cutting down, uprooting, digging out and export of trees and palms from one island to another can only be done if it is absolutely necessary and there is no other alternative. It further states that for every tree or palm removed in the Maldives two more should be planted and grown in the island.

The by law prohibits the removal of the following tree types;

- The coastal vegetation growing around the islands extending to about 15 meters into the island
- All the trees and palms growing in mangrove and wetlands spreading to 15 meters of land area;
- All the trees that are in a Government protected areas;

- Trees that are being protected by the Government in order to protect species of
- Animal/organisms that live in such trees; and
- Trees/palms that are abnormal in structure.

3.7 Regulation on Sand and Aggregate Mining

The Regulation on Sand and Aggregate Mining was issued by the Ministry of Fisheries, Agriculture and Marine Resources on 13th March 2000. This Regulation addresses sand and aggregate mining from uninhabited islands that has been leased and from the coastal zone of other uninhabited islands. Under this Regulation, it is an offence to mine sand or aggregate from the beach, lagoon or reef of any island leased for the purpose of building a tourist resort.

Mining of aggregate or sand for the construction of resorts and associated facilities is discouraged and utilization of alternative construction material is encouraged under the policy of the Tourism Ministry of the Maldives. As an incentive, import duty is exempted for the import of cement, iron, steel, roofing sheets and timber for the construction of tourist resorts. However, sand mining is allowed for beach replenishment projects, primarily from the immediate lagoon of the resort and in the case of a lack of sand on the island, from an area that is decided by the Ministry of Fisheries, Agriculture and Marine Resources.

3.8 Ban on Coral Mining

Coral mining from the house reef and the atoll rim has been banned from 26th September 1990 through a directive from the President's Office.

3.9 Land Act

The Land Act provides for allocation and releasing of land for different needs as well as releasing of public land for housing. The Act also states the conditions that govern the using of, owning, selling, renting and transferring of ownership of public and private land.

3.10 Relevant International Conventions, Treaties and Protocols

3.10.1 United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol

The UNFCCC is an "overall framework for the intergovernmental efforts to achieve stabilization of greenhouse gas concentrations in the atmosphere at a low level enough to prevent dangerous anthropogenic interference with the climate system, recognizing that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases."

The Clean Development Mechanism (CDM) of the Kyoto Protocol allows implementing project activities that reduce emissions in non-Annex I Parties, in return for certified emission reductions (CERs). Accordingly, the CERs generated by such project activities can be used by Annex I Parties to help meet their emission targets under the Kyoto Protocol.

3.10.2 United Nations Convention on Biological Diversity (UNCBD)

The objective of the UNCBD is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies and by appropriate funding."

Maldives was one of the first nations to ratify the UNCBD. In 2002, Maldives developed the National Biodiversity Strategy and Action Plan (NBSAP) through wide consultation and extensive stakeholder participation.

3.10.3 United Nations Conference on Desertification (UNCCD)

The objective of UNCCD is "to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas."

The Convention calls for improved productivity of land and the rehabilitation, conservation and sustainable management of land and water resources in order to improve the living conditions particularly at the community level.

3.10.4 United Nations Convention on the Law of the Sea (UNCLOS)

The UNCLOS provides a legal order for the seas and oceans to facilitate international communication, promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources and the study, protection and preservation of the marine environment.

Under UNCLOS, the Maldives is an archipelagic state and UNCLOS provides important provisions for the utilization of fishery resources within the territory of the Maldives and ensure that there is no serious pollution or dumping of waste by vessels that use the territory of the Maldives.

3.10.5 International Convention for the Prevention of Pollution from Ships (MARPOL)

The MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978. MARPOL includes regulations aimed at preventing and minimising pollution from ships either by accidental or from routine operations.

The Convention currently includes:

- Prevention of Pollution by Oil,
- Control of Pollution by Noxious Liquid Substances in Bulk,
- Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form,
- Prevention of Pollution by Sewage from Ship,
- Prevention of Pollution by Garbage from Ships, and
- Prevention of Air Pollution from Ships

3.10.6 Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

The objectives of Male' Declaration includes:

- Assessing and analysing the origin and causes, nature, extent and effects of local and regional air pollution,
- Developing and/or adopting strategies to prevent and minimise air pollution
- Setting up monitoring arrangements beginning with the study of sulphur and nitrogen and volatile organic compounds emissions, concentrations and deposition.

3.11 Location Jurisdiction

The project location is in Shaviyanu Atoll, which is under the jurisdiction of Shaviyani Atoll Office. However, the island has been leased for agricultural development and hence the island is now under the authority of the Ministry of Fisheries and Agriculture.

4 Existing Baseline Conditions

4.1 Introduction

This section assembles, evaluates and presents baseline data on the relevant environmental characteristics of the study area and includes the following subsections:

1. Study Methodologies
2. Physical Environment
    a) Climate

        General climatic patterns, wind, rainfall

    b) Coastal Environment

        Waves, currents, tides, bathymetry, coastal geomorphology, beaches

    c) Lagoon and reef flat

        Lagoon bottom conditions, marine water quality, sediment levels
3. Natural and Biological Environment

a) Terrestrial Environment

Flora and fauna including coastal vegetation, groundwater aquifer, air quality and noise

b) Coral Reefs

Marine life including coral reef and other marine organisms

4.2 Methodologies

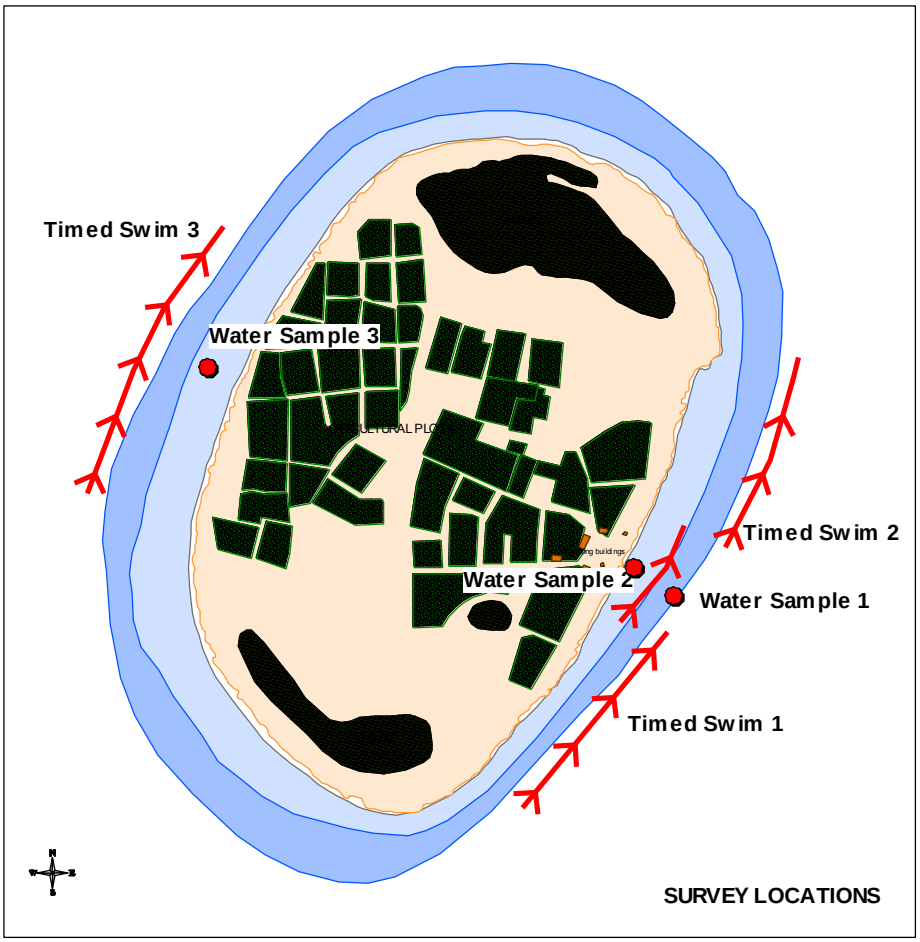
Baseline environment of the study area were analysed by using standard scientific methods. The environmental components of the study area were divided into marine, terrestrial and coastal. The marine environment of the island coral patches, marine water quality and reef slopes. The coastal environment covered the beach and coastal processes including longshore sediment transport, nearshore currents, tides and wave climate. The terrestrial environment covered the flora and fauna in the immediate vicinity of the project and habitats within them, groundwater quality, air quality and noise.

Particular attention was placed in detailed surveys on the marine environment life and coastal processes, as these components are likely to involve the most significant environmental Impacts. The different methods used in assessing and presenting the conditions of the existing environment of the island are given in the following subsections.

4.2.1 Study area and Survey Locations

The study area covers much of the surrounding reef area. Figure 4.1 below shoes the specific study area.

Figure 4.1: Study area boundaries.



The location of data collection sites have been identified using GPS. The details of the locations are presented below.

Site	Longitude	Latitude
Water Sample 1	73.113222	6.300044
Water Sample 2	73.112478	6.300564
Water Sample 3	73.104556	6.304282
Beach Profile 1	73.113255	6.303218
Beach Profile 2	73.111772	6.299476
Beach Profile 3	73.108040	6.295720
Beach Profile 4	73.103817	6.299907

4.2.2 Terrestrial Flora and Fauna

Coastal vegetation was surveyed by walking along the coastline. The types and abundance of species were recorded along the surveyed lines.

Terrestrial fauna was not surveyed in detail as the project is predominantly coastal environment based.

4.2.3 Aquatic Resources

One of the main environmental components that would be affected by implementing the project would be the aquatic resources and water quality. Water quality was assessed at different locations during the field visit in February 2010. Samples were collected in clean 500ml PET bottles after washing them with water to be sampled. Also to test for biological content (faecal coliform), samples were collected in sterilized 100ml glass bottles provided by the National Health Laboratory. Parameters tested for sea water quality assessment were Biological Oxygen Demand (BOD5), Dissolved Oxygen (DO), Salinity, Total Dissolved Solids (TDS), pH, Nitrate, Nitrite and Faecal coliform and for ground water quality assessment parameters tested were Total Coliform, Faecal Coliform, Electrical Conductivity, Chlorine, Nitrates, Nitrites, pH, TDS and Ammonia. All parameters were analysed at the National Health Laboratory

4.2.4 Coastal processes

Four beach profiles were taken from designated locations around the island using standard levelling techniques. These profile locations are marked in figure above. The measurement of beach profiles involves standard practice of surveying with a staff and a dumpy level. Measurements were taken along the beach profile line at different intervals wherever there occured a distinctive morphological feature such as beach ridge, high water mark, an erosion scarp, dip, rise, or other significant break in the beach slope up to a minimum distance of 30m from the Benchmark.

4.3 Physical environment

4.3.1 Geologic setting

Madidhoo is among the largest uninhabited islands in the Maldives with a length of 1,370 m and a width of 880 m at its widest point. The total surface area of the island is 102 Ha (1.02 km^2). Much of the beach area is highly mobile and therefore should not be considered permanent land.

The reef flat of Madidhoo has a surface area of 31 Ha. The reef system is fairly saturated with the island occupying over 75% of the reef system. The average depth of the reef flat is shallow averaging less than -1.2 m MSL.

Madidhoo Island is located at the centre of the Thiladhunmathi Atoll, with about 13.5 km from either side of the atoll rims (east and west). The island is generally high with an average elevation of +1.7m MSL. Madidhoo should be considered a well-established island.

The influence of Indian Ocean oceanographic and climatic factors on the geologic setting and environment is likely to be pronounced in Madidhoo due to the wide atoll openings or reef passes. Environmental forcing is mainly dominated by monsoonal and tidal currents while the influence of swell waves approaching from the Northeast, south east and southwest is pronounced.

4.3.2 Climatic setting

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. There is considerable variation of climate between northern and southern atolls. Table 4.1 provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station in Hanimaadhoo.

Table 4.1: Key Meteorological Information

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 C in November 1973 31.7 C in April
Extreme Air Temperature	34.1 C in April 1973 17.2 C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

4.3.2.1 Monsoons

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. Monsoons can be best characterized by wind and rainfall patterns. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November.

4.3.2.2 Wind

The two monsoon seasons have a dominant influence on winds experienced across Maldives. These monsoons are relatively mild due to the country's location close to the equator and strong winds and gales are infrequent. However, storms and line squalls can occur, usually in the period May to July; gusts of up to 60 knots have been recorded at Male' during such storms.

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer, 2003). Wind speed is usually higher in central region of Maldives during both monsoons, with a maximum wind speed recorded at 18 $m.s^{-1}$ for the period 1975 to 2001. The highest wind speed recorded in the northern region for the period 1992 to 2001 was 12.3 $m.s^{-1}$. Mean wind speed was highest during the months May and October in the central region. Wind analysis indicated that the monsoon was considerably stronger in the central and northern region of Maldives compared to the south (Naseer, 2003). During the peak months of the SW monsoon, Madidhoo may experience strong wind and associate rise in water level.

Table 4.2 summarises the wind conditions in Madidhoo throughout a year. Medium-term meteorological data from Hanimaadhoo Airport weather station (see figures 4.2 to 4.3) and findings from long-term Comprehensive Ocean-Atmosphere Data Set (COADS) were used in this analysis.

Table 4.2: Summary of predicted wind conditions in Madidhoo

season	Month	Wind
NE - Monsoon	December	Predominantly from NW-E. High Speeds from N & NE
	January	
	February	
Transition Period 1	March	From all directions. Mainly NW and E. High Speeds from N & NW
	April	
SW - Monsoon	May	Mainly from W and NW. High Speeds from W & WNW
	June	
	July	
	August	
	September	
Transition Period 2	October	Mainly from W. High Speeds from W
	November	

The project site is not expected to receive regular annual strong winds except for a brief period at the peak of South West Monsoon. However, it is highly likely that wind may increase beyond normal southwest monsoon peaks at times of severe weather such as those resulting from localised storms. This aspect of climate therefore may not have a major bearing on the proposed harbour design.

Figure 4.2: Monthly frequencies of wind direction in Northern Maldives based on Hanimaadhoo Stations 10 year Data (adapted from Naseer, 2003).

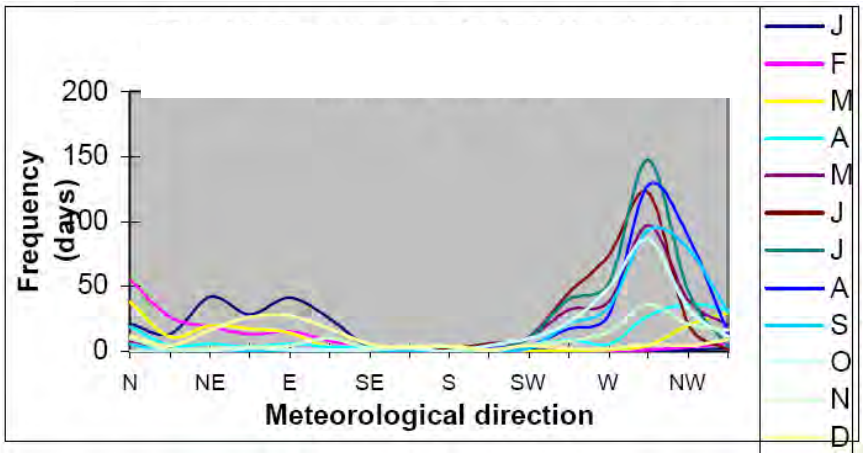


Figure 4.3a: 10 year wind frequency for Hanimaadhoo weather station (in Days) and long term COADS data (adapted from Naseer, 2003).

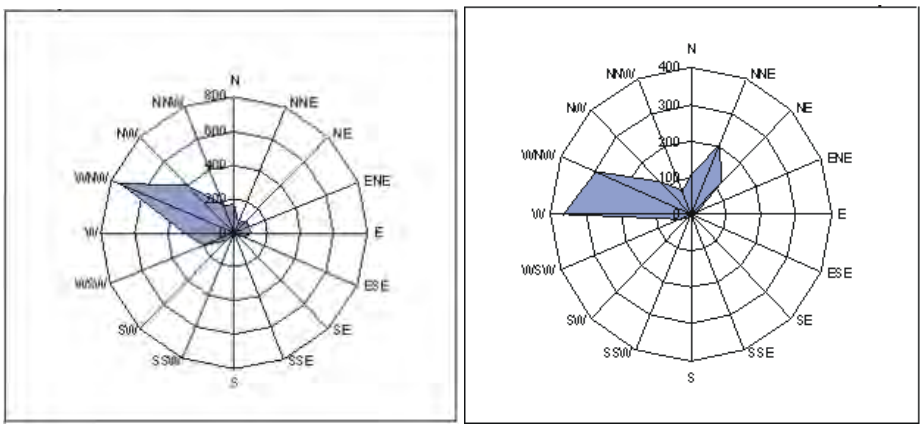
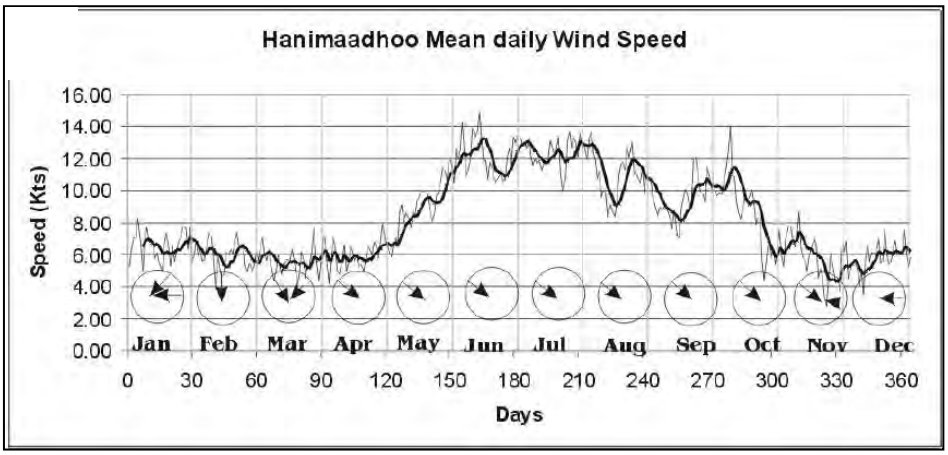


Figure 4.3b Mean daily wind speed and direction Hanimaadhoo Airport. Arrows indicate dominant wind direction (adapted from Naseer, 2003).



4.3.2.3 Waves

Long-term site specific data on wave conditions in Madidhoo was not available. Due to the limitations in data, studies conducted in similar settings of Maldives have been considered as a general guide to wave conditions in Madidhoo.

Generally, two major types of waves have been reported on the coasts of the Maldives: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves. The location of Madidhoo and the openness of the Thiladunmathi Atoll (width of reef passes) increases its exposure to swell waves and monsoon generated wind waves. Madidhoo is also exposed to strong wave activity during the SW monsoon due to the fetch distance available within the atoll and width of atoll passes on the western rim of the atoll.

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system of west coast of Australia, had significant wave heights in the order of 3 metres. Madidhoo could experience the effects of such waves reaching Maldives.

4.3.2.4 Currents

Currents which affect the sea areas around Madidhoo reef system can be the result of one or more of tidal currents, wind-induced currents and wave-induced currents.

It is presumed that dominating two-monsoon season winds have a greater effect on both oceanic currents and lagoonal currents around Maldives. Westwardly flowing currents are dominated from January to March and eastwardly from May to November.

Studies on current flow within a reef flat in Male' Atoll suggests that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie Black & Veatch, 2000).

In general terms, the tidal component of current is eastward during flood tide and westward during ebb tide.

4.3.2.5 Tides

Tides experienced in Maldives are mixed and semi-diurnal/diurnal. Typical spring and neap tidal ranges are approximately 1.0m and 0.3m, respectively (MEC, 2004). Maximum spring tidal range in the central and southern atolls is approximately 1.1m. There is also a 0.2m seasonal fluctuation in regional mean sea level, with an increase of about 0.1m during February to April and a decrease of 0.1m during September to November. Tidal variations in Maldives are presented in Table 4.3. Tidal measurements were carried out during the field surveys in Madidhoo but were insufficient to discern any major trends due to the short duration (2 days) of observation.

Table 4.3: Tidal Variations at Male' International Airport

Tide Level	Referred to Mean Sea level
Highest Astronomical Tide (HAT)	+0.64
Mean Higher High Water (MHHW)	+0.34
Mean Lower High Water (MLHW)	+0.14
Mean Sea Level (MSL)	0.00
Mean Higher Low Water (MHLW)	-0.16
Mean Lower Low Water (MHLW)	-0.36
Lowest Astronomical Tide (LAT)	-0.56

Source: MEC, 2004

The predicted astronomical tides provided above may vary at any given time and location based on a number of meteorological and other factors including:

- Wind set-up or set-down, due to onshore or offshore winds;
- Atmospheric pressure deficiency or excess, due to areas of low or high pressure, leading to a positive or negative surge component respectively.
- Wave set-up or set-down due to „groupiness' of waves reaching the shore, due to „surf beats', or due to ponding of broken waves.
- Seasonal variation in Mean Sea Level; and
- Tsunamis

4.3.2.6 Rainfall

Annual average rainfall in Maldives is about 1900mm. There is a marked variation in rainfall across Maldives with an increasing trend towards south. The annual average rainfall in north is 1977mm and for south is 2470mm.

The southwest monsoon is known as the wet season with monthly average rainfall ranging from 125-250mm. The northeast monsoon is known as the dry season with average monthly rainfall of 50-75mm.

Long term data for Madidhoo area are not available. Medium term records in Hanimaadhoo indicate an average annual rainfall of 1977mm.

Excessive rainfall is a concern for the proposed harbour area as the proposed quaywall design is known to be vulnerable to heavy rainfall related flooding.

4.3.3 Topography

Madidhoo is generally low lying island with an average elevation of +1.7 m MSL on the edges and +1.3 m MSL towards the centre of the island. Topographic variations were analysed for a sample transect towards the centre of the island. At this location, the overall elevation is fairly consistent throughout the island at about 1.2 m.

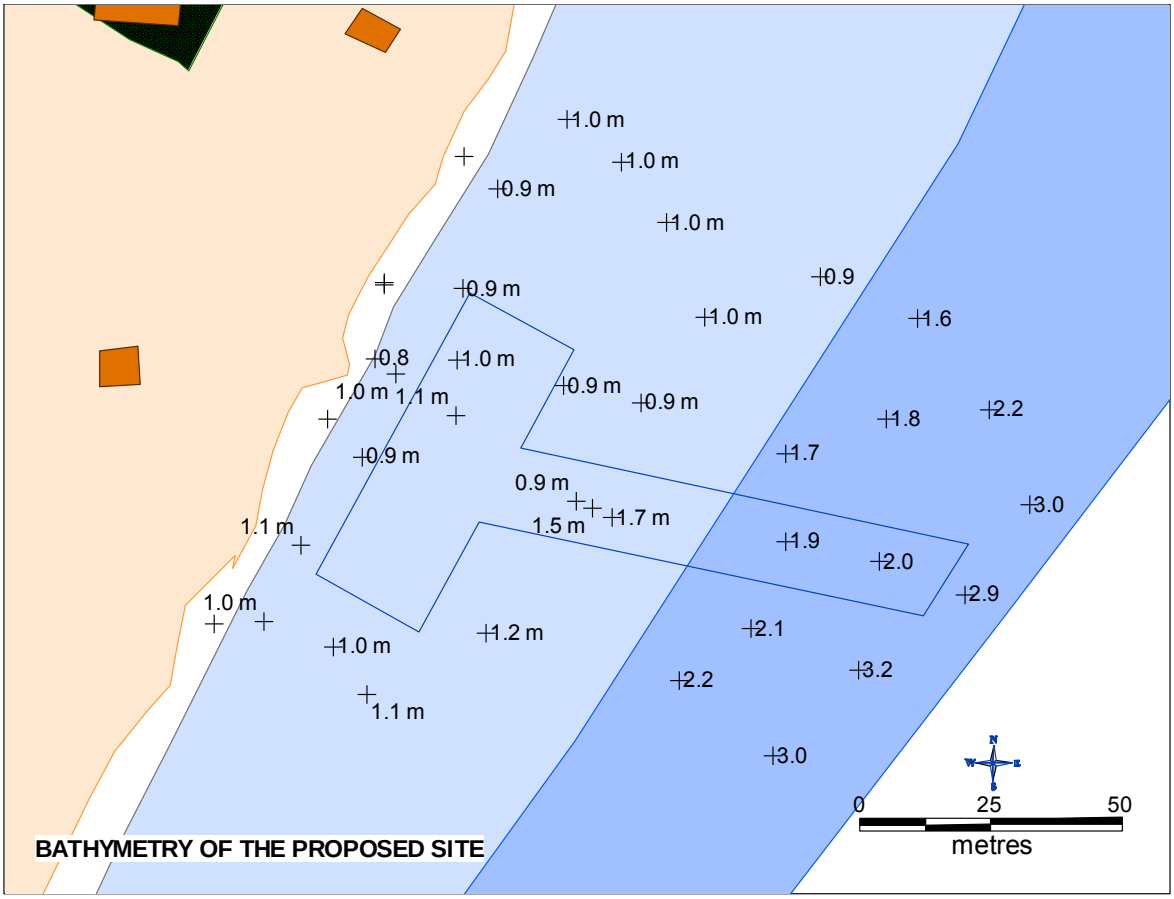
The coastal ridge on the northeastern and western shoreline is the highest point reaching 1.8 m MSL. This higher ridge is the result of strong wave activity in these areas.

Visual surveys in the rest of the island showed that there a numerous depressions on the island, some with significant areas of wetland on the northern and southern end of the island. The water table could generally be reached with close proximity during high tide.

4.3.4 Bathymetry

A detailed bathymetric survey of the proposed site was undertaken during April 2008. Survey results have been summarised in bathy charts presented in Figure below. The depth figures presented are in meters below MSL.

Figure 4.4 Bathymetry of the proposed site



The reef flat areas on the east of the island have a fairly flat depth of -1.0 m MSL. Areas west of the island gently slope into the deep lagoon. Reef edges drop off from 2.0 to 7.0 m in most part of the reef system.

4.3.5 Geomorphology and Coastal dynamics

4.3.5.1 Beach

Madidhoo Island has a well established but a comparatively small beach system. In 2008 the beach area of Madidhoo was estimated at 3 Ha, which is quite small given the size of the island. Seasonal sediment movement appears to be strong with consistent erosion on the eastern side during NE monsoon and on the western side during SW monsoon. There is permanent erosion on the northern and southern end of the island (see figure 4.6 and 4.8). The vegetation line however is very resilient has moved little over the last 30 years.

During the SW monsoon beach shifts its position from east to west along the northern and southern coastline. The reverse occurs along the same route during the NE monsoon (see Figure 4.5 and 4.7). This is mainly due to the generally smooth shape of the island and reef system. Despite these movements the sediment budget of the entire island spears to have remained fairly stable and small over the last 30 years (based on historical aerial photographs).

Figure 4.5: Beach characteristics and vegetation on the eastern coastline

Figure 4.6: Beach characteristics and vegetation on the southern coastline

Figure 4.7: Beach characteristics and vegetation on the western side of the island

Figure 4.8: Beach characteristics and vegetation on the western side of the island

There are also notable variations in coastal geomorphology around the island. The northern and southern coastlines are mainly comprised of coral ramparts, perhaps owing to strong wave activity. The western shoreline is comparatively higher with approximately 1.7-1.8 m MSL.

Detailed baseline measurement of the beach areas have been undertaken as beach profiles and are presented in Appendix D.

4.3.5.2 Coastal Modifications

No major coastal modification has been undertaken except for a manually cleared reef entrance.

4.3.5.3 Beach erosion

As noted earlier, the island is undergoing fairly consistent severe erosion. Historically severe erosion is concentrated on the northern and southern ends of the island (see 4.6 and 4.8). In recent years, severe erosion has been experienced on the eastern side of the island. The design of the coastal structures will have a major bearing on the erosion stability of the island.

4.3.6 Lagoon Water quality

The primary objective of the lagoon water quality sampling was to determine the baseline conditions of the marine water surrounding Madidhoo. Quality of coastal water is not only important for the ecological functioning of organisms living in the habitat but also important for aesthetic and health reasons such as swimming in unpolluted waters. As the proposed project involves significant coastal modification activities, marine water quality should be treated as an important indicator of environmental impacts. Three sampling locations were identified on the island and are shown in Figure 4.1, along with their GPS locations.

The sites were selected based on their location relative to proposed discharge points and close to major development activity zones.

Water quality tests were done at the National Health Laboratory (NHL). Tests covered both biological and ambient conditions as shown in Table 4.5. The results indicate that sea water around Madishoo is reasonably pollution free. Water at all sampling locations were clear and had normal pH levels and trace amounts of copper, iron and manganese. TDS levels were within the range 27100-27500mg/L and fit into the normal seawater levels. The high BOD levels (243-309mg/L) is suspected as an error in the analysis as water bodies having BOD levels above 100mg/L are generally classified as highly contaminated. It is unlikely that the lagoon water of Madidhoo is highly contaminated in reference to the

other parameters tested and also in reference to the visual appearance and absence of foul smell at the time of sampling.

Table 4.5: Sea Water Quality Results

Parameter	SWI	SW2	SW3
Total Coliform (E.coli)/100ml	0	0	0
Faecal Coliform (E.coli)/100ml	0	0	0
Physical appearance	Clear with suspended particles	Clear with suspended particles	Clear with suspended particles
Total Dissolved Solids	27100mg/L	27500mg/L	27100mg/L
Biological Oxygen Demand	309mg/L	279mg/L	243mg/L
pH	8.4	8.4	8.5
Phosphorous	0.21 mg/L	0.19 mg/L	0.19 mg/L
Electrical Conductivity	54400 µ s/cm	55000 µ s/cm	52900 µ s/cm
Chloride	18000 mg/L	17980 mg/L	16500 mg/L
Chlorine free	<0.02 mg/L	<0.02 mg/L	<0.02 mg/L
Turbidity	3 NTU	2 NTU	2 NTU
Iron	0.01 mg/L	0.00 mg/L	0.00 mg/L
Sulphate	2950 mg/L	2900 mg/L	2850 mg/L
Copper	0.00 mg/L	0.00 mg/L	0.00 mg/L
Manganese	0.40 mg/L	0.43 mg/L	0.40 mg/L

4.3.7 Natural disaster risk

The primary sources of natural hazard risks in Maldives are strong winds during monsoons or freak storms, earthquakes, island interior flooding caused by heavy rain, coastal flooding caused by high surf, storm surge, prolonged strong monsoonal wind, high astronomical tides or tsunamis, and sea level rise (Pernetta and Sestini, 1989; Woodroffe, 1989; Severe weather events in 2002 2003 and 2004(2005); UNDP 2005). Coastal flooding and wind damage can be considered as the most frequent natural hazards that occur in Maldives (see Maniku (1990), Luthfy (1994)). Most of these risk factors (apart from earthquake, wind damage and rainfall flooding), stems from the extremely low elevation of all Maldivian islands: the average elevation is 0.8 m above sea level. Despite

the occasional natural hazards, Maldives in general is relatively safe from high risk natural disasters.

Spatial variations in hazards are evident across Maldives (Maniku, 1990; Shaig, 2005). Northern atolls are more exposed to intense storm systems, increasing the risk of wind damage in these atolls. In comparison, southern atolls experience less storms systems, but are more exposed to flooding events, probably as a result of exposure to intense South Indian Ocean storm surges and wind-waves during south west monsoons. In this context, Madidhoo lies in a zone which is exposed to freak storm activity. Historical records state that Madidhoo was severely affected in 1955 when a storm devastated vegetation in some parts of the island and flooded the coastal areas. This event is known to have affected almost all the islands in Thiladhunmathi Atoll.

Madidhoo is also exposed to tsunamis. The Indian Ocean tsunami affected most of the atoll and sections of the island.

4.4 Natural and biological environment

4.4.1 Terrestrial Ecology – General characteristics

The terrestrial environment of the proposed site was assessed during the field visits on February 2010. Vegetation surveys were primarily based on visual observations.

The vegetation for the proposed development site has been modified as it is the main landing area of the island. Similarly approximately 60% of the island vegetation system has been heavily modified to accommodate agricultural activities. These include vegetation clearing and introduced species.

The most pristine vegetation zones around the island are the coastal vegetation (about 75% of the coastline) and the two wetland or marshland areas. The marsh lands and low-lying area were mapped using differential GPS and measuring tape.

4.4.2 Flora

The vegetation of the proposed site as observed during the survey is summarized in the table below.

Table 4.6: Results of the Vegetation Survey of the Line Transect on the Proposed Area for Runway Development

Local Name	Common Name	Scientific Name	Family Name	Occurrence
Boa-kashikeyo	Wild screw pine	*Pandanus tectorus*	Pandanaceae	Dominant
Dhivehi Ruh	Coconut Palm	*Cocos nucifera*	Arecaceae/Palmae	Dominant
Dhiggaa	Sea/beach hibiscus	*Hibiscus tiliaceus*	Malvaceae	Frequent
Hirun'dhu	Tulip tree	*Thespesia populnea*	Malvaceae	Frequent
Kuredhi/Keredhi	Iron wood	*Pemphis acidula*	Lythraceae	Occasional
Kaani/Kauni	Sea trumpet	*Cordia subcordata*	Ehretiaceae	Occasional
Magoo/Gera	Sea lettuce tree	*Scaevola taccada*	Goodeniaceae	Occasional

It should be noted that during the vegetation survey no trees of abnormal structure were found and according to locals, such trees are non-existent on the island.

4.4.3 Abiotic marine environment

4.4.3.1 Lagoon system

The reef of Madidhoo is small with a surface area of 35 Ha. The reef is characterised by a shallow reef flat approximately 1.5 m MSL.

The eastern reef flat zone is comprised mainly of sand and rubble. The wave breaker zone comprises of a poorly developed algal ridge which is commonly found in such conditions. There is a man-made reef entrance this side, which is also the proposed new reef entrance site.

The western end of the reef flat comprises of moderate coral cover. Much of the lagoon bottom in this area is sand and rubble. There is a well formed algal ridge, which may be a response to the strong southwest monsoon wave activity.

Lagoon benthos

Lagoon benthos was surveyed using both visual observations during snorkelling surveys and quantitative LIT surveys. Snorkelling and occasional Manta-tow surveys were used to establish the general characteristics of the lagoon system and were used to cover a broad area within the lagoon. Quantitative LIT surveys were carried out in two sites - one of which correspond to the proposed development zones. The general observation of this assessment are summarised below:

- Initial visual observation revealed that reef flat on both sides is composed of fine sand and unconsolidated rubble.

- The western end of the reef-flat comprised of sparse live coral cover zones. Structural complexity of these areas were poor and mainly comprised of Massive and sub-massive corals.
- The visibility within the surveyed locations was generally moderate to poor with 7-10 m visibility.
- Live coral cover on the reef flat is generally low.
- Fish abundance during the survey was low.
- Reef aesthetics was poor around the lagoon.
- No signs of coral bleaching were observed
- No crown-of-thorns star fish was observed.

Detailed findings

The general conditions of the reef flat during the LIT surveys are summarised in Table 4.7 below. Live coral cover is generally low between 3-5 %. Much of the lagoon areas is dominated by sand and rubble zones.

Table 4.7 Summary conditions of the reef flat from LIT surveys

LIT site	Live corals %	Dead corals %	Sand %	Rubble %	Visibility m
MLT1	3	20	50	20	10
MLT 2	5	30	40	20	7

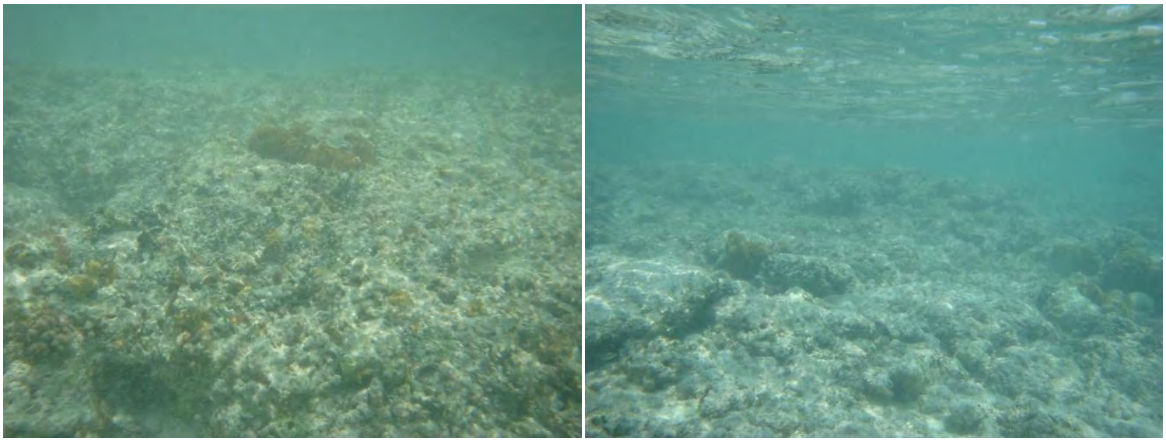
Reef aesthetics of the LIT sites are summarised in Table 4.8 below. In general the lagoon conditions are in moderate to poor condition, in terms of coral cover.

Table 4.8 Summary of Reef Aesthetics of the LIT Sites

Attribute	MLT1	MLT2
Reef aesthetics	Poor	Moderate
Live coral cover	Poor	Moderately low
Structural complexity	Poor	Poor
Coral recruitment	average	average
Fish population structure	Mix of grazers & plankton feeders	Mix of grazers & plankton feeders
Littering	few	Moderately high
Coral bleaching	none	none
Crown-of-thorn starfish	none	none

The general pattern of benthic cover comprised of 20% dead corals covered with filamentous algae, 3% live coral, 1% encrusting algae and 50% sand. Live coral cover was dominated by massive type corals covering 15%, sub-massive corals covering 7% and digitate coral covering 2%. Large porites corals are known to be found in lagoon environments exposed to periodic sedimentation.

Figure 4.9 below shows a representative collection of images which provides a summary of live coral areas found in the lagoon.



4.4.3.2 Manta Tow Findings

Method

Manta tow method involves towing a snorkeller behind a boat at a constant speed with regular stops to record data (e.g. every 2 minutes). The timed swim method involves snorkelling to specified time and recording the findings. These are the best method to obtain a general description of large reef areas or measures of broad changes in abundance and distribution of organisms and large-scale disturbance. Benthic communities are usually assessed using the following parameters:

- Percent hard and soft coral;
- Percent dead coral, rubble and sand;

These parameters are a visually estimated using the following guidelines.

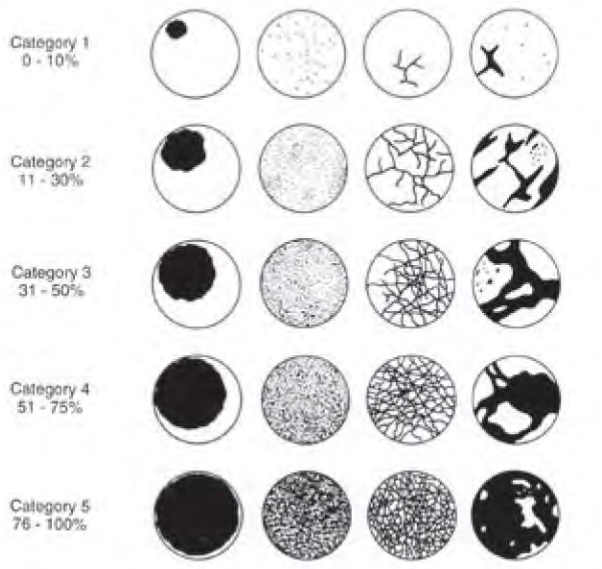


Figure 4.10 Visual estimation categories for percent coral cover from Dahl (1981) in English et al. (1997)

Findings

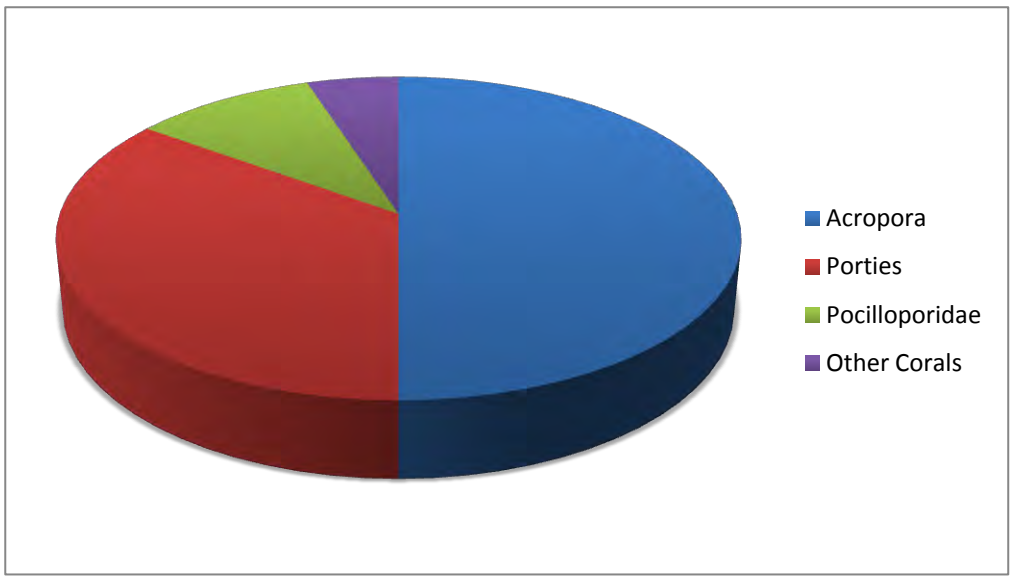
Table 4. below summarises the findings from the Manta tow survey. Live coral cover and fish communities were quantified using the DAFOR scale which is listed below.

Table 4.9 Results of Manta Tow surveys (refer to above for survey locations)

Dominant	>70% Coral Cover	>250 Fish
Abundant	30%-50% Cover Cover	51-250 Fish
Frequent	10%-20% Coral Cover	21-50 Fish
Occasional	5%-8% Coral Cover	6-20 Fish
Rare	1%-3% Coral Cover	1-5 Fish

The coral cover in most zones was observed to be in moderate to poor condition. Branching acropora corals were abundant in the area covering approximately 50% of the studied area. The large boulder coral, also known as porites sp. is also quite abundant and generally found in groups of solitary massive formations. Small frequent sightings of pocilloporidae new growths were also observed.

Figure 4.11 Coral communities and species distribution in the site



The coral reef was about 30% live with frequent observations of rubble. The reef was more live along the reef crest and down the reef slope.

Figure 4.12 Coral communities and species distribution on the reef slope of the site

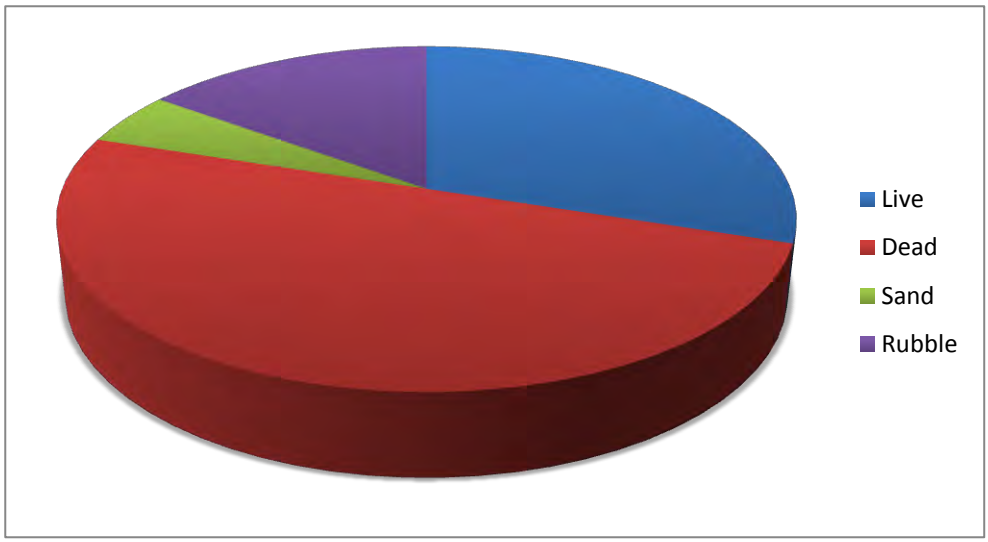


Figure 4.13 Porites sp observed in the project site

Figure 4.14 The reef slope off the project site – dominated by Acropora

Reef aesthetic

Table 4.10 shows various attributes of the reef system that relate to aesthetic of the reef. These attributes were assessed through Manta tow surveys.

Reef aesthetics is a subjective attribute based on the observer's judgment and experience of the relative merits of a reef. This value judgment incorporated live coral cover, fish population structure, and reef structural complexity and general appeal. Reef aesthetics were found to be moderate to poor in most of the locations, based on the attributes.

Table 4.10 Reef aesthetics survey result as observed by manta tow

Attribute	Status
Reef aesthetics	Moderate to poor
Live coral cover	Moderate to poor
Structural complexity	Moderate
Coral recruitment	moderate
Fish population structure	Mix of coral, algal and carnivorous feeders
Littering	Quite a few evident
Coral bleaching	none
Crown-of-thorn starfish	none

The structural complexity of the reef system was assessed based on various natural reef structures including overhangs, reef terraces, caves, depressions in the reef slope and various habitat types within the reef system. The structural complexity of the reef system was found to

Fish Population

Fish community was generally healthy with a standard variety of species. Schooling fish were dominant, which include the Ternate chronis and Fine-lined Bristle tooth. The following table was determined from the fish that was observed at the time of assessment.

Table 4.11 Reef aesthetics survey result as observed by manta tow

Species	Quantification
Blue Surgeon	Occasional
Fine-lined Bristle tooth	Frequent
Blue Damsel	Abundant
Ternate chromis	Abundant
Cleaner Wrasse	Abundant
Parrot Fish	Occasional
Blue Strip Fussilia	Abundant

4.5 Socio-economic Environment

The project is being undertaken in an agricultural island which has little or no interaction with the surrounding islands, apart from employment to some locals.

5 Potential Impacts and Mitigation Measures

5.1 Introduction

The proposed development of access infrastructure on Madidhoo Island is anticipated to cause significant detrimental as well as beneficial impacts. Impact identification (environmental/social/economic impacts) and mitigation measures were primarily based on literature reviews, professional judgment and past experience from similar projects.

For the purpose of this EIA, the chain of events linking activities to specific impacts and knock-on effects are represented in flowcharts to allow for easier interpretation. This is because the cause-effect relationship between a specific activity and its potential impacts are rarely linear and in most cases, a series of casual factors linked to different activities create the conditions that cause an impact. Three separate flowcharts were developed and organized to display logically the following sequence of events:

Activity → *Casual Factor* → *Potential Impacts* → *Short Term Effects* → *Long Term Effects*

Accordingly, Figure 5.1 below illustrates the flowcharts. The first chart will show the potential negative impacts of the proposed development activities during the construction stage and the second chart shows the potential negative impacts of the proposed development activities during the operation stage. Finally the third chart will show the

potential positive impacts expected to arise once the project is complete (operation stage). It should be noted that no potential positive impacts could be identified for the construction stage of the proposed development activities.

5.2 Uncertainties in Impact Prediction

In the EIA process of the Maldives, uncertainties in impact prediction generally arise due to the lack of long term data, limited timeframes to complete EIAs and lack of standard procedures to collect data leading to inconsistent methodologies used by the various EIA consultants. Such issues are mainly linked to the lack of importance given to the EIA process in strategic planning and initial stages of development projects. Typically in the Maldives, EIAs for major development projects are only done after development activities and project locations are finalised. This gives the EIA consultants limited time frames to conduct a comprehensive impact assessment.

Accordingly, the uncertainties in impact prediction for this particular EIA are due to the time constraints in data collection and due to the limited amount and type of data available for measuring or predicting impacts.

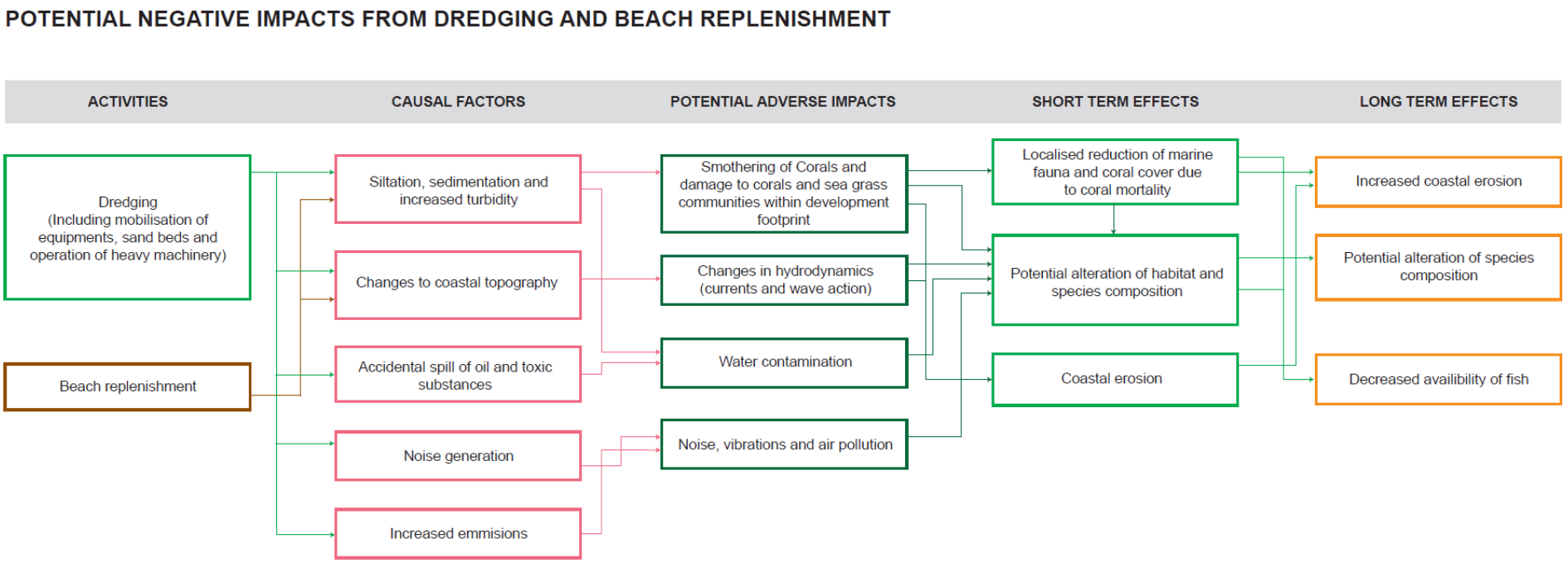


Figure 5.1: Potential positive and negative impacts

5.3 Brief Description of Potential Impacts and Suggested Mitigation Measures for All Adverse Impacts

This section will provide a brief description of each of the potential impacts illustrated in the flowcharts of Figure 5.1 and suggest appropriate mitigation measures for all potential adverse impacts. Similar to the flowcharts, firstly potential negative impacts and mitigation measures during the construction stage will be described. This will be followed by descriptions of the potential negative impacts during the operation stage. Finally all potential positive impacts will be discussed.

5.3.1 Potential Adverse Impact during the Construction Stage and Suggested Mitigation Measures

5.3.1.1 Smothering of corals, siltation of lagoon benthos and affects on fish population

- During dredging and replenishment works, a significant amount of siltation and sedimentation of the lagoon waters is anticipated. Also increased turbidity of the lagoon water is expected.

- These factors will cause adverse impacts such as smothering of corals and reduced light penetration to the coral and benthic communities. As corals have a self cleansing mechanism and can withstand a certain rate of sedimentation, detrimental impacts such as reduced coral growth and recruitment rate and decreased visibility can be short term effects. However if the sedimentation exceeds the rate at which corals can self clean, then it may lead to serious detrimental impacts such as coral mortality and alteration of habitat and species composition within the Madidhoo lagoon. Given the poor state of coral colonies in the immediate area surrounding the proposed dredge site, this loss is expected to be pronounced in the immediate future.

- Lagoon bottom is a habitat for certain organisms such as worms, mollusks, amphipod etc. which are important food sources for bottom feeders such as certain species of fishes. Dredging activities will disturb habitats of these organisms. However, it has been found elsewhere that lagoon bottom dwelling organisms re-establish within few months after such disturbances.

- Fish population is often affected when their gills are stuck by suspended sediments. There will be loss of habitat for a large portion of the juvenile species. Most species will stay out of the harm's way my moving to safer areas of the lagoon.

However, the juveniles may lose their habitats and this may affect the fish population in the short term.

- Direct removal of corals and hard bottom substrate for dredging can result in loss of habitats for fish, and reef benthos in addition to loss of coral colonies.

- Therefore it is vital to take proper mitigation measures to avoid siltation, sedimentation and turbidity as much as possible.

Mitigation measures

- A temporary bundwall with a settlement basin should be placed around the dredge area to prevent suspended sediment outflow during dredging. Once dredging is completed, sufficient time could be given to settle the sediments while other components of the harbor works such as quay wall construction could be undertaken. Once the sediment settles, the bundwall could be removed. Removal should occur preferably at low tide. However it has to be noted that the construction and removal of bundwall itself would cause some disturbance. An alternate option would be to use silt screen to prevent suspended sediments from escaping on to the reef. The cost, small scale of the project and lack of sensitive areas around the dredge site may warrant the use of a cheaper option.

- The projects should be completed in as short period as possible and the work should be carried out during outward drift of current so that sediment settling on the reef would be minimised. It is best to carry out the work during low tide and in calm weather conditions to minimise spread of any sediment plume. In addition, all construction works will be undertaken during SW monsoon when wave activity will be calmer in the proposed site.

- The project manager, and the work force involved during the operation of the work should be briefed of environment friendly practices.

- The work should be properly supervised and monitored to minimise any adverse effect on the environment.

- The marine environment should be monitored for sedimentation and siltation stress and possible impacts on the biological aspects such as bottom benthos. This is further outlined in the monitoring programme given in this EIA report.

- In case heavy equipment and vessels are to be mobilized closer to the reef care should be taken to avoid accidents and damage to the reef.

- The banks of the dredge area shall be at an angle less than 45^{o} in order to reduce shoaling of the channel and also to reduce sediment movement into the channel area.

5.3.1.2 Water Contamination (Marine Water and/or Ground Water)

- During dredging and replenishment works and the construction of quaywall, any accidental spill of oil and toxic substances will contaminate the marine and/or groundwater.

- In the Maldives, groundwater contamination is an irreversible impact due to the absence of impermeable layers to separate the freshwater lens in independent reservoirs. Accordingly, any point sources of pollution would cause the contamination of the entire island groundwater resources. If humans consume such contaminated groundwater, it may lead to serious health risks leading to increased public and private health costs. Therefore, special care should be taken when handling oil, solid waste and hazardous waste to entirely avoid any accidental spills and leakage.

- Construction activities will also require the extraction of groundwater to mix concrete.

Mitigation measures

- All paints, lubricants, and other chemicals used on site should be stored in secure and bunded location.

- Oil, solid waste and hazardous waste should be handled carefully and transported in sealed containers in properly bunded vehicles/vessels

- Construction activities should be carried out under the supervision of a suitably experienced person.

- Vessels, equipment and machinery used for the work should be properly maintained at all times during the operation.

- Littering and accidental disposal of any construction wastes can be avoided by pre-planning modalities for waste disposal or re-use wherever possible. Careful planning of the work activities can also reduce the amount of waste generated.

5.3.1.3 Changes to drainage

- Land reclamation adjacent the existing coastline can cause variations in the topography, leading to unintended changes the drainage patterns. At present the island appears to have a ridge along the shoreline. If reclamation area is lower than the existing coastline there will be surface runoff and low level flooding in reclaimed area. If the reclaimed areas are higher the inner island may get flooded.

- Impacts of rainfall flooding are common in reclaimed areas with new harbours.

Mitigation measures

- If feasible, artificial drainage systems should be put in place between the newly replenished land and the existing shoreline. Alternatively, the reclamation should be done at the same height as the existing coastline and the beach profiling should be done based on exiting profile of the site. The reclamation could consider artificial streams (line reclaimed comparatively lower than surrounding areas) and land could be sloped to allow for runoff into these streams.

- Establish artificial drainage systems around the harbor to avoid low levels of flooding.

5.3.1.4 Noise, Vibrations and Air Pollution

During the mobilisation of equipments and operation of heavy machinery for dredging and reclamation works and construction of quay wall, it is anticipated that significant noise will be generated. Furthermore, noise vibrations may alter terrestrial species behaviour. In addition, dust and emissions from vehicle and machinery exhausts will degrade the air quality. However, these adverse impacts will be short term and the affected population are a few farmers on the island.

Mitigation measures

- All construction works will be carried out during day time to minimise nuisance to the local farmers and disturbances caused to nocturnal fauna such as birds and fruit bats that uses auditory communication.

- All vehicles and machinery will be tuned and well maintained to minimise air pollution

5.3.1.5 Impacts from waste

- Waste is expected from the dredging activities, particularly access dredge material and larger coral material.
- Solid waste, waste water and sewage generated by the workforce may affect the groundwater and general terrestrial environment of the island.
- Construction waste will be generated all the proposed developments.

Mitigation measures

- Dispose all the waste according to the exiting waste management plan of the agricultural operations

5.3.1.6 Changes in Hydrodynamics

During dredging works as well as construction of quay wall and beach replenishment there is a high likelihood abrupt change to coastal hydrodynamics. This may lead to temporary erosion and changes to coral growth.

Mitigation measures

- Dredging activities should be undertaken during low tide and during the calm periods of SW monsoon.
- Compensate for potential erosion in the newly replenished areas by using 10% more sand during profiling.

5.3.2 Potential Positive Impacts from the Proposed Development Project

- The most significant positive impact from the proposed development will be to provide convenient and safe access to and from Madidhoo improving public safety and efficiency of the agricultural production process.

5.4 Cost of Mitigation Measures

Table 5.1 Cost of Mitigation Measures for Impacts during Construction Phase

Impact	Mitigation Measures	Costs
Smothering of Corals	• Silt-screens or bund-walls will be established at selected points around the project site to control sediment disbursing. • All construction works will be undertaken during NE monsoon when wave activity will be calmer.	US$ 2000 NA
Water Contamination (Marine and/or Ground water)	• All machinery will be properly tuned and maintained • All paints, lubricants, and other chemicals used on site will be stored in secure and bunded location. • Oil, solid waste and hazardous waste will be handled carefully and transported in sealed containers in properly bunded vehicles/vessels • Construction activities will be carried out under the supervision of a suitably experienced person.	US$1000 US$500 US$800 US$700
Noise, Vibrations and Air Pollution	• All construction works will be carried out during day time to minimise nuisance to the local community and disturbances caused to nocturnal fauna such as birds and fruit bats that uses auditory communication. • All vehicles and machinery will be tuned and well maintained to minimise air pollution	NA US$1000

6 Alternatives

6.1 Introduction

This Chapter reports on the alternatives for the proposed project. The alternatives were mainly considered for different dredging methods, site location and for alternative technologies for construction quaywall.

6.2 "No-project" Alter native

The "no-project" alternative was not considered in detail since the justification of the proposed project outweighs the "no-project" option. However, it should be noted that in a "no-project" scenario, the environmental impacts such as short-term water contamination and permanent loss of marine habitats will be completely avoided.

6.3 Dredging Alternatives

Table 7.1 indicates the alternative methods for dredging of the harbour basin.

Table 7.1 Summary of Dredging Alternatives

Dredging Method	**Advantages**	**Disadvantages**
Excavator on temporary sand bed	• Most common method practiced by contractors for small scale projects • Does not require specialized skill • Very cost-effective for a small project	• Smothering of corals and increased siltation due to extra dredging for the creation of temporary sand bed
Excavator on barge	• Environmentally friendly due to less siltation and avoidance of unnecessary dredging	• Difficult to operate in limited work space • Shallow depths may not allow for the deployment barges • Extra costs associated with additional equipments such as a tug to haul the barge
Cutter Suction Dredger	• Dredging works can be completed within a short time frame	• Requires highly skilled operators • Not suitable for small scale dredging works • High costs

The preferred option is the excavator on temporary sand bed due to practical and cost considerations.

6.4 Quaywall Alternatives

Table 7.2 indicates the alternative methods for construction of the revetment.

Table 7.2 Summary of Revetment Alternatives

Type of Revetment	**Main Advantages**	**Disadvantages**
Geotextile bags filled with locally sourced sand	• Environmentally friendly • Durable • Cost effective	• Requires specialized equipments and machinery to fill the bags, sew the bags and for installation • Bags are not locally available • High costs
Sheet Pile	• Durable	• Requires specialized design • Costly • Requires specialized equipments, machinery as well as skilled staff
Concrete structures	• Durable	• Requires specialized design • Costly • Requires specialized equipments and machinery
Sand Cement bags	• Cheap – suited for a small project • Requires minimal technology	• Chances of structural failure is high

The preferred and the most environment friendly option are the sand cement bags.

6.5 Alternative for access infrastructure

Table 7.3 indicates the alternative methods for access infrastructure

Table 7.3 Summary of harbor and jetty alternatives

Option	Main Advantages	Disadvantages
Develop a jetty only which extends up to reef edge.	• Avoids negative environmental impacts of harbor development. • Lower cost of development	• Inconveniences during rainy days and NE monsoon • High maintenance cost
Develop a satellite harbor – jetty extended to a basin. Habour protected by breakwater	• Reduces environmental impacts by giving the opportunity to rejuvenate the beach through beach replenishment	• Environmental cost of harbor development. • High cost of development
Construct a harbour adjacent the beach line (current proposal)	• Usable for most part of the year. • Lower cost of development since the ADK group, which provides the funding already have staff and deployed in the region.	• Environmental impacts, particularly future erosion.

The most economically efficient option is to construct a harbour adjacent to the island but the most environmentally efficient option is construct a jetty without the basin. The preferred option is the economically viable option since the scope of the project is small.

6.6 Alternative for harbour location

Table 7.4 indicates the alternative methods for construction of the revetment.

Table 7.4 Summary of Revetment Alternatives

Option	Main Advantages	Disadvantages
Eastern side (current Proposal)	• Calm during SW monsoon • Calm during most part of the NE monsoon • Area required for dredging is relatively small	• Inconveniences during rainy days and NE monsoon • High maintenance cost
Western side	• Calm during NE monsoon	• Very rough during SW monsoon • Reef flat is much stronger and may require blasting

The preferred and the most environment friendly option is on the eastern side.

7 Environmental Management and Monitoring Plan

7.1 Introduction

This Chapter will outline the environmental management and monitoring plan for the proposed project. Environmental monitoring is essential because, although with proper mitigation measures, the overall environmental damage can be significantly minimized, an unforeseen impact may still occur. Furthermore, some of the impacts predicted may turn out to be far greater than predicted, making mitigation measures ineffective. Therefore, in order to avoid or reduce the chances of such events, regular and frequent environmental monitoring is vital.

7.2 Objectives of the Monitoring Plan

The main objectives of the monitoring plan are:

- identify whether the predicted impacts are accurate and mitigation measures taken are effective
- identify any unforeseen impacts so that appropriate mitigation measures can be taken at the earliest

- eliminate or reduce environmental costs

7.3 Aspects of the Monitoring Plan

Table 7.1 below summarizes the key aspects of the monitoring plan. The Table indicates the methodology, frequency and estimated cost for each monitoring attribute that will be required for the proposed project.

Table 7.1 Aspects of the Monitoring Plan

Monitoring Attribute	Indicator	Methodology	Frequency	Estimated Cost
Water Contamination (Marine/Ground)	Water quality	Laboratory analysis	Upon completion of the project, two months after completion and thereafter annually	US$50 per survey
Marine Water Contamination	Oil spills	Visual observation	Daily for the duration of the project	NA
	Oil leakage from machinery or vessels	maintenance and tuning of all machinery & vessels	Weekly during the construction phase	US$50 per week
Coral reef health	Percent of live coral cover Fish abundance	Line transect or photoqudrat surveys; manta tows	Monthly during construction and quarterly thereafter.	US$200 per survey
Erosion and Coastal Changes	Beach profiles	Surveying using level, staff, compass & D-GPS	Two months after completion of the project and thereafter annually.	US$100 per survey
	beach line (at high tide & low tide)	D-GPS tracks along the beach		
	Longshore currents	Drogue method		
Water Depth	Water Depth	Sonarmite or handheld echosounder	Two months after completion of the project and thereafter annually.	US$100 per survey

7.4 Monitoring Report

Based on the data collected, a detailed monitoring report will be compiled annually and submitted to the relevant government authorities for compliance. The report will include methodologies and protocols followed for data collection and analysis, quality control measures and indicate the uncertainties.

7.5 Commitment for Monitoring

The proponent is fully committed to undertake the monitoring program outlined in this Chapter (refer Appendix G of this report).

8 Stakeholder Consultations

8.1 Introduction

Stakeholder consultations are a crucial process in any development project as it reveals invaluable information and empowers the public in decision making processes. Accordingly, key stakeholders for the proposed project were consulted by meetings. Discussions were mainly focused on environmental, social and economic aspects of the proposed project.

8.2 Key Stakeholders

The following is the list of key stakeholders identified and consulted:

- Ministry of Fisheries and Agriculture – Dr. Hussain Rasheed, Minister of State for Fisheries and Agriculture
- Ministry of Housing, Transport and Environment – Mr. Hussain Naeem

8.3 Consultation Outcomes

The outcomes of the consultations are reported in the following sections below:

8.3.1.1 Ministry of Fisheries and Agriculture

- The Ministry generally support all initiatives to improve the agricultural sector and its productivity.
- The Ministry will provide all assistance in the facilitation of improving the infrastructure of existing islands, including the development of harbours.
- The Ministry will however only allow such activities after proper Environmental Impact Assessments and only if the findings show that there are no serious adverse environmental impacts.
- The Minister would like the proponent to apply for permission to develop a harbour both for regulatory and information management purposes.

8.3.1.2 Ministry of Transport, Housing and Envrionment

- It was noted that past reef entrance development projects in the region, particularly, Gaakoshibee Island required reef blasting due to the strong reef substrate. Hence, reef blasting may be required in Madidhoo as well.
- The Ministry welcomes the improvement of transport infrastructure but stressed the importance of environment friendly options during design and construction. Numerous islands have reported severe erosion following harbour development project.
- The regulations relating beach replenishment was also highlighted and recommended to keep the reclamation widths to a minimum.

9 Potential Gaps in Existing Data and Limitations in the Assessment

9.1 Gaps in Information

The environment of Maldives is generally poorly understood. This may be due to the lack of detailed studies in the Maldives. Much of the literatures on coral islands are derived from studies done in the pacific which unfortunately has very different and climatic and geologic settings.

Detailed environmental analysis for an EIA is often required to be undertaken in a relatively short period of time. Give the seasonal climatic variations in Maldives and the differences in local geomorphologic and climate settings in individual islands such a short time frame is often too little to assess selected aspects of the environment. This problem is compounded by the absence of long-term studies in other parts of Maldives. Hence, most EIA's end up being based on an environmental snapshot of specific point in time. However, experienced EIA specialists can deliver a close match to reality based on a number of similar assessments.

In this regard, the following gaps could be identified in information.

1. Absence of long-term site specific or even regional data (at least 2 years). Most critical data include current, wave and sediment movement history.

2. Absence of historical and long-term records on reef and lagoon environment.

3. Lack of detailed data on geology and soil due to time limitation in EIA submission.

These gaps are seriously considered in the assessment and care has been taken to address the issue in designing mitigation measures and the monitoring programme.

1.1. Uncertainties in impact prediction

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. As note earlier, there is also no long term data and information regarding the particular site under consideration, which makes it difficult to predict impacts. However, the level of uncertainty is partially minimised due to the experience of dredging and land reclamation activities in similar settings in the Maldives. Nevertheless, it is important to consider that there will be uncertainties and voluntary monitoring of natural processes as described in the monitoring programme is absolutely essential.

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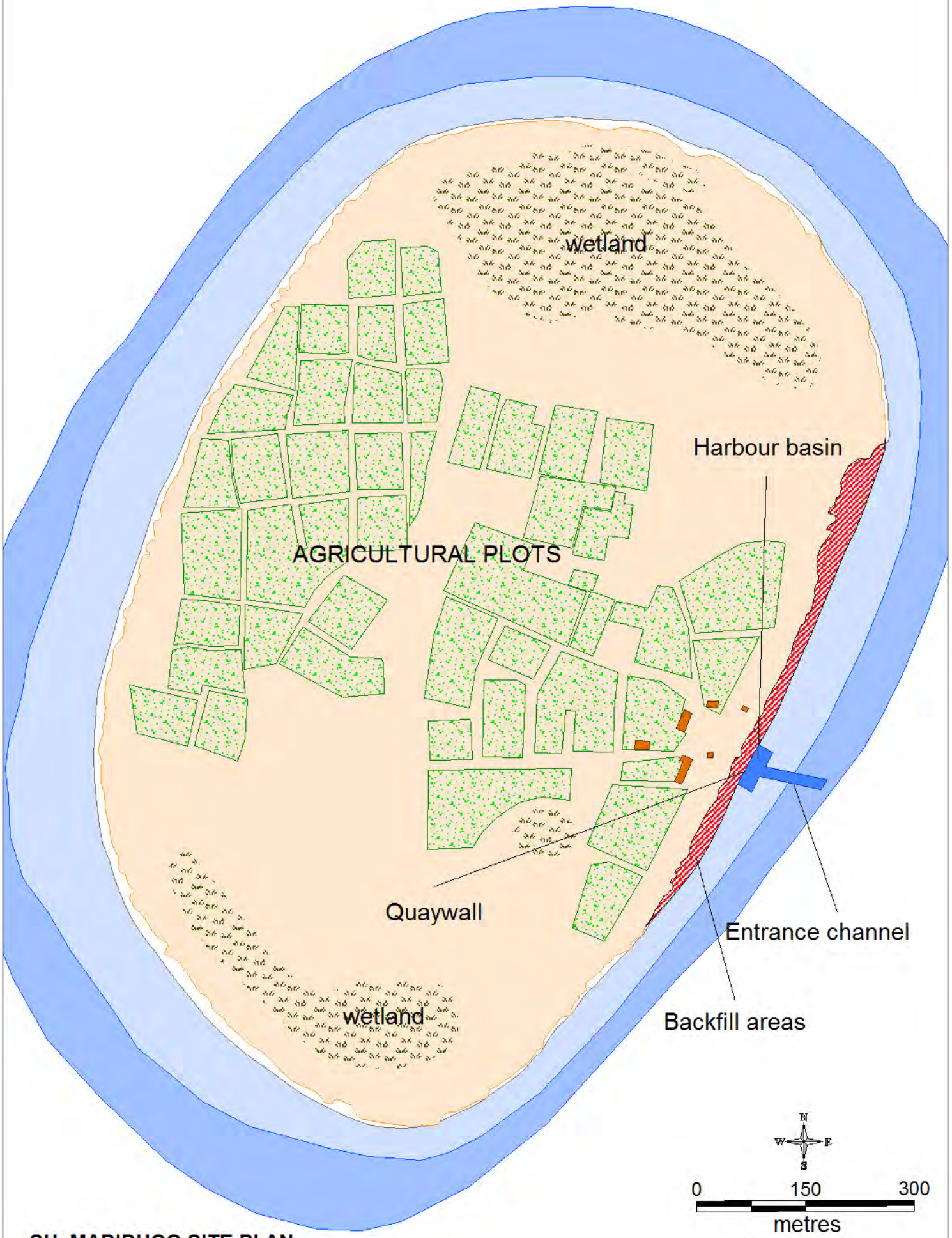
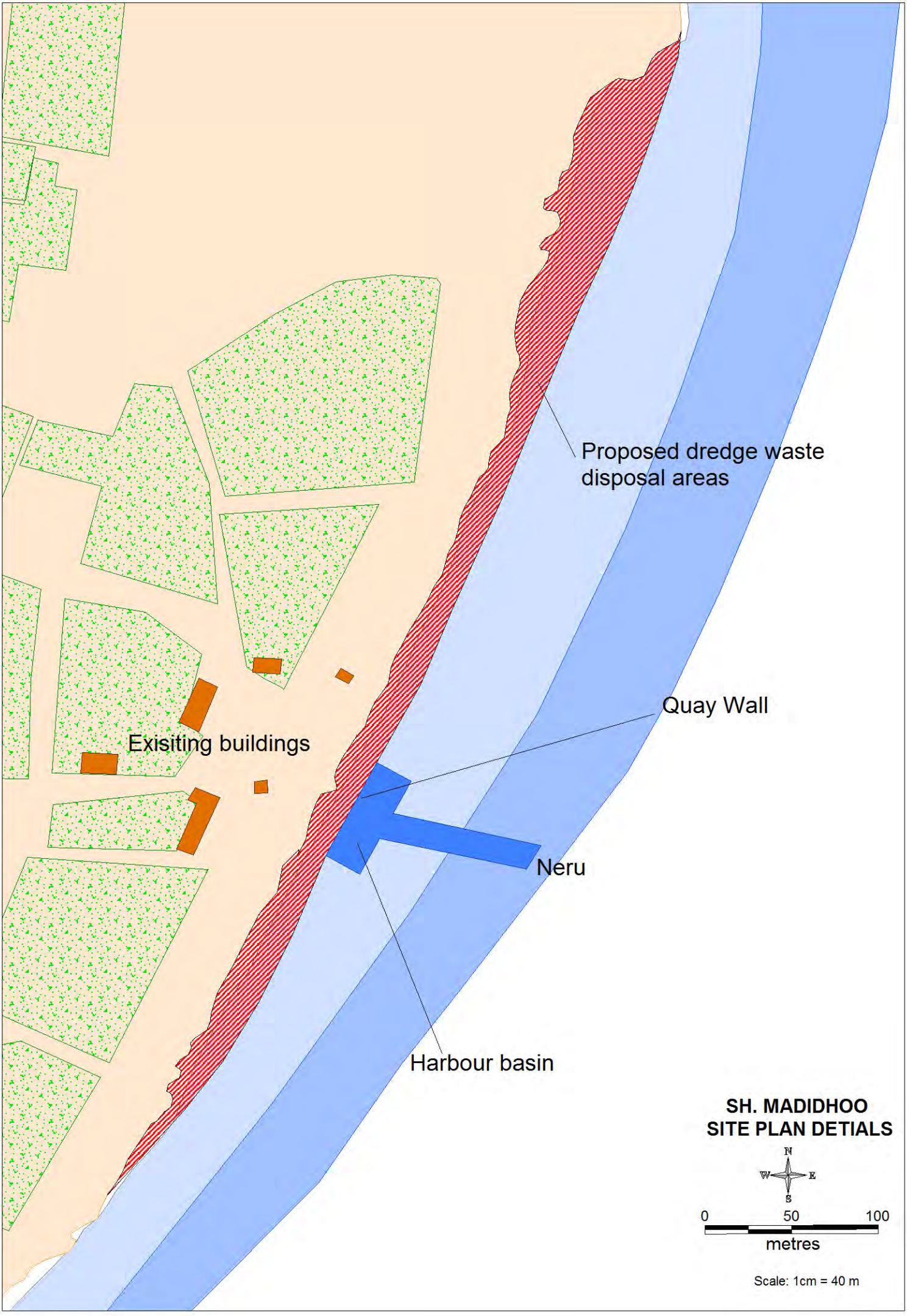
Appendix 1: Site Plans



SH. MADIDHOO SITE PLAN


Proposed dredge waste disposal areas
Quay Wall
Exisiting buildings
Neru
Harbour basin
SH. MADIDHOO
SITE PLAN DETIALS
N
W
E
S
0
50
100
metres
Scale: 1cm = 40 m

Appendix 2: Terms of Reference

بسم الله الرحمن الرحيم

ދިވެހިރާއްޖޭގެ ގައުމީ ފިޝަރީސް ހަސްބޭންޑް ސެންޓަރ

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ތ. ދެއްތަކަށް ކުއްލިއަކަށް ކުރަނޭގެ ކަމަށް ދިވެހިރާއްޖޭގެ (ފ.ހ.ގ) ވަނަ ދަށ ކަމުގައި ހުންނަ ތިބާ ދިވެހިރާއްޖޭގެ ވިލާތުތަކުގައި ދަތުރުކުރުމުގެ ކަންކަމުގައި ދ. ގ.ހ. (ފ.ހ.ގ) ދިވެހިރާއްޖޭ، ގައުމީ ފިޝަރީސް ސެންޓަރ ގެ ވަކި ކުރެވެއެވެ.

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Environmental Protection Agency
Ministry of Housing, Transport and Environment
Male', Republic of Maldives

Terms of Reference for Environmental Impact Assessment

The following is the TOR based on the points discussed in the scoping meeting held on 11th March 2010 for undertaking the EIA of the proposed **channel dredging at Sh.Madidhoo, Maldives**

This document is a legally binding document prepared after consultation with relevant stakeholders and the EIA report must strictly follow the activities under this ToR.

1. *Introduction - Identify the development project to be assessed.*

2. *Study Area - Specify the boundaries of the study area for the assessment as well as any adjacent or remote areas that should be considered with respect to the project (e.g. dredged material disposal site/s).*

3. *Scope of Work - The following tasks will be performed:*

Task 1. Description of the Proposed Project - Provide a brief description of the proponent, how the project will be undertaken, full description of the relevant parts of the project, using clearly labeled maps, scaled site plan (indicating the changes and modifications that will be brought)

Provide details of dredging, volume of sediments to be excavated in area to be dredged; type of dredging equipment to be used and the manner of deployment including handling, transportation, and disposal of dredged material, volume of sediments to be excavated, how wastes and emissions will be managed, project inputs and outputs, project cost, project schedule; and life span.

Task 2. Description of the Environment - Where baseline data is to be collected, careful consideration must be given to the design of the survey and sampling programme. Data collection must focus on key issues needing to be examined for the EIA. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable for use as a baseline to monitoring impacts.

Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (and disposal sites), focused on the marine environment, including the following:

a) Physical environment:

- *General climatic pattern (rainfall, wind) based on available secondary data.*
- *Coastal environment (including waves, tides, coastal geomorphology, beach profile, sand coastal vegetation)*
- *Lagoon and reef flat (including lagoon bottom conditions, bathymetry of the area to be dreged and marie water quality)*
- *The seawater quality parameters shall be; biological oxygen demand (BOD_5), Dissolved Oxygen (DO), salinity, Total Dissolved Solids (TDS), Temperarture, Turbidity, pH, Nitrate, Nitrite, Phosphate and fecal colliform.*

b) *Biological environment:*

- *Detailed marine environmental conditions of the impacted area : Marine environment shall include a quantitative assessment of the coral reef environment (the benthic coral fauna and fish fauna) at the location to be dredged.*

c) *Socio-cultural environment:*

- *Boating activities and use of the entrance, population, need for the proposed project and community perception of the development.*

d) *Hazard vulnerability; vulnerability of area to storm surge.*

The extent and quality of the available data shall be characterized indicating significant information deficiencies and any uncertainties associated with the prediction of impacts. All available data from previous studies, if available shall be presented.

All survey locations shall be referenced with Geographic Positioning System (GPS). All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

Provide description of the work methodology for collection and compilation of report, approach to specific assumptions and predictions made identification of information and data gaps and discussions of major limitations.Characterize the extent and quality of the available data, indicating significant information deficiencies and any uncertainties associated with the prediction of impacts. All available data from previous studies, if available should be presented. Geographical coordinates of all sampling locations should be provided. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. The report should outline the detailed methodology of data collection utilized to describe the existing environment. Baseline conditions should be presented for the marine environment.

An average of at least 5 measurements must be given for each parameter tested and analyzed from a certified laboratory. Provide details of calibration for any onsite data analysis.

Task 3. Legislative and Regulatory Considerations - Describe the pertinent national and international legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project.

Task 4. Determine the Potential Impacts of the Proposed Project – Identify impacts related to dredging and spoil disposal that must be included with potential areas that may be affected by siltation and changes to local hydrodynamic regime. Distinguish between significant impacts that are positive and negative, direct and indirect, and short and long term both during construction phase and operational phase. Identify impacts that are cumulative, unavoidable or irreversible.

It should also describe the methods used identify the significance of the impacts outlined. In particular, the impacts should be described for both during the construction stage and also during the operational stage. The report should outline the uncertainties in impact prediction and also outline all the positive and negative: short and long-term impacts. Identify impacts that are cumulative and unavoidable.

Task 5. Analysis of Alternatives to the Proposed Project. –Describe the alternatives examined for the proposed project that would achieve the same objective including the "no action alternative. This includes alternative dredging methodologies; alternative technologies, material, locations (channel.) and mitigation options. Distinguish the most environmentally friendly alternatives including justification on the selected location.

Task 6. Mitigation and Management of Negative Impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to dredge spoil disposal and dispersal/sedimentation containment and turbidity control. Mitigation measures should be identified for both construction and operational phase. Cost of the mitigation measures, equipment and resources required to implement those measures. A commitment regarding the mitigation measures should be submitted by the responsible person.

Task 7. Environmental Management Plan and Monitoring - A time frame should be outlined for monitoring focused on the construction and operational phase. Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for dredging/disposal operations. Detail of the monitoring programme including the physical and biological parameters for monitoring, frequency, duration and cost commitment from responsible person, detailed reporting time table and ways and means of undertaking the monitoring programme must be provided.

Task 8. Stakeholder Consultation – Major stakeholder consultation to include Ministry of Housing, Transport and Environment ,Ministry of Fisheries and Agriculture, Environmental protection agency (ICZM section) and any other relevant stakeholders. EIA report should include a list of people/groups consulted and the methodology of consultation. The discussions held at the scoping meeting will be also used as a part of consultation.

Presentation - The Environmental Impact Assessment Report, to be presented in print and digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2007.

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 3 months from the date of this Term of Reference.

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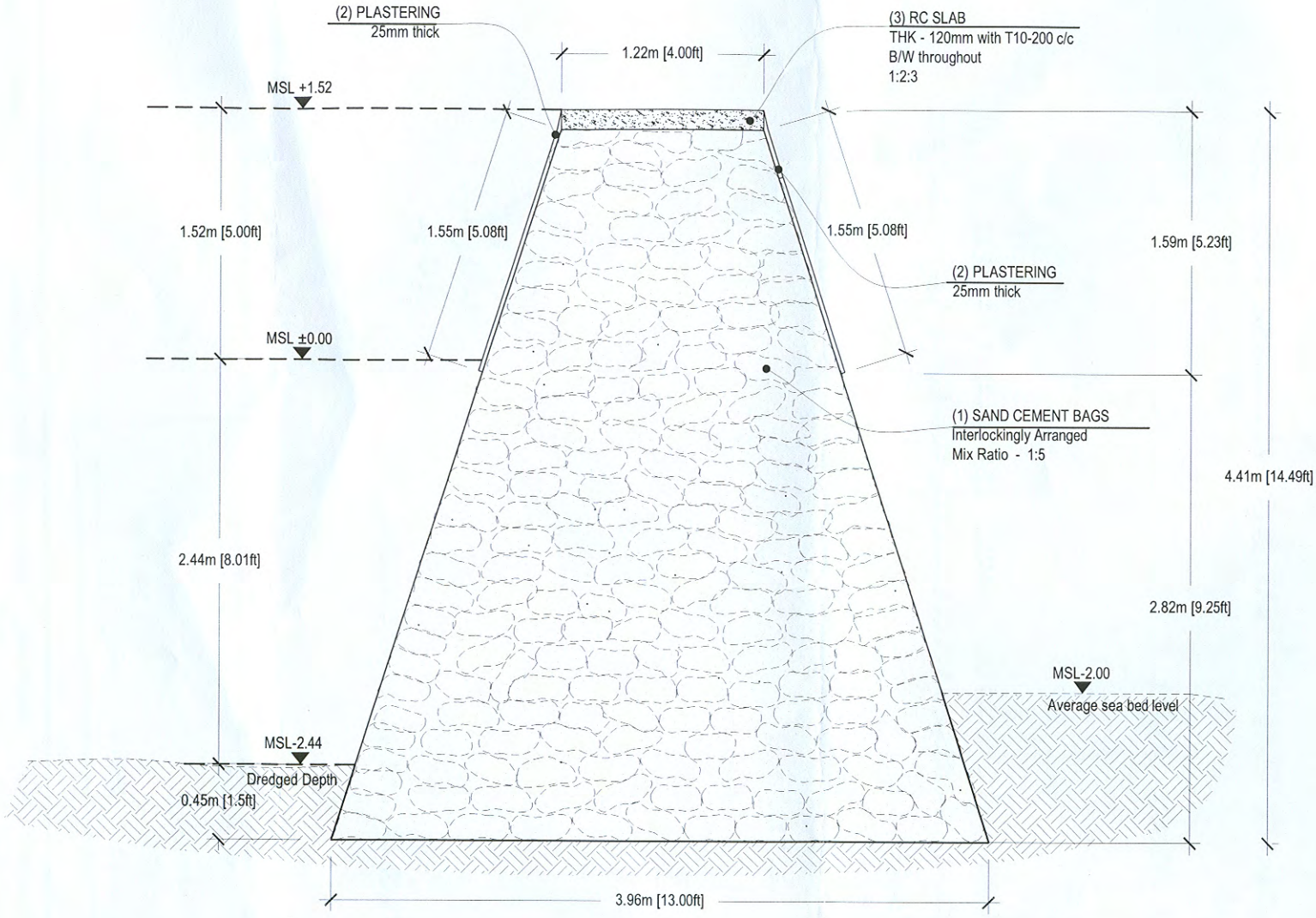
(28 march 2010)

Appendix 3: Quay wall Details

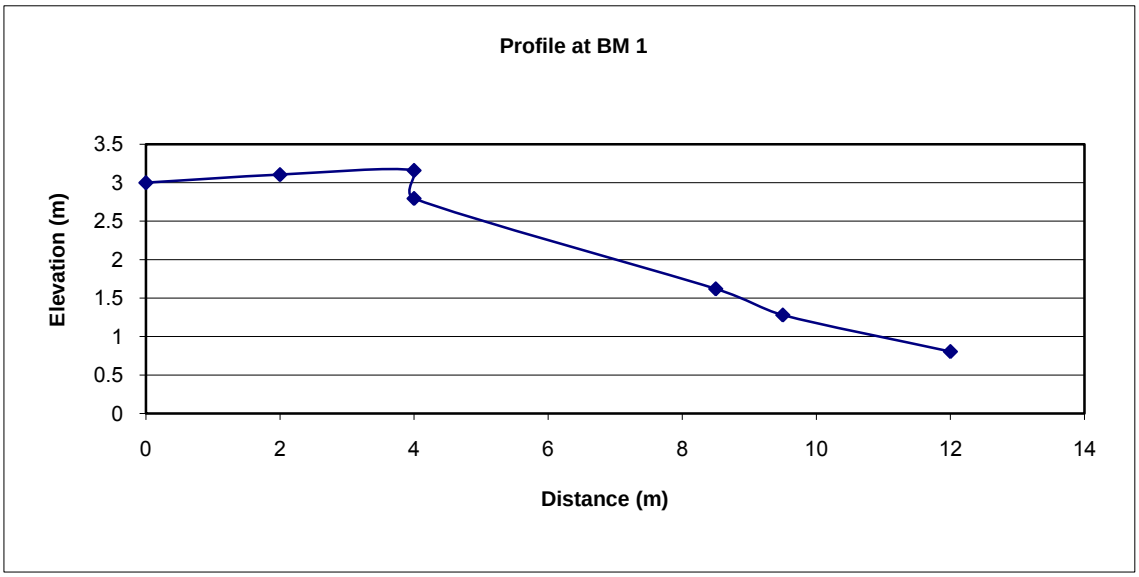


ITEM	DETAILS
1- SAND CEMENT BAGS	Interlockingly Arranged Mix Ratio 1:5
2- PLASTERING - BOTH SIDES	1.55m (5ft 6 in) 25mm thick
3- RC SLAB	THK - 120mm T10-200c/c (1:2:3)
4- CONSTRUCTION JOINT	@ 15.24m c/c with filler & sealer (15mm wide)

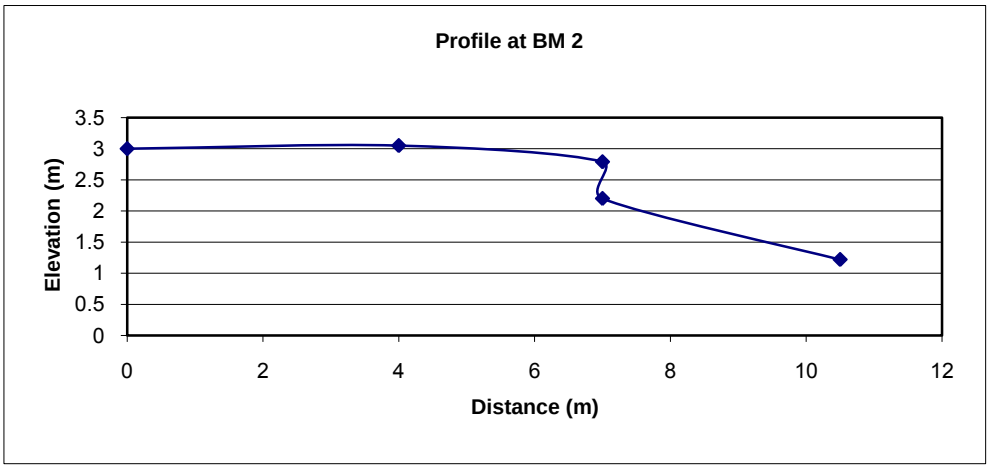
1 TYPICAL SECTION OF A QUAYWALL

ALL DIMENSIONS ARE IN METERS UNLESS SPECIFIED

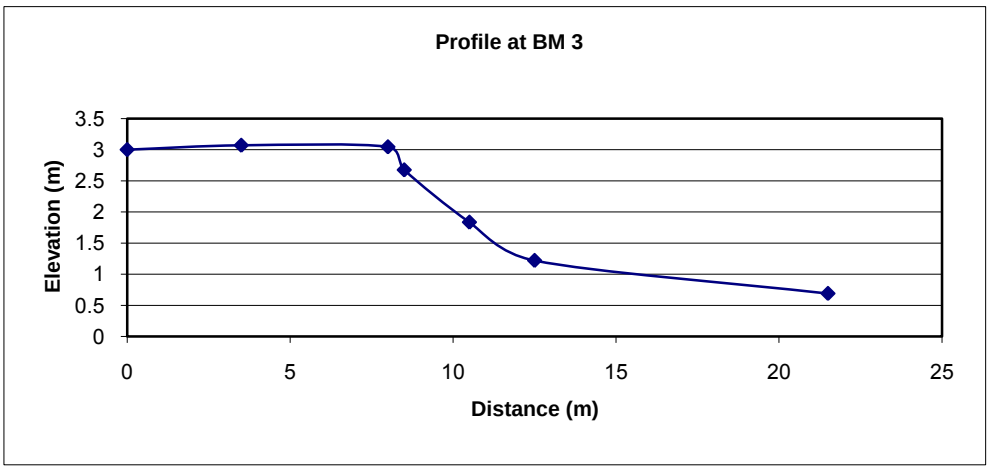
Appendix 4: Beach Profiles



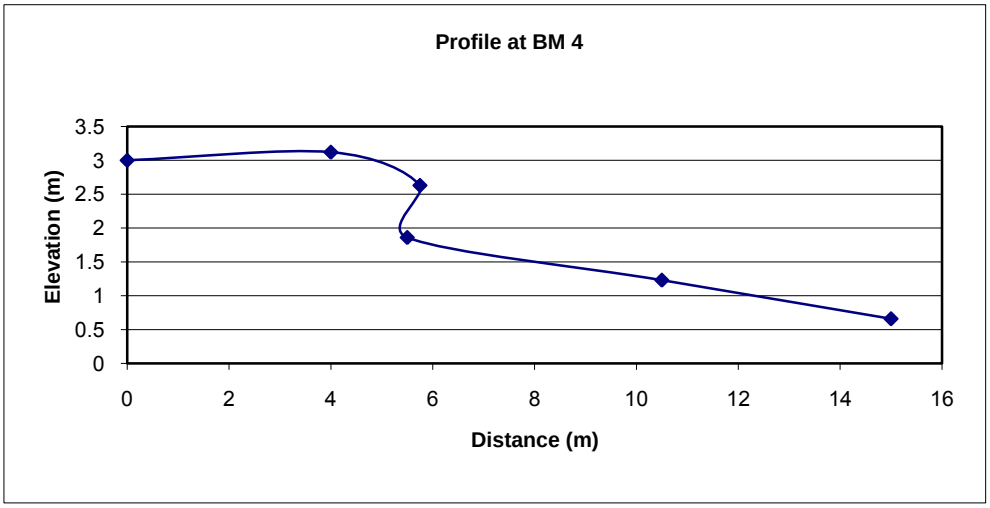
Beach Profile at BM1 (see Image 4.1)



Beach Profile at BM2



Beach Profile at BM3



Beach Profile at BM4

Appendix 5: CV's of Consultants

Appendix 6 – Commitment Letter for Environmental Monitoring