Environmental Impact Assessment for the Construction of a Harbour Quaywall at Maduvvari, Meemu Atoll

Date:

Proposed by: Ministry of Housing and Infrastructure

Prepared by: MEECO

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Acknowledgment

The author would like to acknowledge the kind support and assistance given by the proponent, the technical team and the residents of M. Madduvari in conducting the surveys and obtaining the relevant information to complete this report.

Consultants Declaration

As the lead consultant of this EIA,

This EIA has been prepared according to the EIA Regulations 2012. I hereby, declare that the content in this EIA is complete, true, and correct to the best information that I had while compiling this EIA.

Name:

Signature:

Executive Summary

This document is prepared to meet the necessary requirements to get clearance from the Environmental Protection Agency in order to carry out the proposed harbor quaywall reconstruction project at Meemu atoll Maduvvari. It has been prepared in compliance with the EIA regulation of 2007, under the Environmental Protection and Preservation Act (Act No. 4/93).

The islands existing harbor had been badly damaged by the 2004 Tsunami, rendering it unsafe and unsuitable. A breakwater had not been initially developed, and the rough monsoon waves made the existing quaywall unguarded against the elements of nature. The proposed development will reconstruct a new quaywall and will greatly improve the socio economic conditions of the island by providing a safer harbor with easier access.

This Executive Summary highlights the key findings of the Environmental Impact Assessment (EIA) for this project, which is proposed by the Ministry of Housing and Infrastructure and executed by the Maldives Transport and Contracting Company (MTCC). The proposed development comprises of the following key elements:

- Removal of the existing quaywall and reconstruction of a new quay wall of the same length, using T-block elements.
- Construction of a pavement alongside the length of the new quaywall.
- Carrying out maintenance dredging of the basin to a depth of 3m below sea level.
- Reclaiming land at the northern side of the island using the demolished quaywall
- Using the dredged material (approximated at 550 m^3) to level the road on the northern side of the island.

Justification and Socioeconomic Considerations

This project, instead of the alternatives, is best suited and the most feasible design solution, offering benefits in terms of the proposed location, environment, project activities, and future land developments of the island.

The proponent considers that the views of major stakeholders and the community are important in the planning and design of the project. Public consultation has been conducted throughout the planning stages. The Maduvvari community supports the development of the project and their views have been considered in the planning and design process.

Environmental Impacts and Mitigation Measures

The potential impacts will be minor and localized, with the impacts identified as being caused by the following main project activities.

- Impacts due to maintenance dredging
- Impacts due to reclamation of land on the northern side of the island
- Impacts due to leveling of roads on the northern side of the island

The impacts are however, found to be temporary and weighs less than the benefits of the socio-economic impacts caused by the development. The major negative impacts are listed as follows:

- Noise pollution potential source of noise pollution will arise during the construction phase of the project, with the usage of heavy machinery and equipment
- Unavoidable sedimentation caused by dredging works, which will increase the turbidity of the surrounding waters and adversely impact the marine organisms. Sedimentation of silt on the reef flat will be caused by excavation.
- Changes in the hydrodynamics of the island which could potentially affect the issue of coastal erosion of the island.

Nevertheless, there are greater socioeconomic benefits. These include facilitating easier access to the harbor for the vessels, and minimizing of floods during high tide.

Mitigation measures have been proposed for all the potential adverse impacts arising from the project activities. They include, among others:

- Carrying out the excavation during high tides to allow maximum flushing of the sediments.
- Reclaiming during low tides to minimize erosion of the dredged material.
- Reducing problems arising during construction by making the necessary announcements and posting the related sign boards.
- Limiting the construction hours to day time and avoiding simultaneous operation of the equipment.

And environmental monitoring and management plan will be implemented during the project activities, to assess the effectiveness of the mitigation measures and compliance with the criteria.

Alternate locations and technology

The proposed location where the dredged material would be used is the best location as it is the most needed location to be reclaimed for future plans of the island. Alternative technology are not recommended either due to expensive process or the available technology not suitable to the environmental conditions.

Conclusion

This EIA report has identified and evaluated the potential environmental impacts of the project, in accordance with the rules and regulations. Overall, the report concludes that the project would be environmentally acceptable and in compliance with the environmental legislation and standards. The implementation of the mitigation measures during construction and operation stages will minimize potential negative impacts. This will be examined by a suitable monitoring and management plan.

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މި މަޝްރޫޢުގެ ސަރަހައްދުން ތިރީގެ ހިމާޔަތް ސަރަހައްދުގެ ފަރާތަކީ ކުރިއަށް ގެންދެވޭ ބަލަހައްޓާނެ ގޮތް އަޅުވާ އެކަށީގެންވާނެއެވެ. ނަމަވެސް މިމަޝްރޫޢުގެ ސަރަހައްދަކީ ތިމާވެށީގެ ހިމާޔަތް ލިބިދީފައިވާ އަދި އިތުރު ފިހާރަ ބަލައި މަސައްކަތްކަމަށް ފެންނާތީ މިއީ ކުރައްވަން ގެންދެވެން ރަނގަޅު މަޝްރޫޢެއްކަމެވެ.

1. Introduction

1.1 Purpose of this EIA Report

This Environmental Impact Assessment (EIA) report has been made to assess the environmental impact on the proposed construction of a harbor quaywall at M. Maduvvari. This report was written to comply with the EIA Regulation (2007) and in accordance with the Clause 5 of the Environmental Protection and Preservation Act (Act No. 4/93) and the EIA regulation (2007) of the Maldives.

1.2 Aims and Objectives of EIA

There is a continuous need for coastal facilities in the Maldives islands, and this has grown dramatically due to increasing urban and commercial needs. As such, the existing harbour in Maduvvari is used to moor fishing vessels, cargo vessels and etc. Construction of a harbour quay wall will prevent congestion, help provide adequate facilities for the people using the harbour. It will also help avert potential safety hazards, since the Maduvvari harbour had been severely damaged during the 2004 Tsunami.

Harbors require not only significant portions of coastal land and waters for its construction or extension, but also for the accompanying operation installations and transport systems. Such development projects have a considerable impact on the surrounding environment; however the projects are unavoidable due to the national economic significance of their intended purpose. Construction of a harbor quay wall will boost and strengthen the economic activities of Maduvvari and improve the transport sector of the island.

This project will incorporate opportunities to minimize environmental impacts in its planning and design stages. Since early planning can make compliance with legal and technical requirements achievable without excessive costs and impacts.

1.3 Terms of Reference

The terms of reference for this EIA have been attached as an annex in Appendix A. This EIA has been prepared based on these terms of references.

2. Applicable Policies, laws and regulations

2.1 Overview

This project will be carried out in the context of the Maldivian laws and regulations. This section outlines the environmental regulations which are related to this project. All the activities during both development and implementation stage of the proposed harbour development project will be carried out in accordance to the legislations, policies and laws outlined below.

2.2 Applicable Policies Laws and Regulations

2.2.1 National biodiversity strategy and action plan

The goal of the National Biodiversity Strategy and Action Plan (NBSAP) are:

- Conservation of biological diversity and sustainable utilization of biological resources
- Build capacity for biodiversity conservation through strong governance framework and improved knowledge and understanding
- Foster community participation and support for biodiversity conservation

Consideration of the goals of NBSAP shall be taken into account in implementation of the project activities for minimizing potential loss of biodiversity in the area. The proponent has committed on conservation and protection of environment while undertaking this project. Qualitative and quantitative surveys were undertaken to assess baseline coral reef and marine environment biological diversity. Practical mitigation to minimize the impact and monitoring strategies have been identified to protect the biodiversity.

2.2.2 Protected Areas and Environmentally Sensitive Areas

Under article 4 of the Environment Protection and Preservation Act of Maldives, the Ministry of Environment is vested with the responsibility of identifying and designation of protected areas and natural and drawing up rules and regulations for the management of protected areas and natural reserves in the country.

The proposed project does not propose development in a protected area and there are no protected sites in the vicinity of the site. The site surveys also showed that there no environmentally sensitive areas close to the proposed harbour development site.

2.2.3 Environment Law

It is important to note that the Article 22 of the Constitution of Maldives provides guidance on the protection of the environment and sustainable development. According to this Article no development project will go ahead if its impacts are detrimental to the environment.

The environment law, Law No.4/93 Environment Protection and Preservation Act of Maldives was enacted in April 1993 as an umbrella law to protect and preserve the environment of the country. The articles and clauses of the law are given below.

2.2.4 Environmental Protection and Preservation Act of Maldives (EPPA)

Article 5 (a) addresses the submission of an EIA. It states that any developing project that may have a potential impact on the environment requires an EIA submission.

2.2.5 Regulation on sand and aggregate mining

This regulation addresses sand mining from islands and bird nesting sand bars. Sand and aggregate mining from beaches of any island whether inhabited or uninhabited is banned for protection of the islands. Permissions for sand and aggregate mining from other areas shall be obtained from the relevant authorities.

2.2.6 Regulation on coral mining

Coral mining from the house reef of islands and the atoll rim reefs is banned through a directive from the President's Office dated 26th September 1990. According to this policy coral mining shall not be carried out from house reefs of islands and atoll rim reefs and common bait fishing reefs. Coral and sand mining is only allowed for house construction from designated sites and approval from the concerned authorities is required prior to mining activities. Request for coral and sand mining from residents of inhabited islands are required to be submitted to the Atoll Offices through the respective island offices. The island office is required to estimate the quantities of coral or sand required for the applied construction work of houses to ensure that the permission is grated for minimum amounts required. Every island is required to maintain a log book of permissions granted and the amounts mined and the site where mining was carried out.

2.2.7 Regulation on land reclamation and dredging (R15/2013)

This regulation was gazetted in 2013 and consist of the regulations that has to be considered before attempting to do any land reclamation or dredging for harbour development or any other purposes. According to this regulation, a pre-approval for the reclamation or dredging has to be obtained for any project before applying for scoping or initiation of the EIA process. Approval for this project has been given and approved to start the EIA process.

2.2.8 Waste management policy

MEE has developed a framework for a national waste management policy. The main components of this policy includes safe disposal of solid waste, ensuring safe disposal of chemical industrial and hazardous waste. Waste management of this project will be in line with this policy.

2.3 International conventions, treaties and protocols

International conventions, treaties and protocols of most relevance to the proposed project may be identified as follows:

- **United Nations Convention on Biological Diversity (UNCBD).** The objective of 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".
- **The Marpol Convention.** International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. Pollution and that from routine operations - and 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 Ships; Prevention of Pollution by Garbage from Ships; and Prevention of Air Pollution from Ships.

3. Project Description

3.1 Project proponent

The project is proposed by the Ministry of Housing and Infrastructure (MHI) representing the government of Maldives. MHI is responsible for the development and regulation of the construction sector. All harbour development is handled by MHI.
The execution of the project will be handled by Maldives Transport and Contracting Company (MTCC).

3.2 Study Area

The project is at the island of Madduvari in Meemu atoll. The island is located at the northern edge of the atoll located with the geographic coordinates of 3°6.292'N and 73°34.438'E (see Figure 1). The island is situated in a patch reef system. The closest island to Madduvari is Dhiggaru which is about 1 km to the west of Madduvari.

Figure 1: Location of Madduvari (source: Google Earth).

The existing harbour was among the harbours developed during the tsunami harbour development project carried out after the tsunami of 2004. The existing harbour is located on the southern side of the island. This harbour does not have a breakwater. The island have coastal protection around the island.

The island has a population size of approximately 719 and with the recent reclamation of the island, the total land area is approximately 12 hectares. The main economic activity of the island is fisheries which provides a good economic income to the community.

3.3 Justification for project.

The existing harbour quay wall was developed during the tsunami harbour construction projects of the government. Initially when it was built, there was no breakwater developed. During the SW monsoon season, the harbour basin gets quite rough and significant amount of wave energy is felt on the quay wall as there is no breakwater. Therefore with continuous wave action, the quay wall has been badly damaged. Seepage of sediment underneath the quay wall has led to damage the quay wall in several places. This has made created difficulty in mooring of vessels and access and use of the facility. Therefore, there is a need to reconstruct the quay wall to improve the conditions.

3.4 Existing harbour

In 2004 the harbour was damaged during the tsunami and it was reconstructed in 2005. There was no breakwater developed then.. It was only a landside quay wall which was developed. During the SW monsoon, a significant amount of wave action is felt on this quay wall and sometimes it becomes difficult to moor vessels. Recently during the SW monsoon 2 vessels have drowned Therefore now the bigger vessels are moored offshore. The existing quay wall is of length 255m constructed of concrete cement.

To the south of the harbour an extensive reef flat exists. As there is no breakwater and with strong wave action and current, sediments is moved in to the harbour basin. Therefore with time, the basin has shallowed in several places. Near the shore it is unable to moor due to shallow depth and due to damage of the mooring anchors within the quay wall. As sediment have seeped underneath the quay wall, the wall have been extensively damaged in several places as shown in (Figure 2).

Figure 2: Existing harbour of Madduvari.

3.5 The Project

The project involves redevelopment of the exiting harbour in order to facilitate and improve the facilities provided by the harbour. The exiting quay wall will be removed and a new quay wall using T-blocks would be constructed. In addition to this, a pavement next to the quay wall would also be constructed. The pavement would be along the length of the quay wall. The basin would be dredged to a depth of 3m below the mean sea level. The total length of the new quay wall would also be same as the existing length.

It is proposed that the demolished material of the old quay wall be used to reclaim the land at the northern side of the island. The dredged sand would be used to level the road on the northern side of the island. The roads on the northern side of the island were constructed after land reclamation and these roads get flooded during the high tide. Therefore these roads would be levelled from the dredged material. It is estimated that approximately 550m^3 of sand would be dredged. Figure 3 shows the concept for the proposed new quay wall.

Figure 3: Concept of the proposed changes to the harbor.

3.6 Project boundary and impact zone

As this is a reconstruction project, the impact zone will not be very large. The Figure 4 shows the project boundary and the zone of impact. It also shows where the dredged material from the harbour will be placed. The grudged materials will be used to level the roads on the northern side of the island as these roads gets flooded during high tides. The road levels seems to be lower than the high tide line when they were reclaimed initially.

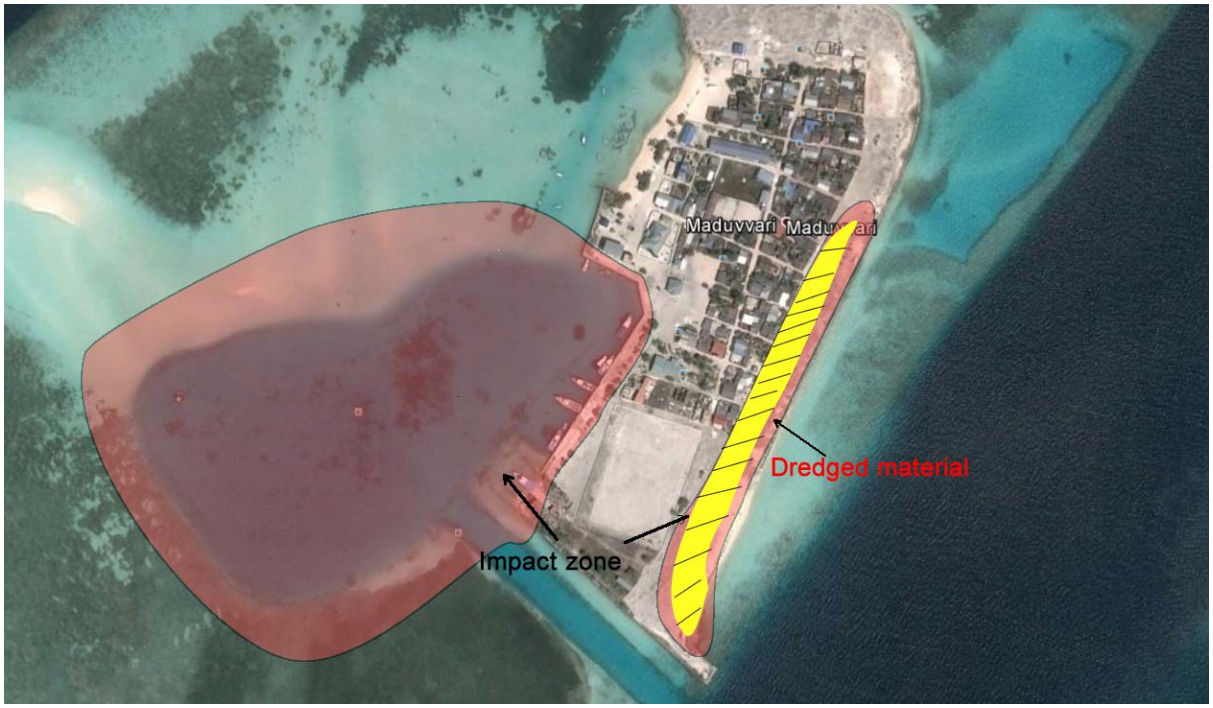

Figure 4: Project boundary with impact zone and dredged material deposition area.

Some of the dredged material will be deposited on the northeast corner of the island. This location was the place used by the island as a dump yard to deposit and burn the waste. As this place get rough during the NE monsoon, the temporary waste yard did not last long. Therefore the Council decided to put the construction waste in this zone to minimize the coastal erosions in this zone. Figure 5 shows the condition of the location where the construction materials would be deposited and the road conditions where the sand would be deposited. The road are always damp and muddy as the waster does not completely drain away during the low tides.

Figure 5: Condition of the places where the construct material will be deposited (above) and the road conditions (below).

3.7 Project duration and schedule

The project is expected to be carried out in 14 months. The details of the schedule is attached in the annex.

3.8 Process and Materials

Standard equipment and materials used in similar projects will be used for this project. The entrance channel will be dredged using an excavator. Large excavators and barges are recommended to minimize the project duration which will in turn reduce the duration of impact on the environment. T-section blocks made from reinforced concrete will be used to make the quay wall.

3.9 Project Management

The project will be managed by the Ministry of Housing and Infrastructure and the construction works will be carried by MTCC. Site engineers and managers from MTCC would

be placed at the construction site where regular reporting to MHI are provided by the MTCC.

3.9.1 Operation and Maintenance

Once the harbour is completed it will be operated and maintained by the island council. Inspections are undertaken by MHI at regular intervals to assess the condition of the harbour on request of the council. The harbours that require maintenance are then taken into account.

3.10 Project Inputs and Outputs

This project has human resource, natural resource and machinery input. Main output of the project is the economic development and other indirect social benefits to the local community. The following tables summarize the input and outputs

Table 1: Project inputs

Input	Method of obtaining resource
Construction workers	Hired by contractor
Construction Materials	Imported or purchased locally where available
Maintenance material	Imported or purchased locally where available
Water supply for construction	Ground or rainwater
Electricity/Energy for construction	Provided by council
Machinery such as excavators, crane, lorries and dump trucks	Provided by contractor
Food and accommodation	Provided by the island hired by the contractor
Health and safety	Fire extinguishers, safety equipment and first aid provided by the contractor

Table 2: Project outputs

Products and waste materials	Method of disposal
Oil and lubricants	Reused or stock to transfer to Thilafushi
Dredge material	Disposed to the locations specified
Construction waste (cement and concrete debris)	Used to fill the land area behind the new constructed landside quay wall

3.11 Risks associated with the project

There are financial and environmental risk factors associated with the project. The most significant risk is not finishing the project in the scheduled duration causing delay in demobilizing from the island and inconvenience caused to the population due to this. This could be caused by changes in weather conditions, delays in obtaining the material for construction and financial restrictions. The risk factors could be minimized by proper planning of the activities taking into account the changes in the weather and management of the financial situations.

3.12 Review of similar projects

Several similar projects have been carried out in various island of Maldives. Where harbours are constructed and repaired after damage by natural disasters or due to long use. Some of the studies and EIAs reviewed are found in the appendix of this report.

3.13 Project risks and impacts

Potential risks associated with the project are damage to the marine environment due to sedimentation by excavation and clearance works. Chronic impacts such as this could be cumulative and long term.

The associated modification will have very little or no impact as the proposed area is already a dredged area.

The area is enclosed mostly of rubbles or dead coral. Risk associated with sedimentation and smothering of live coral that are near the construction areas is very mild.

Positive socioeconomic impacts are envisaged by the proposed project. The construction of the new quay walls and extension of the harbour will bring enormous amount of social benefits improving the livelihood and economic situation of the island.

4. Survey Methods

The following where done in order to complete this impact study. The key components that were considered are, physical, social and economic environment. Following methods were used in the analysis.

- Assessment of existing environment to identify significant environmental components that would be impacted
- Public consultations to exchange information on the project and consider their concerns
- Literature review of similar projects

4.1 General Methodology of Data collection

The methodologies used for scientific analysis of the environment are standard and internationally accepted methods of environmental assessment. Coastal and marine environment was studied using the methods and parameters that is widely practiced.

4.2 Mapping and location Identification

The reef line, shore line and vegetation line and existing harbour was mapped. Mapping was undertaken using standard DGPS and mapped on AutoCAD.

4.3 Bathymetric Survey

A Bathymetric survey was undertaken using a GPS and a transducer. Bathymetry of the harbour basin and the surrounding area were mapped and is attached in the appendix of this report.

4.4 Marine Survey

Standard Line Intersect Transect (LIT) method was used. A 50m LIT was done with 5 equal segments. This is a globally used and accepted methodology to check the condition of the ref environment. The parameters that were measured, species and percentage cover and healthy coral cover. Three transects were taken in different locations of the project site. In addition to this, qualitative methods such as visual observations and photo shoots is used in the analysis. Fish counts were also made to get a snap shot of the fish population.

4.5 Marine Water Quality

The quality of the marine water in the proposed development site was assessed by testing water samples at location in Figure 6. The samples were tested at the MWSC laboratory. The main parameter that was tested are conductivity, turbidity and pH. The results are attached in the annex of this report.

4.6 Public consultation

The baseline socioeconomic condition of the island community was assessed using different methods of stakeholder consultations. A scoping meeting was held at EPA with the involvement of the stakeholders. In addition a consultation session was held at the island council office with the island council and other respective communities within the island. General questions were provided to get their views and concerns regarding the project to be carried.

5. Existing Environment

5.1 General Settings

This section covers the existing environment of Madduvari Island, with special emphasis on the project location and the factors that would most likely be impacted by realization of proposed works. Include topography, climatology, tides, waves etc. in general environment of Maldives. The geographic location and setting of the island was provided in chapter Study Area as shown in Figure 1. Maduvvari is an inhabited island 119 km away from Male' City, and its closest neighbour is the island of Dhiggaru. It has an area of 12.6 hectares, with the length and width being 550 x 230 meters respectively. The island has 4.8 hectares of reclaimed land and 8.0 hectares of vegetation line.

The Maldivian islands are generally believed to be situated above the top layer of beach rock of about 1m thickness, and the islands at 30-60 cm above present mean sea level. The beach rock dips slightly seawards at the island edges, and forms a platform on which the beach sediments are seasonally transported among islands.

5.2 Locations of the surveys

Figure 6: Locations of the water samples and transect surveys.

Three transect surveys were carried around the island. Two transects were taken at the land reclamation site and another transect was taken at the deepening channel shown in Figure 6. The GPS coordinates of the survey locations are as follows:
SW – 3° 6.62647 N, 73° 34.310 E
T1 – 3° 6.231 N, 73° 34.296 E
T2 – 3° 6.280 N, 73° 34.319 E
T3 – 3° 6.276 N, 73° 34.249 E

5.3 Marine Environment

The marine environment of Madduvari consists of lagoon and a reef system. The island of Madduvari have a natural lagoon locally known as a "vilu" on the southern side of the harbour. The status of the marine environment from the baseline survey shows that there are extremely few live coral within the project and impact zone. The major sediment was dead coral, sand, and rubbles. The fish community encountered during the survey was very few to none. Figure 7 and Figure 8 shows the results of the transect surveys and the condition along the transects respectively.

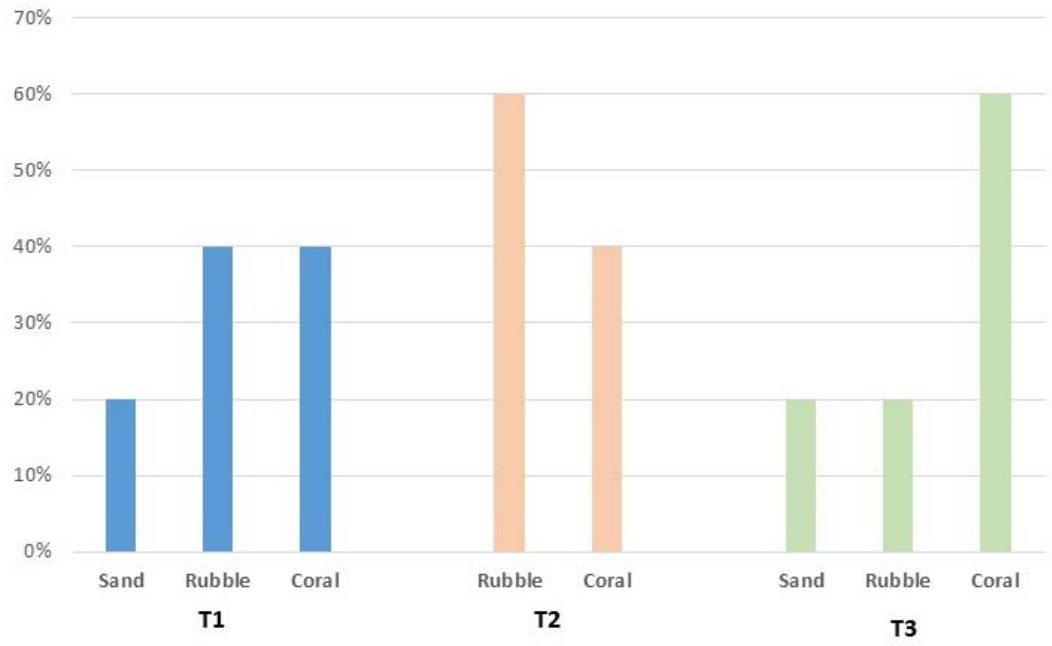

Figure 7: Survey results of transects

Figure 8: Condition of the marine environment along the 3 transects. Rows 1, 2 and 3 are the transects T1, T2 and T3 respectively.

5.4 Rare or endangered species

During the course of the baseline survey no marine protected species were encountered. The impacts from the proposed project on the rare and endangered species are not clear since there were no such species adjacent to the proposed area.

5.5 Climatology

The Indian Ocean Monsoons governs the climatology of the Maldives hence monsoonal reversal plays a significant role in weather patterns. Two very distinct monsoon are observed: the Northeast (*Iruvai*) and the Southwest (*Hulhangu*) monsoon. Monsoons can be best characterized by direction of wind and the amount of rainfall. The southwest (SW)

monsoon is the rainy season which lasts from May to September and the northeast (NE) monsoon is the dry season that occurs from December to February. The transition period of SW monsoon occurs from March and April while that of NE monsoon occurs from October to November. The results are summarized in Table 3.

Table 3: Summary of the seasons.

Season	NE-Monsoon	Transition Period 1	SW-Monsoon	Transition Period 2
Month	Dec, Jan, Feb	Mar, Apr	May, Jun, Jul, Aug, Sep	Oct, Nov

Since there were no site specific wind data, wind regime around the island was assumed to be that similar to the closest meteorological stations. The closest station is the meteorological station at the Male' international airport from 2002 to 2006. Figure 9 below represents mean daily wind speeds and direction. . It was determined that the winds from WSW to WNW is the dominant wind direction in the Southwest Monsoon, where wind from ENE and E was dominant during the North East Monsoon. Wind determines the direction of the sediment movement and have an influence on the alongshore current patterns.

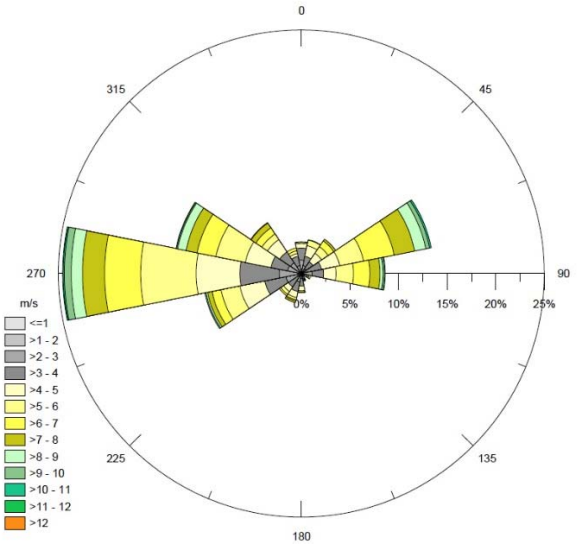

Figure 9: Wind speed and direction at Male' international airport (adapted from EIA Lamer 2008).

5.6 Tides and currents

Maldives experiences mixed semi-diurnal and diurnal tides with a strong diurnal inequality. There was no direct tide measured at the project site. Tide measured at the tide station in Hulhule was used to analyse the tide as in Figure 10. Tide have an influence on the wave conditions and the sediment movements in and out of the reef system. The hourly tide data from the University of Hawaii sea level archive for year 2010 is used in this analysis to cover the spring and neap tides. An approximate tidal range obtained at is 1.73 m (see Table 4).

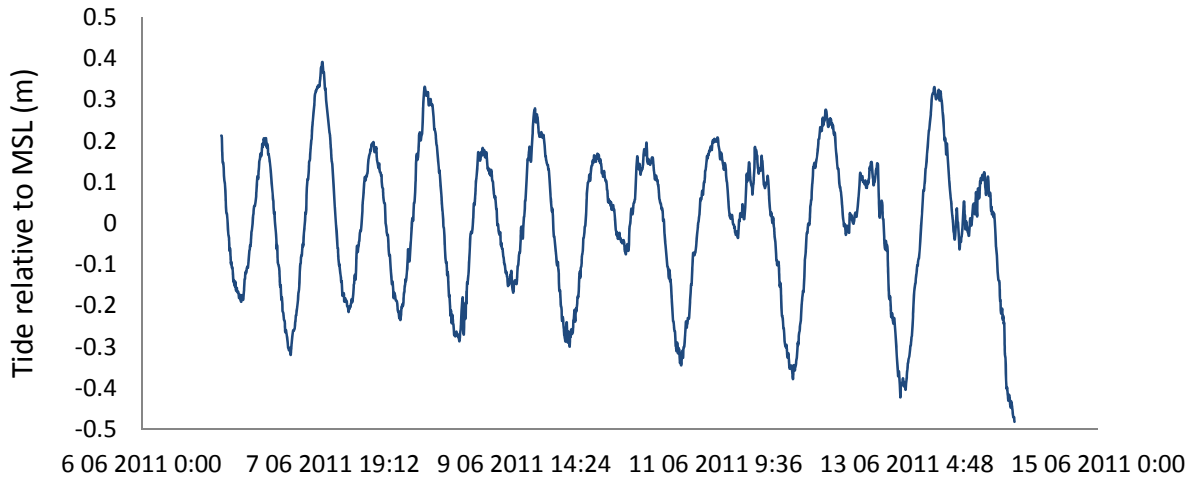

Figure 10: Typical tide at Hulhule tide station.

Table 4: Water levels at Hulhule tide station

Water level from MSL (m)	Levels with respect to MSL (m)
Highest High water (HHW)	0.62
Mean Highest High water (MHHW)	0.34
Mean High water (MHW)	0.33
Mean Low water (MLW)	-0.36
Mean Lowest Low water (MLLW)	-0.37
Lowest Low water (LLW)	-0.72

Tides have significant influence on the formation, development, and sediment movement process (coastal processes) around the islands. Tides play an important role in the flushing of the water from lagoon. This has an influence of on the sedimentation during the excavation process.

Ocean currents play a significant role in sediment movement. Currents could be wind driven or tide driven. No site specific current were measured. Available satellite information is used to draw information about the climatology of the currents around the Maldives region. This climatology is based on 23 years (1992-2014) data and the general pattern is show for the NE monsoon in Figure 11.

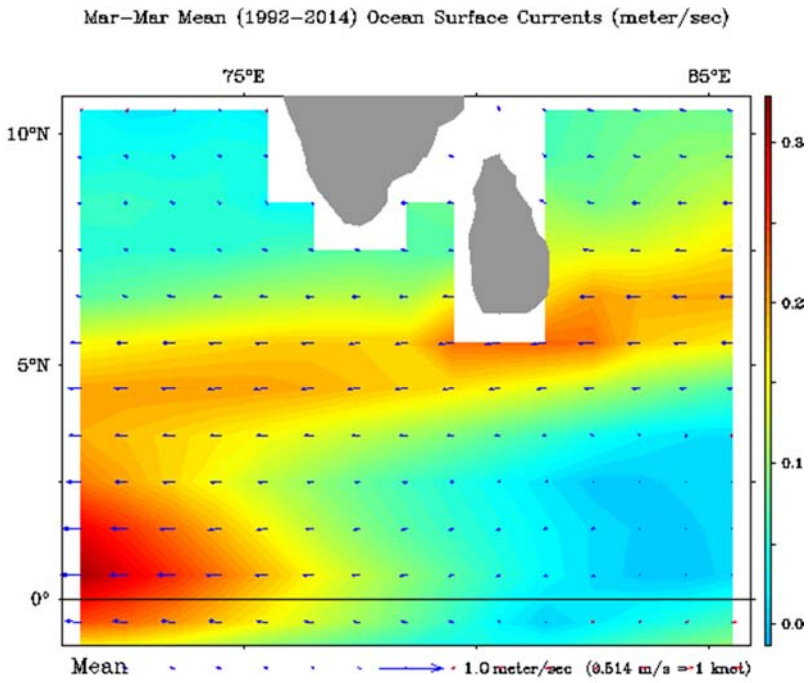

Figure 11: Average current regime around Maldives in NE monsoon.

The long-term average current speeds during NE monsoon varies between 0.08-0.2 ms^{-1} which is typical current speeds around the island (Figure 6). However it can attain speeds between 0.3 to 0.6 ms^{-1} in the SW monsoon.

5.7 Waves

The coastal dynamics such as accretion and erosion of islands depends on wave energy. Waves play a significant role in the modification of the beach environment and the surrounding. There are two major types of waves; wind generated waves and swell waves. Wind waves generated by the monsoon wind usually have a period of 3-8 seconds. Swell waves in Maldives are experienced by the swells generated by distance storms and have a period of 14-20 seconds (Kench et. al 2006, DHI 1999, Lanka Hydraulics 1988a and 1998b). Assessment done by Lanka Hydraulics shows that significant wave height (Hs) for the Male' region was 1.23m which a mean period (Tm) of 7.53s. Maximum Hs was 1.51 with a Tm of 7.74s.

Swell waves in Maldives are generally experienced by swells generated by distance swells generated due to storms. Occasional flooding have occurred in Maldives due to swells and distance storm generated swells were associated with these flooding's.

The possible waves and diffraction patterns around the island is shown in Figure 12

Figure 12: Possible waves and diffraction patterns around the island.

5.8 Vegetation

There is no major clearance of vegetation involved in this project as this involves a rehabilitation of the existing harbour.

5.9 Water Quality

The locations of the water sample is shown in Figure 6 and the results are attached in the annex of this report.

5.10 Bathymetry

Bathymetric surveys were conducted around project area. The bathymetric surveys results are shown in Appendix. Bathymetry shows that some of the areas close to the shore has become shallow and needs a maintenance dredging.

5.11 Coastal Environment

The coastal environment where the new quay wall would be constructed and the area where dredged material would be deposited contains rock and rubble (Figure 13). In addition some of the material would be deposited to the roads on the northern side of the island to level the roads.

Figure 13: Coastal environment of (left) where the new quay wall would be constructed and (right) where the land would be reclaimed.

5.12 Hazard vulnerability

An islands inherent vulnerability to environmental and climatic conditions lies in its geographic and geomorphic characteristics. Factors such as location of the island with in the atoll, its shape, formation and orientation, the degree of protection offered to the island by surrounding reefs and other islands, presence of mangroves and wetlands at the coast, its natural and manmade coastal protection structures, are all contributors to the resiliency of the island to withstand natural hazards.

Based on the outcomes of the DIRAM 1 report, the hazard exposure and vulnerability of Dhiggaru is medium as shown in Figure 14.

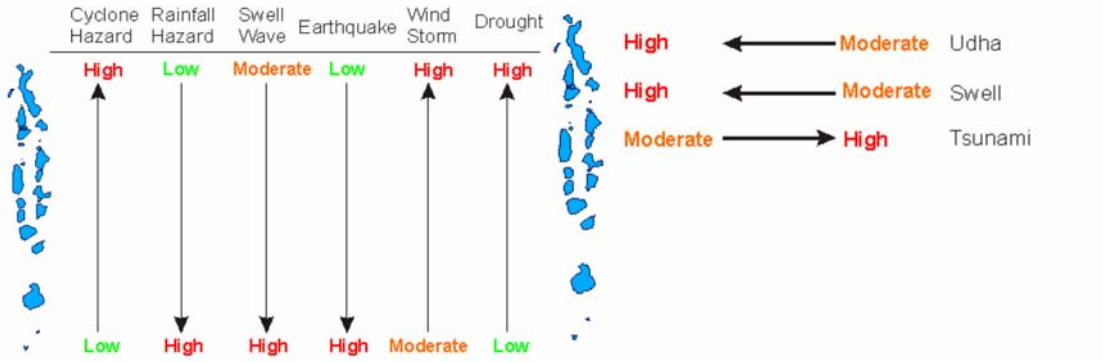

Figure 14: Latitudinal and longitudinal variations of major hazards across Maldives (Source: DIRAM 1, 2008)

6. Socioeconomic environment

6.1 Population

The population of Maduvvari is 660 with the sex ratio being 125.41 according to the census of 2006. But communications with the Council reveals that now it is approximately 750. Figure 15 shows the population of the atoll based on the 2006 census.

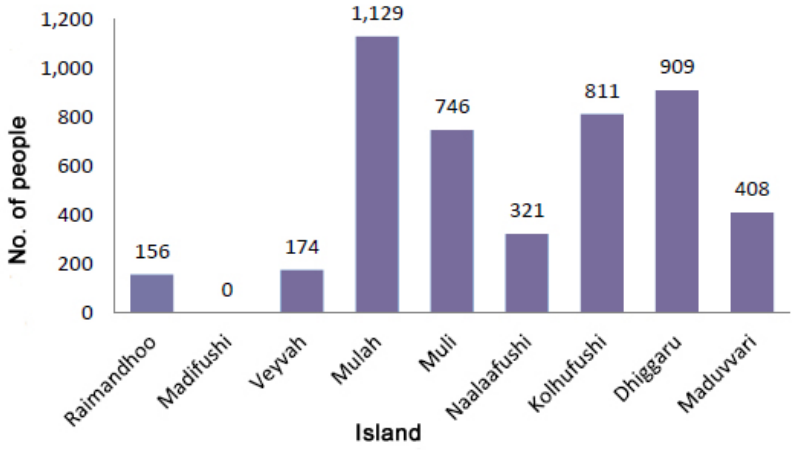

Figure 15: Atoll population.

6.2 Employment

The annual growth rate is -1.66, the literacy rate is 98.12% and the unemployment rate among youth was last recorded at 11%. The major economic activity in the island is fishing. There are no recorded historical/cultural interest sites, and no protected land or marine areas in the island.

About 27.8% of the population are above the age of 15 and 66.2% are employed and 18.5 % is unemployed. Literacy rate is 98.1% and lower secondary completion rate is 14.3%.

7. Environmental Impacts & Mitigation Measures

7.1 Introduction

Impacts on the marine environment from the proposed project have been predicted through analysis of the project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analysed to predict the extent and significance of the impacts that may arise from the proposed project's activities.

The impacts have been identified by

- A consultative process with the EIA team, proponent and community
- Existing literature
- Similar island projects

7.2 Impacts on the environment from the project

All infrastructure development projects have their own set of potential positive and negative impacts. The magnitude and severity of these impacts differ based on the nature of impact, while the cumulative impacts of a certain activity should be taken into consideration. Therefore, all development projects should be undertaken with utmost attention paid to avoid, minimize and mitigate unavoidable impacts of the particular project to the immediate and surrounding environment of the project location.

The project will have both construction and operational impacts on the environment. These impacts may be either short term reversible or long term irreversible damage or alterations. The impacts identified here will be according its location and magnitude. The intensity or severity of the impacts is further grouped into negligible, minor, moderate and major. This will help in identifying and carrying out remedial and mitigation measures. A description of the impact categories are presented below (LAMER, 2006).

- Negligible: no significant impact on environment
- Minor: the impact is short term and cause little damage to the environment which may be reversible on the long run.
- Moderate: Impacts are significant, may cause long term environmental concerns but are likely to be short termed, acceptable and justifiable
- Major: long term impact, large scale environmental alterations

Potential environmental impacts predicted for this project will be mostly due to dredging and land reclamation.

7.3 Impact Assessment Methodology

A purpose built matrix method (a Leopold matrix) is used to assess the impacts. The scale of impacts assessment used in described in Table 5.

Table 5: Impact evaluation scale

Criteria	Scale	Attribute
Magnitude Change caused by impact	-3	Major adverse
	-2	Moderate adverse
	-1	Minor adverse
	0	Negligible
	1	Minor positive
	2	Moderate positive
	3	Major positive
Significance/Reversibility Impact implications / Reversibility of impact's effects	0	Insignificant
	1	Limited implications / easily reversible
	2	Broad implications / reversible with costly intervention
	3	Nationwide or global implications / irreversible
Duration Duration / Frequency of Impact	0	Immediate
	1	Short term/construction period only
	2	Medium term (five years of operation)
	3	Long-term/continuous
Extent/Spatial Distribution Distribution of impact	0	None/within 1m from point of discharge/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

The above scale is used to develop and potential impact matrix based on the literature and expert judgment. Results of the potential impact is shown in Table 6. The impact potential index is based on magnitude (M), significance (S), duration (D) and extent or spatial distribution (D). An Activity Potential Index (API) is derived using the sum of all key component specific indices for an activity (sum row wise). In addition, Component Potential Vulnerability Potential Index (CPVI) (sum column wise) gives an indication of the vulnerability of each key component to activity related impacts. These indices are shown in Table 7.

Table 6: Potential impact matrix

	Marine environment		Soil and groundwater		Lagoon/seawater		Hydrodynamics		Air/Noise/land or seascape		Services and Infrastructure		Health and Safety		Employment		Property Value		Costs to consumer/tax payer	
Construction Phase																				
Mobilization of equipment, machineries and labour force	-1	0	0	0	0	0	-2	2	-1	1	-1	1	0	0	3	1	0	0	-2	1
	1	0	0	0	0	0	3	2	1	0	1	1	1	0	1	0	0	0	1	0
Dredging of the harbour basin	-2	3	0	0	-1	1	-1	1	-1	1	0	0	-1	1	3	0	0	0	-3	3
	2	2	0	0	1	1	1	0	1	1	0	0	1	0	1	0	0	0	1	2
Construction of quaywalls	-3	3	0	0	-2	1	-1	1	-1	1	-3	1	-1	1	3	0	0	0	-3	3
	3	3	0	0	1	1	1	0	1	1	1	3	1	0	1	0	0	0	1	2
Destruction and loss of benthic habitat	-2	3	0	0	-1	2	0	0	-1	2	0	0	0	0	0	0	0	0	0	0
	2	1	0	0	2	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Depostion of dredged material	-2	3	0	0	0	0	-2	2	0	0	3	0	0	0	0	0	0	0	-2	1
	2	1	0	0	0	0	2	2	0	0	3	3	0	0	0	0	0	0	1	0
Temporary road blocks	0	0	0	0	0	0	0	0	0	0	-1	1	0	0	0	1	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	2	0	0	0	0
Operation Phase																				
Operation and maintenance of harbour	-1	1	0	0	-1	1	0	0	-1	1	3	0	3	0	3	0	3	0	0	0
	3	1	0	3	1	0	0	0	3	3	3	3	3	3	3	3	3	3	0	0
Key	**M**	**S**		**Magnitude**					**Significance**											
	D	**E**		**Duration**					**Extent**											

Table 7: Impact potential indices

	Environment					**Socio-economic**					
	Marine environment	Soil and groundwater	Lagoon/seawater	Hydrodynamics	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer	**Total API**
Construction Phase											
Mobilization of equipment, machineries and labour force	0.00	0.00	0.00	0.06	0.01	0.02	0.01	0.06	0.00	0.00	**0.17**
Dredging of the harbour basin	0.06	0.00	0.02	0.01	0.02	0.00	0.01	0.05	0.00	0.04	**0.22**
Construction of quaywalls	0.07	0.00	0.01	0.01	0.02	0.02	0.01	0.05	0.00	0.04	**0.25**
Destruction and loss of benthic habitat	0.05	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	**0.15**
Depostion of dredged material	0.05	0.00	0.00	0.05	0.00	0.11	0.00	0.00	0.00	0.00	**0.21**
Temporary road blocks	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.05	0.00	0.00	**0.09**
Operational Phase											
Operation and maintenance of harbour	0.05	0.04	0.01	0.00	0.07	0.11	0.11	0.11	0.11	0.00	**0.62**
Total CPVI	**0.28**	**0.04**	**0.10**	**0.14**	**0.19**	**0.31**	**0.15**	**0.32**	**0.11**	**0.07**	**1.70**

The above indices shows that the project has a minimum impact on the environment and positive and stronger impact socially and economically.

7.4 Construction phase impacts

Construction phase will have the majority of the impacts on the environment. Some of the impacts could be minor to major with reversible to long-term irreversible impacts. Activities which will have a major impact during construction phase is discussed below.

7.4.1 Impacts due to mobilization

Any construction project would involve mobilization of heavy machineries and heavy duty equipment's. Some of the impacts that might arise during mobilization of the equipment's might include:

- Mooring and anchoring might damage corals
- Accidental spillage of oil and chemicals
- Accidental spillage of construction material such as cements, timber etc...
- Loss of land space due to temporary storage of equipment's
- Transport hazard of overtopping of vessels

Some of the machineries operate on diesel. As they require use of oil, there is a potential hazard of spillage which might seep into the groundwater aquifer. As the groundwater of the islands are already in severe situation, extra care must be taken to minimize any spillage. Moreover, fire hazards are likely especially with use of fuel based equipment and electrical equipment. Therefore ways to manage these hazards must be in place.

7.4.2 Impact due to waste material

Production of waste during any project is inevitable. Waste material such as cement, timber and waste oil can have a significant impact on the terrestrial and marine environment. Wind and waterborne debris can have negative impact on the environment.

Dredge material will be disposed in the areas marked on the maps. This will have a positive impact of reducing the coastal erosion and increasing the land space for other costal and commercial activity. However, changes to the coastal environment due to reclamation must be studied for a longer term before the impact due to the reclamation could be analysed.

Waste material such as timber and iron would be deposited in the waste management place allocated in the island. Any waste oil will be packed and carried to Thilafushi.

7.4.3 Impacts due to construction of quay wall

Construction of quay walls in the new area will involve removal of some of the rocks and rubbles in that area. The existing quay wall will be removed and the construction waste will be moved to the designated location. However, the impact due to this will be very minimal. There might be cement siltation during the construction of the walls. But this will be very local to the surroundings of the quay walls and impact would be negligible.

7.4.4 Impacts due to dredging and reclamation

Sedimentation and saltation during any dredging is unavoidable. The non-contaminated fine sediments will increase in the water and will be suspended increasing the turbidity. Sediment suspended plumes and increase in turbidity will be seen around the area and will get disposed with the current and will settle in time. This suspended material could be disposed onto reef flats depending on the magnitude of the currents and direction of travel.

Deposition of the dredged material and reclamation of land can change the coastal hydrodynamics around the island. Reclaimed sand near the shore will impact the coast and can have a permanent impact on the marine habitats. Since the harbour has been there for a long time, the coastal hydrodynamics must have come to a balance and the changes in the dynamics might not have a major impact.

7.4.5 Impacts to marine habitat

Field survey indicates that this area does not have much live coral. The area is mostly covered by dead coral, sand, rock and rubble. The area where dredged material is to be deposited have seaweed and dead coral. Therefore impact on the marine habitat due to this reconstruction work is expected to be very minimal.

7.4.6 Occupational health and safety

As heavy machinery would be operated during the construction stages, the risk of toppling of excavators and accidents with machineries have occurred. Such accidents are usually due to carelessness and non-compliance with the safety regulations in operation of these equipment.

Among the major issues might be due to the noise and emission disturbances. Employees might be subject to high and long times of noise and emissions and this might have a health impact. However, if the proper gears such as helmets and other necessary gears are used, the risk would be reduced.

7.5 Operational phase impacts

The operation phase will have impacts on the environment. A major impact would be felt on the marine and coastal environment. Impacts would be felt due to disposal of waste,

chemicals and oil. As there is no breakwater, the issue of stagnation would be very less since there would be proper flushing near the shore.

7.5.1 Impacts from solid waste disposal

There would be considerable amount of solid waste generated during the operation of the harbour. Among the major waste would be plastic bags, bottles, cans, tins and other litters. In addition, as there is a fish market nearby, there might be fish waste dumped into the harbour. Disposal of these waste can reduce the aesthetic beauty and can pollute the water which can lead to potential damage to the coral and fish of the surrounding area. In addition, plastic bags and bottles can cause smothering of coral risking their growth.

7.5.2 Impacts due waste water and waste oil disposal

Waste water and waste oil from the fishing and other vessels are major components usually dumped into the basin. In addition to this, detergents and chemicals used for cleaning the vessels are also dumped into basin. Mishandling of oil and spillage can cause pollution due to oil. Pollution due to oil spillage will impact the health of the coral and marine organisms.

7.6 Socioeconomic and cultural impacts

The major socio-economic impact due to the construction of the quay wall will be positive. This will increase the ease of use of the facilities. Easy mooring of the vessels close to the shore will increase the ease of access. Deepening of the channel and the basin will also ease the access which will also increase in the safety of the vessels to some extent. This will also allow more vessels to use the harbour facilities. Ease of access will directly increase the use of the facilities and indirectly will have a positive impact on the local trade and linkages with other islands bringing more positive socio economic gains to the community.

The only negative delay envisaged is the dissatisfaction which might arise due to delays in the implementation of the project. The delay could be related to administrative and weather related events. However, these could be minimized or avoided with proper planning.

7.7 Significance of the impacts

Impacts that may arise from the activities of the proposed project were categorized into the characteristics described in Table 8.

The significance of impacts was determined based on these characteristics and analysis of the impacts from this project and other analogous projects. These impacts correspond in the worst case scenario and after mitigation measures were taken. The Table 8 shows the main impacts that would arise from the proposed project activities and their significance based on impact characteristics.

Magnitude of impact is calculated in relation to the total area. Direct geographic range of impact felt will be the immediate proposed development area and indirect impacts on the environment will be felt on a larger area due to spreading of fine sediment in and away from the lagoon. Duration of the impact is predicted in terms of severity of impacts.

Reversibility of impacts was predicted based on natural recovery of the habitats affected. Coral reefs naturally take longer to recover than the lagoon habitats. Significance of the impacts is predicted based on the nature, geographic range where impacts are felt, magnitude, duration and reversibility of the impacts.

Table 8: Significant impacts of the proposed project

Activity	Contributing factors	Impact	Magnitude of impacts	Duration of impacts	Reversibility of impacts
Operation of Machinery	Use of heavy machinery	Noise and air pollution	Moderate –ve	Short term	Reversible
	Accidental damage by operation of vessels and barges	Damage to coast and reef	Moderate -ve	Short term to medium term	Reversible
	Accidental oil spillage	Pollution of marine environment	Moderate to high –ve	Short term to long term	Reversible
Construction of quay wall	Demolition of existing walls	Increase in turbidity	Minor –ve	Short term	Reversible
	Seepage of sand and aggregate	Increase in turbidity	Minor –ve	Short term	Reversible
Deposition of sand on the roads	Transfer or dredge material	Road blocks	Minor –ve	Short term	Reversible
	Muddy roads	Initially will be soft, but will settle in time	Minor –ve and stong +ve later	Short to long term	Reversible
Disposal of sand and reclamation of land	Coastal modification	Modify the coastal dynamics and loss of habitat	Minor –ve	Short to long term	Irreversible
	Deposition of dredged material	Increase in land space and levelling of graveyard	Major +ve	Long term	-
Deepening of basin	Dredging the basin	Increase in turbidity	Moderate -ve	Short term	Reversible
Waste disposal	Dispose of waste, detergent and oil	Increase marine pollution	Moderate -ve	Long term	Reversible

7.8 Mitigating the impacts

Several actions can be taken to minimize the above mentioned impacts. Expert consultations, past experience and local knowledge are essential in reducing the impacts. Mitigation measures are employed to eliminate or reduce the severity of any predicted impacts. The predicted impacts on the coastal environment can be mitigated by joint cooperation and careful environmental planning. All parties, the proponent and the contractors must work carefully to eliminate or reduce the identified risks. Given the magnitude of impacts for this project, the adverse effects can be mitigated at virtually no cost if best environmental practice and precautionary principles are used. Specific mitigation measures for potential impacts are given below.

Supervision and inspection of the project activities are imperative to minimize adverse impacts. Therefore, competent government staff with experience in same or similar work in the local environment will be consulted and allowed to inspect and monitor the work activities of the project life-cycle. Supervising party will carry out compliance monitoring and reporting to ensure that the predicted impacts are not exceeded. If predicted impacts were exceeded, the work will be halted and impacts re-assessed and reported.

Proposed project's marine work will be carried out to coincide with low tide or the flushing tide so as to minimize effects of sedimentation on the reef. The work will be carried out in calm weather condition.

Machinery, equipment and vessels used in the project activities will be maintained in good condition and operated in a manner that they do not pose a risk of environmental degradation. All activities will be kept to a minimum period of time to reduce impacts on the environment. The Table 9 below provides more information on potential impacts and mitigation measures.

Table 9: Potential impacts during excavation and operation of the roads and mitigation measures to minimize the impacts

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (USD)
Sedimentation and siltation on the reef and lagoon due to excavation	- Creation of a sandy bed to reduce the sedimentation impact, this bed would reduce sediment spreading; work to be carried out in low tides. - Select appropriate time for dredging (e.g. dredging of basin and channels at high tide to allow flushing) - Use of efficient dredging techniques - Regular monitoring of suspended solids or turbidity	Reef-flat and reef slope	During construction	Minor, short term –ve impact. Reversible over long run	Contractor, Proponent	Included in the project budget
Loss of habitat, damage or death of coral	Clearly marking the areas to be excavated.	Reef-flat,	During construction	Extremely minor as there are no live corals, long term –ve impact. Most likely irreversible	Contractor	N/A
Deposition of sand and reclamation	- Select appropriate time for reclamation (e.g. reclaim at low tide to minimize turbidity) - Create settling compartments to for	Coastal environment	During construction	Extremely minor as there are no live	Contractor	Included in the project budget

	maximum settling of sediments - Contain reclamation areas using bund walls	And the northern side roads		corals, long term –ve impact. Most likely irreversible Extremely +ve with the roads being leveled		
Air pollution	Completing the excavation works as soon as possible.	Air	During construction	Negligible, short term –ve impact. Reversible	Contractor	N/A
Accidental spillage	Put up sign boards	Marine and land environment	Construction and Operational phase	Minor, short term –ve impact Reversible	Contractor, Proponent	Included in the project budget
Waste disposal	- Appropriate dispose of construction waste - Do not dispose waste to the marine environment - Establish a waste management plan for disposal of waste during operation - Establish waste collection facilities within the vicinity - Regulatory enforcement for regular maintenance and cleaning	Marine and land environment	During construction and operation	Minor and reversible	Contractor, Proponent	N/A

7.9 Uncertainties in impacts identification

Although measures will be taken to mitigate known impacts, there is always the probability that an unforeseen impact may occur. It is also important to note that some of the impacts may turn out to be far greater than predicted. This could make mitigation measures less effective. To avoid or reduce the chances of such events it is vital to monitor key important parameters at the vicinity of the project.

8. Socioeconomics & Stakeholder Consultations

8.1 Socio-economic status

The stakeholder consultations were aimed at understanding the need for reconstruction of the harbor and how it was planned to be carried out. The key stakeholders met were the Ministry of Housing and infrastructure, Environmental Protection Agency, Island Council and members of the community.

8.2 Stakeholder consultations and outcomes

8.2.1 Aim

The stakeholder consultations were aimed at understanding the current situation of the harbor, why the project needs to be carried and provide information on the future plans explaining how this project would help in their future plans.

8.3 Meeting with Environment Protection Agency

A scoping meeting with the Environment Protection Agency was held on 1st of June 2015 at EPA. The terms of reference for the terms to be considered in the EIA was discussed and the finalized TOR is attached in the Annex.

EPA specifically asked for how the reconstruction work would be carried out. It was explained to EPA by the proponent that, this would be a normal project like any other harbor rehabilitation project.

8.4 Meeting with Ministry of Housing and Infrastructure

Ministry of Housing and Infrastructure is the proponent of the project. The construction work was given to MTCC by the proponent. Information regarding the use of material and design parameters and concepts of design were obtained from the MHI.

8.5 Meeting with the Island council

8.5.1 Objectives

The objectives of the consultations were to:

Understand any reservations with respect to the proposed project. A summary of the discussions are as blow.

- The island council was well aware and was previously consulted by MHI during the design stage of the project.

- The council and the seniors of the island mentioned that they still do not accept this as proper harbor since there is no breakwater.
- They mentioned that the basin get very rough during the monsoon and becomes unusable. Incidents have happened in the past that two vessels got sunk into the basin during the monsoon.
- Their experience is that it will take a while before the basin gets filled with sediments even though it would be dredged now. Unless are breakwater is placed, another episode of a maintenance dredging would be needed.
- Concern was raised that the quay wall needs to be redesigned. It was mentioned before that the Council asked to straighten the quay wall to have a semi-rectangular basin compared to the current shape. It was mentioned that this is not reflected in the final drawing and still to consider this change during construction.
- It was asked that if a separate EIA would be needed for this change. From the experience of the EIA consultant and from the field data findings, it was mentioned to them that no matter of the design change to this semi-rectangular shape, the impact on the environment would be the same and a seprate EIA need not be done from an environmental perspective. But the budgetary constraints have to be considered. The only concern would be to where to get the extra sand to reclaim near the coast should there be a change in the design.

The following were met at the consultations

Name	Designation	Contact number
Ibrahim Rameez Hassan	President of Council	7887161
Ismail Fazil Farooq	Vice President of Council	7697657
Hassan Mahasin	Council Member	7620507
Husnee Hussain	Council Member	7427792
Muktharu Mohamed	Council Member	9733312

9. Alternatives

9.1 Alternative Locations

There is no alternative locations for the project site as the project is about a reconstruction of an existing harbour. However, alternative locations could be considered about where the dredged material would be deposited. The island have some roads which could be levelled. As the priority of the Island Council is to reclaim the land near the harbour, the alternative solution is not viable.

9.2 No Project Scenario

If "no project scenario" was considered, environmental impacts associated with the project could be avoided completely. Considering this option is not worthwhile as this will not provide a solution to the existing problem. The advantages and disadvantages of the no project option are discussed below in Table 10.

Table 10: Advantages and Disadvantages under a no project scenario.

Advantages	Disadvantages
Environmental problems related to project can be avoided.	The harbour facilities would not get better.
No development costs to government.	The socio-economic situation of the island would remain the same or would deteriorate.

9.3 Alternative options

There are alternative options which could be used as breakwaters.

9.3.1 Cement bag quay wall

Another alternative method of constructing the quay wall would be to use cement reinforced bags as a quay wall. However, compared to the proposed technology, cement bag quay walls would be less durable even though it might be cheaper. Considering the costs and benefit, the chosen technology would be more desirable.

10. Environmental management and monitoring

This Chapter outlines the monitoring plan for the project. Adoption of appropriate mitigation measures can significantly reduce the environmental damage caused by a development project. However, occurrence of unforeseen impacts is still possible, even with proper implementation of mitigation measures. Moreover, some of the predicted impacts may turn out to be greater than predicted, necessitating different or more rigorous mitigation measures. Therefore, regular and frequent monitoring of the environment is vital, in order to avoid or reduce the chances of such events, and to minimize the impact and cost of unforeseen events by taking prompt remedial action if such events occur.

Since most environmental changes occur over long period of time, it is important to implement a specific long-term monitoring program for the marine and coastal environment. It is important to monitor the effects of development prior to, during and after project implementation. The proponent is fully committed to carry out environmental monitoring of the development and operation of the facility.

10.1 Aim of monitoring

The primary aim of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods.
The objectives of this monitoring program are to detect and document the changes occurring to the environment and the surroundings due to the proposed project. The purpose will be to:

1) Assess the magnitude of the impacts resulting from the various stages of the proposed work and
2) Undertake take mitigation measures to minimize the negative impacts.

10.2 Monitoring of the harbour basin and deposition site

Monitoring of the basin area during excavation and operation should be made. Following table shows monitoring program suggested for the proposed project. The monitoring program is suggested for during the construction period and during operations which will last for one year from the completion of the project.

Table 11: Monitoring program

Parameters to monitor	Indicator & method	Frequency of monitoring	Responsible partner
Sediment dynamics	Bathymetry, standard bathymetry methods	Every day during the constriction period Every six months before and annually after project implementation	Contractor during construction period Proponent during operation
Coral cover	Percent of coral cover LIT or photo quadrant method	Once every month during construction, every six months during operation	Contractor during construction period Proponent during operation
Shoreline changes	Beach profile	Once every 3 month during construction, every six months during operation	Contractor during construction period Proponent during operation
Water quality	pH, turbidity, conductivity	Once every month during construction, every six months during operation	Contractor during construction period Proponent during operation
Hydrodynamics	Current pattern, current drogue	Once every month during construction, every six months during operation	Contractor during construction period Proponent during operation

10.3 Breakdown of monitoring yearly monitoring cost

Table 12: Estimated cost of monitoring

Activity	Quantity	Cost (USD)
Field data collection	5	1000/-
Document preparation	1	500/-
Logistics	1	500/-
Total		**2,000/-**

10.4 Monitoring Report

Based on the data collected, a mid-term monitoring report will be compiled and submitted to the relevant authorities for compliance. This report shall include methodologies and protocols followed for data collection and analysis, quality control measures. It should also include an analysis of the comparison of the data to the baseline and analyze the changes that have occurred since the project began.

10.5 Commitment by the Proponent

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

11. Conclusions & Recommendations

11.1 Conclusions and Recommendations

This environmental impact assessment study demonstrated that the proposed project will cause both short term positive and negative impacts.

The project will cause both short-term and long-term significant impacts to the basin of the harbor and will bring coastal changes to the reclaimed area. The impact on the marine environment is minimal as there are very few live coral cover and very few fish encountered. However, indirect impact might be felt on the surrounding due to silting which is minor and not long lasting.

Socio-economic impact of the proposed project will be very positive. The project will provide a solution to the deteriorated condition of the harbor and will enable ease of access and space for anchoring of more vessels. This will enable creation of more jobs and ease of access to the fish market facilities near the harbor thereby increasing the economic and livelihood situation of the community.

To minimize the potential impacts due to the construction works, it is advised that the mitigation actions specified in the report be followed and the necessary actions be taken to minimize the impacts.

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Appendix A – Terms of Reference

Environmental Protection Agency EPA

"Dhivehin" – Always Maldivian, Forever Independent

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EPA/ToR/2015/75

Terms of Reference of Environmental Impact Assessment for the Construction of a Harbour Quaywall at Maduvvari, Meemu Atoll

The following is the Terms of Reference (ToR) following the scoping meeting held on 01st June 2015 for undertaking the EIA of the proposed Harbour Quaywall Reconstruction Project at M. Maduvvari.

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

1. **Introduction and rationale** – Describe the purpose of the project and, if applicable, the background of the site and the tasks already completed. Clearly identify the objectives to enable the formulation of alternatives and to furnish criteria for monitoring and evaluation. Objectives should be specific and if possible quantified. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked and sequenced with other projects executed by other consultants, and how coordination between other consultants, contractors and government institutions will be carried out. List the donors and the institutions the consultant will be coordinating with and the methodologies used.

2. **Study area** – Submit an A3 size scaled plan with indications of all the proposed infrastructures. Specify the boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent or remote areas including relevant developments and nearby environmentally sensitive sites (e.g. coral reef, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including preparation, construction and decommissioning phases.

   Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the dredging works, using maps at appropriate scales where necessary. The following should be provided (all inputs and outputs related to the proposed activities shall be justified):

   The main activities of the harbour quay wall construction works are:

   - Removal of existing quay wall
   - Construction of new quay wall
   - Dredging material from harbour basin and depositing at dumping site/nourishment area;
   - Finishing harbour to required levels, including any hazard vulnerability measures such as elevated zone (e.g. "safe island" concept);
   - Environmental monitoring during construction activities;
   - Project management (include scheduling and duration of the project and life span of facilities; communication of construction details, progress, target dates, construction/operation/closure

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of labour camps, access to site, safety, equipment and material storage, fuel management and emergency plan in case of spills)
- Waste management /disposal (construction waste)

Dredging:
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures;
- Justification for selecting the methods and equipment;
- Dredged material usage details, e.g. for land reclamation or coastal protection works;
- Duration of dredging activity;
- Labour requirements and (local) labour availability;
- Housing of temporary labour, and
- Emergency plan in case of spills (diesel, grease, oil)

The EIA report should investigate possibilities for alternatives:
- Operation and positioning options;
- Alternative harbour locations: have these been considered and if so, give arguments why these alternatives have not been selected, and
- Layout of structures, comparison of different materials that could be used.

The EIA should investigate possibilities for alternative:
- Design of additional quay wall, including materials used.
- Construction methods, materials, equipment, man power, expertise and scheduling.

Task 2. Description of the environment – Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction and from at least two benchmarks. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects, vegetation transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

Climate
- Temperature, rainfall, wind, waves, evaporation rates (including extreme conditions);
- Risk of hurricanes and storm surges;

Geology and geomorphology
- Offshore/coastal geology and geomorphology (use maps);
- Bathymetry (bottom morphology) of harbour area (use maps);
- (Seasonal) patterns of coastal erosion and accretion and
- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction;

- Beach profile indicating erosion areas

Hydrography/hydrodynamics (use maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Sea water quality measuring these parameters: temperature, pH, salinity, turbidity, sedimentation rate.

Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector.
- Benthic and fish community monitoring in deep lagoon
- Landscape integrity, and

Socio-economic environment

- Demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities at sea;
- Accessibility and (public) transport to other island;
- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Community needs;
- Sites with historical or cultural interest or sacred places (mosques, graveyard).
- Workforce management

Hazard vulnerability:

- Vulnerability of area to flooding and storm surge.

Task 3. Legislative and regulatory considerations – Identify the pertinent 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. Dredging permit should be included in the final EIA report.

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology;

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- Loss of marine bottom habitat, both in the borrow area resulting in loss of bottom life, which may impact fish stocks and species diversity and density of crabs, shellfish etc.;
- Sediment dispersal in water column (turbidity at the dredging site (overflow), the reclamation areas and related to shore protection activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.;
- Impacts of noise, vibration and disturbance;
- Impact of hard engineered structures. i.e concrete quaywall blocks
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment

- Benefits and impacts of the works in fishing activities and accessibility to island;
- Impacts of the harbour works on resource users (adjacent businesses, nearby resorts and dive sites);
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Impacts of the harbour works
- Level of protection against hazards like sea level rise, storm surges, etc.
- Employment and economic opportunities and diversification;
- Social destabilization of the island community, and
- Monitoring of socioeconomic and demographic development.

Construction related hazards and risks

- Pollution of the natural environment (e.g. oil spills, discharge of untreated waste water and solid waste, including construction waste);
- Risk of accidents and pollution on workers and local population, and
- Impacts on social values, norms and belief due to presence of workers of dredging company on local population.

The methods used to identify the significance of the impacts shall be outlined. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable. Use interaction matrices (E.g. Leopold Matrix) to assess the magnitude and significance of the impacts.

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". The report should highlight how the location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures. Mitigation measures to avoid or compensate habitat destruction, e.g. temporal sediment control structures, coastal protection structures to reduce erosion, coral reconstruction, temporary docking jetty and MPA replacement areas. Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of

commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for coastal modification, beach morphology, sediment movement around the island. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction, after project completion and every three months thereafter, up to one year and then on a yearly basis for five years after. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided. Monitoring is required in:

- Coastal erosion around the island;
- Water quality assessments (surrounding seawater quality);
- Marine ecosystems monitoring (coral reef, seagrass and fish and invertebrates communities),
- Waste Management (construction waste)/ disposal
- Socio-economic monitoring for project success or improvement requirements.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities such as Ministry of Housing and Infrastructure, government agencies, NGOs, engineers/designers, island council. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes.

4. **Deliverables and required resources** – The EIA report will be concise and focus on significant environmental issues. It will be submitted in digital format to the relevant government ministry and to the EPA for review and evaluation. The EIA report will contain findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting such data. The EIA report will be organized according to the points discussed in the final ToR document. Monitoring reports will be submitted according to deadlines stated in the EIA report in a digitalized format to relevant institutions (EPA, MRC, Tourism Ministry, etc.). Inspections on behalf of the EPA may be performed to verify that the developer is complying with the terms agreed in the EIA report.

5. **Relevant documentation, references for consultants** – Include publicly available studies or references relevant to the current project to be used by the consultant.

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

02 June 2015

Environmental Protection Agency
Green Building, 3rd Floor, Handhuvareehingun
Male', Rep. of Maldives, 20392
Tel: [+960] 333 5949 [+960] 333 5951
Fax: [+960] 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

Appendix B – Technical Layout Drawings

M.MADDUVARI HARBOUR

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LOCATION PLAN:

APPROVAL:

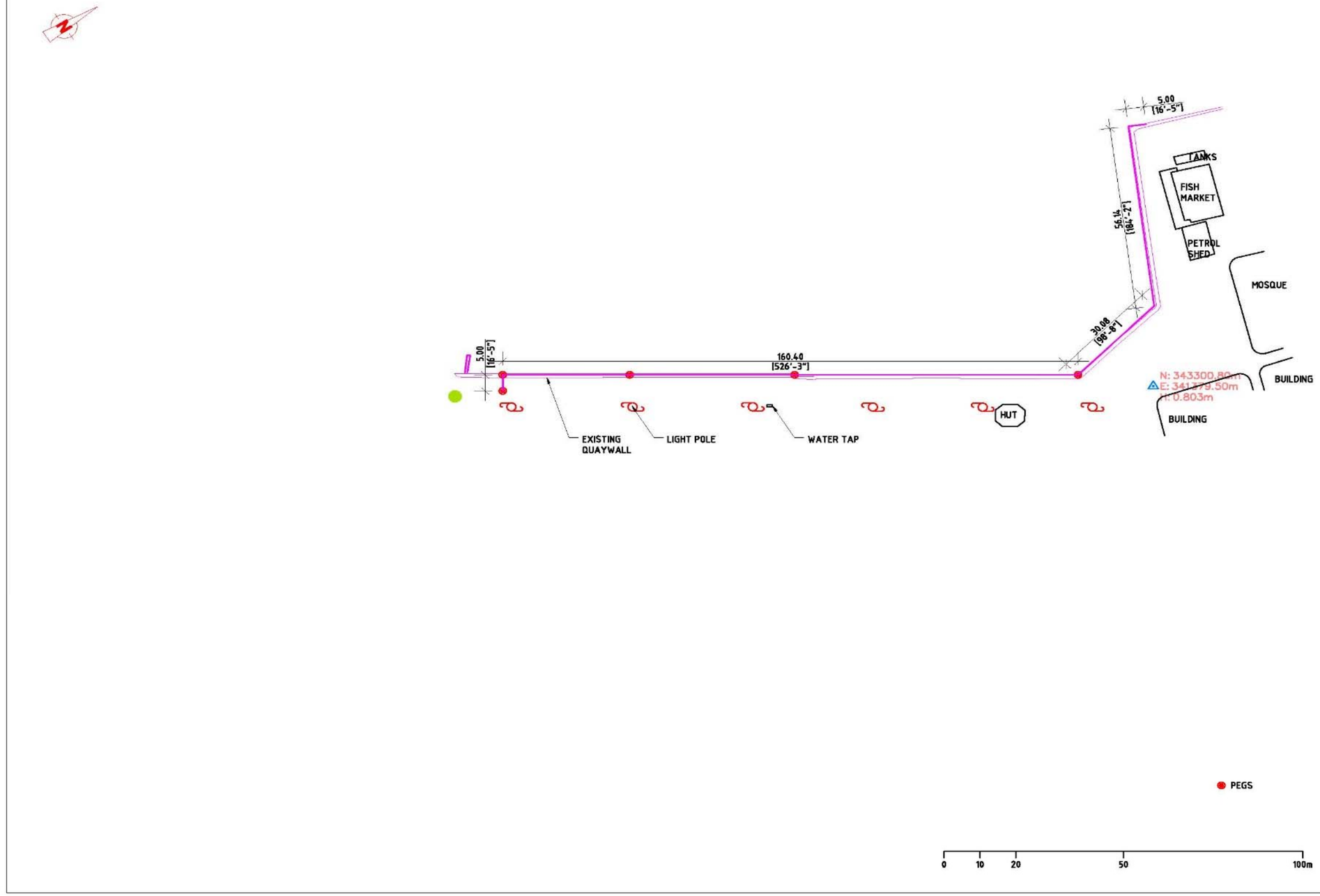
LEGEND:
- QUAY WALL
- DREDGED AREA(DEPTH 8FT)
- RECLAIMED AREA
- BREAKWATER
- ROCK REVETMENT

PROJECT: M. MADUVVARI

CONTENTS: HARBOUR DESIGN

DATE: 05 MARCH, 2015

ENGINEERING & PROJECT IMPLEMENTATION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H: 0.803m
BUILDING
BUILDING
HUT
EXISTING QUAYWALL
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WATER TAP
PEGS
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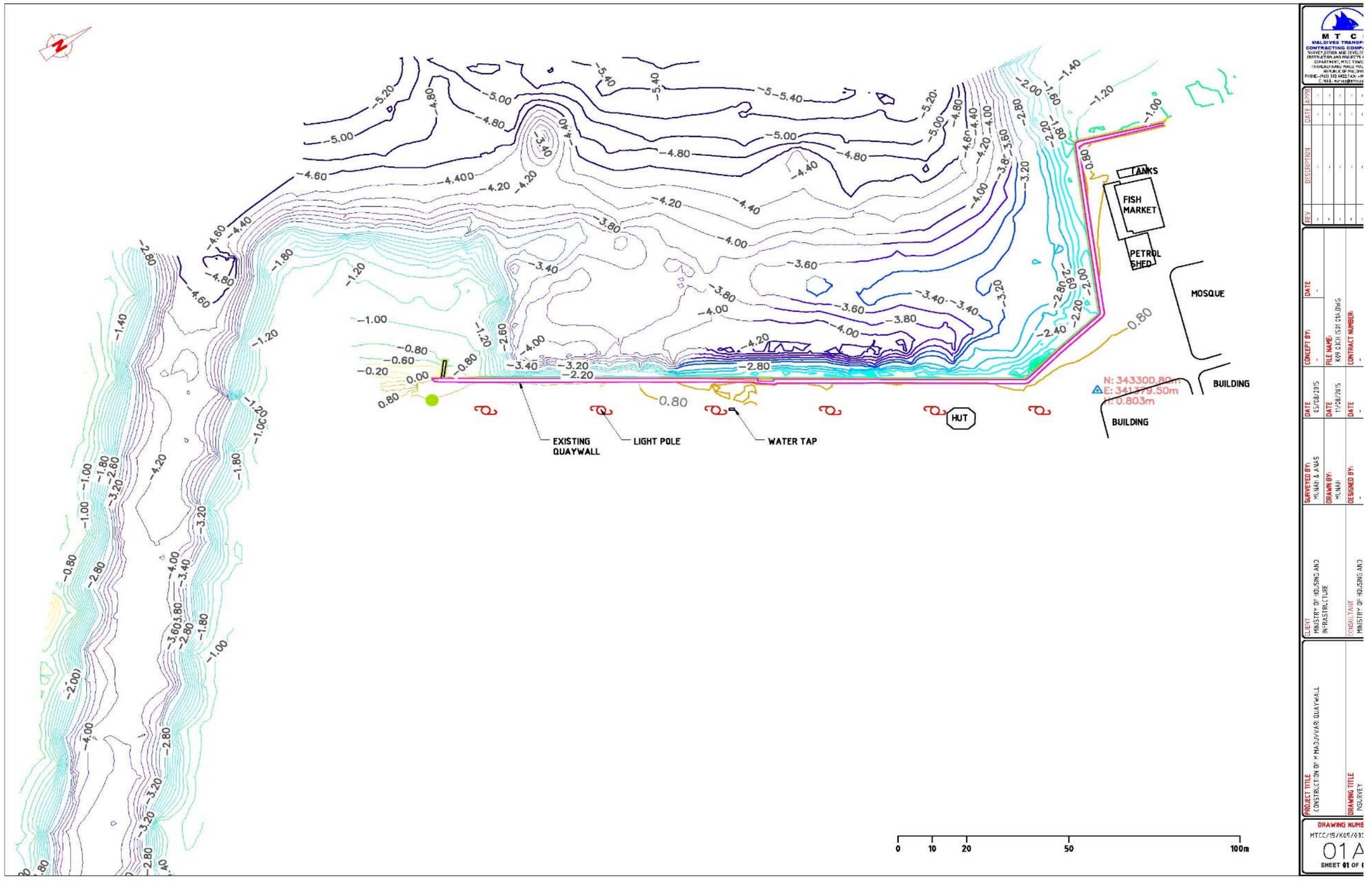
10
20
50
100m

Appendix C – Bathymetry



Appendix D – Water Quality Reports

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameeneemagu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

بسم الله الرحمن الرحيم

MWSC

WATER QUALITY TEST REPORT

Test Report No: 301032/2015/11

Customer Informations : *Meeco,*
G. Aakakaage-1, 2nd Floor,
Alikilegefaanu Magu,
Male'
Rep. of Maldives

Date: 19/08/2015

Sample Description / Location~	M. Dhiggaru Harbour Basin	M. Maduvvari Harbour Basin	TEST METHOD	UNIT
Sample Type~	Sea water			
Sampled Date~	11/8/2015			
Sample Received Date	12/8/2015			
Test Requisition Form No.	900161193			
Sample No.	818372	818373		
Date of Analysis	12/8/2015 -19/8/2015			
PARAMETER	ANALYSIS RESULT			
Physical Appearance	Clear	Clear	Visual	-
Nitrate	5.9	4.0	Method 8171 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
pH	8.15	8.04	Method 4500-H^+ B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	-
Nitrite	0.168	0.073	Method 8507 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Sulphate	3300	3200	Method 8051 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Salinity	35.94	36.70	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	‰
Phosphate	0.08	0.08	Method 8048 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Temperature	24.3	24.3	Electrometry	°C
Biological Oxygen Demand (BOD)	1	1	HACH Method 8043	mg/L
Total Dissolved Solids (TDS)	25600	25600	Conductivity Method	mg/L
Turbidity	<0.1 (LoQ 0.1NTU)	0.117	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU

Keys:

UNITS: mg/L: Milligrams per litre, **NTU:** Nephelometric Turbidity Unit, **‰:** Parts per thousand, **°C:** Degree Celcius

LoQ: Limit of Quantification

Checked by:	Approved by:
Afnan Farooq Laboratory Executive	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

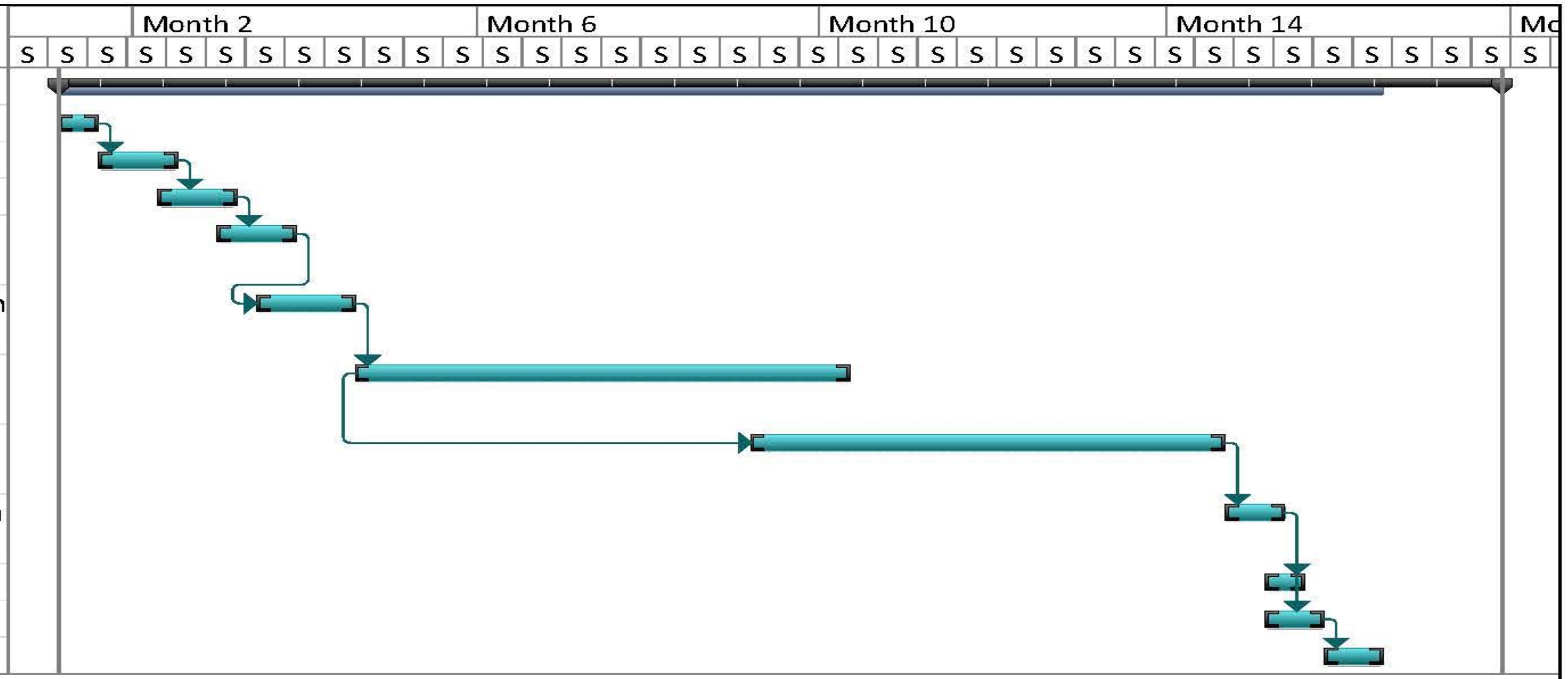
This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

**********END OF THE REPORT**********

Appendix E – Schedule

ID		Task Mode	Task Name
1			**Work Schedule**
2			Preliminary Works
3			Mobilization
4			Site Setup
5			Survey and Setting out
6			Dredging and Excavation
7			Quaywall Construction
8			Breakwater Construction
9			Revetment Construction
10			Out Survey
11			Site Clearance
12			Demobilization



Project: Harbour Project Schedule
Date: Thu 6 08 15

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

Page 1

Appendix F – Letter of Commitment

بسم الله الرحمن الرحيم

Ministry of Housing and Infrastructure
Male', Republic of Maldives.

ހިސާބުގެ ތެރެ ހިންގުމާ ބިނާކުރުމުގެ ވަޒާރާ
ދަތުރު، ތަރައްޤީ.

Date: 29th September 2015

No: 138-PIS2/203/2015/227

Environmental Protection Agency
Ministry of Environment and Energy,
Ameenee Magu, Maafannu, Male', 20392,
Maldives.

Sub: EIA to the Proposed Construction of Harbour in M.Maduvvari:

As the proponent of the project, we guarantee that we have read the report and to the best of our knowledge all non-technical information provided here are accurate and complete. Also we confirm our commitment to finance and implement all construction mitigation and the monitoring program as specified in the report.

Signature:

Name: Aishath Bariyya

Designation: Engineer

Ameenee Magu, Maafannu, Male', 20392, Republic of Maldives. ދާއިރާގެ، ދާދި، 20392، ދިވެހިރާއްޖެ.
+(960) 300 4 300 +(960) 300 4 301 secretariat@housing.gov.mv
www.housing.gov.mv www.facebook.com/housing.gov.mv www.twitter.com/HousingGovMv

Dear Mr. Thoriq Ibrahim

I hereby assure that I have read the EIA for Harbour reconstruction at M. Maduvvari and give you the assurance to undertake the responsibility to do the monitoring and reporting as in this EIA.