ENVIRONMENTAL IMPACT ASSESSMENT

FOR THE SHEET PILING ACTIVITIES IN OLHUVELI, MALE' ATOLL, MALDIVES

Proposed by

Emerald Resorts Private Limited

Prepared by

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EXECUTIVE SUMMARY

This Environmental Impact Assessment (EIA) is an evaluation of the potential environmental, socio-economic and natural impacts of the proposal for the sheet piling project at Olhuveli Beach and Spa Resort.

INTRODUCTION AND KEY FEATURES OF THE PROJECT

PROJECT BACKGROUND AND OBJECTIVES

Several activities have been undertaken in the past to mitigate the effects of beach erosion, which is a major environmental problem at Olhuveli Island. However, the strong current flowing through the narrow channel between Olhuveli and Fun Island is causing the collapse of the existing seawall at the northern coastline, made of cement-sand bags. This area is the site of the service jetty, as well as the powerhouse of the island. Therefore, there is an urgent need for stronger coastal protection measures at the site. The objective of this aim is to reinforce the existing coastal protection using sheet piles, in order to mitigate the risk to infrastructure and human safety.

PROJECT SCOPE AND LIFE SPAN

The proposed project involves the reinforcement of the existing coastal protection on the northern coastline of the island (constructed using cement-sand bag sea wal)l with sheet piles. No additional coastal protection / modification activities will be undertaken as part of this project. Mobilisation for the project will begin after the EIA is approved. The works are targeted for the end of the peak tourist season, and are intended to coincide with the project activities of the planned segrass removal and coastal protection project. It is anticipated that the completion of the sheetpiling project will take 6 months.

CONFORMANCE TO LAWS AND REGULATIONS OF MALDIVES AND INTERNATIONAL CONVENTIONS

The key laws and regulations of the Maldives which are applicable to this proposal are:

1) Environmental Protection Act,
2) Environmental Impact Assessment Regulations 2007,
3) Tourism Act and Regulations

The project components will fully comply with all pertinent laws and regulations.

ENVIRONMENTAL IMPACTS

The potential significant impacts from the project are summarized below:

Potential Adverse Impacts from the Overall Project

1) Damage to coral reef, lagoon benthos and fish population
2) Changes to coastal processes
3) Potential marine water contamination from accidental oil spills
4) Noise and air pollution
5) Vibrations

Potential Positive Impacts from the overall Project

1) Improved tourism product
2) Job opportunities
3) Reduced risk of coastal erosion

ALTERNATIVES

The key alternatives considered for this project are as follows:

1) "No-project" Alternative
2) Alternative Sediment Containment Measures
3) Alternative Materials for Seawall Construction
4) Alternative Piling Techniques

ENVIRONMENTAL MONITORING PROGRAM

The key areas highlighted in the monitoring program are:

1) Sedimentation– Ensure that bundwalls are in place during sheet piling works and check for murkiness of water by visual observation on a daily basis. In addition the water quality of the project site shall be monitored on completion, two months after completion and thereafter annually
2) Marine Water Contamination – All machinery that will be used for the proposed works/activities shall be properly tuned and maintained on a daily basis to avoid any leakage or accidental oil spillage.
3) Erosion and coastal changes
    a. Beach profiles at given locations immediately after sheet piling works and there after annually.
    b. Beachline at high tide and low tide and eroding areas marked using GPS
    c. Longshore currents at beach profile locations and in selected points around the lagoon

Annual monitoring after the completion of construction phase activities will be carried out together with the monitoring activities for the seaweed removal project, as the parameters to be tested are the same.

The proponent is committed to undertake the monitoring programme.

CONCLUSION

This report includes a comprehensive evaluation of the components of the proposed project and the existing environment, and predicted impacts of these project components on the natural environment. Specific mitigation measures to avoid and minimize such impacts have been suggested. In conclusion, the project is expected to result in significant short-term impacts, but they can be mitigated by the proper implementation of the measures prescribed in this report. This includes regular monitoring, in order to anticipate, identify and remediate unforeseen impacts.

1 INTRODUCTION

1.1 PURPOSE OF THE EIA

The purpose of this Report is to fulfil requirements under Article 5 of the Environment Protection and Preservation Act (4/93) of the Maldives to mitigate coastal erosion in Olhuveli Beach and Spa Resort by reinforcing the existing sand-bag sea wall with sheet piles.

This report is developed for Emerald Resorts Private Limited by CDE Consulting.

1.2 PROJECT OVERVIEW AND BACKGROUND

The project discussed in this report is limited to the reinforcement of the existing coastal protection measures at the Northern end of Olhuveli Beach and Spa Resort, using sheet piles. The coastal environment of the area around Olhuveli Island has been heavily modified. In addition to coastal protection and coastal developments, a seagrass removal project was undertaken between 2001 and 2003 to improve the aesthetic quality of the swimming areas and improve the quality of the tourism product offered by the resort. The regrowth of abundant seagrass is several areas of the lagoon has necessitated a second seagrass removal project. An EIA has been conducted for this project, which will include beach replenishment and costal protection measures in addition to the seagrass removal component. The EIA report for this project was completed in November 2009. The project activities are expected to begin at the end of the peak tourist season in 2010, and take 12 months to complete. The sheetpiling activities are planned to coincide with the activities of the second seagrass removal project.

1.3 PROJECT NEED, JUSTIFICATION AND OBJECTIVES

Beach erosion has always been a concern in Olhuveli. Major beach replenishment activities and coastal protection measures have been undertaken in the past to mitigate the effects. However, the coastal protection along the northern coastline (seawall made of cement-sand bags) has proven to be ineffective against the strong current flowing through the 132m-wide dredged channel between Olhuveli and Fun Island, which is causing it to collapse. Critical infrastructure at the site, such as the powerhouse and the service jetty, are being put at risk. Therefore, protection of this coastline is urgently required in order to mitigate the risk to infrastructure and human safety. Sheet piles are more durable and expected to be a more appropriate material for the construction of a sea wall at this high-energy location.

1.4 SCOPE AND TERMS OF REFERENCE OF EIA

This EIA is based on the Environmental Impact Assessment Regulations 2007, within the scope specified in the Terms of Reference (ToR) issued by the Environmental Protection Agency on 13th May 2010. The ToR is based

on scoping meetings held between the stakeholders on 4th May 2010. A copy of the ToR is attached in Appendix A. The EIA report includes the following main aspects.

Chapter 1 and 2: A description of the project including the need for the project, how the project will be undertaken, full description of the relevant parts of the project, implementation schedules, site plans and summary of project inputs and outputs.

Chapter 3: A description of the pertinent national and international legislation, regulations and policies that are relevant and applicable to the project and a demonstration of how the project conforms to these aspects

Chapter 4: Information about the exiting baseline environmental conditions of the site. These include coastal and marine environment of the project site.

Chapter 5: An assessment of the potential impacts (environmental, social, and economic) during both construction and operational stages of the project as well as identification and cost of the potential mitigation measures to prevent or reduce significant negative impacts during both construction and operation stages of the project.

Chapter 6: Assessment of alternatives for the proposed project

Chapter 7: Details of the environmental monitoring plan

1.5 ASSESSMENT METHODOLOGY

The process followed in the preparation of this EIA report consists of five parts. These are: scoping consultations; literature review; field surveys; analysis of results; and compilation of the assessment in the form of a report.

The first step of the process covered consultations with client and government agencies to determine the scope of the impact assessment. During this stage the client clearly outlined their development needs and assessment was geared to match the development plan and environmental assessment needs. The environmental assessment needs was determined based on the EIA Regulations 2007 and the issues brought forward by the stakeholders in the scoping meeting.

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 similar developments in island settings. In this context, the EIA Regulations 2007, best practices from similar development activities, scientific studies undertaken in similar settings around Maldives and previous documents/historical publications was considered. The previous EIA report for the seaweed removal project at Olhuveli was the primary resource used.

Conditions of the existing environment were analysed using established scientific methods and in-house analysis of the field data was conducted using scientific analysis methods. These methods will be explained in detail in later sections.

The final stage involved compilation of individual consultants' findings.

1.6 EIA TEAM MEMBERS

The team members of this EIA are:

Dr. Simad Saeed (Environmental Management and Planning Consultant, Team leader)
Dr. Ahmed Shaig (Coastal Environment, Marine Environment and Remote Sensing Consultant)
Hafeeza Abdulla (Environmental Management Consultant)
Aminath Afrah Rasheed (Environmental Management)

The curriculum vitae's of the EIA consultants are attached in Appendix D of this report.

2 PROJECT DESCRIPTION

2.1 PROJECT LOCATION

Olhuveli Island is located on the eastern rim of South Male' Atoll, about 37km from Male' International Airport. It is approximately 720 m long and 120 m wide, and has a land area of approximately 8 Ha. It's nearest inhabited island is Guraidhoo (5.21 km) and the nearest uninhabited islands are Kudafinolhu (1.24km) and Maadhoo (1.79km). The resort Fun Island is located at 0.17km to the North of the island.

Figure 2-1: Location of proposed project site

2.2 PROJECT SITE PLAN

The proposed conceptual and site plan for the project is presented in Figure 2.2 below and provided in Appendix B.

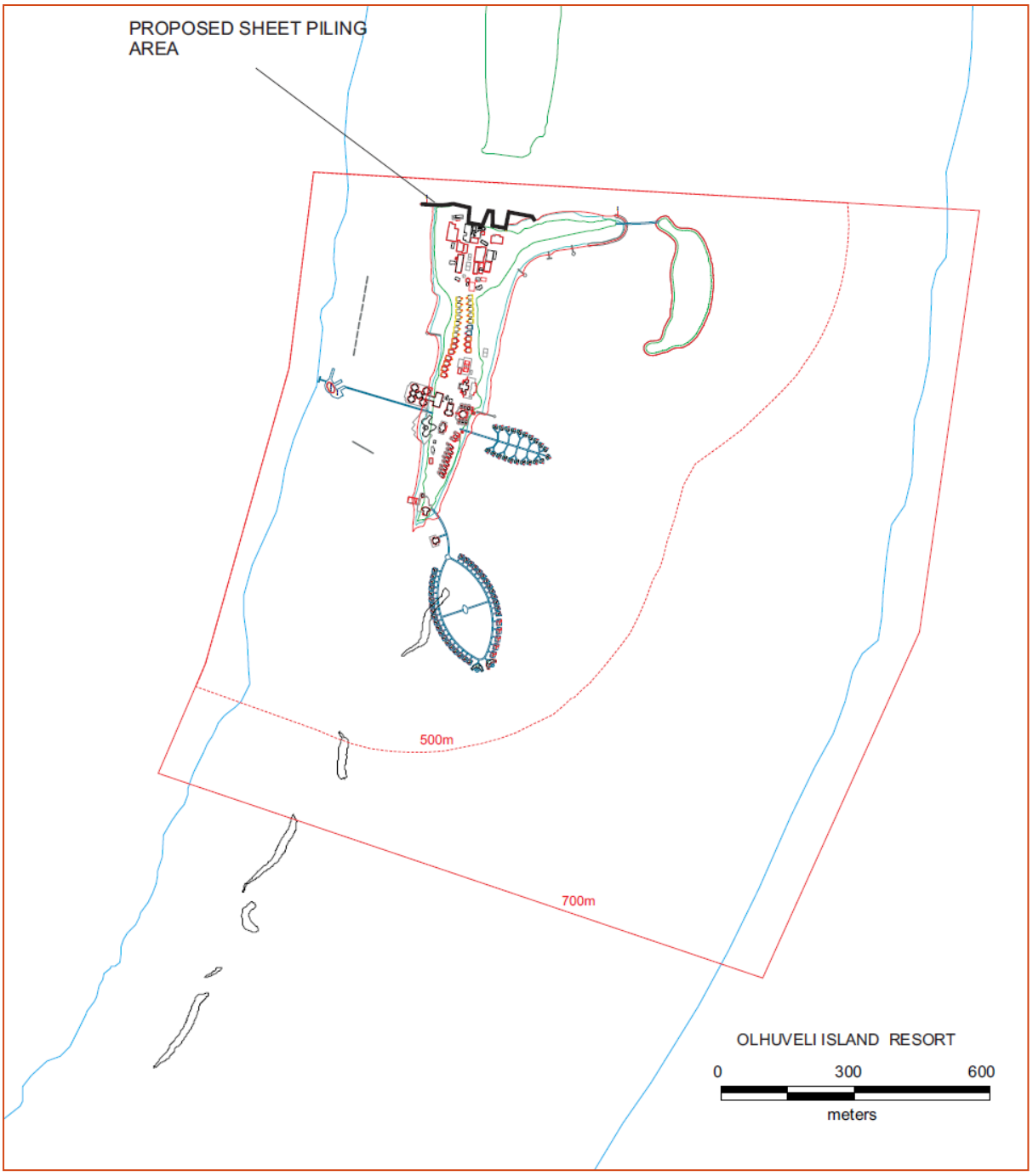


Figure 2-2: Conceptual plan for the project

2.3 EXISTING SITE CONDITIONS

The island of Olhuveli has been significantly modified over the last 10 years. The shape and size of the island has undergone considerable changes due to land reclamation and beach replenishment activities, as well as dredging and coastal developments.

Seagrass removal: The area between Olhuveli and Fun Island (on the northern side of Olhuveli), and an area on the eastern reef flat were dredged before the seagrass removal project of 2001-2003. A second seagrass removal project is planned and will include seagrass removal from four additional areas on the eastern and southeastern reef flat, totaling an area of 335,000 m^2.

Dredging: The area between the two islands have been significantly dredged under the Fun Island Resort operations over the last few years. The most recent activity was in 2008 and 2009 under the Fun Island Redevelopment Project, for which a separate EIA was undertaken in March 2008. The area is very deep reaching over 4 m in some locations and is designed for large vessels to approach the Fun island service jetty on the southern tip of the island. The figure below shows the redevelopment proposal of Fun Island as approved by EPA in 2008. One of the main reasons for undertaking this project is the continued failure of the existing quay wall amidst extensive dredging activities between the two islands.

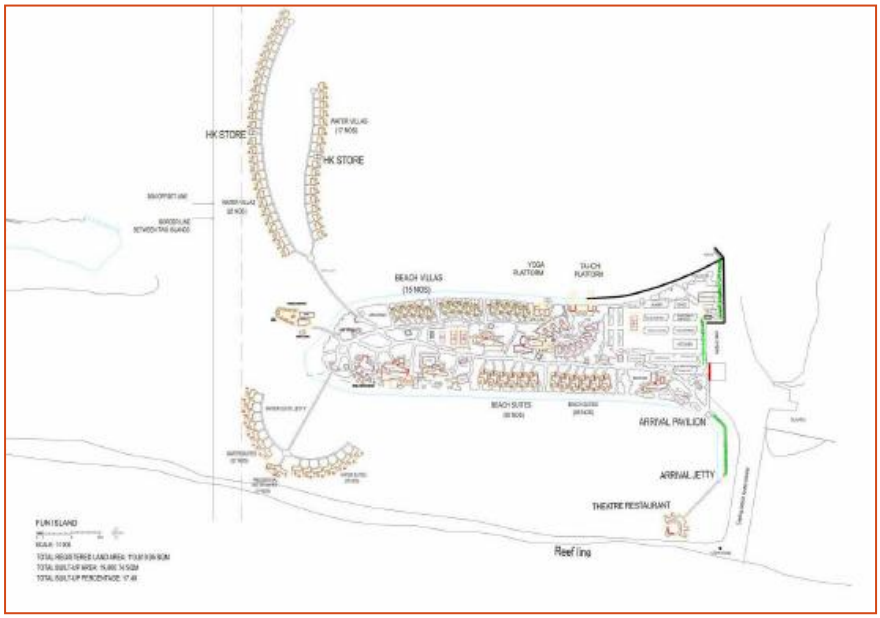


Figure 2.3: Fun Island redevelopment plan approved by Ministry of Tourism and EPA (source: Fun Island Redevelopment EIA, March 2008).

Islet: a small islet was created on the north eastern corner of Olhuveli during the first seagrass removal project. This islet will be enlarged in the second seagrass removal project.

Coastal protection: sand-cement bags have been used for protection of the northern coastline. The north eastern corner is protected using rock boulders. A pilot project using ECOPLAGE technology for coastal protection is planned to be undertaken on the eastern coastline of Olhuveli and the nearby islet.

Coastal hydrodynamics: a very strong current flows between Olhuveli and Fun Island. Wave activity is strongest on the eastern flat during the northeast monsoon, and is generally calm during the southwestern monsoon. Coastal modification activities in the neighbouring Fun Island have also made the area between the two islands a heavily modified region. The natural coastal processes are not in operation at the northern end of the island, due to the extensive land modification and coastal protection.

Figure 2.4 below summarises the existing site conditions.

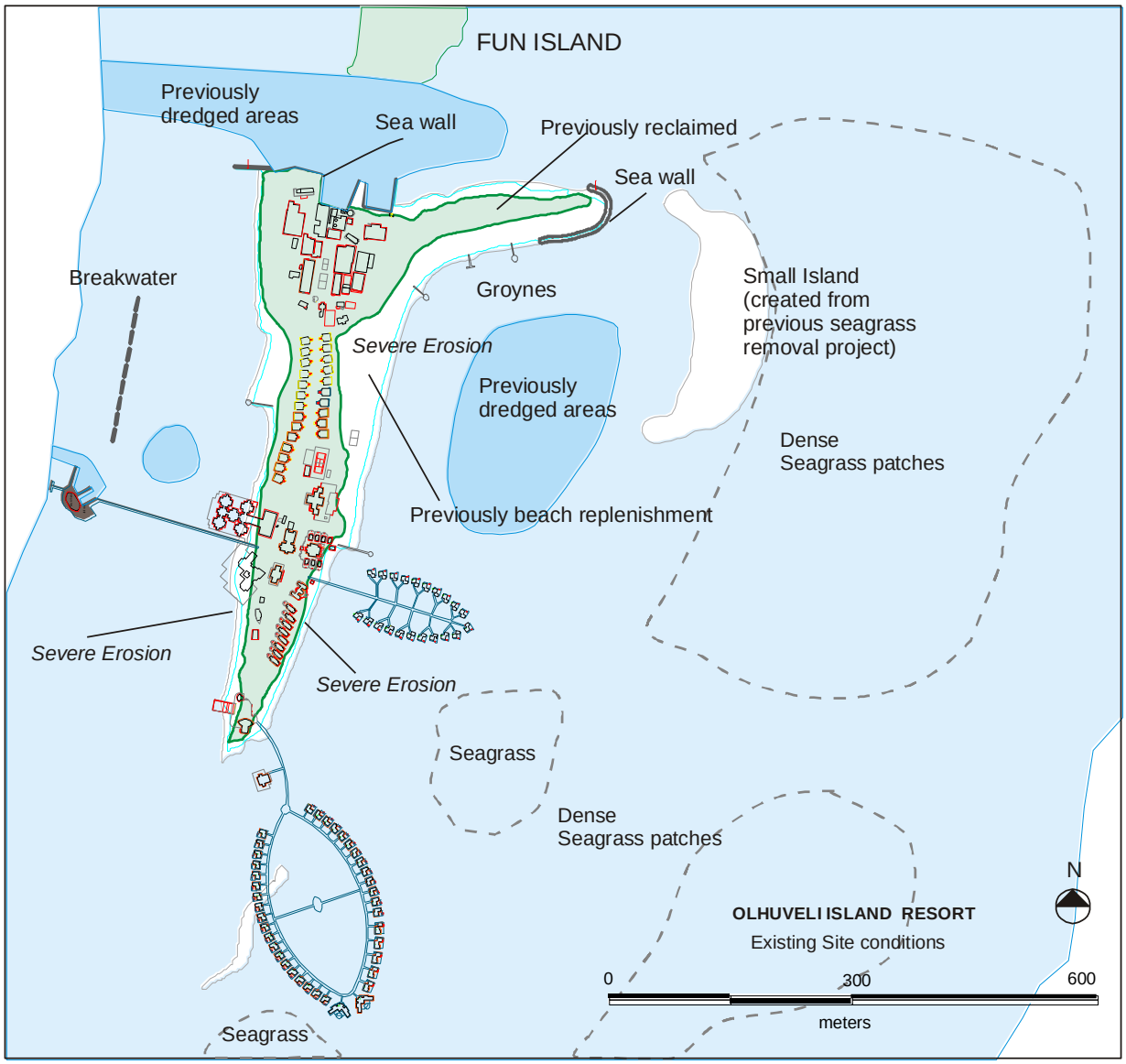


Figure 2.4: Summary of existing site conditions

2.4 PROJECT OUTLINE AND WORK METHODOLOGY

There are three major components in this project:

1. Sheet piling

The project proposes to replace the existing sand-cement bag quay wall and breakwaters with sheet piles to prevent the continued collapse of existing features. The sheet piles will be placed 1-2 m outside the existing structures to provide stability. The existing cement-sand bags will not be removed. The area planned for sheet piling is shown in Figure 2.2. No additional coastal protection, coastal modification or dredging activities will be undertaken as part of this project.

Interlocking steel sheets will be driven into the ground, using the vibratory piling technique to form a continuous, impermeable barrier in the ground. A crane will be used to place the piles. The vibratory pile driver will be positioned over the piles using a crane and fastened using bolts/clamps. Vertical vibrations (generated by a diesel-powered engine) will be transmitted into the pile, driving the pile into the ground.

2. Backfilling

The ground surface between the sheet piles and the old quaywall will be backfilled using dredged material from the harbor basin. Since the existing quay wall area requires maintenance dredging, this activity will be used to acquire sand for the backfilling. A total length of 126 m of coastline on the northern side of the island will be protected using the sheet piles under this project, as shown in Figure 2.2.

2.5 PROJECT SCHEDULE AND LIFE SPAN

Mobilisation for the project will begin after the EIA is approved. The works are planned to coincide with the activities of the second seagrass removal project, for which a separate decision note has been issued. The completion of the sheet piling activities will take approximately 6 months.

2.6 LABOUR REQUIREMENTS AND AVAILABILITY

Due to the nature of the proposed project, the works will be put up for tender amongst pre-identified groups. The total number of employees required for the sheet piling activities will be about 15. They will be based in a designated section of the staff area. Their daily requirements for food, water and other necessities will be provided within the existing staff services framework.

2.7 WASTE MANAGEMENT, LOGISTICS AND SAFETY MEASURES

2.7.1 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

Wastes created due to sheetpiling would include mostly general domestic waste generated by the construction workforce. Small amounts of waste oil may be generated from the operation and maintenance of vehicles.

All waste oil will be disposed according to the standards established by the Environment Ministry. Waste disposal will be accommodated within the existing framework for disposal of construction waste from the second seagrass removal project, the activities of which will coincide with the sheetpiling activities.

2.7.2 POLLUTION AND EMISSION 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 a secure and bunded location to minimize risk of spill.

2.7.3 SEDIMENT CONTAINMENT AND TURBIDITY CONTROL MEASURES

The proponent is committed to preventing any sedimentation of the reef system from this proposed project. The following specific measures will be undertaken during the project.

- Establish bund walls around the project area to control sediment disbursing. Bund walls will be removed after the sediment has been adequately settled within the lagoon.
- Undertake work during calm weather conditions.

2.7.4 HEALTH AND SAFETY MEASURES

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

2.8 SUMMARY OF 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 2.1 and the type of outputs (products and waste streams) and what is expected to happen to the outputs are given in Table 2.2

Table 2.1: Major Project Inputs

Input resource(s)	Source/Type	How to obtain resources
Construction workers	Local and foreign	Contractor's employees or by announcement
Engineers and Site supervisors	Local and foreign	Contractor's employees or by announcement
Water supply (during construction)	Desalinated water	From resort operations
Electricity/Energy (during construction)	Diesel	From resort operations
Machinery	Vibratory pile driver, crane, trucks, etc	Contractor's machinery or hire locally where available
Construction materials	Interlocking steel sheet piles	Import or local purchase where available
Maintenance material	Maintenance parts and fluids required for the machinery and piping.	Import or purchase locally where available
Food and Accommodation	NA	From resort operations
Fire fighting equipment	Smoke Detectors, Fire Extinguishers...etc.	From resort operations
Fuel	Light Diesel, LPG Gas, Petrol, Lubricants	Local suppliers
Telecommunication	Mobile phones, fax machines and internet facilities	From resort operations
Food and beverage bottles	PET bottles, glass bottles, packaging waste, plastic bags and various frozen, packaged and fresh food.	From resort operations

Table 2.2: Major Project Outputs

Products and waste materials	Anticipated quantities	Method of disposal
Waste oil	Small quantities	Barrelled and sent to designated site.
Hazardous waste (diesel)	Small quantities	Barrelled and sent to designated site.
Noise	Only localised	Pile driver, excavator and truck operation will be noisy.
Food waste	Small quantities	Managed under existing waste management plan of the island
Plastic and packaging wastes	Small quantities	Managed under existing waste management plan of the island
Dredge waste	As required for backfilling	Used for back filling between the sheet piles and old quay wall.

2.9 DEMOBILIZATION

Demobilization plan depends on the contractor. In general, the proponent advocates a phased demobilization plan to commence in the last month of the contract. Machinery transported from Male' will have to be demobilized on one specific date.

3 POLICY AND LEGAL FRAMEWORK

These legal and policy provisions have to be fully respected in carrying out the proposed development. All contractors and sub-contractors will be informed of these requirements.

3.1 RELEVANT ENVIRONMENT LEGISLATION

3.1.1 ENVIRONMENT PROTECTION AND PRESERVATION ACT (ACT NO. 4/93)

- Environment Protection and Preservation Act of Maldives (4/93) is the framework law on environmental management in the Maldives. Articles 2, 4, 5, 6, 7, and 8 of the law are relevant to this project.
- Article 2 states that the concerned government authorities shall provide the necessary guidelines and advise on environmental protection in accordance with the prevailing conditions and needs of the country. All concerned parties shall take due considerations of the guidelines provided by the government authorities. The project proponent shall abide by any guidelines or advice given by the concerned Government authorities for the project. The concerned Government authorities are identified in this Chapter.
- Article 4 states that the Ministry of Housing, Transport and Environment shall be responsible for identifying protected areas and natural reserves and for drawing up the necessary rules and regulations for their protections and preservation. The proponent shall ensure that there is no negative impact from the proposed project on any protected areas.
- According to Article 5 (a) of the Act, an Environmental Impact Assessment study shall be submitted to the Ministry of Housing, Transport and Environment (MHTE) before implementing any activity that may have an impact on the environment. This EIA report is prepared and submitted by the project proponent to fulfil the legal requirement stipulated in Act (4/93) Article 5.
- According to Article 6, the Ministry of Housing, Transport and Environment has the authority to terminate any project that has any undesirable impact on the environment. A project so terminated shall not receive any compensation. The project proponent is aware of this provision and will take all practical measures to ensure there is no irreversible and significant negative impact of the project.
- Article 7 of the Environment Protection Act (4/93) prohibits the disposal of wastes, oil and gases in a manner that will damage the environment. Wastes, oil and gases has to be disposed off in areas designated by the Government. Hence, the project proponent shall use the existing Environmental Management Plan for the Olhuveil Island Resort which specifies how the wastes, oil and gases generated by the project will be disposed.

- Article 8 of the Environment Protection Act (4/93) prohibits the disposal of hazardous wastes. Any hazardous wastes that may be generated from the project shall be transferred to the designated waste site in Thilafushi for disposal according to Government regulations and standards.

3.2 RELEVANT REGULATIONS AND GUIDELINES

- Environmental Impact Assessment regulations were issued by Environment Ministry on 1st May 2007. The first step in environmental assessment process involves screening of the project to be classified as one that requires an EIA or not. Based on this decision, the Ministry then decides the scope of the EIA which is discussed with the proponent and the EIA consultants in a "scoping meeting". The consultants then undertake the EIA starting with baseline studies, impact prediction and finally reporting the findings with impact mitigation and monitoring programme. This report follows the principles and procedures for EIA outlined in the EIA regulations.
- The EIA report is reviewed by MHTE following which an EIA Decision Note is given to the proponent who will have to implement the Decision Note accordingly. As a condition of approval, appropriate environmental monitoring may be required and the proponent shall have to report monitoring data at required intervals to the Ministry. The project proponent is committed to implement all impact mitigation measures that are specified in this EIA report. Furthermore, the proponent is committed to environmental monitoring and shall fulfil environmental monitoring requirements that may be specified in the EIA decision note as a condition for project approval.
- With the Tourism Law as the basis, the Ministry of Tourism has released environmental regulations for tourist resort development and operation in 2006. The environmental regulations issued by the Tourism Ministry will be adhered to at all stages of the proposed project.

3.3 ENVIRONMENTAL PERMITS REQUIRED FOR THE PROJECT

3.3.1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) DECISION NOTE

The most important environmental permit to initiate project work would be a decision regarding this EIA. The EIA Decision Note shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Note may only be given to the Proponent after a review of this document following which the Ministry may request for further information or provide a decision if further information is not required. In some cases, where there are no major environmental impacts associated with the project, the Ministry may provide the Decision Note while at the same time requesting for further information.

3.4 RESPONSIBLE INSTITUTIONS

The main government institutions that have roles and responsibilities relevant to this project are the Ministry of Housing, Transport and Environment; the Ministry of Tourism and the North Central Province Office. Their respective roles and responsibilities are described below.

3.4.1 MINISTRY OF ENVIRONMENT

The Ministry of Environment is mandated for the effective implementation of the Environmental Protection Act of the country and has the statutory power over issues related to the environment. It has the central control over the environment protection, management, conservation and environmental emergencies. The Ministry operates mainly at a policy level and the more regulatory and technical assessment activities are mandated to the Environmental Protection Agency (EPA). In this respect EPA has now been mandated to manage all issues relating to Environmental Impact Assessment of individual projects.

The Ministry of Environment also seeks the advice of National Commission for the Protection of Environment (NCPE) on all significant environmental matters. The commission is appointed by the president and is mandated to advice the Minister of Environment on environmental matters such as environment assessment, planning and management, and political decisions with regard to the protection of environment.

3.4.2 MINISTRY OF TOURISM

The Ministry of Tourism is solely responsible to the affairs relating to development and operation of all tourist resorts and tourism developments in Maldives. All matters relating to the development of the beach and mining of sand should be communicated with Ministry of Tourism, who will arrange or facilitate for the matter to be dealt within the government framework. All regulations released by Ministry of Tourism and other agencies pertaining to the operation of tourism projects are monitored and implemented by the Ministry. Hence, the major contact point for this project is Ministry of Tourism.

3.4.3 NORTH CENTRAL PROVINCE OFFICE

The 20 administrative atolls of the Maldives have recently been grouped under seven provinces to facilitate the local governance system and decentralized decision-making as necessitated by the new constitution of the Maldives. Olhuveli, located in Male' Atoll, belongs to the North Central Province. The Province Office, established in K. Maafushi, co-ordinates and liaises with Government Ministries on all issues relating to the North Central Province. A Minister of State for Home Affairs is responsible for the North Central Province Office.

3.5 INTERNATIONAL CONVENTIONS

3.5.1 CONVENTION ON BIOLOGICAL DIVERSITY

The Maldives is party to the United Nations Convention on Biological Diversity. The objective of the convention 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 proposed development activities outlined in this project does not fall on any area recognised for its ecological value. Therefore it is unlikely there will be a major loss of biodiversity. The loss is not going to be significant at atoll or national level. Yet, it is recommended that the developer ensures that silt screens are used during to minimise any impact on the marine biodiversity.

3.5.2 UNFCCC AND KYOTO PROTOCOL

The Maldives is party to the United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. The objective of the Convention is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The IPCC defines mitigation as "an anthropogenic intervention to reduce the sources or enhance the sinks of green house gases." The greenhouse gas inventory of the Maldives forms an integral part of the First National Communication of the Maldives to the UNFCCC. In March 2009, the President of the Maldives has announced the target to make Maldives carbon neutral by 2020. Hence, in the implementation of the project, careful attention needs to be given to ensure energy efficiency and reduce transport related fuel consumption.

The IPCC defines adaptation "as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects." Various type of adaptation include anticipatory and reactive adaptation; private and public adaptation; and autonomous and planned adaptation. The adaptation policies and strategies of the Maldives are given in the Maldives National Adaptation Programme of Action (NAPA). The coastal protection measures can be considered as a long term adaptation measure against beach erosion caused by rising sea levels.

4 EXISTING ENVIRONMENT

4.1 INTRODUCTION

This section includes the compilation and evaluation of baseline data on the relevant environmental characteristics of the study area, comprising of the following subsections:

I. Study Methodologies

II. Physical Environment

   a) Physical Environment Modifications

   b) Geomorphology

   c) Meteorology

   d) Hydrology

      Waves, tides, currents, longshore sediment transportation patterns, bathymetry

II. Biological Environment

   a) Lagoon

      Fish communities, sea grass communities, coral communities and marine water quality

   b) Coastal habitat of impacted area

The description of the existing environment presented here is based on the data presented in the EIA report for the second seagrass removal project compiled in November 2009, and is presented below as in the 'EIA for the Removal od Seagrass and Beach Replenishment Activities in Olhuveli, Male' Atoll, Maldives'.

4.2 STUDY METHODOLOGIES

Olhuveli Island has an ongoing environmental monitoring programme as required under the Environment Regulation of Tourist Resorts. Much of the high resolution data required for this EIA is available from the monitoring database. Additional baseline data specific to the sea grass beds were analysed by using standard scientific methods.

The environmental components of the study area were divided into marine and coastal environment. The marine environment covered the lagoon habitats and coral reef system including coral patches, fish communities, marine water quality, seagrass patches and bathymetry of the site. The coastal environment covered the beaches and coastal processes including longshore sediment transport patterns and coastal erosion of the site. Particular attention was placed in detailed surveys of marine environment life and coastal processes, as these components are likely to involve the most significant environmental impacts.

Lagoon benthos of the site was surveyed by conducting timed swims, quantitative LIT surveys and manta tows. Depths of shallow areas near the shore and seagrass beds had to be taken manually using a staff. Drogue method was used to measure the current. Tidal data was taken from previous research. To assess the marine water quality of the site, samples were collected in clean 1500ml PET bottles after washing them with water to be sampled. Parameters tested were Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Dissolved Solids (TDS), temperature, turbidity, pH, nitrates, nitrites, phosphates and oil and grease. All parameters were analysed at the National Health Laboratory.

To assess the coastal environment of the site, 11 beach profiles are regularly measured using standard levelling techniques. These profile locations are marked in Figure 4.1 below. The measurement of beach profiles involved standard practice of surveying with a staff and a dumpy level.

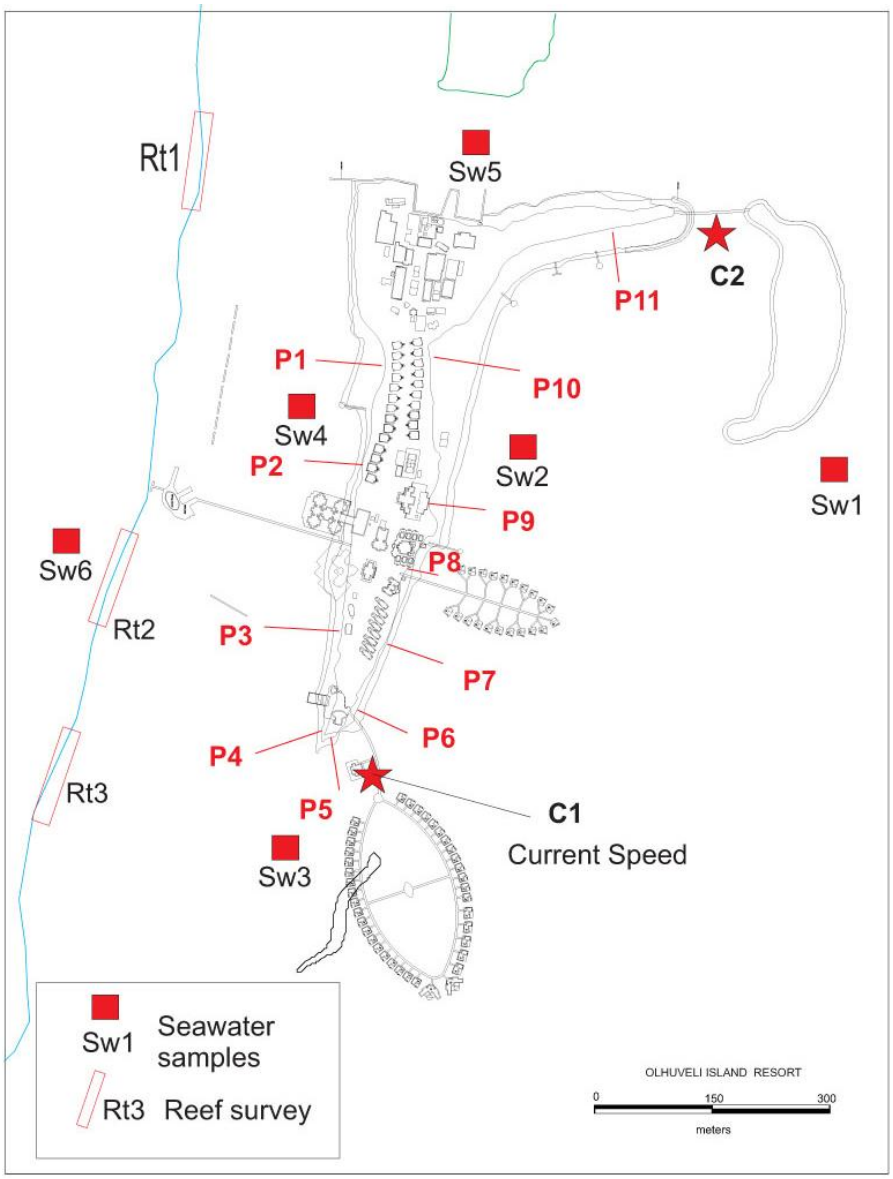


Figure 4-1 Detailed Survey Locations as specified in the Monitoring Plan

4.3 PHYSICAL ENVIRONMENT

4.3.1 PHYSICAL ENVIRONMENT MODIFICATIONS

The physical environment of Olhuveli has been significantly modified and is no longer in its natural state. Much of the changes on the island began after a massive reclamation project on the adjoining Fun Island Resort. Fun Island underwent a ten-fold increase in land area and dredging was undertaken between Fun Island and Olhuveli Island. This project is known to have had a major impact on Olhuveli, particularly severe erosion. Since then, particularly following the Indian Ocean Tsunami of 2004, Olhuveli has undergone significant changes. These changes could be summarised as follows:

- *Beach Replenishment:* Mainly on the eastern side and parts of the western coastline
- *Land Reclamation:* A small island on the eastern side, created from dredge waste. There is no development on this island. Natural and artificial vegetation growth is continuing on the island. There is also a reclaimed section of the island on the northern end (see figure 2.4). The rationale for this project was the extensive construction activities undertaken in Fun Island in the past and its impact on the tourism product in Olhuveli.
- *Dredging:* i) Between Fun Island and Olhuveli; ii) on the oceanward reef flat of Olhuveli; and iii) Access jetty area and lagoonward reef flat.
- *Coastal protection:* i) On the eastern end of the reclaimed land, constructed using boulders; ii) Seawall on the northern side of the island near the service area. Construction undertaken using sand-cement bags. Also used as a quay wall for the service vessels.
- *Erosion Prevention measures:* There are eight groynes located around the island as an erosion mitigation measure.
- *Breakwater:* There is an offshore erosion prevention measure on the lagoonward side designed to protect the beach from strong SW monsoon wave activity. It is constructed using rock boulders.
- *Previous sea grass removal activities:* Approximately 80,000 m^2 of sea grass removed from the lagoonward shoreline between 2001 and 2003, for which a separate EIA was undertaken in December 2001 by Olive Green Pvt. Ltd. The seagrass overgrowth issues on the lagoonward side is very much controlled at present.

Several activities have also been planned to be carried out as part of the second seagrass removal project, which is planned to commence at the end of the peak tourist season of 2010. Components of the project are summarized below.

- The first stage will concentrate on the seagrass removal and cleaning activities. Seagrass areas covering approximately 335,000 m^2 is proposed to be cleared, creating 84,000 m^3 of dredge waste

- The second stage will involve replenishment and development of pilot erosion protection measures. The dredged waste from the sea grass removal activity will be used to replenish the area with severe erosion up to 10 m from the existing shore line. However, in areas with severe beach losses, replenishment up to 15 m has been considered since the beach has already retreated well past the previous beach line. Any excess material will be disposed around the small islet off the western shoreline of the island. The coastal protection component involves using ECOPLAGE technology to prevent coastal erosion.
- The final stage will involve revegetation of the replenished areas and the establishment of erosion protection measures on the eastern coastline. The use of ECOPLAGE technology will depend on the results from the pilot project.

4.3.2 GEOMORPHOLOGY

Olhuveli Island is a geologically young island located on one of the largest reef systems in the Maldives. The island is located closer (270 m) from the atoll lagoonward coastline and about 1000 m from the oceanward reef edge. The island, along with for small islands in the vicinity, appears to have formed with the extensive sediments present on the western side of the reef system. Evidence of it recent geological development is found in the numerous seasonal sand banks that exist on the reef system and its original vegetation system.

The island is oriented in a north south direction, parallel to wave activity during the NE and SW monsoon but adjacent to the predominant current pattern in the lagoon. The elongated shaped is likely to have been cause by the seasonal north-south littoral drift, as is evident from the historical aerial photos. Recent analyses in 2001 and 2005 (EIAs for various developments on the island) indicated that the island is growing southward. This is plausible if the large number of sediments that drift off the southern tip of the island occasionally merges the island. No such evidence was noted during the field survey and the currents along the southern end were observed to be strong.

There is evidence of a strong current flowing east to west along the reef system. Historical photographs show a sediment fan being formed on the lagoonward reef slope between Olhuveli and Fun Island, and off the southern tip of Olhuveli. The reef flat edge and reef slopes are seen to be covered with sediments in these areas. This indicated a net sediment loss and past severe erosion on the two islands.

Olhuveli Island is generally low lying with an average elevation of 1.2 m MSL. This is generally expected in islands located away from the oceanward reef flat. There are no significant coastal ridges. It is difficult to determine the exact nature of topographical and geomorphologic features due to the extensive modifications undertaken on the island.

4.3.3 METEOROLOGY

4.3.3.1 CLIMATE

The climate in Maldives is warm and humid, typical of the tropics. The average temperature ranges between 25°C to 30°C and relative humidity varies from 73 percent to 85 percent. The annual average rainfall is approximately 1,948 mm (MHAHE, 2001). As Maldives lies on the equator, Maldives receives plenty of sunshine throughout the year. Significant variation is observed in the climate between the northern and the southern atolls. The annual average rainfall in the southern atolls is higher than the northern atolls. In addition, greater extremes of temperature are also recorded in the southern atolls.

There is no climate station on the proposed site. The nearest weather station is in Male' International Airport. The mean daily maximum temperature is 30.5°C and minimum temperature is 25.7° C. The average annual rainfall is 1924.7 mm and there is torrential rain during the wet season (Southwest monsoon). Figure 4.2 provides a summary of key meteorological condition at Male' Region.

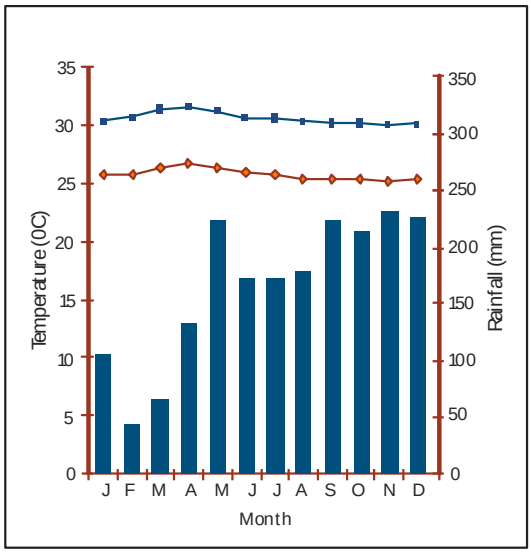


Figure 4-2: Summary of mean rainfall and temperature values for Male' International Airport

4.3.3.2 MONSOONS

The climate of Maldives is characterised by the monsoons of Indian Ocean. Monsoon wind reversal significantly affects weather patterns. Two monsoon seasons are observed in Maldives: the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The parameters that best distinguish the two monsoons are wind and rainfall patterns. The southwest monsoon is the rainy season while the northeast monsoon is the dry season. The southwest monsoon occurs from May to September and the northeast monsoon is 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.

4.3.3.3 WINDS

The winds that occur across Maldives are mostly determined by the monsoon seasons. The two monsoons are considered mild given that Maldives is located close to the equator. As a result, strong winds and gales are infrequent although storms and line squalls can occur, usually in the period May to July. During stormy conditions gusts of up to 60 knots have been recorded at Male'.

Wind has been 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 ms-1 for the period 1975 to 2001. Mean wind speed as highest during the months May and October in the central region. Wind analysis indicates that the monsoon is considerably stronger in central and northern region of Maldives compared to the south (Naseer, 2003).

Wind recorded at National Meteorological Center (Hulhule) indicates that strong windy conditions generally occur during south-west monsoons. Wind gusts of 35 mph to 45 mph were occasionally recorded when effects of cyclones from Arabian Sea were felt in the country. Direction of wind changes predominantly from north-east in the northeast monsoon to west and south-west in the southwest monsoon and variable direction of wind are experienced in the monsoon transition periods.

Table 4.1 summarises the wind conditions in central Maldives throughout a year. Medium term meteorological data from National meteorological center (see Figures 4.4 – 4.6) and findings from long-term Comprehensive Ocean-Atmosphere Data Set (COADS) are used in this analysis.

Table 4.1: Summary of General Wind Conditions for National Meteorological Center

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

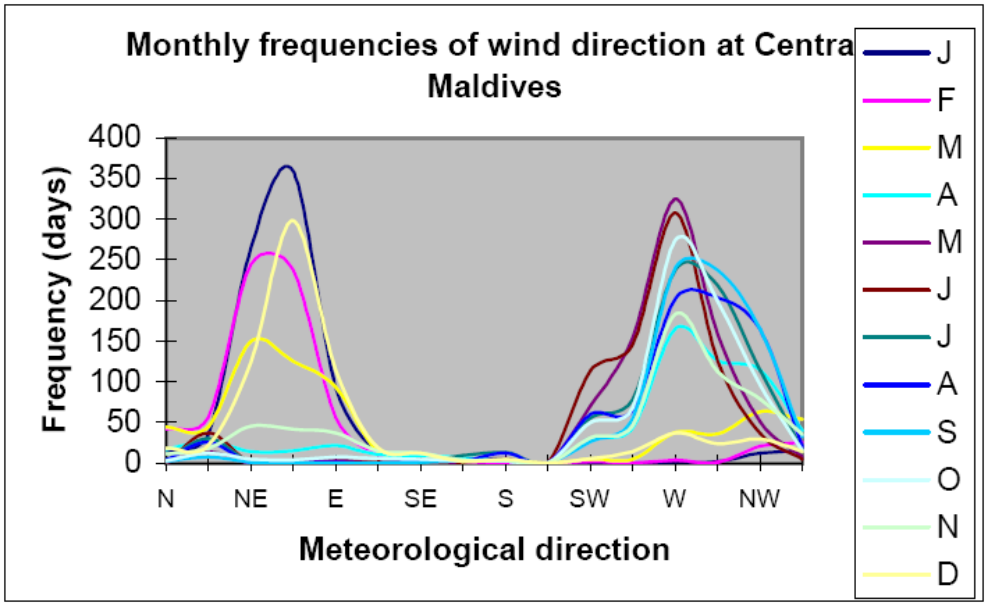


Figure 4-3: Monthly Frequencies of Wind Direction in Central Maldives based on National Meteorological Center 27 year Data (Adapted from Naseer, 2003)

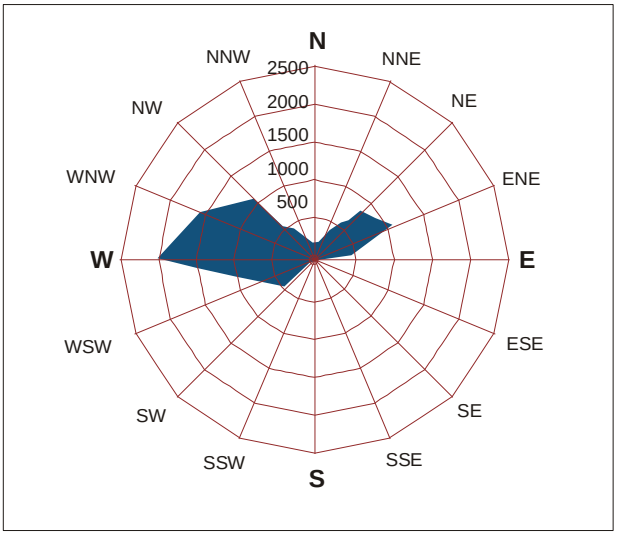


Figure 4-4: 27 year Wind Frequency Recorded at Hulhule' Meteorological Center

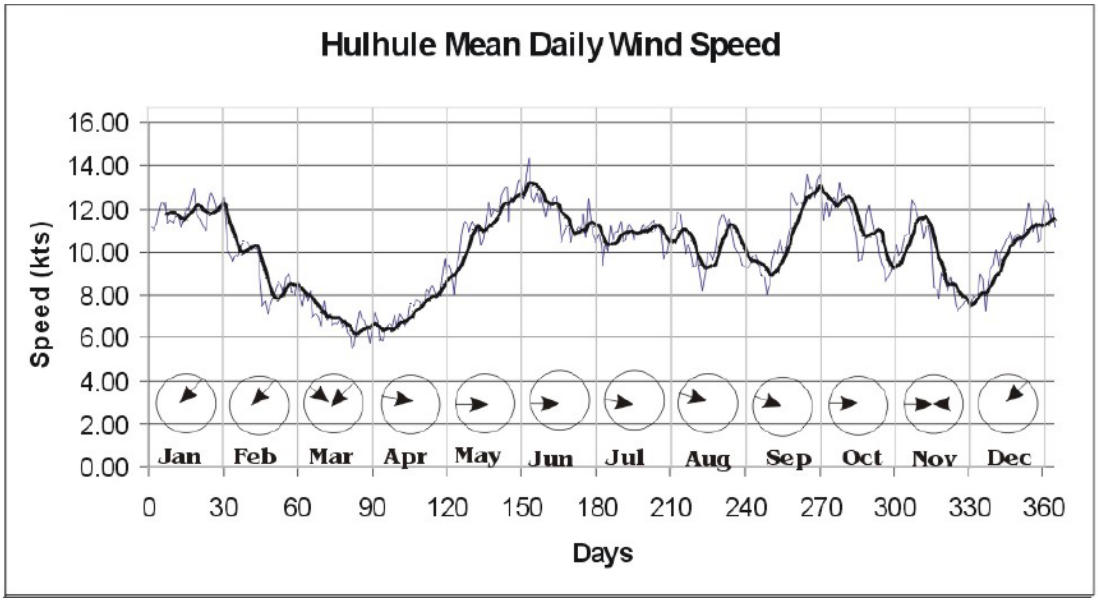


Figure 4-5: Mean daily wind speed and direction recorded at National Meteorological Center. Arrows indicate dominant wind direction (Adapted from Naseer, 2003)

4.3.4 HYDROLOGY

4.3.4.1 WAVES

Two major types of waves are observed along the coast of Maldives. The first type is wave generated by local monsoon wind with a period of 3-8 seconds and the second type is swells generated by distance storms with a period of 14-20 seconds (Lanka Hydraulics 1988a & 1998b). The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. Wave data for Male and Hulhule' between June 1988 and January 1990 (Lanka Hydraulics 1988a & 1998b) shows that the maximum significant wave height (Hs) recorded for June was 1.23 m with a mean period (Tm) of 7.53s. The maximum recorded Hs for July was 1.51 m with a Tm of 7.74s. The mean wave periods for the survey period were 5.0 – 9.0s and the peak wave periods were within 8.0 – 13.0s.

Maldives experiences occasional flooding caused by long distance swell waves that are generated by South Indian Ocean storms (Goda 1988). The swell waves of height 3 metres that flooded Male' and Hulhule' in 1987 are said to have originated from a low pressure system off west coast of Australia. More recently in May 2007 swell waves that originated from the southwestern side of the Indian Ocean caused flooding in 35 inhabited islands across 13 atolls, including Addu atoll.

In addition, Maldives have recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP, 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than 1 occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Choi et al., 2003).

The proposed site is exposed to wind generated waves during NE monsoon and during transition periods. It is also expected to experience swell waves throughout the year. The western side is likely to experience wind waves originating from within the atoll and residual swell waves approaching through the reef passes on the southern end of the atoll.

These aspects of climate and associated wind patterns are considered in the design of the beach replenishment and erosion prevention measures and in the timing of sea grass removal activities. It may be difficult to undertake the sea grass removal activities during the peak NE monsoon due to potentially strong wave activity on the reef flat. However, the distance between the reef edge and the island shoreline may reduce the wave energy in the proposed site.

4.3.4.2 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. Like in most other atolls, semidiurnal tides are experienced in Male' Atoll - that is two high tides and two low tides a day. The tide varies from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year. Tidal variations in Maldives are presented in Table 4.2.

Table 4.2: Tidal Variations at Male' International Airport (Source: MEC 2004)

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

Astronomical tides are related to the motion of the earth-moon-sun system, and have a range of periodicities. The highest astronomical tide was recorded as 0.64 m above the mean sea level and the lowest astronomical tide was recorded as 0.56 m below the mean sea level. Tidal variation of 1.2m from lowest to the highest tide levels were recorded in the country. Tidal variation of about 1 m was recorded at the site during the field surveys.

4.3.4.3 CURRENTS

Currents that affect the reef system of the proposed site can be caused by tidal currents, wind-induced currents and wave-induced currents. It is presumed that generally current flow through the country is defined by the two-monsoon season winds. Westward flowing currents are dominant from January to March with the change in current flow pattern taking place in April and December. In April the westward currents become weak while the eastward currents start to take over. In December, the eastward currents are weak with the westward currents becoming more prominent. Hence, currents within the site are very likely to be heavily influenced by the monsoons.

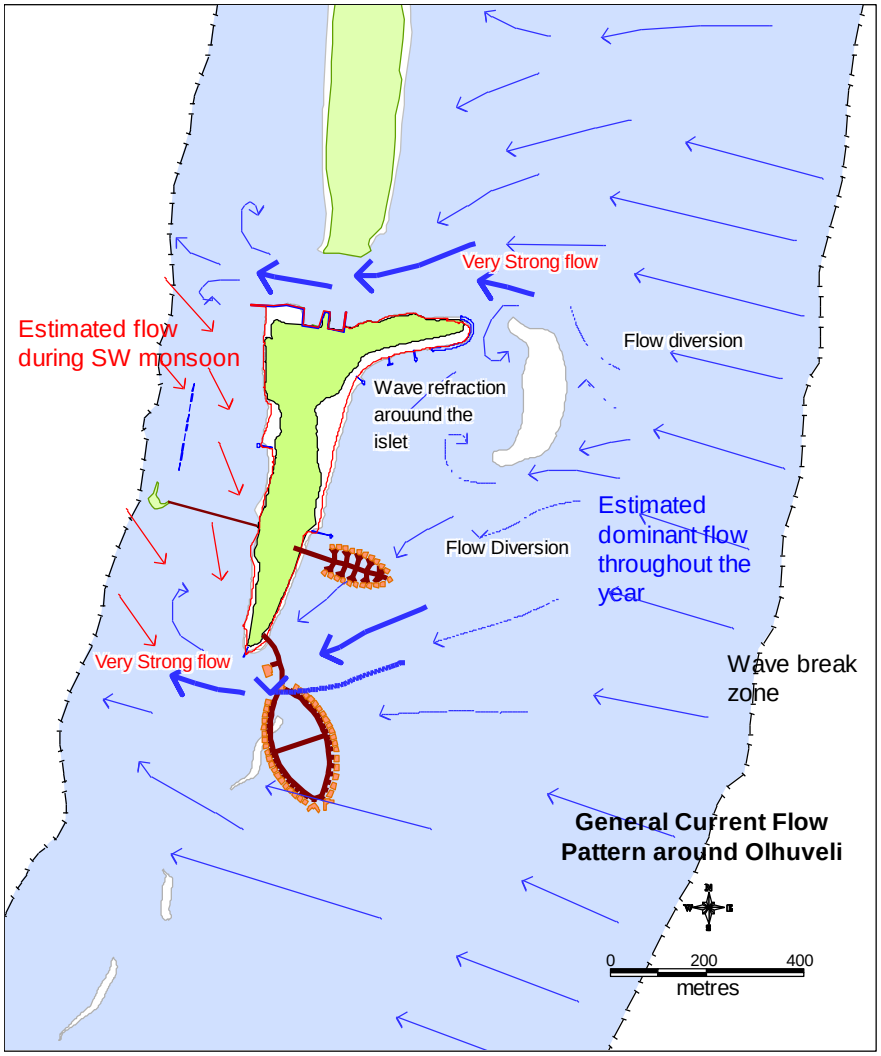


Figure 4-6: Estimated current flow patterns around Olhuveli

Figure 4.6 above presents the estimated current flow pattern around the island. The patterns shown in blue are the estimated general patter throughout the year. This is based on the fact that there are year round long distance swell waves reaching the reef system. The strength of the currents on the oceanward reef flat is likely to be strongest during the NE monsoon and transition periods. Current flow during the SW monsoon is

generally eastward with a southeasterly direction. This pattern has assisted in the island evolution and to the specific shape and location of the island.

Current measurements in the project site showed fairly constant speeds of 0.2m/s during flood and 0.1m/s during ebb. The currents flowed in a westerly to a north westerly direction during the surveys. Current are stronger towards the reef edge and minimal close to the shoreline. Currents between Fun Island and Olhuveli, and on the southern end of Olhuveli is strong with speeds recorded at 0.7 m/s. There is considerable wave diffraction around the small islet leading to the formation of two small sand pits. Currents behind the small islet are negligible.

4.3.4.4 BATHYMETRY

The general bathymetry around the island s provide din figure 4.7 below. The average depth around the island is -1.4 m. The depths around the oceanward side are generally shallow around 1.4 m on average. The average depth of the lagoonward side is -1.5m MSL.

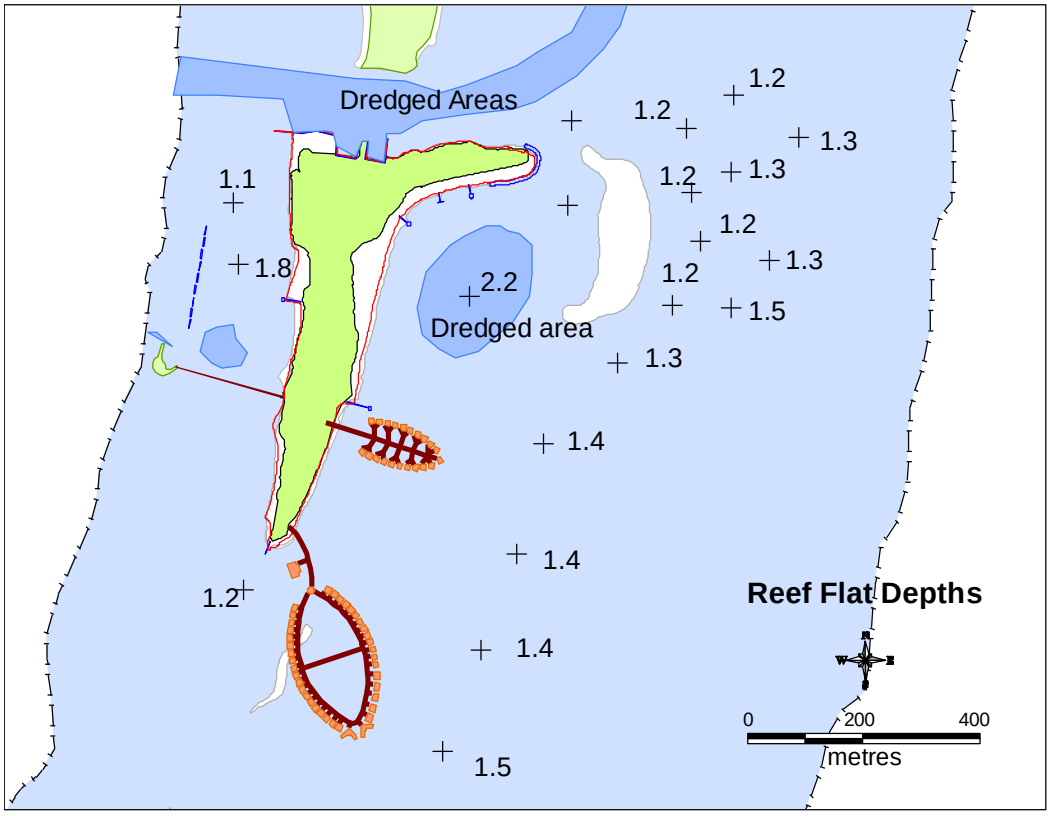


Figure 4-7: Bathymetry around the island

The bathymetry around the proposed project site is on average around -2.2 m. This area has been previously dredged to -2.5 m but has now undergone sedimentation. The depths around the project site is provided in the figure below.

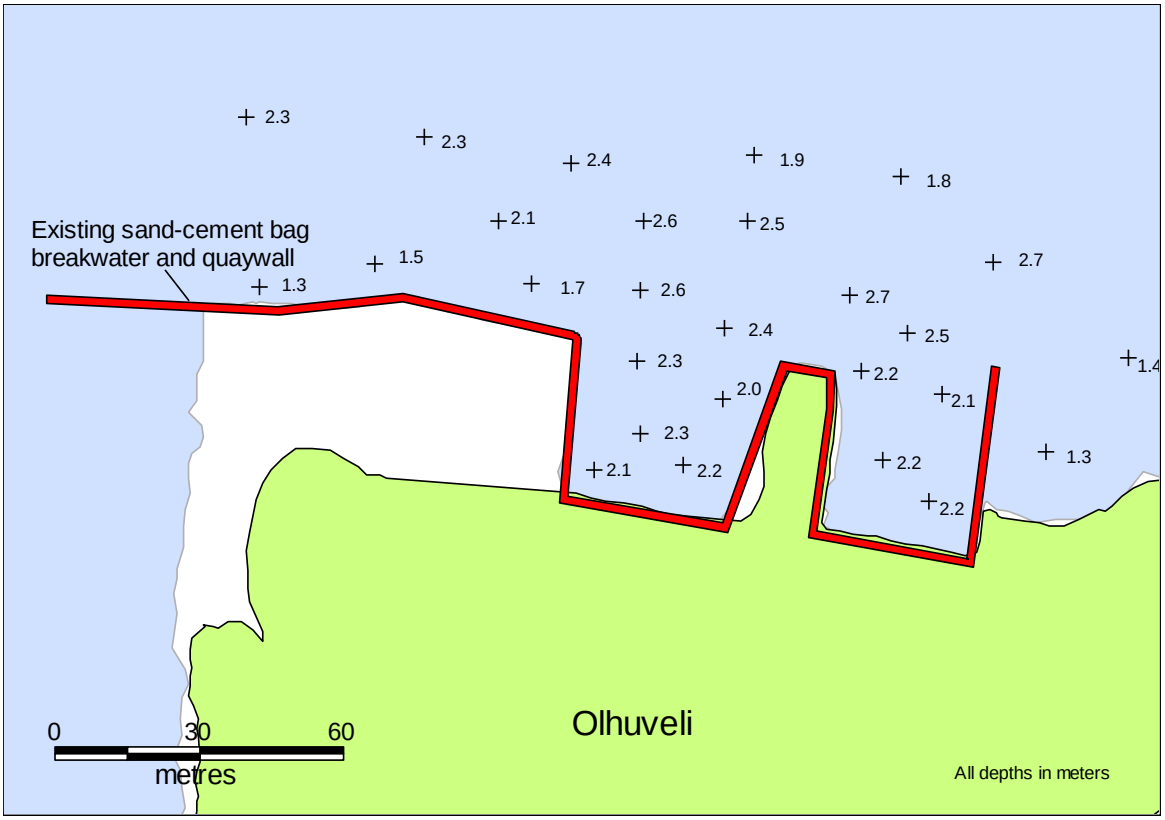


Figure 4-8: Bathym etry of the proposed site

4.3.5 BEACH

4.3.5.1 LONGSHORE SEDIMENT TRANSPORTATION PATTERNS

According to a study on current flow within the Hulhule Reef flat, waves and tides generate currents across the reef platforms that can also transport sediments (Binnie Black & Veatch, 2000). Similar to waves, currents are also modified by reef morphology. Under low-input wave conditions i.e. 0.5m wave height, strong lagoonward surge currents >60cm/sec are created by waves breaking at the crest. Long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system. In contrast, strong short duration surge currents <5sec transport coarse sediments from the breaker zone to seaward margin of the backreef lagoon. Sediment always accumulates at the lee of high-speed current zones. Generally zones of high current speed for example, jets or rips 50-80cm/sec are systematically located around islands.

The proposed site is located close to the lagoonward reef edge. Sediment produced within in the extensive reef flat will be transported towards the island and may contribute to the expansion of the island south wards. Hence island building activities are likely to occur mainly based on the westerly current flow. During the SW monsoon sediment may be shifted across the western shoreline. The most significant shifts are likely to occur towards the south causing erosion in the northern and central areas of the island. These shifts may reverse occasionally.

The extensive coastal infrastructure on the island has caused the sediment flow to be severely disrupted. The most critical modification is the blockage on the northern end of the island preventing sediment flow on to the western coastline. This will eventually, lead to net erosion on the western coastline. The groynes also affect the sediment flow. There are three major groyne systems controlling the sediment: one each on the eastern and western shoreline and one on the southern end.

4.3.5.2 COASTAL EROSION

The coastal erosion patterns around Olhuveli are presented in Figure 4.9

Severe erosion is generally present around the island. The most critical areas for the beach product offered on the island are on the eastern side. In particular, erosion between the two over water room units and around the previously reclaimed areas are of major concern.

The area on the north western corner of the island is in very poor condition of with exposed coral rubble and extensive seagrass debris. No major replenishment activities have been carried out in the past and have so far been discarded as a beach product. The area is closed off to the guests.

All these areas are in urgent need of replenishment.

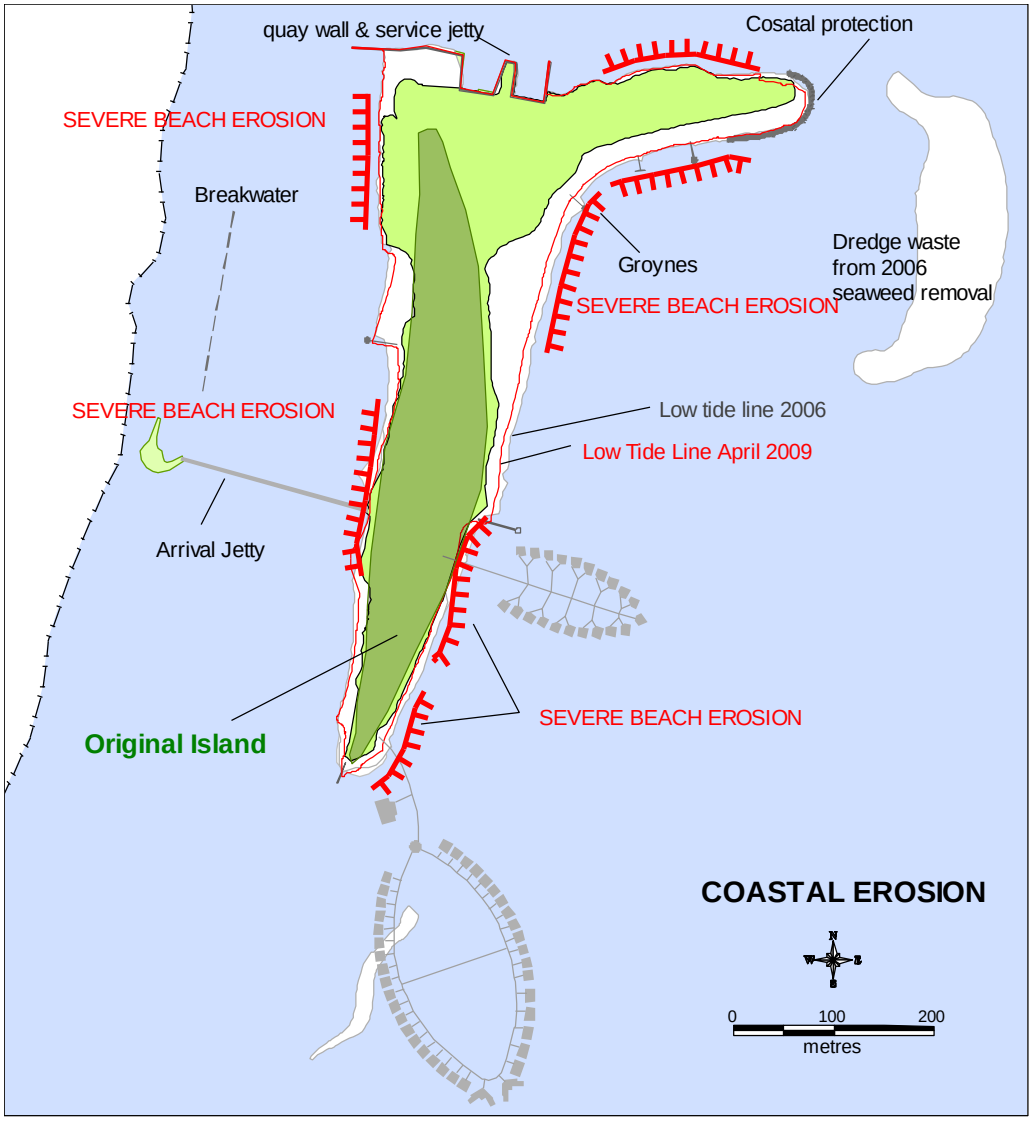


Figure 4-9: Coastal erosion patterns around Olhuveli

Beach profile surveys have been undertaken on the island as part of the baseline survey. Results of the profile surveys are presented in Appendix C.

4.4 BIOLOGICAL ENVIRONMENT

4.4.1 LAGOON AND REEF SYSTEM

Olhuveli Island is located on one of the largest reef systems in Male' atoll, known as Maadhoo Falhu (see Figure 4.10). The reef extends over 16 km and covers 19 km^2. There about 7 islands on the reef and Olhuveli and Fun Island are the largest among them. The average width of the reef system is 1 – 1.5 km. It is estimated to have an average depth of around – 1.1 m MSL.

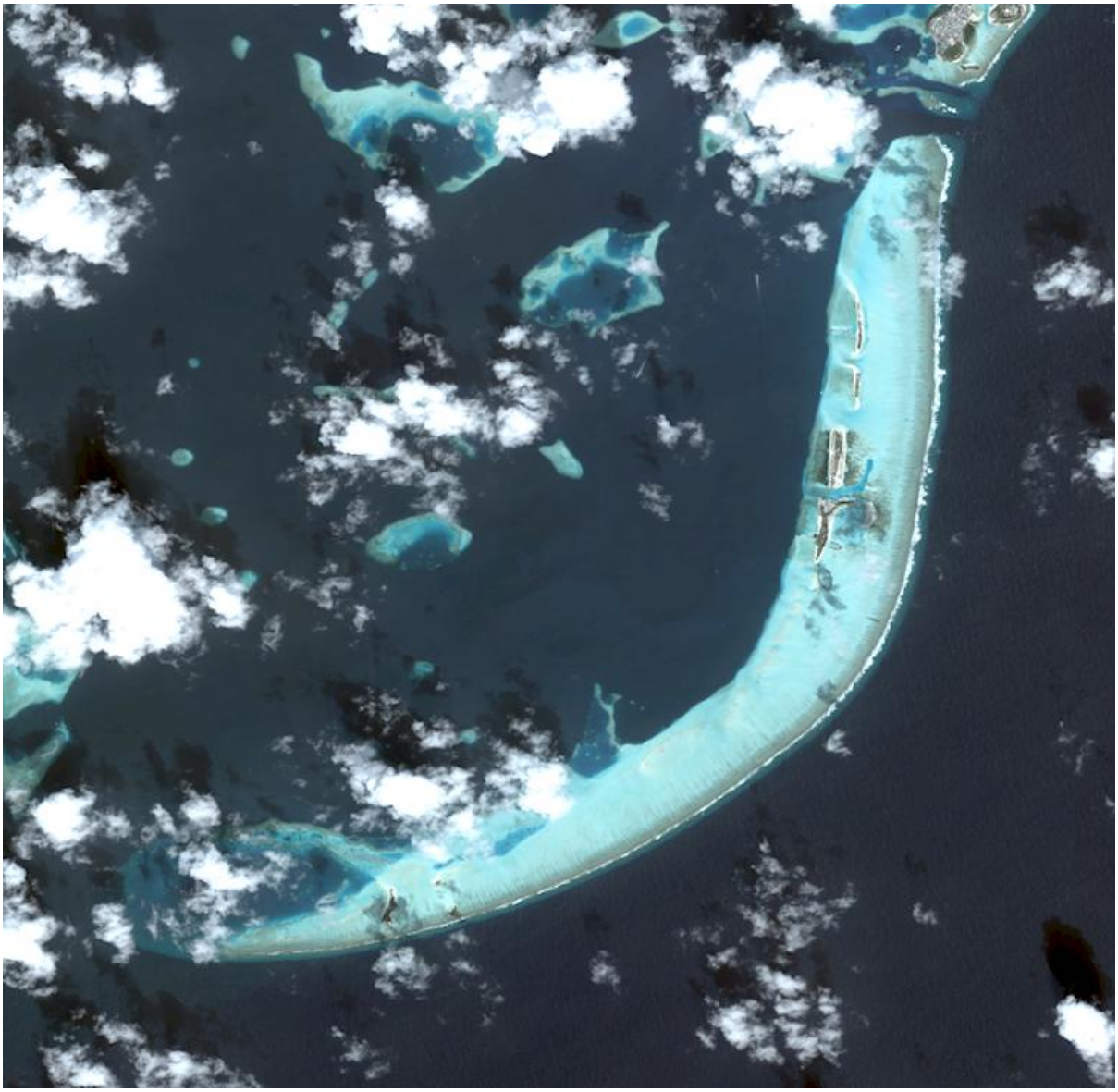


Figure 4-10: Maadhoo Falhu Reef System (source:digitalglobe)

4.4.2 LAGOON ENVIRONMENT – SEAGRASS COMMUNITIES

4.4.2.1 METHOD OF ASSESSMENT

The lagoon environment was assessed using the Manta tow and timed swim methods. Manta tow method involves towing a snorkeler behind a boat at a constant speed with regular stops (e.g. every 2 minutes) to record data. The timed swim method involves snorkeling for a specified period of time and recording the findings. These are the best methods to obtain a general description of large reef areas or measures of broad changes in abundance and distribution of organisms and large-scale disturbance.

The following parameters are usually used to assess the benthic communities:

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

These parameters are estimated visually using the following guidelines.

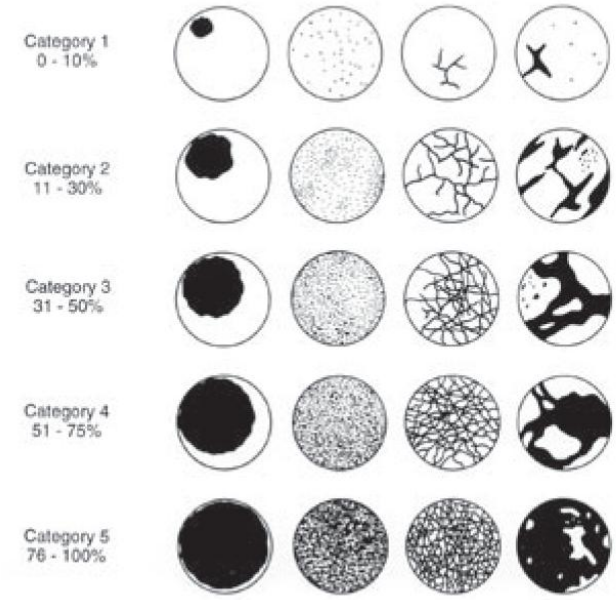


Figure 4-11: Visual Estimation Categories for percent coral cover from Dahl (1981) in English *et al.* (1997)

4.4.2.2 BIOPHYSCIAL FEATURES

The sea grass bed on the north eastern side covers approximately 25 ha of reef area. This figure was at 16 ha during the EIA assessment undertaken in 2005. The rapid growth of seagrass has expanded beyond the island boundaries and continuing southwards rapidly (see figure 4.12 below).

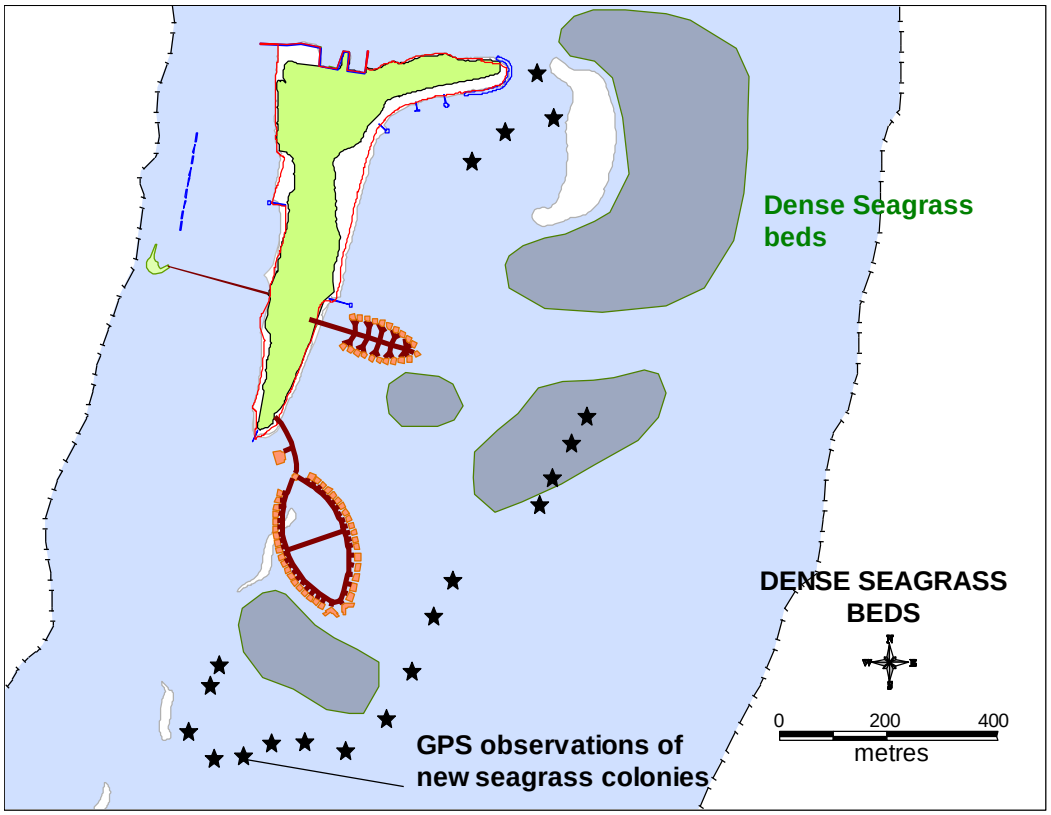


Figure 4-12: Estimated Distribution of seagrass beds and newly established colonies

Sea grass growth began in this area after the resort operations began in Olhuveli and Fun Island. An aerial photograph from 1969 does not show any evidence of sea grass. Only a single species, *Thalassia hemprichii*, was observed in the area. The very dense areas cover approximately 20 ha. Some of the characteristics of the sea grass bed are listed below.

- Leaves distichously arranged on short lateral branches arising from rhizome at intervals of 5-33 internodes, 10-40 cm long, 4-11 mm wide; nerves 10-17 mm, connected by perpendicular cross veins at intervals of about 1 mm; margin entire but sometimes slightly serrulate near the apex (fin cells); leaf-tip obtuse. Transition between reef blade and leaf sheath marked by a straight or upward curved line; sheath 3-7 cm long. Peduncle of the male infloreschecca. 3 cm long; peduncle of the female 1-1.5 cm long, after anthesis elongating to 2-4 cm.
- Spathal leaves oblong to lanceolate, acut or obtuse (apices unequal in size), entire but near the apex sometimes slightly serrulate. Pedicle of the male flower 2-3 cm long; female flower sub sessile.

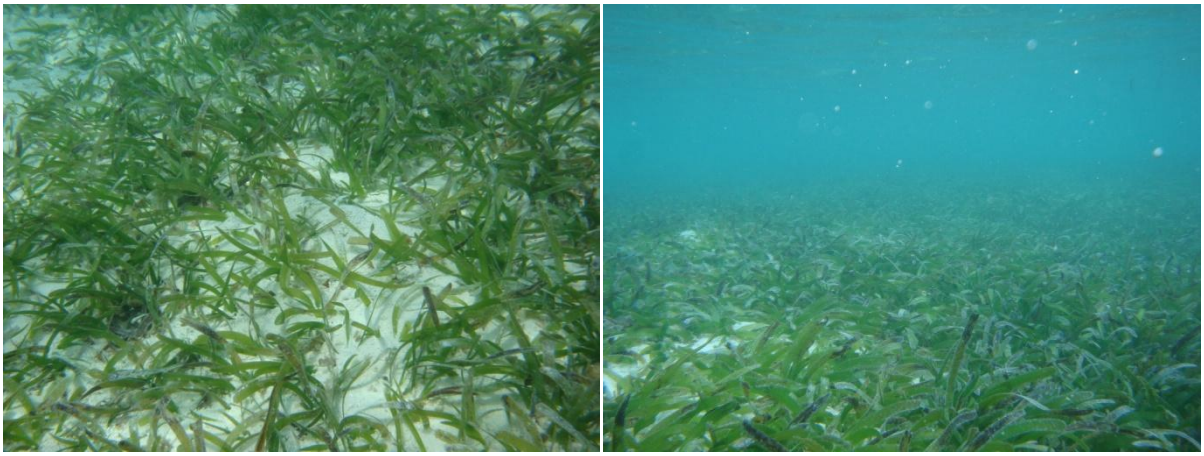


Figure 4-13: Seagrass found in the lagoon of Olhuveli Island

4.4.2.3 DIVERSITY

The visual surveys showed only one species: *Thallasia hemprichii*. This is the most common species of seagrass found in the Maldives. Experimental work has shown that in the sea grass beds consisting of Thallassia, the interactions at the root interface between another species of seagrass hinders establishment of other species. This is likely to be the reason why only a single species is observed in the area.

The diversity of other marine life was moderate. The most abundant fish family was Labridae (wrass family) of which schools of various species were observed. Other fish species emperor fishes, parrot fishes and goatfishes.

Among other marine organisms holothurians (sea cucumber) and urchins were observed. Few Holothurians belonging to Synapia family were observed. Mollusks assosciated with seagrass often burrow inside and therefore could not be observed. Few species of algae were observed including Padina Gymnospora. Usual fauna inhabiting seagrass beds, such as amphipods, other crustaceans, filter feeding invertebrates and polycheates were not observed during the survey.

4.4.2.4 MARINE WATER QUALITY

The main objective of the marine water sampling and testing was to determine baseline water quality conditions and determine whether the proposed development may have an adverse effect on marine water quality of the site.

Seawater samples were collected on two occasions. The first sampling was done on 11 March 2009 and the second sampling was done on 28 April 2009. Total coliform and faecal coliform for seawater from near the waste outfall were tested for samples collected on 18 May 2009.

Table 4.3: Seawater Quality for Samples collected at Olhuveli Resort on 11th March 2009 and 28th April 2009

Parameter	**Brine outfall 3m from powerhouse – 11 March 2009**	**Waste outfall near powerhouse - 11 March 2009**	**Harbour jetty – 11 March 2009**	**SW 5 - 28 April 2009**
Physical appearance	Clear	Clear	Clear	Clear
BOD (mg/L)	393	443	483	103
COD (mg/L)	-	200	-	
TDS (mg/L)	25,300	25,000	25,300	23,800
pH	8.5	8.6	8.6	8.3
Nitrate (mg/L)	0.00	0.00	0.00	0.00
Sulfate (mg/L)	3,100	3,000	3,050	335
Lead (mg/L)	0.00	0.00	0.00	0.00
Conductivitiy (µs/cm)	50,800	50,200	50,700	47,600
Total petroleum hydrocarbons (ppm)	-	-	2-5	
Total coliform count/100mL	-	16	-	
Faecal coliform count/100mL	-	8	-	

5 POTENTIAL IMPACTS AND MITIGATION MEASURES

5.1 INTRODUCTION

This Chapter will discuss all the potential impacts (positive and negative) associated with the proposed development activities and suggest mitigation measures for all potential negative impacts. Impact identification and mitigation measures were primarily based on stakeholder consultations, literature reviews, professional judgment and past experience from similar projects.

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

Activity → Causal Factor → Potential Impacts → Short Term Effects → Long Term Effects

In addition, the significance of impacts was determined based on the following characteristics:

- Nature of impact (direct/ indirect/cumulative)
- Spatial distribution of impact
- Duration of impact
- Reversibility of impact
- Magnitude of impact
    - Negligible: No significant impact
    - Minor: The impact is only short term and reversible on the long run
    - Moderate: The impact maybe irreversible and cause long term concerns but most likely short term and reversible.
    - Major: the impact is long term and irreversible

Table 6.1 shows a summary of the characteristics of the potential impacts identified and the significance of each impact. It should be noted that impacts correspond to the worst-case scenario in absence of any mitigation measures.

Table 5.1: Summary Characteristics of the Potential Impacts Identified and the Significance of Each Impact

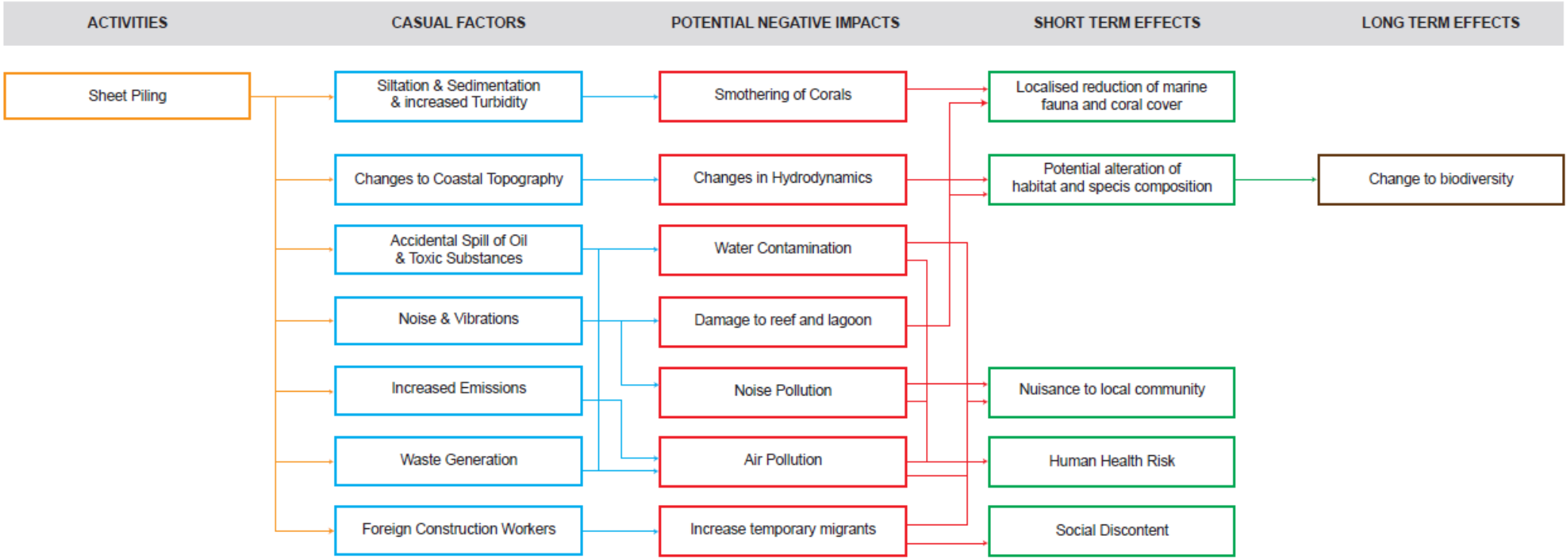
Impact	Nature	Spatial Distribution	Duration	Reversibility	Magnitude	Significance
Smothering of lagoon habitats	Direct		Short term	Yes	Major	Significant
Smothering of coral reefs	Direct	200 m^2	Medium term	Yes	Minor	Insignificant
Increased Coastal Erosion	Direct	Olhuveli northern coastline	Long-term	No	Moderate	Significant
Marine water contamination from accidental oil spills	Direct	1-500m^2	Short term	Maybe	Moderate	Insignificant
Pollution (air/noise)	Direct	1-300 m^2	Short term (only during the project)	Yes	Minor	Insignificant
Generation of waste	Direct	Thilafushi waste site	Short and Long-term	No		Insignificant
Improved tourism product	Direct & indirect	Olhuveli	Short term	No	Major	Significant
Reduced Disaster risk	Direct & indirect	Northern coastline	Long term	-	Moderate	Significant

5.2 BRIEF DESCRIPTION OF POTENTIAL IMPACTS AND SUGGESTED MITIGATION MEASURES

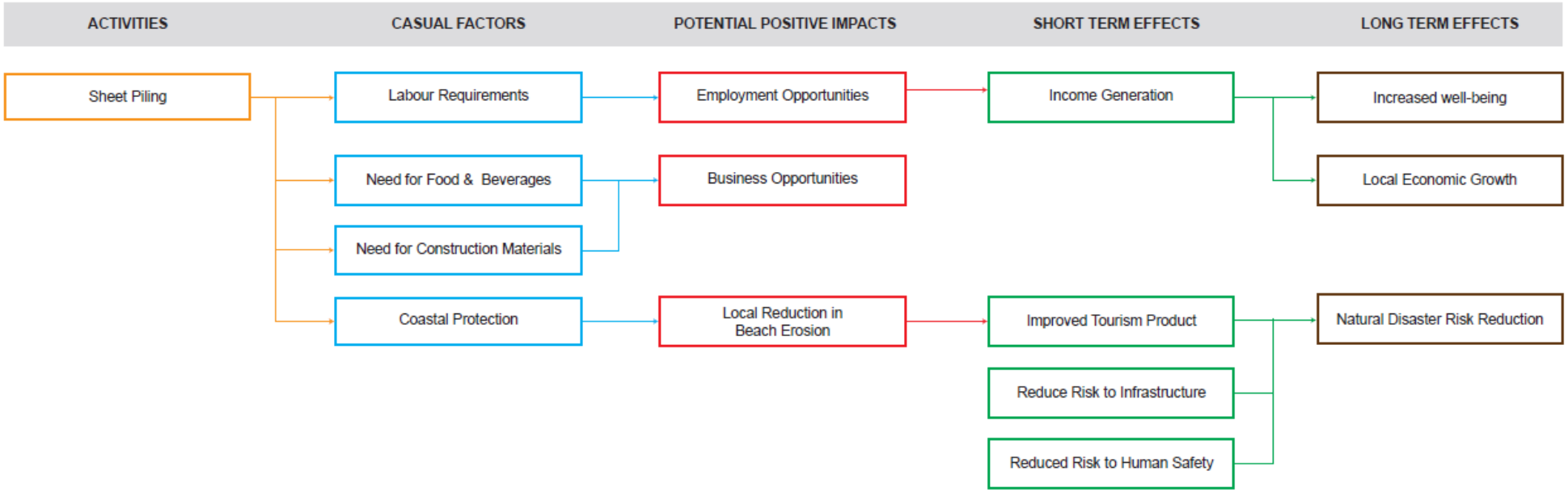
This section will provide a brief description of each of the potential impacts illustrated in the flowcharts and suggest appropriate mitigation measures for all potential adverse impacts.

A summary of the potential negative and positive impacts during construction and operation stage of the report is provided in the diagrams in the next two pages. Details of the key impacts provided in the following subsections.

Potential Negative Impacts of Sheet Piling Activities



Potential Positive Impacts of Sheet Piling Activities



5.2.1 POTENTIAL ADVERSE IMPACTS

5.2.1.1 INCREASED SEDIMENTATION AND TURBIDITY

Moderate to high amounts of siltation and sedimentation of the lagoon waters is anticipated. Similarly, 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. Under normal circumstances, corals have a self cleansing mechanism and can withstand a certain rate of sedimentation. Hence, 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 lagoon.

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

Mitigation measures to prevent smothering of corals

- Establishment of bund walls around the project site to control sediment disbursement.
- Completion of all dredging works in calm weather conditions.

5.2.1.2 DAMAGE TO CORAL AND SEA GRASS COMMUNITIES

Pile driving will generate significant amounts of noise and vibration. This can cause disturbance to organisms in the vicinity of the project site and lead to changes in species behavior and composition. Noise and vibrations generated from pile driving also have the potential to induce hearing loss in certain species of fish and lead to changes in their behavior. Piling activities close to reef areas can dislodge young reefs, thereby leading to changes to the composition of species inhabiting the reefs. The project site is some distance away from reef areas, so such adverse impacts are not likely to be significant.

Mitigation measures to prevent damage to coral and sea grass communities

- Completion of the proposed project in the shortest period possible
- Briefing of the project manager, and the work force involved during the operation of the work on environment friendly practices.
- Proper supervision and monitoring of the work should to minimise any adverse effect on the environment
- Monitoring of the noise and vibration levels both on land and in water. Specific effects on fish species and immediate reef area should be observed.

5.2.1.3 CHANGES IN COASTAL HYDRODYNAMICS

Abrupt significant changes to coastal hydrodynamics are not likely to result from the sheet piling activities, as coastal protection measures are already in place at the site. However, there will be some short-term changes to hydrodynamic during the construction activity and immediately after the works. This is primarily due to the extension of the quawall 1-2 m outside the existing location and the specific nature of wave refraction and diffraction around sheet piles. The erosion resulting from the coastal modification measures is likely to continue in the short term as the natural processes adjust to the modifications. Currently, the sand-cement bag seawall allows some amount of sediment transport, as the strong current has lead to the collapse of the seawall in some areas. Replacing the sand-cement bags with sheet piles will prevent coastal erosion in the sheet piled area. This might lead to a slight temporary increase in coastal erosion in adjacent areas, as the coastal processes stabilize. However given the proposed location is a heavily modified area, the impacts from this specific project are expected to be minimal for both the Olhuveli and Fun Island.

The islet created in the first seagrass removal project is not expected be impacted due to the sheetpiling activities, due to the pattern of current flow in the area. Presently, the current flows towards the project site past the islet (current direction is from East to West). Major changes to the current patterns are not expected to result from sheet piling activities.

Mitigation measures to manage hydrodynamic changes

- No specific mitigation measures except for continuous monitoring to identify abnormal activity.

5.2.1.4 WATER CONTAMINATION

Any accidental spill of oil and toxic substances during the construction phase will contaminate the marine and/or groundwater.

Furthermore, significant quantities of waste will be generated from all construction related activities. Mishandling of solid (non-biodegradable) waste and hazardous waste will contaminate the marine water. Therefore, special care should be taken when handling oil, solid waste and hazardous waste to entirely avoid any accidental spills and leakage.

Mitigation measures to prevent water contamination:

- Proper tuning and maintenance of all machinery
- Storage of all paints, lubricants, and other chemicals used on site in a secure and bunded location.
- Careful handling and transportation of oil, solid waste and hazardous waste in sealed containers, in properly bunded vehicles/vessels
- Undertaking construction activities under the supervision of a suitably experienced person

5.2.1.5 NOISE, VIBRATIONS AND AIR POLLUTION

During the mobilisation of equipments and operation of heavy machinery, it is anticipated that significant amounts of noise will be generated. Such vibrations may alter behaviour of species in the short term, especially for species that use auditory communication. Dust and emissions from vehicle and machinery exhausts will degrade the air quality. These impacts can be nuisances to the guests and employees of the resort and those of the adjacent resort. However, these adverse impacts will be short term and can be mitigated to avoid nuisance to the resort.

Mitigation measures for noise, vibrations and air pollution

- Carrying out all construction works during day time to minimise nuisance to the resorts and disturbances caused to nocturnal fauna such as birds and fruit bats that uses auditory communication.
- Scheduling of all construction works to coincide with the off-peak season when occupancy is low, in order to reduce the impact on guests at the resorts.
- Proper tuning and maintenance of all vehicles and machinery to minimise air pollution

5.2.2 POTENTIAL BENEFICIAL IMPACTS

The potential beneficial impacts during the construction and operational phases of the proposed development are mainly socio-economic impacts. These include:

- Employment opportunities during construction works
- Business opportunity for local suppliers
- Opportunity for local contract workers
- Opportunity for locals to rent out equipments, machinery, vehicles and vessels.
- Increase in sales for the local businesses such as shops and cafés
- Better tourism product.

5.2.3 MITIGATION COSTS

Table 5.2: Cost of Mitigation Measures for Identified Impacts

Impact	Mitigation Measures	Costs
Smothering of Corals	• Establishment of bund walls around the project site to control sediment disbursement. • Completion of all construction works in calm weather conditions, particularly when wave activity is lower.	US$ 10,000 NA
Water Contamination	• Proper tuning and maintenance of all machinery • Storage of all paints, lubricants, and other chemicals used on site in a secure and bunded location. • Careful handling and transportation of oil, solid waste and hazardous waste in sealed containers, in properly bunded vehicles/vessels • Undertaking construction activities under the supervision of a suitably experienced person	US$3000 US$2000 US$1500 US$2000
Noise, Vibrations and Air Pollution	• Carrying out all construction works during day time to minimise nuisance to the resorts and disturbances caused to nocturnal fauna such as birds and fruit bats that uses auditory communication. • Scheduling of all construction works to coincide with the off-peak season when occupancy is low, in order to reduce the impact on guests at the resorts. • Proper tuning and maintenance of all vehicles and machinery	NA US$5000 As above

6 ALTERNATIVES

6.1 INTRODUCTION

This Chapter reports on the alternatives for the proposed project. Alternatives were mainly considered for sediment containment measures, construction materials and sheet piling technologies.

6.2 "NO-PROJECT" ALTERNATIVE

The "no project" alternative refers to leaving the island in its current condition, without reinforcing the existing coastal protection of sand-cement bags with sheet piles. The island is currently exposed to severe erosion at the proposed project site on the northern end of the island. Not reinforcing the existing coastal protection measures at the site would result in continuation of this effect and could increase the safety risk to humans and infrastructure. The "no project" alternative is therefore not preferred, as the potential adverse impacts of the "no project" impact outweigh the potential negative environmental impacts of carrying out the project.

6.3 SEDIMENTATION CONTROL MEASURES

Error! Reference source not found. indicates the alternative technologies for the sediment containment.

Table 6.1: Summary of Sediment Containment Measures

Type of Measure	Advantages	Disadvantages
Bund Wall	Environmentally friendly Durable Cost effective	High impact on marine environment. Cheap option
Silt screen	Durable Easy to handle Environmentally friendly	Large quantities not locally available Costly.

The preferred option based on consideration of the costs involved is the bund wall.

6.4 ALTERNATIVE MATERIALS FOR SEAWALL CONSTRUCTION

Error! Reference source not found. indicates the alternative materials for construction of the sea wall.

Table 6.2: Summary of Construction Material Alternatives

Construction Material	Main Advantages	Disadvantages
Geo-textile bags	• 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

Sand-cement bags	• Locally available	• Relatively less durable
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

The preferred option is sheet piles, as it is durable and highly effective.

6.5 ALTERNATIVE PILING TECHNOLOGIES

A percussive pilling could be used instead of the vibratory piling for seawall construction. Percussive pile driving usually involves repeated striking of the head of a steel pile by a double-acting hydraulic hammer. However, the impacts from percussive piling are similar to the impacts from vibratory piling. The vibration and noise impact is generally stronger in percussive pile driving. Hence the suggested option (vibratory piling) is the most appropriate amongst technology available in Maldives.

7 ENVIRONMENTAL MONITORING PLAN

7.1 INTRODUCTION

This Chapter will outline the monitoring plan for the proposed 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.

7.2 OBJECTIVES OF THE MONITORING PLAN

The main objectives of the monitoring plan are to:

- 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
- identify whether the community benefits from the predicted employment opportunities and positive socio-economic prospects
- identify and resolve any issues of social unrest 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)	Water quality	Laboratory analysis	Upon completion of the project, two months after completion and thereafter annually	US$50 per survey
Waste monitoring	Waste generation levels	Waste census	Once during the construction and annually during operation	US$150 per survey
Marine Water Contamination	Oil spills	Visual observation	Daily for the duration of the project	NA

	Oil leakage from machinery	maintenance and tuning of all machinery	Weekly during the construction phase	US$50 per week
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		

Parameters that will be tested in the laboratory analysis of water quality for monitoring marine water contamination include turbidity, total suspended solids (TDS) and dissolved oxygen (DO) levels. Weather conditions and sea conditions (tidal mode and currents) shall also be monitored during the construction period in order to avoid sheet piling activities during harsh weather and turbulent sea conditions.

Aspects of the monitoring plan presented here are similar to the monitoring plan prescribed for the second sea grass removal project at Olhuveli Beach and Spa Resort. Therefore, post-construction monitoring can be integrated with the monitoring activities for the sea grass removal project, by including the project site as one of the survey locations. The monitoring scheme is different for the construction phase, in terms of frequency and parameters tested. Therefore, the construction phase monitoring program must be carried out separately, as prescribed above.

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. The report shall fulfill the obligation for regular annual monitoring following both the seaweed removal project and the sheet piling project, as the site of the sheetpiling project will be one of the locations surveyed, and the parameters prescribed for monitoring in both the projects are the same.

7.5 COMMITMENT FOR MONITORING

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

APPENDIX A – TERMS OF REFERENCE

APPENDIX B – SITE PLAN

APPENDIX C – BEACH PROFILES

Beach profile locations are presented in Figure 4.1.

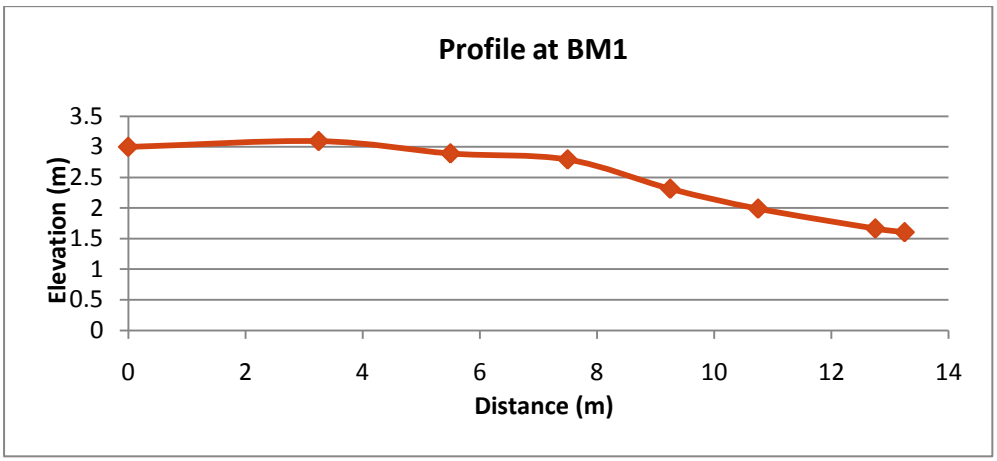


Figure 0-1 BM1: Near the groyne /RM 230 / Life Guard Post

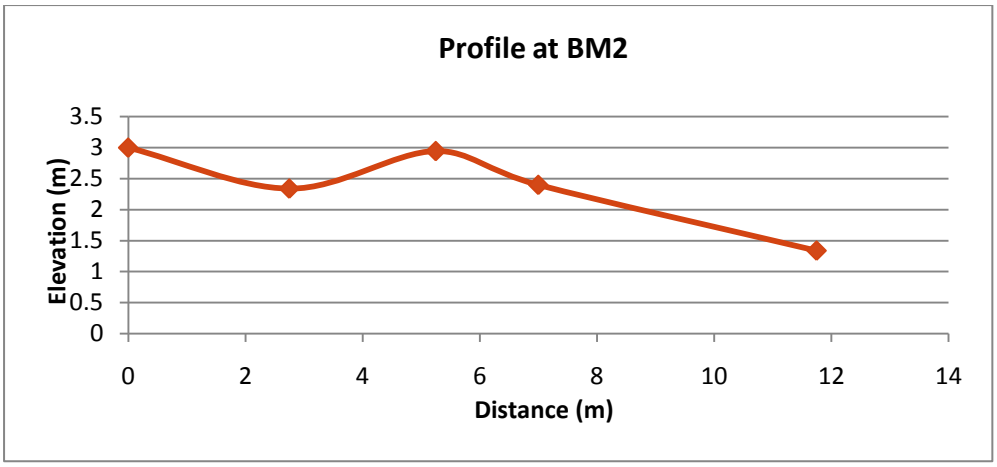


Figure 0-2 BM2: In front of water sports centre

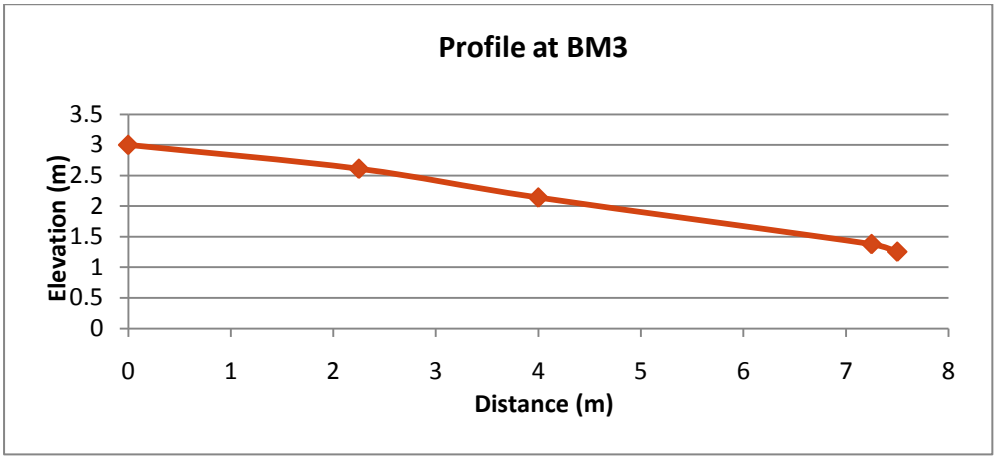


Figure 0-3 BM3: Near Dhoni Bar

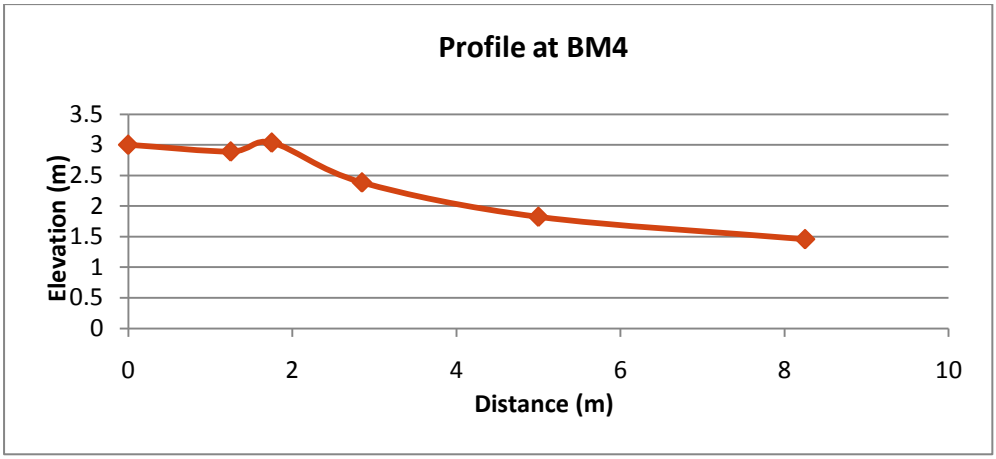


Figure 0-4 BM4: Infront of Sakura Restaurant

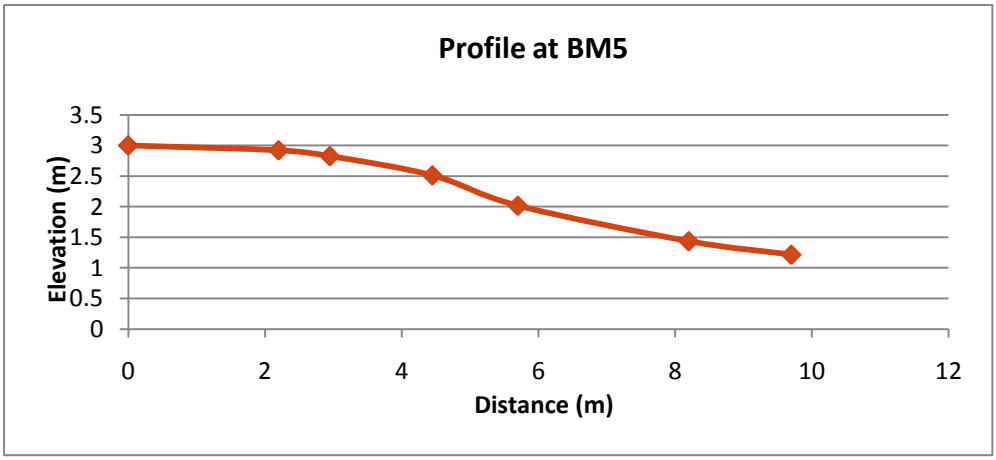


Figure 0-5 BM5: left of Dhoni bar/ Jetty to Water Villa/ Jacuzzi Villas

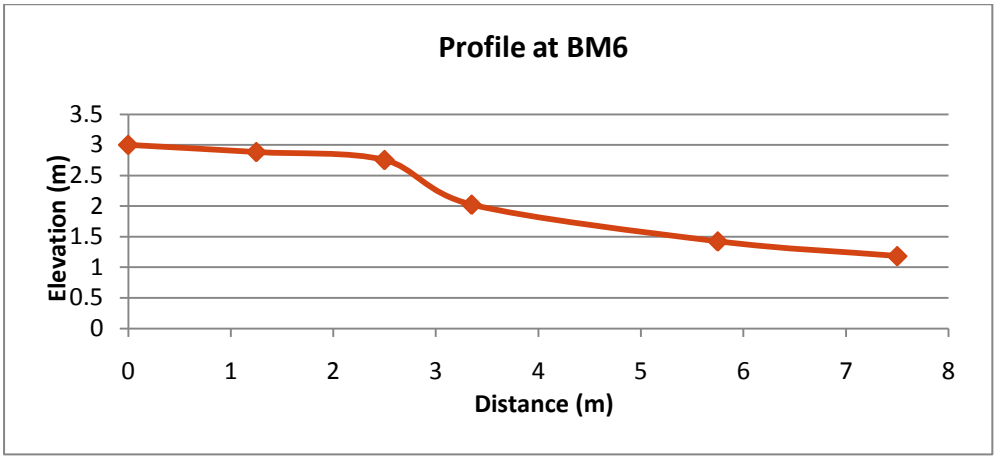


Figure 0-6 BM6: Room 406 – 405

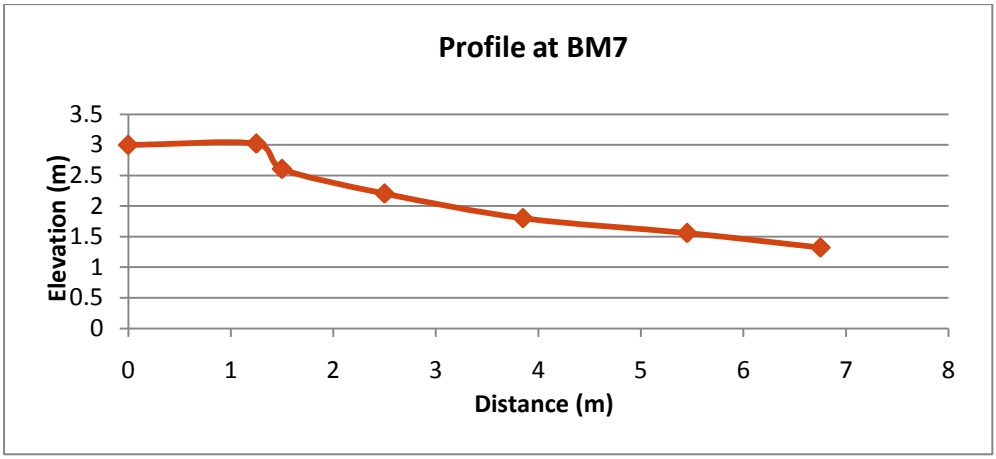


Figure 0-7 BM7: In front of Room 444

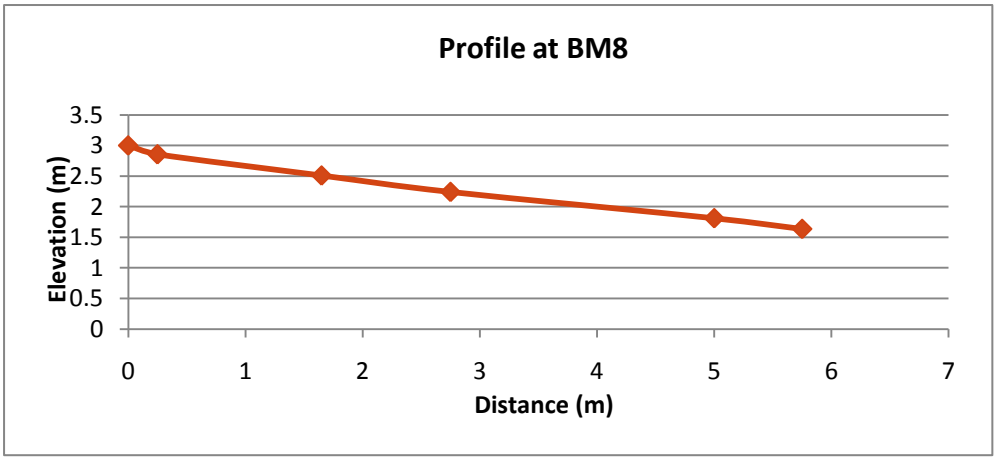


Figure 0-8 BM8: Sun Spa/ In between jetty to Deluxe water villas and groyne

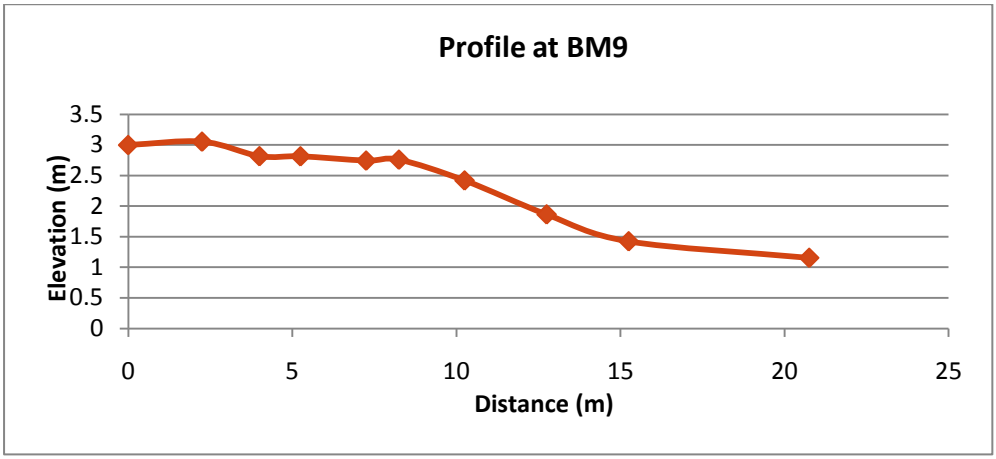


Figure 0-9 BM9: Sun rise spa

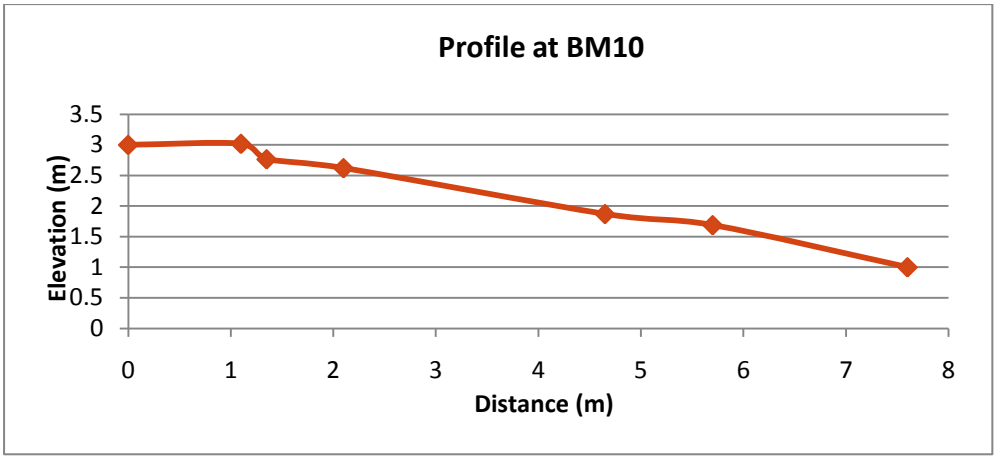


Figure 0-10 BM10: Staff side in front of room 297 – 298

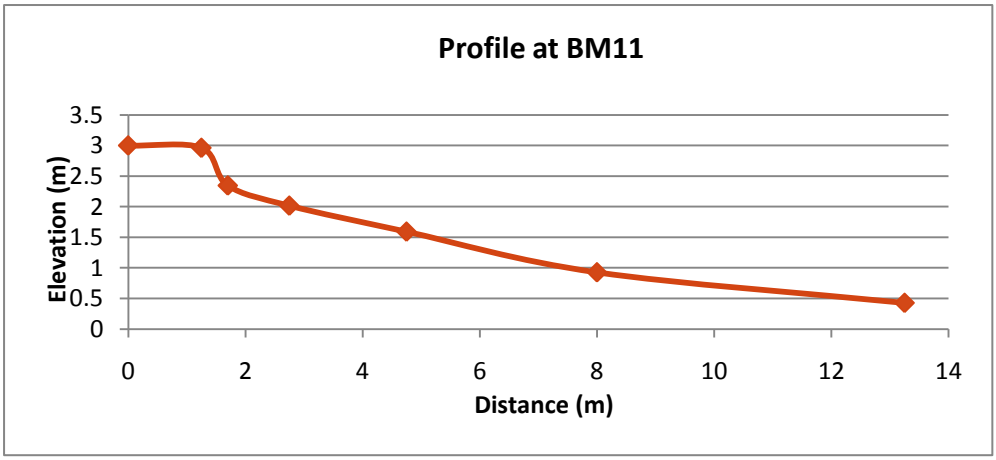


Figure 0-11 BM11: Near dream island front / Left of groyne

APPENDIX D – CV'S OF CONSULTANTS

APPENDIX E – COMMITMENT TO MONITORING