ENVIRONMENTAL IMPACT ASSESSMENT

For Coastal Protection and Erosion Control on West of Runway 18

Malé International Airport, Hulhulé, Kaafu Atoll, Maldives

Proponent: Maldives Airports Company Ltd.

Consultant: Ahmed Zahid (EIA08/07)

Sandcays

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Non Technical Summary

This report addresses the environmental concerns of the proposed quaywall strengthening and erosion control of western coast of Runway 18, Malé International Airport, Hulhulé, Kaafu Atoll. The primary objective of the project is to enhance the safety of the airstrip at the turning pad area, which is prone to flooding during rough weather due to wave overtopping from existing sheetpile structure. As a result there is scour behind the sheetpile wall increasing the threat of subsidence or structural weakening of the western edge of the turning pad area. Therefore, there is an immediate need to protect this area by strengthening existing sheetpile quaywall with additional protection measures.

Hence, different options for the coastal protection have been evaluated and the most practicable options not entailing excessive costs have been recommended. Since this is an immediate and temporary measure, minimal protection has been proposed, which is the protection of the immediate area behind the turning pad where sheetpile structure has been placed. The length of protection is about 100m. The other areas with concrete gravity seawalls have not been considered for protection as these areas are not severely affected and the entire area, including the 100m coastline which is proposed for immediate protection, would be reclaimed in the near future, as per the Airport Master Plan.

The different options for the protection of the proposed 100m coastline immediately behind the turning pad area include revetments along the coastline or offshore breakwaters covering a length of about 250m on the dead reef flat at about 100m from the sheetpile coastline. Two types of materials have been considered for the revetments: single layer Core-Loc armour units and 2.5m^3 geotextile containers filled with sand. The Core-Loc units have very high permeability (50-60% voids) to absorb wave energy while the geotextile containers have no voids when placed together. Therefore, the design using geotextile containers have been revised to incorporate about 15% voids, thereby improving the wave energy absorption capacity. Based on the costs and wave energy absorption potential of each type of material, it is recommended to use the Core-Loc units. However, these units are not readily available in the Maldives, therefore, geotextile containers have been recommended due to the urgency of the project. In both cases, the revetments have been designed to provide adequate wave runup to minimize the force of the wave. Additional protection would not be required. For the breakwater also, the above two types of materials have been considered and submerged breakwaters as well as emerged breakwaters have been considered. The breakwater option is expensive given the length of the breakwater. Also, the distance between the potential breakwater location and the shore area to be protected is about 100m, which makes it less effective as wind-generated waves will reoccur inside the lee of the breakwater. Other options such as groynes have not been considered because the lagoon on this side has been dredged.

Imported rock boulders could also be used for both the revetment option and the breakwater option. However, the cost of boulders and the time to deliver to site makes it impracticable and has not been considered. Moreover, a structure with rock boulders would be less permeable (about 30-40%) than the proposed Core-Loc armour units. Hence, cost was the deciding factor in choosing the Core-Loc units and geotextile containers over rock boulders.

The reef flat at the area in which the proposed offshore breakwater would be constructed is almost entirely dead with high levels of sediment resuspended in the water column. This is due to the increased sediment level from dredging that had taken place in the area. There is also the cumulative effect of sediment resuspension resulting from the Hulhumalé reclamation, but this is expected to be small. The reef slope and edge in this area would not be severely affected as no machinery would be used in or closer to these areas during the implementation of the proposed project activities. All machinery would be used on the shallow reef flat area, which consists of bedrock and a few dead coral porites. Given the level of dredging, reclamation and coastal protection works that have been carried out in the area, the cumulative impacts of the proposed project would be negligible. Therefore, this project is not considered to have adverse environmental or social impacts but there would be economic impacts that would be positive in that the dangers of potential subsidence of the airstrip turning pad is minimized with greater flood control and protection afforded by the proposed temporary coastal protection structures. However, mitigation measures to minimize any damage to reef will be in place and the project components will be well planned considering minimal aesthetic impact although this area is not aesthetically sensitive.

Environmental monitoring is not recommended for the project under consideration except monitoring of the effectiveness of the structures for at least one year after construction. However, it is recommended that the Maldives Airports Company in association with other operators in Hulhulé initiate and conduct an island-wide environmental monitoring programme which would cover the environmental monitoring needs of all projects undertaken on the island.

1 Introduction

1.1 Introduction

This Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts of proposed project for strengthening quaywall and controlling flooding and wave scour behind quaywall of the coastline west of Runway 18, Malé International Airport. This report will identify the potential impacts (both positive and negative) of the proposed project. The report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be suggested. Measures to mitigate any negative impact on the environment would be suggested. Environmental monitoring for the proposed project is not expected to yield any results unless an island-wide monitoring programme is carried out by the Proponent, who basically owns Malé International Airport. Therefore, an island wide monitoring programme would be suggested in addition to any monitoring that would be necessary under this project.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site on 3 December 2009 and site specific data provided in the EIA carried out in 2007 for the reclamation of the area. However, long term site-specific baseline data was lacking and therefore the impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment. Available long term data were collected from available sources, such as long term data on meteorology and climate from local and global databases.

This EIA has been produced in accordance with the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water (now the Ministry of Housing, Transport and Environment).

1.2 Aims and Objectives of the EIA

This report addresses the environmental concerns of the proposed quaywall strengthening and erosion control on West of Runway18. It helps to achieve the following objectives.

- Allow better project planning
- Assist in mitigating impacts caused due to the project
- Promote informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.

1.3 Methodologies

Internationally recognized and accepted methods have been used in this environmental evaluation and assessment. This EIA is based mainly on data collected during a field investigation mission on 3 December 2009 by a team from Sandcays Pvt. Ltd., Maldives. The data collection methods would be described in detail under Section 4.

1.4 EIA Implementation

This EIA has been prepared by Ahmed Zahid, a registered EIA consultant with a number of years of experience in Environmental Impact Assessment in the Maldives and has been involved in several coastal protection project EIAs undertaken in the Maldives.

The different steps involved in the implementation of the EIA and the time frame for those steps/activities are given below.

- EIA application submission 23 November 2009
- Scoping meeting 20 January 2010
- Submission of draft TOR 21 January 2010
- Approval of TOR 11 March 2010
- TOR Received by Consultant 25 March 2010
- Field mission 3 December 2009
- Draft report submission to MACL 10 February 2010
- Submission of final EIA report 5 April 2010

Once the EIA has been submitted it is expected that the review process will not take more than 4 weeks. The review process may result in the requisition of additional information. However, all efforts have been made to ensure that adequate information has been provided with specific attention paid to meet all requirements of the Terms of Reference (TOR). The TOR for this EIA is given in Appendix 1.

2 Project Description

2.1 General context of the study

The proposed project financed by the Maldives Airports Company Limited (MACL) involves the provision of enhanced protection for the coastline west of the turning pad on the north of Runway 18. The specific objective of the project is to strengthen the protection provided by existing sheetpile quaywall by providing added protection so that wave scour from behind the quaywall and flooding of the area due to wave overtopping is controlled. This has been worrisome for the management of MACL due to the potential threat of subsidence of the western edge of the turning pad.

This study is to identify and assess environmental impacts (positive and negative) and to recommend mitigation measures for minimizing or eliminating the negative impacts of the proposed project.

2.2 The Proponent

The project proponent is Maldives Airports Company Limited (MACL). MACL was formed recently (1 Jan 1994) as a result of privatization efforts of the government with Maldives Airports Authority being changed to MACL. The company is entrusted with the smooth operation of the first and most important international airport (Malé International Airport), which connects the Maldives to the rest of the world. MACL is also mandated to manage Gan International Airport and the three regional airports in Hanimaadhoo, Kadhdhoo and Kaadedhdhoo.

2.3 Project Location and Study Area

The project site is the island of Hulhule in Kaafu Atoll, as seen in Figure 2-1. Hulhulé is located just next to the capital, Malé, with Malé International Airport thriving on it over the past history of aviation in the Maldives since 19 October 1960. Malé International Airport has been expanding at a rapid pace with reclamation and protection of the reclaimed areas being the main environmentally damaging components of the expansion projects. The project under consideration is a small component involving the protection of 100m length of sheetpiled coastline on the northwestern corner of the island towards the north end of Runway 18. The proposed area for protection is where the airstrip is closest to the shoreline (see Figure 2-1). Other areas are slightly inland and are not under threat of subsidence or structural damage.

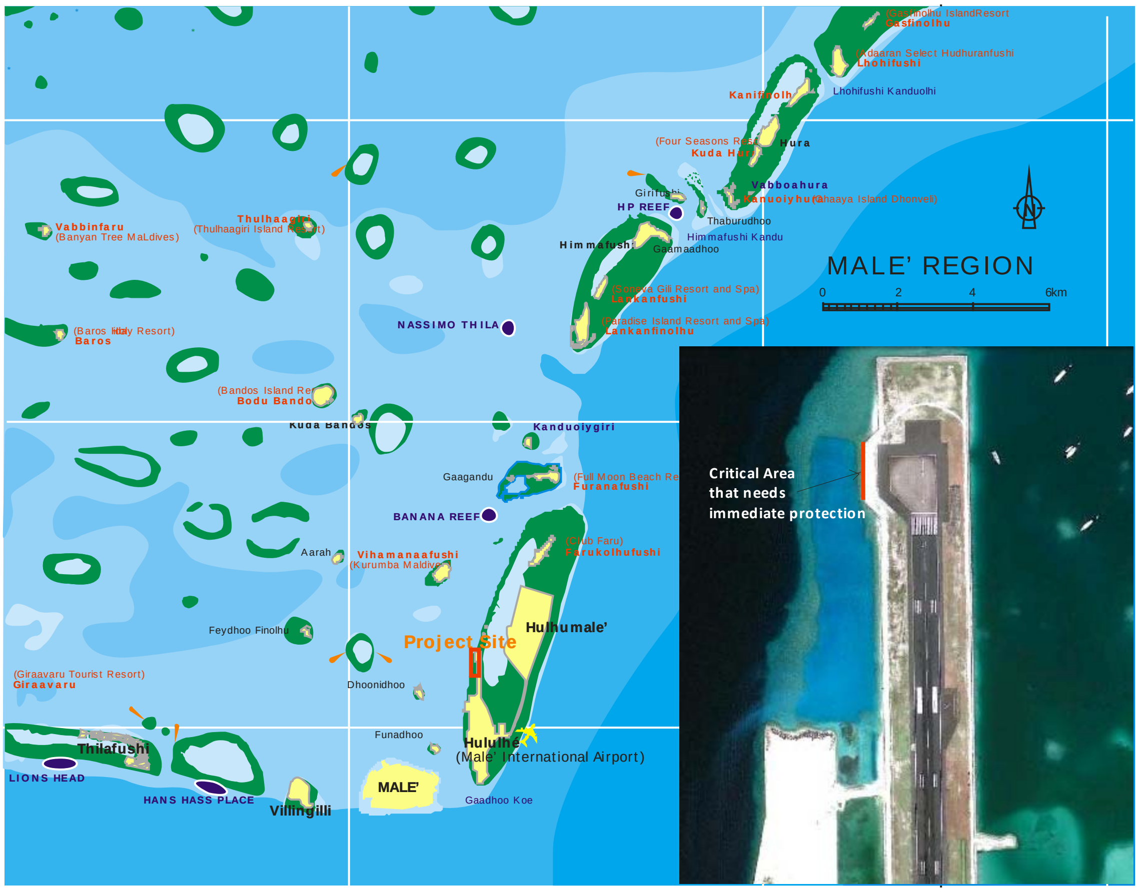


Figure 2-1: Project Location: North end of Runway 18, Malé International Airport, Kaafu Atoll

2.4 The Project

The proposed project involves the enhancement to coastal protection of 100m coastline on the west of the turning pad area of Runway 18, Malé International Airport, as an immediate measure. The project is managed and financed by Maldives Airports Company Limited (MACL). The total estimated cost of the project would be about US$200,000. The project will also be implemented by MACL, with part of the project subcontracted. The overall objective of the project is to protect the turning pad area as a result of wave scour and flooding resulting from wave overtopping past the existing sheetpile structure.

The environmental consultants in coordination with the project engineer at MACL have come up with various conceptual options for cost optimization and to minimize possible environmental impacts. Since this is an immediate and temporary measure, minimal protection has been proposed, which is the protection of the immediate area behind the turning pad where sheetpile structure has been placed. The length of protection is about 100m. The other areas with concrete gravity seawalls have not been considered for protection as these areas are not severely affected and the entire area, including the 100m coastline which is proposed for immediate protection, would be reclaimed in the near future, as per the Airport Master Plan.

2.5 The Different Options

The different options for the protection of the proposed 100m coastline immediately behind the turning pad area include revetments along the coastline and offshore breakwaters covering a length of about 250m on the dead reef flat at about 100m from the sheetpile coastline. Of these the option of revetment outside the existing sheetpile has been recommended for reasons of cost as well as effectiveness with minimal environmental impact. Two types of materials have been considered for the revetments: single layer Core-Loc armour units and 2.5m^3 geotextile containers filled with sand. The details of these options are discussed in the following sub-sections and conceptual design and summary illustrated in

Rock boulders have been commonly used for shore protection and breakwaters in the Maldives in the past. However, in this project, rock boulders have not been considered because of the cost. Only cost-effective materials that the consultants are familiar with have been proposed. Also, the option of using groynes has not been considered because the lagoon on this side has been dredged as a result of which groynes would be expensive. Also, there is no need for beach in this area, which makes groynes as well as offshore breakwaters unnecessary.

2.5.1 Option 1: Revetment

Revetment behind the existing sheet pile structure and along the 100m length on the coastline west of the turning pad area is cheaper and has less environmental impact than the option of offshore breakwater on the reef flat given that the works would be carried out on the nearshore areas and the impact on any live coral in the reef flat areas would be minimal. In this option, two types of material are considered: geotextile containers/bags (design has been done for 5ton ELCORock containers) and armoured tetrapod (design done for CORE-LOC units). For the design of the revetment, the profile for the revetment (at 2H:3L) has to be created using sand borrowed from the already dredged area. A small volume not exceeding 700m^3 will be required. This is then compacted and covered by a layer of ELCOMax or other geotextile of appropriate thickness. For the geotextile revetment option, two different designs have been considered: (1A) compact and (1B) spaced with 0.2m spacing in between. For the Core-Loc revetment option (Option 1C), three rows of Core-Loc units of size 0.7m^3 will be spread on top of ELCOMax.

2.5.2 Option 2: Offshore breakwater

The offshore breakwater option would require covering a total length of about 250m as shown in Figure 2-2. The first two types (options 2A and 2B) use geotextile containers (ELCORock in this case) only while the third type (option 2C) uses both geotextile and Core-Loc units. Option 2A is an emerged structure standing at about 0.25m above high tide. With 0.2m gaps between the containers, the structure would have about 15% cavities. Option 2B is a submerged structure and would act as an artificial reef with its 15m wide base. Option 2B has two layers in each row. This has been tried in Bolifushi reclamation project and appears to be quite effective. Option 2C is also a submerged structure with ELCORock base and Core-loc armour on the seaward side with Core-loc providing 50-60% cavities and greater wave power disintegration.

2.5.3 Recommended Option

The option to recommend has been assessed based on an alternative analysis using matrices. First an environmental impact matrix was developed for the three options. The environmental impact matrix considered the impacts of the different activities on the different environmental components including key environmental indicators, key social indicators and key economic indicators by attributing values to magnitude (major adverse to major positive), significance/reversibility (insignificant or reversible to nationwide implications or irreversible), duration (immediate to longterm) and spatial extent (none or point of discharge to entire island or nation). Next, a product summary of the magnitude, significance, duration and spatial extent was made to estimate the impact indices for the key indicators against the key activities of the project. This matrix showed that the project had net positive impact given the importance of protecting the turning pad area of the airstrip. However, the net index was much higher for the revetment option than the offshore breakwater option.

Table 2-1: Net indices for the different options (a comparative analysis)

	Option 1A	Option 1B	Option 1C	Option 2A	Option 2B	Option 2C
Environmental Impact index	1.2	1.25	1.3	0.85	0.95	1
Performance index	2.5	3	3.5	2	1.5	1.75
Price Index	4.6	5	4.7	1.4	3	2.6
TOTAL	8.3	9.25	9.5	4.25	5.45	5.35

The Core-Loc units have very high permeability (50-60% voids) to absorb wave energy while the geotextile containers have no voids when placed together. Therefore, the design using geotextile containers have been revised to incorporate about 15% voids, thereby improving the wave energy absorption capacity. Based on the costs and wave energy absorption potential of each type of material, it is recommended to use the Core-Loc units. However, these units are not readily available in the Maldives, therefore, option 1B, using geotextile containers, have been recommended due to the urgency of the project. The revetments have been designed to provide adequate wave runup to minimize the force of the wave. Additional protection would not be required.

For the breakwater also, the above two types of materials in combination with submerged breakwaters as well as emerged breakwaters have been considered. The breakwater option is expensive given the length of the breakwater. Also, the greater distance between the potential breakwater location and the shore area to be protected is about 100m, which makes it less effective as wind waves will reoccur inside the lee of the breakwater. There is also slightly greater sedimentation and machinery impact from this option than the revetment option. Therefore, the breakwater option is not recommended for this project.

2.6 Work Method

The work will be carried out according to the methodologies proposed here in order to minimize sedimentation and ensure minimal disturbance to the environment and operations of the airport. First, site mobilisation will occur only after determining all necessary machinery, tools, materials and labour required for the project. If geotextile containers were to be used, filling the containers and placing them can be done together. This will minimize the space required to keep the containers, which would be quite much. The filling can be done on the existing reclaimed land near the project site. Two methods can be adopted for the filling. One is to pump sand using a 6/8" sand pump. This will ensure tight compaction of the geotextile containers. The other method is to use excavator to fill the containers. If excavators are used, it would be necessary to place the sand directly from the borrow location so that water also goes into the containers to ensure compaction.

When placing the geotextile containers, the container at the bottom of the profile shall hold the geotextile (ELCOMax) layer tightly in place so that sand does not move underneath the geotextile filter layer. The same applies to placing the filter layer for the tetrapod units, should they be used. In this case, however, 2-ton ELCORock container can be used in order to minimize cost. In the case of the geotextile containers, the profile can be set as the works progress. However, if tetrapods were to be used, the profile can be set first and then tetrapods placed on the top of the filter layer. The geotextile filter layer can be placed over the sheetpile, so that once the structural protection is in place, some amount of fill can be done to cover the erosion from wave scour that had occurred in the past. This is a small volume of sand and can be obtained from excavating the already dredged area.

2.7 Project duration

The project is expected to start soon after the approval of this EIA report, which should take less than 4 weeks from submission. The civil works are expected to take about one or two months. Therefore, it is expected that the project can be completed at by the end of May. It is important that the project be completed before the onset of the Southwest monsoon, which is when the area would be affected most.

2.8 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is the coastal protection afforded by the new structures. These inputs and outputs are summarised in Table 2-2 and Table 2-3.

Table 2-2: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Workers	MACL and contractor's workforce
Small volume of sand borrowed from lagoon areas	By excavation
Food, water and other resources	Provided on site for workforce
Machinery	MACL owned/contractor owned
Energy for machinery operation	Diesel fuel
ELCOMax containers/Core-Loc armour units	Imported

Table 2-3: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Wastewater from workers	No.of workers X 95L/c/d	Through existing island sewerage system
Possible oil leak from excavator, etc	Trace amount	N/A
Sediment plumes (during excavation)	Minute	Natural dispersion over a short period

2.9 Need and Justification

The primary justification for undertaking the proposed protection measures is to protect the airstrip from structural damage at the turning pad area. Such damage can cause disruptions to aircraft operations, which would create several direct and indirect effects on the national economy. Therefore, it is important to be prepared and take the necessary measures to mitigate such unnecessary impacts. However, it is worth mentioning that the need for such urgent protection measures would have been avoided if the reclamation project undertaken in 2007 was carried out in a planned and appropriate manner. That project was partially completed due to implementation difficulties. It was planned to transport dredged sand around Runway 18 in trucks. However, the practicality of this option was possibly not thought of during the planning and design stage that the borrow area had to be changed closer to the fill area, minimising fill and borrow areas. Current estimates show that about 27% of the proposed reclamation area has been reclaimed. If properly planned, the reclamation project could have achieved the required results with the same resources and time as well as similar environmental costs. Nevertheless, the damage had been done and an internal audit of the project was made, where it was recommended to either complete the reclamation project in a more feasible manner or to undertake immediate protection measures to address the erosion threats on the turning pad area. However, due to the recent global financial crisis, MACL had put off the remaining components of the previously proposed reclamation project. Consequently, the best way to mitigate the current threats to turning pad area is to undertake the immediate protection measures proposed in this EIA report.

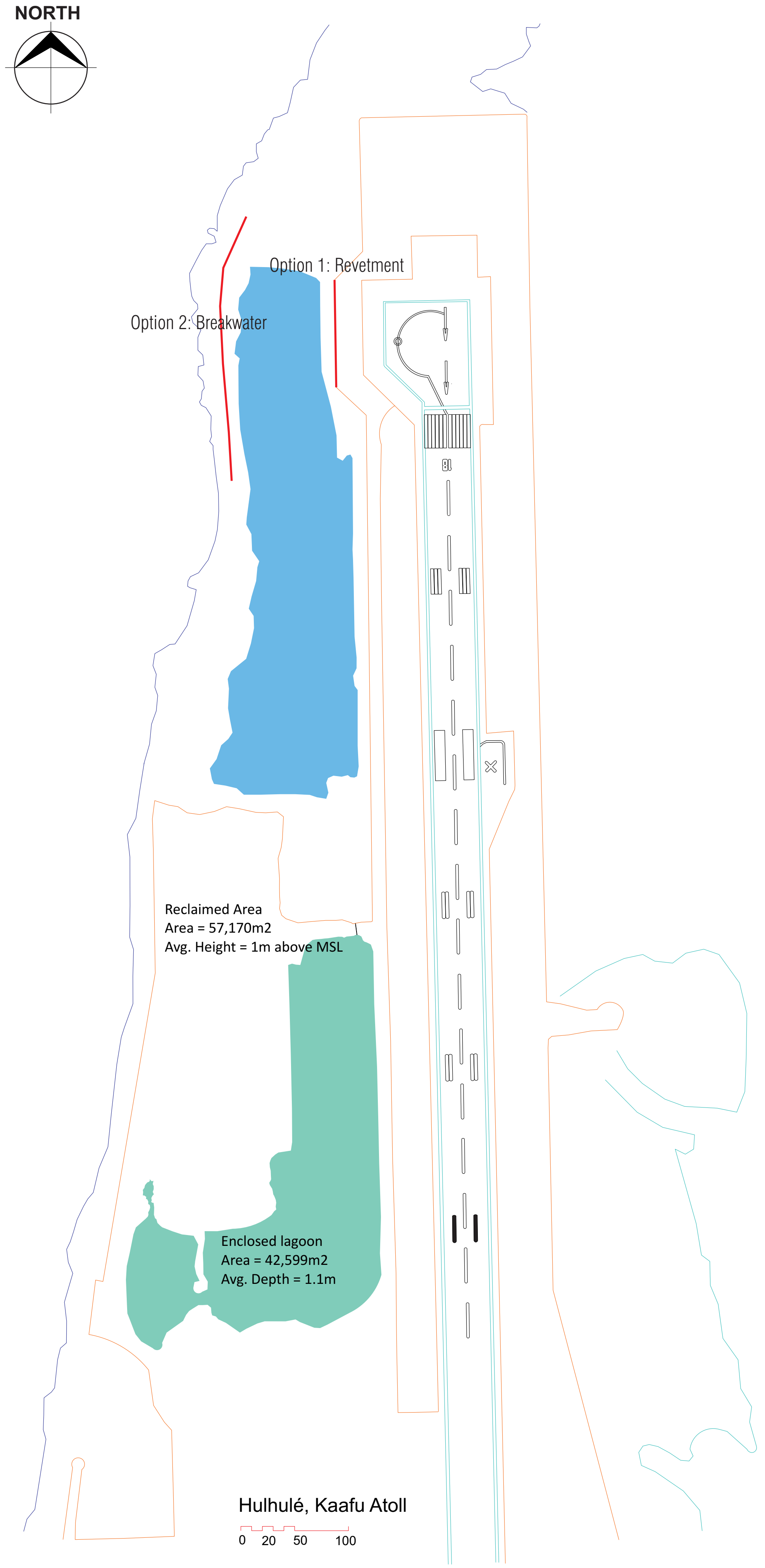
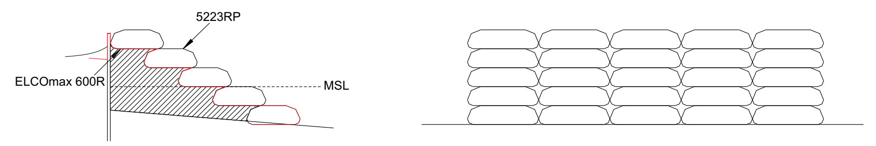


Figure 2-2: Concepts, summary and comparison of the different options considered

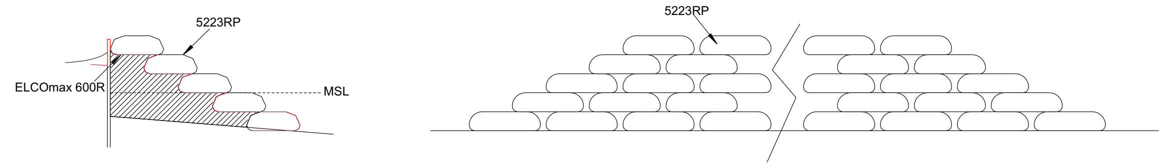
OPTION 1: REVETMENT

in this option, two types of material are considered: Geotextile bags (design has been done for 5ton ELCORock containers) and armoured tetrapod (design done for CORE-LOC units). The profile for the revetment has to be created using sand excavated from the already dredge area. A small volume not exceeding 700m3 will be required. This is then compacted and covered by a layer of ELCOMax or other geotextile of appropriate thickness. For the geotextile revetment option, two different designs have been considered: (A) compact and (B) spaced with 0.2m spacing in between. For the Core-Loc revetment option (Option 1.1C), three rows of Core-Loc units of size 0.7m3 will be spread on top of ELCOMax.

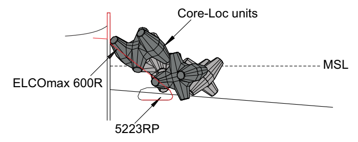
OPTION 1A



OPTION 1B



OPTION 1C



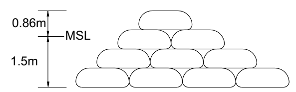
Cost Comparison (crude estimates)

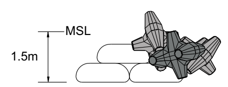
Option 1.1 A	135,000
Option 1.1B	125000
Option 1.1C	130000

OPTION 2: OFFSHORE BREAKWATER

The offshore breakwater option would require to cover a total length of about 250m as shown on the left side. The first two types (options 1.2A and 1.2B) use ELCORock only while the third type (option 1.2C) uses both geotextile and Core-Loc units. Option 1.2A is an emerged structure standing at about 0.25m above high tide. With 0.2m gaps between the containers, the structure would have about 15% cavities. Option 1.2B is a submerged structure and would act as an artificial reef with its 15m wide base. Option 1.2B has two layers in each row. This has been tried in Bolifushi project and appears to be quite effective. Option 1.2C is also a submerged structure with ELCORock base and Core-loc armour on the seaward side with Core-loc providing 60% cavities and greater wave power disintegration.

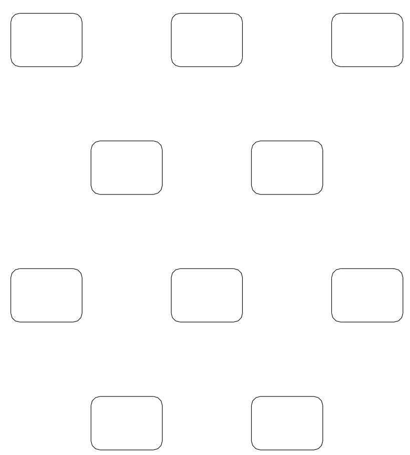
OPTION 2A





OPTION 2C

OPTION 2B (PLAN VIEW)



Cost Comparison (crude estimates)

Option 1.2 A	450,000
Option 1.2B	205,000
Option 1.2C	230,000

3 The Setting

The project takes place in the Maldives environment. Therefore, the extent to which the project conforms to existing plans, policies, guidelines, regulations and laws of the Maldives needs to be considered. Hence, this section will look at the context in which the project activities take place and the legal and policy aspects relevant to those activities. It is important to note that the project is of a local and regional scale and also has some bearing at a national context.

3.1 Applicable Policies, Laws and Regulations

There are few environmental policies, regulations and standards of specific relevance to coastal protection or environmental protection related to coastal protection activities. The main legal instrument pertaining to environmental protection is the Environmental Protection and Preservation Act (Law No. 4/93) of the Maldives passed by the Citizen's Majlis in April 1993. This Act provides the Ministry of Environment with wide statutory powers of environmental regulation and enforcement. This umbrella law covers issues such as environmental impact assessment, protected areas management and pollution prevention. The following clauses of the Environmental Protection and Preservation Act (Law No. 4/93) are relevant to the project:

Clause 5a: An impact assessment study shall be submitted to the Ministry of Environment, Energy and Water before implementing any development project that may have a potentially detrimental impact on the environment.

Clause 5b: The Ministry of Environment, Energy and Water shall formulate the guidelines for EIA and shall determine the projects that need such assessment as mentioned in paragraph (a) of this clause.

Clause 6: The Ministry of Environment, Energy and Water has the authority to terminate any project that has an undesirable impact on the environment. A project so terminated shall not receive any compensation.

Clause 9a: The penalty for minor offences in breach of this law or any regulations made under this law, shall be a fine ranging between Rf5.00 (five Rufiyaa) and Rf500.00 (five hundred Rufiyaa), depending on the actual gravity of the offence. The fine shall be levied by the Ministry of Environment, Energy and Water or by any other government authority designated by that Ministry.

Clause 9b: Except for those offences that are stated in (a) of this clause, all major offences under this law shall carry a fine of not more than Rf100,000,000.00 (one hundred million Rufiyaa), depending on the seriousness of the offence. The fine shall be levied by the Ministry of Environment, Energy and Water.

Clause 10: The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment. This includes all activities mentioned in Clause No. 7 of this law as well as those activities that take place outside the projects that are identified here as environmentally damaging.

Clause 5 is of specific relevance to this EIA. The EIA Regulations, which came into force in May 2007 has been developed by the powers vested by the above umbrella law. The EIA Regulations have been the basis for Environmental Impact Assessment in the Maldives and since its advent it had helped to improve the quality of EIAs undertaken in the country. Today, registered consultants are required to sign EIAs, the EIAs are reviewed by two independent reviewers and final decisions based on the reviews. This EIA would also be subject to these requirements and review criteria.

Several policy documents of relevance have come up in the recent years which are expected to guide the proposed development. One important policy document is the National Environment Protection Plan. This document contains environmental policies and guidelines that should be adhered to in the implementation of the proposed project activities, especially impact assessment, stakeholder consultation, biodiversity conservation and human settlement and urbanisation. The other similar document is the National Biodiversity Strategy and Action Plan, which focuses on biodiversity conservation and sustainable use of biological resources.

A Master Plan for Malé International Airport has also been approved by the Government recently, based on which a project to reclaim the shallow lagoon area on the northwest end of Runway 18 was initiated in 2007. An EIA report was prepared and approved for the project. However, the EIA report was not followed nor was the actual project plan followed during the implementation stage. Consequently, only a quarter of the proposed reclamation was achieved as the fill material was obtained from the wrong location, which again was a fact of poor planning.

3.2 Relevant Regulations, Standards and Guidelines

There are no relevant regulations, standards or guidelines for coastal protection activities in the Maldives. However, this EIA is guided by the EIA Regulations, which came into force recently in 2007. Schedule D of the EIA Regulations lists sea defence structures among the several development proposals requiring an EIA. Therefore, without a need for further screening the EIA process was started with the submission of EIA Application. While the EIA Regulations (pages 6 and 7) sets out the EIA application and approval process, it is sad to note that this process is not strictly adhered to. Sub Clause (4) of Clause 7 of the EIA Regulations clearly state that the "Ministry will endorse the Terms of Reference within ten (10) working days, which has not happened due to unknown reasons.

There are some recreational water quality standards that have been developed recently, which may have been relevant if the proposed area is used for recreational purposes. However, since this is not the case, these standards have not been considered appropriate.

3.3 Environmental Permits required for the Project

3.3.1 EIA Decision Note

The most important environmental permit to initiate proposed coastal protection works at Hulhulé would be a decision regarding this EIA from the Environmental Protection Agency (EPA). The EIA Decision Statement, as it is referred to, 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 Statement may only be given to the Proponent after a review of this document following which the EPA 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 EPA may provide the Decision Statement while at the same time requesting for further information.

4 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental and socio-economic components of the project that were considered are coastal environment, social and economic environment and coral reef areas as the marine environment. Hence, data collection was undertaken for the above components. In order to study the existing environment of the island, the following data collection methodologies were used during the field visit to Hulhulé on 3 December 2009.

4.1 General Methodologies of data collection

Conditions of the existing environment of the study area were analysed by using appropriate scientific methods. Field surveys were undertaken to get further understanding of the existing environment of the island. Field surveys were carried out during field visit to the island in December 2009 to collect baseline data. Before the trip was undertaken all existing information regarding the site was gathered from previous EIA report (2007) and Engineers report of the threats to turning pad area.

The following components of the existing environment were assessed.

- Coastal environment including coastal protection structures, longshore and offshore currents and levels
- Marine water quality
- House reef in the area
- Stakeholder views and grievances

4.1.1 Marine water quality

Marine water quality around the proposed dredging area was tested on site by using YSI water quality logger which can measure pH, electrical conductivity (salinity and TDS), turbidity and dissolved oxygen (DO). These measurements were done for three locations while water quality sampling was done at the house reef location only.

4.1.2 Bathymetry and Ocean Currents

Bathymetry of the lagoon area was done by Sandcays using Sonarmite echosounder connected to Trimble GeoExplorer XH differential GPS. The results of the bathymetry are given in the Appendix while drogue lines are shown in Figure 5-5. A purpose built drogue with a GPS was made to create spaghetti diagrams of the ocean currents. Two drogues were done: one at the project site and the other towards the middle of the west side reef of Hulhulé.

4.1.3 *Condition of the housereef*

Given the small scale of the project and the low cumulative impacts of the proposed project, house reef was not assessed in detail. However, the housereef at the proposed site was chosen to do the assessment by swimming along about 50m length of the reef flat about 5m from the reef edge, and also along the width of the reef flat starting from the reef edge up to the dredged area and recording observations as in a manta tow. Manta tow surveys were also done for the reef slope area towards the middle of the west side reef, from where the second drogue was done.

4.1.4 *Stakeholder consultations*

In the Terms of Reference for this EIA, stakeholder consultations is limited to the discussions held during the scoping meeting since participants including the Department of Civil Aviation had no issues with regard to the project. However, as outlined in the TOR, consultations with the project engineer and the Proponent in finalising coastal protection options is documented.

During the scoping meeting, the Consultant outlined the different options for coastal protection including the option of reclamation of the area as per the Airport Master Plan. However, it was decided that this EIA will focus on the proposed protection of the 100m off the turning pad area and the different options for associated with such protection will be discussed with the project engineer and finalised.

5 Existing Environment

This section covers the existing environmental conditions of the project site. The key environmental, social and economic components of the project under consideration are described below.

Vital Environmental, Social and Economic Components

- Topography
- Marine water quality
- Existing coastal defences
- Coastal resources
- Marine resources and protected marine areas
- Health and safety
- Public transport and aviation
- Employment and other economic benefits

Data was collected using internationally recognized methodologies discussed in the previous section.

5.1 Existing Coastal and Marine Environment

This section will describe the topography, marine water quality, existing coastal defences, seabed, beach and other coastal resources as well as marine resources and protected marine areas in the vicinity, especially potential impact zone of the project. These environmental elements of the project site has been modified to a great extent and the only natural areas that have not been directly modified is the housereef at the project site, which has also been heavily impacted due to various development activities, especially reclamation of Hulhulé and Hulhumalé.

5.1.1 Topography

The topography of the coastal and marine environment of the project area is such that the land area is only about 1.1m above mean sea level and the lagoon and the reef flat areas apart from the dredged area varies between 0.8 and 2m depth. The dredged area (about 46,000m^2) has an average depth of 3.3m. The reef slope varies from 2.5 to 10m with the drop off varying from 10 to 15m depth. Results from the topographic and bathymetric survey are given in Appendix 3.

5.1.2 Coastal and Marine Resources

The aquatic area on the west of Runway18 is the original reef flat of the island of Hulhulé. In fact, the northern end of the airstrip has been built on the reef flat with mainly coral rubble on the seabed (see Google image below). The reef flat in this area is completely dead and turbid, although there could have been live corals in the area before the development of the airport (during early 1970s). There are a few coral massives smothered in sediment, otherwise it is mainly bedrock with sand.

Figure 5-1: Satellite image of the project area (source: Google Earth 2009)

The manta tow at the project location along the reef slope/reef edge indicated that there is less than 2% live coral cover. These few live species also has a lot of sediment collected on them, literally struggling to survive. The manta tow from reef edge towards the shore along the reef flat indicated that the reef flat is almost entirely bedrock with few dead porites. Turbidity was high and fish population diversity and abundance is low in this area.

A comparative swim was also done between the two harbour entrances, where it was less turbid, however, the percentage live coral cover was similar. The abundance and diversity of fish life in this area is also higher.

5.1.3 Coastal Defences

The existing coastal defence consists of about 175m sheetpile seawalls directly close to the turning pad area on the northern end and concrete/cement seawalls in the other areas of the northwest shore (see figure below). Both structures are at about 1.8m above mean sea level. The concrete/cement seawall has been damaged at different points along the length of the wall.

Figure 5-2: Project area coastal protection works

The sheet pile structure is also damaged in some areas and sand is being washed out from the holes. There is wave scour behind the sheetpile structure. It has been reported that during rough weather the whole area including part of the turning pad area gets flooded due to wave attack.

5.2 General meteorological conditions

The climate of the Maldives varies slightly from North to South of the country. Long term meteorological data for Hulhulé is available and has been used in this study.

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. Table 5-1 provides a summary of key meteorological findings for Hulhulé, which is also generally representative of the Maldives.

Table 5-1: Key meteorological information

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February 1900mm annual average
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 C in November 1973 31.7 C in April
Extreme Air Temperature	34.1 C in April 1973 17.2 C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s (115km/h) in November 1978
Average air pressure	1012 mb in December 1010 mb in April

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

5.2.1 Wind

Wind has been shown to be an important indirect process affecting formation, development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore winds are important here, as being the dominant influence on the hydrodynamics in the project area (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too.

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

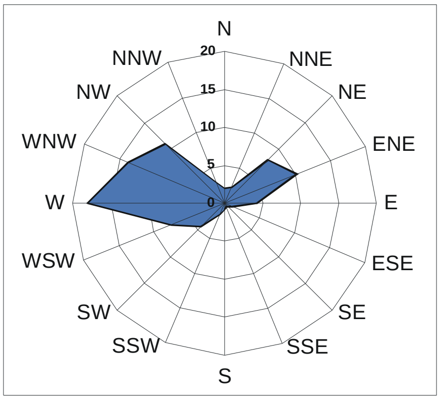


Figure 5-3: General wind rose diagram for the Maldives (source MEEW 2005).

Changes in wind directions need to be taken into consideration in determining the most favourable time period of the proposed coastal protection works. The Maldives experience strong ocean winds at speed of 6m/s to 7.5m/s at a height of 10m during June, July and August (Elliott *et al*, 2003). The southwest monsoon has the greatest impact on the project area. Therefore, it is important that the project is completed before mid May at the latest so as to improve performance of the project area during rough periods of southwest monsoon.

5.2.2 Waves

Wave energy is also important for the movement and settlement of sediments and suspended solids and is also a crucial factor controlling coral growth and reef development.

Studies by Lanka Hydraulics (1988a & 1998b) on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during May-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves. Swell waves, however, would not have any impact on the project area as the area is facing the atoll lagoon and would not be affected by swell waves. It is wind-generated waves during the southwest monsoon that would have the greatest impact on the project area.

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

5.2.3 Tides

Tides affect wave conditions, wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives, where the tidal range is small (1m), tides may have significantly important influence on the formation, development, and sediment movement process around the island. Tides also may play an important role in lagoon flushing, water circulation within the reef and water residence time within an enclosed reef highly depends on tidal fluctuations. However, the tidal movement have been assessed to a limited extent the fact that the house reef is at great distance from project site and zone of influence.

5.2.4 Currents

Studies on current flow within a reef flat in Male' Atoll suggests that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie Black & Veatch, 2000). However, available information suggests that tidal currents are not strong due to small tidal range.

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April the westward currents flow are weak and eastward currents flow will slowly take place. Similarly in December eastward currents flows are weak and westward currents will take over slowly.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef platforms, which are capable of transporting sediments on them. Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoonward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the backreef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

Drogues were done at the project location and towards the middle of the west side reef of Hulhulé as shown in Figure 5-4 in order to assess the movement of the water body around the island in order to determine seasonal current movement and sediment transport patterns around the island. The drogue at the project location travelled at 0.14m/s and the drogue at the central location travelled at 0.41m/s. This indicates that there is good flow at the central areas of Hulhulé, which is closer to the southern end of Hulhulé, where there is a strong current whereas the project area is towards the middle of Hulhulé and Hulhumalé reef system and shadowed by Hulhumalé. Wind speeds on the day of the field trip was an average of 5 km/h. Wave activity was not measured as the day of the field work was a calm day.

Figure 5-4: Drogue studies done in Hulhumalé, 3 December 2009

5.2.5 *Marine Water Quality*

The marine water quality tested at three locations at project site is given in Table 5-2. The water quality results given in this table shows very little variation at the three locations. The enclosed lagoon is slightly less salty with slightly lower levels of dissolved oxygen. It was noted that the enclosed lagoon was recently opened up to the open lagoon by placing a 10-inch pipe through which water circulates following observed water quality deterioration. Since the water quality was taken closer to the opening, it is believed that water quality at the southern end of the enclosed area would be much more degraded.

Table 5-2: Water quality results (3 Dec 2009)

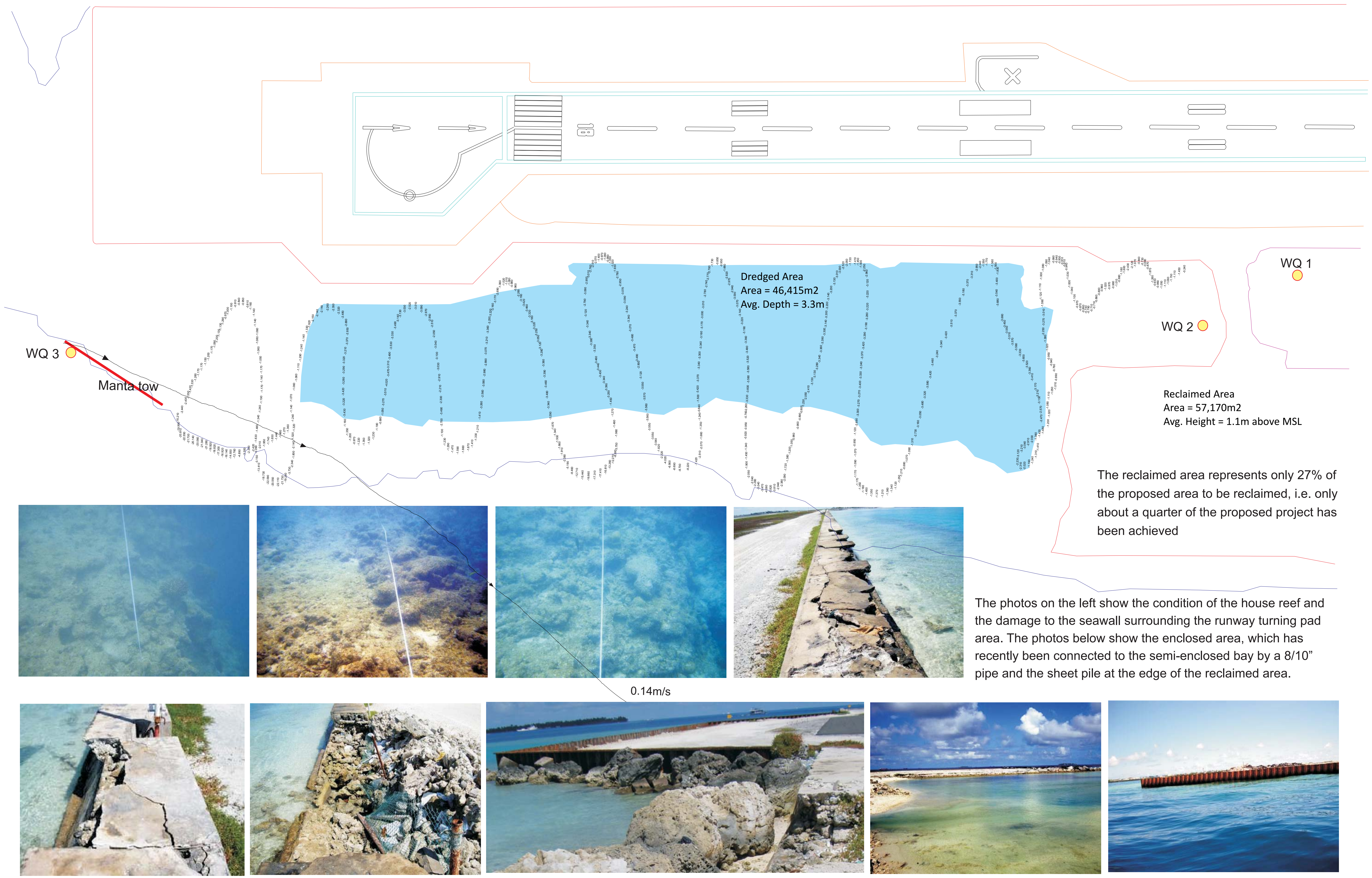
	Unit	WQ1	WQ2	WQ3
GPS Location WGS1984, Zone43	UTM	336644.4346E 464466.5840N	336602.8851E 464518.9359N	336503.5742E 465150.4576N
Temperature	oC	30.6	30.28	29.28
E-Conductivity	uS/cm	57,740	59,015	59,246
TDS	mg/l	34,040	34,830	35,590
Salinity	mg/l	34,320	35,200	36,120
DO	mg/l	7.23	7.79	7.95
pH		8.14	8.14	8.17

Additional parameters were tested in the lab for the sample taken from location WQ3 (marine transect location). The results are given below. The results indicate lower BOD than in more live reef areas due to the low biological activity. The normal BOD for live reef areas have not been determined by any of the studies in the Maldives so far, therefore, BOD is compared to a few values given in EIA reports done in the past. The high COD values are not attributed to chemical pollution but to the high salt concentration of the natural sea water.

Table 5-3: Additional water quality results (3 Dec 2009)

	Unit	WQ3
BOD	mg/l	6
COD	mg/l	1,640
Nitrate	mg/l	0.1
Phosphate	mg/l	0.03
Turbidity	NTU	0.65

Figure 5-5: Photos and illustrated representation of site conditions



6 Stakeholder Consultations

Stakeholder consultations is limited to the discussions held during the scoping meeting since participants including the Department of Civil Aviation had no issues with regard to the project. However, as outlined in the TOR, consultations with the project engineer and the Proponent in finalising coastal protection options is discussed below.

6.1 Consultations with the Proponent

During the scoping meeting, the Consultant outlined the different options for coastal protection including the option of reclamation of the area as per the Airport Master Plan. However, it was decided that this EIA will focus on the proposed protection of the 100m off the turning pad area and the different options for associated with such protection will be discussed with the project engineer and finalised. A summary of the discussions with the project engineer is outlined here.

6.1.1 *List of persons met*

Following are the names and designation of persons consulted.

	Name	Office	Designation
1.	Mohamed Zuhair	EPA	Director General
2.	Ibrahim Naeem	EPA	Director
3.	Ibrahim Mohamed	EPA	Assistant Director
4.	Ahmed Fayaz Shareef	MACL	Head, Built Services Dept.
5.	Mohamed Salah	MACL	Assistant Manager
6.	Akram Ramzy	MACL	Project Manager

7 Impacts and Mitigation Measures

This section covers potential environmental impacts due to proposed coastal protection project. The section also describes the mitigation measures for each identified impact. Methods of identification of potential impacts and possible mitigation measures have been described. Before proceeding on to the potential impacts from the project, it is considered worthwhile looking at the existing environmental concerns so that cumulative and residual impacts of the proposed project are better understood.

7.1 Impact Identification

Impacts on the environment from various activities of the proposed project have been identified through:

- A consultative process within the EIA team and the Proponent
- Purpose-built checklists
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Contractor specifications and bills of quantities
- Baseline environmental conditions described in Chapter 4
- Consultants experience of projects of similar nature and of the areas in which the developments will take place

Possible negative impacts on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in the implementation phase. Potential positive impacts of the project have been considered on a moderate note so that the negative impacts are not ignored, especially during planning as well as implementation of the project.

7.2 Identifying Mitigation Measures

Where an impact identified can be mitigated, mitigation measures are identified and discussed along with the identification of the impact. The mitigation measures proposed will help to alleviate or eliminate environmental problems before they occur. Mitigation measures are important because if identified impacts are significant and/or important, it would be necessary to identify and implement mitigation measures. Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project. Where mitigation is deemed appropriate, the proponent should strive to act upon effects, in the following order of priority, to:

1. Eliminate or avoid adverse effects, where reasonably achievable.
2. Reduce adverse effects to the lowest reasonably achievable level.

3. Regulate adverse effects to an acceptable level, or to an acceptable time period.
4. Create other beneficial effects to partially or fully substitute for, or counter-balance, adverse effects.

7.3 Existing Environmental Concerns

Dredging, reclamation and coastal protection works have been undertaken at the project area from 2007 to 2008. These have caused high level of siltation and sand smothering of coral in the area, leaving the entire reef flat dead. The reclamation of Hulhumalé in the late 90s would also have contributed to the death of corals in the area, however, this is considered insignificant when compared with the damage caused by the dredging and reclamation undertaken at the site in the recent years. In fact, the damage to the reef goes back to the mid 1970s when the airstrip was first built by reclaiming land. Since there had not been any monitoring data from past projects in the area, it is not possible to determine the extent of impacts related to the different projects. It is, however, worth mentioning that the reclamation project undertaken recently has had very poor environmental compliance and performance that it had done more damage than necessary. The enclosed lagoon and the level of sediment resuspended in the water column bear witness to the fact that the project was poorly planned and implemented. There are no other serious environmental concerns related to the project site.

There are concerns of the impacts of the environment on the existing coastal defence structures including direct wave attack on the structure, wave overtopping and subsequent flooding of the area behind the structure resulting in potential threat to turning pad of the airstrip. These have been discussed earlier and are the primary justifications for the proposed project. Again, this is mainly attributed to the inappropriate planning and implementation of the past reclamation project.

7.4 Potential Impacts and Mitigation Measures

Excavation or sand pumping and installation of 100m long revetment are the key components of the proposed project. The degree of adverse environmental impacts caused by this project depends on the timing, methodologies, and distance of ecologically sensitive areas or species and economically important areas. The impacts of these factors in the proposed project are minimal and insignificant. However, as mentioned earlier, negative impacts are considered under a worst-case scenario and the following subsections consider those impacts for the different activities under the project. Yet, it can be safely argued that the cumulative impacts from the proposed project would be much less than the cumulative impacts of the airstrip development and previous dredging and reclamation projects undertaken at the site.

7.4.1 *Workforce*

The impacts from workforce would be mainly related to their sewage and wastewater as well as solid waste disposal. There is no particular proposed method of disposal of waste and wastewater at this stage. Therefore, taking the worst case of onsite disposal, the impact of raw sewage disposal would be minor, insignificant and short-term. The geographic coverage of such impacts would also be restricted to immediate vicinity of the disposal location. However, solid waste, especially plastics including PET bottles used for drinking water would pose greater environmental impact if they are not disposed of properly. While it is not within the scope of this EIA, it is worth mentioning that the safety of the runway may be a cause for concern as workers have direct access to the runway during working hours.

It is expected that the following impact mitigation measures will be in place.

- Existing toilets in the vicinity of the project site will be used by the workforce as workforce will not be accommodated at site but will transfer from Malé to site on regular ferries
- Waste will be collected in medium to large bins and disposed to Thilafushi at definite intervals.
- While all safety precautions will be taken by MACL, the contractor must have a site supervisor to supervise workers at all times

7.4.2 *Machinery*

The possible major impact from machineries would be oil leak or accidental oil spill. While, there has not been major oil spill incidents reported in the past during such works, every precaution shall be taken to minimize the potential for any hazards. Since heavy machinery will be used, manual fuelling processes may and often does result in some spills, which are usually not thought to be a problem. However, attention needs to be paid to make sure that no fuel is spilt on the ground. Other than these impacts, the impact from machineries is minimal and insignificant such as noise generation and emission of exhaust gas during the operation.

7.4.3 *Excavation and filling*

The proposed excavation and filling is for creating the fill profile of the revetment area, optional fill behind the existing sheetpile quaywall and the filling of geotextile containers. This is a small volume of sand that will be excavated from the lagoon. The main environmental impacts of these two processes would be sedimentation and sediment re-suspension in the water column. The impact significance of this activity without mitigation measures would be classified as low or nil given that there is less than 1% live coral and even that is at a considerable distance from the proposed project work areas. Therefore, no particular mitigation measures are proposed for this component.

7.4.4 Revetment installation

Since the area is dredged, movement of excavator for revetment installation is not possible. Therefore, a spud barge would be required. A spud barge will have to be brought into the dredged area. There is an entrance channel cleared from the reef flat from which the barge will enter into the lagoon. Therefore, there will be no further impacts of this activity. Excavators will work from the barge, thereby minimizing sedimentation due to direct movement on the seabed. The impact of the revetment installation works would be low.

Upon completion or during the works, it is possible that algae will grow heavily on the geotextile containers. Once the works are finished and the fines have settled, the algae can be removed manually and used as fertiliser or buried in the ground somewhere. Further algal blooms on the geotextile containers are not expected. Given that aesthetics is not really important in this area, this would also not be a cause for concern. There would be some safety issues when handling geotextile containers. It has been observed that some workers get their hand stuck under the containers during handling. Therefore, it is recommended to brief workers on the appropriate handling of the containers and making sure that they follow handling instructions. There are no further mitigation measures to be proposed with regard to installation of the proposed revetment.

The installation of the proposed revetment has major positive impacts in that it helps to minimize wave overtopping and wave scour behind the sheet pile structure so that the flooding of the area behind the sheetpile and potential risk of subsidence of the airstrip turning pad is minimized to a great extent.

7.5 Impact Evaluation

Impacts of the project have been evaluated according to the following criteria:

1. Magnitude (or severity): the amount or scale of change that will result from the impact

2. Significance: importance of the impact. Reversibility is considered part of its significance

3. Duration: the time over which the impact would be felt

4. Extent/spatial distribution: the spatial extent over which the impact would be felt

The scales associated with the above criteria are given in the table below.

Table 7-1: 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	Longterm/continuous
Extent/Spatial Distribution *Distribution of impact*	0	None/within 1m from point of discharge
	1	Immediate vicinity/household level
	2	Specific areas within the island/atoll
	3	Entire island/atoll/nation

Based on the above scale, an impact matrix was developed for the proposed or recommended option to determine that overall impact of the proposed project. This matrix is given in the table below.

Table 7-2: Impact matrix for the proposed or recommended revetment option

	KEY COMPONENTS									
	Environment					Socio-Economic				
PROJECT ACTIVITIES	Reefs	Live Bait	Lagoon/seawater	Land/seascape	Air/Noise	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer
Construction										
Excavation/sand pumping	-1 1 1 2	0	-1 1 1 1	-1 0 1 1	0	0	-1 1 1 1	1 1 1 1	0	-1 0 1 3
Revetment installation	-1 1 1 2	0	-1 0 1 1	-1 0 1 1	0	0	-2 1 1 1	1 1 1 1	0	-1 0 1 3
Machinery and construction equipment	-2 1 1 1	0	-1 0 1 1	-1 0 1 1	-1 0 1 1	0	-1 1 1 1	1 1 1 1	0	-1 0 1 3
Workforce management	0	0	0	0	0	0	-1 0 1 1	1 1 1 1	0	-1 0 1 3
Operation										
Infrastructure	0	0	0	0	0	2 2 2 1	0	0	2 1 2 2	1 1 2 3
Control of flood due to wave activity	0	0	0	0	0	1 1 2 2	3 2 2 2	0	0	1 1 2 3
Maintenance and repairs (technical)	0	0	0	0	0	1 1 2 2	0	-1 0 2 3	0	2 1 2 3

M	S	Magnitude	Significance
D	E	Duration	Extent (spatial)

An impact potential index was then developed from the above table. The impact potential index table below represents a product of the magnitude (M), significance (S), duration (D) and extent/spatial distribution (E) given in the above table. The sum of all key component specific indexes for one activity (i.e. sum by rows) provides the Activity Potential Impact Index (API) and the sum of all activity specific indexes for one key component (i.e. sum by column) provides the Component Potential Vulnerability Index (CPVI) which gives an indication of the vulnerability of each key component to activity related impacts. The table below represent the impact potential indices for the proposed or recommended option.

	KEY COMPONENTS										
	Environment					Socio-economic					
PROJECT ACTIVITIES	Reefs	Live Bait	Lagoon/seawater	Land/seascape	Air/Noise	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer	TOTAL API
Construction											
Excavation/sand pumping	-0.02	0	-0.01	0	0	0	-0.01	0.01	0	0	-0.03
Revetment installation	-0.02	0	0	0	0	0	-0.02	0.01	0	0	-0.03
Machinery and construction equipment	-0.02	0	0	0	0	0	-0.01	0.01	0	0	-0.02
Workforce management	0	0	0	0	0	0	0	0.01	0	0	0.01
Operation											
Infrastructure	0	0	0	0	0	0.1	0	0	0.1	0.07	0.27
control of flood due to wave activity	0	0	0	0	0	0.05	0.3	0	0	0.07	0.42
Maintenance and repairs	0	0	0	0	0	0.05	0	0	0	0.15	0.2
TOTAL CPVI	-0.06	0	-0.01	0	0	0.2	0.26	0.04	0.1	0.29	0.82

API = Activity Potential Impact Index
CPVI = Component Potential Vulnerability Index

The table above indicates that the project has some negative environmental impacts during the construction phase which are not as strong as the positive outcomes of the project, as a result of which the total potential impact index for the project is slightly positive.

7.6 Uncertainties in Impact Prediction

The level of uncertainty, in the case of the proposed project in Hulhulé may be expected to be low due to the experience of similar projects in similar settings in the Maldives. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring of water quality during and after project implementation in addition to regular evaluation of the performance of the proposed coastal structures, as recommended in the monitoring programme would be useful.

Table 7-3: Summary of negative impacts of proposed coastal protection on west of Runway18

Activity	Negative Impacts	Geographic Extent	Type of impact	Duration	Reversibility	Magnitude
Excavation and fill	• Loss of sand from lagoon (to be reclaimed)	<1,200m^3	Direct	Short term	Reversible	Minor negative
	• Sedimentation on the reef flat (dead) • Re-suspension of fine sediments	<4,000m^2	Direct and indirect	Short term	Irreversible	Minor negative
Site mobilization	• Impacts of workforce	Entire work area	Direct	Short term	Reversible	Minor negative
	• Impacts of machinery (noise, etc)	Worksite only	Direct	Short term	Reversible	Minor negative
Fuel consumption	• Global warming and climate change	Global	Indirect	Long term	Irreversible	Moderate
	• Spillage into environment	Hulhule northwest lagoon	Direct	Long term	Irreversible	Moderate

Table 7-4: Summary of positive impacts of proposed coastal protection on west of Runway18

Activity	Positive Impacts	Beneficiaries/Geographic Extent	Magnitude
Coastal protection structure	• Improved safety of the airstrip/runway	MACL/users	Major positive
	• Minimal maintenance in the long term	MACL	Moderate positive
Contractual services	• Some employment during construction	Contractor	Minor positive
	• Indirect employment due to expansion of contractual services in the future	Contractor	Minor positive
Maintenance of Runway	• Minimize maintenance of turning pad area	MACL	Moderate positive
	• Reduces risk of flooding/subsidence	MACL	Major positive
	• Reduces long term cost of maintenance	MACL/Users	Minor positive

8 Alternatives

This section looks at different alternatives for the proposed project. There are two basic options: (1) leave the problem as it is (no project option), or (2) take measures to resolve the problem (undertake the project options). If the project were to continue, it would be necessary to take economic, ecological and social aspects of the project into consideration and ensure that these concerns exist within a delicate balance. Neither the economic benefits nor the social and ecological concerns can be avoided. Therefore, it is important to consider all options and ensure that the best available option(s) is/are chosen to solve the issues/problems.

The different options for the protection of the turning pad area have been discussed in the Project Description section of this report. Therefore, these options will not be further considered here. The other alternatives to the proposed project considered here would be the no project option and the reclamation option (or the delay option), which is similar to the no-project option.

8.1 No project option

It should be noted that the "no project" option cannot be excluded without proper evaluation. In this report this alternative was considered as the baseline against which to evaluate the other options. The no project option takes the following into consideration:

- It is worth risking the safety of the turning pad area
- Existing flooding and subsidence concerns can remain
- Regular maintenance of the turning pad area would be more meaningful

The main advantages and disadvantages of the no-project option are given in Table 8-1.

Table 8-1: Advantages and disadvantages of the no project option

Strategy	Advantages	Disadvantages
Safety of the turning pad area is not an issue	Costs related to improving the situation may be avoided in the short term	Safety is compromised
Let the problems continue	Costs related to the project can be avoided and costs incorporated into future planning and development	Safety is compromised
Keep testing and repairing the turning pad area	Costs related to the project can be avoided and costs incorporated into future planning and development	Regular repairs would be a financial and technical burden for a long time

A comparison of the no project option with the recommended and other evaluated options indicate that the no-project option is not feasible given that the project has to do with the safety of the main international airport in the Maldives.

8.2 Reclamation Option

This option takes into consideration that the area which was proposed for reclamation in 2007 would be reclaimed in the near future to ensure that the objectives of Airport Master Plan are met.

8.2.1 Shortcomings of the Previous Reclamation Project

A project was undertaken between 2007 and 2008 to reclaim the area on the west of the northern end of Runway 18, which includes the area considered here for protection. The proposed project involved the reclamation of about 21 hectares of land for the purpose of expansion on the northwestern corner of the island towards the north end of Runway 18 by dredging an area of 115,900m^2 on the east of Runway 18 to a depth of about 5.5m below MSL. About 456,000m^3 of sand was estimated for the project. The project also includes a 1.15km quaywall around the reclaimed area. It was planned to transport dredged sand around Runway 18 in trucks. However, the practicality of this option was possibly not thought of during the planning and design stage that the borrow area had to be changed closer to the fill area, minimising fill and borrow areas. Current estimates show that a total area of about 57,170m^2 of land has been reclaimed by excavating an area of 46,975m^2 from the same lagoon area to an average depth of about 3.3m below MSL. Therefore, about 27% of the proposed reclamation area has been achieved.

A review of the reclamation project EIA and implementation indicates that there were shortcomings both in the EIA report as well as project planning. The borrow area and the difficulties that the project proponent may face in borrowing sand to the proposed location have not been considered at all. Alternative borrow area options have not been evaluated in the EIA report.

8.2.2 Future Reclamation and Coastal Protection Options

Although it is beyond the scope of this EIA, the Consultants considered the possible borrow areas and coastal protection options for a future reclamation as alternatives to the project. These are summarised in Figure 8-1

The advantages and disadvantages of a slightly delayed response to potential threat of subsidence of the turning pad area are given in the table below:

Table 8-2: Advantages and disadvantages of waiting for the potential reclamation of the area

Advantages	Disadvantages
- Minimize duplication of protection efforts - Minimizes costs of protection - Reduces cumulative environmental impacts - Helps to achieve Airport Master Plan targets quickly	- Increases the risk of potential subsidence and subsequent disruptions to aircraft operations - Disruptions to airport operations can impact the national economy directly and indirectly - Increases the cost of maintenance

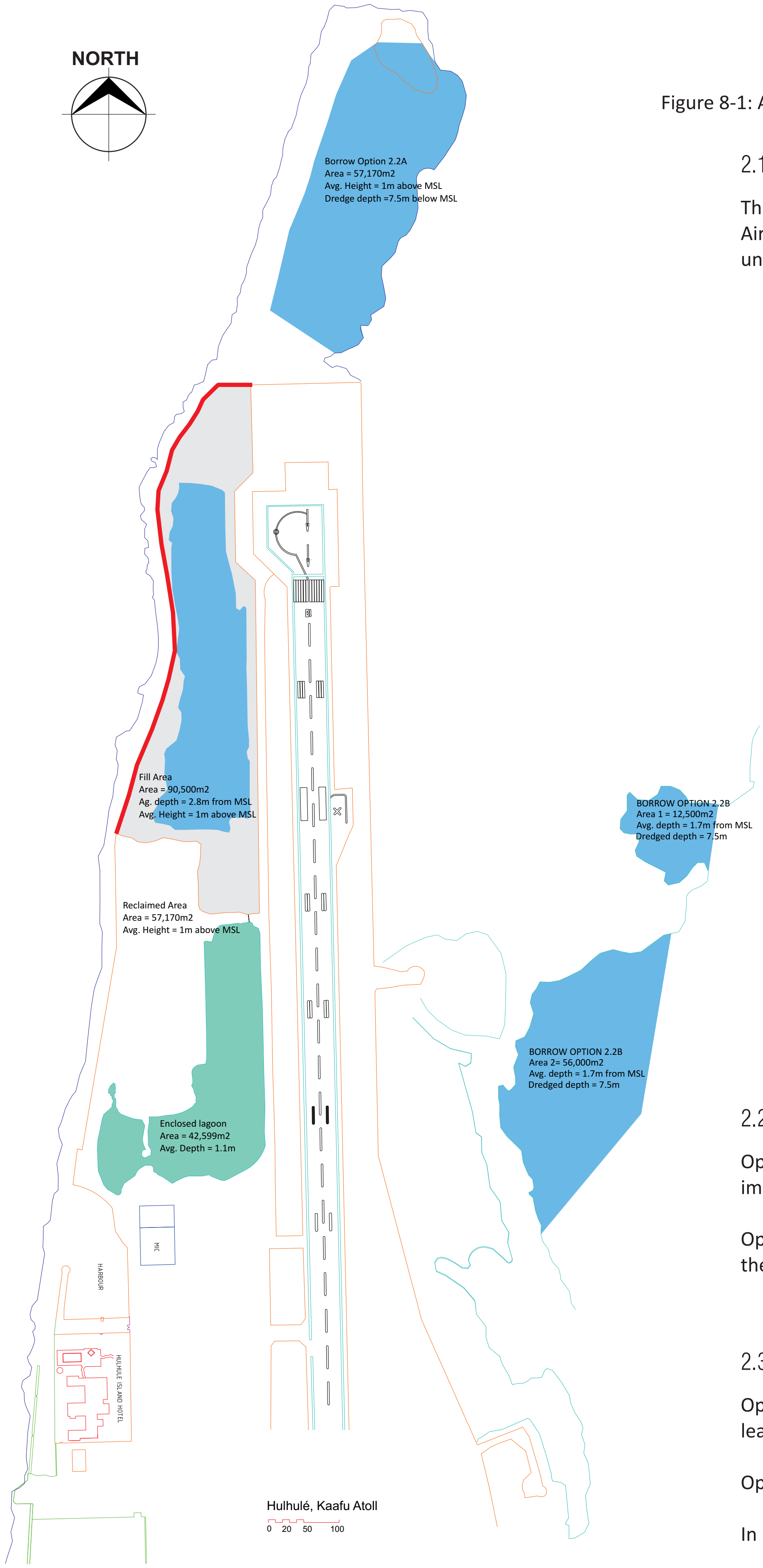
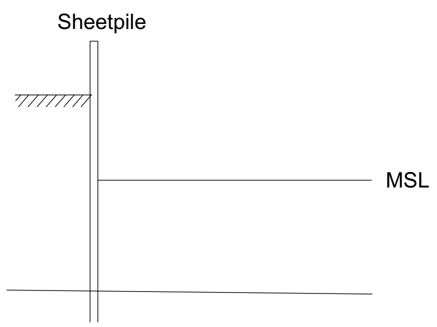


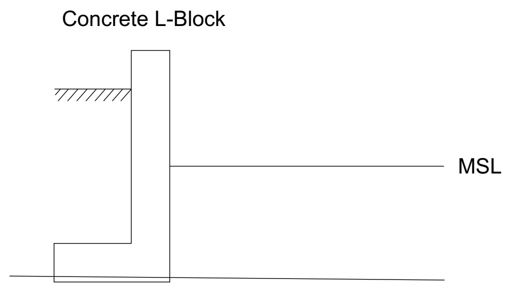
Figure 8-1: Alternative of future reclamation and corresponding coastal protection options

2.1 QUAYWALL/COASTAL PROTECTION OPTIONS

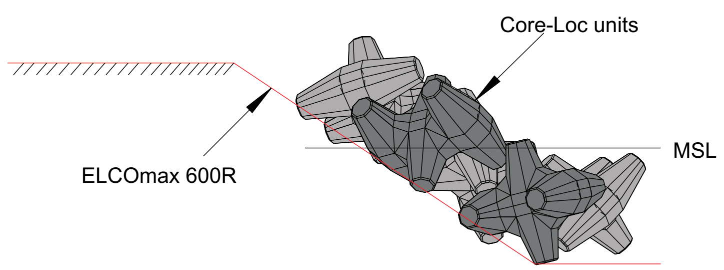
This option takes into consideration that the area which was proposed for reclamation in 2007 would be reclaimed in the near future to ensure that the objectives of Airport Master Plan are met. The two types of quaywalls proposed in the initial EIA report (sheetpile and L-block) are also proposed here along with Core-loc u armour units and ELCORock geotextile tubes with the RP series on top. Sheetpile is used in the previously reclaimed area.



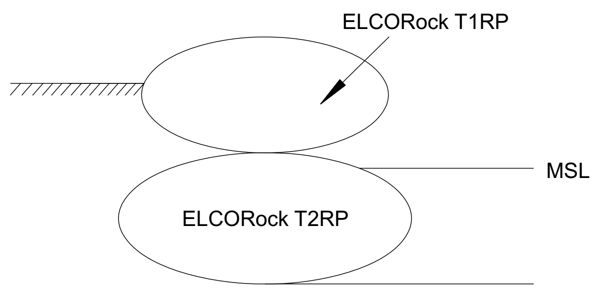
OPTION 2.1A



OPTION 2.1B



OPTION 2.1C



OPTION 2.1D

2.2 BORROW LOCATIONS

Option 2.2 A: From the entrance channel to Hulhumalé towards the airstrip end. This was an option that could have also been identified during the initial project implementation. This location is quite feasible for both dredger and excavator operations (see 2.3 below).

Option 2.2 B: The same location identified in the initial EIA report. What is shown on the left figure is for illustration only. The shape of the borrow area need not be the same and the same or exact location shown here need not be considered.

2.3 DREDGE METHODS

Option 2.3 A: Use of excavators as has been the case in the initial project implementation. However, in order to speed up the works, larger sizes such as 460s and at least three excavators shall be used. This is expected to pump about 1300cbm per day. This method is expected to take about 1 year to complete the dredging.

Option 2.3 B: A large dredger with a capacity of 4500cbm per day shall be considered. This is expected to take about 3.5 months to complete the dredging

In both these options, loaders will be required to spread the sand.

9 Environmental Monitoring

There are only a few potential environmental impacts of the project. No sensitive ecosystems or other environmental resources have been identified in the project area or project impact zone. Therefore, it is not recommended to undertake environmental monitoring for this project. However, in order to understand and document the potential benefits of the project, it would be useful to document the flooding events (following severe storms), sand scour and structural integrity of the turning pad area. This can be done by the Built Environment Services Division of the Maldives Airports Company at regular intervals by checking levels of the area and undertaking appropriate engineering tests following flood events starting from now for at least a year or over the period until reclamation of the area has been undertaken.

Malé International Airport does not have a corporate environmental monitoring programme. Therefore, it is recommended that the Maldives Airports Company Limited initiate an integrated, island-wide environmental monitoring programme. There are several benefits to such a programme including:

- Impacts on the island of different projects ongoing including reclamation, harbour and quaywall, solid waste management, water and sewerage and other projects can be undertaken in a coordinated manner
- Since all projects impact upon the same environmental resources and aspects, the cumulative impacts of all projects combined is better understood
- A holistics approach to environmental management can be adopted
- Cost of monitoring would be reduced and more parameters can be monitored.

MACL could also incorporate other operations such as seaplane operations into such a monitoring programme with their cooperation. Water quality, land use, reef, noise, carbon emissions/fuel and energy efficiency and visitor satisfaction are some of the important elements that can be covered and would provide valuable information.

10 Declaration of the consultant

This EIA has been prepared according to the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water. I certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of my knowledge and abilities.

Name: Ahmed Zahid (EIA 08/07)

Signature:

Date:

11 Sources of Information

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Environmental Protection Agency

Ministry of Housing, Transport and Environment

Male', Republic of Maldives

Terms of Reference for Environmental Impact Assessment for the proposed Coastal Protection and Erosion Control on West of Runway 18 at Malé International Airport, Hulhulé, Malé Atoll, Maldives.

This is the draft TOR for undertaking the EIA of **the proposed Coastal Protection and Erosion Control on West of Runway 18 at Malé International Airport, Hulhulé, Malé Atoll, Maldives.** This TOR is based on the issues raised in the scoping meeting held on Wednesday, 20 January 2010 at Environmental Protection Agency.

1. Introduction – The western coastline at the turning pad area on Runway 18 has been protected by a sheetpile structure as a result of which it is prone to wave scour and subsequent flooding of the area. This has been worsened by the recent excavation/deepening of the shallow lagoon immediately in front of the area. Therefore, there is an immediate need to protect this area by strengthening the quaywall or by providing additional coastal protection measures.

2. Study Area – The study area is on the northwestern end of Runway 18 just off the turning pad area of Malé International Airport. While the entire western shoreline is prone to wave attack and requires protection, the turning pad is the most vulnerable area and needs an immediate solution.

3. Scope of Work – This TOR is specifically for the protection or enhancement of existing structures along about 100m of coastline off the turning pad area at Runway 18, Malé International Airport. The following tasks will be performed:

Task 1. Description of the Proposed Project – Provide a full description of the relevant components and nature of the project, using maps at appropriate scales where necessary. This is to include: brief description of the proponent, justification of the proposed project, a clearly labelled site plan and drawings, a detailed description of how the project activities will be undertaken including work methods, a matrix of project inputs and outputs, details of coastal modifications including strengthening of existing coastal protection structures and a detailed project schedule. The boundaries of the study area for the EIA shall be provided.

Task 2. Description of the Environment – include a description of the existing environmental conditions of the project site with photos of the site where relevant.. All baseline data must be presented in such a way that they may be usefully applied to future monitoring. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable for use as a baseline to monitoring impacts

Specific emphasis should be placed on the following activities of the project or related to the project:

- *Machinery and construction equipment*

- *Coastal protection structures such as seawalls or revetments to protect the project area*
- *Workforce management*
- *Safety of the airstrip*

As such the following field investigations must be considered for baseline data collection:

- *Longshore/offshore currents at the project site and towards the mid area of the western side*
- *General climatic and oceanographic conditions in the project area*
- *Bathymetry of the lagoon at the project site*
- *Sea water quality parameters shall specifically include dissolved oxygen, salinity, pH, temperature, nitrate, phosphate, BOD, COD and turbidity*
- *Condition of the house reef at the project area, especially reef flat area where structures may be constructed and machinery may be used*
- *Condition of existing quaywall and the height of quaywall and western coastline with reference to MSL*

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

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

Task 4. Impacts – Provide an assessment of the impacts of the proposed structures. During the constructional phase impacts of coastal protection works, siting and location of offshore structures, constructional (demolition) waste (if any), impacts of machinery and workforce needs to be considered. The impacts of the structures on the environment and that of the environment on the structures and the impacts of structural maintenance over the life span of the structure shall be discussed. In addition, drainage of flood water, safety of the airstrip (turning pad area) and any other impacts of the project including any post construction stage impacts shall be considered.

In addition to negative impacts, all beneficial impacts of the project shall be identified.

Task 5. Mitigation measures - Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to construction methods and materials that would minimize impact on the environment. Discuss the feasibility and cost effectiveness of each mitigation measure and provide the costs of mitigation and the commitment to it.

Task 6. Alternatives - This section must include the proposed development scenarios evaluated against the no-project option and other alternatives. These include alternative technologies and materials, alternative coastal protection measures and other alternatives such as potential future reclamation of the area. Recommendations based on the evaluated options/alternatives shall be made and how the recommended alternative was selected shall be discussed.

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<u>Task 7. Environmental Monitoring Plan</u> – Environmental monitoring shall focus on the construction as well as post construction stage. Constructional monitoring shall be limited to an inspection of site management issues to ensure that the mitigation plan given in the EIA report is followed. These may include things like daily logs of machinery movement on reef flat areas, incidents and safety issues shall be made by site supervisor or engineer. Post construction monitoring should focus on the effectiveness of the proposed structures in achieving the objectives. Hence, as-built drawing shall be made, wave scour behind the structure, flooding of the area and potential erosion shall be evaluated following each storm event or rough weather which may be expected to affect the structures. The report should also provide a detailed cost breakdown for implementing the monitoring plan. Provide commitment of the Proponent to conduct the monitoring programme.

<u>Task 8. Stakeholder Consultation</u> – Stakeholder consultations may be limited to the discussions held during the scoping meeting since participants including the Department of Civil Aviation had no issues with regard to the project. Consultations with the project engineer and the Proponent in finalising coastal protection options shall be documented.

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

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

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(11march 2010)

ENVIRONMENTAL PROTECTION AGENCY
Malé, Republic of Maldives

بسم الله الرحمن الرحيم

MALDIVES AIRPORTS Co

your journey : our business

OUR REF: 116-D35/OTH/2010/844

DATE: 08th April 2010

Mr. Mohamed Zuhair

Director General

Environmental Protection Agency

Jamaaluddeen Complex, 4th Floor

Nikagas Magu

Male'

Dear Sir,

ENVIRONMENTAL AUDIT & EIA OF COASTAL PROTECTION AT MALE' INTERNATIONAL AIRPORT - RUNWAY-18, TURNING PAD AREA – FINAL REPORT.

This is to inform you that MACL assures it's commitment to undertake the mitigation measures and monitoring programme outlined in the above mentioned EIA report.

Yours faithfully

Mohamed Amir

Chief Engineering & Maintenance

Engineering & Maintenance Services Department

Appendix 3: Bathymetry and topography in the project area