ENVIRONMENTAL IMPACT ASSESSMENT

Coastal Components of Proposed Refurbishment

Chaaya Lagoon Hakuraa Huraa, Meemu Atoll, Maldives

Proponent: Chaaya Lagoon Hakuraa Huraa

Consultant: Ahmed Zahid (EIA08/07)

Sandcays

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Table of Contents

Table of Figures

Table of Tables

Non Technical Summary

This report addresses the environmental concerns of the proposed coastal components of the refurbishment planned for 2010 for Chaaya Lagoon Hakuraa Huraa, Meemu Atoll. The primary objective of the project is to enhance the natural environmental of Hakuraa and to improve the services offered to guests thereby minimizing operational and environmental costs. As such the project encompasses modifications to the existing jetty head to incorporate a fixed seaplane platform that would bring an end to dhoni transfers from existing floating platform, deepening of the existing reef entrance channel so that it can be used by supply and other dhonis saving time and fuel and providing beach on the southside shoreline where there is no beach.

Hence, different options for the proposed project, especially the beach enhancement component have been evaluated and the most practicable options not entailing excessive costs have been recommended. Since the resort is already closed for renovation, it may not be possible to get all the proposed activities done in time for reopening. Therefore, the beach enhancement and entrance channel deepening may have to be put off.

Hakuraa is surrounded by a large expanse of lagoon. Therefore, only the proposed channel deepening activity is expected to impact the coral reef. The impact on the reef is not considerably large as the reef flat in the area has very low cover of live corals and the live corals on the reef slope is expected to be cleared of sediment within a short period by the current in the area. However, it would be useful to monitor such changes. It has also been recommended to transplant any coral that may be directly impacted and may not recover from the effects of sedimentation. In fact, all proposed activities would have short term sedimentation impacts, with the water quality returning to normal within weeks.

The overall environmental impacts of the project have been assessed using appropriate matrices and the results indicated that the proposed project had net positive impact. That is, the project has no major adverse impacts on the environment as far as current knowledge is concerned. Given that the project has major socio-economic benefits and some environmental benefits, it is recommended to allow the project to proceed as proposed. However, alternative analysis for the coastal protection or beach enhancement component indicates that there is a strong argument for added coastal protection. It has, therefore, been recommended to consider headland revetments using geotextile containers in order to retain the sand that has been planned to be added to the southside shore. Other feasible alternatives also have been considered.

Environmental monitoring recommended for the project includes the monitoring of the shorelines of Hakuraa and neighbouring island and water quality and drogue studies of the coastal area for three years from the onset of the proposed project implementation. Annual monitoring reports have to be submitted over the monitoring period.

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 the different coastal components of the proposed refurbishment at Hakuraa Huraa including changes to existing jetty to incorporate a seaplane platform so that seaplanes can directly offload passengers to the jetty thereby reducing dhoni transfer costs and related environmental impacts, dredging of existing reef entrance and beach nourishment because Hakuraa Huraa is faced with a serious problem of beach erosion on the island's southside shore. 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 programme is vital in order to demonstrate the longterm benefits of the proposed project and to undertake mitigation before any impact is severed. Therefore, a coastal monitoring and protection plan would be suggested.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site on 5-7 April 2010, site specific data provided in the EIA carried out in 2007/2008 for coastal modifications as well as 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. It may be necessary to note that consistent, regular coastal data for Hakuraa is lacking.

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 coastal components of Hakuraa refurbishment namely changes to the jetty head to incorporate a fixed platform for seaplane operations, deepening of existing entrance channel and beach nourishment. 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 5-7 April 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 13 April 2010
- Scoping meeting 12 May 2010
- Submission of draft TOR 13 May 2010
- Approval of TOR 27 May 2010
- TOR Received by Consultant 29 May 2010
- Field mission 5-7 April and 18-19 May 2010
- Draft report submission to Proponent 29 May 2010
- Submission of final EIA report 31 May 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 involves changes to existing jetty to include a sea plane platform, maintenance dredging of reef entrance and beach nourishment using sand pumps. These are the project components that require an EIA among other proposed refurbishment activities, which mainly include decorative changes to the existing buildings. This section will provide the details of the project including detailed methodologies of undertaking the changes to existing jetty, dredging of existing reef entrance and beach nourishment with illustrations of the impact areas using maps at appropriate scales.

2.2 The Proponent

This project is proposed by Chaaya Lagoon Hakuraa Huraa / Fantasea World Pvt Ltd, a subsidiary of John Keels group of Sri Lanka Ltd. John Keels group also operates and manages various other resorts in the Maldives under different brand names. The objectives of the company include operation and management of tourist resorts and hotels, investing in tourist resorts and to engage in the operation and management of tourism related business in Sri Lanka and elsewhere in the region, among others.

The history of John Keels Hotels started in the year 1966 when Ceylon Holiday Resorts Ltd., was incorporated as a private limited liability company. The same year, the company leased an extent of 10 acres of land from the Ceylon Tourist Board on a 30 year lease in Bentota, and took over the management of Hikkaduwa Rest House. The company became a public limited liability company on October 14, 1966 by a special resolution. In April 1967, construction began on a 66 roomed hotel in Bentota. In 1969, 12 rooms were added to the Hikkaduwa Rest House, which was renamed Coral Gardens. Bentota Beach Hotel was opened for business in 1970. The company declared its first dividend of 2.5% in 1972. In 1978 Resort Hotels Ltd., a wholly owned subsidiary was incorporated. In 1982 Coral Gardens was demolished and construction commenced on a new 156 roomed hotel. In the following year Bentota Beach Hotel received 4 star classification. In 1991, John Keells Holdings acquired the Whittall's Group, whereby the controlling interest of the company changed hands. Today, John Keels not only operates resorts and hotels in Sri Lanka, but also in the Maldives. Other resorts operated by John Keels group include Alidhoo in Haa Alif atoll, Donveli Beach and Spa resort in North Male' atoll and Ellaidhoo resort in Ari Atoll.

2.3 Project Location and Study Area

Hakuraa Huraa (Chaayaa Lagoon) in Meemu atoll is located in a large reef system on the south eastern rim of Meemu Atoll at 73° 32'E and 2° 51'N. Located towards the middle of one of the longest stretches of reef in the Maldives with a length of about 36km, Hakuraa is the second tourist resort in that reef with 20 sand cays out of which three are inhabited. The other resort, Medhufushi is close to Hakuraa. The inhabited island of Naalaafushi, a fishing village is located about 4 to 5 km to the north of Hakuraa Huraa just next to Medhufushi.

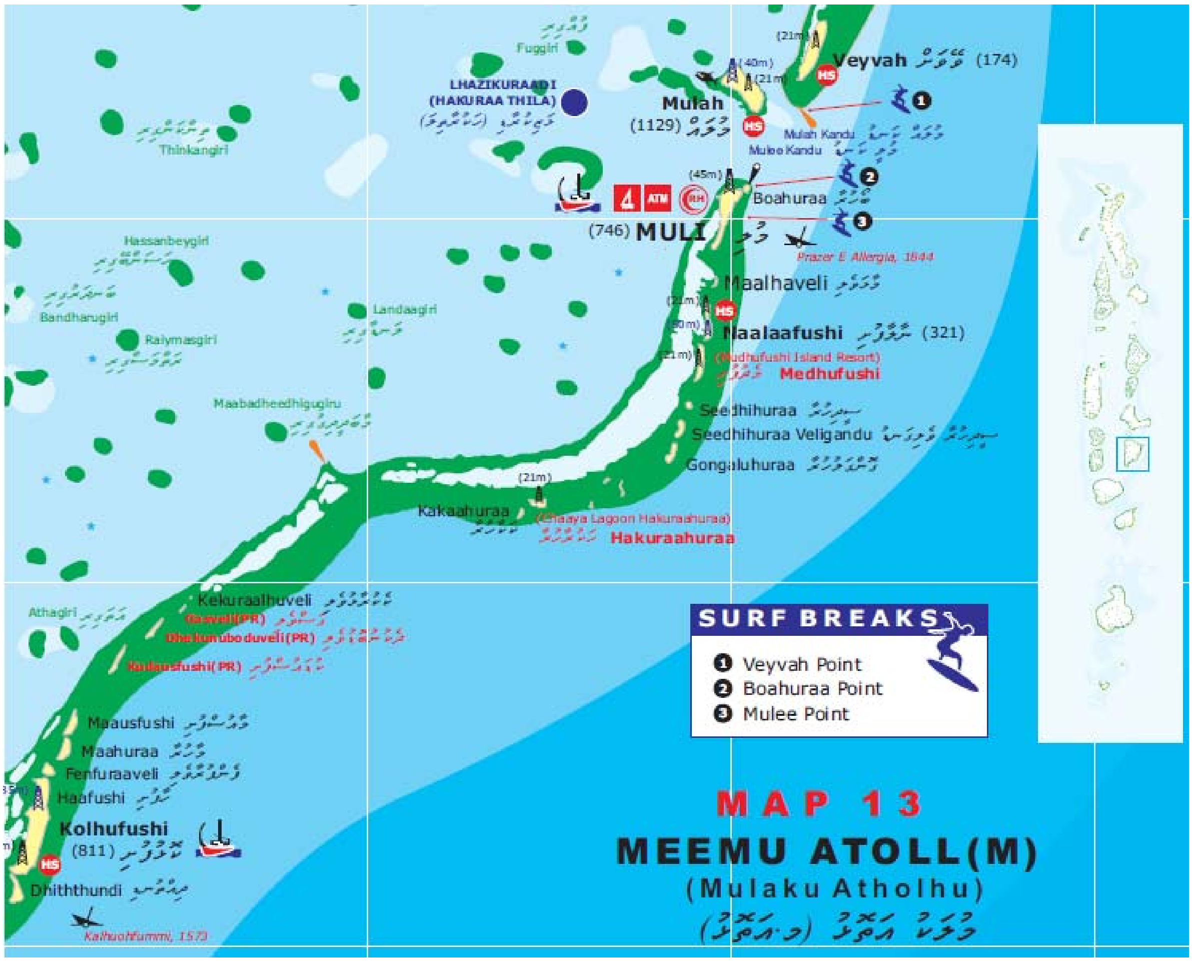


Figure 2-1: Project Location: Hakuraa Huraa in Meemu Atoll

The study focuses on the entire coastal area of Hakuraa Huraa and the existing entrance channel to Hakuraa at the atollward reef. The entrance channel has been dredge some time ago and has undergone severe backfilling making it almost impossible to be accessed at any tide other than high tide. Therefore, this channel needs maintenance dredging and improvement. The channel area including the reef at the entrance to the channel will be studied. The end of the long jetty has been proposed to be modified to incorporate a fixed platform for seaplane operations. Therefore, this area will be studied. The island's southern shoreline from southwest to southeast has had serious erosion since the very first day and several coastal protection measures have been undertaken including seawalls, groyne field and nearshore breakwaters. Therefore, the erosion and coastal sediment movement patterns need to be studied and the shoreline around the island and currents has been studied.

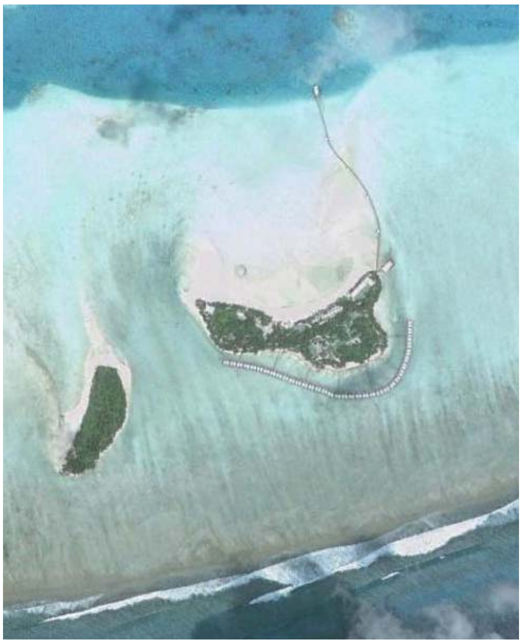


Figure 2-2: Satellite image of Hakuraa Huraa (source: Google Earth, date: 31 March 2006)

2.4 The Project

The proposed project covers three components of the proposed refurbishment of Hakuraa Huraa. They are:

1. Modify existing jetty head and incorporate a fixed platform for seaplane operations.
2. Maintenance and improvement to existing reef entrance channel
3. Replenish southside beaches from northeast corner to the southwest corner with fine sand borrowed from pontential borrow areas in the vast expanse of lagoon

The following subsections discuss the details of these three components and an illustrated summary of the adopted concepts is given in Figure 2-3. Discussions of the different alternatives are also given in Section 8 of this report.

2.4.1 Modifications to existing jetty head

At present, the resort's seaplane platform is a floating one at about 420m from the jetty. Dhonis are used to transfer tourists from the platform to the jetty. The proposed new platform will be fixed to the existing jetty, which provides tourists increased comfort and an improved experience as it facilitates a speedy arrival at their dream destination. Hakuraa's jetty is located in such a way that it enables safe transfer of passengers at all tides and monsoons. The jetty is located at about 400m from the island thereby minimizing distractions to tourists on the island. The jetty head is at the edge of the same vilu in which the existing floating platform is. All requirements for takeoff and landing are met.

The jetty is also used by the diving operations and supply dhonis. Therefore, certain modifications are required to incorporate the fixed seaplane platform. Although the Dive School will be refurbished, there will be no structural changes to the Dive School. The only changes to the jetty would be to incorporate the proposed seaplane platform on the west of the jetty and an extension to the jetty on the opposite side (east side) for supply and dive dhoni operations. This involves five new columns with foundations for the proposed seaplane platform and 20 new columns (with foundations) for the proposed extension for supply and dive operations. Figure 2-3 shows the existing jetty head with the proposed modifications.

2.4.2 Reef entrance channel

The reef entrance channel has become shallow over the past years because the dredged material was kept too close to the dredged area thereby promoting rapid backfilling. Therefore, it is proposed to dredge this channel using excavator and ensure that the dredged material is disposed at an appropriate location. The size of the channel has been based on the size of supply dhonis that would use the channel. A 15m channel along the width of the reef flat up to the deep lagoon would be dredged. With a total length of about 168m, it constitutes an area of 2,520m^2. The average depth inside the proposed area including the depths in the existing channel is about 1.4m. About 4,000m^3 of material is expected to be excavated from this channel. The dredged material disposal location was discussed in the scoping meeting and based on recommendations by the Environmental Protection Agency, it was decided to dispose the dredged material into the deep lagoon on the east side of the proposed entrance channel. Figure 2-3 shows the location of the reef entrance channel and the proposed modifications including the location at which the dredged material would be disposed.

2.4.3 Beach enhancement

The proposed beach enhancement involves the nourishment of the south side shoreline from the northeast end of the island to the western end. This constitutes about 587m of the shoreline. The Ministry of Tourism and Civil Aviation and the Environmental Protection Agency allows beach nourishment for only upto 10m of shoreline. Therefore, this would be the extent to which the beach nourishment would be done. Given that the average depth in the area 10m off the shoreline is about 0.7m and that the average height of the island on the southside coastline is about 1.1m, a total volume of about 10,000m^3 of fine sand has to be placed in the area. This was also discussed in the scoping meeting in which the deep lagoon or the peripheral area of the deep lagoon was suggested as the most practicable options for borrow areas. It is, therefore, recommended to borrow sand from the jetty head area, thereby enabling direct access by supply and dive dhonis to minimize visual impacts to guest arrivals on the opposite side. Figure 2-3 shows the proposed beach fill area and the borrow area. Alternatives to beach nourishment and borrow areas have been identified in Section 8 of this report. It is worth mentioning here that the recommended alternatives include shore protection measures and would have added advantages which the Proponent need to consider during the proposed beach filling or at a later stage. Without adequate shore protection measures beach filling as proposed will be a frequent occurring and a sand pump is to be kept at the proposed borrow area to continue the beach fill operations.

2.5 Work Methods

2.5.1 Jetty modifications

The main environmental elements of the proposed jetty head modifications would be the construction and installation of the 25 new columns. In order to minimize the impacts of the use of cement or concrete on the marine environment, the columns with footings would be precast on land and transferred to site using excavator. Excavator would also be used to place the columns. In order to minimize the movement of the excavator on the shallow lagoon, the columns may also be floated to site. Since this area has been marked as a potential borrow area and if the area was chosen as the borrow area for beach replenishment works, the footings will be placed after excavating the area up to the proposed 3.5m in order to avoid any long term subsidence of the columns.

2.5.2 Reef Entrance Channel

The proposed entrance channel deepening works will be conducted using excavator. The excavator will work from a sand bed created using material excavated from the channel. The work will be started from the seaward end and finished at the deep lagoon end of the channel. The bed will be created on the eastern side and moved with the old bed and finally disposed to the deep vilu.

There are only a few porites in the area which may be directly affected and transplanting is not considered to be necessary. Yet, the area will be further assessed by the contractor and any live corals on the reef flat that may be directly affected would be moved and transplanted at a location further away. The corals at the reef slope or edge will be affected during the initial period. However, it would be impractical to move the corals as sediment will be quickly removed from these. The Proponent would ensure that the contractor follows all mitigation measures given in this EIA report so that the works are carried out with minimal environmental impact.

2.5.3 Beach Enhancement

The beach enhancement of nourishment works will be done using sand pump and small dump trucks or excavator. If it is more economical, a small dredger may be used as it would take less time and the impact period can be greatly minimized. Excavator would be definitely be required if the alternative fill methods with shore protection is adopted in order to fill the geotextile bags as well as to remove existing structures. The proposed beach fill works do not include removal of existing groyne and seawalls as there are no additional shore protection structures. However, if alternative shore protection measures were to be adopted, it may be necessary to remove the existing structures for the safety of tourists who may be using the area and for aesthetic reasons. Also, if the proposed headland structures were to be considered, it may be necessary to construct the structures immediately after filling. These structures would be placed using excavator.

A six or eight inch sand pump would be desirable given that fine sand without rubble needs to be placed on the beach. The rubble content, if any, can be manually removed upon completion of the nourishment works. If there is a lot of rubble in the pumped sand, it may be necessary to sieve it before spreading on the beach. The area into which sand will be pumped shall have a sand bund and preferably some silt screen at the mouth to minimize fine sediment entering the lagoon waters. Sand is proposed to be pumped to the eastern shoreline or the western shoreline depending on the borrow area. If geotextile containers were to be used, their filling would also be done using the sand pump because it will ensure tight compaction of the geotextile containers. Using excavators for the filling of bags require that water be pumped into the bag at the same time as filling with excavator in order to ensure compaction.

When placing the geotextile containers in a revetment setup, 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 or rock boulders were to be used, the profile can be set first and then tetrapods placed on the top of the filter layer.

2.6 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 by the end of August. The resort is currently closed for renovation with minor repairs ongoing. The proposed works will, therefore, be started as soon as the EIA Decision Statement has been issued in an effort to open the resort in time. If delays occur, the entrance channel maintenance and the beach nourishment works would have to be put off to be undertaken the following year. It is important to ensure that the works are started within the normal duration of one year from the date of the EIA Decision Statement in order to avoid further environmental clearance. In case of any delays in the implementation of any of the components described in this report, it would be necessary to write to the Environmental Protection Agency for an extension of the approval.

2.7 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 operational ease and socio-economic and environmental benefits associated with the different components. These inputs and outputs are summarised in Table 2-1 and Table 2-2.

Table 2-1: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Workers	Resort staff and contractor's workforce
About 10,000m^3 of sand for beach nourishment	Using 6 or 8-inch sand pump/mini dredger/excavator
Food, water and other resources	Provided on site for workforce
Machinery	Contractor
Energy for machinery operation	Diesel fuel
Geotextile containers/Core-Loc units/rock boulders (if used)	Imported

Table 2-2: 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)	Moderate	Natural dispersion over a short period
Material (mainly rubble) from excavation of existing channel area	About 4,000m^3	Disposed to deep vilu on the east of entrance channel

2.8 Need and Justification

2.8.1 *Fixed seaplane jetty*

At present, the resort's seaplane platform is a floating one at about 420m from the jetty. Dhonis are used to transfer tourists from the platform to the jetty. For the guest, this is an inconvenience that adds to the inconvenience of the long jetty that awaits. For the management, it means the rent of dhonis. For the environment, it means unnecessary carbon emissions and the risk of oil spills and soot emissions into the marine environment. Therefore, it is not a single step forward but a giant leap as far as socio-economic and environmental benefits are concerned. This component alone is expected to offset at least about 7,500kg of CO_2 emissions every year in addition to the reduction in other greenhouse gas emissions and soot. This is an offset equivalent to the total annual emissions of at least 3 average Maldivians.

2.8.2 *Reef entrance channel*

The reef entrance channel has been in need for a makeover for a long time. According to the supply dhoni captain, it has been quite some time since they have been avoiding using the reef entrance in front of Hakuraa for safety reasons. Instead, they have been using the entrance channel in front of Naalaafushi, which takes about half an hour more than the use of Hakuraa entrance. Therefore, it would save a lot of fuel and time if Hakuraa entrance could be used by supply dhonis and at times by dive dhonis. It would, however, involve a cost to the resort operator while the resort operator would not directly benefit from dredging the entrance channel. Yet, it contributes to the carbon neutral goal of the resort and most probably adds to the resort's Green Globe Certification score as it is expected to be certified soon. In fact, the project is estimated to offset at least about 14,000kg of CO_2 every year in addition to the reduction in other greenhouse gas emissions and soot. This is an offset equivalent to the total annual emissions of over 5 average Maldivians.

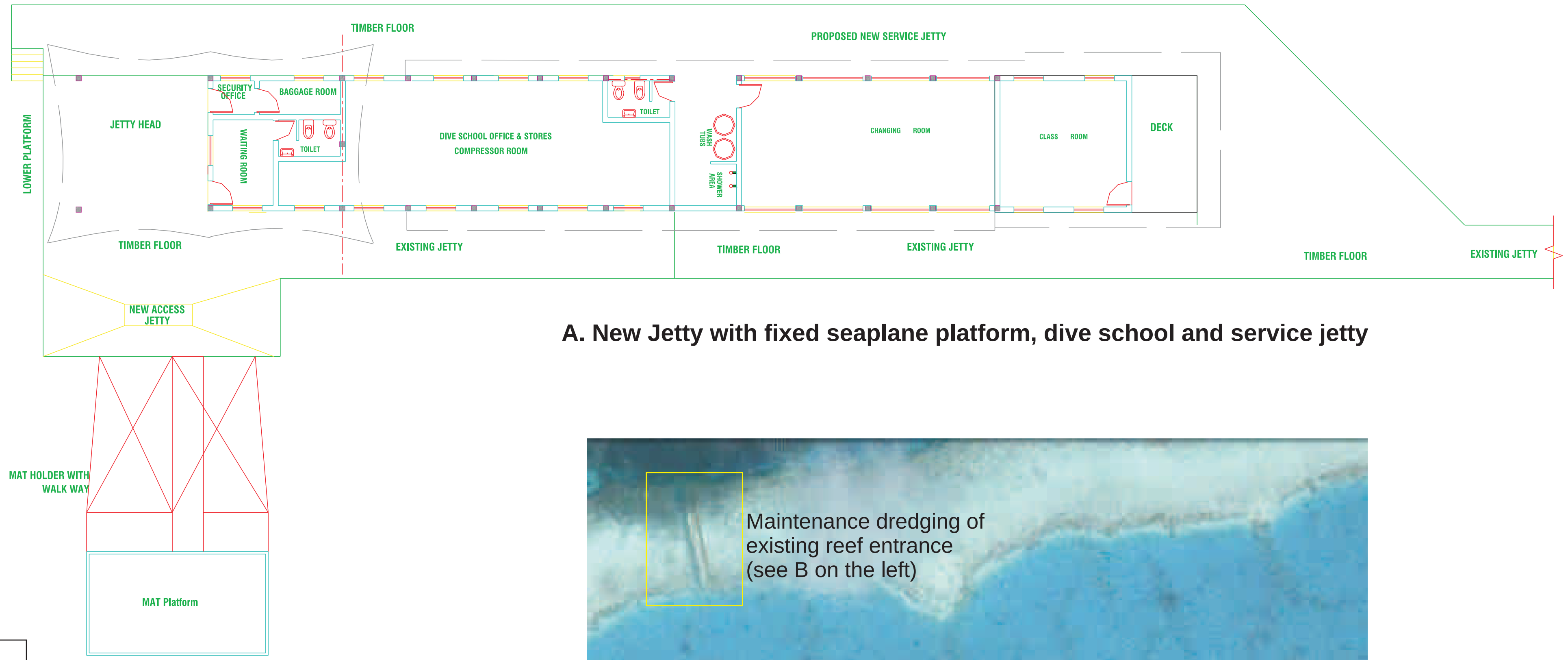
2.8.3 Beach enhancement

The island of Hakuraa Huraa has been struggling with beach erosion on the island's southern shoreline from the southeast to the southwest ever since its operations began. Although there is a shallow lagoon with a long stretch of beach on the northern side, only 10 beach bungalows can be found on this side while the rest of the rooms are water villas sitting on the shallow lagoon on the southern side. The resort has undertaken several shore protection measures on the southern side including seawall, groyne field and recently a submerged narrow concrete wall as a submerged breakwater.

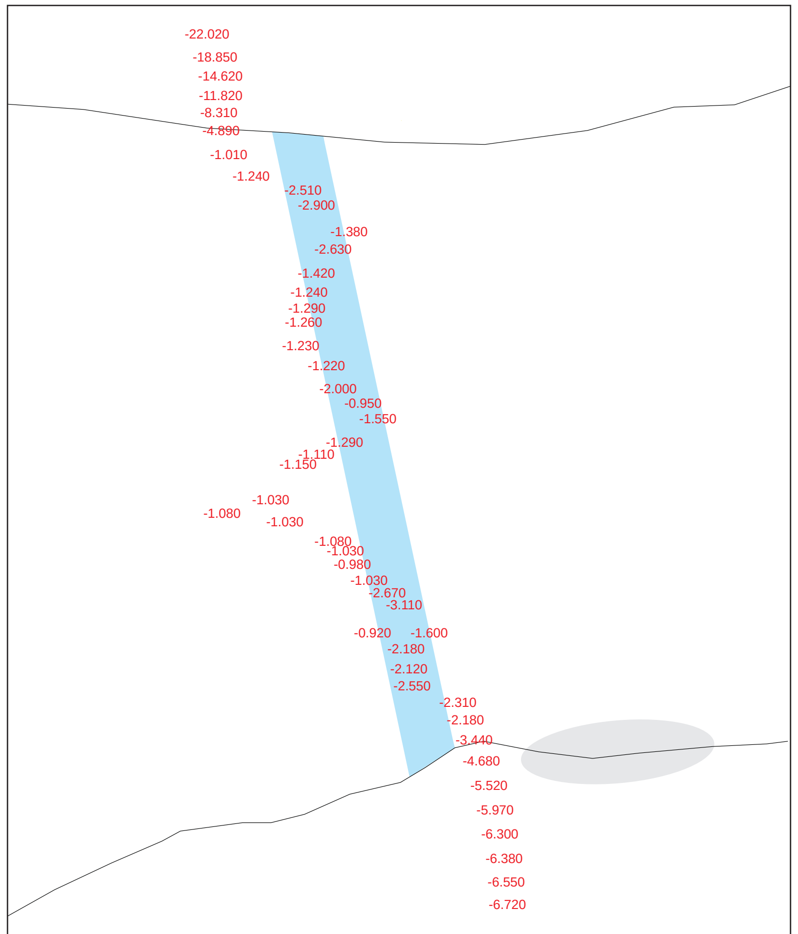
At present the seawall helps to minimize erosion of the sand behind it although in some areas the seawall has been damaged with high annual repair costs. Similarly, the groynes also have high repair costs associated with them, however, their functionality is very low. In fact, seawalls and groynes are not appropriate for this side given that there is a net onshore-offshore movement of sediment rather than longshore movement. The seawall, in fact, reflects most of the incoming wave energy and as water topples over the structure it causes scour of material behind the structure and damage to the structure adding to the cost of maintenance. Therefore, it is important to have a structure that dissipates a large percentage of the wave energy and minimizes the cost of maintenance. Recently a submerged breakwater was suggested (Zahid, *et al* 2008) but the breakwater that was placed was a submerged concrete wall which only affects the movement of the water body without energy being dissipated.

Therefore, it is important to have a coastal structure that can minimize the devastating effect of monsoonal wave activity on the shoreline. Also, the existing groyne field will require some amount of beach nourishment between the groynes for the groynes to be effective. This has never been done. Hence, it is proposed to replenish the areas between the groynes as there is plenty of sand in the shallow lagoon as well as the deep lagoon (vilu) on the northern side of the island.

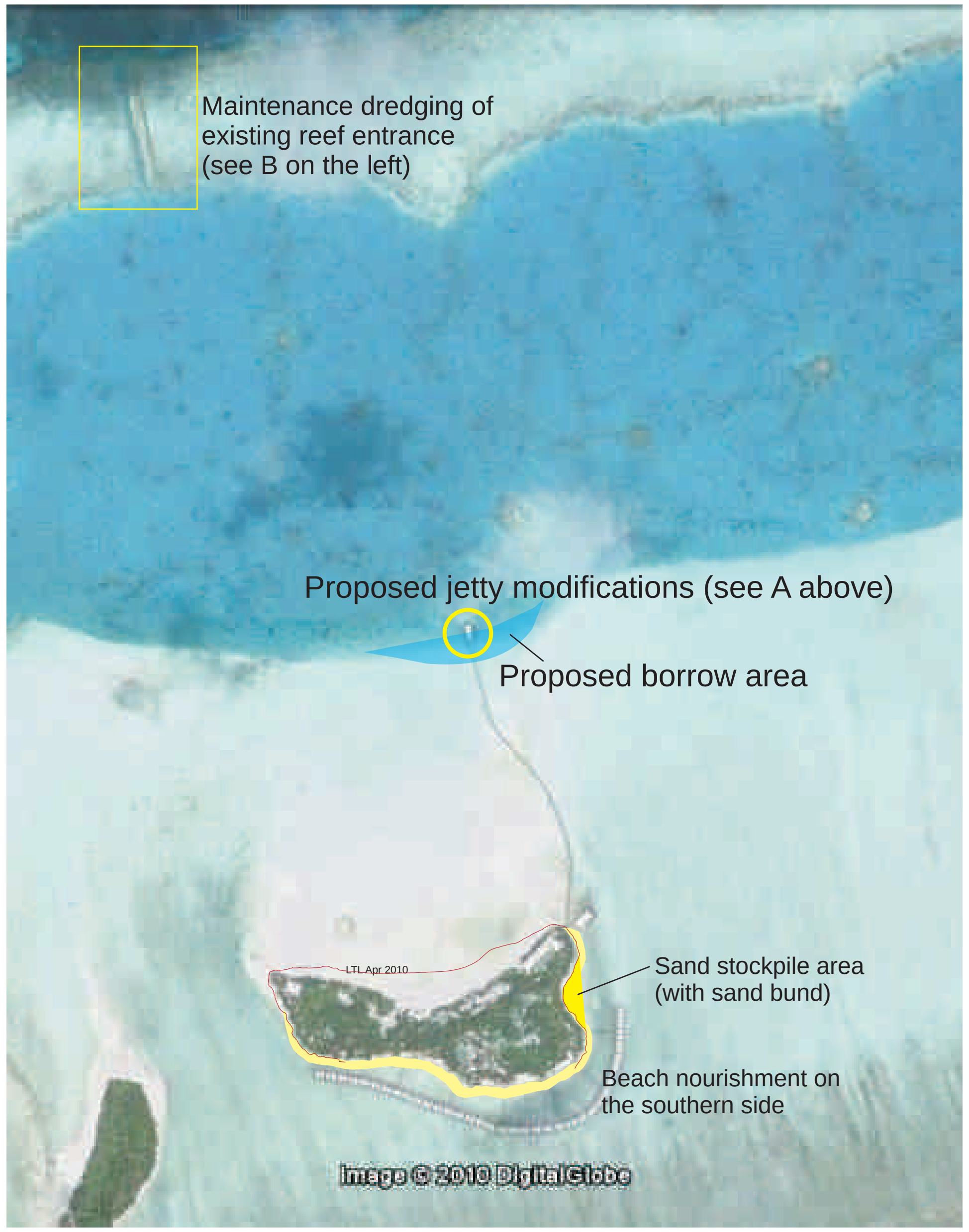
Figure 2-3: Proposed project components



A. New Jetty with fixed seaplane platform, dive school and service jetty



B. Deepening 15m wide channel



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 scale but it 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.

3.2 EIA Regulations

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.

Schedule D of the EIA Regulations lists the different environmental projects that require an Environmental Impact Assessment study and entrance channel and coastal protection have been included in the list. The EIA Regulations sets out the requirements for the contents of Environmental Impact Assessment reports in Schedule E and format for monitoring reports have been given in Schedule M. Therefore, these requirements have been taken into consideration in preparing this EIA report.

3.3 Regulation on Protection and Conservation of Environment in the Tourism Industry

The Regulation on the Protection and Conservation of the Environment in the Tourism Industry came into effect on 20 July 2006. Clause 2.1 of the regulation requires that any coastal work in a resort including beach enhancement by pumping sand should be undertaken by obtaining permission from the Ministry of Tourism. Clause 2.4 requires that an EIA report be submitted to the Ministry in order to carry out the works. As part of submission for coastal modifications under clause 2.3, the Ministry of Tourism has also prepared an Application Form for Coastal Modifications. This form has been submitted to the Ministry as a first step towards the application.

Clause 2.14 is also of relevance to this project in that it requires that jetties must allow free flow of water and sand beneath it. Clause 2.15 requires that no coral be used in the construction of coastal protection structures.

3.4 National Energy Policy

As one of the first countries to sign and ratify the Kyoto Protocol in 1998 and as a member of the UN Framework Convention on Climate Change, the Maldives is committed to implement national policies towards sustainable energy management and reduction of greenhouse gas emissions. The President has recently announced that the Maldives would work towards becoming the world's first carbon neutral country by 2020. The National Energy Policy introduced subsequently is focussed on this goal. As such the National Energy Policy looks at existing issues, constraints and emerging issues. The policy addresses issues of energy supply, consumption, environment, renewable energy, energy efficiency and sustainability. Sustainable supply and consumption is the main focus of the policy.

The key policies outlined in the National Energy Policy are:

Policy 1: Provide all citizens with access to affordable and reliable supply of electricity

Policy 2: Achieve carbon neutrality by Year 2020

Policy 3: Promote energy conservation and energy efficiency to reduce costs

Policy 4: Increase national energy security by diversifying energy sources

Policy 5: Promote Renewable Energy Technologies

Policy 6: Strengthen the institutional and legal framework of the energy sector

According to the policy document, only 3% of energy is from biomass and solar energy while the rest is from refined petroleum products with diesel fuel accounting to 83% of the total energy consumption in the Maldives. The proposed project, therefore, contributes to the reduction in the use of imported diesel fuel and associated carbon dioxide emissions thereby paving way for carbon neutrality.

3.5 Regulation on Coral, Sand and Aggregate Mining

This regulation addresses sand mining from uninhabited islands that have been leased; sand mining from the coastal zone of other uninhabited islands; and aggregate mining from uninhabited islands that have been leased and from the coastal zone of other uninhabited islands.

3.5.1 Ban on coral mining

Coral mining from the house reef and the atoll rim has been banned through a directive from the President's Office dated 26th September 1990. Under Article 7 (c) of the Regulation on Sand and Coral Mining issued by the

Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) on the 13th of March 2000, it is an offence to mine sand or coral from the beach, lagoon or reef of any inhabited island and islands leased for the purpose of building a tourist resort. Coral would not be mined and used in this project.

3.6 Environmental Permits required for the Project

3.6.1 EIA Decision Statement

The only environmental permit to initiate proposed works 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 Hakuraa Huraa on 5-7 April 2010 and 18-19 May 2010.

4.1 Methods 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 April and May 2010 to collect baseline data. Before the trip was undertaken all existing information regarding the project and site was gathered from previous EIA report (2008) and reports from the Proponent including documents from Maldivian Air Taxi.

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 behind the reef entrance channel
- 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) and dissolved oxygen (DO). These measurements were done for housereef location as well as the jetty end. Samples were also taken from these locations for further testing at the laboratory for hydrocarbon, BOD, COD and nitrates.

4.1.2 Bathymetry and Ocean Currents

Bathymetry of the lagoon area at affected areas was done 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 5-3. A purpose built drogue with a GPS was made to create spaghetti diagrams of the ocean currents. Six to seven drogues were done at different locations.

4.1.3 Condition of the housereef

Methodologies adopted for these surveys are internationally accepted and widely used to assess the status of coral reefs in the Maldives as well. Line intercept transect and visual observations of the reef and lagoon of the proposed development areas were carried out according to the methods described in English *et al* (1997). A Line Intercept Transect was used to carry out a quantitative assessment of the live reef on the east and west of the mouth of the entrance channel. Qualitative visual surveys were conducted for the dead reef flat area of the existing entrance channel and the reef flat on the southside of the island.

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 and consultations with resort management, dhoni crew and other relevant parties such as Maldivian Air Taxi. During the scoping meeting, input was given by the Environmental Protection Agency on the potential borrow areas and dredge spoil disposal.

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
- Transport and guest transfers
- 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 zones of the project.

5.1.1 Formation and Topography

Hakuraa has a land area of about 4.2hectares inside its vegetation line. The island is about 1.1m above mean sea level on the southern side and about 1m high on the northern side. The island is located in the middle of a long stretch of reef extending from Muli, the capital of Meemu Atoll to Kolhufushi, one of the inhabited islands most severely damaged during the 2004 tsunami. Hakuraa was also among the most severely damaged resorts during the 2004 tsunami. The cause of such severe damage was considered to be the long stretch of shallow reef flat or lagoon. The island is roughly 380 meters from the southern reef edge, beyond which is the open ocean. The southern rim of Meemu atoll is exposed to the swells from the Indian ocean. There is a small uninhabited island on the west of Hakuraa Huraa roughly 190m away in the same lagoon. The southern side of the island is prone to long-period swells from the Indian Ocean. The strong current in the channel together with the influence of swells within the channel probably creates the dynamic conditions observed in the southeast and southwest sides of the island.

Most islands in the Maldives are formed from sand produced and delivered to the coast by healthy coral reefs mainly by the action of waves and reprofiled by the action of longshore currents, as illustrated in below. Such is the case of Hakuraa Huraa. The supply of sand occurs mainly from the southern side. Deposition occurs mainly during the southwest monsoon while reprofiling of the beaches occurs during the northeast as well as the southwest monsoon. As a result sand accumulation is greatest on the northern side with a sandbank on the north side of the island, slightly towards the east at about 116m from the shoreline of Hakuraa Huraa. Due to the formation and shape of the reef system, there is a net northward flow of swell and surf-induced currents. As a result, there are stronger frictional forces acting on the southern beaches throughout the year. Such frictional forces create strong currents on either ends of the island making beaches susceptible to erosion. Hence, sand mainly moves along the northern shoreline from the west to the east and vice-versa according to the monsoons.

Hakuraa seems to be formed from a nodal point in the southeast corner of the existing island. The original island appears to have connected with an offshore sandbank that was formed on the west of the original island and become a single island, which is now known as Hakuraa Huraa. The island appears to be growing in an east to west direction engulfing northwest wards due to the presence of strong currents in the channel between Hakuraa Huraa and neighbouring Kakaa Huraa on the west.

5.1.2 Coastal Resources

Lagoon exists on all sides of Hakuraa Huraa. However, the northern lagoon is very shallow with much of it exposed at low tide. This makes it difficult for the Water Sports Center to operate at low to mean tide despite the large deep lagoon on the north. The south side has a narrow lagoon that gradually saturates with the reef flat. In general, the lagoon around the island is quite shallow with most of the areas less than 1m at mean sea level. The area between Hakuraa Huraa and the neighbouring Kakaa Huraa is also around 1m at mean sea level. There is a deeper lagoon (vilu) at the end of the arrival jetty which is about 400m from the shoreline. This *vilu* extends close to the narrow reef flat on the northern side where there is entrance channel to the island.

The lagoon consists of medium-fine sandy floor, and small rubble especially at the western and eastern ends. There is also a lot of fines and low level growth of algae. The water quality is in a pristine state with minute levels of phosphates and nitrates. There is no sign of faecal contamination of the lagoon surrounding Hakuraa Huraa.

There is no distinctive variation in beach composition around the island. However, the beach exists only on the northern side including the northwest and northeastern tips. The beach material is mainly composed of loose skeletal carbonate sediments, mainly fragments of green calcareous algae *Halimeda* sp., encrusting and branching red algae, molluscs, foraminiferans, echinoderms and bryozoans. A minimum of 7m of white sandy beach exists on the northern side of the island whereas the southern side has no beach but mainly seawall.

5.1.3 Coastal Defences

Almost the entire southern shoreline is protected by seawall and a closely spaced groyne field. The existing seawall on the southern side is roughly 270 meters and constructed of sand-cement bags. It was also damaged during the 2004 tsunami which dismantled the sea wall. The groynes are rubble mound structures. The height of the groynes from the seabed is about 2.2m with around 1m wide on top and 2m at the bottom with a wider circular end. Recently, a submerged breakwater was suggested (Zahid et al 2008) and it was designed as a submerged concrete wall. Therefore, the desired objective of a submerged breakwater, which is to absorb wave energy, was not achieved.

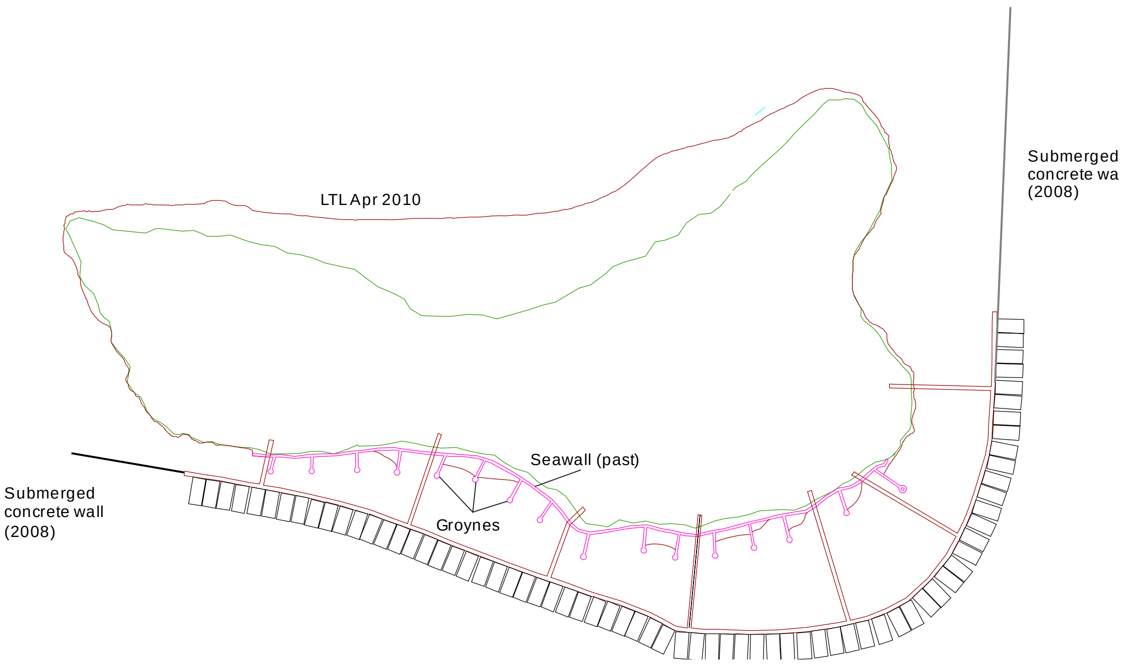


Figure 5-1: Existing coastal protection works in the project area

5.1.4 Marine Resources

As discussed earlier, Hakuraa has a large lagoon around it with a lot of rubble content on the south and mainly fine sand on the north. The north also has a deep lagoon separating the shallow lagoon and the housereef on the atollward side. There are few coral patches in the deep area but only one of them fall within the 700m area surrounding Hakuraa Huraa. The reef-flat and near shore area on the north side was mainly sandy with relatively poor diversity of species, although young rays and sharks can be observed on the shallow lagoon. The shallow lagoon on the northern side forms a gradual sandy slope to the deep lagoon (*vilu*) on the northern side. This lagoon on the northern side is followed by a shallow reef-flat again before inclining into the atoll basin. Reef slope condition on the atoll-basin ward reef has an intermesh of coral cover and fish and other marine life. The results of the LIT undertaken in this area is shown below:

There are heavy levels of natural sedimentation on the coral patch on the projected section of the deep lagoon on the east of the jetty head. Therefore, this projection does not have live coral cover. A line transect at this location was not possible on the day of the survey due to high degree of siltation.

The reef flat on the south is very poorly developed with hardly any live coral cover in the area. This is due to the presence of the extensive shallow reef-flat (600m wide) which was dominated by sand, rubble and un-consolidated rock. Massive type corals namely Porites spp., Favites spp. and encrusting type Pavona varians were the dominant live coral types found in this area where the percent cover of such porite species was less than 1. The reef-flat on the southern side stretched up to the edge of the atoll rim reef. The slope here is steep. The southward reef slope is 500m away from the proposed development area. Therefore no surveys were conducted at this area. It is also worth noting that the predominant Indian Ocean swells were from the southern side (Young 1999 cited in Kench et al. 2006) therefore the proposed beach nourishment or even breakwater construction will have very little impact on reef-slope on the southward side.

5.2 Climate and Coastal Dynamics

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 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.

The currents are also quite strong on the western side due to the existence of the small island on this side which causes a funneling effect for the body of water moving between these two islands. However, the current measured on the eastern side is even greater. During this monsoon there is a net easterly current and sediment movement is expected to be in the easterly direction too. Hence, the sand spit on the west is shifting to the eastern end but quite slowly. This movement of sediments is expected to reverse in the other monsoon. Unfortunately, there is no site specific data to support this.

Tidal influence on this net longshore current is also expected to be low due to the superficial nature of the lagoon. Tides affect wave conditions and 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 flushing of the Hakuraa Huraa's nearshore lagoon environment is little for some reason that may be useful to be determined by longterm monitoring.

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. The seabed of the lagoon around Hakuraa indicate that long-period oscillations in water level is the main cause of sediment transportation around Hakuraa Huraa as there is high level of cemented fines in the lagoon.

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.

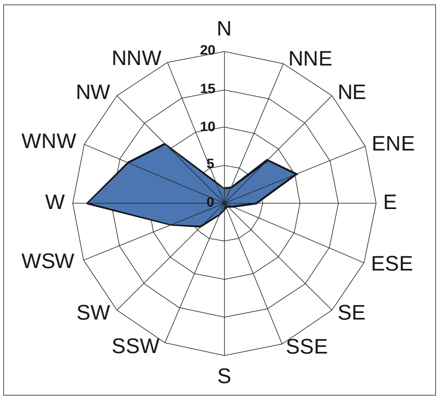


Figure 5-2: General wind rose diagram for the Maldives (source MEEW 2005).

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, the beach nourishment works will be difficult to be undertaken during the proposed time period. Yet, the best period for such renovation works is during May to August which is considered the off-peak season for tourism. Therefore, it may be best if the beach nourishment works can be undertaken during August.

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.

The southern side of Hakuraa Huraa is mainly exposed to "regenerated oceanic swells". The swells that break on the reef looses most of their energy on the reef. However, the reef as it is only acts as a submerged breakwater, especially during high tides, do not absorb/reflect all the wave energy, but allows partially broken waves to travel in to the shallow reef flat. These partially broken waves regenerate on the reef flat and travel across the flat until they reach the shore of the island. The characteristics of these regenerated waves depend very closely on the tide level over the reef and the magnitude of the original waves. In general, for any given deep water wave, the magnitude of the regenerated wave is higher when the tide is high.

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. According to the annual wave height data reported by the US Navy for Area 12, a region containing southern Maldivian Atolls, indicate that long period waves with heights above 2m and 3m occur for 22% ad 3% of the time respectively and arrive mostly from the south-east, south-west and westerly quadrants during the SW monsoon (see Environmental Assessment report of Sun Island Resort 1995). The US Navy data also suggest that the majority (67%) of long waves over 2m in height are from the south and southeast.

5.2.3 Tides

Tidal influence on the net longshore sediment transport is also expected to be low for Hakuraa due to the superficial nature of the lagoon. 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.

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 different locations around the island and at the entrance channel as shown in Figure 5-3 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 drogues indicated that there was very slow movement of water on the shallow lagoon on the north and similar was the movement on the south side during the day of the field. However, there was a strong currents on both the east and western end of the island, especially between Hakuraa and the neighbouring island. The results of the drogue study indicates that the higest current speeds occur on the east and west ends while the middle of north and south have very small current speeds.

As has been observed in past studies, sediment generally accumulates at the lee of high-speed current zones. So, a great deal of sand accumulation occurs on the northern side. The currents are also quite strong on the western side due to the existence of the small island on this side which causes a funneling effect for the body of water moving between these two islands. The drogues indicate that the two ends of the island have strong currents of about 0.2 to 0.3m/s. During the southwest monsoon there is a net easterly current and sediment movement is expected to be in the easterly direction. Hence, the sand spit on the northwest is seen to be slowly shifting to the northeastern corner. This movement of sediments is expected to reverse in the other monsoon.

5.2.5 *Marine Water Quality*

The marine water quality tested at two locations at project site is given in

Table 5-2. The water quality results given in this table shows very little variation at the two locations. Both locations have water at its pristine state and does not show any signs of degradation due to biological or chemical contamination of any sort whatsoever. There are very low levels of phosphates and nitrites. BOD and COD could not be tested at the laboratory.

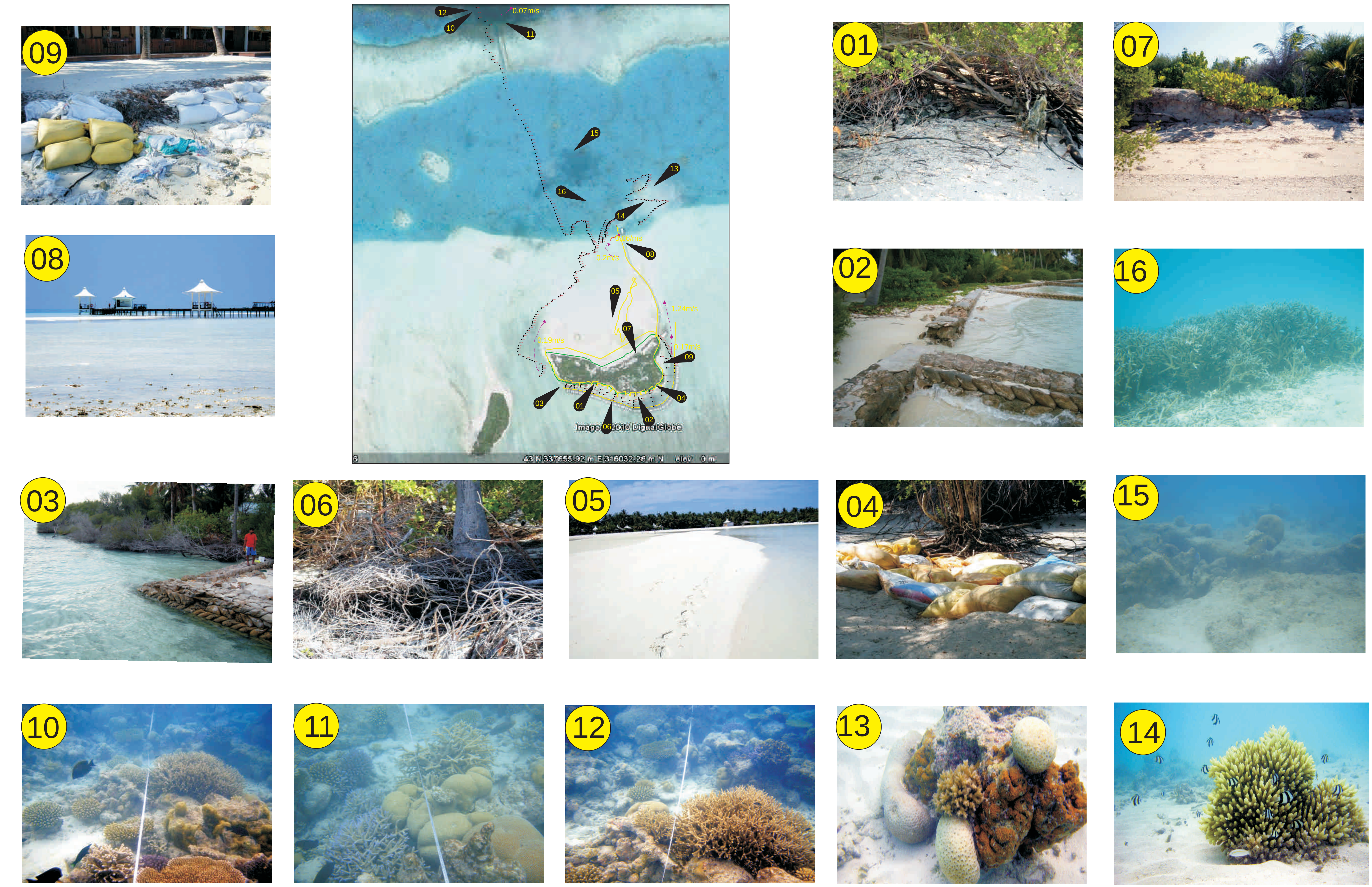
Table 5-2: Water quality results (7 April 2010)

	Unit	WQ1	WQ2
GPS Location WGS1984, Zone43	UTM	337212.7063E 316795.9552N	337625.6119E 316042.8137N
Temperature	oC	29.74	30.22
Salinity	mg/l	34,230	34,430
DO	mg/l	7.64	7.82
pH		7.94	8.11
Nitrite	mg/l	0.01	0.003
Phosphate	mg/l	0.04	0.05

5.2.6 Sea level changes

A further cause of long-term shoreline retreat is the rise in mean sea level relative to the land. In recent centuries, Maldives may have slightly suffered from the increase in global sea levels, which has been averaging about 1mm to 1.5mm/year. This is because all islands of the Maldives are about a metre or two above mean sea level. As sea level rises relative to a beach, there is an inevitable tendency for the shoreline to move inland. In the future, the consequences of atmospheric pollution, and hence global warming, may include an acceleration of the increase in mean sea levels around the world. As a consequence, large parts of the coast of Maldives may begin to experience a net increase in sea levels. However, there are also theories that support that a reduction in sea level may occur around equatorial zones as a result of global warming and subsequent increases in sea surface evaporation. Hence, such sea level rise scenarios could not been taken into consideration at this stage and have little direct relevance to the proposed project.

Figure 5-3: Photos and illustrated representation of site conditions



6 Stakeholder Consultations

Stakeholder consultations are limited to the discussions held during the scoping meeting, supply dhoni captain, staff and management of Hakuraa Huraa.

6.1 Consultations with the Management and Staff

Discussions with the General Manager, Mr. Roshan de Silva and the new Engineer, Mr. Jeewantha D. Jayasekera throughout the EIA process helped in the evaluation of different options for the different project components. Also, the guidance from Mr. Suraj Perera, Vice President of the John Keells Group has been very useful. Their input to the final draft was incorporated. The innovative modifications to the jetty were discussed with the Consultant before the final design was sent to the Ministry of Tourism.

The Maldivian staff in the Dive School and the Water Sports Center provided information relating to diving and water sports operations and the difficulties in accessing the lagoon for water sports except at high tide. The supply Dhoni captain and the dhoni crew provided information regarding the dhoni operations. According to the supply dhoni captain, the use of the entrance channel would save 30 minutes of their journey and associated fuel savings. The safety associated with the use of the existing entrance channel was raised by almost every staff among the boat crew.

6.2 Scoping Meeting

The scoping meeting for Hakuraa was held on 12 May 2010 at Environmental Protection Agency. In the scoping meeting, EPA suggested that the borrow areas need to be identified from the north side, preferably within the deep lagoon (vilu) or the sides of the vilu because of the necessity for fine sand required on the beach. EPA identified that in some resorts borrow pits created near shore poses safety risks to tourists. Therefore, EPA required that such pits should be avoided.

EPA also requested not to create an islet on the side of the entrance channel with the dredge material. Instead, it was suggested to dispose the dredge material at the vilu edge. EPA as well as the Ministry of Tourism stated that the area of the island had to be revised if there is any beach fill other than beach replenishment which includes up to 10m of beach from the vegetation line. EPA also required that alternatives must include protection measures to hold the nourished beaches in place. Due to the uncertainty in impacts on the neighbouring island, Kakaa Huraa, EPA also required to include 4 beach profiles and the island shoreline of the adjoining island within the TOR.

6.2.1 List of Participants

Following are the names and designation of persons who participated in the scoping meeting.

	Name	Office	Designation
1.	Ibrahim Naeem	EPA	Director
2.	Fathimath Reema	EPA	Assistant Director
3.	Mariyam Shifna	EPA	Environment Officer
4.	Fathimath Shifa	Min. of Tourism	Environment Officer
5.	Ilham Atho Mohamed	Env Dept/MHTE	Environment Analyst
6.	Ismail Habeeb	JKMR	HR/Admin Manager
7.	Ahmed Zahid	Sandcays	Consultant

7 Impacts and Mitigation Measures

This section covers potential environmental impacts due to the coastal elements of the proposed refurbishment 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
- Baseline environmental conditions described in Chapter 5
- Consultants experience of projects of similar nature

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 Concerns

There are some existing environmental concerns apart from the erosion on the southern side and subsequent coastal protection measures. They include the extremely shallow lagoon on the northern side posing difficulties in the operation of water sports activities except at high tide, the long jetty, which poses operational difficulties. All these are due to the natural environmental setting of the island.

The coastal protection works that have been undertaken at the project area from the early days of operation of the resort can be considered to be ineffective. To start with, the entrance channel dredging was done in such a way that the dredge material was placed just close to the dredged area as a bed placed parallel to the dredged area. As a result, the bed got washed back into the dredged area making the channel shallow and unusable.

A rubble-mound groyne field has been constructed on the southern shoreline of the island with groynes spaced at about 15m between each other. These structures were constructed with the hope of combating the ever-present erosion on the southern side of Hakuraa. However, groynes do not significantly control onshore/offshore sediment movement during storms and are therefore not usually effective as a means of managing erosion in an environment in which wave scour due to onshore processes is the main cause of erosion. As a result, in the case of Hakuraa Huraa, the groynes do not appear to aid in retaining sand placed for beach enhancement but more of an eyesore to tourists. The aesthetic impact of the groynes on the southern shoreline of Hakuraa is quite considerable while it helps little to control erosion on this side. Groyne fields have even greater visual impacts than submerged breakwaters. This is because emerged groynes are seen at all times and all tides. According to the management, the groynes were constructed based on suggestions and observations of a coastal engineer without consideration or study of longshore current patterns and appropriate design. Therefore, it was only after their construction it was seen that the groynes serve no real purpose. Therefore, the works had high cost implications with little or no purpose served.

The seawall helps to prevent or alleviate overtopping and flooding of land and structures behind it due to storm surges and waves (USACE 2001). According to the management, the seawall was built with the purpose of protecting the spa and similar structures from flooding. Flooding is controlled to a great extent, however, the lack of beach has been an issue, especially for the present management. Also, the sea wall reflects the incoming wave energy, part of which is deflected to both east and western sides, thus exacerbating the erosion problem from these areas.

The recently installed submerged concrete wall does not absorb wave energy but acts as a weir at high tide creating scour beneath it on the leeward side. In addition, the same structure on the west changes the flow pattern between Hakuraa and the neighbouring island (Kakaa Huraa), which may have some adverse impacts on the shoreline of that island. In fact, it may be better that this structure be removed.

The shallow lagoon on the north with part of it getting dry at low tide is a unique feature of the resort but it is also a concern as far as water sports are concerned. The shallow lagoon on this side also necessitates the use of a long jetty. Again it is a unique element of the resort. At the end of the jetty is the dive school. With the dive school operations and guest arrivals as well as supply dhonis, it is a bit of a mess. It is not the natural environmental setting that needs to be changed but a design that takes these concerns into consideration.

7.4 Constructional Impacts and Mitigation Measures

Channel dredging, sand pumping and changes to the jetty to incorporate a fixed seaplane platform 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 the three different components are considered in the following subsections and mitigation measures are provided for those impacts which can be mitigated.

7.4.1 Jetty Changes and seaplane platform

The jetty changes would have minimal and insignificant environmental impacts because the resort is closed for renovation, least impact methodologies would be adopted and no ecologically sensitive or socio-economically important areas would be affected. The impacts are mainly related to the placement of prefabricated columns and footings using excavator. The movement of the excavator will add to the natural sedimentation levels in the area. However, the sedimentation levels would not affect any sensitive areas except the dead patch of reef projecting in to the vilu. This may be considered as a short term impact with little significance.

There are also some short-term and insignificant impacts of the proposed changes to the jetty including the emissions from the excavator, workforce resource utilization and waste disposal, use of resources such as timber, cement, steel, aggregates and sand and damage to seabed and some bottom dwellers.

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

- Appropriate planning and site supervision to minimize excavator movement
- Disposal of waste generated by workers
- Ensure that timber supplies come from reliable sources and renewable means have been adopted.
- Take precautions to minimize the potential for any hazards

7.4.2 Beach enhancement

The proposed pumping of sand to the east and west ends of the island and subsequent filling on these and southern shoreline areas involves a high volume of sand. The impact of the dredging and filling on the environment would be mainly that of fine silt spreading around the fill area and areas onto which the fines have been spread. The fines could accumulate in a place slightly further away creating muddy conditions and this could have some dangers associated with it especially during the operational phase.

The impact significance of this activity without mitigation measures would be classified as low or nil given that there is just a handful of live coral colonies in the vicinity of the proposed project work areas.

The beach enhancement works would also have some short-term and insignificant impacts including the emissions from the excavator, workforce resource utilization and waste disposal.

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

- Appropriate planning and site supervision to minimize silt deposition on the nearby areas
- Transplantation of any live corals that may be directly affected
- Create a sand bund with some silt screen at the mouth to minimize siltation
- Take precautions to minimize the potential for any hazards

7.4.3 *Dredging of reef entrance channel*

The proposed dredging of reef entrance channel will have moderate impacts on the live corals at the reef slope on the atoll basin ward reef. However, this impact will be short-lived and it is expected that the currents in the area would quickly remove any sediment settled on the corals. The significance of this impact is low given that the impact is short-lived and the impact area's ecological significance is low. However, the following mitigation measures would help to minimize this impact and improve the performance of the channel over the long term.

- Appropriate planning and site supervision to minimize silt deposition on the reef
- Take advantages of tides and winds during the works to ensure that the works are carried out when the net flow or current is towards the vilu and not out into the atoll basin
- Ensure that all dredged material is disposed into the vilu
- Transplantation of any live corals that may be directly affected
- Take precautions to minimize the potential for any hazards

7.5 Operational Impacts and Mitigation Measures

7.5.1 *Jetty changes*

Operational impacts of the proposed changes to the jetty include (1) improved access, (2) separation of guest transfer from dive operations and especially supply and garbage and other service operations, (3) minimized costs of operation, and most importantly (4) reduction in carbon emissions. The existing dhoni transfers will no longer be required as seaplanes will embark and disembark guests directly to the jetty. It is estimated that current dhoni operations between the floating seaplane platform and the jetty contribute to annual carbon dioxide emissions of over 7,500kg. The new design of the jetty head also helps to keep the garbage and supply operations away from the guest arrival jetty hidden by the Dive School in between.

7.5.2 *Beach Enhancement*

The proposed beach nourishment component is expected to improve the southside beaches. However, the nourished sand may not hold in place and is expected to shift to the northside over time. Therefore, continuous beach replenishment will be necessary. This will not only be a recurrent expense but would also involve long term sedimentation which would affect the quality of water, beach and lagoon sediments in the long run. It would also be aesthetically unpleasant to have a sand pump and more so when the pipe would be seen on the bottom of the shallow lagoon. The way to mitigate these impacts would be to consider appropriate coastal protection measures after monitoring for one or two years.

7.5.3 *Dredging of reef entrance channel*

The reef entrance channel would have several operational benefits including easy access by dhonis, especially supply dhonis and subsequent fuel and associated cost savings. It is reported that 30 minutes of travel time is saved when using the Hakuraa access channel. The excess carbon emission due to the alternative route from the access channel in front of Naalaafushi is estimated at about 14,000kg of CO_2. This is a great saving that would contribute to the country's goal of carbon neutrality by 2020. There are also several other simple steps that can be taken by the resort to reduce its carbon foot print.

7.6 Overall Impact Evaluation

This section provides a summation of the impacts of the project components discussed above. The 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/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

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 project

		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
ELCORock revetment	**Construction**										
	Jetty modifications	-1 0 1 1	0	-1 1 1 1	-1 0 1 1	0	1 1 1 3	-1 0 1 1	1 1 1 3	0	-1 1 1 1
	Excavation of channel and dredge material disposal	-2 2 2 1	-1 0 2 1	-1 0 1 1	-1 0 1 1	-1 0 1 1	1 1 1 3	-2 1 1 1	1 1 1 3	0	-1 1 1 1
	Sand pumping and beach replenishment	-1 1 1 1	0	-1 1 1 1	-1 0 1 1	-1 0 1 1	1 1 1 3		1 1 1 3	0	-1 1 1 1
	Machinery and construction equipment	-1 0 1 1	0	-1 0 1 1	-1 0 1 1	-1 0 1 1	1 1 1 3	-1 1 1 1	1 1 1 3	0	-1 1 1 1
	Workforce management	0	0	0	0	0	0	-1 0 1 1	1 1 1 1	0	-1 1 1 1
	Operation										
	Modified jetty	0	0	0	0	1 1 3 1	2 2 3 1	1 1 3 1	0	2 1 2 2	0
	Improved access channel	0	0	0	0	1 1 3 1	2 1 3 1	2 1 3 1	0	1 0 3 1	0
	Continued sand pumping and beach replenishment	0	0	0	0	1 1 3 1	1 1 1 2	0	1 1 3 1	-1 1 3 1	-2 1 3 1
	KEY:	M S D E		Magnitude Duration		Significance 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 project.

Table 7-3: Impact potential indices for the proposed project

		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
Completed Project	Construction											
	Jetty modifications	0	0	-0.01	0	0	0.04	0	0.04	0	-0.01	0.06
	Excavation of channel and dredge material disposal	-0.1	0	0	0	0	0.04	-0.02	0.04	0	-0.01	-0.05
	Sand pumping and beach replenishment	-0.01	0	-0.01	0	0	0.04	0	0.04	0	-0.01	0.05
	Machinery and construction equipment	0	0	0	0	0	0.04	-0.01	0.04	0	-0.01	0.06
	Workforce management	0	0	0	0	0	0	0	0.01	0	-0.01	0
	Operation											
	Modified jetty	0	0	0	0	0.04	0.15	0.04	0	0.1	0	0.33
	Improved access channel	0	0	0	0	0.04	0.07	0.07	0	0	0	0.18
	Continued sand pumping and beach replenishment	0	0	0	0	0.04	0.02	0	0.04	-0.04	-0.07	-0.01
	TOTAL CPVI	-0.11	0	-0.02	0	0.12	0.4	0.08	0.21	0.06	-0.12	0.62

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 positive.

7.7 Uncertainties in Impact Prediction

The level of uncertainty, in the case of the proposed project in Hakuraa Huraa 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 during and after project implementation as recommended in the monitoring programme given in this report.

Table 7-4: Summary of negative impacts of proposed project

Activity	Negative Impacts	Geographic Extent	Type of impact	Duration	Reversibility	Magnitude
Excavation of entrance channel	• Sedimentation on the reef flat	<30,000m²	Direct	Short term	Reversible	Minor negative
	• Sedimentation on the reef slope	<2,500m²	Direct and indirect	Medium term	Irreversible	Moderate negative
Sand pumping (borrow area)	• Sedimentation and sediment resuspension	~50,000m²	Direct and indirect	Short term	Reversible	Minor negative
	• Loss of sand	~11,000m³	Direct	Long term	Reversible	Moderate negative
Beach replenishment	• Loss of sand	Large percentage per year	Direct	Medium term	Irreversible	Moderate negative
	• Sedimentation and sediment resuspension	~20,000m²	Direct and indirect	Short term	Reversible	Minor negative
Jetty modifications	• Material and resource use	Worldwide	Direct	Short/medium term	Reversible	Minor negative
	• Sedimentation and sediment resuspension	<2,500m²	Direct and indirect	Short term	Reversible	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	Worksite only	Direct	Long term	Irreversible	Moderate

Table 7-5: Summary of positive impacts of proposed project

Activity	Positive Impacts	Beneficiaries/Geographic Extent	Magnitude
Excavation of entrance channel	• Improved and safe access and cost savings	Users	Major positive
	• Reduction in carbon emissions	Global environment	Major positive
	• Employment opportunity during construction	Contractor	Moderate positive
	• Minimal maintenance in the long term	Proponent/Operator	Major positive
Jetty modifications	• Employment during construction	Contractor	Moderate positive
	• Reduction in carbon emissions	Global environment	Major positive
	• Improved access	Operator/guests	Major positive
	• Separation of service area from guests	Guests/operator	Moderate positive
Beach replenishment	• Beach access to guests	Guests/operator/tourism sector	Moderate positive
	• Reduces risk of flooding coastal areas	Operator	Moderate positive
	• Reduces capital cost of coastal protection	Operator/developer	Moderate 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 three different components considered in this report have been discussed after a discussion of the no project option. The options for the jetty modification and the entrance channel dredging are few but for coastal protection, there are a few options, some of which had been suggested earlier (see Zahid *et al* 2008).

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 taking passengers by dhoni to jetty from floating platform thereby reducing capital cost of installing a fixed platform to the jetty.
- There is no need to separate and hide garbage and other service operations as guests would not mind that or those services can be undertaken at night without disturbance to guests.
- Beach on the southern side is not really necessary because it is all water villas there.
- Let the supply dhoni and other vessels use alternative access channel or use the Hakuraa channel only at high tide.

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
Use the floating platform for seaplane operations	Costs related to improving the situation may be avoided in the short term	Guest dissatisfaction; operational costs and difficulties and no improvement to carbon footprint
Let the dhonis/vessels use alternative access channels or use existing channel as it is	Costs related to the project and environmental impacts avoided	Safety is compromised and no improvement to carbon footprint
Keep southern shoreline as it is	Costs related to the project and environmental impacts can be avoided	Regular repairs would be a financial and technical burden for a long time; no beach on this side

A comparison of the no project option with the recommended and other evaluated options indicate that the no-project option is practicable but involves long term costs, tourist dissatisfaction, operational difficulties and would not provide the carbon emission reductions and other associated environmental benefits of the proposed project. For the beach nourishment component, the no project option may have advantages given that the sand may not hold in place without added protection.

8.2 Project Alternatives

The Proponent has decided that the best option not entailing excessive costs would be adopted after an evaluation of the different options. Therefore, the different options for the three components of the project discussed above are evaluated in this section. Recommendations have been made based on the assessment of the different alternatives.

8.2.1 Jetty modifications

It is not possible to provide alternatives for the jetty modifications apart from a few design changes to incorporate the different services requiring the use of the jetty. These include an area for the diving and water sports operations, an area for the services and a fixed platform for the seaplane operations. However, the incorporation of all these services especially if water sports were to be incorporated, it involves a separate arm of the jetty for all different services. Therefore, such an option is not considered practicable given the cost implications of the project. Therefore, no options have been suggested for the jetty modifications.

8.2.2 Entrance Channel Clearance

This project involves the maintenance dredging of the existing entrance channel. Therefore, alternative locations cannot be considered. The only alternative that can be considered is the methodology of channel clearance and disposal of dredged material.

8.2.2.1 Alternative Method of Channel Clearance

The alternative method of dredging the channel would be to use a small cutter suction dredger. The same cutter suction dredger can be used for the sand pumping operation, thereby economizing on time. However, the use of a sand pump becomes necessary as the sand pumping operation proposed here would be a continuous operation as there is no additional shore protection measures proposed. Also, an excavator would be useful for the proposed jetty modifications although it can be done without using an excavator.

8.2.2.2 Alternative dredge spoil disposal

The alternative method of dredge spoil disposal would be to use the dredged sand for beach replenishment works. However, the material that will be dredged from this reef flat location would be mainly rubble and would not be suitable for use on the beach without sieving. If sieved, the volume would be too small. Even without sieving, the volume would be less than a third of the volume required for beach nourishment. Therefore, this alternative is not practicable.

The other alternative is to dispose the material as a rubble bank (rubble cay) at some distance from the entrance channel. However, this is not encouraged by the Environmental Protection Agency. The likely reason for discouraging such an alternative is the potential for use of such cays for several other purposes including garbage disposal and possibly revenue generating activities. Also, if an islet is created in such a manner, its land area has to be registered and revenue has to be paid to the government for its use.

8.2.3 Borrow Area

Two alternative locations for the borrow area has been identified. They are both on the north side. The first one is the area at the end of the northwest thundi where sand from the channel between the two islands get deposited. This area has average depth of about 0.8m and it is recommended to dredge the area to about 1.5m below MSL. This means that a total area of about 16,000m^2 would have to be dredged from this location. The main advantage of this location is that is closer to the western shore and dredging the area would also provide some operational ease for the water sports activities at low tide. This area is not in the vortex behind the island, therefore, sand accumulation would not be critical. The main disadvantage with this location is that it is the face of the island and not the kind of location in which a sand pump should be kept.

The second alternative is to level the projected area just off the first alternative location. This area can be dredged to a depth of about 3.5m just like the proposed area. With average depth of about 1.5m, a total area of about 6,000m^2 would have to be dredged. There are no particular advantages associated with this particular location except that the area to be dredged is smaller than other areas and that there would not be any threats similar to dredge holes in the middle of shallow lagoon areas.

8.2.4 Beach enhancement

The existing structures certainly do not dissipate energy. The seawall is not effective for this purpose. The groyne field would allow dissipation only if the area between the groynes can be filled with fine sand, whereby the sandy beach profile between the groynes would help dissipate wave energy to some extent while the groynes minimize sand movement alongshore. However, given that the net longshore current is small compared to the net onshore-offshore sediment movement on the southside, the groynes would still pose problems in terms of retaining sand between two groynes. Therefore, it may be necessary that an alternative coastal protection structure is considered along with beach nourishment.

The different options for the proposed beach enhancement on the southside beach include (1) continuous beach nourishment, (2) revetment-type headland structures, (3) nearshore breakwater or submerged sill and (4) offshore breakwater. For offshore breakwaters, two types or methods have been suggested, OB1 and OB2. These options are further discussed below and illustrated in Figure 8-1.

8.2.4.1 Continuous beach nourishment

Continuous beach nourishment is the option that has been discussed with the consultant. Given that beach nourishment between the groynes has never been done, it may be important to try to see the results of this. However, based on hydrodynamics at site and past experience, the sand is not expected to retain. Therefore, continuous pumping by keeping a sand pump at site would be required. This has aesthetic impacts and associated guest complaints.

8.2.4.2 Headland revetment

For the proposed headland structures, a minimum of 15m structure placed at not more than 40m between each other has been considered to be effective. The optimum design is considered to be 20m length headland revetments placed at about 40m from each other except for the eastern end where beach is not a serious requirement. These headland structures would work effectively if it can be vegetated. Therefore, vegetation using iron wood from existing iron wood trees would be ideal.

Two types of materials have been considered for the revetments: z-blocks used in some islands along the entire shoreline and 2.5m^3 geotextile containers filled with sand. Rock boulders is also an option given that it would dissipate about 35 to 50% of the energy. However, for aesthetic reasons and ease of adjustment geotextile containers placed with gaps in between is preferred over the rock boulders.

8.2.4.3 Nearshore breakwater or submerged sill (SS)

Nearshore breakwater acts in a similar manner to headland structures, however, allow water to pass between the structure and the beach unless a tombolo connects the shoreline with the structure. Nearshore breakwaters have been designed in the same way as the headland structure proposed above but as breakwaters rather than revetments using rock boulders (RBSS). Neashore breakwaters have been designed to remain emerged except during high tide. As a result, the structures would have high aesthetic impacts compared to headland revetments proposed above.

8.2.4.4 Offshore breakwater

Offshore breakwater covering a length of about 500m on the dead reef flat at about 50m from the closest water villa has been proposed. The structure is designed for optimum performance with minimal aesthetic impact. Therefore, the structure would be submerged at high tide. However, wave energy absorption is of critical importance, therefore, structure must be designed for optimal wave energy absorption, especially at high tide. If geotextile containers alone are to be considered, the structure should have adequate cavities or space between the bags to absorb wave energy. Even for rock boulders, the size is critical so that permeability can be increased, thereby improving structural efficiency. Tetrapod structures or Core-Loc units are considered to be the most appropriate given the high permeability or large number of cavities absorbing over 50% of the wave energy. In fact, estimations given below indicate that tetrapod is the cheapest option while geobag with Core-Loc on the seaward side is expected to perform better with Core-loc providing over 60% cavities and greater wave power disintegration. Since the price difference is small, the geobag with CoreLoc option is recommended.

	Boulders (RBBW)	Geobags (GTBW)	Geobag+CoreLoc (GT+CLBW)	Tetrapods (2 layer) (TPBW)
Length of breakwater	500	500	500	500
Mean depth at location	1	1	1	1
No. of bags/tetrapods/tons of boulders	7,020	1,063	531	625
No. of Core-Loc units			249	
Total cost (in US$)	842,400.00	430,515.00	365,737.50	328,125.00

8.2.4.5 Offshore breakwater, DMBW

In this option, it is suggested to dredge from the shallow reef flat behind the water villas to create a deeper area of about 1.5 to 2m depth and at the same time create a breakwater that will shelter the dredged area and the southside beach as well as the water villas. Similar setup now exists in Royal Island, although in Royal Island the breakwater was placed right on the southside reef killing the entire southside reef. However, the proposed setup for Hakuraa is quite a distance from the reef flat and also at a considerable distance from the water villas. This option needs further evaluation, however, is suggested here as a practicable option not entailing excessive costs. If it can be designed well, the setup can provide adequate shelter for the southside beach thereby providing a sandy beach with several aesthetic advantages.

8.3 Recommended Alternatives

There are no recommended alternatives for the proposed jetty modifications and the proposed entrance channel deepening. However, recommendations are made here for the proposed beach enhancement based on the discussions above and on the alternative analysis provided below. The impact matrix was developed by assigning indices to five parameters namely environmental impact, performance, maintenance, aesthetics and price. The maximum value assigned to each is 5 and the lowest is 1. Below is a discussion of the findings.

Table 8-2: Net indices for the different options (a comparative analysis)

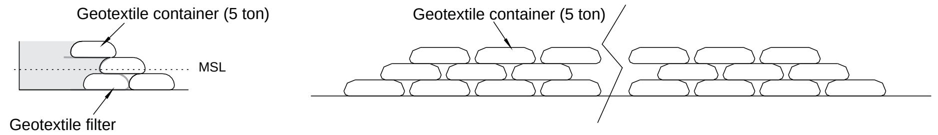
	None	5HL	9HL	RBSS	RBBW	GTBW	GT+CLBW	TPBW	DMBW
Environmental Impact index	1	4	5	3.5	3	4	4.5	4.2	3.5
Performance index	1	2.5	4	4.5	4.5	4	5	3.5	4
Maintenance index	1	3	4	4.2	4.2	4.2	4.5	4.8	3
Aesthetic index	3.8	3.5	3	3	3.5	3.8	4	3.6	4
Price Index	5	2.8	2.1	1.3	0.4	0.7	0.8	0.9	1.7
TOTAL	11.8	15.8	18.1	16.5	15.6	16.7	18.8	17	16.2

The results indicate that the use of 9 headland structures using geotextile bags is the best solution followed by two types of breakwaters (geotextile bags with Core-Loc followed by tetrapod) and that plain nourishment of the southern shoreline would be the least effective method although it is the least costly method. The Core-Loc units have higher permeability and lesser environmental and aesthetic impact than the tetrapod 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, the headland structure using geotextile containers or offshore breakwater with tetrapods are recommended if the project were to be carried out immediately. The revetments have been designed to provide adequate wave runup to minimize the force of the wave.

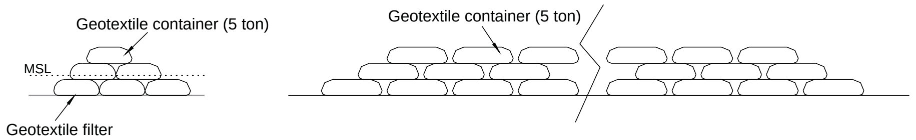
Figure 8-1: Alternative beach enhancement options

Conceptual illustrations of the proposed structures

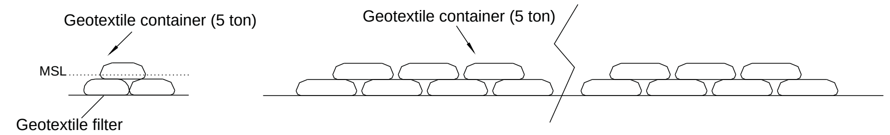
1. Headland revetment



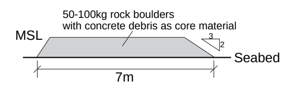
In case of fear of failure of the above setup a breakwater like structure may be adopted as shown below.



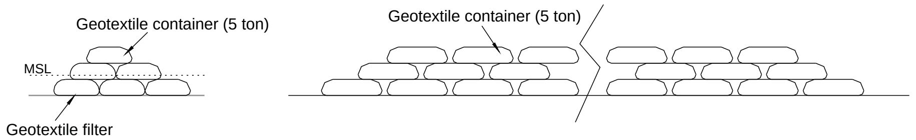
2. Nearshore breakwater or submerged sill

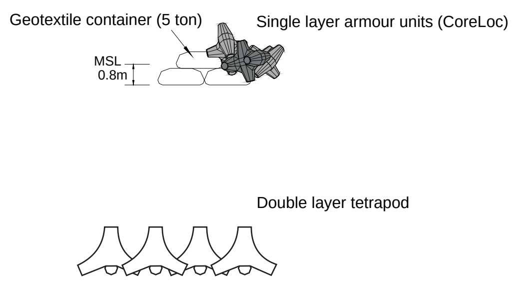


A rubble mound submerged breakwater can also be considered



2. Offshore breakwater options





9 Environmental Monitoring

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The purpose of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods. The proposed monitoring programme will yield beneficial results if it is undertaken for a longer period. Therefore, the proposed monitoring programme is recommended for at least three years from the onset of the proposed project. Longer term monitoring would also be useful.

The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. Therefore, the monitoring programme will cover the following aspects of the proposed project:

- coral cover and nektonic fauna
- marine water quality
- beach and hydrodynamic changes
- Incidents/accidents
- Fuel consumption during construction
- Tourist satisfaction (especially repeaters) and staff opinions

9.1 Recommended Monitoring Programme

Outlined here are minimum project specific monitoring requirements that can be considered. This monitoring programme for the proposed project includes at least three monthly monitoring and covers the three stages of the project implementation.

Stage 1: Immediately before starting works

Stage 2: During construction

Stage 3: Operational phase

The monitoring needs of each stage are discussed in detail below:

Stage 1 (before construction)

- Marine water quality for pH, Conductivity(mg/l), dissolved oxygen(mg/l), turbidity (NTU) and Salinity

Stage 2 (during construction)

- Marine water quality for pH, DO, EC, salinity, turbidity at possible reef areas into which sediment plume is expected to move. Drogue studies may also be useful to understand the plume movement.

Stage 3 (operational phase)

Three monthly monitoring starting from the completion of proposed works shall be undertaken.

- Shorelines (low tide, mean tide and high tide) immediately after beach enhancement using differential GPS. Shorelines of the neighbouring island, Kakaa Huraa, should also be included.
- Beach profiles of southern shoreline of Hakuraa and the four profiles taken for Kakaa Huraa
- Drogues at the same locations shown in this report and possibly additional locations
- Marine water quality – pH, DO, salinity, COD and turbidity.

In addition, it may be worthwhile undertaking a tourist satisfaction survey aimed at understanding the environmental or aesthetic improvements targeted by the proposed project before the end of the first year of monitoring for inclusion in the annual monitoring report.

9.2 Cost of monitoring

The following table outlines a cost estimate for the monitoring assuming the monitoring will be undertaken by environmental consultants and most of the parameters would be tested in-situ.

Table 9-1: Costs of the annual monitoring programme

Item No.	Details	Unit cost (US$)	Total (US$)
1	Field allowance for 2 consultants for 1 day	200.00	800.00
2	Monitoring equipment depreciation and other charges	230.00	920.00
3	Laboratory charges	50.00	200.00
4	Compliance reporting (annual report)	1,500.00	1,500.00
	Total		3,420.00

9.3 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency of the Ministry of Housing, Transport and Environment. The report must be based on the data collected for monitoring the parameters included in the monitoring programme given in this report.

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. The Proponent's commitment to undertake the monitoring programme and to report annually to the Environmental Protection Agency is attached with this report.

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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بسم الله الرحمن الرحيم

Environmental Protection Agency

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EPA

Terms of Reference for the Environmental Impact Assessment on the proposed refurbishment works at Chaaya Lagoon, Hakuraa huraa, Meemu Atoll, Maldives.

The following is the Terms of Reference (TOR) for undertaking the EIA of **the proposed refurbishment of Chaaya Lagoon Hakuraa Huraa, Meemu Atoll, Maldives.** This TOR is based on the issues raised in the scoping meeting held on Wednesday, 12 May 2010 at Environmental Protection Agency.

1. Introduction – This TOR has been prepared for the Environmental Impact Assessment of the proposed fixed air taxi platform development, maintenance dredging of the entrance channel and beach nourishment at Chaaya Lagoon Hakuraa Huraa, Meemu Atoll. These are the coastal elements of the proposed refurbishment for which the resort will be shut down from May to August 2010.

2. Study Area – The study involves the jetty head area of the existing jetty, existing entrance channel at the inner reef, and the entire shoreline on the southern side. The study also incorporates the different potential locations from which sand can be dredged/excavated for the beach nourishment and the disposal of dredge material from the exaction of the existing entrance channel.

3. Scope of Work - 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 method for dredging and dredge spoil disposal, a matrix of project inputs and outputs, details of beach nourishment and coastal modifications including any 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. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they may be usefully applied to future monitoring.

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

- *Excavation of the existing entrance channel*
- *Beach nourishment on the south side coastline*
- *Machinery and construction equipment as well as workforce management*
- *Coastal protection structures such as headlands (if proposed).*

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

- *Mapping of existing shorelines, vegetation line, coastal structures including the jetty, air taxi platform and other relevant structures using differential GPS*
- *Long shore/offshore currents around the island, especially project areas*
- *General climatic and oceanographic conditions in the project area*
- *Bathymetry of the island lagoon, especially in areas where developments are proposed*
- *Sea water quality at the proposed locations. Water quality parameters shall specifically include dissolved oxygen, salinity, pH, temperature, BOD and turbidity*
- *Condition of the reef at the entrance to the existing channel and any other relevant areas*

All survey locations shall be referenced with Geographic Positioning System (GPS). All water samples shall be taken at a depth of 1m from 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.

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 including the constructional and operational impacts. During the constructional phase impacts of excavation, beach nourishment, coastal protection works (if any), air taxi platform, dredge spoil disposal, etc. needs to be considered. During the operational phase impacts on the coastal processes and shoreline (i.e. sediment movement), impacts on the neighbouring island and the socio-economic impacts from the proposed air taxi platform and channel deepening shall be considered. Impacts of any proposed changes to existing coastal structures or any additional shore protection measures shall be identified.

In addition to negative impacts, positive socio-economic impacts and enhancement to natural environment (if any) 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 sediment control and construction methods and materials that would minimize impact on the environment. Transplantation of any live corals in the project area that may be adversely affected shall be considered as an important mitigation measure. 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 scenario evaluated against the no-project option and other alternatives. These include alternative technologies and materials, alternative borrow areas (for pumping sand required for beach nourishment) and alternative coastal protection measures. The report should discuss how the recommended alternative was selected.

ENVIRONMENTAL PROTECTION AGENCY, Republic of Maldives

Task 7. Environmental Monitoring Plan – Environmental monitoring shall focus on the construction as well as the operational stage. Constructional monitoring shall cover sea water quality to understand sedimentation by including monitoring of pH, DO and turbidity at regular intervals before, during and sometime after the construction phase. If coral transplantation was considered as a mitigation measure, an ongoing monitoring

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programme to assess the health of the transplanted coral in the transplanted area shall be considered. Operational stage monitoring should focus on the effectiveness of the air taxi platform, beach nourishment programme including any shore protection measures and the impacts (if any) on the neighbouring island. 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 are limited to consultations with the management of the resort and the dhoni crew and any other relevant parties such as Maldivian Air Taxi who may be directly involved with the project. Views of line government agencies have been discussed at the scoping meeting, which shall be incorporated in the EIA report and list of participants of the scoping meeting shall be attached.

<u>Presentation</u> - The environmental impact assessment report, to be presented in print and digital format, shall be concise and focus on significant environmental issues. It shall 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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27 May 2010

ENVIRONMENTAL PROTECTION AGENCY
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Chaaya LAGOON HAKURAA HURAA

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02nd June 2010

Hon Dr Sawad,
Minister of Tourism Arts & Culture,
Male,
Republic of Maldives.

Dear Sir,

Chaaya Lagoon Hakura Huraa Environment Impact assessment report

We refer to the above report and wish to hereby express our commitment towards undertaking Mitigation measures. We also wish to continue with the Monitoring Programme outlined in the report.

Thank you

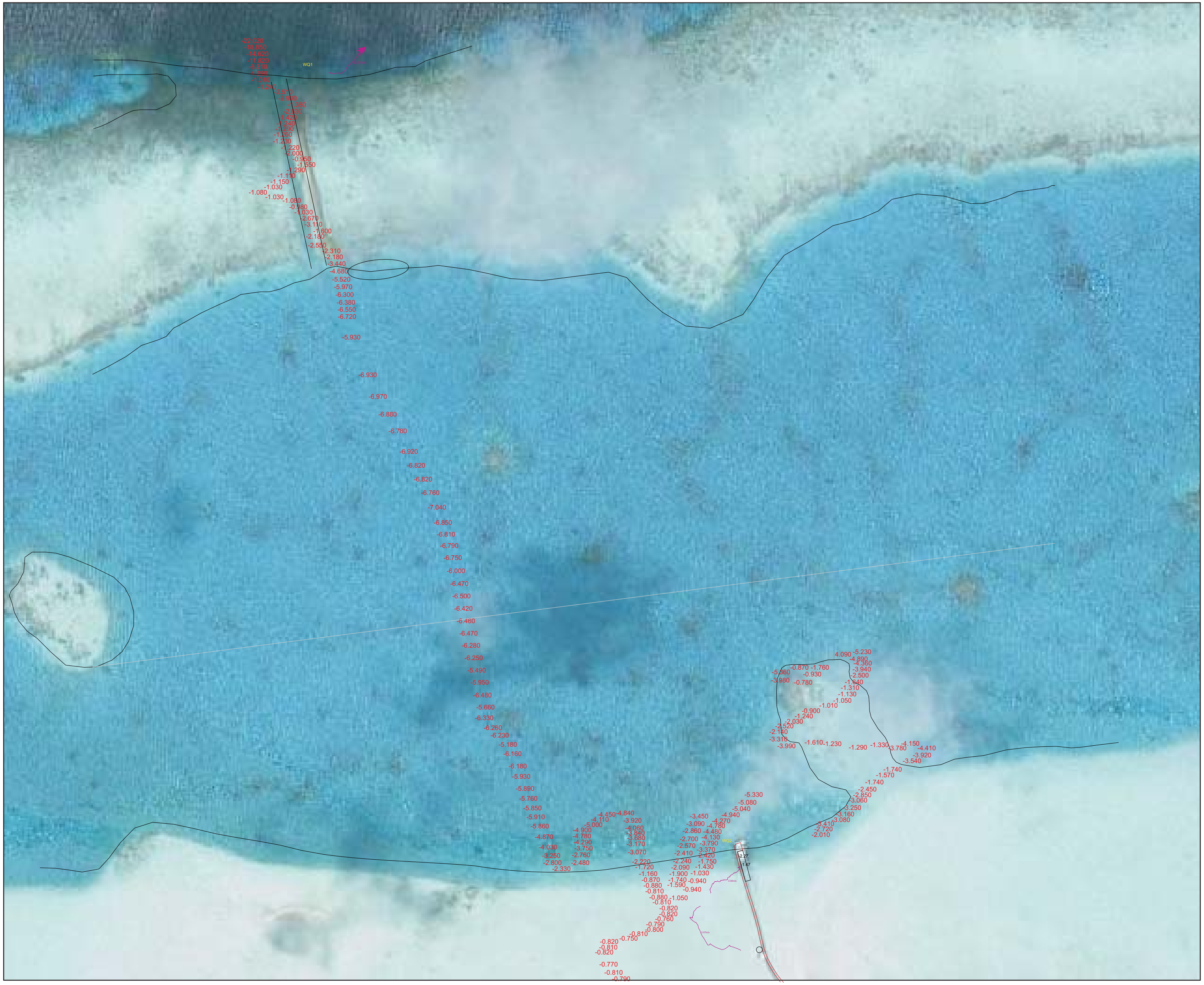
Yours sincerely,

Roshan de Silva
General Manager

FANTASEA WORLD INVESTMENTS PVT. LTD.

Appendix 3: Bathymetry and topography in the project area

Appendix 3: Bathymetry and topography in the project area



Appendix 4: Profiles and photo representation of kakaa Hura