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# Environmental Impact Assessment

## Four Islands - Ha. Dhidhdhoo

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# 1 Introduction

## 1.1 Background

The aim of the Three Islands Project is to turn three islands in three different atolls into larger, safer community centres for the entire atoll in which they are located. This is achieved by building land reclamations at each of these islands, and protecting these reclamations (and the existing islands) with new revetments. This approach to increasing safety and enabling social and economic development is based on the Safer Island/Focus Island policy that was developed by the Government of the Maldives at the beginning of the 21st century, well before the tsunami of December 2004 struck.

The Government of the Maldives initially selected three islands to be developed in the Project, but later changed the scope into four islands to be developed. These islands include:

- Hinnavaru in Lhaviyani atoll
- Thulhaadhoo in Baa Atoll
- Velidhoo in Noonu Atoll
- Dhidhdhoo in Haa Alif Atoll

The execution of this Four Islands Project will be under the responsibility of the Ministry of Housing, Transport and Environment (MHTE), which will therefore act as the Project Proponent.

The Project as a whole (four islands) will involve the placement of approximately 2.5 million cubic meters of sand, which will more or less be evenly distributed over the reclamation areas of the four islands. Approximately 5000m of revetments will be constructed, and at Thulhaadhoo a new quay wall will be constructed in the existing harbour.
The total cost for the Project is approximately 34 million euros.

A separate EIA is done for each of the four selected islands in order to better emphasise the environmental and socio-economic impacts at each island and atoll. The islands are located at more than 150 km distance from each other, so no cumulative environmental effects are expected that need to be addressed in an EIA for the project as a whole.

## 1.2 Aim and scope of EIA

The present scope of the EIA is based on the EIA Regulations from the Ministry of Housing, Transport and Environment (EIA Regulations 2007, ref. 1), the IFC Performance Standards (ref. 2,) and EHS Guidelines (ref. 3). and on EIA's for two other, similar, projects in the Maldives (Vilufushi Island Reconstruction and Viligili Island Reconstruction, ref. 4, ref. 5). The EIA report covers both the natural and the social environment and includes the following main aspects (see also Appendix 1 for cross reference of IFC Performance Standards):

- a description of the project including the usefulness and need of the project
- the policies and plans of which the project is a part and the legal framework of the project;
- information about the general environmental settings of the project area, covering both the marine and terrestrial environment and including physical and climatological characteristics;
- information on the social and economic baseline conditions;
- information on potential impacts of the project and the characteristics of the impacts;
- information on potential mitigating measures to minimise undesired environmental and social impacts;
- assessment of the best alternative for the project or for certain project components;
- basic information for formulating the environmental monitoring program and the environmental and social management plan;
- inventory of possible gaps in presently available information.

The focus of this EIA is on the construction phase of the project. The Three Islands Project is part of the National Environmental Action Plan III (ref. 6), which calls for the construction of coastal

protection around six Safe Islands, and fits well within goals set in the National Strategy for Sustainable Development (ref. 7).
The Safe Islands/Focus Islands program was conceived by the Government of the Maldives well before the tsunami struck the Maldives in 2004. The plan called for the development of larger islands, which would contain areas with higher elevation above sea level and would be protected from storm and tidal surges by modern coastal defences. This coastal defence would include a high bund along the ocean side of the island, paved with stone revetments on the outside, and an Ecological Protection Zone consisting of trees and shrubs just behind the bund on the island itself. The Safer Islands/Focus Islands program started out as a separate development plan, but has since been incorporated into the National Environmental Action Plan III, and the National Strategy for Sustainable Development.

The decision to develop the islands of Hinnavaru, Thulhaadho, Velidhoo and Dhidhdhoo for the Project was made within the framework of these programs.

## 1.3 Terms of Reference

The Terms of Reference (TOR) for this EIA were submitted to the Ministry of Housing, Transport and Environment on 8 December 2009. Formal approval was received on the same date during a scoping meeting with the Ministry of Housing, Transport and Environment, the Ministry of Fisheries, the Ministry of Planning, and the Environmental Protection Agency (EPA). In addition a separate meeting was held with the Ministry of Tourism.
The TOR follow the Environmental Impact Assessment Regulations 2007, as prepared by the Ministry of Environment, Energy and Water. The TOR also address requirements arising from the IFC Performance Standards on Social and Environmental Sustainability and the IFC Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals.
The Terms of Reference can be found in Appendix 2.

## 1.4 Experience of proponents with similar projects

In 2005-2006 and 2007-2008 the Government of the Maldives, in the form of the then Ministry of Construction, developed the Safer Islands Vilufushi (Thaa atoll) and Viligili (Gaafu Alif atoll) respectively, under the Safer Islands program initiated by the then Ministry of Planning and Development. Royal Boskalis Westminster was contracted to do the land reclamation works for each of these two islands.
Both projects were developed by the Ministry of Construction under the same premise as the Three Islands Project: to create new and safer land adjacent to an existing island to create more space for population growth and economic and social development. The reclamations have a higher elevation above sea level than the existing island, and are protected on the ocean side with a revetment that can withstand severe storm and tidal surges. This so-called “Safer Island” concept is described in further detail in Chapter 3.

## 1.5 Funding Agency

The Government of the Maldives has obtained a loan from the Dutch ING Bank to finance the Three Islands Project.

## 1.6 Field work

The field work necessary for the environmental and social impact assessment was carried out by expert professionals.

The environmental field work was coordinated and supervised by Ms. Astrid Kramer MSc, Project Engineer Marine Environment with Hydronamic b.v.. Seamarc Pvt. Ltd. of Male was subcontracted to execute the coral reef surveys, in conjunction with divers from Marine Multi Services Pvt. Ltd., also of Male.

The social consultations were done by Mr. Chris Geerling PhD, of Carnbee Consult. Previously, Mr Geerling was in charge of the social impact studies for the projects in Vilufushi and Viligili.

# 2 Problem Analysis and Justification of Project

## 2.1 General

In the Maldives, there are significant problems regarding the natural environment. The most important problems are caused by:

- sea level rise;
- extreme weather conditions;
- tsunamis;
- population pressure;
- lack of space for future development.

These problems with the natural environment lead to problems in economic development, living standards and well-being of the inhabitants.
In order to address these problems and ensure sustainable social and economic development, the Government of the Maldives has defined long and short term goals. The National Environmental Action Plan III contains the short term goals and plans to reach these goals. The National Strategy for Sustainable Development contains the long term goals to ensure a safe and healthy future for all Maldivians.

The tsunami of 26 December 2004 and the damages caused have created a further threat to the environment, but also an opportunity for appropriate action. In this chapter the relevant problems will be analysed and the need for the project and its general outline and dimensions will be discussed.

## 2.2 Problem analysis

### 2.2.1 Lack of space for future development

On most of the inhabited islands of the Maldives, every last square meter of space has been used for housing or public facilities. Most islands have some green areas, mostly strips of shrubbery along the shore of the island, and a few slightly larger areas of higher bushes and palm trees in the far corners of the island.
On most islands, there is no space left to build more houses to accommodate population growth, there is no space for small industrial development, improved fish market, fish drying and fish smoking facilities, or to build a waste management and sewage water treatment facilities or even expand power generation facilities to meet current, let alone future power demands.
On top of this, most islands are subject to erosion, which has reduced useable space even more.

### 2.2.2 Population pressure

Only part of the surface area of the Maldives is inhabited. Usually the population is concentrated on a limited number of rather densely populated islands, thereby providing a reasonable basis for social subsistence. Twenty atolls are populated ranging from 1,600 to 18,000 people (not including Malé). The entire population of the Maldives is scattered over 200 inhabited islands. By mid 2009, the population was calculated at 298,000, with about a quarter of the population concentrated in the capital. The population growth in the Maldives has recently been as high as 2 to 3%; in the outer atolls the majority of the population is below 20 years of age. These outer atolls experience a large outward migration predominantly to Malé.

Due to the significant population growth, on many of the islands there are no more empty lots available for development. This means that there is no place for additional people, for further communal and/or commercial activities, and for natural migration from smaller islands to the larger regional centres.

### 2.2.3 High costs of communal infrastructure and provisions

Due to the relatively ‘small’ populations (average 500-1,500 persons) per island, the costs of providing community infrastructure (electricity, water supply, sewerage, waste collection) and communal services (health, education, local administration) is high. Also the limited depth of the islands ports and the low transport volumes, may lead to high per-ton transport costs for import of food, construction materials and other goods.

In a country with high GDP growth, and a society that is rapidly modernising, demand for better infrastructure and services will often grow at a much faster pace than GDP growth. This may result in migration to a larger island, often to Malé, which is already filled to capacity and cannot provide livelihoods for newcomers.

### 2.2.4 Sea level rise

The Maldives are vulnerable to climate change and predicted sea level rise, due to the low elevation of the islands and therefore large impacts of even small rises in the sea level. During the past century the global temperature increased by about 0.6 degree. Climate modelling calculations predict that global mean surface temperature of the earth could rise by about 1 to 4.5 degrees by 2100 (see Figure 2-1).

Due to the higher temperature many glaciers and ice caps are melting and the melting mass of water will cause a rise in sea levels. During the past century the average sea level increased by about 15 to 20 cm. The estimated predicted sea level rise in the period 1990 to 2100 is 0.1m to almost 1.0m (see Figure 2-2). This sea-level rise combined with more frequent extreme weather occurrences makes the Maldives one of the most vulnerable countries to climate change and sea level rise in the world. Due to the effects of future climate change and related sea level rise, it may be expected that the Maldives will face a number of impacts, being:

- increased coastal erosion;
- higher storm surge flooding;
- more extensive coastal inundation;
- changes in groundwater characteristics;
- increased flood risk and potential loss of life;
- loss of tourism and recreation.

*Figure 2-1 - Global climate change*

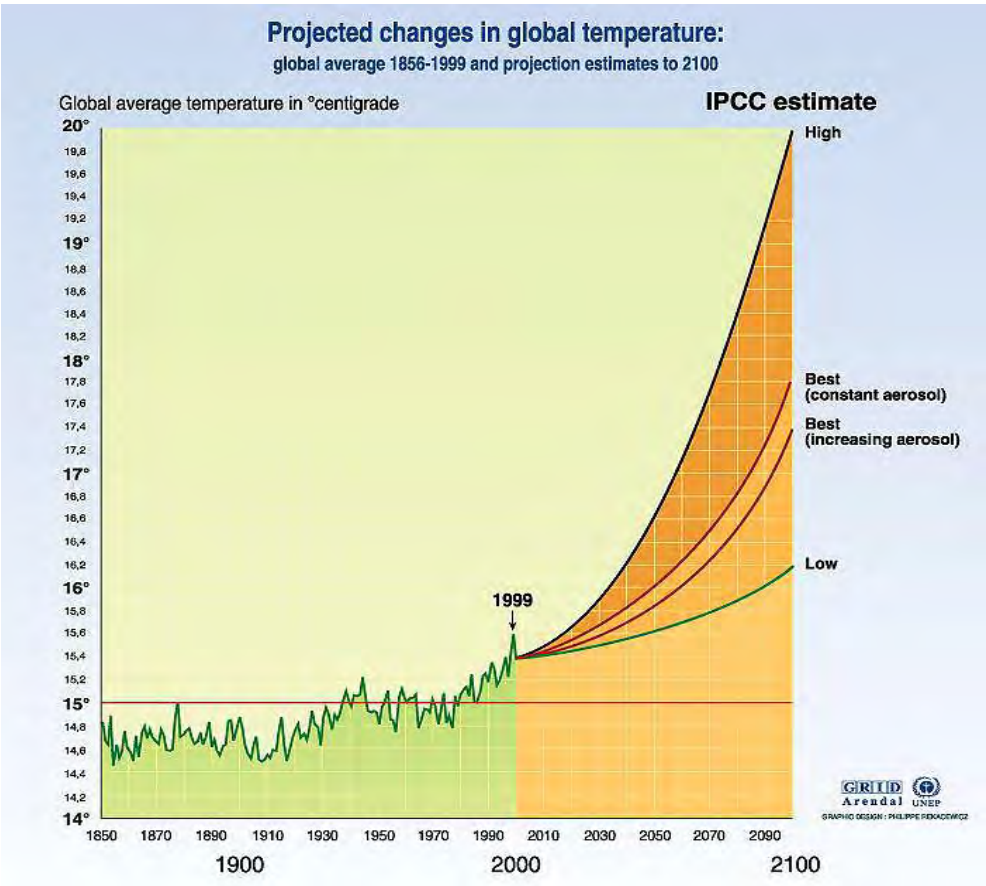
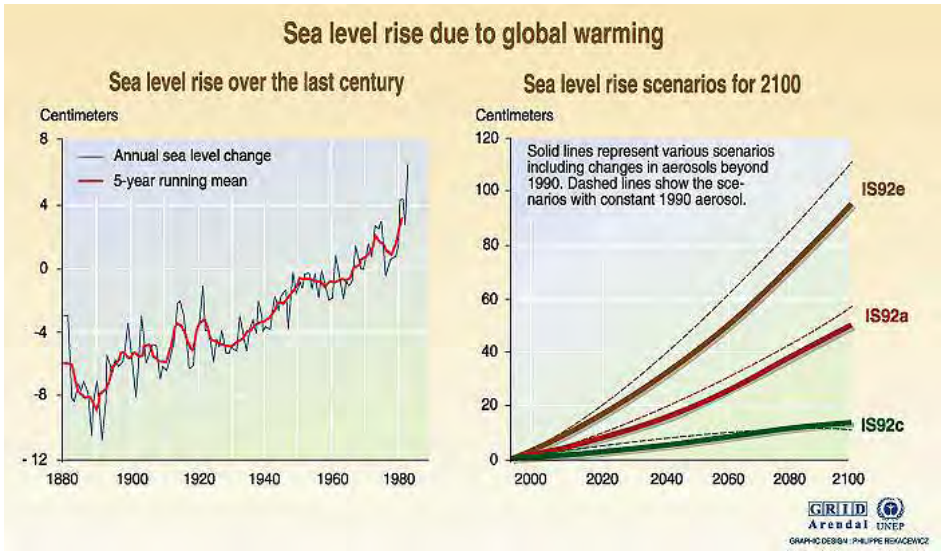


*Figure 2-2 - Sea level rise*




### 2.2.5 Extreme weather conditions

At the Maldives virtually no cyclones occur, but sometimes there are significant storm surges with up to one meter sea level rise. In April 1987 there was a storm surge at Malé, which resulted in unusually high waves. One third of Malé was inundated by about 60 cm of water, and Male' International Airport sustained damages worth US$ 4.5 million. Again in 1991 a storm surge occurred near Malé. Although the damage was minimal, the experience was a forceful reminder of how vulnerable the Maldives can be to even a small rise in water level. The initial response to this threat was to start construction of a series of breakwaters on the outer coast of Malé, which protect the capital from damaging storm waves.

In the Maldives high waves and storm surges are considered natural hazards. Most of the atoll islands are very low and significant damages, including changes in groundwater characteristics, can occur.

A recent report by RMSI of India for the UNDP ("Developing a disaster risk profile for Maldives', November 2005) gives more information with respect to the extreme weather conditions and their consequences, including the tsunami hazard.
There is a low earthquake hazard for most of the Maldives; the three most southern atolls, have a medium earthquake hazard.

### 2.2.6 Tsunamis

The Maldives are highly dependent on the fragile ecosystem of the coral reefs, because energy of the high waves is dissipated and reduced by the reef crest (breaker zone). This protects the islands and their inhabitants from direct impact by the waves. The coral reefs also play a very important role the tourist industry, luring scuba-divers from all over the world for a unique diving experience.
The December 2004 tsunami has proven once again the extreme vulnerability of such small and low lying islands. It was reported that 35% of the country's 200 inhabited islands had been subject to high or very high impact by the December 2004 tsunami, with major physical damage to buildings, infrastructure, crops and natural vegetation. The tsunami-related environmental damage can be summarised in five main groups:

- Disaster waste: uprooted vegetation, re-distributed domestic and hazardous waste, drums, large amounts of demolition waste were spread over the impacted islands.
- Groundwater contamination: shallow freshwater aquifers were impacted by infiltrated flood water, oil spillages from generator stores and leaks from septic tanks.
- Coral reef damage: damage was caused by direct wave impact and secondary damage occurred from sedimentation and excessive amounts of debris.
- Coastal damage: extensive beach erosion and damage to coastal protection measures occurred.

- Beach, soil, vegetation and crop damage: extensive washing-off of soils, stress and dieback in certain species from direct impacts as well as possible salt contamination occurred.

The tsunami hazard in the Maldives comes mainly from the eastern direction; of the total of 85 tsunamis that hit the Maldives since 1816, 67 originated from the Sumatra Ocean. Especially islands along the eastern fringe of the eastern atolls are exposed to this hazard. The probable maximum tsunami wave height is estimated at between 4 and 5 meters. The return period of the 26 December 2004 tsunami is in the order of 200 years (ref. 4 and 5).

## 2.3 Justification of the project

### 2.3.1 Justification

There are two main objectives of the project,:

- increase the usable space on the island, allowing space for social and economic development,
- providing more safety against the sea for at least the next 50 years (storm events, sea-level rise),

The first justification of the present project is the increase in space for urban use to allow for population growth, migration from other smaller islands to the larger island, and new developments on the island, including those creating new employment. At present, all available space on the islands is used for housing, commercial and community facilities. In addition, the extension of the islands allows for space for extra social infrastructure such as schools, sport facilities and medical facilities and for a solid waste management area.

The second justification is that the tsunami disaster has again underlined the critical importance of providing environmental safe zones for isolated communities living on distant islands. For this and other reasons, the Government of the Maldives had already, prior to December 2004, developed the so-called ‘Safe Islands Programme’. The main objective of the government’s Safe Islands Programme includes:

- protection against storm events and the effects of sea-level rise;
- rebuilding and improving existing infrastructure and economic facilities;
- providing better services and more employment opportunities on ‘larger’ islands;
- ability to plan and implement effective measures to mitigate environmental hazards and for surviving disasters.

This will be achieved by providing ecologically safe zones including bunds, principally to mitigate the impact of storm surges and tidal swells.

Numerous studies, in particular related to various social and economic aspects and consequences of the Safer Islands policy, have been executed in the last 5 to 10 years, especially after the tsunami of 2004 (see ref. 4 and 5). It is therefore not surprising that the World Bank / ADB / UN program for post tsunami reconstruction and the EU tsunami indicative program, accept the linkage of island reconstruction with a certain number of safer and larger islands to be constructed.

There are a number of reasons/ criteria for the selection of the three islands as being the future focus island of their respective atoll:

- the present population is larger than average, which makes it economically sustainable to develop community services;
- there is already a wide range of services and amenities present on the islands;
- the islands already have a harbour;
- increasing the islands’ sizes is possible without creating (large) erosion elsewhere;
- the reef area is large enough to allow winning of enough coral sand resulting in fairly low costs for enlargement of the island.

# 3 Project Setting

## 3.1 General

The Maldives are a democratic republic with a written constitution. The protection of the environment is a national priority in the Maldives and efforts have been made to incorporate environmental protection and preservation across all sectors. As such, environment is granted ministerial status (Ministry of Housing, Transport and Environment); in addition, an Environment Protection Agency (EPA) and a high level National Commission for the Protection of the Environment (NCEP) have been set up.

## 3.2 Environmental legislation

The enforcement of EIA regulations in the country began with the formulation of the Environmental Protection and Preservation Act (Law 4/93) in April 1993 in order to protect, preserve and safeguard the fragile environment of the country. The Environmental Act or Law 4/93 is the single most important legal instrument with regards to environmental management. The main aim of the legislation is to protect and preserve the environment of the Maldives, and to sustainably manage its resources for the collective benefit and enjoyment of present and future generations.
It is currently being implemented by the Ministry of Housing, Transport and Environment. Under this act, regulations and guidelines have been developed concerning the environmental protection, especially regarding development activities, through implementation of EIA procedures.

Important national environmental legislations relevant to this study are, including the above-mentioned act no. 4/93:

- National Environmental Action Plan III (2008/2009);
- Environmental Protection and Preservation Act of the Maldives (law No 4/93);
- the law of Tourism (law No15/79);
- Environmental Impact Assessment Regulations (2007);
- regulations for coral mining (1992);
- Fishery Law of the Maldives (law No 5/87);
- National Biodiversity Strategy; project initiated late 1998;
- National Strategy for Sustainable Development (2009).

The Environmental Act also provides the basic framework for the Environmental Impact Assessment (EIA) process in the Maldives. Under article 5a of the act, an impact assessment study shall be submitted to the Ministry of Housing, Transport and Environment before implementing any project related to economic development that has potential environment implications. According to the EIA regulations, for example, all new resort developments require an EIA before approval for development can be issued. In an early stage of project-development a so-called IEE (Initial Environmental Examination) may be prepared. After the evaluation of this IEE, the Ministry of Housing, Transport and Environment, together with the project proponent will decide whether a full EIA study is still required.

## 3.3 National policies

In addition to the relevant environmental legislation, various National Policy Plans address the environment as well. The most important ones are:

- the Third National Environment Action Plan (NEAP III);
- the National Strategy for Sustainable Development, and;
- the Seventh National Development Plan.

The National Strategy for Sustainable Development is a new policy developed by the new government. Its aim is to unite all existing policies regarding environmental, social and economic development, and to provide a framework for future policies addressing these issues.

The aim of NEAP III is to protect and preserve the country's environment and to properly manage natural resources for the sustainable development of the country. It also encompasses a framework for action for the future. The NEAP III identifies the environmental priorities and policy directions for the next five years and also addresses key issues and respective measures towards the betterment of the environment, which will benefit present and future generations. The NEAP III aims to achieve six results:

- Resilient Islands
- Rich Ecosystems
- Healthy Communities
- Safe Water
- Environmental Stewardship
- Carbon Neutral Nation

To achieve these six results, thirty 'Goals' have been formulated, addressing issues such as protection of human settlements, increasing resilience of the coral reef to climate change, improving waste and sewage management, providing safe drinking water, improved environmental education and awareness, environmental legislation and research. The development of Safe Islands is one of the goals listed under "Resilient Islands".

The seventh National Development Plan was developed in 2007 and also identifies important measures and the role the government will play in terms of developing and implementing sound environmental management strategies. The goals formulated for economic, spatial and social development are also incorporated in the NEAP III and the National Strategy for Sustainable Development, both of which were developed after the NDP7 was released.

As part of these development and action plans, the Government of the Maldives has adopted a policy of passive population consolidation that encourages mobility of the population by connecting all the islands with a proper transport network, rather than the active relocation of people.

## 3.4 Safe islands Program, Focus Islands

Already before the tsunami struck, the Ministry of Planning and National Development had disclosed its decision to develop safe islands in each of the 20 atolls under the "Safe Islands Program" (ref.4 and 5). According to the minister, these safe islands, or focus islands, will have seawalls, a vegetation enclosure surrounding the island, high ground areas and drains to clear away floods should there be high waves. The present plan for construction of safe islands for the Three Islands Project is in line with this Safe Islands Program. The design includes a land level of 1.4 meter above sea level and a protecting bund wall of 2.4 meter above sea level at the islands vulnerable east side. At the inner part of the EPZ (Environment Protection Zone), which is on the outside of the island, palm trees will be planted.

## 3.5 International Context

The major global issue facing the Maldives is climate change, global warming and subsequent sea-level rise. The small size of the islands and their low elevation above MSL makes the islands susceptible to sea level rise. Consequently, the country plays a prominent role in fore fronting environmental issues faced by many other small-island developing states, mainly located in the Pacific regions of Polynesia and Micronesia. The Maldives is therefore, a party and signatory to various international conventions and declarations. These include:

- UN Framework Convention on Climate Change;
- Kyoto Protocol;
- UN Convention on Biological Diversity;
- Montreal Protocol on Substances that Deplete Ozone Layer;
- Basel Convention on Transboundary Movement of Hazardous Waste;
- UN Convention on Law of the Sea;
- Washington Declaration of Protection of the Marine Environment from Land-based Activities;
- UN Convention to Combat Desertification;

- Regional Agreement to Conserve Marine Turtles under the Convention on Migratory Species.

## 3.6 Responsible Ministries and Institutions in the Maldives

The main governmental institutions, involved in the construction of the Three Islands and the EIAs for this project, are described below.

The act 4/93 names the (then) Ministry of Planning and Environment as the main responsible ministry for safeguarding the environment. Some years later this responsibility went to the (then) Ministry of Home Affairs, Housing and Environment; whereas in 2004 the responsibility went to the Ministry of Environment and Construction (MEC), and more recently to a new Ministry of Environment, Energy and Water. Under the new government of President Nasheed, who was elected president in 2008, the Ministry of Housing, Transport and Environment (MHTE) is responsible for safeguarding the environment.

At present, the MHTE is the authoritative and responsible body for the effective implementation of the Environmental Protection and Preservation Act in the Country and has the statutory power over various issues related to the environment. The MHTE plays the main role within the government system with regard to environmental matters. It has the central control over environmental protection, conservation, management and related matters. This is mainly manifested at the policy level. The ministry is also responsible for developing, advising and undertaking environmental policies and government positions in national and international context as well as undertaking monitoring and research related to the environment.

In May 2004 the Environment Section of the (at that time) MEC published the so-called "Information Handbook for Proponents for EIA" (draft), which describes and clarifies the EIA process to be followed. In 2007 an updated version, Environmental Impact Assessment Regulations 2007, was published by the Ministry of Environment, Energy and Water.

The MHTE will, in case of project approvals, normally seek the advice of the National Commission for the Protection of the Environment (NCPE). The NCPE was appointed by the President in 1989 and restructured in 1993 at the time of the Environmental Act (Law No 4/93). The Commission was again restructured in 1999 to broaden the consultative process on environmental protection among the government concerned agencies. The mandate of the NCPE is to advice the Minister of Environment on environmental matters such as environmental assessment, planning and management and political decisions with regard to protection of the environment. A number of government agencies and ministries (Ministry of Tourism, Arts and Culture, Ministry of Fisheries and Agriculture) have environment-related mandates, sometimes these overlap with the mandate of the MHTE.

In the case of tsunami-reconstruction projects also the two following ministries play an important role:

- the Ministry of Economic Development, which coordinates data gathering and specifies/proposes long term responses, and
- the Ministry of Finance and Treasury, which coordinates donor assistance and other financial resources for tsunami reconstruction.

In the wake of the tsunami-disaster, the then Ministry of Planning and Development set up the National Disaster Management Center (NMDC) which focuses on the reconstruction process, ensures that pre-tsunami risks are not automatically build in again and establishes guiding principles for reconstruction.

In the case of the Three Islands Project the Ministry of Housing, Transport and Environment will act as client (employer) for the construction contract execution, as project proponent, as Responsible Agency, and as Licensing Agency.

## 3.7 IEE or EIA

In case a proposed project may cause significant adverse impacts, an EIA study is required. Whether this is necessary is generally considered in an early project stage by developing a so-called IEE (Initial Environmental Examination).

For this project, Hydronamic bv of Papendrecht, the Netherlands has prepared the Initial Environmental Examinations (IEE's). The reports have been submitted to the competent authorities in the Maldives. One of the recommendations of this IEE is to execute a full scale EIA for the project. The IEE contains terms of reference (TOR) for such EIA which are fully in accordance with the demands of the relevant authorities in the Maldives in this respect; they are also very similar to the ToR prepared for a similar projects 'Reconstruction of Viligili island' and 'Post-tsunami reconstruction of Vilufushi island', as proposed in 2007 and 2005 respectively for those projects by the Netherlands Commission on Environmental Impact Assessment.

The full ToR (Terms of Reference) for the EIAs for the Three Islands Project were accepted and approved by the MTHE during the scoping meeting on 8 December 2009, which was organised by the EPA. The EIA scoping phase of the Three Islands Project can be considered as completed.

## 3.8 Owner's consent to the project

The reef surrounding the islands is owned by the Government of the Maldives and is not classified as private property. The Ministry of Housing, Transport and Environment is the project proponent on behalf of the Government of the Maldives. Since the areas that will be affected by the project are the property of the project proponent, no separate procedure to obtain formal consent for the project is followed.

## 3.9 Follow-up after reclamation works

The Ministry of Economic Development is currently working on developing 7000 housing units across the Maldives. These units are divided into 20 packages, one package for each atoll. Several of these packages, have been released by the Ministry since December 2009. Developers and contractors have been invited to submit proposals for these packages.
The housing units have to be developed based on the neighbourhood concept. Therefore, the development will have following social infrastructure facilities within a five minute walking distance:

a) Primary school
b) Pre-school(s)
c) Mosque(s)
d) Community Centre

As a general guideline, for every 100 housing units, the following social facilities will be developed:

- One mosque with a minimum capacity of 200 people
- One pre-school with minimum 5 classrooms
- Improvement of medical facility in the island.

Since the housing units will be developed on inhabited islands, developers are stimulated to integrate the existing social infrastructure into the development of the neighbourhood. In doing so, the existing social infrastructure (mosque, healthcare facilities, schools, commercial centres) may need to be upgraded or new structures may require to be developed.

# 4 General project description

The global construction design of the Three Islands and the main construction activities are described in this chapter. First, some general information about the project is given.
This section describes the general design outline of the Three Islands and the main construction activities. The following items are addressed:

- Design outline of Safer Islands
- Previously constructed Safer Islands
- Planning of the works
- Environmental constraints
- Dredging & reclamation method alternatives
- Revetment construction
- Quay wall construction
- Applied Environmental Management System
- Availability of utilities, resources etc.
- Promotion of sustainable development
- Employment opportunities
- Enhancement works

## 4.1 Safer Islands

### 4.1.1 Design outline

The Three Islands will be designed according to Safe Island principles. Important elements of the Safe Island Concept are

- the Environmental Protection Zone (EPZ),
- the High Grounds (HG) and
- some buildings prepared for emergency evacuation.

The EPZ is in fact a broad crested dike along the part of the coast that is facing the outer reef and consequently the open seas. The EPZ needs an appropriate slope protection (revetment) against erosion due to currents and waves. The high grounds and the buildings for emergency evacuation need to be distributed evenly over the island in such a way that they can always be reached within a few hundred meters. The coast of the island with the harbour, facing the inner reef, needs less protection as the lagoon side is relatively sheltered against waves.

The High Grounds will have a higher elevation above sea level than the rest of the island. These High Grounds will provide refuge in case the waves do run over the top of the EPZ revetments. The buildings on these High Grounds will be suitable for emergency evacuation of the inhabitants of the island.

The principles of the safe islands concept as used for the design of the Three Islands are given in Figure 4-1.

*Figure 4-1 - Principles of the "Safe Island" concept*


### 4.1.2 Previously developed Safer Islands

In 2006, in the wake of the December 26, 2004 tsunami, the island of Vilufushi in the Thaa atoll was the first island to be reconstructed according to the Safer Island concept. The island had been completely evacuated after the tsunami, and the inhabitants had found a temporary, and very crowded, home at the nearby island of Buruni.
Vilufushi is located on a wide reef, which provided ample space for both the reclamation of new land and the borrow area that was needed to provide sand for the reclamation works.
Due to the devastation brought by the tsunami, all the existing houses on the island were demolished, and the entire 'old' island was brought from an average of 1.1m above sea level to 1.4m above sea level with several areas raised even higher above sea level.
The total area of Vilufushi was doubled and along the eastern shore, facing the open ocean, revetments were constructed to give extra protection against storm and tidal surges.

In 2008, at the island of Viligili in Gaafu Alif atoll new land was reclaimed on the eastern (ocean facing) side of the island. In the past, there had been land here, but this had disappeared due to the eroding forces of the ocean. The new land was protected by a dyke and revetments on the ocean side, and the surface area of the island of Viligili was doubled.
Reclamation works were carried out while the inhabitants of Viligili continued their normal day-to-day lives on the island.

Both these projects were developed and executed by Royal Boskalis Westminster dredging company, and were financed by loans from the Dutch Government.

## 4.2 Planning of the works

For the construction works of the Three Islands Project, roughly 3 million cubic meters of sand will need to be dredged and placed in the reclamations of each of the three islands. Each reclamation will require roughly 1 million cubic meters of sand.
After the sand is placed, revetments will be constructed to protect the parts of the reclamation that are exposed to the ocean.

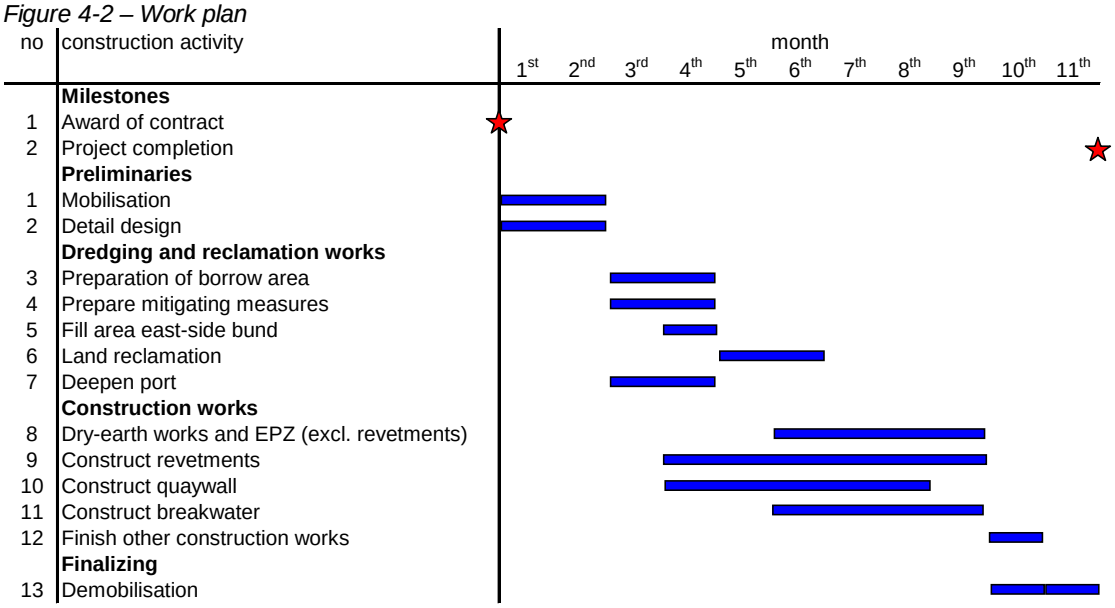
Detailed design of the exact shape and size of the reclamations at each island, and of the revetments and quay walls will be done after this EIA has been submitted, but before the start of construction works.

The main activities to implement the construction of the Three Islands are listed below.

- surveys;
- detailed design
- site preparation;
- mobilization of dredging and survey equipment, office and housing,;
- dredging the borrow area, land reclamation and stockpiles;
- profiling the reclaimed land and existing island to the required levels;
- construction of revetments on the slope of the EPZ, facing the outer reef;
- construction of quay-wall, breakwaters;
- demobilization of dredging equipment, office and housing
- environmental monitoring during construction,;
- measures to protect environmental values during construction and thereafter;

In general terms the work plan, see Figure 4-2, shows that preparatory activities like site preparation and mobilization take about 2 months per island. The duration of dredging is mainly related to the capacity of the deployed dredge and the location of the borrow area. The dredging will take about 2 months when using a mid size dredge, shorter when a large size CSD is employed. The construction works of revetments, breakwater and quay-wall will take about 6 months. The total duration of the project will take about 10 to 12 months.

*Figure 4-2 – Work plan*




Coordination with activities outside the project is required, especially regarding use of the harbour.

In principle the dredge/survey fleet, dry-fill- and auxiliary equipment will be transported to the Maldives aboard a dock-ship. The equipment will reach the project site with several transport loads as equipment is coming from different locations abroad.

*Dredging fleet*
The fleet consists of:

- one dredge;
- one transport barge with pipeline and containers (spares, workshop, etc.);
- one multicat (self-propelled barge with a hydraulic crane);
- one derrick barge or A-frame (for handling of pipeline);
- one general purpose launch for survey work, crew shifts, etc.;

*Dry-fill equipment*
So-called dry-fill equipment will comprise:

- two excavators;

- 2 dumpers;
- two bulldozers and one wheel loader

*Survey and logistics*
The following equipment needs to be on site in order to execute hydrographical surveys and an efficient project

- a fast launch for long distance transport of personnel;
- from the local market a tug and a barge or a self-propelled cargo vessel and a speedboat will be rented to maintain logistic services between Malé and Viligili (for food, fuel, etc.);
- the general purpose launch (mentioned above under fleet) will be equipped with the - Motorola DGPS positioning system;
- atlas Deso dual frequency echo-sounder;
- niskin water samplers;
- laboratory equipment for sediment analysis

## 4.3 Global environmental constraints

This paragraph summarises the most important weather and sea conditions affecting the project activities (for more details see Chapter 6).

### 4.3.1 Climate

The Maldives experience two seasons per year. The rainy southwest monsoon lasts from May to September and the dry northeast monsoon from December to January, with transition periods in between. Winds get stronger in the southwest monsoon especially during June and July (Beaufort force 8 is possible). Wind forces of 5Bft are common in both monsoons. Mean annual temperature is 30.8$^{o}$C with day-/night-time variations of a few degrees only. Monthly rainfall amounts to 50-75 mm in the dry season and 125-250 mm in the wet season.

### 4.3.2 Bathymetry

The islands of the Maldives are generally located on a submerged reef. The size of the submerged reef varies from several tens of meters diameter to several thousands of meters long or wide. Islands that are located on the atoll edge seem to have one of two types of reef on the ocean side:

- The reef flat is very shallow and almost equally shallow all the way to the edge of the reef. The edge of the reef is slightly above MSL just before it drops off steeply into the deep ocean.
- The reef flat has one or more terraces, each of which is deeper than the previous one when moving from the island to the deep ocean. The deepest terrace is between 10 and 20m below MSL and drops off steeply into the deep ocean.

### 4.3.3 Sediments

The islands and reef consist of coral reef formations consisting of coral sands, gravel and coral rock. The sediments have a very high permeability.

### 4.3.4 Sea conditions

Typical tidal ranges during spring and neap are 1.0m and 0.3m respectively. The tides are mixed, diurnal/semi-diurnal. The seasonal changes are +0.1m in February to April and -0.1m in September to November. Oceanic currents, driven by the monsoon winds, are flowing westerly from January to March and easterly from May to November. Tidal currents, flowing eastwards during flood and westwards during ebb are rather weak. Local currents on the reef plane often include an important wave-induced component. Recent flow measurements on the reef indicated maximum current velocities in the order of 0.5m/s. Considerable swell at the ocean side may occur with heights of 2 to 3m and periods of 18 to 20s. Local wind waves have periods of 2 to 4s and heights up to 1.5m. The shallow depths on the reef plane cause significant wave breaking, reducing the wave height to about 1m (maximum).

## 4.4 Dredging & reclamation methods alternatives

This section describes the different options for dredging methods and borrow areas. Options include the use of a Cutter Suction Dredge (CSD) to dredge material from a borrow area in the reef surrounding the island, or the use of a Trailing Suction Hopper Dredge (TSHD) to dredge material from a borrow area in the atoll lagoon area.

### 4.4.1 Method and equipment, alternatives

*Sources of fill material and type of dredger*

The potential available sources of fill material, which can be used in this project, are given below:

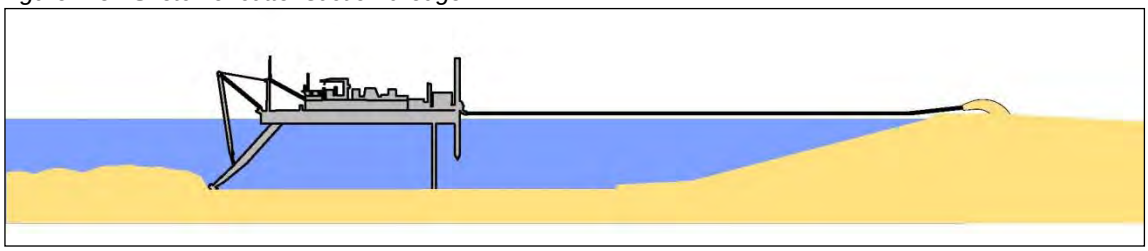
1. sand and coral material from the shallow reef flat area next to the island, to be dredged by a cutter suction dredge (CSD);
2. sand from the bed of the lagoon of the atoll (away from islands), to be dredged by a trailing suction hopper dredge (THSD);
3. sand and coral material from the reef elsewhere in the atoll, to be dredged by a CSD;
4. sand imported from overseas using a large scale TSHD.

Option 1 has simple logistics, the impacts on the environment are localised (limited to an area around the island where dredging and reclamation activities take place) and manageable.
Option 2 also has relatively simple logistics, although deep water access to the islands is required. The impacts on the environment are localised (limited to the borrow area and the island where reclamation activities take place) and manageable.
Option 3 involves more complicated logistics for transportation of the dredged material from the borrow area to the reclamation area. The impacts on the environment are also more severe, due to the fact that coral reefs will be exposed to dredging and reclamation activities at two different locations. Environmental impacts are therefore more difficult to manage. This makes this option environmentally prohibitive.
Option 4 involves very long sailing distances for the TSHD and a very long execution time of the project. This makes this option economically prohibitive.

*Option 1: Dredging with a CSD in the reef near the island*

A CSD is a stationary dredger, which dislodges the material with a rotating cutter head mounted on a ladder (see also Figure 4-3). The cutter head is equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of a centrifugal pump, which is installed on the dredge pontoon or on the ladder of the dredger. The amount of material not entering the suction mouth may be as much as 30% of the total dislodged material. Much of this material will fall immediately to the seabed and will be dredged on the next cut. Only the finer particles will stay in suspension and will be distributed throughout the water column by the local currents. With a CSD, the creation of turbidity is a more or less a continuous process. Due to the fact that a rather deep basin will be created by the CSD of about 6 – 7 meters depth, the majority of the suspended sediments will stay within this created basin. As the cut material will be disposed by a discharge pipeline to the land reclamation site no additional turbidity will be created at the dredging site. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local hydrodynamic conditions.

*Figure 4-3 - Sketch of cutter suction dredge*

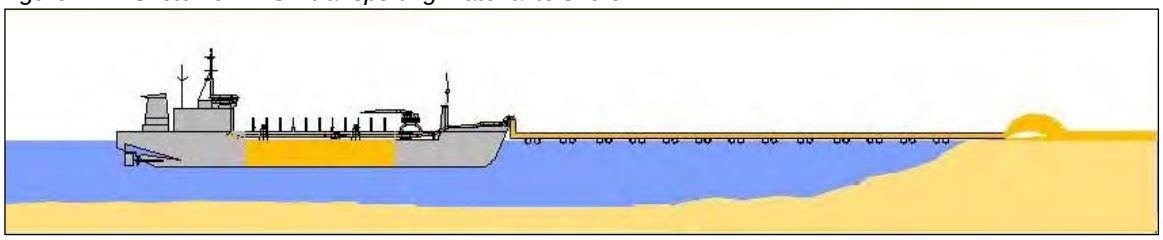


*Option 2: Dredging with a TSHD in the lagoon area*

A TSHD is a normal sea-going ship equipped with one or two suction pipes. At the end of each suction pipe is a drag head, which can be lowered onto the seabed while the TSHD navigates at

a reduced speed. The material loosened by the drag head, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump, and subsequently placed in the hopper of the dredger. The TSHD will transport the sediments to the shore connection, where the TSHD will be connected to a pipeline system (see Figure 4-4).
Most of the turbidity generated by a trailer suction hopper dredge is caused by the overflow of turbid water during the hopper filling operations. Overflow is the flowing overboard of excessive process water, together with a part of the finer material. Overflow is used to maximise the load of sand inside the hopper. When dredging pure sandy sediments the amount of overflow of particles is mainly determined by the grain size distribution of the dredged sediment. It is to be noted that the overflow process will not be a continuous activity, since its duration will be limited to operational dredging time, which is usually less than half the total cycle time.
The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas. As no dredging site has been identified within the lagoon no relevant impact can be assessed.

*Figure 4-4 - Sketch of THSD transporting material to shore*



*Preferred option*
With both types of dredgers a sediment-water mixture will be pumped to the reclamation site from where the excess of water will flow back (return flow) to the sea and most of the sediments stay behind. The potential issue of turbidity is basically the same for both dredging methods. The main difference between the methods is that impact of the re-suspension from the CSD at the borrow area can be better controlled than from the THSD at the lagoon. For this reason option 1 would be preferred above option 2.
Other issues may have to be included in the evaluation, such as

- sailing distance,
- affected surface in the borrow area etc.;
- keeping the reef intact

*Size of CSD*
Three alternatives can be considered, viz. a small, a medium and a large CSD. For the selection a number of aspects have been taken into account:

- dimensions in relation to mob/demob;
- dimensions in relation to the access to the borrow area;
- dimensions in relation to the size of the borrow area (including depth = thickness of layer of relatively loose sediments);
- capacity in relation to pumping distance (max length of pipeline is an important factor);
- capacity in relation to construction time;
- economical and environmental consequences;
- operational consequences.

The small size cutter dredge is advantageous in relation to the dimensions but not in relation to the capacity. The use of a medium size CSD seems to be positive, also in relation to the economical, environmental and operational aspects.

*Size of TSHD*
Three alternatives can be considered, viz. a small, a medium and a large TSHD. For the selection a number of aspects have been taken into account:

- dimensions in relation to mob/demob;
- dimensions in relation to the distance to the borrow area;
- dimensions in relation to the depth of the seabed at the borrow area (including thickness of layer of relatively loose sediments);

- capacity in relation to pumping distance (max length of pipeline is an important factor);
- capacity in relation to construction time;
- economical and environmental consequences;
- operational consequences.

A small sized TSHD will not be able to dredge sand from the seabed at the required depths (20-80m), and even a medium sized TSHD will not be able to do this. There is therefore a technical need to use a large size TSHD.

## 4.5 Revetment construction

The slope of the outer bund and the final level of the reclamation area will be profiled during the hydraulic fill of the reclamation area by using dry fill equipment. The profiling activity will start as soon as sufficient reclaimed material is available. The reclamation area will be protected with an environmental protection zone, EPZ. The construction of revetment will start right away after a section of the EPZ has been put in required profile. Figure 4-5 shows an example of how the EPZ may be designed. Detailed design for each of the Three Islands will be done at a later stage, before construction starts.

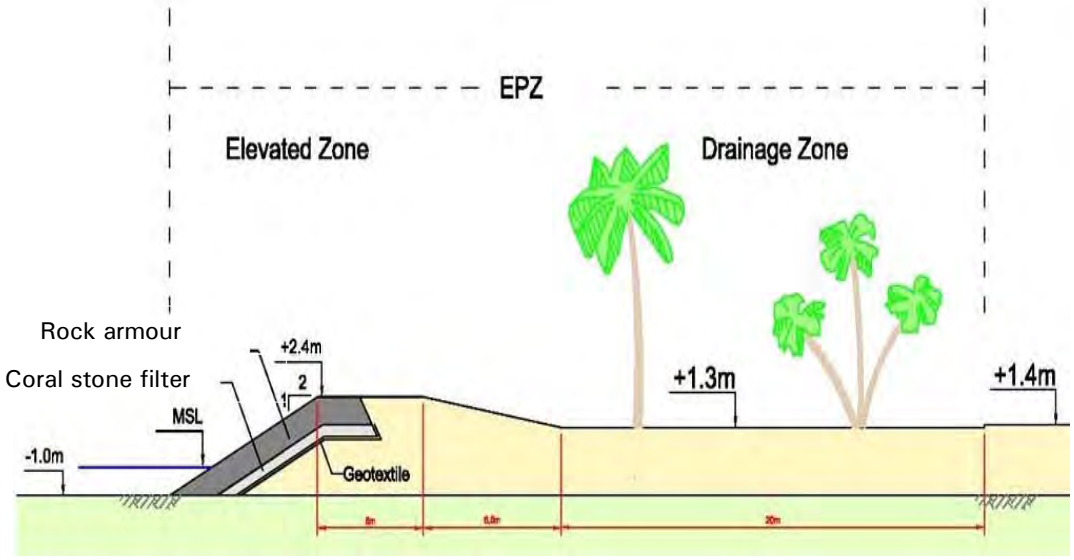



*Figure 4-5 - EPZ example design*

The revetment consists of geotextile, which is positioned on top of the profiled slope. The geotextile is subsequently covered with a filter layer of rubble coral rock which is dredged in the borrow area. Suitable material will be gathered and transported with dump trucks. The filter layer is subsequently covered with an armour layer of rubble granite rock material. The material will be positioned with a hydraulic excavator (see Figure 4-6).

For revetment materials, there are two alternatives: rock and sand cement bags. Rock and sand cement bags both have to be sourced from Sri Lanka or India.
Rock revetments have two major advantages over sand cement bag revetments:

- Rock is reusable when the revetments have to be made higher in 30 year's time. Sand cement bags would have to be removed and disposed of properly, and new sand cement bags would have to be obtained and placed.
- Rock provides a more natural substrate for marine life

Personnel and equipment required to place rock revetments are already available, as they are also needed to construct the reclamation.
Based on these aspects, rock is a more sustainable solution for this project, than sand cement bags.

*Figure 4-6 - Construction of revetment with armour layer of rock*

*Testing the materials*
Inspection and testing of materials will be carried out as an integral part of the contractor's quality control programme with the objective to ensure the quality of the works. All materials proposed by the contractor will be subject to the engineer's acceptance before transported to the site.

## 4.6 Applied Environmental Management System

Royal Boskalis Westminster nv has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.
Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OSHA and environmental requirements, and are adjusted if a client has even more stringent requirements.
All vessels are IMS certified and have to meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Appendix 3 contains the framework that is used to make a specific Environmental Management Plan for each individual project that Royal Boskalis Westminster undertakes. Similar frameworks are applied for project specific Safety and Health Management Plans.

## 4.7 Availability of utilities, resources, space for work shop etc

On shore activities will be organised in such a way as to minimise the interference to the day-to-day life of the inhabitants of the island.

*Stores and workshop*
Stores and workshop areas will be created as close to the reclamation area as possible, at the edge of the existing island in an area where no human activities take place.
Facilities needed will consist of:

- container based stores for spares and food;
- container based workshops for maintenance and repair of equipment.

*Mobilisation of office and housing*
Most of the required accommodation will be land based. Existing houses will be used, if available, for lodging of staff and reclamation workers, and for office space. Alternatively houseboats or barges with house- and office containers need to be considered.

## 4.8 Employment opportunities

Specialised equipment is usually operated by expatriate personnel. However, local employees will be employed as much as the work will allow. Employment opportunities are for instance available on the fleet, the workshops and/or on the reclamation site.

Indicative numbers are shown in Table 4-1 about employment opportunities of local employees during project construction phase.

*Table 4-1 - Employment opportunities*

| Group | Unit | Specialists | Spec no's | Labour |
|---|---|---|---|---|
| Dredge fleet | Dredge (CSD or TSHD) | master, eng | 4 | 6 |
| | transport barge | operator | 1 | 1 |
| | Multicat | operator | 2 | 2 |
| | general purpose launch | driver, surveyor | 2 | 1 |
| Dry-fill | Reclamation area | recl. supervisor | 1 | 4 |
| | Dumpers | drivers | 2 | |
| | excav. bulldozer, loader | operator | 4 | |
| Special equipment | excavator, sheet piling crane | operator | 2 | 4 |
| | concrete plant | operator | 2 | 4 |
| Workshops | for fleet and dry-fill | engineers | 2 | 4 |
| Logistics | fast launch | driver | 1 | 1 |
| | cargo vessel | master, eng | 2 | 2 |
| | kitchens CSD+landbase | cooks | 2 | 2 |
| | Housekeeping, laundry | | | 4 |
| | | **totals** | **27** | **35** |

It needs to be noted that the dredge will be working 24 hours per day and the crew working in 2 shifts, so at least there will be a double dredge crew. Furthermore, the reclamation supervisor is responsible for the reclamation works such as the timely construction of temporary bunds, the handling of the landline and spreading of the dredged material. The actual number of employment of local people will depend strongly on the available skills in relation to required skills for the construction works.

## 4.9 Enhancement work

No additional enhancement works are planned, although some roads may have to be improved to be able to carry the heavy equipment necessary for the reclamation and construction activities.
Any such improvements necessary to execute the dredging, reclamation and revetment construction works will be left after project execution is completed.

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# 5 Specific project description per island

## 5.1 General

The present plan for reconstruction of the island Dhidhdhoo is in line with the Safe Island Program. The designs include:

- a (higher) land level of 1.4 meters above mean sea level for the newly created areas
- a protecting bund wall on the exposed sides of the island of 2 meters above mean sea level.
- an EPZ (Environmental Protection Zone), directly behind the bund wall on the island side.

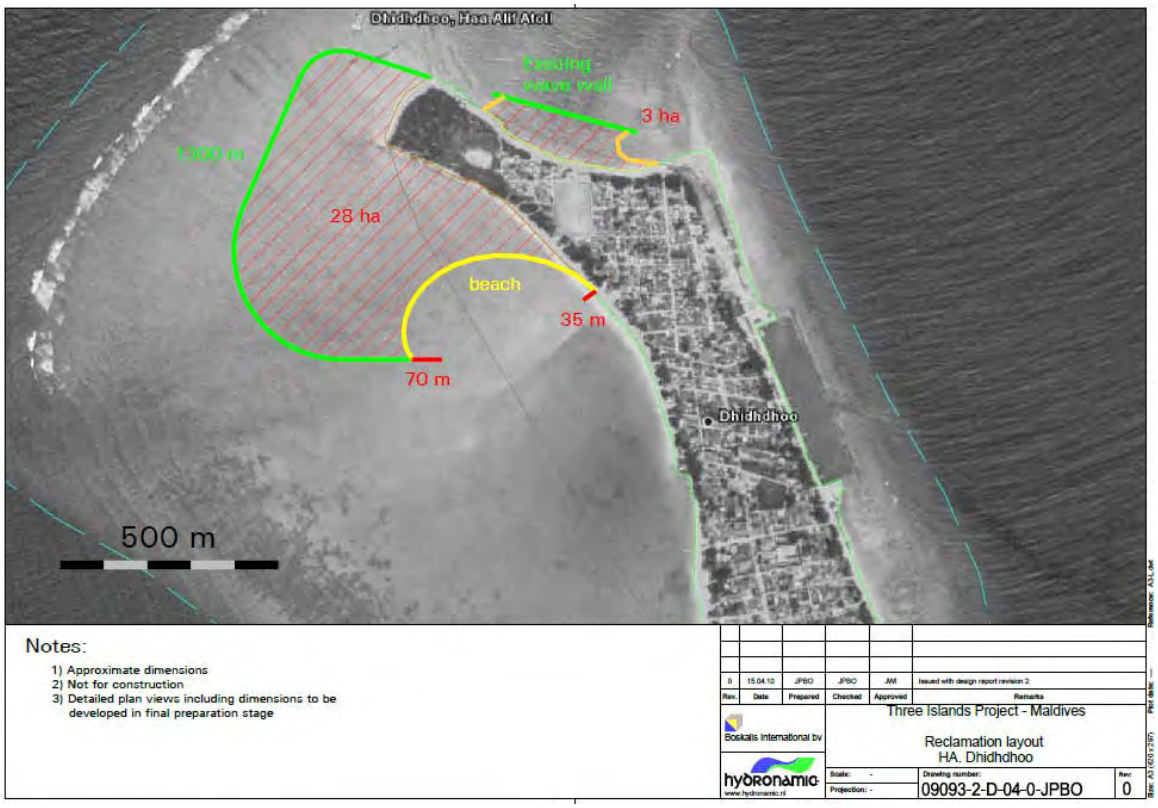


*Figure 5-1 - Preliminary design of reclamation areas, revetments, beach and groynes at Dhidhdhoo*

Dhidhdhoo island would be enlarged from 59 hectares at present to about 87 hectares after the reclamation area has been constructed.

The main land-use categories at Dhidhdhoo are the following;

- Existing island-housing-social infrastructure (76% of 59ha) 45 ha
- Existing island-green zone (24% of 59ha) 14 ha
- Reclamation-housing-social infrastructure-industrial (75%) 21 ha
- Environmental Protection Zone (EPZ), green zone (25%) 7 ha

Total 87 ha

Figure 5-1 (above) shows the project layout including of the reclamation area, bund walls, revetments, beach and groynes.

Currently, Dhidhdhoo has approximately 2500 inhabitants, with a total of 3790 persons registered as inhabitants of the island. The expected population increase will be around 1800 people, and the future total registered inhabitant number will be 5600.

The Government of the Maldives has a passive population consolidation policy, which encourages mobility of the population by connecting all the islands with a proper transport network, rather than seeking to actively relocate people.
The islands chosen for reclamation will be developed to serve as major commercial centres with relatively high population numbers and connections to other islands through a proper transport network. Land use will be regulated through planning, and allocation for commercial activities will create job opportunities and economic activities, which in turn will encourage passive population migration towards these islands.
Currently, the islands are densely populated, which has created a dire need for housing within the existing population.

At the time of completing this EIA, the preliminary land use plan for Dhidhdhoo is being developed by the Ministry of Housing, Transport and Environment. . The preliminary layout of the reclamation has been designed by the Ministry of Housing, Transport and Environment. This design is based on the available knowledge of currents, erosion and sedimentation, and projected population growth and socio-economic development in the atoll.
The design was further verified and optimised by engineers of Hydronamic B.V.. The design was to be optimised to use as little sand and as little rock revetment as possible without compromising safety and durability.
A design report has been written, in which all the decisions made leading to the final design are explained and supported. The final design was approved by the MHTE.

## 5.2 Planning

The reclamation project at Dhidhdhoo would include the following construction activities (see also Figure 5-1).

- Dredging and reclamation of about 1 million $m^3$ of coral sand;
- Construction of approximately 1300 meter EPZ, including revetment;
- Construction of a beach;
- Construction of approximately 100m of groynes to protect the beach
- Mitigating measures for the environment.

Duration of the construction is estimated to be between 6 and 8 months. Dredging and reclamation works will take 4 to 8 weeks.

Housing and social infrastructure development in the Three Islands is part of a large project to provide 7000 new social housing units in the whole of the Maldives. The Government of the Maldives is currently seeking developer financing for several work packages, including those for the islands included in the Three Islands Project. The GoM have already sent out RFP documents seeking a private sector partner (a single provider or a group of partnering providers) to finance, construct and deliver the housing units and related social infrastructure in these islands. The planned housing project is aimed at providing affordable housing throughout the country. These social housing projects are 100% cost recoverable projects and from past experience of the GoM State-Owned Enterprises, such as HDC, it has been found that the recovery performance has been positive.

## 5.3 Island specific environmental constraints

The actual plans foresee that the borrow area will be located to the south east of the existing island, in the atoll lagoon (see Figure 5-2). This is an area where current speeds are generally low, which is favourable for minimising the dispersion of suspended sediments caused by dredging with a TSHD.
Dredging in the proposed borrow area will be at a minimum distance of 1000m to the nearest coral reefs.


*Figure 5-2 - Preliminary borrow area locations at Dhidhdhoo*

## 5.4 Detailed design

### 5.4.1 Dredging and reclamation

The amount of sand required for the reclamation is estimated at about 1 million $m^3$ for Dhidhdhoo.
For Dhidhdhoo, this material will be dredged from the seabed within the atoll.
The borrow area will be some 85-100 hectares in size.
The equipment required for the dredging and reclamation works comprise:

- A medium to large size trailing suction hopper dredge;
- A pipeline system;
- Various bulldozers and wheelloaders.

The total time required for the reclamation works is estimated at 1 to 2 months.

*Possible sources of fill material*
The possible sources of fill material and dredging equipment are the following:

- Option 1: Sand from the shallow reef flat area around the island by a CSD (cutter suction dredger) with a pipeline system.
- Option 2: Sand from the bed of the atoll lagoon by a TSHD (trailing suction hopper dredger) with a pipeline system
- Option 3: Sand and coral material from a coral reef (faro) elsewhere within the lagoon.
- Option 4: Sand imported from overseas by a Jumbo trailer.

For Dhidhdhoo, option 2 is preferred, based on the following criteria:

- Technical feasibility: there is enough sand available at the borrow area, and there is enough space available to create a borrow area that is large enough.
- Environmental aspects: minimizing the amount of coral that will be affected and the size of the spheres of influence at the borrow area and the reclamation area.
- Economical feasibility: environmental benefits of a more expensive option should outweigh the extra cost

### 5.4.2 Revetments

Total length of the shore protection (part of the EPZ) at Dhidhdhoo will be approximately 1300m. The protection will be executed as a 1:2 slope protected by rock placed on geotextile. The rock protection will be lighter on the less exposed sides. The rock will be imported from India.

### 5.4.3 Dewatering

The standard method for reclaiming land is to pump dredged material to the location of the reclamation area. Mitigation measures are taken to ensure a controlled release of the excess water from the pumping process into the surrounding area and to prevent the reclaimed land becoming fully exposed to waves and currents.

For the Three Islands Project, these measures consist of bunds constructed around the reclamation areas, protecting the reclaimed area against waves and currents and controlling the outflow of the excess pumping water. To allow for sufficient settling of suspended sediments, special purpose settling basins will be constructed in the reclamation areas with outlets at predetermined locations.

The final layout of these settling basins will be based on the positive experience obtained at Vilufushi and Viligili. The final design of the settling basins at Dhidhdhoo had not been made at the time this EIA was finalized.
Items still being addressed are the locations where the dredging equipment can connect to the shore pipeline, layout of the settling basins and the location of the dewatering points. Final choices regarding the layout will be made before start of the reclamation works.

# 6 Description of Natural Environment

## 6.1 General

The island Dhidhdhoo is located in the north-western part of the Haa Halifu Atoll (see Figure 6-1) around 6° 53' 14" N and 73° 06' 51" E. The island has an elongated shape with a length of almost 2 kilometers and a width varying between 200 and 400 m. The total surface area of the island exceeds 58 hectares.

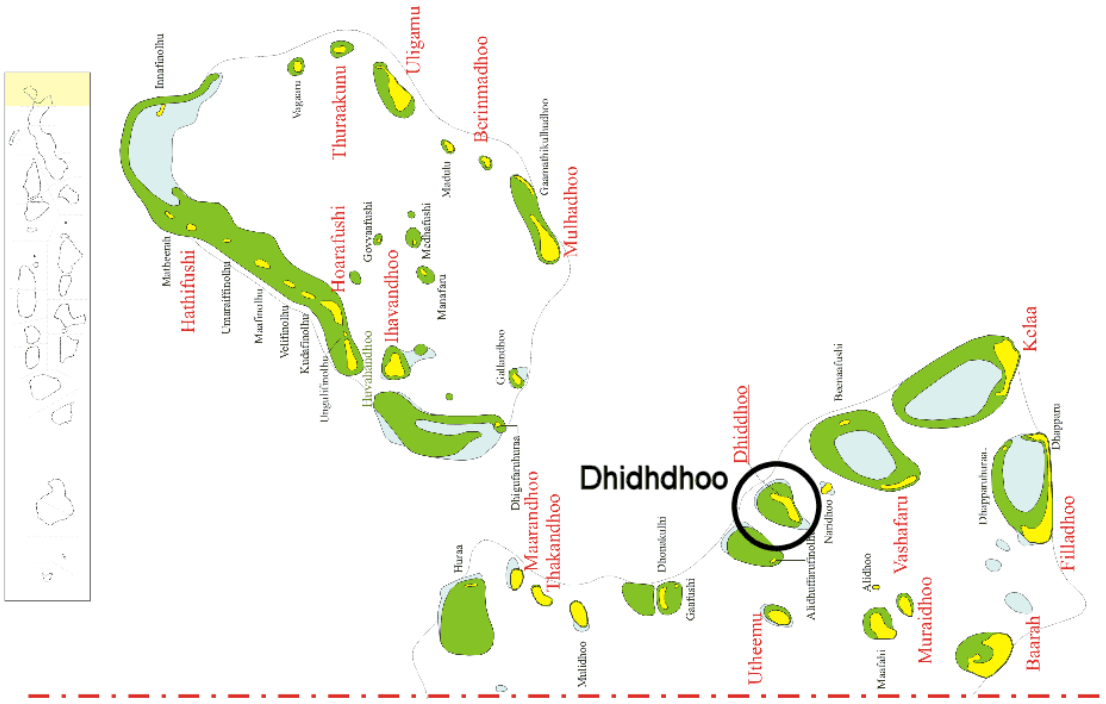


*Figure 6-1 – Location of the island Dhidhdhoo in the Haa Alifu Atoll*

The island lies on an oval shaped shallow reef flat with a width of 100-200m on the east side, 400 m on the north side and up to 1000m on the western side. The typical reef flat depth around Dhidhdhoo is on average -2m MSL on the western side with a large depression in the middle where water depth reaches -6 m MSL, -1.5m to -2 m MSL on the Northern side and -0.5 m MSL on the lagoon side around the reef crest and -3.5 m within the harbour. The existing island surface is 1.8 meter above mean sea-level.

On the island Dhidhdhoo there are no fresh water bodies, wetlands or extensive terrestrial natural spaces. The harbour of the island is located on the eastern side of the island.

## 6.2 Methodology

In December 2009 ecological surveys have been conducted on Dhidhdhoo. The objective of the site visit was to collect data and information about the local ecosystems. A dive and snorkel survey at various depths have been carried out to determine the distribution of habitats in the marine waters around Dhidhdhoo and a terrestrial survey was conducted to determine the flora and fauna on the island. Furthermore a literature study was performed. The collected information has been described in this chapter and has been used to determine the sensitivity and vulnerability of the land and marine flora and fauna with respect to the proposed dredging and reclamation works at the island Dhidhdhoo.

The consultancy team for the dive surveys was composed of 2 divers and one snorkeler from Multi Marine Services Pvt. Ltd. in charge of the underwater photography and dive safety, and 1 marine biologist from Seamarc Pvt. Ltd. to organize the survey layout together with the

Hydronamic environmental engineer. The terrestrial survey was conducted by the environmental engineer from Hydronamic B.V..

For the analysis of the results of the dive and the snorkel survey the software programme CPCe was used to determine the percentages live coral and live seagrass cover. The used work method will be described in paragraph 6.5.

## 6.3 Physical environment

### 6.3.1 Geology

Figure 6-2 shows the typical geological structure of an atoll in the Maldives. The island itself owes its origin to the deposition of shingle or coral debris during storms. The island is made up of coralline sand, partly covered with a thin layer of soil consisting of a mixture of sand and organic matter.

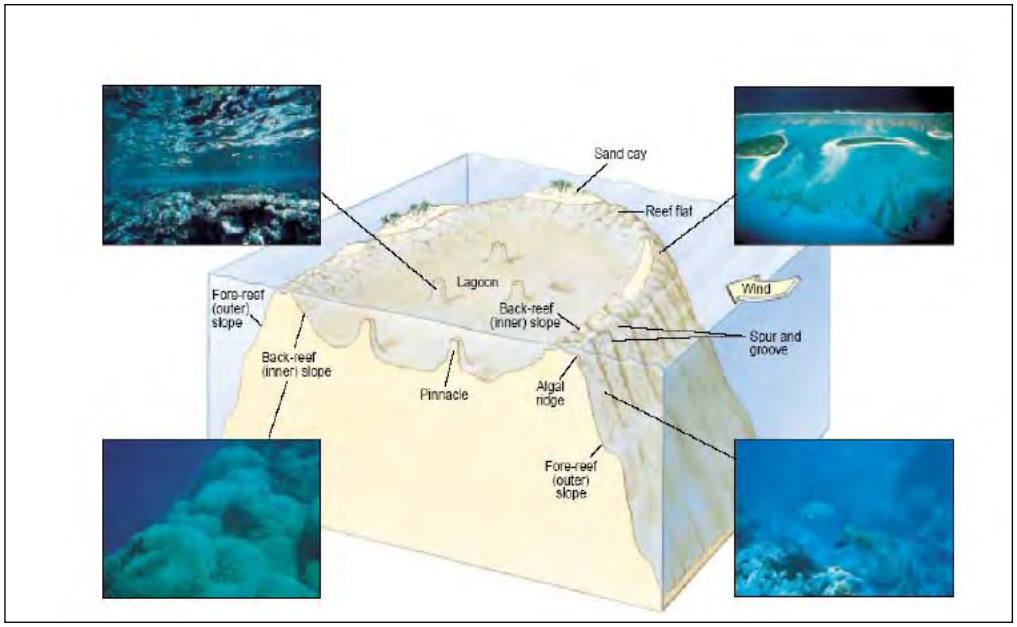


*Figure 6-2 - Typical structure of an atoll*

On top of the coral reef formation, most of the islands have shallow, humus topsoil layers only where there is vegetation. Residential areas are almost free of topsoil layers. In agriculture zones, thin topsoil layers are concentrated only around plants, i.e., in the fertilizing zone.

The soils have a very high permeability for water. Much of the rain comes down in short, intense showers, but no signs of erosion are observed, confirming the high infiltration capacity. The hydraulic conductivity (K-value) of medium sized sand should be at least several meters per day. Also the underlying coral bedrock has a high permeability (K-values of at least 5-10m/day). Groundwater aquifers in the Maldives islands normally lie between 1 and 1.5 meters below the soil surface. The proximity of the aquifers to the island surfaces makes them vulnerable to pollution and contamination from human activities as well as saltwater intrusion. In addition, population and development pressures have led to increased groundwater extraction, resulting in depletion of the country's freshwater lenses.

### 6.3.2 Sand search results

During a desk study, locations were pre-selected for sand borrow areas for the Three Islands project in the Maldives. These pre-selected areas were investigated by seismic surveys and vibrocore analyses. An initial seismic survey was done in August 2009. In January 2010, vibrocore samples were taken and analysed to ensure a proper quality of sand was present in the surveyed locations.

Based on the information gathered during these surveys, sand borrow areas were selected at Baa Atoll, Lhaviyani Atoll, Noonu Atoll and Haa Alif Atoll.

To the south and southeast of Dhidhdhoo, an extensive area was found containing sandy material that is relatively coarse and contains a low percentage of fines. The fines are made up of calcareous material only and therefore uncontaminated. Chemical pollutants such as heavy metals, PCBs, PAHs and nutrients do not adhere to calcareous material.

Dhidhdhoo is located far away from large ports and other significant sources of pollution, such as rivers. The closest port, which is located about 300km south of Dhidhdhoo at Male, does not have a shipyard or a slip way, which are generally the largest sources of pollution within a port complex. The main activity of the port of Male is the transfer of mostly containerized cargo, which has some effects on air quality, but hardly any effect on the marine environment.
The closest rivers can be found in Sri Lanka and India, and are too far away to have any impact on the seabed in the Maldives.

The sediments found near Dhidhdhoo were tested according to OSPAR Guidelines for the Management of Dredged Material. The sediment that will be dredged for the Three Islands Project is:

- composed of previously undisturbed geological material
- composed mainly of sand or coarser material (96% on average at the Dhidhdhoo borrow area, see also Figure 6-3)
- located in areas where there are no appreciable pollution sources (river run off, industry, intensive port activities) nearby

With these criteria, the OSPAR guidelines state that no further chemical and biological testing is needed.

The sand found near Dhidhdhoo can be characterised as follows:

| | |
|---|---|
| Water depth | 25 – 50m |
| Type of environment | Several areas containing suitable sandy seabed are located within the atoll lagoon. Coral reef formations such as farus, thilas and giris are located outside the perimeter of these areas. |
| Typical D50 | 440 |
| Typical D10 | 180 |
| Typical D90 | 611 |
| Percentage fines | 4 |
| Percentage coarse material | 12 |
| Percentage sand | 84 |

*Table 6-1 - Characteristics of sand found near Dhidhdhoo*

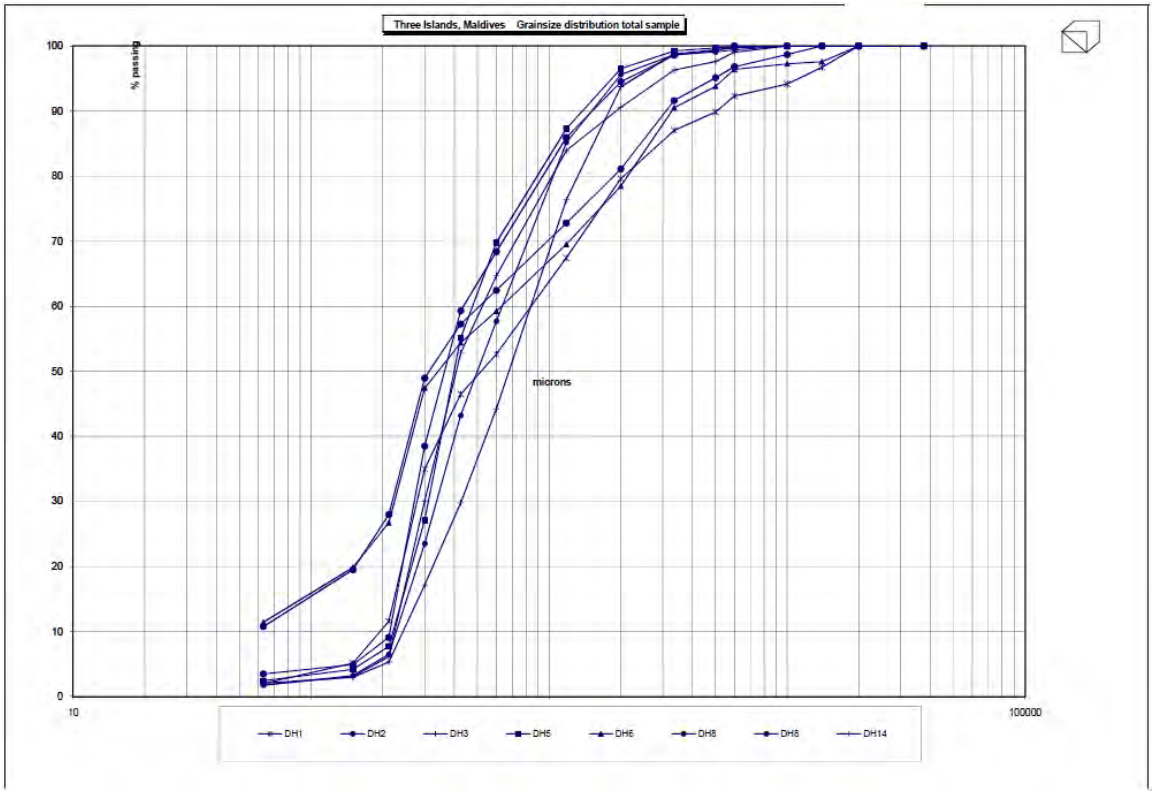


*Figure 6-3 - Grain size distribution envelope of sands found near Dhidhdhoo*

### 6.3.3 Climate

The Maldives lie in the monsoon area of the northern Indian Ocean and consequently the Maldives have a rather complex climate. There are two seasons in the Maldives, being a dry northeast monsoon (iruvai) and a wet southwest monsoon (hulhagu). The wind comes from the south west from May up to November and brings an average rainfall of 200 mm, and 200 sun-hours per month. In the middle of December the wind turns to the northeast and the climate becomes a lot dryer, the quantity of rain decreases to 75 mm per month and the number of sun hours is 250 per month.

During the entire year the days are hot and humid, with temperatures of 25 up to 30 °C and a humidity of 60 to 80%. If it is raining in the Maldives it rains very hard, but generally the showers do not last long. In April/May and in October/November frequently hurricanes pass through the Gulf of Bengal. These storms rarely hit the Maldives and the impacts are generally of short duration. The area around the equator is known as the Doldrums, an area with often little to no wind. During the ecological survey on Dhidhdhoo in November and December it did not rain.

### 6.3.4 Tides

The tidal cycle at Dhidhdhoo is a semi diurnal cycle with a small and large peak. Dhidhdhoo island is surrounded on all sides by flat reefs with coral formations on the outer edges of the reef. At Dhidhdhoo, two deep channels run from the open ocean into the atoll lagoon, one on the northeast side of the island and one on the southwestern side of the reef. During the survey works carried out in Dhidhdhoo in December, the tide readings ranged from -0.35 m to +0.32 m MSL (neap tide period).

Currents which affect the areas around the islands and on the shallow reef flats can be caused by tidal currents, wind-induced currents, wave induced currents and oceanic currents. The tidal currents can be quite strong in the deep channels between the shallow reef flats, despite the limited tidal range. The wind (especially during the monsoons) can be a major factor affecting current velocities on the shallow reefs. Over the reef flats, wave over wash is also a major factor

in generating currents. The oceanic currents are influenced by the monsoon climate. In the Maldives, the oceanic currents flow eastwards during the southwest monsoon period (May – Nov) and westward during the northeast monsoon period (Dec – Mar).

Referring to the ATT for the Maldives, Dhidhdhoo is located 20km E-SE of Ihavandhoo, where water levels in 2009 were as follows:

- Highest High Water MHHW 1.27 m
- Mean Sea Level MSL 0.68 m
- Lowest Low Water MLLW 0.00 m

Predicted heights are in meters above Chart Datum and tides are (semi) diurnal. The tide of Dhidhdhoo shows a pattern similar to that of Ihavandhoo. The tide type is mixed diurnal and semi-diurnal with the semi-diurnal components dominating. According to the ATT, the water level varied between -0.68m and +0.59 m MSL in 2009. During the survey works carried out in Dhidhdhoo on Dec 12-16, 2009, the tide readings ranged from -0.52 m to +0.50 m MSL (close to spring tide).

The present estimates for the sea level rise at the Maldives due to the climatic changes are in order of about 0.5 cm per year. This is based on the fact that the sea level has risen 20cm over the past century.

### 6.3.5 Wind, water, waves

The swell and wind waves in the Maldives are conditioned by the two monsoon seasons, being the north east monsoon from December to March, and the south west monsoon from May to November. The combination of wind and strong currents in the channels around Dhidhdhoo can cause waves to build up.

It is estimated that the maximum wave height outside the flat reefs can reach more than 3m (ocean side, northwest side of Dhidhdhoo), whereas on the flat reef areas the wave height can reach from 0.6 to 1.2 meters (maximum). During the survey period in December 2009, wave activity was minimal and well below 0.5m.

### 6.3.6 Wave and current information used to verify the design

The dimensions of shore protection and revetments are based on conservative estimates of current and wave patterns using information and experience from earlier land reclamations on Vilufushi and Viligili.
The design wave conditions for the revetments have been verified by Hydronamic, based on the following starting points:

- Design water level +0.60 m MSL
- Local detailed bathymetry around the islands based on in-survey conducted by BKI
- Offshore wave and wind conditions from in-house database (WorldWaves)
- Offshore to nearshore transformation calculated using the numerical SWAN model

Data on wind, wind wave and swell conditions over 10 years were used.
The revetments were designed to withstand severe conditions that occur once in 100 years. These include significant wave heights of 0.7 – 1.3 m, wave periods varying from 5 to 15 seconds, and water depths of 1.1 – 3.6 m.

The soft shore protection (beach areas) were designed to withstand average annual conditions, including a significant wave height of 0.25 – 0.7 m and water depths of 0.5 – 3 m

## 6.4 Terrestrial environment

### 6.4.1 Flora

The soil on the island Dhidhdhoo has no organic layer since leaf material is removed daily. The vegetation on Dhidhdhoo is therefore limited to a small number of species which can grow under low nutrient and saline conditions. Tree species consist mainly of coconut palm trees, sea lettuce

and Tangjong trees. In the residential area there are breadfruit trees, a few banana trees, fig trees, cashew trees and pumpkin plants (see Figure 6-4, Figure 6-5 and Figure 6-6).

*Figure 6-4 - Coconut palm tree (Cocos Nucifera) and fig tree*

*Figure 6-5 - Morning Glory (family Convolvulaceae)*

*Figure 6-6 – Cashew fruit and pumpkin plant*

### 6.4.2 Fauna

A small number of animal species live on the island, such as lizards, fruit bats, crows, geckos, insects and several species of crabs. No rats were observed during the survey. Local inhabitants however have confirmed that rats are present on the island but in small numbers. Domestic cats are kept as pets. The insect species on the island consist of flies, dragonflies, butterflies, ants, mosquitoes, bees, wasps and beetles.


*Figure 6-7 – Domestic cat and crab*

Over 190 different bird species have been recorded in the Maldives including seabirds, shorebirds and terrestrial birds. Most of the birds are seasonal visitors, migrants or vagrants. Most of them are seabirds due to the small islands ecosystem. The bird species spotted on Dhidhdhoo are: crows, terns, grey heron (see Figure 6-8) and several wading shore birds like plovers, snipes and sandpipers.

*Figure 6-8 - Heron*

The occurrence of only common bird species on the inhabited islands of the Maldives can be explained by the very high population densities on the islands. The rarer bird species often prefer habitats with as few humans as possible, and they can be found on the uninhabited islands.

### 6.4.3 Green zones

A strip of vegetation is present almost around the whole island. This strip is not much wider than 30-40 meters except on the northern part of the island, where it is wider, and consists mainly of palm trees and tangjong trees. The strip is being used as recreational area and dump location for garbage. On Dhidhdhoo there are numerous places with fallow land. At these plots grass species and shrubs have developed creating a habitat for butterflies, dragonflies and other insects.

### 6.4.4 Waste & waste management

The roads on the island are cleaned every day and waste is brought to the designated location on the southeastern side of the island where it is collected and partially burned. However a lot of waste can be found on the beaches, in the strip of trees around the island and on the shallow reef flat areas. Figure 6-9 shows the beach on the eastern side where waste is collected against the eroded coastline.

*Figure 6-9 – Garbage on the shoreline*

### 6.4.5 Sewage system

Sewerage is collected in an underground collection point located under the main street on the island. From there two pump stations pump the sewerage into the sea on the northeastern and on the southeastern side of the island into the channel. There is no treatment of the sewerage before it is disposed at sea. The discharge of the sewerage therefore creates a substantial input of nutrients in the seawater around the island but due to the location and water depth of the discharge pipes the sewerage has no substantial effect on the growth of seagrasses on the reef flats. No substantial seagrass beds were found on the reef flats only very small patches.

## 6.5 Marine environment

The Maldives are well known for its rich marine biodiversity found along the reefs. More than 250 species of coral, 1,200 reef fish species, 5,000 species of shells, 100 – 200 species of sponges, over 1,000 species of marine crustaceans and more than 100 species of echinoderms have been recorded at the waters surrounding the islands.

The coral reefs are the most important ecosystems in the Maldives. Up until 1998 the extensive coral reefs throughout the Maldives were found to be in good condition. In 1998 an extensive bleaching event occurred due to the increase in sea surface temperatures and destroyed large areas of shallow-water coral reefs. As a result, in several areas about nearly 90% of the corals died. Although new recruitment has been noticed at numerous sites, the cover of live coral is not nearly as extensive as before the bleaching event.

The dominant species on the reefs are corals and fishes. The top ten families of fishes in the Maldives are: gobies, wrasses, groupers, damsel fishes, snappers, cardinal fishes, moray eels, blennies, butterfly fishes and surgeon fishes. 37 species of sharks can be spotted in the Maldives. The only protected shark specie, by law, is the whale shark. Some species can be found close to the edge of the reef, but most can only be found in deep waters. Stingrays are bottom feeders, they dig out clams and other animals which are covered in the seabed and can be spotted on the shallow reef flats close to shore. During the dive surveys around Dhidhdhoo, manta rays, barracuda and schools of red snapper were seen.

The most popular fishes for divers are sharks (especially the whale shark) and rays. The whale shark is the largest fish in the world; the manta ray is very popular and can have a width of about 3m; both fishes are plankton feeders.

Five species of sea turtles can be spotted in the waters of the Maldives, being: the Hawksbill turtle, the Loggerhead turtle, the Green turtle, the Olive Ridley turtle and the Leatherback turtle. The Green turtle (Chelonia mydas) and the Hawksbill (Eretmochelys imbricata) are the most common two species that breed in the Maldives. During the ecological survey green turtles were observed on the lagoon side of the island at the slope of the reef flat.

Seven species of dolphins can be seen in the Maldives. The most common specie is the spinner dolphin - *Stenella longirostris*. Large groups of dolphins can be found at the ocean side as well as at the atoll side of the island. These dolphins roam from area to area.

Several components of the marine environment of the atoll islands can be distinguished. A cross section of a typical atoll reef in the Maldives is given in *Figure 6-10*

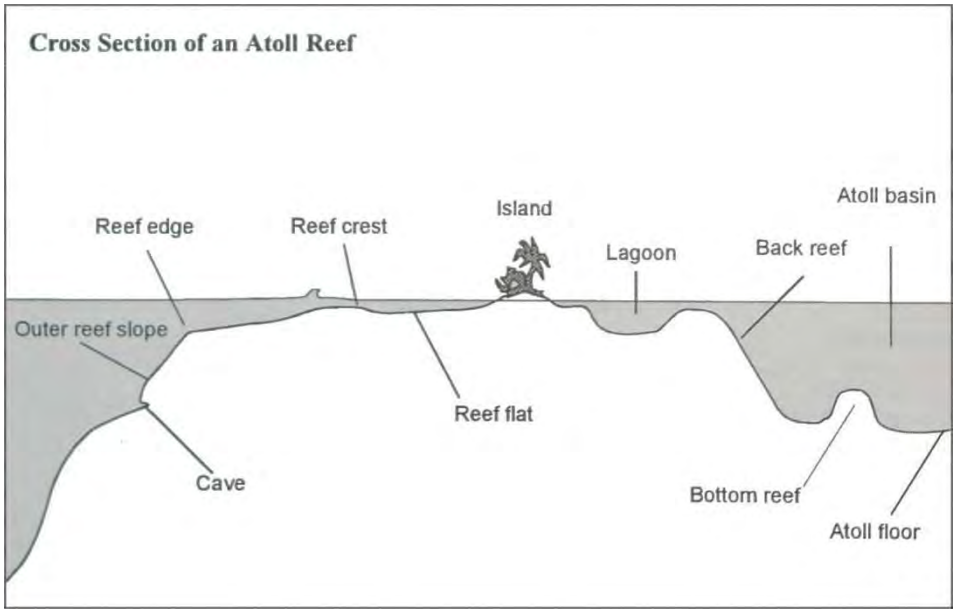


*Figure 6-10: Cross section of an atoll reef*

The edges of the reef flat end in a reef crest which falls completely dry (+1.0 above MSL). The reef then goes down on the Ocean side with a steep to very steep slope. On the lagoon side the reef flat also goes down with a steep slope but to a less great depth.


*Figure 6-11 - Location of Dhidhdhoo and nearby sensitive receivers. Coral reef in blue, dive sites in bright green, possible CSD borrow area in orange, reclamation in yellow.*

### 6.5.1 Beach areas

Dhidhdhoo has beaches with different widths. On the west side of the island beaches may be up to 20 meters wide and further north even 50 m wide. On the point of the island furthest north there is an old reef that falls dry on a low tide. Here the beach is less wide. On the eastern side the beach is varying between 5 and 15 m wide. On the eastern and southern side there are signs of erosion.

The island Dhidhdhoo has no importance as a turtle nesting area. Marine sea turtles are however present in the waters around Dhidhdhoo but there are no protected turtle nesting sites in the Haa Alifu atoll. Appendix 5 shows an overview of the protected turtle nesting sites in the Maldives. Appendix 5 shows an overview of the protected turtle nesting sites in the Maldives.

### 6.5.2 Reef flat and lagoon areas

Dhidhdhoo Island is surrounded on all sides by flat reefs with coral formations on the outer edges of the reef. At Dhidhdhoo, two deep channels run from the open ocean into the atoll lagoon, one on the north side of the island and one on the southern side of the island. The shallow reef flats on the west side are wider (up to 1000 m) compared to the east side (up to 200 m). The typical reef flat depth around Dhidhdhoo depends on the tidal influence and varies on average from -0.5 m MSL on the East side to -2.0 to -6.0 m MSL on the West side.

No seagrass beds were observed on the reef flats. This is remarkable since many inhabited islands in the Maldives are surrounded by seagrass beds. Worldwide seagrasses are considered as one of the world's most productive coastal systems. Seagrass patches are often found in the shallow lagoons just behind coral reefs where fish molluscs and crustaceans inhabit the beds. The seagrass beds around Dhidhdhoo are not very extensive and only a small number of patches were recorded. Only one type of seagrass, *Thalassia hemprichii*, was found.


*Figure 6-12 - Seagrass species around Dhidhdhoo*

The reef flats around Dhidhdhoo mainly consist of bare sand and very sparse coral (<5% live coral cover). The corals on the western reef flat were dominated by table and finger corals.

The reef flat contains a steep to very steep slope on the Ocean side. Towards the east the reef flat goes down in to the lagoon to approximately -20 m MSL with a steep slope.

### 6.5.3 Coral reef survey

Transects were investigated at 7 sites, more or less evenly spaced around the island reef. Sites 1 and 2 are located closest to the possible CSD borrow area, sites 1, 6 and 7 are located around the proposed reclamation area.


*Figure 6-13 - Map indicating the survey sites around Dhidhdhoo*

Given the secondary abundance of live corals, the site discussion will present the main categories with a focus on the structure of the abiotic substrate, which components, pavement, rubble sand and silt are shown separately. This enables a discussion on sediment regimes and an assessment of recovery process at each site.

### 6.5.4 Reef in the channels and on the atoll side

Sites 1 and 2 on the west side show a higher abundance of live coral (average about 20%) than sites 3-5 (5-10%) on the south and east sides. Sites 4 and 5 may suffer from the sewage outfall and site 3 is somehow subject to more intense wave action..

Site 1 (see Figure 6-14), exhibits a flat reef top, mostly rocky and with little live coral colonies (6 % live coral cover) followed by a steep slope and a vertical wall with small caves. The surface with a lot of barren rock and protrusions should be conducive to coral recruitment.

*Figure 6-14 - Important roughness and barren substrate at the reef top at site 1, Dhidhdhoo*

At the break to the steep slope, the coral cover increases to reach 20 %. These are mostly massive and encrusting (16 %), but a few Acroporidae have grown in the area. The bare substrate with little sand or rubble should allow for a good recruitment, and the area appears recruitment limited.
The fish life was not particularly abundant at the time of the survey, but the rocks are heavily grazed and herbivorous fish must frequent this area.

Site 2 is located further to the east and more representative of a lee side reef than site 1, with in particular more rubble and more live coral cover. In these areas, rubble (38 %) is present among protruding coral heads, which offer quite good recruitment opportunities.

*Figure 6-15 - Rubble among protruding dead coral heads with live corals at site 2*

Further down along the reef wall, the live coral cover is quite good compared to the rest of the reef (27%). A number of *Acropora* have grown, the tabular forms especially have a few large colonies. Soft corals have also colonized well in some areas (see Figure 6-16).

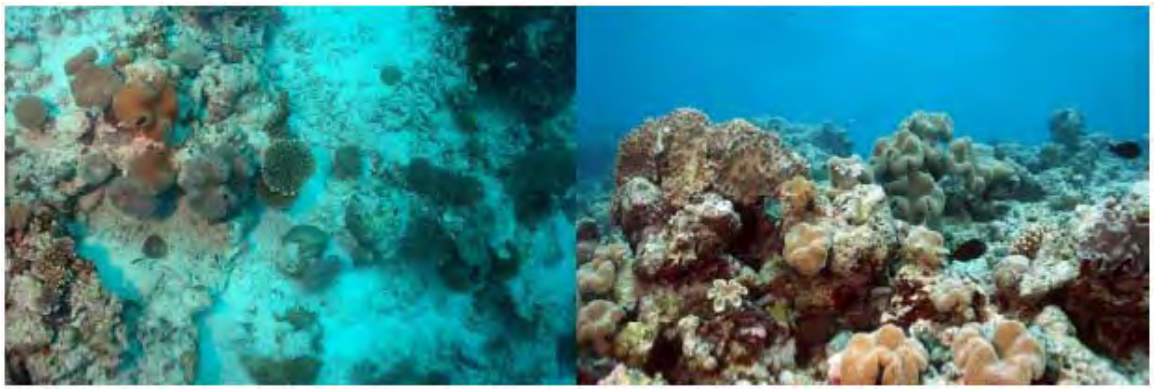

*Figure 6-16 - Soft coral growing on dead coral along the wall and at the top of the reef*

Site 3 is located on the south-eastern tip of the reef system. Even though this is the inside of the atoll, the wave action in this area is still important and the area is submitted to consequent currents. The live coral cover is not great at 10 % both on the reef top and on the slope. The substrate is rockier on the reef top, and the broken pieces of rubble are transported down the slope by wave action. The slope is consequently not steep.
Along the slope, a number of table corals have grown nicely (see Figure 6-17).

As expected in these conditions, the current patterns and the dead coral outcrops on the reef top attracts a vast fish fauna, mostly constituted of planktivorous species (see Figure 6-17), and herbivores, feeding an array of predators, such as blue fin trevallies, *Carangoides melampygus* (Fig. 16).

*Figure 6-17 - Table corals at the top of site 3. Also visible a school of fusiliers.*

*Figure 6-18 - School of blue fin jacks at site 3*

At site 4, further north of the eastern coastline, the reef still looks devastated and has not recovered from the 1998 bleaching event (see Figure 6-19). The coral cover is low and the pavement tends to be covered in turf and coralline algae (44 %). A feature of this area is the presence of the blue coral, Heliopora coreulea, counted here in the soft coral category (8 %).

*Figure 6-19 - The reef top at site 4 still looks devastated*

Down the slope, the finer particles accumulate with sand at 17 % and rubble at 26 %.
The fish life is relatively abundant, but with a grazing oriented food chain.

Site 5 is located towards the northern corner of the island, in an area where the reef deepens and allows for some wave intrusion into the lagoon, resulting in an embayment in the island. A former cave possibly collapsed at the site, as some irregular reef features tend to show (Fig 21).

*Figure 6-20 - Features in the reef structure indicative of a possible collapse of a cave in the reef structure*

The coral cover is low (6 % at the top and 7 % further down) and the substrate on the reef top extremely rubbly (48 %).
The lesser proportion of rubble at depth and the absence of a marked deposit slope show that the rubble seems to be moving back and forth on the reef top and the particles are channelled through a narrow band, where sand escapes the reef flat area (see Figure 6-21).
At depth, this sand seems to be transported towards the outside of the atoll.

*Figure 6-21 - A large dead coral head in a layer of sand seems to have escaped from the reef flat.*

### 6.5.5 Reef ocean side

Sites 6 and 7 are located on the north side of the reef, which is the ocean side of the atoll. Despite the higher wave energy that the reef is exposed to in this area, the coral reef is healthier on this side of the island.

Site 6 is located on the outer side of the atoll and consequently, the reef there gets more wave energy from the oceanic swell. The good water quality and the substrate almost devoid of loose sediments, with 6 % rubble at 5 m and 10 m and 5 % sand at 10 m makes this site a better place for coral growth.
There is a clear dominance of digitate and tabular (Fig. 27), which is a good sign in terms of recruitment of Acropora, most heavily impacted in 1998. The short turf and coralline algae present are not considered a hindrance for coral recruitment and this part of the reef should look less barren in the near future.

*Figure 6-22 - Acropora species at site 6*

Site 7 is also exposed to the oceanic swell and is very similar to site 6 for live coral cover with 37 % at 5m, and 17 % on the slope. Here the tabular clearly dominate on the top while massive and encrusting life forms remain predominant on the slope. The substrate is also devoid of loose rubble and the coralline and turf algae should not hinder recruitment.

Intermediate predators such as the blue striped snapper (*Lutjanus kasmira*) and the gold spot emperor (*Gnathodentex aurolineatus*) were present at the site (see Figure 6-23).

*Figure 6-23 - Intermediate preditors at site 7.*

### 6.5.6 Summary of coral survey

The results from the photographic transects carried out on the 9th of December 2009, are given in table form (Table 6-2) and bar chart form below (Figure 6-24).

*Table 6-2- Results of the coral survey at Dhidhdhoo, December 2009*

| MAJOR CATEGORY | S1D5 | S1D10 | S2D5 | S2D10 | S3D5 | S3D10 | S4D5 | S4D10 |
|---|---|---|---|---|---|---|---|---|
| CORAL | 6.40 | 20.00 | 16.00 | 26.40 | 10.57 | 9.68 | 7.32 | 5.65 |
| OTHERS | 0.00 | 1.60 | 0.80 | 2.40 | 0.81 | 1.61 | 8.13 | 1.61 |
| ALGAE | 25.60 | 20.00 | 13.60 | 4.00 | 17.89 | 15.32 | 43.90 | 19.35 |
| SAND, PAVEMENT, RUBBLE | 68.00 | 57.60 | 69.60 | 66.40 | 70.73 | 73.39 | 40.65 | 72.58 |
| DEAD CORAL | 0.00 | 0.80 | 0.00 | 0.80 | 0.00 | 0.00 | 0.00 | 0.81 |
| TAPE, WAND, SHADOW | 0.00 | 0.00 | 0.00 | 0.00 | 1.60 | 0.80 | 1.60 | 0.80 |

| MAJOR CATEGORY | S5D5 | S5D10 | S6D5 | S6D10 | S7D5 | S7D10 | Average |
|---|---|---|---|---|---|---|---|
| CORAL | 5.60 | 7.20 | 35.77 | 13.60 | 37.10 | 17.07 | 15.60 |
| OTHERS | 0.00 | 1.60 | 2.44 | 1.60 | 1.61 | 0.81 | 1.79 |
| ALGAE | 10.40 | 20.80 | 38.21 | 27.20 | 46.77 | 40.65 | 24.55 |
| SAND, PAVEMENT, RUBBLE | 84.00 | 70.40 | 20.33 | 57.60 | 12.10 | 41.46 | 57.49 |
| DEAD CORAL | 0.00 | 0.00 | 3.25 | 0.00 | 2.42 | 0.00 | 0.58 |
| TAPE, WAND, SHADOW | 0.00 | 0.00 | 1.60 | 0.00 | 0.80 | 1.60 | 0.63 |

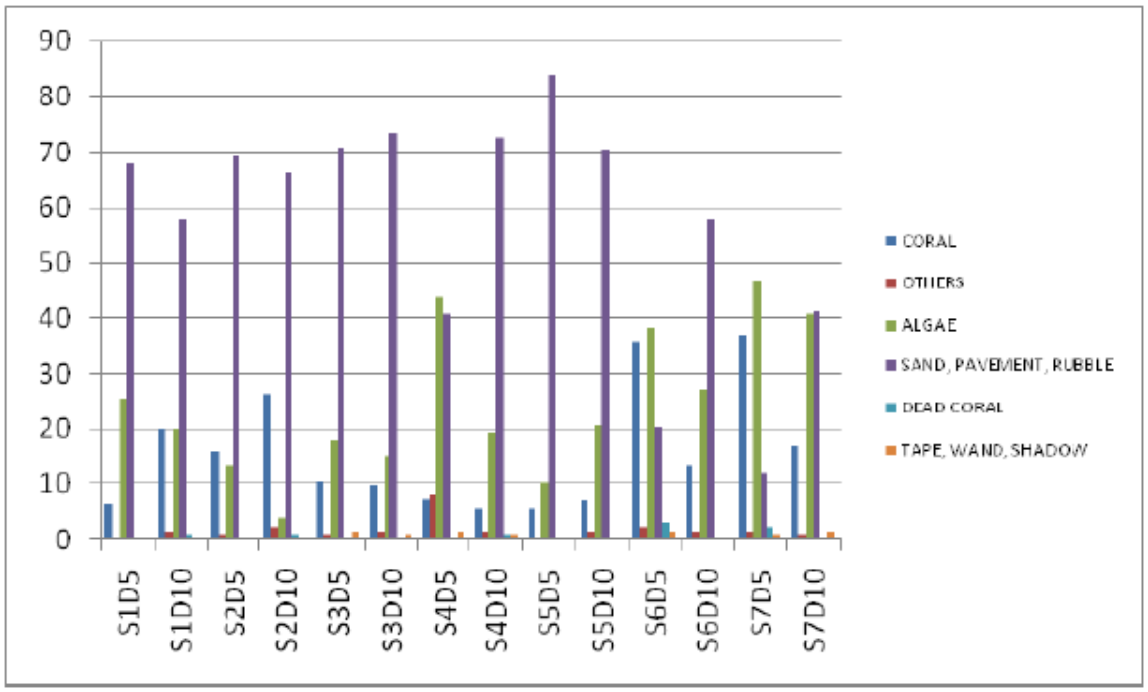


*Figure 6-24 - Results of the coral survey at Dhidhdhoo, December 2009*

With an average coral cover of 16 % live coral cover; the reef has not recovered very well from the 1998 bleaching. Surprisingly, the diversity of life forms is more important than expected with 4 groups quite well represented, the tabulars, the massives, the encrustings and the digitates, whereas branching and foliose forms are virtually absent. The presence of tabular and digitate life forms tend to prove that the genus Acropora is starting to come back in this area.

## 6.6 Fisheries

Fishing is an important activity in the Maldives, and so it is on Didhdhoo with about 175 fishermen active.

Hook and line tuna fishing, the methods used, involves catching baitfish from the inner atoll, using lights and nets. The baitfish is then held in tanks on the fishing dhonis (boats) until tuna are found.

Fish caught is mainly reef fish and skipjack tuna, most of it is sold in the resorts, but some of it is taken by collecting vessels to canning factories elsewhere. Fish processing – cooking and drying or wood smoking - is carried in the compounds and on a site near the landing area.
It should be noted that fishing is not necessarily always a fulltime occupation.

Catches are fluctuating, the best periods mentioned were June-July and November-December. Demand was seen as stable, but as a consequence prices are fluctuating with the catch.

The last twenty years have seen a downward trend in catches because of overfishing, Fishermen nowadays have to go out for up to 60 km for a good catch.
The need for a fish market on the island was expressed a few times.

## 6.7 Resorts and Dive sites

In the Haa Alifu atoll there are 3 resorts operational. Another 2 resorts are under construction. The closest resort is located southeast from Dhidhdhoo Island at less than 5km away (Cinnamon Resort). The other resorts, Island Hideaway and Manufaru, are located approximately 11 and 20 km away from Dhidhdhoo. All three operating resorts were visited to discuss the reclamation of the island Dhidhdhoo and the possible impacts on:

1. the resort and the surrounding waters and/or
2. the dive and snorkel sites used by the dive centers on the resorts.

A meeting with the general manager / manager of operations was held sometimes in combination with a representative from the dive center.

The following concerns and issues were brought up in these meetings:

**Dive sites & coral reefs**

- On the west side of Dhidhdhoo Island there are no dive sites. The reef flat consists of mainly sand so there are no “nice” corals or special marine life. The closest dive site on the western site is located around Dhonakulhi at 11 km distance.
- The island Naridhoo, located at approximately one km distance from Dhidhdhoo on the northeast side, needs to be protected. The island has a beautiful coral wall, soft corals, a nice house reef and a lot of fish species such as Cashmere snappers, humpback snappers and jackfish, It is also a place were sea turtles are commonly seen. The island is a dive site which is regularly visited. Since it’s so close to Dhidhdhoo protection from the reclamation activities is needed.
- Further east are the dive sites around Vashafaru which are important for the dive centers.
- The closest dive site to the southeastern side of Dhidhdhoo is the Alidhoo house reef. It is the main concern of Cinnamon Resort that no sedimentation occurs on this reef.

**Other marine life**

- The channel between Dhonakuhli and Mathi Faru is a natural feeding station for manta rays around December. Sea turtles, eagle rays and dolphins are also regularly observed here. This is a main attraction for the guests of the resort.
- The big channel Gallandhoo Kandu is not a dive site and there are no reefs in the channel but the channel is being used by schools of Humpback whales in December. On occasion Orca whales have been spotted but these were considered to be lost since the water temperatures are too high for this species.

**Currents**

- The currents around Dhidhdhoo are hard to forecast since they might switch every so many weeks or even days. The monsoon seasons do not have such a clear influence on the current pattern compared to the more southern atolls. Turbidity created by the dredging and reclamation activities might therefore affect a larger area. For the resort located at Alidhoo island the concern was raised if turbidity from the reclamation could reach the resort.

**Planning**

- The planning of the works will be important for the resorts. December up until April/May is the high season. When the reclamation activities cause reduced visibility on the dive locations and/or around the resorts this will be a concern.

**Waste**

- When the reclamation of Dhidhdhoo attracts more people more waste will be produced. The lack of plans on waste treatments is a major concern.

A list of the current dive and snorkel sites of all three resorts was requested and obtained from all 3 resorts. The lists can be found in appendix 6.

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## 6.8 Protected areas and species

In the Maldives there are 28 Marine Protected Areas (MPA). The areas have been chosen for a number of reasons such as their underwater beauty, fragility and their unique biodiversity. In the Haa Alifu atoll there are no Marine Protected Areas.

A number of species have been protected for the whole Maldives in relation to the biological diversity convention. The marine protected species are:

- Napoleon wrasse (*Cheilinus undulates*),
- Lobsters (of the family Palinuridae),
- All marine sea turtles; Hawksbill (*Eretmochelys imbricate*) and Green Turtles (*Chelonia mydas*) are the most common species in the Maldives,
- Conch (triton) shell (*Charonia spp.)*
- Black coral (*Antipathes aperta*)
- Giant clams (of the family Triacnidae)
- Whale shark (*Rhincodon typus*)
- Dolphins (of the family Delphinidae)
- Whales (of the order Cetacean)

The channels around Dhidhdhoo are known for the presence of marine turtles.

In addition, 70 bird species (including 5 species which are native to the Maldives) are protected under the Environment Protection and Preservation Act (Act 4/93 of the Maldives. These include Noddy's, Terns, Shearwaters, Frigate birds and the White-tailed tropic bird. The bird species living in the Maldives are Herons, Maldivian water hen and the Asian Koel.

## 6.9 Gaps in baseline information

*Currents*
A detailed study of the currents around Dhidhdhoo has not yet been executed during this ecological survey. A better understanding of the complex current system is needed in order to predict plume dispersion during the dredging and reclamation works.

# 7 Description of Economic and Social Environment

## 7.1 Dhidhdhoo

The whole island has a long harbour on the east side. The built-up-area is a rather narrow grid with government (Didhdhoo is the Atoll capital) offices, 6 mosques – 2 for ladies, 4 for gents -, a hospital, schools and a mix of residential compounds and small shops. A few houses have two stories, most have one story only. The island has 656; plots the existing plot size is variable, the land is government-owned, houses, - 'compounds'- are private. The availability of houses shows a contradictory picture, on the one hand usually more than one family – up to 5 ! - per house, on the other hand empty plots or half-constructed houses. The explanation is that plots were given to people supporting the previous regime and since then the loans needed to build stopped being provided. The number of new houses required to lodge the present population is about 200. Housing was the only really important subject. An issue raised several times was the need for apartments, rather than 'houses', by people who only could afford to rent, rather than buy or construct. The two graveyards also need more land.
An issue raised was the strong erosion, especially on the southern side, where the last couple of years a hundred meters were lost, including part of the Youth Centre fence. Protection and maintenance of the reclamation area was seen as important..

### 7.1.1 Drinking water supply

The abundant rainfall – some 2.000 mm a year - is the source of fresh water on the island. Practically all houses are to have tanks collecting the water from the roof for drinking water. The tank programme has resulted in more than 1000 rainwater tanks installed.

The fresh water lens on top of the salty seawater underneath was contaminated by sewerage in the past. The construction of a water plant has been delayed.

### 7.1.2 Waste management and sewage system

*Waste*
Remarkable is the clean beach on the western side of the island, women are cleaning it in the evening.
Didhdhoo has two waste facilities, one on the southern tip of the island, with an incinerator and storage for sorting out items e.g. cans and plastic, and huge piles of waste yet to be treated. In the northern tip there is a rather isolated facility which is not really operational.
The waste sites have to be upgraded and waste has to be centrally collected, separated and treated on site.

*Sewage*
The whole built-up area has a sewerage system, which is connected to a central pipe that runs from the north to the south of the island. The sewage is pumped out to sea at both ends by two pumping stations on the south-west and north. The outfalls are located at 4-5 meters depth.

### 7.1.3 Landmarks, cultural and heritage sites

Dhidhdhoo is a typical Maldive island and as such quite characteristic, but there are no sites or buildings with an otherwise special status.

### 7.1.4 Island administrative offices

The Dhidhdhoo Island office is centrally located and has the facilities – including internet access – necessary for its functioning.

### 7.1.5 Postal and other utilities

Dhidhdhoo has a complete range of services and amenities, albeit not necessarily up to standard in all areas.

*Communications*
The communication with the outside world is fairly comprehensive. Mail is delivered, and there is a Post Office. Satellite TV is 'everywhere', cell phones have an excellent transmission with two masts on the island. No cyber café is present.
Transportation in this island country is an important item. Small dhonis and speedboats maintain the connection between the islands.
Print media are not important, the size of population is too small and transportation is a major obstacle.

## 7.2 Socio-economic characteristics

### 7.2.1 Population

The population consists of 3734 people, 1822 female, 1912 male. They are divided over the following age classes:

| Age | Number | % |
|---|---|---|
| 0-18 | 1221 | 48 % |
| 19-25 | 313 | 13 % |
| 26-64 | 833 | 33 % |
| 65+ | 145 | 6 % |

Temporary workers are the most conspicuous among the non-locals present. About 300 non-Maldivians from mostly from Bangladesh, and some from India and Sri Lanka are employed in a wide range of jobs, including the school and the pharmacy.

### 7.2.2 Economy, present and future

No statistics on employment were available.
**Fishing** – men – **curing of fish** – women -, tourist resorts, masonry and carpentry are the main earners.
Women are employed in shops, restaurants, the Health Centre, school, and administration.
The island provides services to the **Tourism** industry, a reason that land for warehouses for resorts is mentioned as something the reclamation could provide.
Government employs about 250 people.
**Home gardening:** fruits – banana, bread fruit, coconut, guava – and vegetables - cabbage, salad, herbs and the like, are present in all compounds.
Local private businesses number about 73, including:

| | |
|---|---|
| Cafe restaurants | 7 |
| Pharmacies | 3 |
| Workshops | 7 |
| Vehicle repair shops | 2 |

Didhdhoo has 32 vessels, of which 6 are fishing boats. A dhoni beaching area was mentioned as important for maintenance and the like. It required to be at least 50 m away from living areas because of the chemicals used.

### 7.2.3 Unique cultural characteristics

*Social structures*
Differentiation within the Dhidhdhoo population is along tree lines:

- the local population, rather homogenous in background and culture (Traditional Islamic), including those from neighbouring islands; and the temporary foreigners (Bangla Desh, India, Sri Lanka);
- gender, with the women in a rather traditional position of household and typical female employment, women hold jobs in the school, the youth centre, hospital, government offices and shops;
- income, and hence education, this also within families. Some difference is found in the size of houses, but the minimum is simple, not poor.

Conflicts are not an issue, it was not mentioned.

*Culture*
The culture of the island population can be characterised as 'modernising, non-fundamentalist Islamic'

- Islamic: no alcohol to be found outside tourist resorts, Friday and Saturday 'weekend', prominent mosque and prayers in the 6 mosques, two for ladies, four for gents.
- Modernising: satellite TV and cell phones, 'everywhere', most women are wearing a head scarf, with young women in modern dress, dress code is liberal.

### 7.2.4 Services

*Health Centre*
The hospital has 12 doctors and 35 nurses. If the population increases it will have to expand, but this can be done on the present site.
The main medical issues mentioned were hypertension and diabetes. Seasonal viral fever when it occurs can be tackled in 2 hours, Chikunguya fever is under control and a few cases influenza are reported, but not on Didhdhoo itself.
The Island has three pharmacies.

*Non-Governmental Organisations (NGOs)*
The most important NGO's are the Didhdhoo Sports Academy and Madharasathul Ghaazee Mohamedge Isdharivarunge Jamiyya.

*Education*
Didhdhoo has 2 privately owned pre-schools and the Educational Centre which has both a primary and a secondary level. The School has 65 teaching staff, a total staff of 85 and 625 students up to grade 10.
The Centre's capacity has its limitations, e.g. classrooms, in particular when people will be drawn in from elsewhere.

*Fire fighting*
Nothing centrally organised.

*Bank*
Banking facilities are available.

*Power*
Electricity is provided by a three-genset power plant with a total capacity of 700 KVA, maximum demand is currently 350 KVA. It has the capacity to serve twice the size of the present island.
The genset are cooled with groundwater. The system is governmental, people are metered and pay in advance.
In the future a new location will be needed, with more space e.g. for the high voltage area, and also because of the noise nuisance.

## 7.3 Description of power structure, government

Dhidhdhoo is situated in the north western tip of Tiladummati Atoll of the North Province of the Maldives. Dhidhdhoo is also the atoll capitol.
Dhidhdhoo has an island counsellor, who reports to the atoll chief, also located on Dhidhdhoo, who in turn reports to the government in Male'.

## 7.4 Location of resorts & related activities

The closest resort is the Cinnamon Island Resort, which lies southeast of Dhidhdhoo. The resort is approximately 5 km away.
Tourists occasionally visit the island on day trips, but this is not a significant contributor to the economy.

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# 8 Public Consultation

## 8.1 Methodology

Consultations were conducted by Mr Geerling of Carnbee Consult in the Netherlands. Mr. Geerling visited Dhidhdhoo in December 2009 and had formal meetings and informal interviews with authorities as well as "regular people in the street".

The socio-economic assessment was organised along the following lines:

1. Meetings with government authorities, first in Malé with Mrs. Shanaa Farooq, Ministry of Housing, Transport and Environment, and then on Didhdhoo with the Deputy State Minister of Home Affairs, Mr. Adam Nasser en the Island Councillor, Mr. Mohammed Shareef and his staff.
2. Introductory meeting organised by Mr. Naseer and attended by about 30 persons from Government and NGO as well as Mrs. Farooq and Mr. Gabe Venema, Boskalis.
3. Introductory meeting organised by Mr. Shareef, attended by about 50 persons from the general public and business people, as well as Mrs. Farooq and Mr. Gabe Venema, Boskalis.
4. Follow-up meetings for more specific subjects pertaining to the people or institutions in question.
5. Visits to institutions such as the Health Centre, Secondary School, power plant, etc.
6. 'Random walk' interviews, covering the whole of the island, with 18 interviews with 33 women and 20 interviews with 45 men, covering the age classes.
    - The interviews were conducted by CG and a professional interpreter, Mr. Hassan Nyaz. All people approached responded positively, the discussion was open and easy, and bystanders ventured opinions. No names were asked, or given.
    - Interviews and the 'specific' meetings with more specific questions for the focus of the groups and the individuals, and adjusting for emerging themes. Opinions expressed were usually rather clear.

The people of Dhidhdhoo can lodge their grievances over any government actions with the Island Councillor, who represents the people of the island. He will bring the issues to the attention of the Atoll Chief, who in turn will address the issues with the government in Male'.
Both the Island Councillor and the Atoll Chief have the power to address certain issues without having to involve the government in Male'.

Grievances that are related directly to Boskalis' dredging and reclamation works during construction can be lodged directly with the Boskalis Project Manager or Works Manager. Issues related to traffic, noise, air pollution, water from the reclamation area etc. will be addressed immediately by the Project Manager or Works Manager.

## 8.2 List of persons consulted

The following persons were consulted:

| **Function** | **Name** |
|---|---|
| Minister of State for Home Affairs | Adam Naseer |
| Island Councillor | Mohamed Shareef |
| Ministry of Transport, Housing and Environment | Mrs. Shanaa Farooq |
| Hospital | Mr. Ibrahim Jaleel<br>Mr. Hassan Mustapha<br>Mr. Mohammed Rasheed |

| | |
|---|---|
| Noona Atoll Educational Centre | Mohamed Atheeq |
| Power Plant | Mr. Mohamed Latheef |
| General public | 18 interviews with 33 women<br>20 interviews with 45 men |

The management of the resorts in Haa Alifu atoll and the dive centers at the resorts were also consulted (see par. 6.7)

## 8.3 Summary of outcome of consultation

The attitude of all categories encountered towards the project was positive, people were thinking in terms of potential for development, in particular for the younger generation. No negative impacts of the project as such were identified. The project should start as soon as possible. Disposal of waste was the only more general issue.
On the public communication most people had heard about the project. It is strongly advised to continue with an open (everybody is welcome) and structured (with an agenda – we are we now, and what is next - and proceedings) stakeholders' consultation, in order to mobilise and stimulate the present potential.

*Main recommendation*
The process of information and consultation is all-important, even a condition for succeeding and has to be continued in order to mobilise the potential and ideas present: the Dhidhdhoo people think about the project in terms of opportunities. In particular the female part of the population will have to be stimulated to actively participate.

Appendix 7 contains a report of the public meetings held at Dhidhdhoo from the Ministry of Housing, Transport and Environment.

## 8.4 Consultation and Grievance

The Government of the Maldives and Royal Boskalis Westminster will have to continue the process of consultation that was started during the execution of this EIA. Stakeholders will have to be kept appraised of the progress of the project at regular intervals. The stakeholders also need to be informed about the ways in which the project will affect them and their activities during all stages of the project.

Any individual is entitled, under Maldivian law, to access information, or raise any concern, or lodge grievances, in relation to public development projects. These concerns or grievances can be lodged locally at the island, atoll or province offices. Grievances can also be lodged at the relevant government authorities (e.g. EPA for environmental issues, MHTE regarding issues related to land allocation, etc.). If there is a greater public concern, these issues may be raised with local Members of Parliament, they may be submitted to petition committees within the parliament for investigation, or inquiries may be made with the relevant Minister.

To address any grievances, the general Laws in practice with regard to the issue will be used to solve the problems that arise. With regard to environmental concerns the Environment Protection Act 1993 (and Environmental Impact Assessment Regulations 2007) will be used. Similarly, the Land Act 2002 (and Land Use Planning Regulations 2005) will be used in solving any grievances regarding allocation of land.

Grievances that are related directly to Boskalis' dredging and reclamation works during construction can be lodged directly with the Boskalis Project Manager or Works Manager. Issues related to traffic, noise, air pollution, water from the reclamation area etc. will be addressed immediately by the Project Manager or Works Manager.

# 9 Assessment of Environmental and Social Impacts

## 9.1 General

This chapter discusses the environmental and socio-economic impacts, both during construction of the Safe Island and after construction has finished. It also discusses the different dredging and reclamation options and the option of No Construction and the environmental effects related to these options.

## 9.2 Environmental impacts during construction

The major environmental impacts during construction at Dhidhdhoo are related to:

- The selection of the dredging location and impact of dredging processes on benthic communities;
- Suspension of sediments caused by the dredging and reclamation works with effects on the marine ecology, and
- Waste handling and pollution control by the contractor

Smaller short term environmental aspects of the dredging and reclamation works at Dhidhdhoo are related to:

- Noise, light and air
- Socio-economic impacts (see paragraphs 9.5 and 9.6)

### 9.2.1 The dredging locations

There are four alternative locations for the mining of 1,000,000 $m^3$ of sand for Dhidhdhoo.

1. Mining sand by trailer dredger (TSHD) from the seabed in the atoll lagoon. In this case it is most likely that the dredging dept will be 1 meter or less; in that case the affected area will be some 1,000,000 $m^2$ for Dhidhdhoo.
2. Dredging sand (by cutter dredger/ CSD) within the island's own shallow reef area, provided there is enough space. The area affected, will be between 65,000 and 80,000 $m^2$.
3. Dredging sand (by cutter dredger/ CSD) within a lagoon present in the reef of the island.
4. Dredging sand (by cutter dredger/ CSD) within a shallow reef area nearby.

Since benthic organisms live in the top 30 – 40 cm of the seabed and on the seabed, the damage to the benthic communities at the reef flat area will be much smaller compared to dredging the atoll lagoon area. It is expected that on the sandy reef flat area, limited benthic communities are present, due to the limited water depth and the high water temperatures. On the sandy seabed areas in the atoll lagoon, it is likely that more benthic communities will be present, due to the conditions being less extreme. However, in areas where high current speeds occur, the presence of benthic fauna will also be limited. Additionally, benthic fauna communities have the capacity to recolonise areas with disturbed seabed fairly quickly. Recovery in highly dynamic systems is quick, taking anywhere from as little as a few months up to a few years.

Concluding: from an ecological point of view regarding the benthic communities, dredging at the reef flat area would be preferred over dredging in the atoll lagoon area. However, given the availability of suitable dredging material in the atoll lagoon, this area is preferred above the island's shallow reef flat. Dredging in the atoll lagoon is also the preferred option with respect to the coral reefs.

### 9.2.2 Suspension of sediments

The distribution of suspended sediments is related to three aspects:

- Dredging with a Cutter suction dredger (CSD) at the flat reef area;
- Dredging with a Trailing suction hopper dredger (TSHD) at the atoll lagoon area;
- Outflow of the pumped water at the reclamation area.

Each of the dredging methods and the outflow of water from the land reclamation areas will re-suspend sediment to a greater or lesser extent in the open sea. This may cause significant effects on the coral reef areas.

*CSD*

A CSD is a stationary dredger, that dislodges the material with a rotating cutter head mounted on a ladder. The cutter head is equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of a centrifugal pump, which is installed on the dredge pontoon or on the ladder of the dredger. The amount of material not entering the suction mouth may be as much as 30% of the total dislodged material. Much of this material will fall immediately to the seabed and will be dredged on the next cut. Only the finer particles will stay in suspension and will be distributed throughout the water column by the local currents. With a CSD, the creation of turbidity is a more or less a continuous process. Due to the fact that a rather deep basin will be created by the CSD of about 6 – 7 meters depth, the majority of the suspended sediments will stay within this created basin. As the cut material will be disposed by a discharge pipeline to the land reclamation site no additional turbidity will be created at the dredging site. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local hydrodynamic conditions.

*TSHD*

A TSHD is a normal sea-going ship equipped with one or two suction pipes. At the end of each suction pipe is a drag head, which can be lowered onto the seabed while the TSHD navigates at a reduced speed. The material loosened by the drag head, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump, and subsequently placed in the hopper of the dredger. The TSHD will transport the sediments to the shore connection, where the TSHD will be connected to a pipeline system.

Most of the turbidity generated by a trailer suction hopper dredge is caused by the overflow of turbid water during the hopper filling operations. Overflow is the flowing overboard of excessive process water, together with a part of the finer material. Overflow is caused by continued loading after the hopper has been filled to its maximum. When dredging pure sandy sediments, the amount of overflow of particles is mainly determined by the grain size distribution of the dredged sediment. It is to be noted that the overflow process will not be a continuous activity, since its duration will be limited to operational dredging time, which is usually less than half the total cycle time.

The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas. As no dredging site has been identified within the lagoon no relevant impact can be assessed.

*Outflow of the pumped water*

The reclamation works can result in considerable volumes of sediment escaping into the water column and this will affect the local marine habitats and may cause significant turbidity and sedimentation at the coral reef locations. To prevent this, it is necessary to construct permanent or temporary bundwalls around the reclamation areas in the shallow water, using suitable materials. This is needed before the land reclamation will be carried out. In addition correct adjustable weirs have to be installed at the outflow area.

Working with a reclamation area that was fully enclosed by bunds and included settling (or siltation) basin(s) proved very effective in minimising the release of suspended sediments to the ocean during the reclamation works at Viligili and Vilufushi.

*Area of influence*

*Figure 9-1* shows the area of direct influence (bright green) by suspended sediments generated at the borrow area and from the reclamation area run off. In the bright green area, a temporary increase in suspended sediment concentrations may be measured at any time during the dredging and reclamation works, depending on weather conditions, tide and currents. In the darker green area, a temporary reduction in visibility may be observed during, and for a short time after, storm events.

These areas will be monitored during dredging and reclamation works as part of the water quality monitoring program (see chapter 11). When suspended sediment concentrations exceed warning levels, appropriate actions will be taken.

This Figure is based on the assumption that the outflow of water from the reclamation area is directed through the existing harbour (just northwest of the proposed borrow area), while the

entrance to the borrow area is as close to the harbour entrance as possible to minimise the area in which suspended sediments are released.

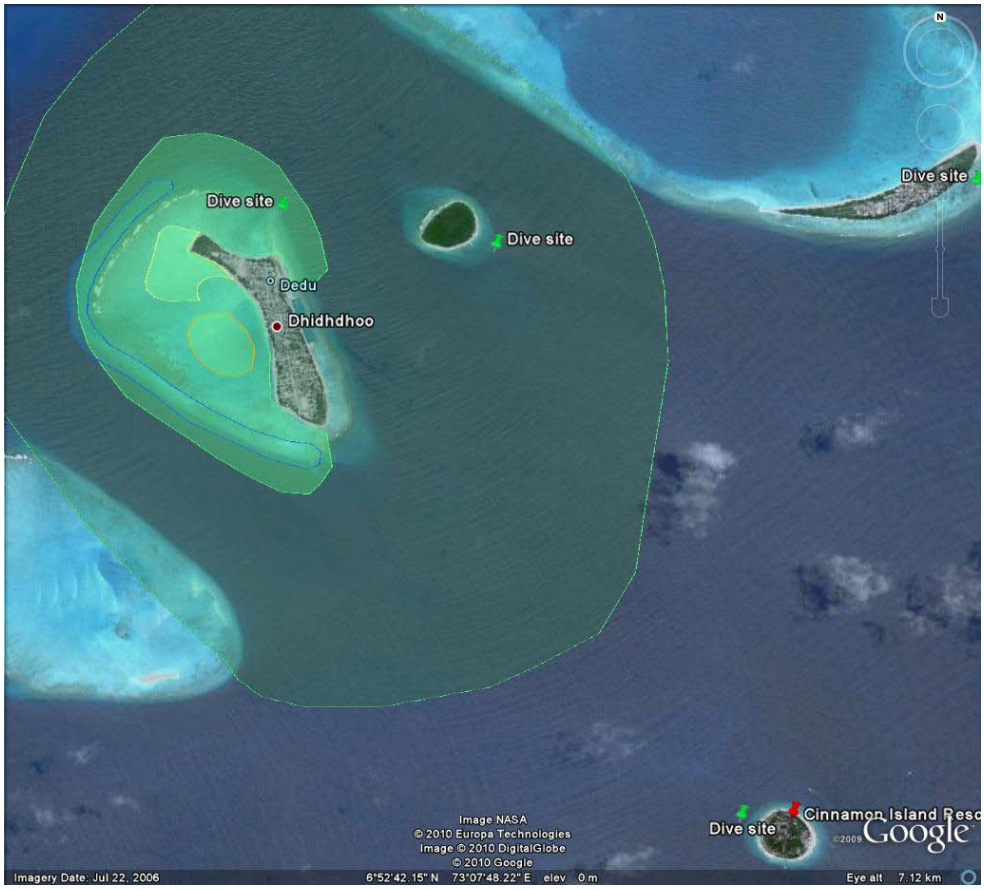


*Figure 9-1 - Possible area of direct influence (bright green, temporary increase in suspended sediment concentration during dredging and reclamation works) and less direct influence (darker green, short term reduction of visibility during storm events) of suspended solids released from the proposed borrow area and the reclamation area under worst case conditions*

### 9.2.3 Waste handling and pollution control

At the working sites on land, as well as on board the construction vessels, waste water, oily wastewater and solid waste will be produced. To prevent pollution of the coastal waters the following restrictions are set:

- AII the construction vessels need to be equipped with wastewater and solid waste handling facilities, to collect and handle the wastewater and the solid waste generated by each vessel. Disposal of wastewater and solid waste directly into the sea is not allowed.
- Oily wastewater and oily contaminated material generated from the construction machinery during the construction activities is also not allowed to be discharged directly into the sea. These wastes need to be collected and transferred back on shore for treatment/disposal, to avoid causing any adverse impact on the marine environment.
- Solid construction wastes generated during offshore construction works are also not allowed to be discharged directly into the sea. They shall be collected and transferred for onshore disposal, to avoid causing of any adverse impact on the marine environment.

### 9.2.4 Noise, light and air quality

Dredging and reclamation works will continue 24 hours per day.

*Noise*

Experience from the projects at Viligili and Vilufushi has shown that the dredge (in those cases a CSD) cannot be heard on the island while it is working. Distance from the island to the dredge varied from 100m to 500m. A TSHD generates a similar amount of noise while pumping material ashore as a CSD, so no noise impacts are expected from the dredges.

At the reclamation area, bulldozers, excavators etc will be working non-stop. This will generate some noise at the houses located closest to the reclamation area, but this noise will be less than that experienced at the houses located next to the power generators for the island.

*Light*
When using a CSD to dredge sand from the reef around the island, the CSD will be visible day and night. Lighting on deck is necessary to maintain safe working conditions during the night. The lights can be directed away from the surrounding water as much as possible, as long as this does not jeopardise safe working conditions.
When using a TSHD, the dredge will be near the island at intervals. Same as on board a CSD, lighting on deck is necessary to maintain safe working conditions. These lights can be directed away from the surrounding water as much as possible, as long as this does not jeopardise safe working conditions.
The reclamation area will be lit during night times to maintain safe working conditions. These lights can be directed away from the surrounding areas as much as possible, as long as this does not jeopardise safe working conditions.

*Air quality*
Due to the open nature of the working areas (enough ventilation) the impact is assumed to be light. Nevertheless, the following actions should be undertaken in order to ensure that pollution of the atmosphere is minimised:

- The engines will be maintained in good working conditions, so that exhaust emissions of pollutants will be kept to a minimum.
- With complete combustion, emissions of soot particles, hydro carbons and carbon monoxide are minimised.
- The vessels will be subjected to regular inspection and maintenance programs.

Equipment used on land will also be subject to regular maintenance in order to minimise emission of pollutants to the air.

Since the dredging activities take place entirely in a wet environment dust problems will not be encountered.

## 9.3 Boskalis SHE-Q

Royal Boskalis Westminster nv has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.
Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OSHA and environmental requirements, and are adjusted if a client has even more stringent requirements.
All vessels are IMS certified and have to meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Appendix 3 contains the framework that is used to make a specific Environmental Management Plan for each individual project that Royal Boskalis Westminster undertakes. Similar frameworks are applied for project specific Safety and Health Management Plans.

## 9.4 Environmental impacts after construction

The major long term aspects for the dredging and reclamation works at Dhidhdhoo are related to:

- Loss of marine habitats due to the land reclamation;
- The safety of the local population and the land ecology;
- A large basin within the shallow reef flat (in case of a CSD);
- Alien species transported to the island
- Increased population.

#### 9.4.1 Loss of marine habitats

The land reclamation to enlarge the island will result in a permanent loss of marine habitats and resources. However, the land reclamation is limited to a part of the shallow reef area and will not destroy the coral reef areas at the lagoon side and the ocean side. The reef flat itself is of low ecological value.

#### 9.4.2 Safety of the population and the land ecology

The existing island is mostly less than 1.2 meter above MSL. Due to the changing climate conditions, the sea level rise is estimated at about 0.5 cm per year. This means that serious threats to the population and the land ecology of Dhidhdhoo island exists during storm periods and the additional risks of tsunamis. Due to the higher land reclamation and the bundwalls around the island up to +2 meters above MSL, the risks for both the population and the land ecology is strongly reduced.

#### 9.4.3 A large basin at the shallow reef flat

When a CSD is employed, the borrow area for the land reclamation works may be located inside the shallow reef flat. A basin will be created with a depth of 7 – 9 meters. Due to the wave activities and the local currents, it is likely that sand will be transported from the surrounding areas into the basin area. In time this may result in changes in bathymetry and morphology around the borrow area.

#### 9.4.4 Alien species

Ships and vessels selected for the construction works are likely to come from areas outside the Indian Ocean. These vessels may contain foreign ballast water. Ballast water is fresh or saltwater held in the ballast tanks and cargo holds of ships. It is used to provide stability and manoeuvrability during a voyage, or when more stability is required due to rough seas. Organisms living in coastal waters may be pumped into ballast tanks along with the water. If a ship takes on ballast water in a shallow area, sediments and any associated organisms may be pumped into the ballast tanks. When ballast water is released, these organisms may also be released.
The release of ballast water may introduce non-native organisms into the Maldives coastal waters. These introduced species, or bio-invaders, are also referred to as exotic species, alien species and non-indigenous species. Typically, very few organisms are able to survive in new surroundings because temperature, food, and salinity are less than optimal. However, the few that do survive and establish a population have the potential to cause ecological and economic harm. Populations of bio-invaders may grow very quickly in the absence of natural predators. In turn bio-invaders may displace native organisms by preying on them or outcompeting native species for food and habitat space. Economic damage may occur when a bio-invader displaces species that are harvested for food or other goods, or when bio-invaders damage structures. Worldwide, the introduction of foreign species is a leading environmental issue.
The introduction of alien invasive organisms is now considered to be one of the most serious threats to the biological diversity of the Maldives.
To prevent exotic species from being introduced in the Maldives, all dredging and auxiliary vessels that are brought into the Maldives will follow international conventions and regulations regarding ballast water.

#### 9.4.5 Increased population

An increase in population will lead to more waste and sewage being generated. This creates an increased need for sustainable waste and sewage management to ensure safe and healthy living conditions on the island.

## 9.5 Social impacts during construction

The effects and impacts of the dredging and filling on the present island and its population are rather limited. A dredger, including the crew will be out on the sea. Relocation and the like is not an issue, neither people nor the built-up area will be affected.
On the Island a small number of people will be active and 10 – 20 people, local or from elsewhere, will be employed for something like 6 -8 weeks. All this is well within the range of what is going on the Island at any given time and there are no specific categories of people which

could be vulnerable anyway. Taking on the access to the jetty as early as possible will already solve a major problem.
With Boskalis´ wide experience in such matters there are no special issues to be addressed. Continuous contacts and access to information and issues arising will be an integrated part of the operation.

The impact on the fishing community will be minimal. The majority of fishing (for tuna) takes place on the open ocean. The effects of increased suspended sediments will mainly be limited to within 500m from the reclamation run off point and the borrow area. Fishing for bait fish will still be possible within the lagoon, and north of the reef where the pearl farm is located.

Marine traffic will not be affected by the dredging and reclamation areas.

Suspended sediment levels will be monitored at the dive sites as part of the water quality monitoring program described in chapter 11.

Rocks needed for the revetments will be sourced from India. The subcontractor responsible for the construction of the revetments and the supply of the needed materials, MT Hojgaard, has issued a statement regarding the absence of child and forced labour at the quarries they contract (see Appendix 8).

## 9.6 Socio-economic impacts after construction

The social-economic impacts of the project are large in relation to the number of people and the size of the economy. These impacts are expected to be positive. No potentially adverse effects have been identified, the risks do not appear to be evident.
The outcome means land for:

- housing
- schools: classrooms
- a hospital
- recreation and a youth centre
- industrial developments, a fish market

This, together with the new harbour and better access to the jetty in the meantime, which will improve current conditions and give an impetus to (economic) development.

In addition, the revetments and EPZ will provide more safety for the people and their economic activities against flooding.

The development of the Safer Island projects, of which the Three Island Project is a part, is based on expectations for population growth and economic and social development. The Government of the Maldives has the wish to concentrate the population, in order to be able to provide better facilities to more people. By concentrating the population on fewer islands, providing better facilities to more people will become more affordable for the government.
Once the Safer Islands are developed, there will be no forced relocations. The people of the Maldives will be free to choose to take advantage of the facilities offered on the Safer Islands by moving to these islands whenever they choose. As stated before, the Government of the Maldives has a passive population consolidation policy, rather than seeking to actively relocate people.

No conflicts between the original inhabitants and new inhabitants of the island are expected. These islands are small communities, where people are used to helping their neighbours, whether they live on the same island, or an island nearby. Any conflicts that do occur will be settled by the Island Councillor.

## 9.7 Comparison of No Development and different dredging & reclamation options

For this EIA there are two main options, which are (1) no-construction at all and (2) the accepted construction of the Safe Island. Regarding the overall design of the safe island there are no

alternatives, but there are several alternatives with respect to construction methods. This paragraph discusses the impacts on the natural environment related to no-construction and the alternative construction methods.

### 9.7.1 No construction

In case the construction of Safe Island Dhidhdhoo would not take place at relatively short notice, the direct impacts on the land and the marine environment would seem to be neutral. In the somewhat longer term some environmental impacts will take place, mainly due to the fact that the pressure on the marine environment will increase. The more people living on the same island-surface, the more waste and wastewater will end up at the eastside in the sea. For the same reason groundwater quality will no doubt deteriorate.

### 9.7.2 Dredging alternatives

The project requires up to 1 million $m^3$ of suitable fill sand. The possible sources of fill material are the following:

- Option 1: Sand from the shallow reef flat area next to the island to be dredged by a CSD (cutter suction dredger) with a pipeline system, as planned;
- Option 2: Sand from the seabed of the lagoon in the atoll to be dredged by a TSHD (trailing suction hopper dredger) with a pipeline system;
- Option 3: Sand and coral material from a coral reef (faro) elsewhere in the lagoon to be dredged by a CSD;
- Option 4: Sand imported from overseas by a jumbo trailer (very large trailer).

Option 1 is an attractive alternative both from an economic and an environmental point of view (see also chapters 4 and 5), provided there is enough space on the reef flat.
Option 2 is a realistic alternative depending on the water depth of the seabed in the lagoon, and the available quantity of sand within the lagoon. Sand mining in the lagoon can be done by a Trailing suction hopper dredger. As the water depth is between 20 – 80m, a large TSHD is required.
Option 3 will cause considerable damage to the environment.
Option 4 will result in very high costs. .

### 9.7.3 The dredging location and its impact

Two alternative locations for sand mining for the reclamation can be used. The selected area is located on the shallow flat reef area; an alternative is dredging sand from the seabed in the lagoon.

Dredging within the shallow reef flat by a CSD (option 1) will affect an area of about 70,000$m^2$. The created depth within the dredging area will be about 6 – 7 meter. In case dredging is carried out within the lagoon by a TSHD (option 2), it is most likely that the dredging depth will be less than 1m. In that case the affected area will be at least 1,000,000$m^2$, which is 6-7 times larger than in case of dredging within the reef flat.

Since the benthic organisms live in the top 30–40cm of the seabed and on the seabed, the damage to the benthic communities when dredging at the reef flat area will be limited to 20%, compared to dredging in the lagoon area. Also it is expected that on the sandy reef flat area, limited benthic communities are present, due to the limited water depth and the high water temperatures, the more so since the coral bleaching effects of 1998. On the sandy seabed areas in the lagoon it is likely that more benthic communities will be present. However, recovery of the benthic communities in these areas is expected to happen relatively quickly after the dredging works have finished.

For this project, the depth of the borrow area is directly related to the dredging method used. When a Cutter Suction Dredger (CSD) is employed, a relatively small but deep borrow area will be created on the reef flat. A Trailer Suction Hopper Dredger (TSHD) will create a relatively large and shallow borrow area in the seabed of the atoll lagoon at greater water depths.

Working with a TSHD in the atoll will generate a source of suspended sediments in a location further away from Didhdhoo. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected. The process of

filling the reclamation area by TSHD however will allow for more control over the release of suspended sediments from the reclamation area, and the release can be minimised further than when using a CSD. The suspended sediment plume generated near Dhidhdhoo would be much smaller than when using a CSD to dredge sand from the reef near Dhidhdhoo.
Another positive aspect of bringing sand into the reclamation by TSHD is that through this process, sand is added to the shallow system surrounding Dhidhdhoo. This may have a more favourable effect on the erosion and sedimentation processes around Dhidhdhoo.

Working with a CSD elsewhere in the atoll will cause damages to the life organisms at a second reef and coral patches.

### 9.7.4 Resuspension of sediments

The distribution of resuspended sediments is different for the dredging processes:

- Dredging with a cutter suction dredger at the flat reef area;
- Dredging with a trailing suction hopper dredger at the lagoon area.

Each of these dredging methods will cause resuspension of sediments; this may in turn have significant effects on the coral reef areas.

*CSD (option1)*
A CSD is a stationary dredger which dislodges the material with a rotating cutter-head. During the dredging process part of the finer particles will stay in suspension and may be distributed by the local currents. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local current regime (see chapter 6). Given the limited water depths over the reef (0.5 to 1.0m) this effect will be rather small at most times. Furthermore, due to the fact that a rather deep basin will be created by the CSD (depth 6-7 meters), the majority of the suspended sediments will remain within this basin.

*TSHD (option 2)*
A TSHD has one or two suction pipes and dragheads; the material is loosened by the draghead from the sea bottom, sucked into the suction pipe and placed in the hopper of the dredger. The TSHD then moves to an offshore connection point close to the island, where the dredger is connected to a pipeline system for discharging into the reclamation. Most of the turbidity generated by a TSHD is caused by the overflow of water and part of the finer materials during the hopper filling operations. The resuspension of these sediments and the effects on the coral reefs will mainly depend on grain size distribution, local currents and distance to the reef. The relevant impact has not been assessed (no specific borrow area has been selected), but is probably manageable.

*Table 9-1 comparison of dredging options*

| Dredging alternatives | No dredging | CSD/ reef | TSHD/ lagoon | CSD/reefs in atoll | TSHD/ overseas |
|---|---|---|---|---|---|
| *Environmental impacts* | | | | | |
| Disturbed bottom $m^2$ | 0 | 65,000 | 1,000,000 | 150,000 | 1.000.000 |
| Turbidity | 0 | + | + + | + + + | + + + |
| Loss of sea grasses | 0 | 10% | 0 | 0 | 0 |
| Loss of corals | 0 | + | + | + + + | 0 |
| Loss of macro benthic | 0 | + | + + + | + + + | + + + |
| Loss of fishes | 0 | + | + + | + + | + + |
| Loss of vegetation | 0 | + | + | + | + |
| Groundwater | + | 0 | 0 | 0 | 0 |
| Alien species | 0 | 0 | 0 | 0 | + + |
| *Economic impacts* | | | | | |
| Costs dredging | 0 | + | + + | + + + | + + + + |
| **Total** | **0** | **+** | **+ +*** | **+ + +** | **+ + + +** |

0 = no impact,
+ = small impact,
++ = medium impact,
+++ or ++++ = big impact.

The increased overall impact is mainly caused by the fact that dredging with a TSHD leads to a second area being exposed to increased suspended sediments concentrations. However, this area would be less sensitive, as it would be chosen well away from coral reefs.

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# 10 Selection of Preferred Alternative and Mitigating Measures

## 10.1 Preferred Alternatives

From an ecological point of view regarding the benthic communities, fisheries, corals and sea grasses, dredging with a CSD at the reef flat area is a better option than dredging in the lagoon area. The only damage at the reef flat is the destruction of some of the sea grass area, but as the water will be rather clear, sea grasses can recover at the bottom of the borrow pit.

Working with a TSHD in the atoll will generate a source of suspended sediments in a location further away from Dhidhdhoo. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected. The benthic fauna will, over time, recolonise the seabed at the borrow area.
Bringing sand to Dhidhdhoo from elsewhere in the atoll may have a more favourable effect on the erosion and sedimentation processes around Dhidhdhoo.

Working with a CSD elsewhere in the atoll will cause damages to the life organisms at a second reef and coral patches.

The costs of dredging overseas with a jumbo trailer will be very high.

Based on these results, dredging sand from a borrow area inside the reef near Dhidhdhoo by CSD is the preferred option. Dredging sand in the atoll by TSHD is a viable alternative option, provided the borrow area is chosen properly (i.e. away from coral reefs and patches, resorts, dive sites, Marine Protected Areas and other sensitive receivers)

## 10.2 Mitigating Measures

### 10.2.1 Preventive measures

The following preventive measures will have to be taken at the dredging and reclamation areas:

- Construction of bunds to fully enclose the reclamation area before the start of dredging and reclamation works to minimise the loss of suspended sediments from the reclamation area.
- Construction of one or more settling basins (depending on the final layout of the reclamation area), to further minimise the loss of suspended sediments from the reclamation area
- Ensuring that there will be settling basin space available at all times until the dredging works have completed by creating of a stockpile of material that will be used to fill the final phase of the reclamation area.
- Choice of location of the TSHD borrow area away from coral reefs, coral patches, Marine Protected Areas, resorts and dive sites.
- Dredge the entrance to the CSD borrow area at the minimum depth and width necessary for the CSD to move into the borrow area. The borrow area itself should be dredged deeper. The threshold that is created this way will help reduce the dispersion of suspended sediments from the borrow area

### 10.2.2 Mitigating measures

The following mitigating measures will have to be given consideration during the detailed engineering and preparation phases of the project:

- Construction of bunds around the borrow area in the reef flat to minimise effects of the currents running over the reef on the borrow area. This may help minimise the dispersion of suspended sediments from the borrow area.
- Use of limited overflowing when dredging sand from the atoll seabed by TSHD. Limiting overflow has large consequences relating to the cost of the dredging operations.

Experience at Vilufuhsi and Viligili has shown that creating temporary bunds using an excavator generates only a minimal amount of suspended sediments that does not disperse beyond 50 m from the excavator.

The decision to take additional mitigating measures such as the construction of temporary bunds will depend on the results of the water quality monitoring program. Warning levels and maximum allowable levels for suspended sediment concentration are defined. When warning levels are exceeded, an assessment is made of the best mitigating measure(s), based on where levels are exceeded, the activities, weather conditions etc, encountered before and during the incident.

# 11 Environmental Monitoring Plan

The monitoring program and its equipment, monitoring locations and frequencies and reporting requirements, is based on the information needs for the project. The monitoring program includes three sections:

- information needs
- the monitoring program including the equipment, the locations and frequencies
- the monitoring reports

## 11.1 Information needs

Several parties are involved in this project, including several ministries, the contractor, the local residents and the fishery communities, and resorts and dive centers located near the project site. Each of these parties has its own interests and concerns and consequently specific information is needed.

In this monitoring plan, which includes both the construction phase (which will be the responsibility of the contractor) and the long term (which will be the responsibility of the project proponent, allowing them to evaluate the success of the project), the most relevant information needs are described:

- water quality aspects, including suspended sediments and sedimentation;
- ecological aspects related to coral;
- soil salinity;
- the re-colonization of the borrow area at the flat reef;
- erosion around the borrow area.

### 11.1.1 Water quality aspects

Information need: what is the actual effect of the dredging and reclamation activities near the islands on the water quality?

One of the most important potential marine environmental impacts associated with dredging and reclamation works is the deterioration of water quality due to increased levels of suspended sediments and possible reduced oxygen levels.

Due to the re-suspension of the fine fraction of the coral sand, dispersion and resettling of the sediments during the dredging and the reclamation activities, a wide range of effects can be caused, including damage to coral and other organisms that cannot leave the area to escape the increased suspended solids. If the turbidity level is continuously high for a period of 3 months or more, significant damage can occur to coral. Significant sedimentation will also cause damage to coral and other sessile organisms. In the EIA a wide range of mitigating measures has been selected to minimize the re-suspension and dispersion and sedimentation of suspended sediments at the reef flat. Experience with similar projects on the islands of Vilufushi in Thaa atoll, and Viligili in Gaafu Alif atoll, has shown that there are two very important mitigating measures to reduce the release of suspended solids into the ocean.

The first one is closing off the reclamation area from the ocean by placing a bund before reclamation activities start. By doing this, the inevitable run-off from the reclamation can be concentrated in one location, minimising the area that is impacted.
The second important mitigating measure is using sufficient space to allow the finest particles to settle out of the reclamation run-off water before it is released to the ocean. The more fine particles can settle in the reclamation area and/or settling basin, the fewer fine particles get released into the ocean.
Due to the mitigating measures, the potential reduction of oxygen levels will also be minimised.

However, because the exact effects of the dredging and reclamation works at the islands cannot be predicted in detail, it is necessary to monitor the actual effects of the works on water quality. In this way the scale of the impacts as well as the duration of the impacts and the influence of the weather conditions will become clearer. The monitoring will have two purposes:

- to evaluate the effectiveness of mitigating measures already in place, such as the bund closing off the reclamation area from the ocean and the settling basing
- to signal the need for additional mitigating measures, such as the placement of silt curtains and adjustments in the dredging and reclamation processes.

The effects of dredging and reclamation on water quality are directly related to the working activities and the local physical characteristics, like the currents and waves. It is recommended to periodically monitor the currents along the reef to get more information on where the suspended sediments released at the borrow and reclamation areas may be transported to by the local currents.
During the construction of the reclamations at Vilufushi and Viligili, the suspended sediment plume did not disperse further than 2.5km away from the source under poor conditions. Suspended sediments settled within 2-5 days.

### 11.1.2 Ecological aspects related to coral.

Information need: what can cause damage to coral?

At the shallow reef area around the island there is hardly any coral. After the surveys at the shallow reef areas it is estimated that the life coral is less than 1%. Even at the reef edges there is practically no coral coverage. This is mainly due to the coral bleaching in 1998 and the tsunami in December 2004. Consequently at the shallow reef no monitoring of coral is required. At the line transects that were surveyed around the shallow reef area, the life coral coverage varies from less than 5% to 35% at the ocean side and from 6% to more than 70% at the atoll side.

*Turbidity and sedimentation*
If turbidity levels are significant during several months, the light available to the coral is reduced and consequently coral colonies may die. The critical value of turbidity for coral is 50mg/l. Sedimentation on coral is quite different. Soft corals and branching corals are less vulnerable than massive and table corals. The critical value for sedimentation on corals is 0.1kg/$m^2$/day. Most coral species have a mechanism to clean very fine sediments off of their surface, but they have difficulty cleaning off coarse sediments.

### 11.1.3 Soil salinity

Information need: can salt contained in the sediment used for the reclamation cause damage to the fresh water aquifer of the existing island?

By creating many low stockpiles instead of one big stockpile at the reclamation area, the rain will wash the salt from the sand on the reclamation area. The aquifer beneath the reclamation area will still be salt, but no effect is expected in the aquifer beneath the existing island. Any sand that needs to be put on the existing island will be transported by bulldozers (not using pipelines). Consequently there will be no impact on the aquifer. However, the sand can only be transported in case the rainfall has removed the salt.

### 11.1.4 The re-colonization of the borrow area at the flat reef

Information need: how long will it take for the borrow area to be colonised by marine organisms?

Re-colonisation of meiobenthos (< 1mm) is a much faster process than the recovery of the macrobenthos (>1mm). Complete restoration of the nematodes community can take place within some days. The restoration of the macrobenthos community after the sand extraction depends on the degree in which the new substrate is arranged for re-colonisation and establishment of larvae. Due to the presence of sea grass in the area, it is likely that the sea grass will cover the bottom of the borrow pit. The biological period of recovery can take place within some months to 2 or 3 years. It is expected that a lot of fish and benthic organisms will use this new area.

### 11.1.5 Erosion around the borrow area

Information need: what can cause damage around the borrow area?

The borrow area created by a TSHD will be located at relatively large depth (20-80m). It will be shallow, but covering a large area. At these depths, waves will not hit the seabed to stir up sediments.
It is expected that currents will barely influence these borrow areas, since the fastest currents run through the channels between islands and reefs where no dredging of sand will take place.

The borrow area created by a CSD will be located in the reef flat, and will have a basin-like shape. When sediments are stirred up by wave action, they will be trapped in the borrow pit. As a result the borrow area will silt up slowly. However, in time the sea grass may (re)grow around the borrow area, where it will trap the sand. Consequently only a limited quantity of sand will be transported to the borrow area by the currents.

## 11.2 The monitoring program

In this section, the requirements, methodology, equipment and monitoring locations and frequency for the monitoring components are presented. Included in this section are:

- water quality monitoring;
- sedimentation rate monitoring;
- erosion around the borrow area;
- recolonisation of the borrow area.

### 11.2.1 Water quality monitoring

Water quality monitoring at the islands shall be carried out by the environmental monitoring team of Boskalis to ensure that any deteriorating water quality is readily detected and that timely action is taken to rectify the situation. The objective of the water quality monitoring program is to determine the effectiveness of the operational controls and mitigation measures employed, and the need for supplementary mitigation measures to protect the coral.

General parameters to be recorded during sampling and measurements

- Location;
- time and date;
- weather conditions;
- sea conditions;
- tide;
- monitoring / sampling depth.

Parameters to be measured in situ

- dissolved oxygen (DO) (% saturation);
- dissolved oxygen (DO) (in mg/l);
- temperature (°C);
- turbidity (NTU);
- water depth (m).

Additionally, water samples will be taken periodically in conjunction with turbidity readings to determine Suspended Solids Concentration (SSC) and establish a relationship between Suspended Solids Concentration (mg/l) and turbidity (NTU). This relationship will help translate the turbidity readings that are taken at the monitoring locations into SSC so that comparison with the maximum allowed value is possible.

Parameters to be measured in the laboratory

- suspended solids (mg/l)

*Methodology*
For water quality monitoring the following equipment is required:

a survey vessel with DGPS positioning equipment;

- dissolved Oxygen and temperature measuring equipment;
- turbidity measurement equipment;
- water depth gauge;
- water sampling equipment.

*Locations and frequency*

The sampling and monitoring locations for the water quality will be determined at a later stage, after detailed engineering has been finalised, but before the dredging and reclamation works start. Water quality will be monitored at dive sites that may be impacted by increased suspended sediments, as well as the pearl farm and the edges of the fish spawning areas closest to the dredging and reclamation works.

Prior to the start of dredging activities a baseline survey will be done.

During detailed engineering, the monitoring programs for the Three Islands will be integrated in such a way that water quality data will be gathered before the start of dredging and reclamation works, during dredging and reclamation works, and after the completion of dredging and reclamation works.

*Table 11-1 water quality sampling and monitoring*

| Type | Parameters | Locations | Frequency |
|---|---|---|---|
| In situ monitoring<br>• 1m below surface<br>• middle of water column<br>• 1m above seabed | • Dissolved oxygen (% saturation)<br>• Dissolved oxygen (in mg/l)<br>• Temperature (°C)<br>• Turbidity (NTU);<br>• Water depth (m). | All locations | 2 times per week during dredging and reclamation works + once per day during one week before the start of dredging and during the first week after the start of dredging and reclamation works and during 1 week after completion of the works |
| Water sampling for laboratory investigations anywhere in the water column | Suspended solids (mg/L) | In the vicinity of dredging and reclamation works | Covering a sufficient range of suspended solids concentration to establish a satisfactory correlation + monthly to update the established correlation |

*Maximum value*

The maximum value of turbidity for coral is 50 mg/l.

### 11.2.2 Sedimentation rate monitoring

Sedimentation rate monitoring should be carried out by the environmental monitoring team to ensure that a proper assessment is made of the sedimentation levels on coral. The objective of the sedimentation rate monitoring program is to determine the effectiveness of the operational controls and mitigation measures employed, and the need for supplementary mitigation measures to protect the coral.

General parameters to be recorded during sampling and measurements:

- Location;
- time and date;
- weather conditions;
- sea conditions;
- tidal mode;
- monitoring depth.

Parameters to be measured in the laboratory:

- sedimentation rate (kg/m$^2$/day).

Parameters to be assessed by a scuba diver (visual inspections):

- percentage coral covered with sediment.

*Methodology*
For sedimentation rate monitoring the following equipment is required:

- survey vessel with DGPS positioning equipment;
- sediment trap tubes to be placed at the monitoring locations;
- scuba diver with photo/video camera.

*Locations and frequency*
The sampling and monitoring locations are indicated in *Table 11-2*. The frequency and the monitoring and sampling depths are indicated in Table 11-2.
Exact monitoring locations for sedimentation and coral health monitoring will be determined based on the final layout of the works. Locations will be chosen in areas where coral may be impacted by the dredging and reclamation works, but accepting the fact that there will be some inevitable impact in an area up to 500 m from the borrow and reclamation areas.

*Table 11-2 sedimentation rate monitoring*

| Type | Parameters | Locations | Frequency |
|---|---|---|---|
| Placing and collection of sediment trap tubes Approx 1m above seabed | Sedimentation rate (kg/m$^2$/day) | Half the locations on the reefs (depends on location of reclamation and the local currents). | 1 time per fortnight during dredging and reclamation works + 1 time after completion of the dredging and reclamation works |
| Visual inspection At coral areas investigated during the baseline benthic surveys | Coral coverage with sediment | All locations | 1 time before the start of the dredging and reclamation works + once per fortnight during the dredging and reclamation works + 1 time after completion of the dredging and reclamation works |

*Maximum value*
The maximum value for sedimentation on corals is 0.1 kg/m$^2$/day.

### 11.2.3 Erosion around the borrow area

It is expected that the erosion around the borrow area will be rather limited due to the presence of the sea grass. The local authorities will have to check this area. In case significant erosion takes place some rubble coral material can be placed around the borrow pit in order to stabilise the slope.

## 11.3 The monitoring reports

*Weekly monitoring reports*
The weekly reporting will be based on the monitoring results, site inspections and the evaluation/ interpretation of the monitoring results.

Based on the weekly monitoring results the effectiveness of the operational controls, the mitigation measures employed and the need for supplementary mitigation measures will be discussed between the Engineer and the contractor on a weekly basis. In case of extreme urgent matters a meeting between the engineer and the contractor will be arranged within 24 hours. The weekly reports shall be submitted to the engineer, the employer and the contractor.

## 11.4 Monitoring after construction

In the year(s) after construction of the reclamation and revetments has been completed, monitoring will be undertaken by the Ministry of Housing, Transport and Environment (see appendix 9 for letter of intent),

At the reclamation area, it is recommended that the following aspects are monitored:

- Signs of erosion and/or sedimentation
- Recolonisation by benthic flora and fauna at areas that were affected by the construction
- Condition of the revetments

At the borrow area, it is recommended that the following aspects are monitored:

- Sedimentation and/or erosion inside the borrow area and at the entrance (in case of dredging with CSD)
- Recolonisation of the borrow area by benthic flora and fauna
- Stability of the reef outside the borrow area (in case of dredging with CSD)

Additionally, the land use plan needs to be finalised, after full consultation with the Dhidhdhoo community, and progress of the implementation of the land use plan needs to be monitored by the Ministry of Housing, Transport and Environment.

## 11.5 Monitoring Responsibility

Boskalis is responsible for mitigation and monitoring during execution, whereas the Ministry of Housing, Transport and Environment (MHTE) is responsible for mitigation and monitoring after construction. MHTE's commitment is stated in the letter in Annex 9 of this EIA. Boskalis' commitment for monitoring and mitigation during construction is covered in Boskalis' SHE-Q (Health, Safety, Environment and Quality) system.

All mitigation measures as described in chapter 11 of the EIA will be implemented as part of the construction work method. Cost for these adjustments are included in the project budget. Construction of bunds to create a closed reclamation area before the start of dredging works has been included in the project planning (see chapter 4, figure 4-2, item 4)

Monitoring efforts after completion of the dredging and reclamation works are limited to surveys of bathymetry and coral health, with survey works taking approximately two days per island per six months.

# 12 Conclusions

*Environmental*

The following conclusions are drawn, based on the gathered information:

- The development of Dhidhdhoo as a Safe Island is acceptable from an environmental point of view, and project risks are relatively small.
- The reclamation of Dhidhdhoo with the EPZ and the higher bundwalls with revetments on the exposed sides can be done with minimal impacts on the environment, provided that preventative measures (closed reclamation, use of siltation basins) are implemented during construction and further mitigating measures are implemented when necessary.
- During detailed engineering, choices will be made regarding the final location of the borrow area and the final shape and size of the reclamation area. Environmental impacts, as well as economic feasibility, will be important factors in making these choices.
- During the dredging and reclamation activities, good care should be taken to allow only a pre-determined minimum of suspended sediments (50 mg/l) to escape from the working areas. Preventative measures will be in place to ensure minimal loss of suspended sediments, and additional mitigating measures will be available for implementation should the need arise. Monitoring should concentrate upon these aspects.
- Some coral reef will be damaged at locations where dredging takes place. All feasible measures will be taken to minimise the amount of coral damage by dredging the absolute minimum required depth and width to create access to the sand borrow area.

*Socio-economic*

The social-economic benefits of the project are large in relation to the number of people and the size of the economy. No potentially adverse effects or any risks have been identified.
The project results in new land for:

- housing
- schools: classrooms
- a hospital
- recreation, and a youth centre
- industrial development

This will improve current conditions and give an impetus to – economic - development.

The following conclusions are drawn, based on the gathered information:

- Consultations took place in an open and positive atmosphere, from both the local authorities and the population at large.
- The information on the Three Islands project has been somewhat haphazard and should profit from a more systematic approach.
- Dhidhdhoo has a position as provider of services and amenities, however the direct potential of tourism is limited.
- The creation of the new land is widely seen as providing opportunities for development.
- The project is also seen as an opportunity for redressing some current shortcomings such as the waste problems. This however is beyond the scope of the project addressed in this EIA.
- Infrastructure issues are lack of space, for school and hospital capacity, and fish landing and processing.
- Home gardening has some potential to be developed, but availability of land is the limiting factor.
- No negative effects – under the preposition of careful planning and execution - are identified.

**Recommendations – socio-economic**

The process of information and consultation is important, even a condition for succeeding, and has to be continued in order to mobilise the potential and ideas present: the Dhidhdhoo people think about the project in terms of opportunities.
In particular the female part of the population will have to be stimulated to participate actively.

*Gaps in information*
The current patterns around the islands and their possible effects on plume dispersal have been addressed in section 9.2 and will be assessed in more detail during the baseline survey immediately prior to the start of dredging operations and during the monitoring in the operations phase. These activities will be addressed in the Environmental Management Plan (also see chapter 11).

# 13 Appendices

1. IFC Performance Standards cross reference table
2. ToR approved by GoM
3. Boskalis SHE-Q
4. Dhidhdhoo preliminary land use plan
5. Turtle nesting sites in the Maldives
6. Dive sites & resort in the Haa Alifu Atoll
7. Meeting report of public consultation at Dhidhdhoo
8. Letter from MT Hojgaard regarding labour at quarries
9. Letter from Government of Maldives stating intent to continue environmental and social monitoring after completion of construction
10. Water quality monitoring Dhidhdhoo

# 14 References

1. *Environmental Impact Assessment Regulations*, Ministry of Environment, Energy and Water, Government of the Maldives, 2007

2. *International Finance Corporation's Performance Standards on Social & Environmental Sustainability*, International Finance Corporation, World Bank Group, 2006

3. *International Finance Corporation's Environmental Health and Safety Guidelines for Ports, Harbours and Terminals*, International Finance Corporation, World Bank Group, 2007

4. *EIA for the Post-tsunami Reconstruction of Safe Island Vilufushi, Thaa Atoll*, EDC, 2005

5. *EIA for the Construction of Safe Island Viligili*, EDC, 2006

6. *National Environmental Action Plan III*, Ministry of Housing, Transport and Environment, 2008

7. *National Strategy for Sustainable Development*, Ministry of Housing Transport and Environment, Government of the Maldives, UNEP, 2009

8. *Dhidhdhoo Benthic Survey,* Seamarc, 2009

# Appendix 1

**Cross Reference Table IFC Performance Standards**

| IFC PS # | Title | Points of Attention | Found in EIA |
|---|---|---|---|
| 1 | Social and environmental impact assessment and management systems | • Conducting EIA and/or SIA<br>• Involve local communities in EIA/SIA process<br>• Management of environmental and social issues through a management system | Main report contains EIA and SIA<br>See Chapter 7 & 8<br><br>See par 4.7 & 9.3 |
| 2 | Labour and working conditions | • Labour-Management relations<br>• Equal opportunities, no discrimination<br>• Meet Legal requirements<br>• Prevent child and forced labour<br>• Safe and healthy working environment | See par 4.10<br><br>See par 4.10<br><br>See App 2<br>See par 7.2.1, 9.4 and App XX<br>See 4.7, App 2 |
| 3 | Pollution prevention and abatement | • Prevention/mitigation of the risk of effects to public health and the environment | See App 2 |
| 4 | Community health, safety and security | • Prevention/mitigation of the risk of effects on health and safety of local community during project cycle, under normal and special circumstances<br>• Protection of personnel and property | See par 4.7, ch 9, app 2<br><br>See 4.7, ch9, App 2 |
| 5 | Land acquisition and Involuntary resettlement | • Preventing of minimising forced relocation where possible.<br>• Mitigating social and economical effects of land acquisition or restriction of use of land that is in the possession of (private) stakeholders<br>• Improvement or at least reinstatement of standard of living for relocated people | Not applicable. There will be no relocation of island inhabitants<br>Not applicable. The project will create new land, rather than require land acquisition.<br><br>Not applicable. No relocations of people will take place |
| 6 | Biodiversity conservation and sustainable natural resource management | • Protection and conservation of biodiversity in natural, impacted and critical habitats<br>• Measures to minimise the net loss of biodiversity<br>• Projects in critical and protected areas need to meet requirements of | See Ch 6, 9, 10, 11, 12<br><br>See Ch 9, 10, 11<br><br>See Ch 6, 9, 10, 11 |

| | | | |
|---|---|---|---|
| | | management plan for these areas<br>• Use of renewable natural resources should be sustainable, especially use of natural or planted forests, fresh water and marine systems (fisheries) | |
| 7 | Indigenous peoples | • The definition of indigenous peoples can differ between countries. Effects on these groups should be avoided.<br>• When this is impossible, effects should be minimised, mitigated or compensated (Indigenous Peoples Development Plan)<br>• Consultation. Participation and providing information to the local community are part of the project<br>• Development benefits have to be defined in line with the project.<br>• Effects on cultural heritage sites should be avoided or minimised.<br>• If required, relocation may be offered to an alternative location that has similar amenities to the original location. Need to meet PS 5<br>• The use of cultural resources for commercial purposes needs to be compensated after consultation | There are no indigenous minorities on the islands. All residents are affected equally. See Ch 7, 8, 9<br><br>See previous point<br><br>See Ch 8<br><br>See Ch 1, 2, 3<br><br>Not applicable. The project creates land, rather than using existing land.<br>Not applicable as there will be no relocations.<br><br>Not applicable. |
| 8 | Cultural heritage | • The PS applies to all cultural heritage whether protected by law or not, whether disturbed or not.<br>• Both National and International law are applicable.<br>• When the status of the heritage is not clear, an expert will be hired to assess the situation<br>• Cultural heritage may in principle not be removed. In case of relocation, an assessment needs to be made of alternatives and the benefits of the project and whether they justify the removal of the cultural | None of these items are applicable. Dredging and reclamation activities will be done well away from any cultural heritage sites. |

| | | | |
|---|---|---|---|
| | | heritage.<br>• Consultation with stakeholders whose heritage may be affected is part of the project.<br>• The use of cultural resources for commercial purposes needs to be compensated after consultation | |

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# Appendix 2

## Terms of Reference – EIA Three Islands

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# Terms of Reference (TOR)

## Reclamation and coastal works for Dhidhdhoo Island, Haa Alif Atoll, Maldives

**Doc number:** **09093-01-R-12-SROS-1-TOR Dhidhdhoo.docx**
**Date : 05 May 2010**


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## Document Control Sheet

| | |
|---|---|
| Client: | Government of the Maldives, Ministry of Housing, Transport and Environment |
| Title: | **Terms of Reference EIA (TOR)**<br>**Reclamation and coastal works for Dhidhdhoo Island, Haa Alif Atoll, Maldives** |
| Summary: | |

| Copy: | Issue Date: | Recipient(s): | Remark(s): |
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| 1-2 | | Archive Hydronamic bv, Master file | |
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| Rev: | Issue Date: | Engineer: | Sign | Review (DIC/IDC): | Sign |
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| a | 5-May-10 | S. Ross | | J.W.H. van de Meene | |

DIC: Department Internal Check / IDC: Inter-Department Check

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# 1 TOR for Environmental Impact Assessment (EIA)

The present chapter gives guidelines and describes Terms of Reference (TOR) for the proposed EIA for the reclamation and coastal works at Dhidhdhoo.

## 1.1 Problem analysis and project objectives

In the EIA report the following aspects should be addressed:

- Relationship with New Safe Islands Project, which has been developed to address the problems of sea level rise and increased extreme weather conditions, while at the same time aiming at concentrating population to provide better services and infrastructure;
- Whether and how environmental considerations played a role in the selection of Dhidhdhoo;
- Description of the living conditions including public health situation and safety aspects;

The main objective of the project is to create a safer and larger island for the present residents as well as for residents of some other smaller nearby islands who may move to the enlarged islands. The planned activities for this phase of the project are restricted to dredging, land reclamation, shore protection and the improvement of the harbour. The EIA report should also indicate required follow-up activities to fully contribute to the solution of the problems as identified in the preceding section.

The EIA report should contain a clear definition of the objectives of the proposed activity to enable identification and formulation of alternatives and to furnish criteria for monitoring and evaluation. Objectives should be formulated in such a way that identification of alternatives – meeting the same objectives- remains possible. Finally, the objectives should be specific and if possible quantified.

## 1.2 Project Setting

The EIA report should describe national laws, rules, regulations and policies governing the proposed activity and if relevant, international conventions and regulations. The EIA report should assess the probability of compliance of the intended activity with these legislative and regulatory considerations and policies.

The EIA report should give a clear description of the legal and administrative framework in the Maldives, including competent (licensing) authorities directly involved in the execution of the project and in the control of the executed works. A description of the EIA procedures to be followed is provided in the Environment Act 4/93 and in the EIA guidelines (2007).The EIA report must also indicate which competent (licensing) authority is committed to the follow-up activities once project activities are finished and how maintenance of the works will be secured.

The EIA report should contain a description of the stakeholders in the project and how their opinions and interests influenced the contents of the EIA report. The views of the following stakeholders should be taken into account:

- Project beneficiaries, men as well as women (inhabitants of Dhidhdhoo);
- Local fishermen possibly affected by dredging works;
- National, regional (atoll and island) government agencies with formal responsibilities in environment and social welfare, and
- National and international organizations (including NGOs) involved in the implementation of the project and follow up activities.

The EIA report must indicate in which way the inhabitants are involved in the project design and the project execution.

## 1.3 Description of the project and alternatives

The main project activities of the reclamation and coastal works for Dhidhdhoo are the following;

- Dredging of approximately 1 million $m^3$ of coral sand from a nearby borrow area and pumping the material into the reclamation area;
- Finishing the reclamation area to the required levels, including the elevated zone surrounding the island, based on the 'safe island' concept;
- Construction of revetments over a length of about 1300 m;
- Detailed design and construction of a beach area;
- Detailed design and construction of groynes (approx. 100m) to protect the beach area;
- Environmental monitoring during construction activities;
- Measures to protect environmental values during construction and once the new island has been established.

The project execution is expected to take about 6-8 months for each island.

Dredging

The EIA report must describe the following aspects of the dredging activities:

- Location and size of sand borrow area(s) on a map;
- Justification for the selection of this location;
- Quantity, quality and characteristics of fill material;
- Indication of guarantees for sufficient availability of fill material;
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures;
- The arguments which form the basis for choosing this technical alternative;
- Way of operation; from which side and how will the dredging equipment be positioned in the designated borrow area (including depth of access channel, anchoring);
- Duration of the dredging activity;
- Labour requirements and (local) labour availability;
- Housing of temporary labour, and
- Emergency plan in case of spills (diesel, grease, oil).

The EIA report should study promising alternatives such as:

- Operation and positioning options;
- Alternative borrow area locations: have these been considered and if so, give arguments why these alternative locations were not selected, and
- Lay out of borrow pits, large shallow pits versus small deep pits to allow quick recovery of the seabed.

Land reclamation by filling

The EIA report must describe:

- Design of the reclamation area, including a justification (both from a social as well as from an environmental point of view) for the choice of the shape;
- Planning and timing of sub-activities (order of the works, clearance, dredging and reclamation);
- Method and equipment for transport of fill material and hydraulic filling;
- Distance of transport;
- Need for and location of temporary stockpile(s);

- Location and design of the external bunds for the containment of the sand, together with a description of their stability against waves and current attacks;
- Location(s) and method of discharging water from the reclamation area;
- Description of safety measures during the construction phases and
- Labour requirements and (local) labour availability.

The EIA report should investigate possibilities for alternative:

- Location, routing and design of pipelines;
- Design of bunds, including materials used.

Shore protection works

The EIA should indicate:

- Design criteria;
- Planning for construction of EPZ ( Environmental Protection Zone) and of the shore protection works and
- Methods and equipment used for the construction of these works.

The EIA report should investigate alternatives for materials used in shore protection works (rock, sand-cement bags).

Harbour related activities

The EIA report should indicate:

- Construction and design of quay wall
- Construction and design of break waters, and
- Methods and equipment used for construction.

Mitigating measures and alternatives

Mitigating measures to prevent or reduce negative environmental or social effects during the implementation of the project must be described. These may include alternative dredging methods, measures to diminish risks (e.g. safety precautions), phasing, such as the preferred season in relation to fish migration and sediment dispersal and measures to prevent disturbance, pollution or smothering of valuable ecosystems.

The decision to reclaim additional land at Dhidhdhoo has already been taken; this implies that only implementation alternatives have to be described.
The EIA report must describe at least two alternatives:

- The preferred alternative developed by the proponent;
- An alternative which contributes maximally to sustainable development, which may be a combination of the environmentally most favourable implementation with least hindrance for stakeholders.

## 1.4 Description of the natural and socio-economic environment and its autonomous development

The EIA report must contain a description of the current situation of the natural and socio-economic environment and its development if no project will be established (the autonomous development or reference situation). This serves as a basis for comparison of the impacts of various alternatives.

Natural environment

The EIA report must address the following aspects:
Climate:

- Temperature, precipitation, evaporation and wind (including extreme situations), and
- Risks of hurricanes and storm surges;

Geology and geomorphology:
- Offshore/coastal geology and geomorphology;
- Bathymetry (bottom morphology);
- (Seasonal) patterns of coastal erosion and accretion, and
- Characteristics of the seabed sediments;

Hydrography/hydrodynamics:
- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Turbidity/sediment concentrations;
- Sediment transport patterns by currents and waves.

Ecology:
- Protected areas, protected or endangered species;
- Ecosystems and their characteristic flora and fauna (terrestrial, coastal zone and marine environment, including the benthic layer);
- Identification of vulnerable ecosystems and environmentally valuable areas (eg. coral reefs, spawning sites for fish, nursery areas for crustaceans or specific sites for marine mammals, sharks, and turtles) and Ecological conditions required for sustainable fisheries and;
- Landscape integrity.

Socio-economic environment

The EIA report must describe:

Demography:
- Total population at Dhidhdhoo;
- Population structure, sex ratio, density, growth, and
- Population pressure on land and marine resources;

Economic:
- Income situation and distribution;
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Fishing methods deployed;
- Seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities at sea;
- Land tenure and land allocation, and
- Accessibility and (public) transport to other islands.

Social and living conditions:
- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Living conditions (e.g. size of plots, houses and households);
- Sites with historical or cultural interest or sacred places (eg. graveyard, mosques).

## 1.5 Impacts

The potential impacts must be described per alternative considered. Negative as well as positive impacts have to be described. Also impacts of the project activities after finalization of the construction phase have to be described.

Impacts on the natural environment
The EIA-report must describe:

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology;
- Loss of marine bottom habitat, both in the borrow area as well as due to enlargement of the islands, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity and density of crabs, shellfish etc.;
- Sediment dispersal in water column (turbidity at the dredging site, the reclamation areas (overflow) and related to harbour construction activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.;
- Impacts of noise, vibration and disturbance;
- Impacts on ground water table and quality as a result of reclamation (leaching of salts in the deposited sediments and change in groundwater quantity);
- Estimated time required to reach water quality of acceptable levels and soil conditions suitable for home gardening;
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment
The EIA-report must describe for the proposed activity:

- Impacts of the works on fishing activities (disturbance);
- Impacts of the dredging and reclamation works on tourism (nearby resorts and dive sites);
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Impacts of reclamation works on (diminished) access to groundwater and risks of covering up hazardous materials, and
- Level of protection against natural hazards like sea level rise, storm surges etc.

The follow-up activities of the proposed activity will also have socio-economic impacts, which require due attention, such as:

- Size and allocation of plots, including possibilities for home gardening;
- Impacts on food and nutrition security (fisheries, agricultural activities, supply of other food);
- Social services like health and education;
- Employment and economic opportunities and diversification;
- Increased demands on natural resources and services: domestic water supply, waste water disposal and treatment systems, solid waste disposal systems, energy supply etc.;
- Impact equity (economic activities, employment, income);
- Social destabilization of the island community, and
- Monitoring of socio-economic and demographic development.

Construction related hazards and risks
The EIA report should describe:

- Pollution of the natural environment (e.g. oil spills, discharge of untreated waste water and solid waste, including construction waste);
- Impacts of noise, risks (accidents) and pollution on workers and local population and

- Impacts social values, norms and belief due to presence of workers of dredging company on local population.

## 1.6 Comparison of implementation alternatives

Environmental and socio-economic impacts of implementation alternatives must be compared, leading to at least the preferred alternative of the proponent and the alternative contributing maximally to sustainability. It is recommended to present the comparison in the form of tables and diagrams. All alternatives must be compared according to international and commonly accepted standards as much as possible. The comparison must yield the preferred alternative for implementation. For comparison, selection and valuing of alternatives discriminating economic, technical, ecological and social criteria have to be identified.

## 1.7 Monitoring and evaluation

In the EIA report an environmental monitoring plan must be presented, for both the construction phase and long term. This plan must include monitoring of at least:

- Turbidity;
- Sedimentation rates on nearby coral reefs, benthic system and sea grass beds;
- Condition of the sensitive ecosystems and marine resources;
- Re-colonisation of the benthic organisms in the borrow areas;
- Erosion and accretion;
- Environmentally sound site clearance;
- Environmentally sound removal of dredging and other equipment including construction materials, and
- Employment of available local labour force.

The monitoring plan must indicate the institutions responsible for its implementation and the way implementation is funded. It must also include a description of where, how and when (duration and frequency) the sampling and monitoring should be conducted.

A project evaluation plan has to be included in the EIA report, indicating which institution will be responsible for evaluation. The main item of evaluation will be to which extent project objectives have been fulfilled.

## 1.8 Format and presentation of the EIA report

The EIA report will be written in format as described in Schedule E of the EIA Guidelines (2007) of the Maldives. A non-technical summary must be included; it must address the major subjects of the EIA report and be written in such diction that it provides non-technicians with a clear insight in the issues treated.

# 2 Conclusions

1. The reclamation of the islands with the EPZ and the higher bundwalls on the exposed sides will protect the local population and the land ecology. The project is required for social and economic reasons. It is acceptable from an environmental point of view, and project risks are relatively small.

2. In case the island would not be provided with some kind of protection against the sea and not be increased in size, in time the population will have to move to other (safer?) islands.

3. The exact location of the borrow area has yet to be determined, based on the results of ongoing surveys.

4. During the dredging and reclamation activities, good care should be taken to allow only a pre-determined minimum of suspended sediments to escape from the working areas. Mitigating measures such as protection bunds on the reef and/or settlement basin(s) in the reclamation area should be employed when the necessity arises. Monitoring should concentrate upon these aspects.

5. Considering the Maldivian regulations it is recommended to execute an EIA for the project, using the TOR as described in chapter 7. However in view of the limited detrimental environmental effects of the project and the similarity to the recent EIA's for the Vilufushi reclamation project, for the construction of safe island Viligili project, no unforeseen EIA results are expected for the EIA of the Dhidhdhoo project.

6. Soil investigations and ecological surveys have to be carried out before the start of the project.

# 3 Reference

Most of the information presented in this document was obtained from the environmental studies that were done for the reconstruction of Vilufushi in 2006, Viligili in 2008 and the preparation for the reconstruction of Thulusdhoo (2007-2008) and the experiences gained during the execution of the projects at Vilufushi and Viligili.

EDC, 2005, Inintial Environmental Evaluation for the Post-tsunami Reconstruction of Safe Island Vilufushi, Thaa Atoll

EDC, 2005, EIA for the Post-tsunami Reconstruction of Safe Island Vilufushi, Thaa Atoll

EDC, 2006, Initial Environmental Evaluation for the Construction of Safe Island Viligili

EDC, 2006, EIA for the Construction of Safe Island Viligili

EDC, 2006, Initial Environmental Evaluation for the Reconstruction of Thulusdhoo Island, Kaafu Alif Atoll

EDC, 2006, EIA for the Reconstruction of Thulusdhoo Island, Kaafu Alif Atoll

# Appendix 3

## 1 ENVIRONMENTAL MANAGEMENT PLAN FRAMEWORK

### 1.1 General

Boskalis International bv is one of the working companies of Royal Boskalis Westminster nv. As such Boskalis International bv subscribes the statements of and works according to the standards and policies set by Royal Boskalis Westminster nv based on the relevant ISO-standards (9001 and 14001) and the International Safety Management code (ISM). As such the Environmental Management Plan (EMP) is based on Boskalis Standards with the inclusion of project specific requirement and conditions.

The Environmental Management Plan forms an addition to the Boskalis' Policy Statement HS&E (RBW-002).

### 1.2 Responsibilities

The ultimate responsibility for the environment on the Project remains with the Project Manager, who will or will ensure that:

- The Project Environmental Plan meets local safety regulations.
- Sufficient qualified people are on site/board.
- The Project Environmental Plan is available to all persons with permission to frequent the site.
- Undertake random spot-checks on site to verify compliance with the Project Environmental Plan.
- Administer, update and revise the Project Environmental Plan.
- Prior to the start of the works and on a regular interval during the execution of the works, the Project Manager will hold environmental meetings to inform and instruct all personnel about the environmental regulations in force at the site.

### 1.3 Laws, notices and permits

The works will be carried out according to prevailing laws, notices and permits within the designated project working area. Special reference is made to the Environmental Monitoring program.

### 1.4 Avoidance of nuisance

All works and movement of plant will be carried out in such a manner as to cause as little inconvenience and disturbance as possible, to the residents.

The site will be maintained in a clean tidy condition, and all materials will be stored in an orderly manner. Provision for the discharge or disposal of all wastewater products will be made, in consultation with the Client and any concerned local authorities.

All temporary works and structures will be removed from site upon completion.

### 1.5 Water quality control

The works will be carried out in such a manner as to minimize adverse effects on the water quality during the execution of the works. The method of working will be arranged in such a way as to minimize adverse effects at the site itself, on transport routes, and at loading, unloading, dredging and reclamation areas.

The vessels will bunker at the site. During bunkering activities oil spillage is the main incident through which the aquatic environment may be affected. The following measures will be taken to prevent spillage:

- Bunkering activities will only take place under safe weather conditions.
- The fuel tank will be sounded regularly during the bunkering operation to avoid overspill.
- All hoses will be sufficiently drained before being stowed.

For wastewater originating from a/o the engine room, pump room and decks (bilge water), the dredger is provided with a separator. In this way water containing oily substances can be separated into sludge oil and purified water. The sludge oil will remain on board and later disposed of through the concerned local (Port) authority.

A potential risk for water pollution is the chemicals on board the dredger. This concerns mainly fuel, lubricant oil, hydraulic oil, grease, anti-freeze, degreasing products and paint. However, the quantities of these chemicals are low and they will be properly stored in the engine room, engine room store and paint storeroom. There is a requirement that containers in which dangerous substances are supplied have clearly visible signs showing the chemicals particulars.

For dredging activities the working method will aim to achieve the following:

- Minimize disturbance to the seabed as far as practicable and possible, other than in the actual area being dredged and reclaimed.
- Minimize loss of material during the dredging process, transportation and discharge.
- Ensure that discharge takes place only in the areas designated for such purposes
- Minimise deterioration in water quality, which could cause adverse effects on marine life.

Plant will be designed and maintained in a condition that will minimize the risk of material being released into the water or being deposited at locations other than those designated.

## 1.6 Air quality control

Measures will be taken to avoid pollution of the atmosphere by ensuring that fuel-burning equipment does not produce unacceptable levels of exhaust gases, etc. Air quality may be affected by the emission of pollutants in the exhaust gasses of dredging equipment. The exhaust gas consists of the following pollutants:

- soot particles
- sulphur oxide
- nitrogen oxide
- hydro carbons
- carbon monoxide

The quantity of the sulphur emission depends directly on the sulphur content of the fuel. The rate of emitted soot particles, carbon monoxide and hydro carbons results from incomplete combustion. The quantity of emitted nitrogen oxides is influenced by the load and the number of revolutions.

The floating equipment is subject to the Dutch shipping inspectorate and thus complies with Dutch norms for air emissions. Due to the open nature of the working areas (enough ventilation) the impact is assumed to be light. Nevertheless, the following actions should be undertaken in order to ensure that pollution of the atmosphere is minimised:

- The engines will be maintained in good working conditions, so that exhaust emissions of pollutants will be kept to a minimum.
- With complete combustion, emissions of soot particles, hydro carbons and carbon monoxide are minimised.
- The vessels will be subjected to regular inspection and maintenance programs as regular practise.

Since the dredging activities take place entirely in a wet environment dust problems will not be encountered.

## 1.7 Noise control

All practical measures will be taken to ensure that the dredger and support vessels will not cause unnecessary or excessive noise. Engines will not be permitted to run idle for excessive periods. Normal measures, based on good reasonable practice, for limiting noise, such as silencers, mufflers, acoustic linings, shields or screens, will be used where circumstances require.

Noise originates from mechanical sources such as winches, gearboxes, hydraulic pumps and engines. Working personnel of the dredges are properly protected from noise according to proper Health and Safety Procedures. The floating (dredging) equipment is subjected to the Dutch Shipping Inspectorate (the Dutch Government), and thus complies with its norms for noise emissions.

The effects of noise on fauna, like birds and fishes should be local, temporary and of small magnitude. Prior to deployment the condition of the selected equipment is checked and during the execution of the project the engines are not permitted to run idle for excessive periods.

## 1.8 Waste disposal

All inert waste shall be segregated, collected, brought ashore and disposed of at an allocated, public dumping site. All non-inert waste will also be sorted into various categories, collected, brought ashore where applicable, and disposed of through the relevant Port authorities in Maldives or abroad in accordance with local "Waste Disposal Regulations".
No garbage, refuse, waste oil, or other deleterious matter shall be discharged from any vessel, but shall be sorted, collected and disposed of in a manner befitting its nature.
No heated water shall be discharged form any vessel in areas where such a discharge could adversely affect the ecological balance.

Reference is made to the following sections of Boskalis' procedures:

- Safety instruction Booklet (appendix I): paragraph 1.31 'Waste dumping';
- CTD-Procedure EQP-301: 'Garbage Collection, Storage Disposal';
- RBW-516-01c: 'Sludge and Garbage Disposal';

## 1.9 Spillage control

Liquids, such as fuel and lubricants, shall be stored in leak proof containers, and where appropriate, such as when emptying, or filling containers, drip trays shall be used.
During bunkering operations precautions shall be taken to ensure that no spillage takes place during uncoupling of hoses, and that all hoses are suitably drained before being stowed.

### 1.9.1 Steps to minimize oil spillage

#### *1.9.1.1 Preventive measures*

The prevention of oil spills should be regarded as a high priority in any dredging operation. The most commonly recorded cases of operational spills are, bunker overflows, pipeline leakage and oil spray from tank vents.

If despite the adherence to proper procedures, an oil spill does occur, all bunker
operations should be stopped by the quickest possible means and should not be re-started until the source of the leak has been identified, rectified and all hazards from the oil released have been eliminated.

#### *1.9.1.2 Tank Overflow*

Should a tank overflow occur, the flow to the tank should be stopped immediately and the level in the tank lowered by the most practical means.

#### *1.9.1.3 Pipeline Leakage*

Should a leakage occur from the dredger on-deck pipe work the bunker operation should be stopped immediately and pressure relieved from the leaking section of line. The line content may be dropped if necessary pumped into an empty or slack tank.

#### *1.9.1.4 Oil Spray from Tank Vents*

In case an oil spray occurs from the tank vent, the flow should be stopped. The cause of the oil entertainment in the vapour flow should be established and the necessary measures taken to rectify this.

#### *1.9.1.5 Containment on Board*

In the event of an oil spill on deck, the following steps should be taken to prevent or minimise overboard pollution.

1. Stop source of leak.
2. Place drip trays to catch leakage.
3. Soak up oil with absorbent material, sawdust etc.
4. Ensure scupper plugs are tight and any excess water drained off.

### 1.9.2 Spills resulting from casualties

#### *1.9.2.1 Priority Actions*

In the event of a casualty the Captains and Senior Dredge Masters prime concern will be for the safety of the ship and its crew, and taking whatever measures are necessary to prevent escalation of the incident. When spillage has occurred immediate measures should be taken to prevent fire and explosion.

## 1.10 Dangerous materials handling

Handling of dangerous materials in relation to dredging and reclamation operations are described in several Boskalis' safety and environmental procedures, the most relevant procedures:

- Safety instruction Booklet (appendix I): paragraph 1.30 'Dangerous Materials';
- CTD-Procedure EQP-209: 'Working with Radioactive Sources (ISM vessel)';

All vessels under Dutch flag (ISM) are to comply with ARBO-regulations (Dutch Occupational Health and Safety Act) regarding handling of dangerous materials and goods, and thus comply with its norms for handling of dangerous materials and goods.

## 1.11 Flora and fauna

Except with the express permission of the Client, and if appropriate any relevant
Authorities, no vegetation, plants, shrubs or trees shall be removed from any part of the site. Care will be taken to ensure that disturbance to any bird or animal life in the vicinity is kept to the minimum, compatible with the nature of the construction activities. Co-operation will be sought with conservation bodies, all instructions and guidelines relating to ecological protection will be observed, and our activities so organised as to cause the least practical interference with the local wildlife population.

## 1.12 Environmental account

Diesel and lubrication oil delivered on board the cutter dredger and the cutter section dredger is registered on the daily log sheets of the engine room. The fuel and lubrication oil received is

registered through approved delivery notes from the supplier. The supplies are checked by means of sounding of the fuel and lubrication tanks.

Waste oil is being registered in the Oil Record Book which correspond with Marpol reg.20 Annex I. The consumption of fuel is measured on a daily basis and recorded in the daily log sheets.

## 1.13 Reporting of environmental accidents and dangerous situations

Before commencing work on site the requirements of environmental protection and all applicable legislation will be explained to all employees.

- In the event of such an accident, the following emergency procedure must be activated:
- The Project Manager will be informed
- Call Project Manager phone number (to be defined) and forward:
  - The address and location of the accident
  - Project Name/Identification
  - Type of accident, fuel, oil, personnel involved
  - Time of accident
- Project Manager will notify the relevant authorities and the nearest pollution combat unit.

All personnel and equipment accidents, near misses, damages and environmental calamities will be reported to Boskalis' head office in the Netherlands. Specific procedures apply, as outlined in RBW-585 'Accident/Damage/Sopep Reporting'. An investigation into the cause of the accident or damage will be conducted followed by taking appropriate actions to prevent similar situations in the future (see also next paragraph).

## 1.14 Utilisation of recorded data

All reported accidents to the environment will be analysed, in order to determine the cause, and if practical, their effect on the environment. The results of such analyses will be documented. Dependent on the nature of the accident and its cause, consideration will be given to one or more of the following courses of action to ensure that such an accident do not occur again:

- Revise or adapt method of working.
- Take additional preventative measures.
- Re-instruct and/or retain involved persons in existing methods of working.
- Draft / revise documented procedure / work instructions.

The actual course of action to be followed will be in line with existing environmental laws and regulations, the requirements of the contract specification, and the instructions of the Client.

## 1.15 Project specific requirements

#### *1.15.1.1 Water quality management and Ecosystem protection*

As standard practice of Boskalis International bv, dredging and reclamation activities will be carried out in a manner so as to minimize disturbance to the environment, and in fully accordance with relevant legislation and regulation on environmental matters. Target and goal of Boskalis International is to plan, carry out, check, review and improve the Environmental Management Plan in order to keep environmental short-term impacts to an acceptable level in keeping with the practical nature of the operations.

Boskalis International will prevent pollution to seawater and operate in accordance to best international practices. As stated in the Policy Statement of Boskalis international, all employees will execute their work with proper concern for the protection of the environment.

Special areas of interest in the vicinity of the dredging works are seagrass and coral, which are described in Chapter 6. The impact of the dredging and reclamation activities on the environment

and mitigating measures that may be necessary are described in Chapter 8, the subsequent monitoring program are presented in Chapter 11.

## 1.16 Oil spill management

Reference is made to paragraph 12.9.2.

According to the standards of MARPOL 73/78, Annex I, Regulation 26, the crew is promptly trained to apply the Shipboard Oil Pollution Emergency Plan (SOPEP), under the responsibility of the Chief Engineer.

## 1.17 Personnel environmental training programmes

Workforce personnel undergo regular safety and environmental training programmes. Most important courses include:

- In-house Boskalis courses by HS&E Department;
- Full VCA course, detailing safe working with hazardous goods;
- SOPEP-training (Shipboard Oil Pollution Emergency Plan);
- Shipping Transport College courses; 'Working with contaminated soils and dredge material';
- Marine fire fighting course (including dangerous and toxic goods handling);
- First Aid Course.

For site staff personnel different safety and environmental related training programmes and courses apply, some examples:

- At Bureau Veritas the Environmental Management Systems Training have been followed
- DLP (Professional Leadership for Projects) course
- Intercultural management course;
- Communication course;
- First Aid Course.

Both workforce and staff personnel are obliged to keep their knowledge up to date by attending HS&E (refreshment) courses on a regular basis.

## 1.18 Promotion of environmental awareness

Boskalis applies the slogan 'Safety is in your hands' for promotion of personnel safety and environmental awareness. Several posters are available to be put up at site (offices) and at dredging spreads. Moreover a safety booklet and HS&E stickers (RBW-511) are available. All Boskalis' project-personnel have been handed out the Safety instruction Booklet, updates will be provided as new versions are released.

# Appendix 4

## Land Use Plan

Under development by Ministry of Housing, Transport and Environment

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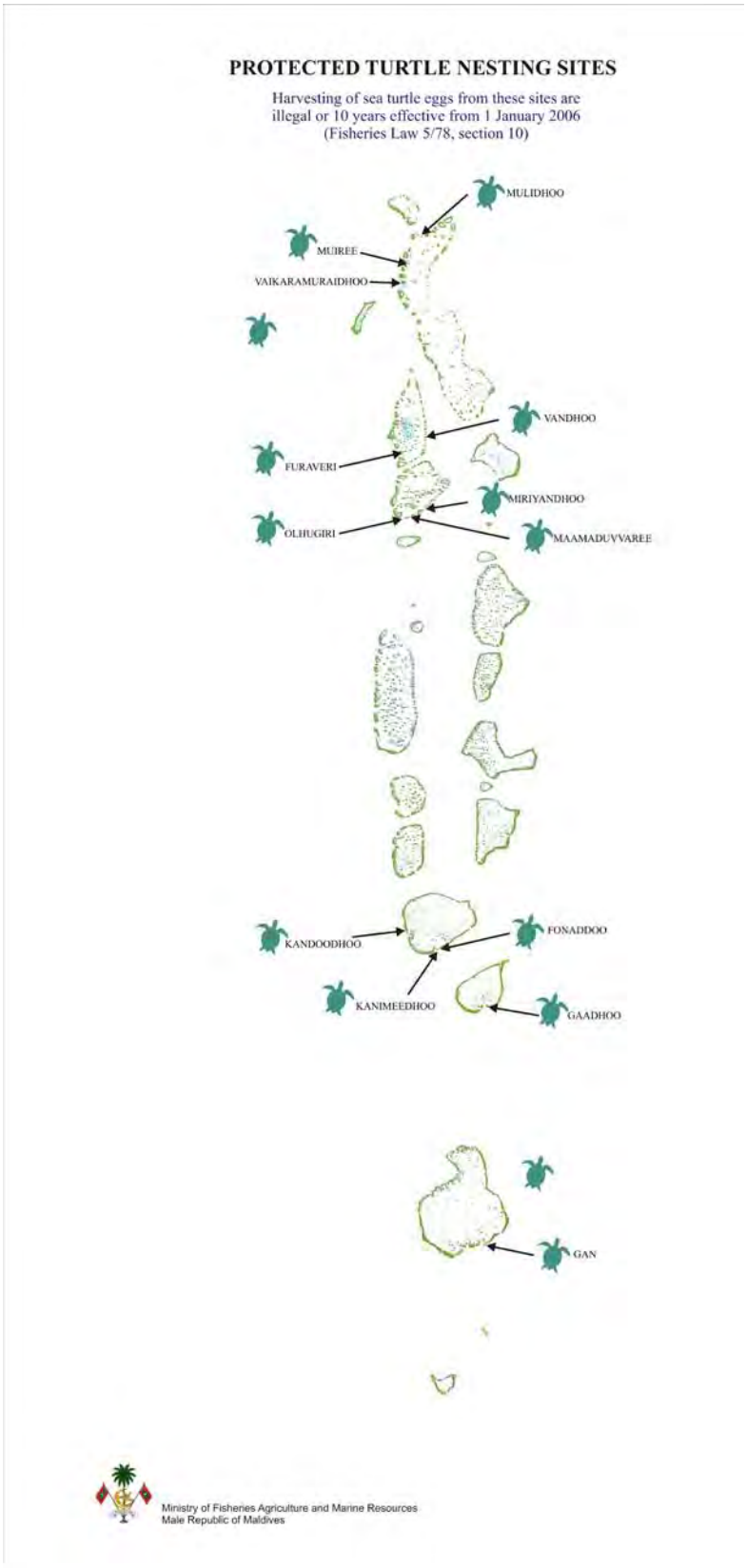
# Appendix 5


PROTECTED TURTLE NESTING SITES
Harvesting of sea turtle eggs from these sites are illegal or 10 years effective from 1 January 2006 (Fisheries Law 5/78, section 10)
MULIDHOO
MUIREE
VAIKARAMURAIDHOO
VANDHOO
FURAVERI
MIRIYANDHOO
OLHUGIRI
MAAMADUVVAREE
KANDOODHOO
FONADDOO
KANIMEEDHOO
GAADHOO
GAN
Ministry of Fisheries Agriculture and Marine Resources
Male Republic of Maldives

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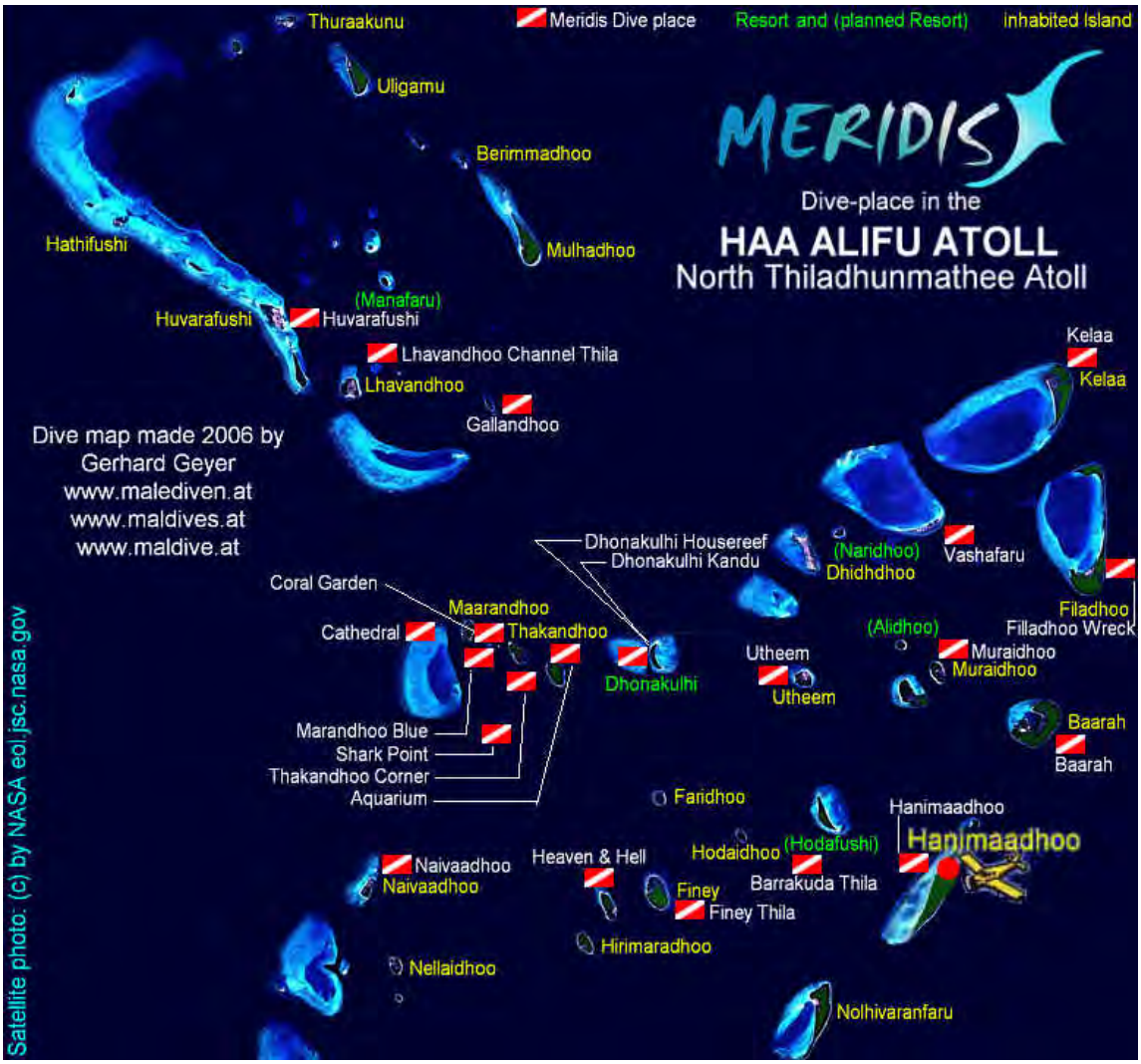
# Appendix 6

## Dive site locations in Haa Alif Atoll

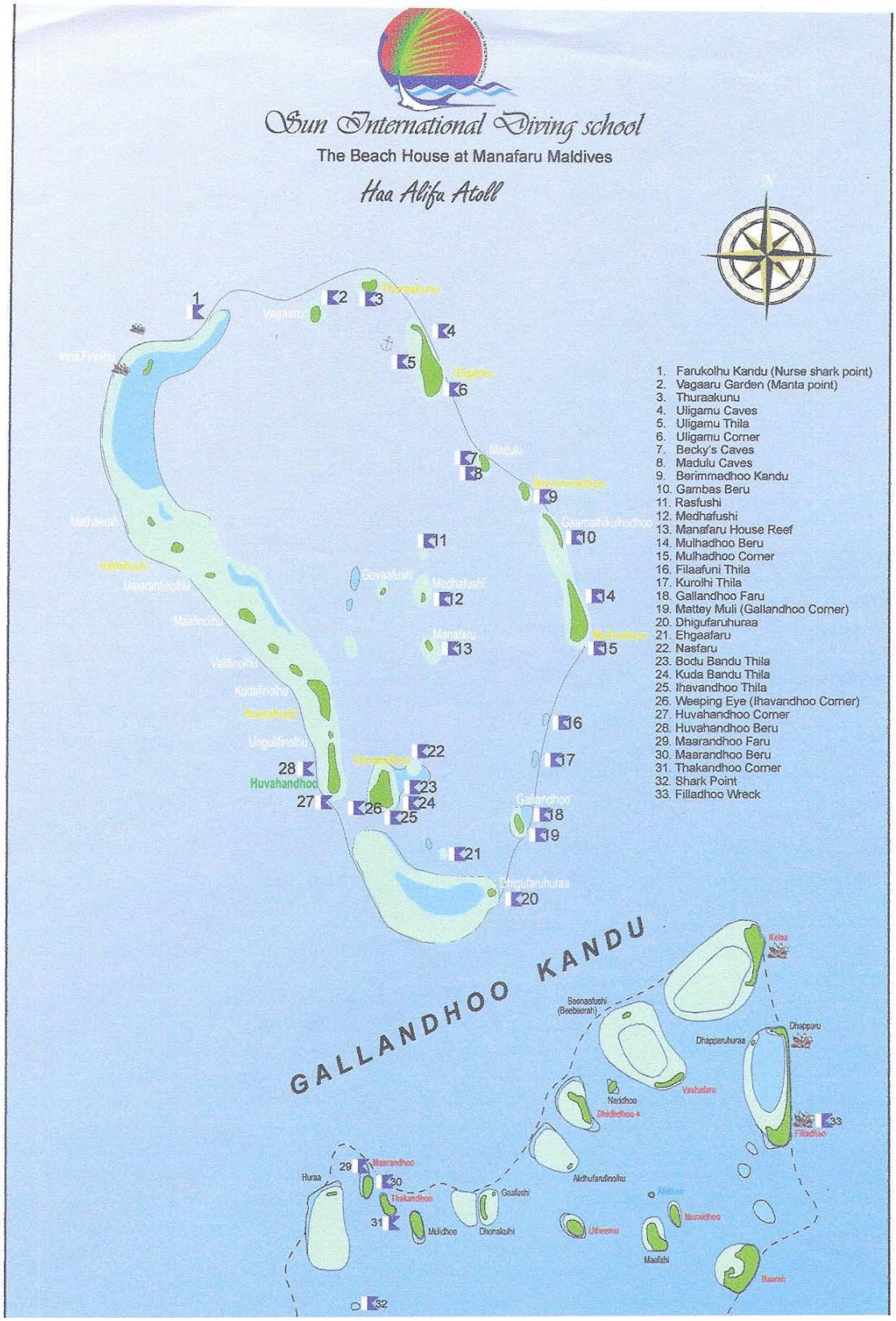
Dive site map from the Meridis Dive Centre at Cinnamon Island Resort, Alidhoo

| No. | Name | Distance in Minutes |
|---|---|---|
| 1 | Alidhoo Housereef | 0' |
| 2 | Aquarium | 60' |
| 3 | Baarah Blue | 35' |
| 4 | Baarah Thila | 30' |
| 5 | Baarah Wall | 40' |
| 6 | Bodu Maagu Thila | 75' |
| 7 | Cathedral | 110' |
| 8 | Coral Garden | 80' |
| 9 | Dhapparu | 40' |
| 10 | Dhonakulhi North | 45' |
| 11 | Filladhoo Wreck | 40' |
| 12 | Finey Thila | 75' |
| 13 | Hanimaadhoo Housereef | 45' |
| 14 | Heaven & Hell | 80' |
| 15 | Hirimaradhoo Housereef | 90' |
| 16 | Hirimaradhoo Thila | 90' |
| 17 | Hodaafushi | 40' |
| 18 | Hodaidhoo Thila | 45' |
| 19 | Hondhadhoo Thila | 50' |
| 20 | Hukuru Thila | 35' |
| 21 | Kelaa Wall | 60' |
| 22 | Kihafen Thila | 90' |
| 23 | Maafahi Beiru | 15' |
| 24 | Maafahi Corner | 15' |
| 25 | Maafahi Housereef | 10' |
| 26 | Maarandhoo Blue | 80' |
| 27 | Mathi Faru | 55' |
| 28 | Meridis Thila | 60' |
| 29 | Muraidhoo Corner | 15' |
| 30 | Muraidhoo Housereef | 10' |
| 31 | Muraidhoo Thila | 15' |
| 32 | Mushroom Thila | 120' |
| 33 | Naridhoo Housereef | 35' |
| 34 | Naridhoo Wall | 35' |
| 35 | Nellaidhoo Thila | 120' |
| 36 | Sunset Faru | 55' |
| 37 | Thakandhoo Caves | 75' |
| 38 | Thakandhoo Corner | 75' |
| 39 | Tropical Garden | 75' |
| 40 | Vasha Faru | 45' |

Dive site map from the Meridis Dive Centre at Island Hideaway, Dhonakuli



Dive sites map from Sun International Diving School at The Beach House, Manu Faru



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# Appendix 7

## Public Consultation Report by Ministry of Housing, Transport and Environment

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بسم الله الرحمن الرحيم

**ENGINEERING SECTION**
**MINISTRY OF HOUSING, TRANSPORT AND ENVIRONMENT**

*Public Consultation Report*

# DREDGING, RECLAMATION & SHORE PROTECTION PROJECT





| | | |
|---|---|---|
| *PROJECT* | : | **3 Island Reclamation Project** |
| *EMPLOYER* | : | **Ministry of Housing, Transport and Environment** |
| *CONSULTANT* | : | **-** |
| *CONTRACTOR* | : | **Boskalis International bv.** |

# B. THULHAADHOO PUBLIC CONSULTATION MEETING

Venue: B. Thulhaadhoo School hall
Date: 01st December 2009, Tuesday
Time: 11:30 am

## PARTICIPANTS:

| | | |
|---|---|---|
| MHTE: | Maizan Ali Manik | Director General |
| | Shaana Farooq | Project Coordinator |
| | Sudhakar Samudrala | Civil Engineer |
| Boskalis: | Gabe Venema | Works Manager |
| | Chris Geerling | Social Impact Assessment Consultant |
| North Province Office: | Hussein Adam | Deputy Under Secretary (Person in-charge of North Province) |
| | Mohamed Shaheen | Economic Development & Projects in-charge |
| | Mohamed Basheer | Project Coordinator |
| Baa Atoll Office: | Abdul Bagir Ahmed | Deputy Atoll Chief |
| Thulhaadhoo Island Office: | Mohamed Usmaan | Councillor |
| | Ahmed Mohamed | Deputy Island Chief |
| | Abdul Raheem Yoosuf | Deputy Island Chief |
| | Mohamed Waheed | Deputy Island Chief |
| B. Thulhaadhoo Public (approximately 50 participants from various organizations and development committees attended the meeting) | | |

## SUMMARY OF DISCUSSIONS:

The participants of the meeting was informed that the purpose of this meeting was to introduce and provide information on the reclamation, shore protection and harbor construction project of B. Thulhaadhoo which has been now contracted to Boskalis International of the Netherlands. The current status of the project is that the contractors' team is now conducting the necessary field surveys to prepare the Social Impact Assessment and the Environment Impact Assessment. The floor was opened to the participants to ask any relevant questions that the public need to clarify regarding the project and express their opinion or highlight any critical issues with regard to the project. The participants were particularly asked to identify any issues relating to the current environmental conditions of the island, benefits expected from the expansion of land on the island and the impact this project would have on the livelihood of the community. The following points highlight the major issues identified by the participants.

| PARTICIPANTS INQUIRIES | MHTE CLARIFICATION |
|---|---|
| • Harbour size and location was one of the main inquiries of the participants. | • Participants were informed that the location of harbour is the currently dredged basin using the existing channel. The scope of works assigned to contractor by this project is to construct a quaywall of 750ft (228m) and construction breakwater for the protection of harbour. |
| • Many participants complained regarding the harbour size being smaller than what | • The size of harbour was set during the time project was tendered and the current |

| | |
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| was previously communicated to them by the Ministry. They noted that they have been assured that the harbour size will be increased to 1200ft and highlighted the current size is small will not be enough to cater to the number of vessels currently using the harbour. They informed that the main occupation of the island is fishing and many fishing vessels in the atoll also use the harbour to moor their vessel during major fishing season. So the size of harbour is not acceptable to them. | scope of works is what the contractor have been assigned under this contractor. No plans have been made to change the size of the harbour as this would be a variation to the current contract. However it is the policy of the Ministry to design the harbour such that it caters to 6 functional requirements being, areas for passenger arrival and departure, cargo loading and unloading area, mooring area, beaching area, fish/local market area, fuel services area. When designing the harbour Ministry will only take into consideration only the registered vessels on the island. |
| • The current location of harbour has caused some problems because of its proximity to the island health center. The major problem identified is when materials like cement is unloaded, due to wind direction dust is blown into the health center. Another issue is that the current location of harbour is located to the side of the island and so have requested to Ministry on earlier occasions to move the location so that it is at the center of the island. | • When space is allocated for loading and unloading of cargo Ministry will consider the issue of disturbances to health center, and the information will be provided to the Contractor. MHTE highlighted that the location of harbour is considered to make use of the current dredged area and also the current location will fall to the center of the new Thulhaadhoo, when Reclamation is complete. (NOTE: Some of the participants refused to accept this saying this is not the wish of the community since they don't know when the new areas will be occupied) |
| • Participants inquired if any studies will be done on the effect of the water quality and sewerage network on the island. Several sewerage outlets will be falling within the boundary of the reclamation area. | • Informed that Boskalis will collect information on the existing sewerage pipes and the current condition and address the issue before works start. All other related studies will be included in the Environment Impact Assessment report which will be available for public comments once it is submitted to the environment protection agency. |
| • Inquired regarding the location of the borrow area.<br>• Will this be near or away from the island?<br>• Will the contractor study any effect on the surrounding environment and how will erosion areas be addressed.<br>• It was noted that if the reclaimed areas is left without any protection then it will be washed with the time. What is the size of | • The contractor will complete the studies that are being carried out on the island at the moment and then decide on a borrow area. It will be decided based on the feasibility to the contractor and measures will be taken to minimize any negative effect on the surrounding environment. The current reclamation plan takes into consideration all the erosion areas and the areas that are likely to undergo |

| | |
|---|---|
| reclamation area? | erosion will be protected using revetment. The size of reclamation area during tender is 200,000 square km, however after completing all the depth surveys only the final shape and reclamation land will be decided. |
| • Have the land use plan been developed for the land and what areas will be taken for the land.<br>• Definitely island community will need area for housing because even now 300 people have asked for housing plots and there is no more space.<br>• Also the current football field is not enough for the island youth. Also many businessmen cannot further develop their business due lack of land and therefore land for commercial activities will also need to be allocated.<br>• If any flats are being developed on the new area it should be noted that people will need areas to dry fish as this is a major economic activity and now people do this kind of work in the backyards, which will be impossible to do in flats. | • Draft land use plan have been developed for the reclamation area and it has been shared with the contractor. When the in-surveys are complete and contractor finalises the reclamation area it will be shared with the ministries planning section that is responsible for the development of Land use plan. They will then develop final draft and bring it for community consultation. Also the information gained from this meeting will be forwarded to them. |
| • Participants hope to see that the project starts as soon as possible and all that has been said in this meeting is used for the development of the project. | • Assured that the project will start sometime in the middle of next year and final reclamation plan will be shared with the province and island office so that island community can be informed. |

## CONCLUSION:

After the Q&A session in was announced that Mr. Chris from Boskalis will be walking around the island with his translator Mr. Hasan and any questions or necessary information or concerns can be forwarded to him during his time on the island. This information will be used for the Environment and Social Impact Assessment reports. The meeting was adjourned at 12:45pm. The main issues raised during the meeting were briefly summarized to the participants from Boskalis at island office.

# LH. HINNAVARU PUBLIC CONSULTATION MEETING

Venue: Lh. Hinnavaru island office
Date: 05th December 2009, Saturday
Time: 12:30 pm

## PARTICIPANTS:

| | | |
|---|---|---|
| MHTE: | Maizan Ali Manik | Director General |
| | Shaana Farooq | Project Coordinator |
| | Shareefa Abdulla | Assistant Director |
| | Zeeniya Hameed | Senior Architect |
| | Hussein Rasheed | Planning Officer |
| | Yoomee Rasheed | Asst. Planning Officer |
| Boskalis: | Gabe Venema | Works Manager |
| | Chris Geerling | Social Impact Assessment Consultant |
| North Province Office: | Hussein Adam | Deputy Under Secretary (Person in-charge of North Province) |
| | Mohamed Shaheen | Economic Development & Projects in-charge |
| | **Rasheed** | Raa Atoll Councillor |
| | Mohamed Habeeb | Baa Atoll Councillor |
| Hinnavaru Island Office: | Adam Yoosuf | Hinnavaru Councillor |
| | Mohamed Aboobakuru | Island Chief |
| Lh. Hinnavaru Public (approximately 20 participants from various organizations and development committees attended the meeting) | | |

## SUMMARY OF DISCUSSIONS:

The participants of the meeting was informed that the purpose of this meeting was to introduce and provide information on the reclamation, shore protection works of Lh. Hinnavaru which has been now contracted to Boskalis International of the Netherlands. The current status of the project is that the contractors' team is now conducting the necessary field surveys to prepare the Social Impact Assessment and the Environment Impact Assessment. The floor was opened to the participants to ask any relevant questions that the public need to clarify regarding the project and express their opinion or highlight any critical issues with regard to the project. The participants were particularly asked to identify any issues relating to the current environmental conditions of the island, benefits expected from the expansion of land on the island and the impact this project would have on the livelihood of the community. The following points highlight the major issues identified by the participants.

| PARTICIPANTS INQUIRIES | MHTE CLARIFICATION |
|---|---|
| • What is the size of reclamation area? | • The size of reclamation area during tender is 39 hectares; however after completing all the depth surveys only the final shape and reclamation land will be finalized. |
| • Where will the reclamation material be dredged from?<br>• Material from the island lagoon was | • The contractor will complete the studies that are being carried out on the island at the moment and then decide on a borrow |

| | |
|---|---|
| dredged for the previous reclamation project and lot of damage was done to the reef on the western side from that area as visible on island chart. If this project also uses the lagoon to get reclamation material then further damage will be made to the project.<br>• Can the contractor use the nearby shallow lagoons (the shallow areas on the eastern side) for reclamation works? | area. It will be decided based on the feasibility to the contractor for the transportation of material and measures will be taken to minimize any negative effect on the surrounding environment. A condition assessment of the existing reef area will be done and then the borrow location will be decided. The two lagoons on the eastern side shows good coral growth and is noted as a protection to Hinnavaru from eastern side, so have to study and decide on the most minimum environmental impact area. Hinnavaru lagoon is the first priority area and contractor will do the studies to minimize the impact on the reef. . All studies will be included in the Environment Impact Assessment report which will be available for public comments once it is submitted to the environment protection agency. Province office will be informed when it is published. |
| • It was highlighted that the western side of the island gets very rough during the south west monsoon season. A breakwater will be needed for the protection of the reclamation area, especially if the lagoon area is deepened. What kind of measures will be taken for the protection of reclaimed land? | • Informed the participants that no breakwaters will be placed on the main reef from this project. However shore-protection works will be carried out on the reclaimed land on those areas that are more likely to have severe erosion. |
| • Have the land use plan been developed for the land and what areas will be allocated for the land. Space for housing is an issue and area for football field has to be allocated. Participants gave preferred land use allocations which included space for commercial, social and recreation activities. | • Draft land use plan have been developed for the reclamation area and it has been shared with the contractor. When the in-surveys are complete and contractor finalizes the reclamation area ministries planning section will then develop final draft and bring it for community consultation. Also the information gained from this meeting will be used in the development planning. |
| • Participants hope to see that the project starts as soon as possible and all that has been said in this meeting is used for the development of the project. | • Assured that the project will start sometime in third quarter of next year and final reclamation plan will be shared with the province and island office so that island community can be informed. |

## CONCLUSION:

After the Q&A session in was announced that Mr. Chris from Boskalis will be walking around interviewing individuals for his study with his translator Mr. Hasan and any questions or necessary information or concerns can be forwarded to him during his time on the island. This information will be used for the Environment and Social Impact Assessment reports. The meeting was adjourned at 02:00pm. The main issues raised during the meeting were briefly summarized to the participants from Boskalis at island accommodation house.

# N. VELIDHOO PUBLIC CONSULTATION MEETING

Venue: N. Velidhoo island office
Date: 09th December 2009, Wednesday
Time: 13:00 pm

## PARTICIPANTS:

| | | |
|---|---|---|
| MHTE: | Shaana Farooq | Project Coordinator |
| | Shareefa Abdulla | Assistant Director |
| | Yoomee Rasheed | Asst. Planning Officer |
| | Aishath Nadiya | Asst. Planning Officer |
| Boskalis: | Gabe Venema | Works Manager |
| | Chris Geerling | Social Impact Assessment Consultant |
| North Province Office: | Hussein Adam | Deputy Under Secretary (Person in-charge of North Province) |
| | Mohamed Shaheen | Economic Development & Projects in-charge |
| Velidhoo Island Office: | Adam Faiz | Velidhoo Councillor |
| N. Velidhoo Public (approximately 65 participants from various organizations and development committees attended the meeting) | | |

## SUMMARY OF DISCUSSIONS:

The participants of the meeting was informed that the purpose of this meeting was to introduce and provide information on the reclamation, shore protection works of N. Velidhoo which has been now contracted to Boskalis International of the Netherlands. The current status of the project is that the contractors' team is now conducting the necessary field surveys to prepare the Social Impact Assessment and the Environment Impact Assessment. The floor was opened to the participants to ask any relevant questions that the public need to clarify regarding the project and express their opinion or highlight any critical issues with regard to the project. The participants were particularly asked to identify any issues relating to the current environmental conditions of the island, benefits expected from the expansion of land on the island and the impact this project would have on the livelihood of the community. The following points highlight the major issues identified by the participants.

| PARTICIPANTS INQUIRIES | MHTE CLARIFICATION |
|---|---|
| • What is the size of reclamation area? | • No detail surveys have been done on the island before. Therefore the total reclamation area will be decided after the depth surveys are completed. Ministry wish to find out the views of community in deciding the reclamation area. The volume available to the contractor will be used to create the maximum land area to fit the available budget. |
| • What the island people want is to reclaim upto the extents of Velidhoo reef so that more land will be available for housing | • Informed that the reclamation area will not cover to the extent of the reef. But as mentioned before after completion of the |

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| and commercial activities. Even now upto 900 people have asked for housing plots at the island office. | surveys Contractor will come up with the best ways to maximize on the available volume and keep as much as possible the original shape of the island. When the reclamation plan is finalized a draft land use plan will be developed and community will be given the opportunity to comment on it. |
| • Where will the reclamation material be dredged from? Will the material be transported from other lagoon to complete the works or will it be dredged from deeper areas.<br>• Few people did not agree with dredging from lagoon area.<br>• Many agreed that EIA studies have to be most important consideration when determining the location of borrow area and reclamation area. The current and weather conditions must also be considered.<br>• Some areas of the island have been subject to erosion over the years. Will these areas be addressed?<br>• Some pointed out that some area of Velidhoo reef is used as diving spots by people on Safari. How will these areas be addressed when reclamation starts? | • The contractor will complete the studies that are being carried out on the island at the moment and then decide on a borrow area. Velidhoo lagoon will be studied to use as borrow area. Borrow area will be decided based on the feasibility to the contractor for the transportation of material and measures will be taken to minimize any negative effect on the surrounding environment. A condition assessment of the existing reef area will be done taking into consideration weather conditions and flow of current and then the borrow location will be decided.<br>• Erosion areas will be identified during the field surveys and priority will be given to cover these areas. As for reclaimed land, the project includes shore protection on area that will most likely be subject to erosion.<br>• Any areas that are environmentally significant can be pointed out to Boskalis team so that they can include these in their report. It is highly recommended that as much information as possible is passed to the team regarding local environment by the community. |
| • The local harbour is very shallow and need expansion. Can the material be taken from the harbour. | • Informed the participants that Boskalis will consider this. But if there is any risk of damaging the existing harbour structures then contractor will not dredge from the harbour. |
| • Participants wanted the following to be taken into account when allocating land on the newly relocated area.<br>• Boat building works is the major industrial work carried out in Velidhoo. The proximity of the boat yard area to the | • Draft land use plan will be developed once reclamation plan is finalized. Some of the issued rose during this meeting have also been identified by the Ministry and will be considered when developing the land use plan. Final reclamation plan |

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| community has created many problems. (Use of fibre material). If this area is moved away from residential area it will be very helpful.<br>• Space for housing is the number one priority and therefore land must be allocated for this purpose.<br>• Waste management area is also something that the island need.<br>• Land for other commercial activity such as storage of timber also need to be allocated. | will be shared with the community before works start. Also the Land use plan will be brought for community consultation. |
| • Participants wish to see the project start on the island as scheduled and hope as much expectations are met when the final plans are put in place. | • Informed that the reclamation will take place sometime in the fourth quarter of next year and the project will be developed in such a manner that the main issues highlighted in the meeting is addressed through this project. |

## CONCLUSION:

After the Q&A session in was announced that Mr. Chris from Boskalis will be walking around interviewing individuals for his study with his translator Mr. Hasan and any questions or necessary information or concerns can be forwarded to him during his time on the island. This information will be used for the Environment and Social Impact Assessment reports. The meeting was adjourned at 02:30pm. After the session island councilor met with Ministry team, Boskalis and Province office team to clarify details of the project.

# HA. DHIDHOO PUBLIC CONSULTATION MEETING

Venue: HA. Dhidhoo Violet Maalam
Date: 14th December 2009, Monday
Time: 13:00 pm

## PARTICIPANTS:

| | | |
|---|---|---|
| MHTE: | Shaana Farooq | Project Coordinator |
| | Shareefa Abdulla | Assistant Director |
| | Yoomee Rasheed | Asst. Planning Officer |
| Boskalis: | Gabe Venema | Works Manager |
| | Chris Geerling | Social Impact Assessment Consultant |
| Upper North Province Office: | Adam Naseer | Deputy State Minister |
| Dhidhoo Island Office: | Zakariyya Hussein | Island Chief |
| | Adam Naseer | Island Chief |
| HA. Dhidhoo Public (approximately 100 participants from community attended the meeting) | | |

## SUMMARY OF DISCUSSIONS:

The participants of the meeting were informed that the purpose of this meeting was to introduce and provide information on the reclamation, shore protection works of HA. Dhidhoo, which has been now contracted to Boskalis International of the Netherlands. The current status of the project is that the contractors' team is now conducting the necessary field surveys to prepare the Social Impact Assessment and the Environment Impact Assessment. The floor was opened to the participants to ask any relevant questions that the public need to clarify regarding the project and express their opinion or highlight any critical issues with regard to the project. The participants were particularly asked to identify any issues relating to the current environmental conditions of the island, benefits expected from the expansion of land on the island and the impact this project would have on the livelihood of the community. The following points highlight the major issues identified by the participants.

| PARTICIPANTS INQUIRIES | MHTE CLARIFICATION |
|---|---|
| • What is the size of reclamation area? Will it be to the extent of the reef? | • No detail surveys have been done on the island before. Therefore the total reclamation area will be decided after the depth surveys are completed. Ministry wish to find out the views of community in deciding the reclamation area.<br>• The volume available to the contractor will be used to create the maximum land area to fit the available budget. Initial recommendations have been made during the environmental impact assessment which is to cover any erosion areas and as much as possible keep to the natural shape of the island. However this project will not cover upto the extent |

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| | of the Reef. |
| • Where will the reclamation material be dredged from? Will the material be transported from other lagoon to complete the works or will it be dredged from deeper areas.<br>• During this time the weather is very calm and hence real condition on the western side might not be observed now. It gets very rough during monsoon season. The current and weather conditions must also be considered.<br>• Some areas of the island have been subject to erosion over the years. Will these areas be addressed?<br>• Protection of the reclaimed land will be important. Perhaps jumbo bags can be used to protect the area between main reef and the reclaimed shoreline which will surely be eroded over the years. How will this contractor observe these areas and rectify any damage. | • The contractor will complete the studies that are being carried out on the island at the moment and then decide on a borrow area. Dhidhoo lagoon will be studied to use as borrow area. Borrow area will be decided based on the feasibility to the contractor for the transportation of material and measures will be taken to minimize any negative effect on the surrounding environment. A condition assessment of the existing reef area will be done taking into consideration weather conditions and flow of current and then the borrow location will be decided.<br>• Erosion areas will be identified during the field surveys and priority will be given to cover these areas. Immediately identified area are the north and south of the island. As for reclaimed land, the project includes shore protection on areas that will most likely be subject to erosion. In contractual practice dredging and reclamation defect liability period does not apply. However contractor will take responsibility for any structures. The design of shore protection structures will be done by the contractor and Employer will only approve it. Contractor will need to rectify any failures of those structures within a year. |
| • How long will it take to reclaim the land?<br>• Will the island be given the opportunity to express their opinion during the reclamation and raise any concerns about the project?<br>• How long will it take to construct the shore protection structure? | • It will take around 4 weeks to complete the reclamation.<br>• The reclamation duration will not be so long and therefore there won't be much time to have public consultations project. However if there are any issues it can be communicated to the Ministry through the province office or island office. Mostly the concerns raised during this meeting and the information gathered during field surveys and public consultation on the island will be taken into consideration.<br>• The shore-protection works will take up to 4 - 5 months. |
| • Request for an allocation to construct a | • Informed the participants that scope of |

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| slip way through the reclamation project. | works does not include construction of a slipway.<br>• State Minister informed that even though the slipway is not included in the project, the area can be identified when finalizing the reclamation plan. |
| • Participants wanted the following to be taken into account when allocating land on the newly relocated area.<br>• Land for housing is an important issue. Even now up to 1000 people have already asked for housing plots.<br>• Many football teams have emerged in the island over the years and space for football fields is also something that the island community looks forward to.<br>• The government offices on the island also need to be located around the same area and this is also something the island leaders wish to see in the future.<br>• Land for other commercial activity such as bank need to assigned. The bank cannot expand their branch due to lack of land on the island/ | • Draft land use plan will be developed once reclamation plan is finalized. The issues highlighted during this meeting will be considered when developing the land use plan. Final reclamation plan will be shared with the community before works start. Also the Land use plan will be brought for community consultation. |
| • Participants wish to see the project start on the island as scheduled and hope as much expectations are met when the final plans are put in place. | • Informed that the reclamation will take place sometime in the fourth quarter of next year and the project will be developed in such a manner that the main issues highlighted in the meeting is addressed through this project. |

## CONCLUSION:

After the Q&A session in was announced that Mr. Chris from Boskalis will be walking around interviewing individuals for his study with his translator Mr. Hasan and any questions or necessary information or concerns can be forwarded to him during his time on the island. This information will be used for the Environment and Social Impact Assessment reports. The meeting was adjourned at 02:30pm.

*End of Report*

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# Appendix 8

## Letter from MTHojgaard

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MTHøjgaard

**TO WHOEVER IT MAY CONCERN**

11th December 2009
Tel +94 11-286 2444
Fax +94-11-287 6522
jj@mthojgaard.dk

Dear Sir/ Madam

**3 ISLANDS PROJECT - MALDIVES**

We have been supplying various types of rock materials for all our projects in the Maldives through our quarry operators in the state of Tamil Nadu, India, for the last more than eight years.

We will be identifying the required quarries from the same areas that we do operate now, for the supply of rock materials for the above project.

We do confirm that to the best of our knowledge, during the several visits that we have made to these areas, we have not come across any sign of forced or child labour deployed by our quarry operators.

We also ensure that in any quarry that would be selected as source/s of rock material for the proposed project, no forced and / or child labour shall be engaged by our sub contractors or operators.

The same shall apply to all forms of sub contractual works with regard to quarry operations and transport.

Yours faithfully,
**MT Hojgaard a/s**

MT HØJGAARD A/S

**Jonas Jacobsen**
Commercial Manager

**MT Højgaard a/s**
94A, Jayanthipura
Battaramulla
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CVR No. 12 56 22 33

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# Appendix 9

## Letter from Ministry of Housing, Transport and Environment

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بسم الله الرحمن الرحيم


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**Ministry of Housing, Transport and Environment**


# ރާވާ ދަށް

# OFFICE MEMO

| | | | |
|---|---|---|---|
| From: | Engineering and Project Management Section | | |
| To: | Environmental Protection Agency | | |
| Copy: | | | |
| Subject: | 3 Island Reclamation Project | | |
| Number: | 138-ES/INT-MEMO/2010/14 | Date: | 18 January 2010 |

Ministry of Housing, Transport and Environment as the proponent of the Reclamation project awarded to Contractor Boskalis International, hereby confirm our commitment to carryout the environmental mitigation measures and monitoring program for the post – construction phase of the project.

Yours sincerely,

Shifaz Ali
Senior Engineer




Ameenee Magu,
Maafannu,
Male', 20392,
Republic of Maldives.

Tel: +(960) 300 4 300 ގުޅުން:
Fax: +(960) 300 4 301 ފެކްސް:
Email: secretariat@mhte.gov.mv ޕޯޓަލް:
Website: www.mhte.gov.mv ވެބްސައިޓް:

ހއ. ދިވެހިފުށ،
ދ. ފަހަނަ،
ގދ. 20392،
ދިވެހިރާއްޖެ.


2010 International Year of Biodiversity

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# Appendix 10

## Baseline water quality monitoring Dhidhdhoo

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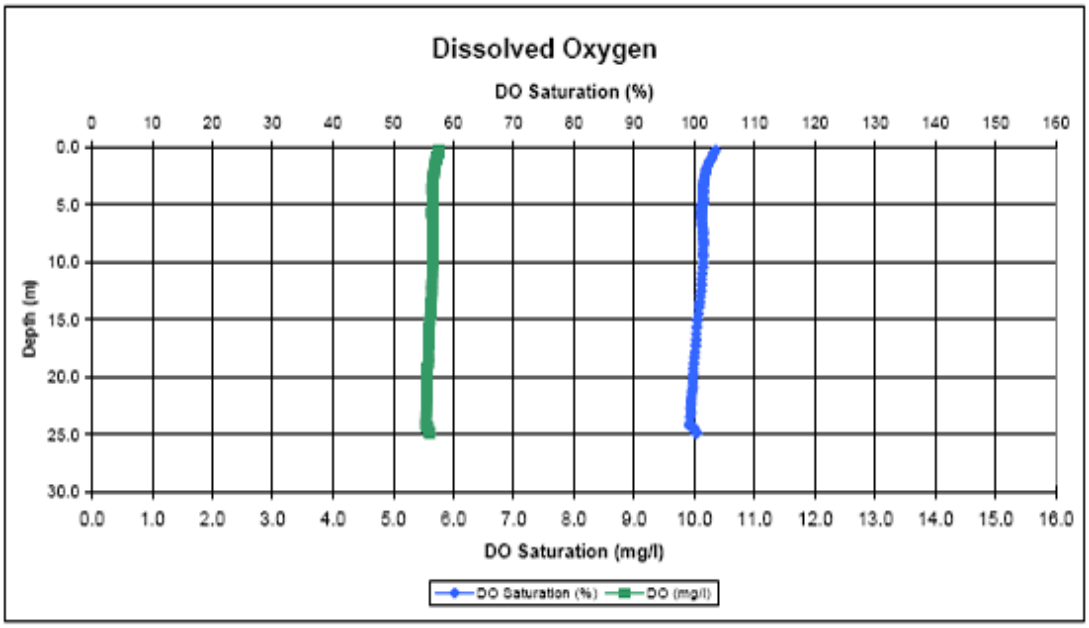
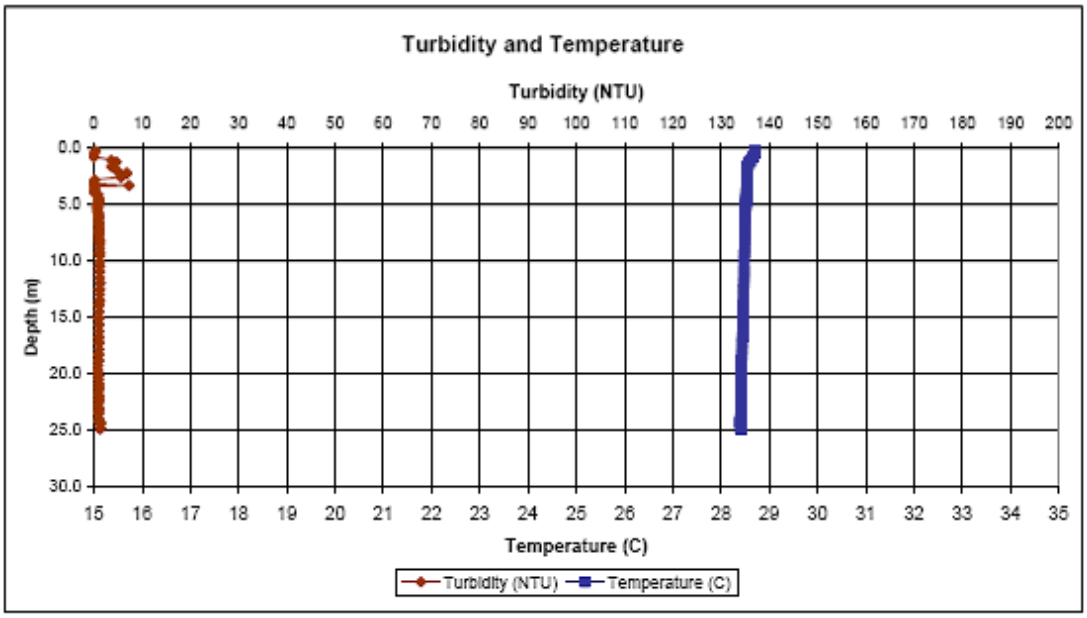
**Project:** 4 Islands, Maldives
**Location:** Dhidhdhoo

**Measurement report** 03-05-2010
**Time** 15:54
**Location** Loc 1
**Max. depth (m)** 24.87

| Depth interval (m) | | Time interval | | Average | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (min) | Depth (max) | Start time | End time | NTU* | Temp (°C) | DO sat (%) | DO (mg/l) | Salinity (ppt) |
| 1.00 | 2.00 | 15:56 | 15:58 | 4.2 | 28.6 | 102.3 | 5.7 | 36.0 |
| 11.00 | 13.00 | 15:56 | 15:58 | 1.2 | 28.5 | 101.1 | 5.6 | 36.1 |
| 23.00 | 25.00 | 15:56 | 15:58 | 1.2 | 28.4 | 99.6 | 5.6 | 36.1 |

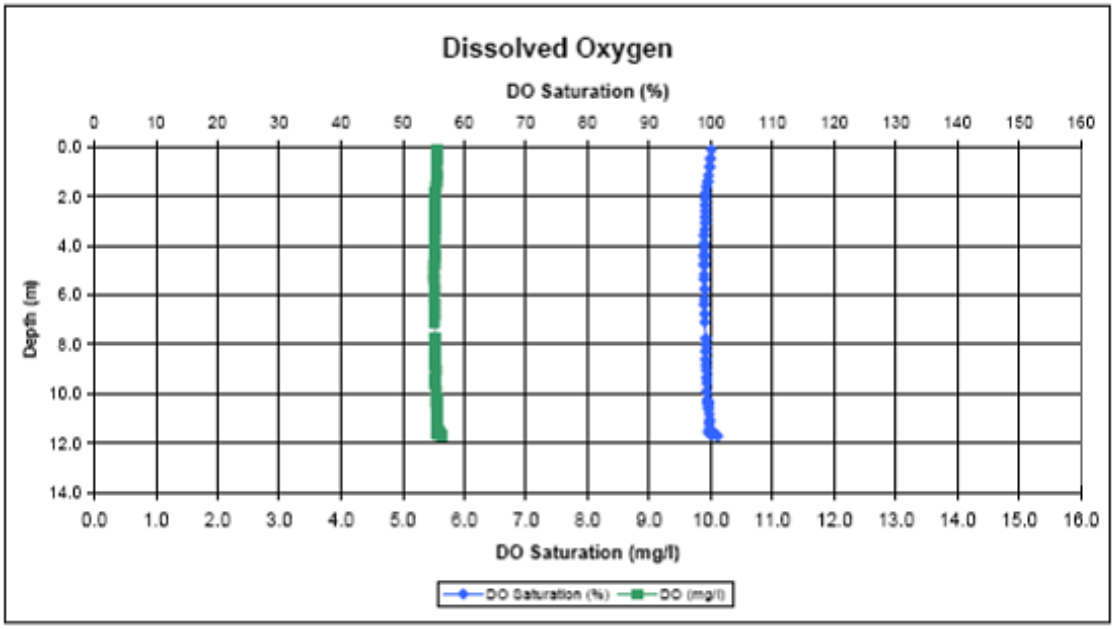


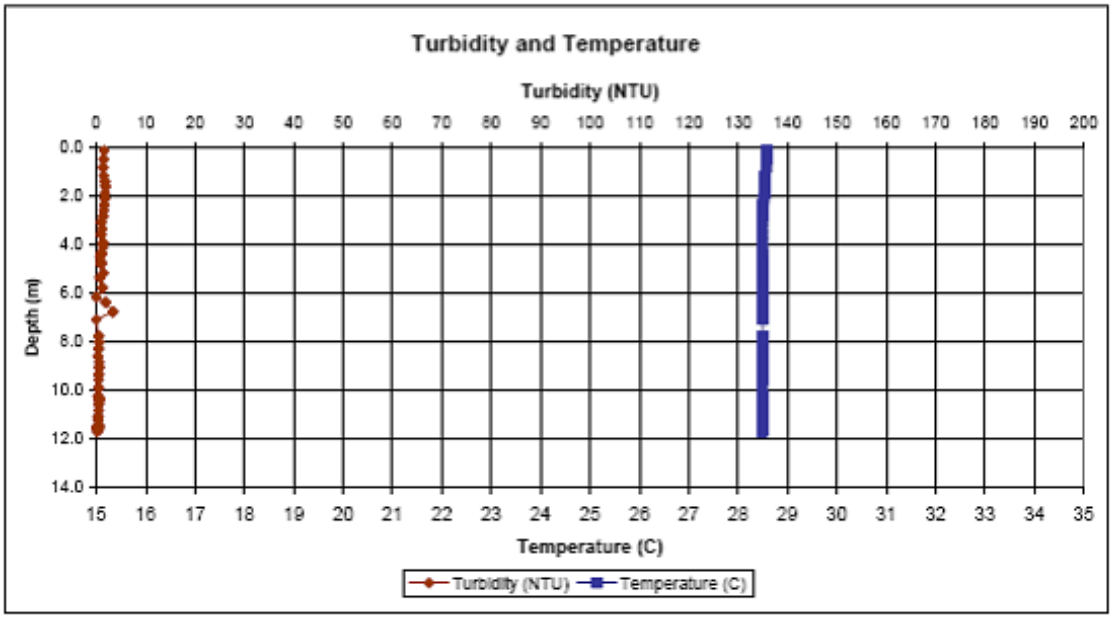



**Project:** 4 Islands, Maldives
**Location:** Dhidhdhoo

**Measurement report** 03-05-2010
**Time** 10:52
**Location** Loc 2
**Max. depth (m)** 11.71

| Depth interval (m) | | Time interval | | Average | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (min) | Depth (max) | Start time | End time | NTU* | Temp (°C) | DO sat (%) | DO (mg/l) | Salinity (ppt) |
| 1.00 | 2.00 | 10:53 | 10:54 | 1.8 | 28.5 | 99.4 | 5.5 | 35.9 |
| 4.00 | 6.00 | 10:53 | 10:54 | 1.0 | 28.5 | 98.9 | 5.5 | 36.1 |
| 10.00 | 12.00 | 10:53 | 10:54 | 0.4 | 28.5 | 99.8 | 5.6 | 36.1 |

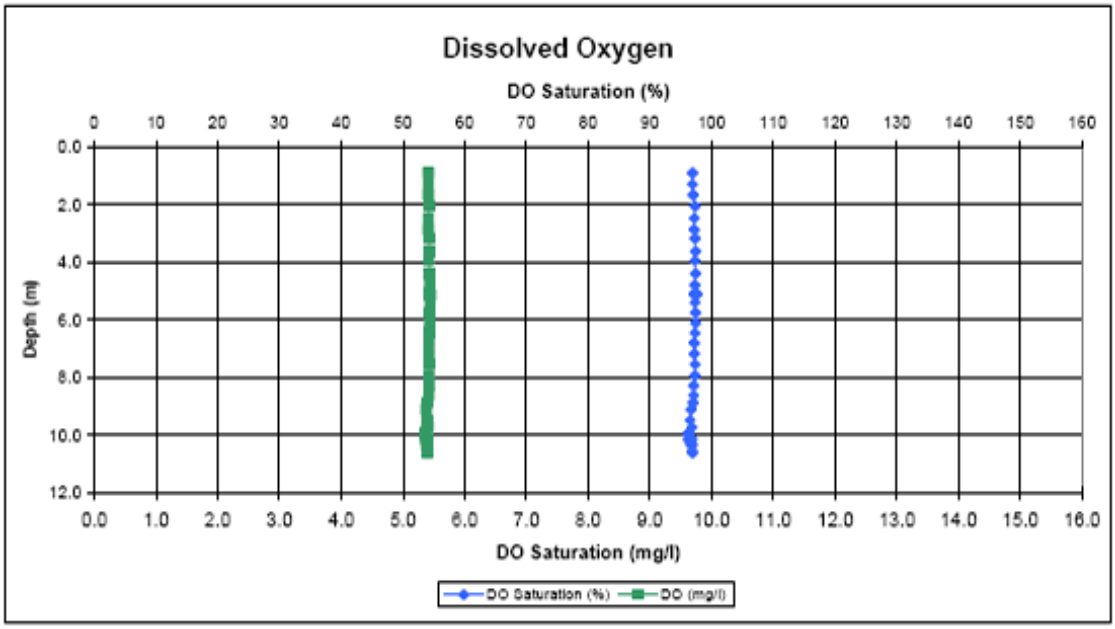


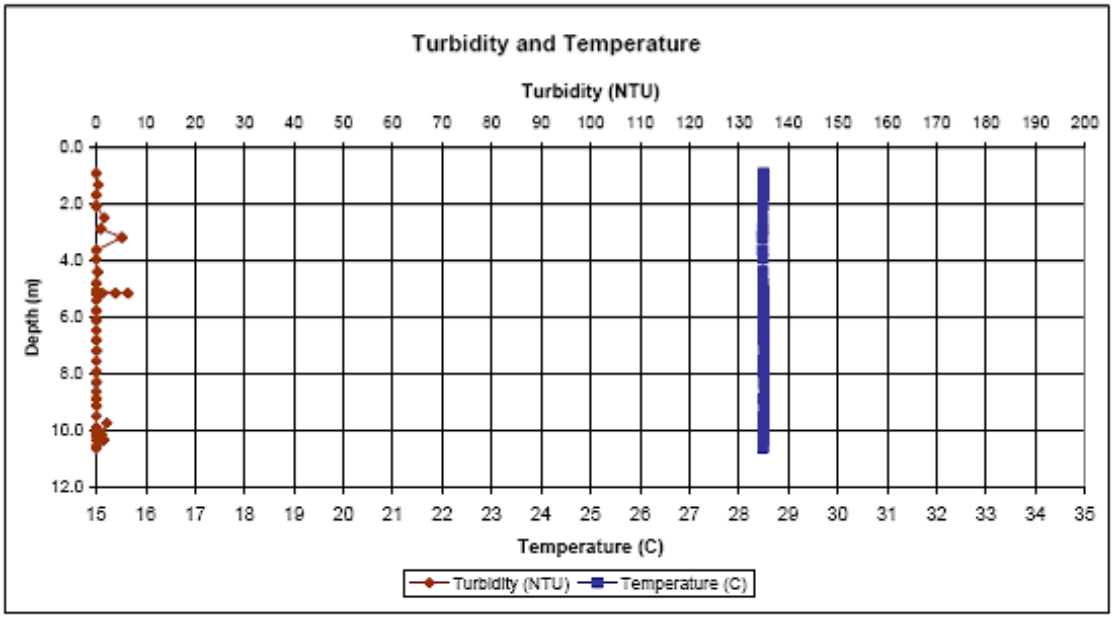



**Project:** 4 Islands, Maldives
**Location:** Dhidhdhoo

| | |
|---|---|
| **Measurement report** | 04-05-2010 |
| **Time** | 11:44 |
| **Location** | Loc 3 |
| **Max. depth (m)** | 10.63 |

| Depth interval (m) | | Time interval | | Average | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (min) | Depth (max) | Start time | End time | NTU* | Temp (°C) | DO sat (%) | DO (mg/l) | Salinity (ppt) |
| 1.00 | 2.00 | 11:45 | 11:47 | 0.1 | 28.5 | 97.0 | 5.4 | 36.0 |
| 6.00 | 8.00 | 11:45 | 11:47 | 0 | 28.5 | 97.3 | 5.4 | 36.0 |
| 9.00 | 11.00 | 11:45 | 11:47 | 0.3 | 28.5 | 96.5 | 5.4 | 36.1 |

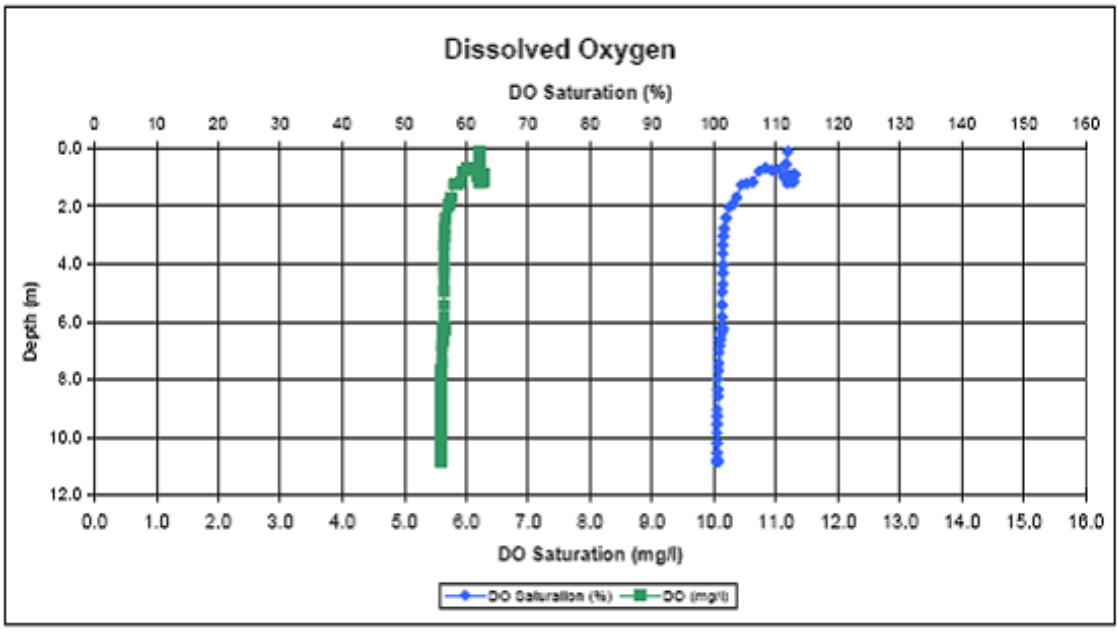


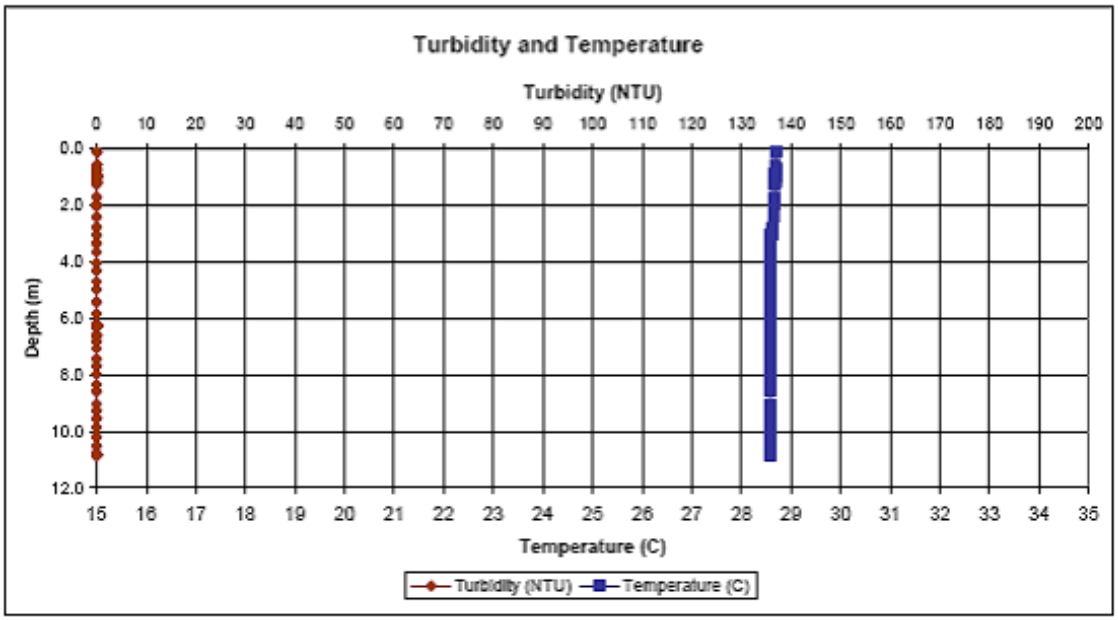



**Project:** 4 Islands, Maldives
**Location:** Dhidhdhoo

| | |
|---|---|
| **Measurement report** | 04-05-2010 |
| **Time** | 15:42 |
| **Location** | Loc 4 |
| **Max. depth (m)** | 10.87 |

| Depth interval (m) | | Time interval | | Average | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (min) | Depth (max) | Start time | End time | NTU* | Temp (°C) | DO sat (%) | DO (mg/l) | Salinity (ppt) |
| 0.90 | 2.00 | 15:43 | 15:45 | 0.0 | 28.7 | 110.1 | 6.1 | 36.1 |
| 5.00 | 7.00 | 15:43 | 15:45 | 0 | 28.6 | 101.2 | 5.6 | 36.3 |
| 9.00 | 11.00 | 15:43 | 15:45 | 0 | 28.6 | 100.5 | 5.6 | 36.3 |



**Project:** 4 Islands, Maldives
**Location:** Dhidhdhoo

| | |
|---|---|
| **Measurement report** | 02-05-2010 |
| **Time** | 16:13 |
| **Location** | Loc 5 |
| **Max. depth (m)** | 12.25 |

| Depth interval (m) | | Time interval | | Average | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (min) | Depth (max) | Start time | End time | NTU* | Temp (°C) | DO sat (%) | DO (mg/l) | Salinity (ppt) |
| 1.00 | 2.00 | 16:14 | 16:16 | 1.2 | 28.6 | 104.1 | 5.8 | 36.1 |
| 6.00 | 8.00 | 16:14 | 16:16 | 0.9 | 28.6 | 100.9 | 5.6 | 36.3 |
| 11.00 | 13.00 | 16:14 | 16:16 | 1.0 | 28.6 | 99.5 | 5.5 | 36.3 |