ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Water Supply and Sewerage System

N. Velidhoo

Proponent: Ridgewood Hotesl and Suites Pvt. Ltd.

January 2012

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1 Introduction

1.1 Introduction

The environmental protection and preservation act (Law No. 4/93) of the Maldives emphasis on preparation of environmental assessments of any development projects that may cause impacts to the fragile environment of the Maldives. Particularly, clause 5 of the act highlights the preparation of environmental impact assessments (EIA) for such a development projects. According to Bell and McGillivray (2008) EIAs are emerged as one of the key environmental law mechanisms in the developed world in the last thirty years. However, EIAs has gained more attention and established in most national regimes after the world summit on sustainable development and Agenda 21.

This EIA report is, therefore, prepared as per the requirements of the above mentioned national environmental protection and preservation act of the Maldives. the law has stressed to protect and preserve the natural environment and its resources considering those as part of the national heritage which needs to be preserved and protected for the benefit of future generations. By, protecting the environment and its resources are a key precursor for the sustainable development of the country.

This EIA report will identify the potential impacts of the proposed sewerage development works to be carried out at N. Velidhoo with emphasis on recommendation on how to mitigate the impacts and take necessary measures to minimize any impacts arise during the project period and after completion of the project. This EIA will also discuss on project justification, alternatives to location of project components such as sea outfalls, project designs and environmental considerations. The report will further, provide a mitigation plan and a monitoring program which can be implemented during and after completion of the proposed development works.

The EIA was compiled based on qualitative and quantitative data collected from Velidhoo during the site inspections and assessment carried out between 31 December 2011 to 2nd January 2012. However, assessments carried-out by various consultants under AFD project for the Ministry of Housing and Environment during 2010 were utilized during preparation of the report. It has to be noted, the limitation on collecting and compiling the data on a very short period due to logistical and other issues such as unavailability of long-term base line data has made the consultants to restrict the report on data collected recently from the field, personal judgments and experiences gained from similar projects. Similarly, long-term data on some aspects such as meteorology and climate were collected from secondary sources through previously published reports and global data bases.

This report has been compiled in accordance with the EIA Regulations 2007, published by Ministry of Environment, Energy and Water in 2007, which is enforced by Environmental Protection Agency (EPA) of the Maldives.

1.2 Aims and Objectives of the EIA

This EIA report will address the environmental impacts arise from the proposed sewerage development works to be carried-out at N. Velidhoo. Particularly, it helps to achieve the following objectives.

- Allow better project planning through identification of key impacts and measures for mitigating these impacts;
- Ensure efficient resource use, minimize serious and irreversible damage to the environment;
- Allow informed decision making which are environmentally sound and sustainable; and
- Demonstrate the commitment of the proponent on the importance of environmental protection and preservation throughout the project period

1.3 Methodologies

This EIA report was prepared based on widely accepted and established scientific methods which are used for preparing such an assessments. The data collection methods are described in the section 5 of this report. The data was mainly collected by a field investigation mission visited Velidhoo from 31st December 2011 to 2nd January 2012 by a team of surveyors from Altec Maldives and Sandcays Pvt. Ltd. However, published data and literature available from similar projects were cited during the preparation of the EIA.

2 Project Setting

The proposed project takes place in the Maldives environment. Therefore, the extent to which the project conforms to existing plans, policies, guidelines, regulations and laws of the Maldives needs to be considered. Under EIA regulation 2007, all prescribed activities in Schedule D of EIA regulation 2007 are required to carry out a detailed EIA study to obtain environmental clearance before commencing any physical work on the project. Sewerage system development is a prescribed activity under Schedule D of Maldives EIA Regulation, 2007 formulated under the umbrella law of Maldives Environment Protection and Conservation Act (Law No.4/93). Hence, this section will look at the context in which the project activities take place and the legal/policy aspects relevant to activities anticipated in the proposed project.

2.1 Applicable Policies, Laws and Regulations

2.1.1 *Maldives Environmental Protection and Preservation Act (Law No. 4/93)*

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management, which are relevant, understood and adhered to in the proposed project.

- An EIA shall be submitted to EPA before implementing any developing project that may have a potential impact to the environment.
- Project that has any undesirable impact on the environment can be terminated without compensation.
- Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.
- The Penalty for Breaking the Law and Damaging the Environment are specified in the Law.
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

2.1.2 *Land Act (Law No.1/02)*

The land Act of Maldives formulated in 2002 provides allocations for releasing of lands for different needs, releasing of public land for housing and the conditions that govern the owning, selling, renting and transfer of ownership of public and private land.

2.1.3 National Biodiversity Strategy and Action Plan

The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities care need to be given to ensure that the national biodiversity strategies are adhered to.

2.1.4 National Solid Waste Management Policy (NSWMP, 2008)

The National Solid Waste Management Policy published in 2008 has been focused on the following key principal objectives

- Establish and activate a waste management governance
- Establish waste management infrastructures
- Activate the waste management system
- Influence consumer choices and waste management practices

2.1.5 Consultation and Public Participation Laws

In the Maldives public participation has been limited to the review stages of the EIS until recently. However with the EIA Regulation 2007, which considers public consultation as an important and integral part of the EIA process.

2.1.6 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was recently issued by the Ministry of Environment, Energy and Water. Clause 5 (a) of the regulations states that Prior to the commencement of any project(s) that would require the indiscriminate removal and export of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the Regulation to prepare and Environmental Impact Assessment Report stating clearly the details of the Project(s) with all necessary information and submit the same through the relevant Ministry to Ministry of Environment Energy and Water, and the project(s) can only commence upon the grant of written approval from the Ministry of Environment, Energy and Water.

Article 8 (a) requires permission be obtained from Ministry of Environment, Energy and Water, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (Article 8 (c)).

2.2 International conventions, treaties and protocols

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

2.2.1 United Nations Convention on Biological Diversity (UNCBD)

The objective of UNCBD is “the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding”.

Maldives was one of the first nations to ratify UNCBD. Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002. Formulation of NBSAP was through wide consultation and extensive stakeholder participation.

2.3 Relevant Environmental Standards and Guidelines

There are no relevant own environmental standards such as water quality criteria in the Maldives. Recently, the Maldives Water and Sanitation Authority in collaboration with World Health Organisation introduced some recreational water quality standards for the Maldives. However, there are some specific bio-indicators missing in these guidelines, which may be developed by the Marine Research Centre in cooperation with the Ministry of Housing and Environment for Maldivian reef ecosystems. Table 2-1 below provides a general indication of the parameters that will have to be measured in relation to coastal development activities. These have been drawn from the MWSA standards as well as international standards such as USEPA standards.

Table 2-1: Water quality criteria for recreational areas near coastal development projects

PARAMETER	GUIDELINE	METHODOLOGY
Microbiological		
Fecal coliforms	2,000 per 100ml	Minimum 5 samples collected over a month period. Counts according to MPN or membrane filtration on suitable culture. *Sampling must be in sterilised containers*
Tot. coliforms	10,000 per 100ml	
Physico-Chemical		
pH	$<$ 0.2 pH unit change	Electrometry (calibration at pH 7and 9)

Temperature	< 2°C increase	Thermometer
Dissolved Oxygen (DO)	> 6 mg/l or 80-90% saturation	Winkler's method or oxygen meter. Needs to be measured over at least one diurnal cycle. It is dependent on pH, temperature and salinity. In-situ measurements are preferable.
Turbidity	<10% of background	Spectrophotometry. In-situ measurements are preferable.
Phosphates (PO_4) *	1-10 µg/l	Molecular Absorption Spectrophotometry
Nitrates (NO_3) *	10-60 µg/l	Molecular Absorption Spectrophotometry
Chlorophyll-a *	< 1 µg/l	Spectrophotometry
Toxic Substances (monitored annually, if required)		
Ammonia (NH_4)	< 5 µg/l	Nessler's Method or Indophenol blue method
Mercury	< 0.1 µg/l	Flameless Atomic Absorption Spectrophotometry
Phenol	< 50.0 µg/l	Verification of absence of oudor or Absorption Spectrophotometry or Paranitraniline method. *Glass sampling container*
PAHs	< 3.0 µg/l	Measurement of fluorescence under UV after thin layer chromatography. *Glass or aluminium sampling container*

* The ranges of concentration values for these parameters are provided by the Australian Water Conservation Council as an indication of levels at which eutrophication related problems have been known to occur depending on a series of other factors (light, T°C, water circulation, zooplankton grazing etc.).

Furthermore, disposal of sediments through coastal development projects shall not cause:

- Floating, suspended, or deposited macroscopic particulate matter or foam in marine waters at any location more than 30 m (100 ft) from the project boundary or point of discharge, except unless authorized by the EIA/IEE Decision Statement.
- Visible floating, suspended, or deposited oil or other products of petroleum origin in marine waters in the vicinity of the coastal development, which may be related to the development of jetty, harbour, access channel etc.
- No toxic or other deleterious substances shall be present in concentrations or quantities which may cause deleterious effects on aquatic biota, wildlife, or waterfowl, or which render any of these unfit for recreation either at levels created in recreational areas or as a result of biological concentrations within the development zone.

Turbidity would be the main parameter that needs to be monitored in such coastal development sites. Given that the water quality of the marine environment in the Maldives has very low levels of turbidity usually below 2 NTU, an increase in 1 NTU would be a considerable increase. However, in such operations, within an allowable zone of dilution turbidity may be taken to be less than 10 NTUs or 10% of the background level, whichever is greater.

2.3.1 Wastewater Disposal Guidelines

The general guideline for domestic wastewater disposal (2006) formulated by Maldives Water and Sanitation Authority carries full responsibility of formulating regulations and standards for wastewater disposal and management in Maldives. This guideline applies to all the islands in Maldives and special permission need to be obtained from MWSA for wastewater disposal from industrial activity or an industrial island. However the authority no longer exists as an independent regulatory body. The authority has been merged with newly formed Environmental Protection Agency (EPA) of Maldives with the new administration that began on 11th November 2008

2.3.2 *Regulation on Environmental Liability*

The environmental regulation (Regulation 2011/R-9) came into force on 17th February 2011 covers a wide range of issues which enable to charge penalties and compensation on environmental polluters and environmental damages. It has been enforced by Environmental Protection Agency of Maldives acting under Ministry of Housing and Environment. Apparently the key objective of the environmental liability regulation formulated under Maldives Environmental Protection and Preservation Act 4/93 to practice polluter pay principles in the Maldives.

2.4 Environmental Permits required for the Project

2.4.1 *EIA Decision Statement*

The most important environmental permit to initiate the proposed water supply and sewerage system in N. Velidhoo would be a decision regarding this EIA from the Environmental Protection Agency (EPA). The **EIA Decision Statement**, as it is referred to, shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Statement may only be given to the Proponent after an independent review. Based on the outcome of the review EPA may request for further information or approve it if further information is not required.

3 Project Description

3.1 General context of the study

Access to safe water and improved sewerage services has been a major issue in most of the islands of the Maldives. Prior to tsunami very few islands accept the capital Male' has access to piped water supply and communal sewerage facilities. This may be due to high investment and maintenance costs compared to the population living in most islands of the Maldives. the residents of Male' and its administrative parts (islands) representing almost one third of the population have access to piped desalinated water and sewerage disposal facilities prior to Indian Ocean tsunami of December 2004. However, during the late 1990s the government has initiated establishing gravity sewer systems in some of the heavily populated islands such as Sh. Komandhoo, R. Dhuvafaru, B. Thulhadhoo, Lh. Naifaru, K. Gulhi and Gdh. Thinadhoo. Most of these systems were unsuccessful due to many reasons, including issues related to designs, low maintenance, community acceptance and island development and expansion programs.

In most islands sewerage disposal is via individual septic tanks constructed and operated by house owners. In few instances, community sewerage services are operated by constructing beach outfalls which are maintained based on monthly payments charged from houses connected to the outfall. Both individual septic tanks and community sewerage facilities are causing pollution to ground and recreational water. Hence, ground water is unfit for potable use in most of the islands. Therefore, rainwater is the main source of potable water in most islands of the Maldives.

Indian Ocean tsunami of December 2004 has caused huge damages to water and sanitation infrastructure most affected islands. This has leaded to receive more resources and financial support to establish water and sewerage services in the islands. In this regard various schemes were established to build water and sanitation infrastructure in the island communities taking into consideration long-term development plans and commitments of the Maldives to international treaties and targets such as MDGs. According to data available from government sources such as Maldives Infrastructure Map, by end of 2010 improved island wide sewerage facilities have been built in 11% of the island communities.

The proposed sewerage development project of N.Velidhoo has been designed (concepts) under French Development Agency (AFD) loan assistance received by the government to provide improved sewerage disposal facilities for tsunami affected islands. Therefore, proponent of the project will consider the previously approved concept for provision of sewerage facilities for the island. The preferred concept design includes gravity sewer main, lift stations, round manholes, main sumps and a sea outfall. The concept or preliminary design proposed by the Proponent is given in Appendix 3.

The EIA report will help to identify potential impacts (positive and negative) and to recommend mitigation measures to minimize the negative impacts during construction and operation of the development works. Similarly, socio-economic impacts of the proposed project will be addressed in the EIA report.

Similar to other development projects, the proposed project will have direct and indirect impacts to the environment including loss of small number of vegetation, impacts to terrestrial and marine species, impacts to groundwater and marine environment. These impacts, depending on their intensity, duration and type will be of short and long term, reversible and irreversible. Therefore, possible measures for mitigation and alternatives have been suggested in the report. These may either eliminate or minimize the impacts to the environment.

3.2 Project scheme – CSR

The project is under the recently established Cooperate Social Responsibility (CSR) concept of the government. SCR is a concept where business establishments integrate social and environmental concerns in their business operations or commitments given by such business establishments to contribute improved facilities in the communities across the nation. The CSR concept is widely advocated in the Maldives in recent days which is also integrated to provide infrastructure facilities in islands decided by the government. Such projects includes water, sewer and harbor works.

3.3 The proponent

The proponent of the proposed sewerage project is Ridgewood Hotels and Suites Pvt. Ltd., which is company registered in the Maldives for the purpose of undertaking tourism related activities.

3.4 Project location and study area

3.4.1 The location

Velodhoo is located in Noonu Atoll. There are 73 islands in the atoll out of which only 13 are inhabited. Mandhoo is the capital of the island where most government institutions such as Atoll Council Office, Atoll Hospital and Bank is available. Velidhoo is the most populous island of the atoll with a population 2242 people. Velidhoo is situated in the south-west region of the Noonu atoll, and is located in between 5°58’ N and 72º33’ E.

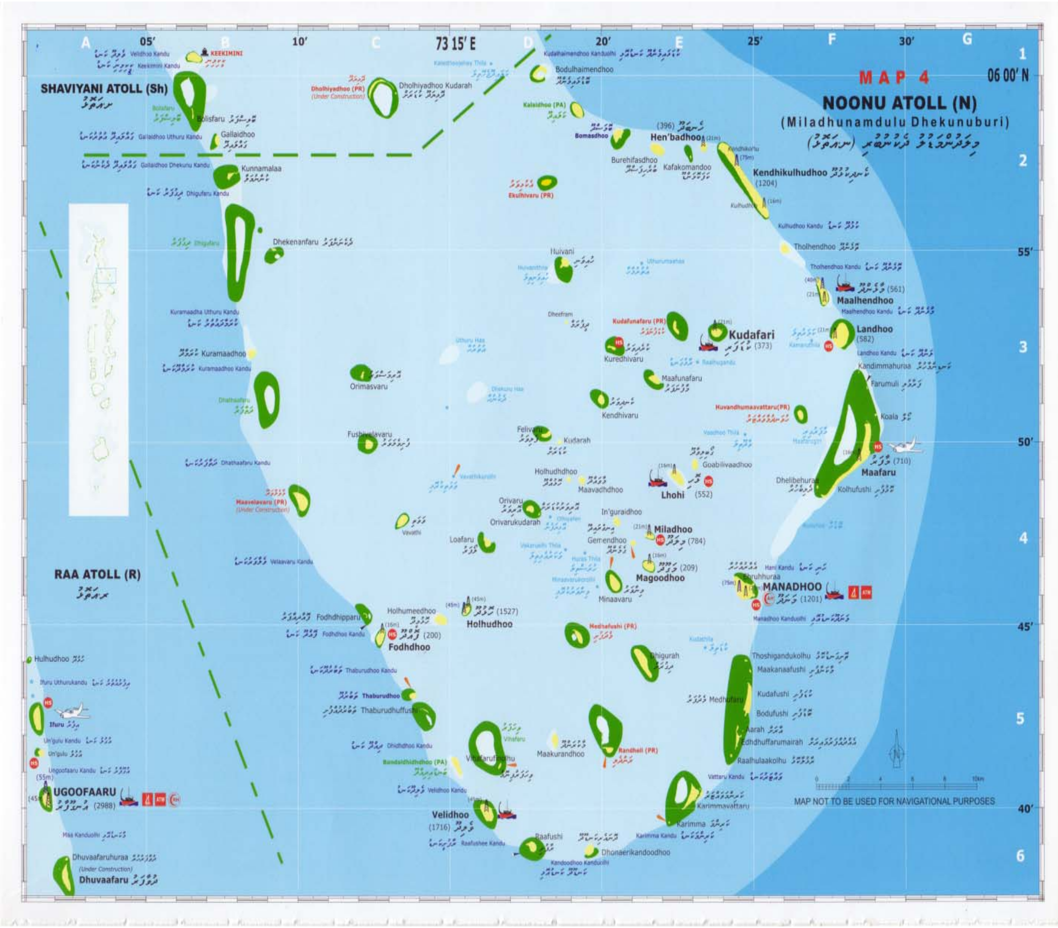


Figure 3-1: Location of N.Velidhoo (Water Solutions 2006)

3.5 The project

The concept of the proposed sewerage development project of N.Velidhoo has been developed by Ministry of Housing and Environment during 2010. The concept was prepared by BCL for the Ministry as part of AFD's loan assistance to the government of Maldives under tsunami recovery and reconstruction program. The proposed project involves island wide sewerage facilities including house connections, laterals, sewer mains, road manholes, lift stations, main sumps and sea outfall.

3.6 Brief description of the proposed concept design

The design concept of the proposed water supply and sewerage facilities are given in the Appendices. The EIAs prepared during the concept stage have manifold benefits in terms of environmental aspects as such it will help to address the major environmental concerns of the proposed development. It will also enable to directly communicate with designers and clients which in turn save cost, time and avoid shortcoming which may cause serious environmental issues. The following will briefly identifies the main components involved in the proposed sewerage development works.

- Sewer network: island wide network which covers all existing households and facilities including extension to the newly reclaimed area;
- Household catch pits: a house catch pit will be provided to each lateral connection provided;
- Laterals: to be provided from main sewers to households in which waste water is allowed to flow from household catch pits to the main sewer;
- Road main holes: to be constructed at defined intervals along the main sewers, particularly at each road junctions and road crossings;
- Lift stations: to be provided when there is no gravity slope available as these stations will help to take the flow into the main pump stations;
- Pump stations: two to three pump stations will be built to pass the waste water into the final discharge points to discharge into the sea via the sea outfall; and
- Sea outfall: one outfall will be built adjacent to the newly reclaimed area as the area has access to more land and the outfall location will help to disburse the effluent into the sea.

3.6.1 Need and justification

Lack of improved sewerage disposal facilities are a major concern for a congested island like Velidhoo. This issue was worsened after the Indian Ocean tsunami of December 2004 since Velidhoo was highly affected by the disaster, causing damages to the water and sanitation infrastructure of the island. In this regard the government has received financial support from AFD towards building sewerage facilities in the island as part of tsunami recovery and reconstruction program. Unfortunately, funds available to provide sewerage disposal facilities for the island are not enough for the purpose. Therefore, other alternatives were explored and later Velidhoo was selected as priority islands to provide sewerage facilities under the CSR project. Groundwater assessments carried out by Ministry of Housing and Environment through its consultants in 2010 has found that, ground water is contaminated in most parts of the island. However, existing sewerage disposal facilities build by individual households are polluting the thin freshwater lens available in the island. Therefore, building improved sewerage disposal facility is high priority to avoid further contamination of the groundwater lens and also overcome public health issues which may arise due to groundwater pollution.

3.6.2 Project duration

The project is expected to be completed within 12 months after awarding the contract. This has been the main practice so far in the Maldives. However, CSR projects are required to be completed within 6 months and which may not be feasible due to issues related to materials, manpower and logistics. The work schedule of the project is not available to the consultants at the time this EIA report was compiled.

3.6.3 Environmental design consideration

The proposed project will consider the following environmental issues while making the final designs:

- Technical and financial feasibility;
- Social acceptance;
- Groundwater protection and improvement; and
- Sustainable operation and maintenance.

3.6.4 Effluent collection and disposal

The estimated waste water generated per person per day at Velidhoo is estimated to be 120 litres (MHE, 2010). Therefore it is estimated that, on average a daily volume of (2242 X 120 l/d) 269 cbm waste water will be generated in the island. The waste water generated from houses and other will flow into the catch pit under gravity which then flow into main sewers via laterals into main sewer lines and collected into main sumps or pump stations. Lift stations will help to lift the waste water in places where levels are below the design depth unable to work with gravity. The waste water which flows into the main sumps will be pumped into the sea via sea outfall. The effluent will be diluted and dispersed on the receiving water body.

3.6.5 Proposed sea outfall location

The concept given in Appendix 3 shows the proposed sea outfall location proposed by the consultants after the assessments. The location is different from the location proposed in the previously approved design (MHE 2010) and the options considered (see figure below). The new location has advantages as more land is available for further expansion of the final disposal facility and its treatment works to be built in the future when required. Similarly, dilution and dispersion of effluent is more likely in the newly proposed area since the area would be subjected to ocean currents at all times.

Figure 3-2: Previously proposed outfall locations as options (Google Earth)

3.6.6 Process and materials

The process will be similar to that of other such developments in Maldives. All raw materials required for development have to be transported to the island by sea transport. These activities will be processed on a work schedule which is not made available to consultant at the time this report was prepared.

3.6.7 Construction materials

Construction materials will include PVC pipes, cement, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, PVC conduits, diesel, petrol, tar, PVC adhesive, timber etc. These are the basic materials that are used for such developments.

3.7 Implementation schedule

The implementation of the proposed sewerage system is expected to be started as soon as the approval including EIA has been obtained from concerned government authorities. The project is expected to be completed in 6 months from the date of getting the final design approved from EPA. However, the time frame of 6 months may not be feasible due to logistical and other issues. This project similar to other CSR sewerage projects is supposed to complete according to the process flow chart made available to proponent as part of the agreement made between proponents and government. A detailed schedule has not been made available at this stage. Copies of the detailed schedule will be submitted to EPA construction begins.

3.8 Implementation phase activities

In the construction phase key activities includes, site preparation for development which includes clearing of vegetation where necessary for pump stations, land surveys for proper levelling, excavations for sewer network lines, mobilization of materials and equipment, material transport, power generation facilities, sewer outfall and staff mobilization

3.8.1 Site preparations

Site preparation considered to be one of the key elements of any such projects which include fixing of secure place (house) for material storage and administrative work or build a site office attached to material storage facility in an appropriate location. Other important preparation work include

- Identification of exact locations for lift stations, pump stations, manholes, and sewer outfalls;
- Carry out ground level surveys and build a level profile on each section of the proposed networks;
- Appoint staff for site management and material stock control; and
- Clear vegetations and make access to areas where work will be carried out (e.g. locations for pump stations)

3.8.2 Mobilization of equipment and materials

Site mobilization involves mobilization of workforce, machineries/equipment and construction materials to Velidhoo to begin physical work. Materials, equipment/machineries and all other related items will be transported to the island by sea.

3.8.3 Workforce and services

This is one of the key components that need appropriate management on site during the construction phase. In the proposed sewerage system to be built in Velidhoo, an estimated number of 100 staff including labourers, engineers and supervisors will be stationed in the island. This number may increase during the peak period.

3.8.4 Material transport

All materials that are required for the implementation of the proposed project need to be transported to the island. The transportation will mainly be on *Dhoni*. Transportation of materials is considered to be one of the key activities that cause impact to environment mainly due to accidental spills and direct/indirect physical damage to coral reefs due to careless boating/mooring activities and emission of greenhouse gases which will be further discussed under impact analysis.

3.8.5 Waste management

A considerable site waste will be generated including organic refuse during site clearing. These leafy and biodegradable organic materials (e.g. leafs, shoots etc) and other off site waste will be disposed through municipal solid waste stream. However, waste generated from staff will be taken to the island waste management facility.

3.8.6 Pollution control and waste minimization

Pollution control/waste minimization going to be one of the key aspects of any developments. Cleaner production through appropriate waste minimization and pollution control measures have been on the agenda of many development projects in other parts of the world. However, this has not been given much attention in development projects such as water supply and sewerage in Maldives, although it is written in our development agendas.

3.8.7 Health and safety

Workers health and safety is also an important aspect that needs careful consideration during the implementation from beginning till end. Protection of employees from likely adverse effects will be one of the core duties of the proponent or contractor. All machineries and equipment must be operated by trained and experienced personals wearing necessary safety gears. In the event, if there is any need an employee to work on a different work site, he/she must be given appropriate training before the work. These elements fully will be applied on workers.

3.9 Operational phase activities

Key activities identified throughout the operation of the proposed sewerage development works would be sewage effluent disposal, sludge disposal (if sludge separated through STP) and operation of pump stations/lift stations.

3.9.1 *Effluent disposal*

Wastewater including black and grey water generated in the island will be collected into sewage treatment plant or pump station. If sewage Treatment Plant (STP) is not in place, sewage effluent will be discharged into the ocean via sea outfall on condition that an STP will be installed within 5 years period from the date of commissioning the system. This has been discussed during the EIA scoping meeting held at EPA between the proponent and consultant. In case if STP is to be built effluent will be either discharged into the sea or on land for groundwater recharge. However, land disposal can be allowed only if the effluent quality meets BOD level of 5mg/l or less (wastewater disposal guideline of MWSA, 2007). This can be achieved only with tertiary treatment plants and which may not be feasible in small islands due to operational expenses.

3.9.2 *Sewage Treatment*

Sewage treatment as discussed in Section 3.8.1 will be undertaken if it is required. However, EPA requests to treat the effluent before discharge in to the environment. Similarly, the timing of constructing STP is made flexible as discussed due to high costs anticipated. It is also arguable due to the stringent effluent quality set by EPA which requires less than 40mg/l prior to disposal. Consideration has to be given to the nature of the effluent as it is purely organic in the small islands. Similarly, ocean current and dilution factors also need to be considered while setting such a standard.

3.9.3 *Sludge handling*

As the sewerage system will be built without treatment at first there will not be any sludge available. While when the treatment works are in place, sludge will be disposed carefully. However, the volume of sludge generated in the island will be very minimal which can be treated in the purposely build a sludge drying bed where water can be drained back to the STP

3.10 Project Inputs and Outputs

The project has inputs in terms of human resources, and natural resources and machinery. The main output of the project is island wide community sewerage system implemented in N. Velidhoo. The inputs and outputs are summarised in

Table 3-1: Matrix of key inputs

Input resource(s)	How to obtain resources
Construction workers	Contractor's responsibility
Management and maintenance staff	Appointed by proponent
Construction materials:- timber, cement, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, PVC pipes, diesel, petrol, tar etc	Import and purchased where locally available at competitive prices – Contractor's responsibility
Water (during construction)	Rainwater harvested
Electricity/Energy (during construction)	Diesel-based electricity
Machinery and equipment	Contractor's responsibility
Sulphate resistant cement	Imported or locally purchased
Fuel (e.g. diesel, petrol)	Locally purchased
PVC Adhesives	Imported or purchased locally

Table 3-2: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Waste oils from machinery	Minute	Re-used to other applications
Cleared green waste	Minor	natural decompose
Wastewater effluent	major	Disposed into sea where dilution and dispersion happens
Timber, cardboard, gunny bags and scrap metals (construction site waste)	Moderate	Recovered, reused , recycled
Used oil (waste oil), grease	minute	Reused
Solid waste (kitchen waste, waste from accommodation blocks)	Major/moderate	Taken for disposal through island SW system

4 Project Alternatives

4.1 Introduction

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

4.2 No project option

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

The main advantages and disadvantages of the no-project option are given in the following table.

Table 4-1: Advantages and disadvantages of no project option

Strategy	Advantages	Disadvantages
Keep the existing situation as it is	• Cost saving • No environmental damage on the specific project site • Positive towards carbon neutral policy • The ecological system around the island will be saved • No contamination • Vegetation of the island will be left untouched • The amount of pollutants released into the Maldives environment will remain as its is • Contribution to global warming from Maldives will remain as it is etc • Healthy population due to safe sanitation facilities.	• Long term socio-political problems may arise • Public frustration and anger will increase • Impacts to politicians • Disease burden due to water pollution

4.3 Alternative Sea outfall Location

The alternative sea outfall can be at southwest as indicated in figure below. This site has been considered based on the proposed design concepts prepared by MHE's design consultants BCL in 2010 and the design proposed by the Proponent. However, option 2 given here may not be appropriate due to low ocean current in the area which may result in low dilution and dispersion of effluent. Similarly, land use issues related to unavailability of adequate land for construction of STP and future expansion is also a disadvantage of the area.

Figure 4-1: Alternative sea outfall area

5 Methodology

This section covers methodologies used to collect field data on the existing environment of Velidhoo. The field investigation was carried out from 31st December 2011 to 2nd January 2012. During the field investigation terrestrial, coastal, marine, groundwater and socio-economic aspects of the island and its surrounding environment were assessed based on established procedures.

5.1 General Data Collection Methodologies

Existing environment of the study area were analysed using appropriate scientific methods. Field surveys were undertaken to get further understanding of the existing environment of the island. Field surveys were carried out during a field visit made to the island on 18th December 2011 to collect baseline data. The following components of the existing environment were assessed.

- Terrestrial Environment
    - Terrestrial vegetation, groundwater quality, estimation of groundwater aquifer, estimation of aerial extent of groundwater aquifer, terrestrial fauna.
- Marine Environment
    - Coastal environment, shoreline, back reef, fore reef, reef flat, marine water quality, fishes, protected species, endangered species etc.

5.1.1 Groundwater quality

Groundwater quality was measured in situ using YSI and Hatch potable water quality testing hand held meters. Parameters tested include, electrical conductivity (µs/cm), dissolved oxygen (mg/l), salinity (%), total dissolved solids (mg/l).

5.1.2 Marine Water Quality

Marine water quality around the island on selected locations was tested in situ by using YSI water quality logger which can measure pH, electrical conductivity (salinity and TDS) and dissolved oxygen (DO), Turbidity (NTU) Water quality testing was done at four selected locations WQ1, WQ2 and WQ3

5.1.3 Ocean Currents

Ocean and lagoon current was measured by conducting drogue tests on selected locations around the island. A purpose built drogue with a GPS (Trimble Juno) was made to create spaghetti diagrams of the ocean currents.

5.1.4 Condition of the House Reef

Marine environment was surveyed to assess and obtain baseline data of the existing marine environmental conditions. Both quantitative and qualitative methods were used to assess the benthic substrate at the survey sites including Manta Tow survey, quadrants and visual assessments were used to quantify benthic types. .

This study was complemented with extensive underwater photographs of the areas in question. Methodologies adopted for these surveys are internationally accepted (English et al. 1997) and are widely used to assess the status of coral reefs in the Maldives as well.

5.1.4.1 Quadrat Survey

Quadrat surveys were carried out to assess the benthic types and coral species at the survey sites. It was carried on five different sites around the reef line including proposed outfall locations. It is one of the survey technique widely applied for ecological sampling.

Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. In this EIA study during the field visit made on 18th December 2011, a square shaped quadrat measuring 1m x 1m was used for reef flat sampling.

6 Existing Environment

This section covers the existing environmental of proposed work site. In this case the work site is Velidhoo island of Noonu Atoll where and the proposed island wide sewerage facility will be developed. The key environmental components of the project under consideration are described below.

- Vegetation of the island
- Coral reef systems – status and health of coral reef system
- Groundwater aquifer – quality and quantity
- Marine and coastal environment – oceanography, marine water quality and oceanic currents
- Meteorological conditions – local wind, current, rainfall and tides
- Socio economic – public perceptions, the status, health and wellbeing of the community

6.1 6.1 General meteorological conditions

The Maldives has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. (MHHE,2001).

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the Northeast (*Iruvai*) and the Southwest (*Hulhangu*) monsoon. Monsoons can be best characterized by wind and rainfall patterns. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November. However, according to Elliot et al (2003) due to proximity to the equator, the monsoon seasons in Maldives are not as well defined as they are in Sri Lanka. The monsoons in Maldives are best defined in the northern part of the country where a distinct monsoon seasons including the strong southwest monsoon from June through September and a noticeable northeast monsoon from December through February occurs

Table 6-1: Key meteorological characteristics of the Maldives

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February 1900mm annual average
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 ^{0}C in November 1973 31.7 ^{0}C in April
Extreme Air Temperature	34.1 ^{0}C in April 1973 17.2 ^{0}C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

The climate of the Maldives varies slightly from South to North of the country. As pointed out by Elliot et al (2003) the monsoon in north region is more pronounced and distinct. In Maldives, meteorological data are not recorded in all islands across Maldives. It has been recorded at islands where regional airports operated.. General meteorological conditions prevailing in the region based on meteorological data for Hulhulé has been used to understand climatic factors affecting Velidhoo Island. The table below shows summary of seasons in Maldives.

Table 6-2: summary of seasons in the Maldives

Season	Months
North East-Monsoon (Iruvai moosun)	December
	January
	February
Transition Period - 1 (Hulhangu Halha)	March
	April
South West-Monsoon (Hulhangu moosun)	May
	June
	July
	August
	September
Transition Period - 2 (Iruvai Halha)	October
	November

6.1.1 Wind

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

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

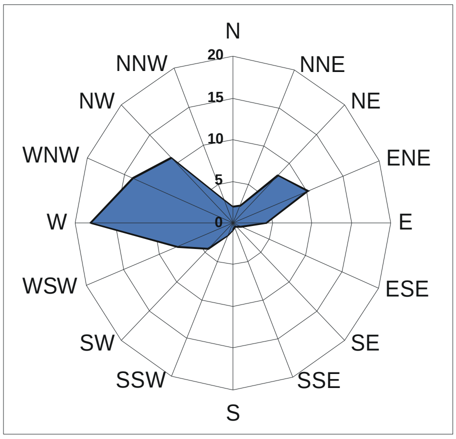


Figure 6-1: General wind rose diagram for the Maldives (after MEEW, 2005)

Changes in wind directions need to be taken into consideration in determining the most favourable time period of proposed work. The development of outfall work may disturb the floor sediments to some extent and form sediment suspension which depending on the wind speed, direction and ocean current will move until naturally settles down.

The extreme northern part of the region experience wind climate with a strong southwest monsoon from May through August and a moderate northeast monsoon from December through February. The Maldives experience strong ocean wind at speed of 6m/s to 7.5m/s at a height of 10m during June, July and August (Elliott *et al*, 2003).

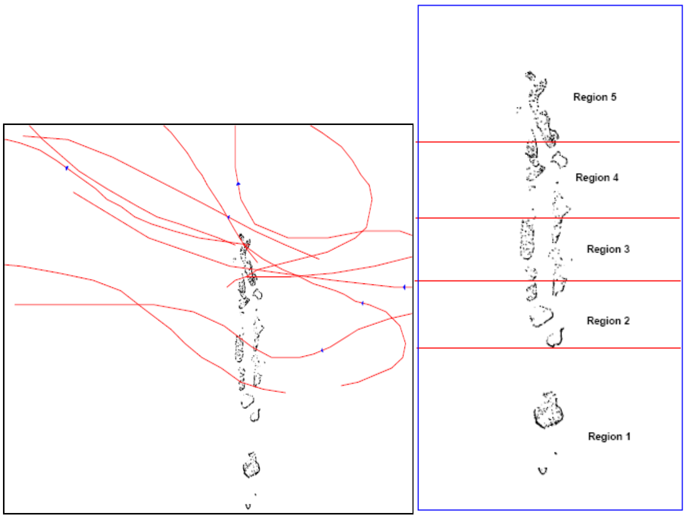
6.1.2 Rainfall

The northeast monsoon is known as the dry season with average monthly rainfall of 50-75 mm. The intensity of rainfall is a concern in the Maldives since intensity is high with low frequency. It is sometimes believed that the interval of rainfall (frequency) is important in considering the groundwater recharge potential from precipitation.

6.2 Natural Hazard Vulnerability

An island's natural vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island and location of the island with respect to the country, the formation of the island, location of the island respect to the atoll, orientation of the island, region of the country where island is located, level of protection to the island from the reefs and other islands; area of the inland lake found on the island, width of the island's house reef, coastal defence structures on the island, shape of the island and the area of the island. Although Maldives is generally considered to have moderate risk to natural hazards or disasters, islands across Maldives experience varying degree and magnitude of natural disasters.

Referring to Suffir-Simpson Scale, Velidhoo is considered at vulnerable zone when cyclonic winds and storm surges over the Maldives are concerned and also low risk when tsunamis and earthquakes are concerned.(RMSI/UNDP 2005). The island was heavily affected during tsunami disaster of 2004.



Hazard Zone	Probable Maximum Wind Speed (knots)	Saffir-Simpson Scale
1	0.0	0
2	55.9	0
3	69.6	1
4	84.2	2
5	96.8	3

Figure 6-2: Natural hazard map of Maldives (after UNDP, 2005)

The stormy weathers around the world are affecting coral reef systems directly and indirectly due to global climatic changes. Intense storms can wipe out the natural coral "recruitment" process (Daily Science, April 29, 2008) as a direct effect of climatic change. Healthy coral reef systems are vital assets to many economies around the world on which large numbers of island communities depend on range of fisheries activities including Maldives. In Maldives for instance according to NAPA (2006) local demand on reef fishery has increased in recent years. Therefore, the concern of natural hazard vulnerability on corals reefs in Maldives is very high, which needs a solution through local and global effort.

6.3 Existing coastal and marine Environment

Velidhoo with a total initial land area of 42 hectares is located at 5°40'N and 73°17'E has been reclaimed recently. At the time when the EIA survey was conducted an additional land of size one fourth of the original island has already been reclaimed at northern end of the island. The shoreline around the island indicates local erosions particularly at the north western side of the island. The island is famous for safari boat building, where huge huts were built on beach front western side of the island with slipways.

The coral reef system in general around the island appeared comparatively poor with most live coral cover on the eastern side. 90% of the surveyed sites were found dead mixed with algal growth/coral disease, coral rubbles and sand/sediment mix. Majority of the coral species identified were massive porites with isolated branching corals.

In terms of fish population, the surveyed sites have poor diversity and abundance of fish communities. The fish abundance is poor perhaps because of sedimentation due to recent land reclamation and dredging works in the area. However, most of the reef areas have now been cleared of sediment and turbidity is low.

6.4 Oceanography

6.4.1 Waves

Wave energy also plays a key role in the movement and settlement of sediments and suspended solids, and is also a crucial factor controlling coral growth and reef development. Studies by Lanka Hydraulics (1988a & 1998b) on Malé reef indicated that two major types of waves in Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during May-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988).

6.4.2 Water Currents

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

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

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

Study of current around the island identified to be one of the key aspects relevance to the proposed sewerage system. Flow of water current would play a key role in assessing the pattern of sewage dilution and dispersion. In order to assess the current pattern around the island in particular the proposed out fall location, drogue tests were conducted in the proposed locations.

6.5.1.1 Drogue Tests

In order to assess the current pattern around the island four drogue tests were conducted around the island including the proposed sewer out fall locations. Those four drogues –DR1 – DR4 were done at reef edge around the island as indicated in the figure. Drogue 1 released on the outer reef edge at northeast corner of the island travelled towards south-east at 0.34m/s. Drogue 2 released on the southern side of the island travelled south-east direction at 0.18 m/s (which is the area where original sea outfall was proposed by MHE's design consultants BCL (MHE,2010) earlier). Drogue 3 released at south-west side travelled toward at 0.07m/s north-east direction. This is the area were recent reclamation took place in 2010. Drogue 4 was released on north-east side of the island travelled at 0.16 towards south west. The overall current movement around the island is towards south-westerly direction. This indicates the proposed outfall location of the EIA consultants are better compared to the proposed location of MHE's design consultants BCL(MHE, 2010) as it will help to carry sediments away from the island.

LEGEND

- SHORELINE
- VEGITATION LINE
- PROPOSED OUTFALL LOCATION
- ALTERNATIVE OUTFALL LOCATIONS

N.Velidhoo Current Monitoring

ISLAND	N.Velidhoo
ATOLL	Noonu Atoll
CLIENT	-
SCALE	-
SURVEYED DATE	31st December 2011
SURVEYED BY	Shifaf & Luayyu
DRAWN BY	Shifaf
DRAWING DATE	4th January 2012

REVISIONS: -

SANDCAYS PVT LTD

Sandcays

6.4.4 Marine water quality

Seawater samples were taken and tested in situ from four different locations around the island. These samples show no remarkable difference between the locations. Therefore, it is assumed that water quality is good at the time of investigation. However, it is important to conduct regular sampling to monitor the seawater quality. This can be done throughout the year on regular basis. Monitoring of marine water quality will help to indicate the state of health of marine water and to reveal the long term changes in water quality.

Table 6-3: Water quality results

	Units	WQ1	WQ2	WQ3	WQ4
Temperature	⁰C	28.10	28.20	28.24	28.10
E. Conductivity	mS/cm	52.45	52.33	52.34	52.45
TDS	mg/l	34.04	34.02	34.03	34.09
Salinity	%	34.40	34.37	34.39	34.46
DO	mg/l	5.29	4.42	5.11	5.85
pH	NA	7.67	7.88	7.98	7.96

6.5 Terrestrial Environment

The terrestrial environment of Velidhoo is similar to other inhabited islands across the Maldives. The island is relatively small in size with less vegetation mainly due to land scarcity issues. Therefore, vegetation surrounding the beach is perhaps where main plantations are is seen. Coconut palms are the dominant plants found in the island.

6.5.1 Geological setting and hydrogeology

The islands of Maldives are small, low lying with average height of less than 2.5 above mean and flat with common type of vegetation. (Riyaz et al., 2010). The groundwater in Maldivian islands occurs in the form of "freshwater lenses", which are highly susceptible to saline intrusion and vulnerable to pollution from surface and subsurface activities particularly from sanitation practices (Falkland, 2001b). However, the quantity of fresh groundwater in these islands depends on island size, recharge rate and ease of transmission of freshwater through the aquifers (White et al., 2007). Narrow atolls with transmissive aquifers have limited potential for viable fresh groundwater and the only viable option that remains for these islands are rainwater harvesting and desalination (Falkland 2002). Maldivians traditionally depended on fresh groundwater abstracted from shallow wells for potable and other purposes (MHHE, 2002). groundwater availability in most of the small islands are often restricted due the small land areas, depriving the communities from freshwater supply to their basic needs, for instance freshwater is imported to islands of Fiji, Tonga and Nauru during the droughts (White et al., 2007).. The extremely limited groundwater resources available in the islands of Maldives are often contaminated from various sources and in most cases it is unfit for potable purposes (Falkland, 2001a; Falkland, 2001b). Therefore, rainwater harvesting has been widely practiced in the islands and accounts for more than 94 % use by the population of the rural islands (MPND, 2006; MHE, 2011).The low lying atoll island nations are facing water supply problems that are among the most critical in the world as fresh groundwater available in these islands are extremely susceptible to natural process and human activities (White et al., 2007). At the core of these issues, climate change will exacerbate the problem of water scarcity in the small islands affecting both the quantity and quality of water resources (Bates et al., 2008; White et al., 2007). The studies conducted by MHE consultants (BCL) in 2010 has found that Velidhoo has a small fresh groundwater lens with the thickest parts being about 3.5m near the centre and south of the island (MHE 2010).

6.5.1.1 Size of groundwater lens

The size of groundwater lens depends on several factors including size of the island, width of the island, rainfall pattern and extraction of groundwater. the size of groundwater lens of the islands were estimated by Falkland (2001) under the ADB funded Regional Development Project Phase 1.The estimation was based on average ratio of groundwater lens area (ha) taken as 0.45 and area of the island (ha). Moreover, in 2010 MHE hired consultants BCL have conducted a thorough investigation on groundwater condition of Velidhoo. The study was conducted using EM survey equipments. In the survey estimation freshwater thicknesses at selected locations from the EM surveys were combined with the salinity measurements at wells were used to map the Velidhoo freshwater lens boundaries and thickness contours. The following table shows the areas and volumes of the freshwater lens based on EM survey calculations.

Table 6-4: N.Velidhoo water lens statistics (after MHE, 2010)

Freshwater lens area (ha)	Freshwater lens volume (million m3)	Fresh groundwater Volume (ML)	Average freshwater lens thickness (m)	Average fresh groundwater thickness (m)	Average residence time (years)
37.6	0.36	109	0.97	0.29	0.38 (4.5 months)

The investigation on EM survey has found that the boundary of the lens extends close to the edge of the island assumes that this boundary is about 20 m from high tide level. It was also found that maximum thickness of the lens is approximately 3.5 m and occurs in the centre of the island.

6.5.1.2 Groundwater quality

Groundwater quality of the island was investigated during the period where EIA filed works were carried out. Samples from groundwater wells were tested from 20 locations as shown in the table. The investigation aims to assess the groundwater quality with particular emphasis on salinity and microbial contamination from onsite sewage disposal systems. This results show that groundwater salinity level is low and at acceptable level.

Table 6-5: Groundwater quality results

Sample location	Water quality parameters					
	Temp (C)	E.Conductivity (Ms/cm)	TDS (mg/l)	Salinity (%)	DO (mg/l)	pH
Mosque	29.17	0.835	0.542	0.4	0.16	7.47
Dhifusshi	28.17	0.573	0.372	0.27	0.16	7.72
Fehivillu	28.19	0.652	0.424	0.31	1.7	7.32
Malaka	28.19	0.899	0.585	0.44	0.6	7.12
Heylhi	28.17	0.721	0.469	0.35	3.82	7.29
Beach Heaven	28.4	1.752	1.146	0.29	3.33	7.3
Alimaa	28.07	0.964	0.627	0.47	1.26	7.18
Hushiyaaru	28.37	0.987	0.642	0.48	2.3	7.15
Ithaa	27.95	0.806	0.524	0.39	2.43	7.28
Sunnylodge	28.25	0.915	0.595	0.45	1.33	7.11
Ranthari	26.85	0.587	0.382	0.28	5.82	7.65
Asrafeege	28.29	0.845	0.549	0.41	3.02	7.31
Mosque (Ihsaan)	27.24	0.516	0.335	0.25	3.3	7.6
Mosque	28.49	0.489	0.318	0.23	2.17	7.39
Health Center	28.87	0.817	0.531	0.4	1.9	7.77
Vagutheehiyaa	27.8	0.557	0.362	0.27	1.79	7.89
Beach Wave	27.53	0.847	0.551	0.41	1.38	7.25
Jambuge	27.87	0.509	0.331	0.24	2.84	7.59
Maaolhu	28.88	0.935	0.608	0.46	1.34	7.14
Maaveyo	28.27	0.657	0.427	0.32	1.4	7.31
South Happy	28.11	0.666	0.433	0.32	4.89	7.33

Groundwater quality of Velidhoo conducted by MHE (2010) via its consultants has found that faecal coliforms were present in four of the 16 selected wells. Similarly, 69% of wells tested positive for ammonia concentrations above the 'natural concentration' for groundwater and 25% were above the WHO drinking water guideline value. However, Nitrate and nitrite were detected in 60% and 81% of wells, respectively, but no samples had concentrations above the WHO drinking water guideline values based on health considerations. Phosphate was also detected in all wells and 25% of them had phosphate at concentrations where sewage or grey water pollution could be suspected.

6.5.2 *Existing sewage disposal practices*

In Velidhoo, there is no island wide sewerage disposal facilities provided. The population depends on household septic tanks and soak pits for discharge of sewage. This practice is contributing towards the pollution and contamination of groundwater lens. Septic tanks are often made from bricks by, which are rarely maintained and cleaned. Therefore, septic tanks are leaching the sewage into the freshwater. As the island has less space within household plots, septic tanks and soak pits are often located close to groundwater wells contributing pollution of well water. However, some houses have connected their sewage disposal facilities to the lagoon via pipes managed by houses. This practice is also contributing towards pollution of recreational water near the island. Hence, Velidhoo is an island which requires urgent solution for improved sewage disposal facilities.

7 Socio-economic Conditions and Stakeholder Consultations

The socio economic assessment involved conducting stakeholder consultations and interviews with Velidhoo community and council. The assessment also included developing a profile of the island.

7.1 The island Velidhoo

Velidhoo is among the 13 inhabited and most populous island of Noonu Atoll. The island Velidhoo is situated in the south-west region of Noonu atoll, and is located in between 5°58' N and 72º33' E. The distance between the island and the capital Male' is 166.52 kilo meters. According to 2006 national census the total population of Velidhoo is 1705, but there are 2242 registered people in the island now. This is an increase of 3.5% since 2006 which means the population is increasing 1% per annum. However, according to island council estimation there are more than 300 non-resident populations living in the island.

7.2 Land use and livelihood

The Island measures approximately 701.04 metre from east to west and 2225.06 metre from north to south. The total area of the island is 44.ha. Scarcity of land is a major issue facing the population of Velidhoo. The increase of population compared to the available land is creating more demand on land and requires additional land to be reclaimed and added to the island. Due to high demand on land, a land reclamation project has been recently initiated by the government adding more land to the existing land area of the island. The livelihood of the population depends upon fishing, tourism, carpentry, masonry, civil service and private businesses. Velidhoo is famous for building private yachts.

7.3 Social and physical infrastructure

There are various infrastructure facilities available in the island including island council office which is the main administrative office of the island. Other facilities including magistrate court, Noonu atoll education centre, Velidhoo health centre are major social infrastructure available in the island. There is an island guest house operated through island council. There is a preschool, recreational grounds and children's park operated by island council. Existing utility services of the island including island power house and a small desalination plant is operated by Northern Utilities Limited. Water is supplied via household rainwater tanks and community tanks. Sewerage disposal is a major issue facing the island. There is a good waste disposal site available in the island.

7.4 Community Consultations

7.4.1 Meeting with Island Council

The EIA consultants met island council officials and discussed about the proposed project. The meeting was held on 1st of January 2012 on 2115 at island council office. The meeting was attended by the following members of Velidhoo Council.

- Mr. Mohammed Adil, President
- Mr. Ahmed Saeedh, Vice president
- Mr. Mohammed Siraj, member
- Mr. Ahmed Ziyadh, member

The following issues were raised by Council members.

- Due to lack of sewerage disposal facility, unavailability of land and disposal within household plots groundwater pollution is very high in the island. In addition to the mentioned issues, there are more than 25 houses connected their sewage facilities to the lagoon now, thereby increasing pollution of recreational waters;
- There are several surveys conducted by different groups previously including the Utilities Company with almost no practical work so far. Therefore, physical work for building the facility needs to be started at the earliest. This is a major concern of the people of the island;
- Collection of tariff from users could not be a big issue, provided that the tariff rates have to be affordable and rates need to be shared with the public prior to finalization.

7.4.2 Willingness to pay

The EIA team has interviewed 20 houses on their attitude towards willingness to pay the tariffs of sewerage services. Among the 20 respondents, 95% of the respondents are willing to pay the services if it is affordable. However, 5% of the respondents are unwilling to pay for the services.

8 Impacts and Mitigation Measures

This section covers potential environmental impacts arise from the proposed sewerage works in Velidhoo, Noonu Atoll. The following pages will discuss the potential impacts from the proposed project activities and measures that needs to be taken to mitigate the project activities.

The environmental aspects of the project would impact upon the following resources of the environment.

- Groundwater – quality and quantity
- Coral reef areas around the outfall locations – marine biodiversity
- Marine and coastal water quality
- Lagoon and beaches – aesthetics
- Human health and well being
- Land use – availability and constraints
- Social and economic development

8.1 Impact Identification

Impacts on the environment from various activities of the proposed sewerage development work (constructional impacts) and operation of the sewerage facility (operational impacts) have been identified mainly through the following indicators:

- A consultative process within the EIA team, the Proponent and affected communities
- Purpose-built checklists for environmental evaluation of sewerage system development projects
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Concept designs and design reports prepared by Bangladeshi Consultants Limited (BCL) for the Ministry;
- Baseline environmental conditions of the project setting described in this EIA report;
- Experiences gained from similar development projects in various parts of the Maldives particularly in the area of water and sewerage services.

Possible negative impacts of the proposed development on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in both constructional and operational phases.

Impacts on the environment were identified and described according to their location/attribute, extent (magnitude) and characteristics (such as short-term or long term, direct or indirect, reversible or irreversible) and assessed in terms of their significance according to the following categories:

1. **Negligible** – the impact is too small to be of any significance;
2. **Minor adverse** – the impact is undesirable but accepted;
3. **Moderate adverse** – the impact give rise to some concern but is likely to be tolerable in short-term (e.g. construction phase) or will require a value judgement as to its acceptability;
4. **Major adverse** – the impact is large scale giving rise to great concern; it should be considered unacceptable and requires significant change or halting of the project.

Since it is difficult to distinguish between direct impacts (i.e. resulting directly from a specific activity) and indirect impacts (i.e. induced by a series of ecological, social or economic knock on effects and bearing no apparent connection to any specific activity), such distinction has not been made. All possible impacts that may be related to project specific activities have been discussed.

8.2 Identifying Mitigation Measures

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

1. Eliminate or avoid adverse effects, where reasonably achievable.
2. Reduce adverse effects to the lowest reasonably achievable level.
3. Regulate adverse effects to an acceptable level, or to an acceptable time period.
4. Create other beneficial effects to partially or fully substitute for, or counter-balance, adverse effects.

8.2.1 Mitigation Options

The following are some of the mitigation options which can be beneficial for mitigating the impacts.

- Design alterations (e.g., different locations for sewage outfalls, etc.)
- Work method alterations (e.g. changes in construction scheduling)

- Provision of environmental protection and health and safety equipment (e.g., provision of first aid or noise mufflers, pollution abatement equipment)
- Changes in management practices (e.g., contractor's awareness on environmental issues, keeping work areas clean, public awareness)
- Changes in operation (e.g. operational procedures, specific responsibilities for clean up and maintenance).
- Environmental monitoring during construction and operational phases.

8.3 Existing Environmental Concerns

8.3.1 Natural hazard vulnerability

Maldives is not in a hurricane or seismically active region. Therefore, there is no threat of hurricanes or seismic activity such as volcanoes. However, seismic activities have increased in the near vicinity of the Maldives which may affect the Maldives.

There is no record of tsunami emanating as a result of earthquake or landslides in the South Asia region. However, the Indian Ocean tsunamis of December 2004 have caused devastating impacts to almost all islands of the Maldives. therefore, infrastructure facilities to be built in the islands need to designed to address the high waves and also floods and other natural disasters which may if not consider cause severe damages. Veldhoo was one of the islands affected by tsunami and planned to rebuild water and sewerage facilities under various schemes.

Storm surges during southwestern and northeastern *halha* and corresponding wave scour and subsequent beach erosion during storms is a major cause for concern in the Maldives, which may threaten coastal structures and coastal works such as sewage outfalls.

8.3.2 Existing sewage disposal impacts

There is no island wide sewerage disposal facility in Velidhoo. According to BCL (2010) current sewerage disposal method includes household septic tanks followed by a soak pit for treatment of sewage. However, septic tanks are made from bricks or concrete and due to poor construction and lack of maintenance these tanks are leaching sewage into groundwater. In most cases septic tanks and soak pits are located very close to wells due to lack of space within household plots. This leads pollution of well water and makes it unsafe for potable uses. The septic tanks are considered as the major source of pollution to groundwater contributing high levels of microbial contaminants.

8.4 Overall impacts of the proposed project

The environmental impacts that maybe associated with the proposed sewerage development works are summarised by using a simple matrix and a purpose developed checklist given in the annex. The matrix given in the following table shows the types of environmental impacts that may be associated with the sewerage development works thought the project period including implementation and operation.

Table 8-1: Matrix of key components which may impact to environment during implementation and in operation

Environment Component	Implementation Phase					Operation Phase				
	Excavation for pipe laying, manholes, lift stations and pump stations	Clearance of vegetation for pump stations/lift stations	Installation of pump stations/lift stations	Installation of road manholes and household catch pits	Installation of sewage and brine ocean out falls	Material Transport to work site	Untreated wastewater discharge into ocean	Desludging of main sumps and lift stations and manholes	Use of Power	Extraction of groundwater for toilet flushing
Marine										
Corals					X	X	X			
Reef fish					X		X			
Lagoon bottom					X		X			
Coastal waters					X	X	X			
Oceanography					X		X			
Terrestrial										
Flora	X	X	X	X	X	X				X
Fauna	X	X	X	X						X
Soil	X	X	X	X	X	X				X
Groundwater	X		X	X	X					X
Air		X	X	X	X	X	X	X	X	X

8.5 Impacts from implementation

Implementation phase will have the major, direct short-term impacts and some secondary long-term impacts on the environment. The proposed sewerage development works will mainly involve excavation for pipe laying and construction of pump stations and ocean outfalls.

8.5.1 Mobilization

8.5.1.1 Impacts

The transport and supply of material, barges, excavator, truck and any other machinery may have impacts that may arise from:

- Accidental spillage of construction materials (e.g cement).
- Accidental oils and other chemical spills.
- Accidental grounding of large vessels such as barges.
- Propellers' wake can break fragile corals.
- Anchor damage from the vessels.
- Hazards of transport of material and machinery to site including overtopping of barges.

8.5.1.2 Mitigation Measures

Precautionary measures need to be in place while loading and unloading of such materials and machineries at work sites under supervision at all times throughout the cycle of the process.

8.5.2 Machinery

8.5.2.1 Impacts

In addition to accidental damage caused to corals from barges and other machinery, these machines run on diesel fuel, which will have fuel management and handling issues in addition to carbon emissions. Poor handling and management of diesel and other fuel as in many islands, often lead to contamination of the aquifer. Some degradation of the marine environment is also likely. Moreover, improper handling of fuel could result in accidents and mishaps such as fires, which has in the past had caused major damages.

8.5.2.2 Mitigation Measures

Efforts must be made to avoid accidental spillages from machinery including overtopping leading to severe spillages. Machines must be operated by experienced operators and make sure machines are clean all the time. Avoid throwing of cleaning materials and changed oils into the environment.

8.5.3 Impacts from Materials

8.5.3.1 Impacts

Materials such as cement and fuel for machineries have the potential to damage the marine and terrestrial environment. Both terrestrial and coastal activities can pollute the environment including soil, aquifer and coastal water due to accidental spill of oil and chemicals. Sometimes these materials are thrown into the environment due to absence of appropriate supervision at work sites.

Pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction. Reefs also get damaged due to boating activities including mooring, loading and unloading of materials.

8.5.3.2 Mitigation Measures

Efforts must be made to avoid any such contamination of the environment in particular of handling of fuel, chemicals, and construction materials. Workers and helpers must be provided information. Other aspects to be considered include to

- Avoid boating activities in low tide
- Avoid damage to coral reefs through proper navigations
- Avoid loading, unloading and boating activities at night times

8.5.4 Impacts from Excavation

8.5.4.1 Impacts

Excavation will be undertaken for pipe laying, manholes, lift stations and pump stations. If the excavation happens to dredge below water table it would affect water table. It may require dewater for installation of these components associated into the system. Impacts associated in the excavation includes

- Emission of greenhouse gas
- Loosens sub soil layer
- Dewatering might induce salinization
- Accidents and falls

8.5.4.2 Mitigation Measures

The mitigation measures include

- To ensure appropriate supervision and monitoring
- Complete the work as soon as possible
- Keep the workers informed with these aspects to minimize the impacts
- Avoid mass extraction of water at one time
- Avoid excessive excavation
- Wear safety and protection measures (personnel protection equipment)

8.5.5 Installation of sewage outfalls

8.5.5.1 Impacts

The key impacts of sewage outfalls would be degradation of marine water quality due to sedimentation, discharge of sewage effluent, damages to coral reefs and loss of habitat. Construction of sewer outfall would impact to coastal water, lagoon bottom and reef. During construction and mobilization of equipments would cause re-suspension of bottom sediments. Depending on the current movement, the suspended fine sediments may move to healthy corals which in turn may get killed due to excessive sedimentations.

8.5.5.2 Mitigation Measures

The mitigation measures include

- To ensure appropriate supervision and monitoring
- Carry out the work in low tide
- Complete the work as soon as possible
- Keep the workers informed with these aspects to minimize the impacts
- Avoid construction of solid structures inside water
- Avoid washing tools, equipments etc into lagoon
- Use physical barriers to avoid effects of sedimentation on reefs

8.5.6 Changes in Coastal Water Quality

Sewage outfall development would cause excessive rate of suspended particles in water which change turbidity level in turn will affect the quality and intensity of light reaching reef organisms. Additionally it would cause stagnation of water if there is no proper circulation within the discharge point. Hence it will affect coral metabolism, productivity and growth of reef building corals. The effects of turbidity on corals may be lethal, sub-lethal or acute or chronic depending on the intensity and duration of disturbance. In many cases the marine water where sewage effluent discharged get contaminate with faecal coliform and elevate the BOD and COD level.

8.5.6.1 Mitigation Measures

Precautions need to be taken at all times during construction work inside water. Supervision and monitoring need to be in place making sure that these impacts are minimized. Avoid discharge of untreated sewage into marine environment.

8.5.7 Impacts on baitfish, reef-fish and other marine organism

As a result of sewerage system development along with sewage outfalls, associated activities and consequential impacts on the physical and biological environments, the marine organisms such as juvenile fish found in the area will be impacted and may decline in its numbers and diversity as well as eventual death in certain species. Sedimentation may also reach short distances within the same reef and causing similar threats to species. However, the magnitude of the impacts will be determined by current flow patterns and resilience of the species in the region. Measure of current is hence very important to determine the flow pattern around the island. In absence appropriate data to assess the direction, sewage effluent might flow into lagoon. However, some fish communities are found to live near outfall areas such as observed in Male' and some other places.

8.5.7.1 Mitigation Measures

Mitigation measures to these impacts include monitoring and supervision of all work sites, in particular of installation of sewage outfall and exaction and installation of catch pits, road manholes, main pump stations, sewer line etc. Which are likely of causing impact to environment

8.5.8 Health and safety

The main health and safety issues during the construction stage would be in the operation of heavy machinery and equipment such as excavators with the risk of toppling. Falls and accidents due to carelessness in the project site has been a concern in many construction sites and must be addressed during the planning and implementation stages.

Noise levels felt by workers can be a health issue too. However, noise levels at the project site would not be too high and would be intermittent and not continuous. Therefore, acceptable average daily exposure levels would not be exceeded for construction workforce.

8.6 Operational Impacts

The operational phase will impose threats to the marine environment and groundwater aquifer that are of a continuous nature and are often difficult to deal with due to the complexity of certain impacts. The groundwater impacts will be of significant.

8.6.1 Impacts from Operation of Sewage System

8.6.1.1 Impacts

According to World Resource Institute (WRI), 2000, 41% of reef systems in the Pacific region are under medium-high pressure from human developments. The impact to environment due to anthropogenic physical structures such as breakwaters, access channels and harbours on the coastal processes and marine flora and fauna, can be quite significant and often permanent. Some of these include:

- Change in near shore hydrodynamics.
- Erosion and loss of vegetation at the low energy areas during either monsoons.
- Sedimentation and turbidity resulting in poor water quality which negatively impacts vitality of marine organisms.
- Alteration of bottom substrate.
- Degradation of sea water quality due to increased sediment or turbidity.
- Loss of coral reefs

The long term impact of the proposed project is difficult to quantify due to the lack of past monitoring and research on this aspect in the Maldives and specifically that of the project site. However, the impact is expected to be moderate in scale and long term.

8.6.1.2 Mitigation Measures

Mitigation measures are dependent on the long term monitoring. It is important to consider regular and consistent monitoring of littoral transport patterns over a period of about three years to understand the specific impacts of the coastal developments.

8.6.2 Transport Related Impacts

8.6.2.1 Impacts

The use of diesel as well as petrol in vehicular engines and operation of machines cause emissions of carbon dioxide, sulphur dioxide and nitrogen oxides with fine particular matter. Carbon dioxide being the primary greenhouse gas and the main contributor to global warming, likely future carbon emissions would be a cause for concern, as the impact cumulatively adds to the global burden of carbon emissions.

8.6.2.2 Mitigation Measures

Mitigation these aspects include

- Use light fuel where appropriate
- Avoid unnecessary operation of vehicles, machines and boats
- Keep in place appropriate transport management system
- Keep in place appropriate logistic management system during construction and operation phase

8.6.3 Socio-Economic Impacts

8.6.3.1 Impacts

The social economic impacts from the proposed sewerage development works will be positive and negative; in terms of job opportunities it is positive. The negative impact would be that it will damage groundwater aquifer by elevating salinity level depending on the rate of extraction for flushing. The positive impacts would be that people would be satisfied with the system and will minimize groundwater contamination from domestic sewage.Similarly; disease burden associated with ground water use will be minimized. There are concerns which may have impacts on the community due to fees to be levied for operation of the facility.

8.6.3.2 Mitigation

The mitigation measures would be to inform islands communities about the proposed sewerage system. Involve community members within the implementation phase until handed over to utility for operation. Reviewing the tariff rates and levying the fees in consultation with the community is a key paramount for the sustainable operation and maintenance of the facility.

8.7 Uncertainties in Impact Prediction

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. There is also no long term data and information regarding the particular site under consideration, which makes it difficult to predict impacts. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring as described in the monitoring programme given in the EIA report.

Table 8-2: Summary of socio-economic and environmental impacts of the proposed project

Activity	Causal Factors	Impact	Short Term Effects	Long term Effects	Impact Significance
CLEARING OF VEGETATION ON LAND AND COASTLINE (PIPE LAYING, PUMP STATIONS, OUT FALL)	Reduced number of trees on the island	Loss of vegetation Loss of habitats for birds and domestic animals Elevated atmospheric CO_2	Disappearance of birds Nesting birds lose their habits	Contributed global warming Contributes global warming	Moderate Moderate
INSTALLATION OF SEWER NETWORK	Alters groundwater quality Elevated atmospheric emissions Discharge of oil, chemical and wastewater into ground	Poor water quality Atmospheric pollution Pollutes soil, water	Elevated salinity Contributes global warming loss of freshwater, and soil	Change of water quality and changes life style Contributes global warming Disappearance of freshwater aquifer	Moderate Moderate low
INSTALLATION OF PUMP STATIONS, LIF STATIONS AND MANHOLES, SEWER OUTFALLS	Re-suspension of fine sediments	Water quality degradation	Increased water turbidity		Low
	Imported material use	Introduction of alien matter			Low/moderate
MACHINERY & EQUIPMENT	Heavy machinery operation and construction	Local noise and air pollution	Temporary disturbance to particularly habitats/people	None	Insignificant
	Accidental damage from operation of barges, etc.	Local damage to reefs			Low to moderate
	Accidents during machinery and material transport to site	Oil and waste spillages to oceans/reefs	Sudden death of marine life to water quality deterioration		Low to moderate
WASTEWATER DISPOSAL	Discharges or accidental spill of motor oils, lubricants, hydraulic fuels, other chemicals such as antifoulants and paints in vessels Discharge of wastewater effluent	Marine water pollution	Contamination of marine biota and fisheries resources	Decrease in fish and live corals	Low to moderate
HANDLING AND TRANSPORT OF GOODS AND MATERIALS	Loading/unloading noise Dust and air emissions	Air and noise pollution		Disturbance to terrestrial and marine ecological systems	Low
	Transport including road transport	Increased risk of accidents Increased pollution	Increased casualties, air and noise pollution	Increased casualties, air and noise pollution	Low
INFLOW OF GOODS AND MATERIALS	Increased traffic of vessels to and from the island	Increased inter-island transport and inter-atoll transport Creation of business opportunities Direct and reliable supply of goods	Increased sales to related local business establishments	Creation of employment	Positive

Table 8-3: Summary of mitigation measures

Mitigation measures for minimizing impacts		Implementing responsibility	Technology/ equipment	Time frame	Cost
Design Phase	Identify areas for development on land and marine Clearly identify and mark the areas required clearing of vegetation and coral reefs Design all development on the principle of cleaner production	Project engineer/design engineer/consultant	Conventional Gravity with STP and RO plant	To be decided	
Construction phase	Adoption of early warning mechanism through regular monitoring for level of suspended solids and /or turbidity during construction works Ensure proper and efficient operation Selection of appropriate development windows (e.g. execute coastal and marine work in low tide) Monitor suspended solids in water flowing out and spreading Contain marine and coastal work sites to avoid sediment flow away from work site Completion of work as soon as possible but by avoiding working at night Minimized felling of old trees Replant on another location any old coconut palm removed from work site Minimize clearing of vegetation Avoid any spilling into the ground that can contaminate soil and groundwater Keep sensitive areas protected from damage (e.g. grave yard) Avoid discharge of untreated sewage/wastewater effluent into ocean Minimize removal of corals for sewer, jetty and detached water villas development	EIA Consultant Contractor	Chose appropriate technologies and equipment environmentally sound	To be decided	
Operation phase	Monitor coastal water, beach profile as well as other areas at designated locations, groundwater quality Ensure enforcement from government regulatory bodies	Utility, Island Council and EPA, MHE		To be decided	
Mitigation measures for mitigating impacts of machinery and equipment		Implementing responsibility	Technology/ equipment	Time frame	Cost
Design Phase	Plan for the use of appropriate equipment. Provide appropriate working windows	Project engineer		To be decided	
Construction phase	Ensure proper monitoring of construction activities Establish strict regulations and safety measures for machinery operation Locate storage area on the island Provide effective management of fuel handling area and other dangerous substances storage	Contractor		To be decided	
Mitigation measures for mitigating impacts of waste disposal		Implementing responsibility	Technology/ equipment	Time frame	Cost
Design Phase	Design for appropriate solid waste disposal such as provision of disposal facilities and collection procedures Establish appropriate mechanism for waste management employed with trained and informed personals	Project engineer developer	Chose appropriate technologies	Detailed design stage	
Construction phase	Construction waste must be disposed appropriately Construction debris shall not be disposed in the marine environment	Contractor/developer			

Operation phase	Produce and enforce strict regulations for liquid and solid waste disposal from vessels and in the service jetty area Disposal of solid waste including fish waste, wastewater and waste oil disposal other than designated areas shall be prohibited Fuelling of boats and vessels on sea shall be closely supervised and monitored Signboards indicating "Keep the environment clean" shall be placed on jetties, water villas, and all service areas Ensure emergency procedures in case of spill out of dangerous substances are in place Appropriate solid waste collection facilities shall be placed on the resort	Developer/operator			
Mitigation measures for mitigating impacts of goods and material handling		Implementing responsibility	Technology/ equipment	Time frame	Cost
Design Phase	Raising awareness and utilizing environmental best practice Careful planning to ensure minimal disturbance to accessibility to island	Project engineer/ Consultant/developer			
Construction phase	Development shall be carried out in a manner it will not affect or minimize the effects on the existing ecological system	Contractor/developer			
Operational phase	Produce and enforce hazardous material handling and storage procedures Ensure emergency procedures in case of spill out of dangerous substances are in place. Identify clear responsibilities. Enforce health and safety procedures at all work sites	Operator	Implement good housekeeping, provide training and raise awareness		

9 Environmental Monitoring

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. These include turbidity and nutrient, sedimentation, and live coral cover and nektonic fauna. Monitoring will be carried out as part of the environmental impact assessment and mitigation of possible negative impacts from the proposed project.

Monitoring would ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

The purpose of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods. This will help to minimize environmental impacts of projects in future.

The monitoring plan shall target to measure:

- live coral cover and nektonic fauna
- the amount of sedimentation on the reef
- water quality and visibility
- beach profile and hydrodynamic changes
- impacts are accurate and mitigation measures taken are effective and
- the thresholds are kept within the baseline limits predicted.

9.1 Recommended Monitoring Programme

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

Stage 1: Immediately before starting works

Stage 2: During implementation of water supply and sewerage system

Stage 3: Operational phase of water supply and sewerage system

9.1.1 *Environmental Indicators Recommended for Monitoring*

The recommended environmental indicators to be monitored in the three phases include as follows

A. Sewerage System

<u>Stage 1 (before beginning the development)</u>

- Marine water quality for pH, Conductivity(µS/cm), dissolved oxygen(mg/l), turbidity (NTU) and Salinity (%) , TDS (mg/l)
- Groundwater quality for pH, Conductivity (µS/cm), Salinity (%)

<u>Stage 2 (Implementation Phase)</u>

- Marine water quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (µS/cm) , Salinity (%), Turbidity (NTU), BOD (mg/l), COD (mg/l).
- Groundwater quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (µS/cm) , Salinity (%), BOD (mg/l), COD (mg/l), TOC (mg/l), Faecal Coliforms (CFU/100ml)

<u>Stage 3 (Operation Phase)</u>

- Shorelines (low tide, mean tide and high tide) immediately after development using differential GPS
- Shorelines (as above) every three months for two consecutive years
- Marine water quality - pH, Dissolved Oxygen (mg/l), E. Conductivity (µS/cm) , Salinity (%), Turbidity (NTU), BOD (mg/l), COD (mg/l) immediately after development and after three months
- Groundwater quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (µS/cm) , Salinity (%), BOD (mg/l), COD (mg/l), TOC (mg/l), Faecal Coliforms (CFU/100ml) immediately after development and after three months

B. Water Supply System

<u>Stage 1 (before beginning the development)</u>

- Marine water quality for pH, Conductivity(µS/cm), dissolved oxygen(mg/l), turbidity (NTU) and Salinity (%) , TDS (mg/l)
- Groundwater quality for pH, Conductivity (µS/cm), Salinity (%)

<u>Stage 2 (Implementation Phase)</u>

- Marine water quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (µS/cm) , Salinity (%), Turbidity (NTU), BOD (mg/l), COD (mg/l).

- Groundwater quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (μS/cm) , Salinity (%), BOD (mg/l), COD (mg/l), TOC (mg/l), Faecal Coliforms (CFU/100ml)

Stage 3 (Operation Phase)

- Shorelines (low tide, mean tide and high tide) immediately after development using differential GPS
- Shorelines (as above) every three months for two consecutive years
- Marine water quality - pH, Dissolved Oxygen (mg/l), E. Conductivity (μS/cm) , Salinity (%), Turbidity (NTU), BOD (mg/l), COD (mg/l) immediately after development and after three months
- Groundwater quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (μS/cm) , Salinity (%), BOD (mg/l), COD (mg/l), TOC (mg/l), Faecal Coliforms (CFU/100ml) immediately after development and after three months
- Product Water Quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (μS/cm) , Salinity (%), BOD (mg/l), COD (mg/l), TOC (mg/l), Faecal Coliforms (CFU/100ml) every three months
- Product Water Quality for pH, Dissolved Oxygen (mg/l), E. Conductivity (μS/cm) , Faecal Coliforms (CFU/100ml) and residual chlorine daily

9.2 Cost of monitoring

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

Table 9-1: Estimated cost of the proposed monitoring programme (annual)

No	Details	Unit cost (MRF)	Total (MRF)
1	Transport cost	10,000.00	30,000.00
2	Field allowance for 2 staffs for 2 days	2,000.00	8,000.00
3	Accommodation and food and miscellaneous for 2 staffs for 2 days	500.00	2,000.00
5	Monitoring equipment	5,000	30,000.00
6	Water quality testing and analysis	1,500	1,500.00
	Total		71,500.00

9.3 Monitoring Report

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

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

10 Declaration of the consultant

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

Ahmed Zahid (EIA 08/07)

8 January 2012

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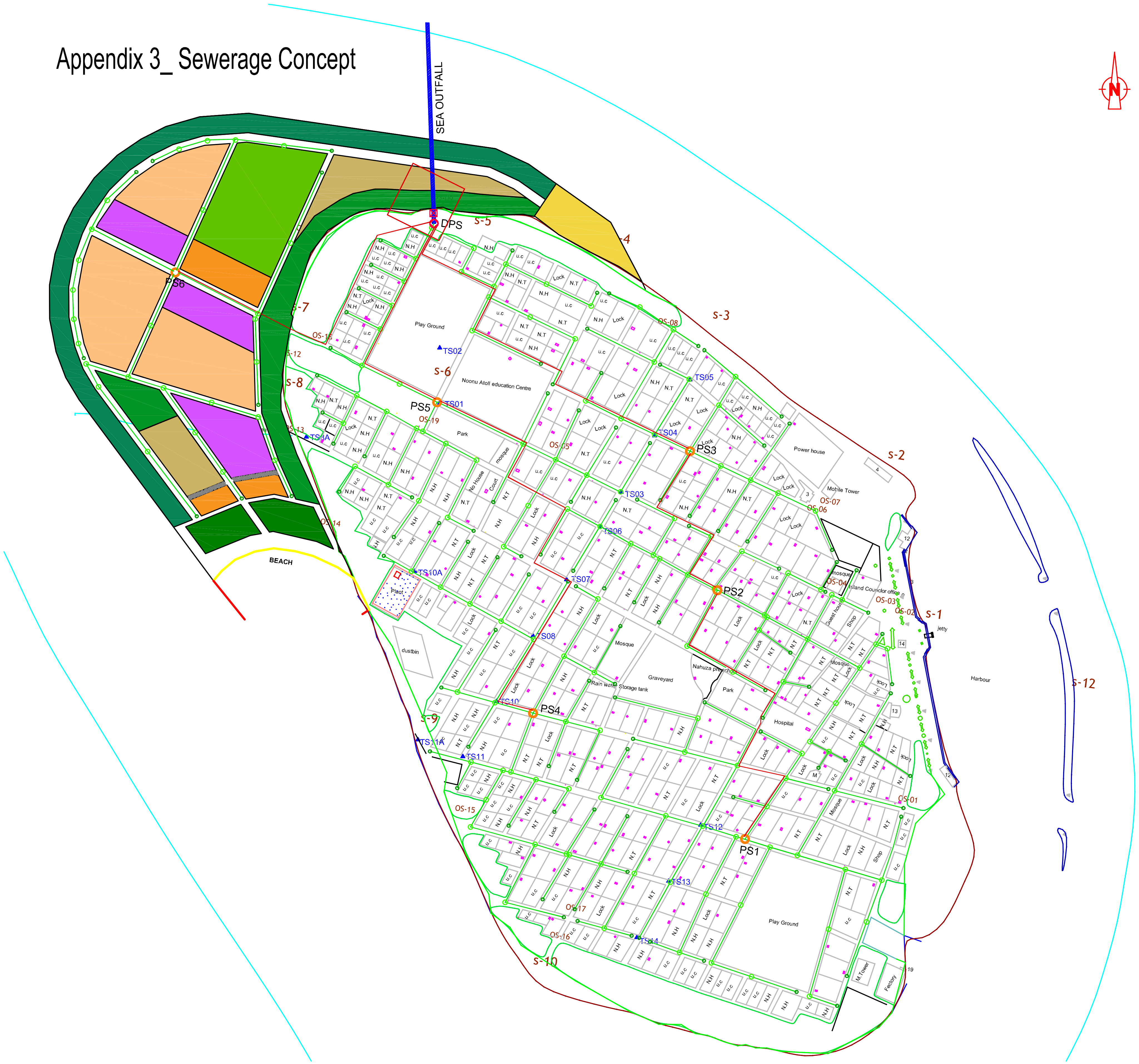
Appendix 1: Terms of Reference

Appendix 2: Commitment letter from the proponent to undertake monitoring

Appendix 3_ Sewerage Concept



LEGEND :

- Existing plots
- Propsed plots
- Vegetation
- Reef line
- Shore line
- Centre line
- Lamp post
- Flower bed
- 001 Demarkated plots
- Traverse station
- Clean Out
- Manhole
- Pumping Station
- Disposal Pumping Station
- Sewage Treatment Plant
- Ø150 Gravity Line
- Pressure Main

1. Island Office
2. Rahvehige
3. Park
4. Ware House
5. Power House
6. School
7. Football Ground
8. Island Office
9. Island Court
10. Water Supply
11. Cemetery
12. Fish Market
13. Stage
14. Public Shelter
15. Youth Center
16. Antennae
17. Desalination Plant
18. Waste Site
19. Toilets

M .Mosque

Reference Point of BM=TS01, RL=1.871
MSL=0.0m

PROJECT: DESIGN AND CONSTRUCTION OF WATER & WASTE WATER SYSTEM FOR N.VELIDHOO		
DESIGN BY: ALTEC MALDIVES PRIVATE LIMITED		
TITLE : CONCEPT DESIGN FOR WASTE WATER SYSTEM		
CHECK BY :IN	DRAWN BY : MA	DATE: Jan 2012
DRAWING NO: NV/SS/CD/01		SCALE : NTS

Appendix 4_ Water Supply Concept

LEGEND :

- Existing plots
- Propsed plots
- Vegetation
- Reef line
- Shore line
- Centre line
- Lamp post
- Flower bed
- 001 Demarkated plots
- Traverse station
- Fire Outlet
- Gate Valve
- Ø75 PE Pipe
- Ø90 PE Pipe
- Ø110 PE Pipe
- Ø160 Feed Line
- Ø110 Reject Line

1. Island Office
2. Rahvehige
3. Park
4. Ware House
5. Power House
6. School
7. Football Ground
8. Island Office
9. Island Court
10. Water Supply
11. Cemetery
12. Fish Market
13. Stage
14. Public Shelter
15. Youth Center
16. Antennae
17. Desalination Plant
18. Waste Site
19. Toilets

M .Mosque

Reference Point of BM=TS01, RL=1.871 MSL=0.0m

PROJECT: DESIGN AND CONSTRUCTION OF WATER & WASTE WATER SYSTEM FOR N.VELIDHOO	
DESIGN BY: ALTEC MALDIVES PRIVATE LIMITED	
TITLE : CONCEPT DESIGN FOR WATER SUPPLY SYSTEM	
CHECK BY :IN / DRAWN BY : MA	DATE: Jan 2012
DRAWING NO: NV/WS/CD/01	SCALE : NTS

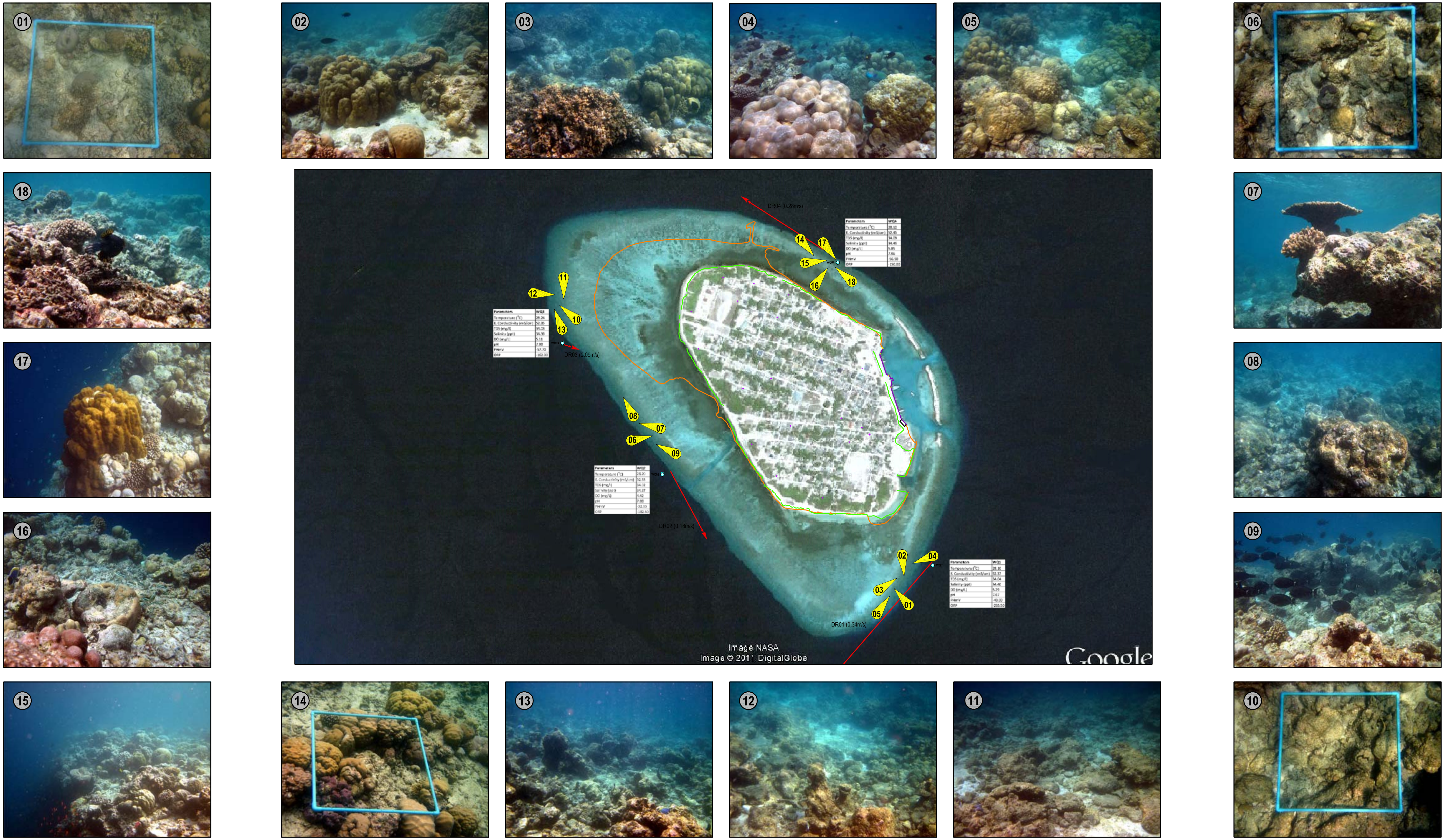
Appendix 5: Impact Identification Checklist

Project: Sewerage development works of Noounu Velidhoo				Impact Significance					
Proponent: Ridgewood Hotels and Suites Pvt. Ltd.									
Contractor: N/A									
Date: 31 December 2011									
Topical issues	Yes	Maybe	No	Negligible	Minor	Moderate	Major	Beneficial	None
A: Air									
Will the project result in:									
a. Emission of air pollutants to an undesirable concentration or deteriorates ambient air quality (e.g CO_2, SOx, NOx etc)?		✓				✓			
b. Objectionable odors?			✓	✓					
c. Emission of hazardous air pollutants regulated by MHE/EPA?			✓	✓					
B: Water									
Will the project:									
a. Affects groundwater aquifer of the island?	✓						✓		
b. Alter the volume of existing aquifer?	✓					✓			

c. Affects marine water quality?	✓					✓			
d. Changes in current or water movement around the island?		✓				✓			
e. Alters the course of flow of water around the island?			✓			✓			
f. Contaminates marine water?	✓					✓			
C: Land/beach									
Will the project results in:									
a. Alteration of lands?		✓				✓			
b. Reclamation of land to increase land?			✓			✓			
c. Disposal of excavated soil material into land?			✓						✓
d. Alteration of natural beach formation?			✓				✓		
D: Natural resources									
Will the project									
a. Affect the coral reefs?		✓				✓			
b. Cause significant damage to the reef system?			✓	✓					
c. Cause damage to vegetation	✓						✓		

E: Solid waste/wastewater/spent oil									
Will the project:									
a. Generate significant quantity of solid waste or litter?	✓						✓		
b. Generate significant volume of wastewater?	✓						✓		
c. Generate significant volume of spent oil?	✓					✓			
F: Noise									
Will the project									
a. Increase noise level?		✓				✓			
b. Expose people (workers) to excessive noise?		✓			✓				
G: Energy									
Will the project									
a. Use substantial amounts of energy or fuel?	✓						✓		
H: Transportation									
Will the project result in									
a. Addition of new vessels and boats?	✓					✓			

b. Alteration of present pattern of access facility?	✓					✓			
I: Accident risk									
a. Involve the risk to health of workers, staff etc?									
b. Involve the release of potentially hazardous substances (e.g. oil, chemicals, or other toxic substances) in the event of accidents or upset conditions		✓			✓				
J: Human health									
Will the project									
a. Create any health hazard?		✓			✓				
b. Expose people to potential health hazard?		✓			✓				
K: Economic									
Will the project									
a. Have any adverse effect on national economy?	✓							✓	
b. Have any adverse effect on income of island communities?	✓							✓	
c. Have effect on employment?	✓							✓	
d. Will it create new market and business opportunities?	✓							✓	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