Ministry of Environment and Energy

Environmental Impact Assessment

Development of Sewerage System at Hithadhoo, Addu City

Report Prepared by LaMer Pvt Ltd:

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Proponents Name:
Ministry of Environment and Energy

Prepared for:
Male' Water Sewerage Company (MWSC) Pvt Ltd

April 2017

La Mer GROUP

Land and Marine Environmental Resources Group Pvt Ltd, Maldives

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Consultants Declaration

I certify that to best of my knowledge the statements made in this Environmental Impact Assessment report for Development of a Sewerage System at the Southern and Northern zones of Hithadhoo, Addu City are true, complete and correct.

Name: Hussein Zahir

Consultant Registration Number: 04-07

Signature:

Company Name: Land and Marine Environmental Resource Group Pvt Ltd

Date: 19th April 2017

Details of consultants participate in preparation of EIA report

Chapter	Name of consultant	Registration number of consultant	Signature
Introduction	Hussein Zahir	04-07	
Project description	Hussein Zahir Shahaama Abdul Sattar	04-07	
Project setting	Shahaama Abdul Sattar		
Existing Environment	Hussein Zahir Shahaama Abdul Sattar	04-07	
Impact, alternatives and Mitigation	Hussein Zahir Shahaama Abdul Sattar	04-07	
Stakeholder consultation	Hussein Zahir	04-07	
Monitoring	Hussein Zahir	04-07	
Recommendation and Conclusion	Hussein Zahir	04-07	

Proponents Declaration and Commitment letter

بسم الله الرحمن الرحيم

Ministry of Environment and Energy
Male', Republic of Maldives.

މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީ
މާލެ، ދިވެހިރާއްޖެ.

Date: 20 April 2017

No: 438-OFID/203/2017/57

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Male', Republic of Maldives

Dear Sir,

<u>Sub: Commitment Letter for Proposed Sewerage System Development Project to be carried out in S. Hithadhoo (North and South region)</u>

This is in reference to the Environmental Impact Assessment report for the proposed sewerage system in S. Hithadhoo (North and South region).

As the proponent of the above mentioned project, we guarantee that we have read the reports and to the best of our knowledge all information provided here are accurate and complete.

We also assure you our commitment to undertake the proposed mitigation measures and monitoring programme outlined in the EIA report.

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Sincerely,

Shaheeda Adam Ibrahim
Director General

LED SAVES

VISIT MALDIVES YEAR 2016

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1 Non-technical Summary

1.1 Background

The non-technical summary outlines the findings of the Environmental Impact Assessment of the construction of a sewage collection and disposal system at the northern and southern regions of Hithadhoo, Addu City. The proponent of this project is the Ministry of Environment and Energy and total estimated cost of the project is approximately MVR 100 million.

The proposed sewerage network scheme for the island is a Conventional Sewage System with a gravity flow networks integrated pump stations (13 in total), a pressure network leading to a disposal pumping station and pumping out the effluent to the sea via sea outfall. The installation of a sewerage treatment plant is planned for a later phase of this project and once installed, the pressure lines from disposal pumping station shall bypass to sewerage treatment plant and pump out the effluent through the same sea outfall.

1.2 Key impacts, mitigation measures and alternatives

Impacts on the environment from various activities of the project development work (constructional impacts) and operational impacts have been identified through interviews with the project management team, field data collection and surveys and are also based on past experience of consultant in similar projects. Impacts were analysed for their significance with the aid of a Leopold Matrix.

In any development project, major direct impacts to the environment occur mainly during the construction phase. Potential direct or indirect impacts on the environment from the proposed project include:

- Impacts to the groundwater resource during trenching works;
- Physical damage to live coral due to trampling during pipe laying works;
- Impact on the designated Marine Protected Area, which is located near the project site on the northern region
- Impact on vegetation due to the need to cut down vegetation located at the plots allocated for construction of infrastructure;
- Impact due to air and noise pollution during construction work;
- Impact on marine environment due to wastewater discharge; and
- Positive impact on social wellbeing and health

Mitigation measures are discussed for the activities which would have potential impacts during the construction and operational phase of the project. In general, during the construction stage it is important to use a method of construction which has the least impact on the environment. Specific measures highlighted include following of established guidelines when carrying out excavation works and dewatering. Detailed mitigation measures are discussed in Section 11 of the report.

Alternatives have been considered for various components of the project and are given as possible options that may be either more practical or less expensive to the preferred options. The proposed alternatives also have taken into consideration the environmental consequences resulting from these options as compared to the preferred options. The following components of the project have been discussed in providing these alternatives:-

- Design of wastewater disposal system
- Outfall discharge location

As mentioned, the northern region outfall is within close proximity of the protected area (approximately 100m south) and thus has the potential to have a negative impact on this area due to continuous discharge of untreated wastewater. One of the key outcomes of the Stakeholder Consultations was that EPA will not allow any impact to the protected area and hence the need for an alternative means of sewage disposal for the northern region is required. The proponent has now agreed to reroute the pressure line from the northern side to the southern side and use the southern zone outfall for disposal of waste water.

The no-project scenario is also considered, which would mean that all environmental impacts due to the project would no longer be an issue. However, this also means that method of sewage disposal on the island of Hithadhoo (areas that are not included in vacuum system wastewater collection network) would remain the same, thus leading to further contamination of the groundwater resource of the island. Additionally, it would also mean increased health risks faced by the community due to the use of contaminated water and the loss of potential additional job creation during the operation of the service. Details of the various alternatives considered and the selected alternatives are shown in Section 10 of the report.

The environmental impacts predicted for the project are moderate, hence the benefits of establishing the system, though with a cost to the environment is seen to be far more beneficial than the cancellation of the project, as the health risks faced by the community is not something that should and can be overlooked. Therefore, the “no-project” scenario is not a feasible solution and it is recommended that the project be continued, but with the proper implementation of all mitigation measures and selected alternatives proposed in the report.

1. ޚުލާޞާ

ތައާރަފު

މި ޚުލާޞާއިން ދައްކައިދެނީ ސ. ހިތަދޫގެ އުތުރާއި ދެކުނު ސަރަހައްދުގައި ޤާއިމުކުރަން ރާވާފައިވާ ނަރުދަމާ ނިޒާމު ޤާއިމުކުރުމުގެ މަސައްކަތް ފެށުމުގެ ކުރިން ތައްޔާރުކުރެވިފައިވާ ތިމާވެއްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓުގެ ޚުލާޞާއެކެވެ. މިމަޝްރޫޢުގެ އެދިއާރަކާ މިނިސްޓްރީ އާއި އިންވެސްޓްމަންޓް އެންޑް އެސްޓިމޭޓްކުރެވިފައެވެ. މިމަޝްރޫޢުގެ ޖުމްލަ ހަރަދުގެ ގޮތުން އަންދާޒާ ކުރެވިފައިވަނީ 100 މިލިއަން ރުފިޔާއެވެ.

މިމަޝްރޫޢުގެ ދަށުން ސ. ހިތަދޫގައި "ގްރެވިޓީ ބޭސްޑް ވޭސްޓްވޯޓަރ ކަލެކްޝަން އެންޑް ޑިސްޕޯސަލް ސިސްޓަމް" އެއް ޤާއިމު ކުރެވޭނެއެވެ. މިމަޝްރޫޢުގެ ދަށުން ޤާއިމުކުރެވޭ ނަރުދަމާ ނިޒާމުގެ ބައިތަކުގެ ތެރޭގައި ގްރެވިޓީ ފްލޯ ނެޓްވޯރކް، އިންސްޕެކްޝަން ޗެމްބަރ ޕަމްޕް ސްޓޭޝަން (ޖުމްލަ 13)، ނަޑިސްޓޭޝަންތަކާ ޕަމްޕިންގ ސްޓޭޝަން އާއި ޕްރެޝަރ ސީވަރ ނެޓްވޯރކް އަދި ނަޖިސް ބޭރުކުރުން ހިމެނެއެވެ. މިމަޝްރޫޢުގެ ދެވަނަ ފިޔަވަޅުގައި ސްޓަރޓަޖީ ޓްރީޓްމަންޓް ޕްލާންޓެއް ބެހެއްޓުމަށް ވެސް ހަމަޖެހިފައެވެ.

ތިމާވެއްޓަށް ކުރާނެ އަސަރު، އަދި މިއަސަރު ކުޑަކުރުމަށް އެޅިދާނެ ފިޔަވަޅުތަކާއި ބަދަލުގައި ކުރެވިދާނެ ކަންތައް

މިމަޝްރޫޢުގެ ސަބަބުން ތިމާވެއްޓަށް ކުރާނެ އަސަރާއި ބެހޭ ގޮތުން މައުލޫމާތު ހޯދުމަށް މިމަޝްރޫޢު ހިނގާ ފަރާތްތަކާއި ވާހަކަ ދެއްކުމާއި، ފީލްޑް މަސައްކަތުން އެއްކުރެވުނު މައުލޫމާތު ބައްލަވައިގަތުމާއި، މިގޮތަށް މަސައްކަތްތަކުން ކަނޑައެޅިފައިވާ ތިމާވެއްޓާ ބެހޭ މަޢުލޫމާތު ބެލުމަށެވެ. މިމަޝްރޫޢުގެ ސަބަބުން ކުރާނެ ކަމަށް ފާހަގަކުރެވޭ އަސަރުތަކުގެ ބޮޑު/ކުޑަމިން ހާމަވެފައިވާ އިތުރުކޮށް ދެނެގަތުމުގެ އިތުރަށެވެ.

މިގޮތަށް ބޮޑެތި ތަރައްޤީގެ މަޝްރޫޢުތަކުގައި ތިމާވެއްޓަށް ސީދާ ގޮތުން ކުރާ ބޮޑެތި އަސަރުތައް މައިގަނޑު ގޮތެއްގައި ކުރަނީ މަޝްރޫޢުގެ ކޮންސްޓްރަކްޝަން ފޭސް ނުވަތަ އޮޕަރޭޝަން ހިނގާ ދުވަސްވަރުގައެވެ. ލިބިފައިވާ މައުލޫމާތުގެ އަލީގައި ހޯދުން ގޮތުން، މިމަޝްރޫޢުގެ ސަބަބުން ތިމާވެއްޓަށް ސީދާ އަދި ނުސީދާގޮތުން އަސަރު ކުރާނެ ކަމަށް ފެންނަ ހަރަކާތްތަކަކީ:

- ➢ ވަގުތީގޮތުން ސަބަބުން ބިމުގެ ފެންގަދަވުމަށް އަސަރު ކުރުން
- ➢ މޫދުގައި ހުރިއެއްޗެހީގެ މަސައްކަތުގެ ތެރޭގައި ފަރަށް ގެއްލުން ލިބުން

- ހިދުމަތުގެ އުމުރުގައި ރިޢާޔަތް ކުރުމުގެ ސަރަޙައްދާ (އިދާރީ ކަމާއި ވަޒީފާގެ ސަރަޙައްދު) އުޅޭ ފަރާތްތަކަށް މަސައްކަތް ކުރުމަށް ހަމަޖެހިފައިވާ ސަރަޙައްދާ ހުރި ގާތްކަމުގެ ސަބަބުން ރިޢާޔަތްކުރުވިފައިވާ ސަރަޙައްދަށް ކުރާ ނުރައްކާ އަސަރު
- އިމާރާތްކުރުމުގެ ކަންކަމުގެ ސަރަޙައްދުން ބޭރުގެ ގަސްގަހާގެހި ތިމާވެށްޓަށް އަސަރުކުރުން
- މަސައްކަތުގެ ސަބަބުން އަޑު ގަދަވުން، ވައި ތަޣައްޔަރުވުމުގެ ސަބަބުން ކުރާ އަސަރު
- ނަޖިހާއި ބޭކާރު ބާކީ ހުރުމުގެ ސަބަބުން މޫދުގެ ވެށްޓަށް ކުރާ އަސަރު
- ނަރުދަމާ ނިޒާމު ޤާއިމުކުރުމުން ރަށުގެ މޫދުގެ ފަރުގެ މާހައުލަށް ސިއްހީ ގޮތުން ކުރާ ދަރަޖަ އަސަރު

މިމަޝްރޫޢުގެ މަސައްކަތް ކުރިއަށްދާ ދުވަސްވަރު އަދި މަޝްރޫޢު ނިމުމަށްފަހު ނަރުދަމާ ނިޒާމުގެ އަދި ފެން ޕްރޮޖެކްޓުގެ ސަބަބުން ތިމާވެށްޓަށް ކޮށްފާނެ އަސަރުތަކުގެ ތަފްޞީލު ދިރާސާކޮށް ކަނޑައެޅުމުގައި މިޕްރޮޖެކްޓުގެ ބަޔާންތަކުގައި ބަޔާންކޮށްފައިވާ ގޮތަށް މަޝްރޫޢުގެ މަސައްކަތް ކުރިއަށްދާ ދުވަސްވަރު މަސައްކަތްކުރުމުގެ ބާވަތްތަކާއި ގޮތްތަކާއި އެކަށީގެންވާ ސަބަބުން ތިމާވެށްޓަށް ލިބޭ ގެއްލުން ވަކިން ކަނޑައަޅާ، ތިމާވެށްޓަށް ކުރާ ނޭދެވޭ އަސަރުތަކާއި އެއަސަރުތަކުން ރައްކާތެރިވުމަށް ގޮތްތައް ދެއްކިފައިވެއެވެ. މީގެ އިތުރުން ތިމާވެށްޓަށް ކުރާ އަސަރުތައް ކުޑަކުރުމަށް އުޅޭނެގޮތް ދިރާސާކޮށް 11 ވަނަ ބައިގައި ބަޔާންކޮށްފައިވާނެއެވެ.

މިމަޝްރޫޢުގައި ހިމެނޭ އެކި ބައިތައް ކުރިއަށް ގެންދިއުމަށް ޚަރަދުވާ ގޮތުގެ ބަދަލުގައި ކުރެވިދާނެ ކަންތައް ބެލުމަށްޓަކައި ބަލާފައިވާ ކަންތައްތައް:

- ނަރުދަމާ ނިޒާމު ޤާއިމު ކުރެވިދާނެ ގޮތް
- ނަރުދަމާ ނިޒާމުގެ އަސާސީ ހާލަތުގައި ހުރިހާ ސަރަޙައްދު

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2 Introduction

The proposed project involves installation of a gravity type wastewater collection and disposal system at the northern and southern regions of Hithadhoo, Addu City. The Central region of the island is not covered in this project, as a Vacuum sewerage network is currently being constructed in this region through a different project (FENAKA Corporation Ltd). The proposed project will function independently and will not be incorporated into the system being built for the Central region of the island. The current project also does not involve treatment of the waste collected, although the proponent proposes to construct a treatment plant at a later stage, whereby sewage waste collected from the northern and southern region will then be pumped to the treatment plant prior to being discharged to sea.

Existing sewerage facilities at the proposed project sites include the use of septic tanks with very few outfalls. Most disposal is through soak pits into the ground. Poor maintenance of the existing system have resulted in leakage of sewage into the ground resulting in contamination of the groundwater lens of the island. Groundwater is commonly used by the community for various daily uses including washing and bathing. Contamination of one of the main source of water to the island is a threat to the wellbeing of the people and also the environment in general.

Hence to prevent such hazards, the project has proposed a better solution for the sewerage management by installing a contemporary sewerage system. Although the Central region of the island is being developed with the installation of a vacuum type sewerage network, the proponent has opted to go for a gravity type network for the proposed areas, as these are the more commonly used systems in the other islands within the Atoll and also would be easier to maintain. The proposed sewerage network scheme for the Island is a Conventional Sewage Collection System with a gravity flow networks integrated pump stations, a pressure network leading to a disposal pump station and pumping out the effluent to the sea via sea outfall. In later stage the pressure lines from disposal pumping station shall bypass to sewerage treatment plant and pump out the effluent through the same sea outfall. At current phase of the project details of STP are not available, and will be covered in a separate EIA.

The proponent for the project is Ministry of Environment and Energy and the total estimated cost of this project is MVR 100 million.

2.1 **Purpose of the report and need for the EIA**

This document presents the findings of an Environmental Impact Assessment (EIA) for the development of a gravity type wastewater collection and disposal system at Hithadhoo, Addu City. Developers of such projects are required to carry out EIA studies under the Environmental Act of

Maldives. The developer is required to obtain approval of the Environmental Protection Agency (EPA), prior to the implementations of any development activities on the island.

The project was awarded as design and build contract Male' Water and Sewerage Company Pvt Ltd (MWSC) and environmental consultancy work was won by Land and Marine Environmental Resource Group Pvt Ltd (LaMer). LaMer Group Pvt Ltd is tasked with preparation of the EIA and provision of assistance in other environmental related activities. This EIA is prepared in accordance with Environmental Impact Assessment Regulations 2012 and the environmental policy and guidelines of the Government of Maldives.

3 Terms of Reference (ToR)

All development projects that have a socioeconomic environmental relevance are listed in Appendix Raa of the EIA Regulations 2012 and are required to submit an EIA report which forms the basis for this project approval. As such, projects are required to follow a screening process identifying the environmental impacts associated with the project. Projects which are not listed in the above mentioned schedule has to follow a screening process, based on which EPA decides whether the project requires the submission of an Initial Environment Evaluation report or and Environmental Monitoring report. Based on the findings of this report, EPA as the regulator makes a decision on whether the specified project further requires the submission of an EIA based on the impacts associated with the project.

In accordance with the regulations of Ministry of Environment and Energy, an EIA application form and project brief was sent stating the nature of the project and likely impacts associated with the environment. Although a date for a scoping meeting was set, the meeting was cancelled on the date meeting was scheduled and EPA issued a TOR for the project based on the EIA application and project brief submitted by proponent. The ToR was finalized and approved by EPA on the 26th of March 2017 (see Appendix 2).

4 Project Setting

The project conforms to the requirements of the Environmental Protection and Preservation Act of the Maldives, Law no. 4/93. The EIA has been undertaken in accordance with the EIA Regulations 2012 of the Maldives by a registered consultant. Furthermore, it adheres to the principles underlined in the regulations, action plans, programs and policies of the following Ministries of the Government of Maldives:-

- Ministry of Environment and Energy (MEE)

Table 1. Legislations pertaining to the project and how project conforms to the legislation

Legislation	How does current project conform to legislation
Environmental Protection and Preservation Act (Law 4/93)	EIA undertaken as stipulated in the Act, which states that any developmental project which has a potential impact on the environment should have an EIA done prior to commencement of the project. List of such projects are given in the EIA Regulations 2012 Designation of protected areas falls under the EPPA. Areas of relevance to the project, Eidhigali Kilhi and Koattey in Addu Atoll, were designated as protected areas under the Environmental Protection and Preservation Act (Law 4/93) on the 7th of December 2004. The protected area is divided into 3 zones and the regulation details list of activities which are prohibited in the three zones. It further states that offenders will be penalized as per the EPPA.
Third National Environment Action Plan (2009 – 2013) (NEAP III)	The plan sets out the agenda for environmental planning and management for the period of 2009 – 2013. One of the targeted goals of the plan is to strengthen the EIA process. By undertaking the EIA prior to the project, the project ensures that environmental impacts due to the project are minimized.
National Biodiversity Strategy and Action Plan (NBSAP)	The objective of NBSAP was to *"achieve biodiversity conservation and sustainable utilization of biological resources in the Maldives"* by integration of biodiversity conservation into all areas of national planning, policy development and administration (MHAHE, 2002). To achieve this objective, one of the first actions listed is "formulation and adoption of suitable development planning procedures, land use plans and strengthening of the EIA process". The current project conforms to this policy, by carrying out the EIA prior to commencement of the project, so as to minimize impact on the environment and to incorporate ways of environmental monitoring and management during the project works.
Waste Management Regulation (R-58/2013)	This Regulation was gazetted on the 5th of August 2013 and came into effect 6 months from the date, on 5th of February 2014. The main objective of this regulation is to implement the national policy on waste management.

	Article 8 of the regulation addresses management of hazardous waste, where Section Raa specifies that transport of hazardous waste from one location to another should be in a manner where the waste is packed in tightly sealed containers so as to prevent leakage. The Article further specifies that hazardous waste should not be dumped or burnt under any circumstance. Hazardous waste has to be separated and stored separately in a manner which ensures no leakage of waste. As per the regulation, hazardous waste generated during the project will be collected and stored separately Transportation will also be as per Regulation stipulations.
By-law on cutting down, uprooting, digging out and export of trees and palms from one island to another	The bylaw states that the cutting down, uprooting, digging out and export of trees and palms from one island to another can only be done if it is absolutely necessary and there is no other alternative. It further states that for every tree or palm removed in the Maldives two more should be planted and grown in the island. The bylaw prohibits the removal of the following tree types; • The coastal vegetation growing around the islands extending to about 15 meters into the island are protected by this bylaw; • All the trees and palms growing in mangrove and wetlands spreading to 15 meters of land area are protected under this bylaw; • All the trees that are in a designated protected area; • Trees that are being protected by the Government in order to protect species of animal/organisms that live in such trees; • Trees/palms that are unusual in structure The current EIA addresses the vegetation clearance works which will be undertaken as part of the project and the impacts on the environment due to this work. It also highlights measures which will be implemented to minimize impact on the environment due to this work. The above guidelines will be followed while carrying out all vegetation clearance work.
Dewatering Regulation (2013/R-1697) – 31st January 2014	The Dewatering Regulation has been formulated to introduce measures so as to minimize impact on the environment and ecosystem due to dewatering which may be carried out as part of construction works or during other works. Any development which requires dewatering as part of the project, can only be implemented after obtaining the required approval from the EPA, which is the implementing agency for the regulation. The regulation does not apply to dewatering which may be required for the installation/cleaning of a groundwater well for personal use or use of groundwater for agricultural purposes.

	Prior to carrying out dewatering the proponent of such projects have to submit an application form to EPA with required documents which are detailed in the regulation and application form. It is also the responsibility of the proponent to inform the relevant councils, if there are residential areas or agricultural lands within 100m radius of the site where dewatering will be carried out. The regulation further details what should be done with the water extracted during dewatering, and what actions should be taken should dewatering impact resource users within 30m radius of the site. The regulation further specifies fines which will be applicable if the regulation is not followed. The proposed project will conform to the regulation, by first submitting an application to carry out dewatering within the project site. The proponent will also carry out all the additional measures necessary to obtain the approval for EPA and to abide by the regulation.
General guideline for domestic wastewater disposal	General Guidelines on Wastewater Disposal have been drawn up by Maldives Water and Sanitation Authority (MWSA, currently operated by EPA) in 2007 (MWSA 2007), to assist those providing public sewerage networks and private house owners constructing on-site sanitation systems, whose activities may pose a pollution risk. These guidelines have been mainly targeted at provisions in local inhabited islands. The Guidelines require wastewater disposal to be undertaken with written consent of the Authority.
Discharge of domestic wastewater into deep sea	Deep sea discharge in the context of the Maldives means discharge of wastewater beyond the shallow reef and at a depth which will ensure proper dispersion and rapid dilution. Deep sea discharge does not imply discharge of wastewater inside the atoll. The values presented in the National Waste Water Quality Guidelines Maldives 2007 (MWSA 2007) provide the maximum allowable concentration of listed components that has to be complied with at all times. If these maximum values are exceeded, one or more of the users of the marine environment will be affected. The values presented assumed proper dispersion as well as thorough and instant mixing at the point of discharge to limit impact at the point of discharge.

5 Project Description

5.1 Project Proponent

The proponent of the proposed project is the Ministry of Environment and Energy (Water and Sewerage Section) and the total estimated cost of this project is MVR 100 million.

5.2 The Project

The proposed project involves installation of a Gravity Type Wastewater Collection and Disposal System at the northern and southern regions of Hithadhoo, Addu City.

5.2.1 Wastewater collection and disposal system

The sewerage system comprises of the following:-

- Household inspection chambers;
- A gravity sewerage reticulation network; and
- Reticulation pumping stations and pressure main system
- Sea outfall

The proposed sewerage system for the northern and southern regions of Hithadhoo is a gravity sewerage system. The systems at either region will function independently and wastewater from the each region will be drained using a gravity pipe system to zonal pumping stations at each region. As such four pumping stations are proposed for the northern region, while nine pumping stations are proposed for the southern region. Pump stations located at each catchment will be able to effectively cater the wastewater generated at Average Wet Weather Flows. Each pumping stations will transfer its collected sewage to the disposal pumping station located in each region (North & South region) through the HDPE pressure pipes. Sewage from the disposal pumping station will be pumped out to the deep sea through the respective sea outfall, located at 15m depth.

The sewerage system is designed with assumption of full flow velocity to be at least 0.60m/sec, with a minimum pipe slope of 1 in 250, and access chamber spacing of not more than 60m, and with inspection chambers within the boundary perimeter of each property. The gravity main sewer pipes will be of uPVC type with minimum OD of 160mm. The lateral pipes will be of type uPVC with minimum of 110mm OD and force main pipe will be of HDPE material with minimum size 110mm OD.

Details of the system design are sourced from the concept design report for the sewerage system, which was formulated by MWSC (MWSC, 2017). The report is also given in Appendix 5 of this EIA report.

5.3 **Need for the Project**

The Central region of S. Hithadhoo is currently being developed with the installation of a vacuum type sewerage network. The project was initiated during 2011, but due to various issues project has not been completed yet. Major networks are already constructed with the sea outfall and pump stations (most of pump station), but household lateral connections are not completed yet. However, this project does not include the northern and southern region of the island and hence the households in these regions are left with the existing system of septic tanks and soak pits. The use of this system over the years has led to the contamination of the groundwater resource of the island. Groundwater is used by the island community in their daily lives and hence the use of contaminated water has the potential to cause serious health issues. Therefore, the use of the existing system is not feasible, either for the environment or health of the island community, clearly stressing the need for the establishment of a proper sewage and wastewater collection and disposal system on the island.

5.4 **Location and Extent of Site Boundaries**

The project will be undertaken at S. Hithadhoo located in Addu City, which is the southernmost Atoll of Maldives. Hithadhoo is located at the northern end of the western peripheral reef of the Atoll, at coordinates of S 0°36'33.92" and E73° 5'19.14".

The proposed project will be undertaken at the northern and southern regions of the island, with pumping stations and sea outfall pipes for both regions being located at the respective region (See figure 1 and Site Plan in Appendix 3 for the location of pumping stations and outfalls).

Figure 1. Locations of pumping stations and proposed sewerage treatment plant (STP): Red line shows where the outfall pipes will located, temporary construction is shown as Purple square and Blue lines shows northern and southern zones

5.5 Construction phase and schedule of implementation

The construction phase for the sewage network is estimated to last approximately 11.5 months, while the whole project, inclusive of design and EIA works is estimated to last approximately 18 months. Listed below are the construction phases. For a more detailed schedule see Appendix 4.

- Procurement and mobilization (delivery of materials, machinery, equipment and workforce to project site) – 90 days
- Construction of sewerage system – 241 days
- Mechanical and Engineering Installation – 21 days
- Testing and Commissioning – 7 days
- Project handover – 1 day

5.6 Major Inputs and Outputs

5.6.1 Inputs

5.6.1.1 Mobilization and material unloading

Construction materials will be brought to the project area on barges and heavy cargo *dhonis*. Materials will be unloaded at the harbour on the southern side of the island and stored at the temporary construction yard set up at MWSC site (reclaimed land near the Regional Port).

5.6.1.2 Materials, machinery equipment and workforce

Details of materials and equipment required for the construction phase are shown in Table 2 and workforce details are shown in Table 3.

Table 2. Inputs for the construction of Sewerage system at Hithadhoo

	Input resource(s)	Source/Type	How to obtain resources
Construction Phase	80 Construction workers	Local / foreign	MWSC work force and contracted subcontractors

	Materials	• Network and house connection pipe
		  ○ Sewer pipe – DN 150, SN4, L = 5 (total numbers 6489)
		  ○ Wavin Sewer pipe – DN 100, SN4, L = 5 (total numbers 1306)
		• Manholes with cover and concrete protection
		  ○ Wavin 425mm diameter Tegra Sewer Manhole (total numbers 508)
		  ○ Wavin 600mm diameter Tegra Sewer Manhole (total numbers 206)
		• House connection chamber – 315x110mm, straight (Total numbers 871)
		• Sewerage disposal pumps (working – 13 numbers, standby – 13 numbers)
		• SRC cement (50kg) – 1100 bags
		• Course sand – 2200 bags
		• Aggregate – 3300 bags
		• R6, Reinforcement bar – 52.14 kg
		• T10, Reinforcement bar – 6976.12 kg
		• T16, Reinforcement bar – 1100.78 kg
			Imported

	Equipment	• Survey equipment (Total Station, dumpy level etc.) • Measuring tapes • Excavator- Komatsu • Skid steer loader (Bob Cat) • Plate Compactors • Vibrator Rammer • 1 ton roller • Water Bowser • Air compressor • Air Breaker • Concrete Mixer • Dewatering Pump 4” • Poker Vibrator • Generator- Komatsu- 40KVA • Welding Generator- 5KVA • Lighting Generator- 3KVA • Tractor with Tailor • HDD- Vermeer • Diving equipment • Crane Truck- 3ton • Diving Boat • Barge	Heavy machinery from Contractor

Table 3. Workforce profile for proposed project (assumed based on projects of similar scope, as subcontractors has not been assigned at the time of report preparation)

Project Management	Worker Profile	Required No. (Approximation)
Construction Supervisor	• Consulting Engineer • Project Coordinator • Sewerage network construction supervisor • Treatment plant construction supervisor • Electrical Insulation Supervisor	6
Construction Manager	• Project Manager • Deputy Project Manager	2
Administration	• Administration • Finance • Logistics • Surveyor • Quantity Surveyor • Site Office Manager • Store Keeper	7
Foreman	Skilled	5
Labourers		60
Total		**80**

5.6.1.3 **Power supply**

Power supply necessary for the project works is planned to be sourced from the existing power grid of the island community. Total power required for the sewerage system is 130 kW. Hithadhoo has electricity for 24 hours generated from the powerhouse which has total installed capacity of 9MW, while generation capacity is 5.6MV. This system is also complimented with solar power.

In addition to this, mobile generator sets will be provided, which can be used in cases of emergencies such as power cuts.

5.6.1.4 **Gravity type sewerage system**

Sewer Mains

The length of the gravity sewer main required is approximately 7.9 km (northern segment) and 24km (southern segment). Minimum uPVC pipe diameter for house laterals will be 110mm OD. Minimum main sewer uPVC pipe diameter used will be 160mm OD and above as per EPA guidelines. Force main pipes will be of HDPE material and discharge capacity of sewer depends on size of sewer and flow velocity. Pipe cover over sewer pipes are of 600mm, unless deemed necessary onsite in a special case. Minimum slope required for 160 mm diameter pipe conventional sewer of 1 in 250 (0.4%) is maintained to lay the pipes within a depth range of 0.6m to 2.5m. However, the slope is adjusted if the minimum cover could not be achieved. As such few of the main lines will be at slopes greater than 0.4%. Due to the small gradient and limited sewage generated at the current flow levels, minimum velocity could not be maintained at upper reaches. Project daily Peak Flow (15 year design period) is 871.92 m^3/day (northern segment) and 2,761.56 m^3/day (southern segment).

House Connection and laterals

All premises will be connected to the sewer main with uPVC pipe of 110mm OD gravity sewer laid at a minimum grade of 1.5-2.5% to facilitate the flow of solids. A pre-fabricated catch pit will be placed at the boundary of each property connection prior to downstream connection with a Y fixture, lateral connection. The maximum depth of the connection will be 600mm. The households should provide the provision to connect with connection chamber in this area.

Pipe laying works

In order to ensure that the sewerage line to function as intended, it shall be laid according to the plans and specifications of the tender document. All care shall be exercised that the line and grade of each sewer line is carefully established and maintained so that the self-cleansing velocities are obtained.

Prior to the construction the contractor shall have a setting out of the required line and grades and put the required markings on all junctions, inlet and outlet points at manholes, and valve locations. Reference markings will be established and well protected from disturbance.

Before the pipe is lowered into the trench, the grade of the bedding material will be checked with levels. The grade will be held to within 10mm of that shown on the drawings. The pipe will be inspected to ensure that it is sound and that ends are not damaged. The pipe sections are placed on line and grade in the bottom of the dewatered trench and then pressed together with a hand-lever or a winch. Y and T sections will be provided in the mains for the household connections.

Checks and tests will be undertaken for every laid section for any damage on pipes or fittings, leaks, and suitability of flow.

Collection system

- Pumping stations (lifting stations)

The pump station (PS) will lift the flow from deep sewer and discharge to a disposal pump station through pumping main. The pumping station generally comprises a wet well, submersible sewage pumps (one duty and one stand by) and an adjacent valve chamber. The pumping station will be below ground level with an adjacent panel shelter for pump control.

A comprehensive study was carried out to identify the best locations for the pump stations, with respect to the area to be served to ensure entire tributary can be adequately drained with respect to future overall development of the area. The availability of land, scope of expansion, type of equipment and their arrangement, structure, external appearance and general aesthetics were some of the basic considerations in the design of the proposed pumping stations. Sites identified were discussed with MEE and MHI Addu City Office; with approval being given by MHI Addu City Office. Locations of the pump stations are provided in Figure 1.

A total of thirteen pumping stations will be constructed to effectively service the network based on the design criteria and specifications. Of these 13, four will be located at the northern region and will service the network at the northern region, while remaining 9 will be located at the southern region to service the network at that regions. List of pumping stations and their details is given in Table 4 below. The pumping stations will be constructed with reinforced cement concrete with internal FRB coatings. Sulfate resistant cement shall be used for constructing sump wells.

Table 4. List of pump stations and their specifics

PS	Land Area	Depth	Pump Well Diameter	Remarks
01	7m x 8m	3.5m	2.4 m (OD)	
02	7m x 8m	3.2m	2.4 m (OD)	
03	7m x 8m	3.5m	3.9 m (OD)	Disposal Pump Station
04	7m x 8m	3.4m	2.4 m (OD)	
05	7m x 8m	3.5m	2.4 m (OD)	
06	7m x 8m	3.5m	2.4 m (OD)	
07	7m x 8m	3.2m	2.4 m (OD)	
08	7m x 8m	3.5m	2.4 m (OD)	
09	On Road	3.5m	2.4 m (OD)	
10	7m x 8m	3.4m	2.4 m (OD)	
11	7m x 8m	3.4m	3.4 m (OD)	Disposal Pump Station
12	On Road	2.9m	2.4 m (OD)	
13	On Road	3.4m	2.4 m (OD)	

Each pumping station will have 2 pumps (one duty and one standby) each capable of pumping peak flow. Since the pump life is approximately 5 years, pumps will be selected for the 15 year design flow.

The pump well will be capable of accommodating two submersible pumps, associated pipe work, electrical wiring and access equipment and personnel access. Three of the pump station will be located at road centers (PS9, PS12 and PS13) while the rest will be at road side plots of dimensions 7m x 8m (the plot will include ventilators, tanks, electrical panel boards and back up machinery).

Road Manholes, cleanouts, bends and vents

Pre-fabricated HDPE circular shafts for manholes and inspection chambers will be used and will be of non-biodegradable material and resistant to salt. Opening access of two sizes will be used for the main network; 600mm diameter (1.20m to 2.50m depth range) and 425mm (0.50 to 1.20m depth range). The manholes are at a maximum of 60m intervals and at every road junction. The manholes/access chamber covers are designed for heavy duty load.

Cleanouts or rodding points will be installed at the start of all main sewer lines with a 160mm OD PVC 45 degree bend, a threaded end cap and a rubber gasket.

All bends will be provided with reaction blocking, tie rods or restrained joints designed to prevent movement.

Vents in household plumbing are sufficient. However to avoid foul gases inside the network and pump stations , a 6m high GI pipe vent stack will be provided at the pumping stations.

STP facility design

The proponent proposes to construct the treatment plant at a later stage, although land area has already been identified for the purpose, at the southern region of the island. Hence this will be addressed in a separate EIA or Addendum to this EIA. Current scope of work for MWSC does not include STP facility.

Catchment area and flows

A total of 13 pumping stations are proposed, 4 in the northern region and 9 in the southern region (See Figure 1 and site plan in Appendix 3 for locations of the pumping stations). Each catchment basin will be sufficient to cater for the sewage generation at average wet weather flows which has been estimated at 475.2 m^3/day for the northern region and 1,504.67 m^3/day for the southern region (MWSC, 2017).

Average per capita wastewater generation will be taken as 120 l/Unit/D Average Dry Weather Flow (ADWF) (Table 5). For the purposes of estimating Average Dry Weather Flow (ADWF) the flowing waste water flow rates shall be used.

Table 5. Waste water flow rates used for estimating ADWF

Wastewater Source	Unit	L/Unit/D
Domestic	Person	120
Mosque	Person	16
Community Centre	Person	12
Product Centre	Person	12
School	Person	16
Hospital	Bed	40
Office	1000^2ft	400

For the purpose of estimating Average Wet Weather Flows (AWWF) infiltration shall be 10% of ADWF taken as per EPA guidelines.

Wastewater loading estimations for the northern and southern regions for 15 and 35 years design period are given in Tables 6 and 7 respectively.

Table 6. Wastewater loading estimations for full 15 and 35 years design period (North region)

No	Description	Unit	Estimated Quantity (15 year design period (2031))	Estimated Quantity (35 year design period (2051))
1	Water Consumption (Daily Average)	l/p/d	150	150
2	Estimated wastewater loading with 80% of total Consumption	l/p/d	120	120
3	Target design population (North region)	persons	2,422	3,600
4	Wastewater loading (Daily Average) ADWF	m3/day	290.64	432.00
5	Flow Peaking factor		3	3
6	Projected daily Peak flow	m3/day	871.92	1,296.00
7	Total length of pipe lines	m	7955.00	955.00
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows			
8a	Sewage Loading per meter length(average)	m3/day	0.037	0.054
8b	Design Loading per meter length (average)	l/s	0.00042	0.00063
8c	Design Peak Loading per meter length	l/s	0.0013	0.0019
9	Infiltration (10% of ADWF)	m3/day	29.06	43.20
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	m3/day	319.70	475.20
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	m3/day	900.98	1,339.20

Table 7. Wastewater loading estimations for full 15 and 35 years design period (South region)

No	Description	Unit	Estimated Quantity (15 year design period (2031))	Estimated Quantity (35 year design period (2051))
1	Water Consumption (Daily Average)	l/p/d	150	150
2	Estimated wastewater loading with 80% of total Consumption	l/p/d	120	120
3	Target design population (North region)	persons	7,671	11,399
4	Wastewater loading (Daily Average) ADWF	m3/day	920.52	1,367.88
5	Flow Peaking factor		3	3
6	Projected daily Peak flow	m3/day	2,761.56	4,103.64
7	Total length of pipe lines	m	24,015.00	24,015.00
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows			
8a	Sewage Loading per meter length(average)	m3/day	0.038	0.057
8b	Design Loading per meter length (average)	l/s	0.00044	0.00066
8c	Design Peak Loading per meter length	l/s	0.00133	0.00198
9	Infiltration (10% of ADWF)	m3/day	92.05	136.79
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	m3/day	1,012.57	1,504.67
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	m3/day	2,853.61	4,240.43

Zone area flow calculation

The sewer zones have been selected considering an equal distribution of the residences and institutions for each pump station, thus resulting in fairly uniform loading of the wastewater for each of the pipes laid in the sewer networks. Tables 8 and 9 shows the Wastewater loading estimations for 15 and 35 years design period for each of the pump stations in both regions.

Table 8. Wastewater loading estimations for full 15 and 35 years design period for the Northern region

Network area	Year*	Length of gravity network (m) (Zone area length)	ADWF (m^3/day)	AWWF (m^3/day)	Peak factor	PWWF (m^3/day)
PS10 area	**2031**	1544.55	57.15	62.86	3	177.16
	2051		83.41	91.75	3	258.57
PS11 area	**2031**	3271.56	121.05	133.15	3	375.25
	2051		176.66	194.33	3	547.66
PS12 area	**2031**	1434.61	53.08	58.39	3	164.55
	2051		77.47	85.22	3	240.15
PS13 area	**2031**	1704.41	63.06	69.37	3	195.5
	2051		92.04	101.24	3	285.32

**Years 2031 and 2051 represents 15 and 35 year design periods respectively*

Table 9. Wastewater loading estimations for full 15 and 35 years design period for the Southern region

Network area	Year*	Length of gravity network (m) (Zone area length)	ADWF (m^3/day)	AWWF (m^3/day)	Peak factor	PWWF (m^3/day)
PS1 area	**2031**	2131.96	81.01	89.12	3	251.14
	2051		121.52	133.67	3	376.72
PS2 area	**2031**	1687.33	64.12	70.75	3	198.77
	2051		96.18	105.8	3	289.15
PS3 area	**2031**	2501.99	95.08	104.58	3	294.73
	2051		142.61	156.87	3	442.1
PS4 area	**2031**	1862.89	70.79	77.87	3	219.45
	2051		106.18	116.8	3	329.17
PS5 area	**2031**	2171.62	82.52	90.77	3	255.82
	2051		123.78	136.16	3	383.73
PS6 area	**2031**	3369.7	128.05	140.85	3	396.95
	2051		192.07	211.28	3	595.43
PS7 area	**2031**	3466.25	131.72	144.89	3	408.32
	2051		197.58	217.33	3	612.49
PS8 area	**2031**	3791.39	144.07	158.48	3	446.63
	2051		216.11	237.72	3	669.94
PS9 area	**2031**	3031.98	115.22	126.74	3	357.17
	2051		172.82	190.11	3	535.75

**Years 2031 and 2051 represents 15 and 35 year design periods respectively*

Dewatering and excavation

Excavation will be done with mechanical equipment / excavator or manual labour depending upon the site condition. Work will be done in sections so as to keep the pit open. This would also mean that the excavated material would only be kept on site for a short period. Proper caution will be observed in carrying out excavation not to damage existing utilities encountered underground.

The trench shall be excavated a minimum of 200 mm below the final grade so that suitable bedding materials can be placed beneath the pipe. A minimum width of 600 mm will be maintained for proper working and laying of the pipes. Since "bell and spigot" pipe is to use, hand-excavation of the bedding material will be made at each bell end. Hand excavation is also required in the other subsurface utilities in order to ensure that they are not damaged. Water extracted will be disposed at nearby areas to minimize loss of groundwater. To minimize dewatering impacts, excavation will done in 30m segments, once pipe is laid, next segment will be excavated. Water extracted during dewatering will be disposed at adjacent areas close to excavated trench.

For the purpose of Hithadhoo design, the maximum depth of excavation should not exceed 2.5m, which will allow installation of pump stations to a depth of 3.5m. These also follow the design criteria and technical specifications for conventional gravity sewerage systems guideline released by the Water and Sanitation Unit of the Environmental Protection Agency. Strict adherence to these criteria is necessary as the streets are very narrow and congested, leaving limited space for mechanical excavation between buildings for the installation of pipelines.

Soft sand and underground water will be encountered in the course of the works. Vertical sheeting will be used in shallow trenches, and caissons will be used in deeper excavations so as to avoid damage and slipping of the soil. When groundwater is already reached, the use of dewatering pumps will be employed. Dewatering will be done as per EPA rules and regulations after obtaining necessary approvals.

As per the guideline, Design criteria and technical specifications for conventional gravity sewerage systems guideline released by the Water and Sanitation Unit of the Environmental Protection Agency, all fill material removed during excavation for trenching and construction will be disposed of inland from the excavation for use as backfill after sieving. Backfilling material must be free from debris, large rocks and other sharp objects. No rocks will be placed within 900 mm on top of the pipe nor within 400 mm of the ground surface. The fill will be carefully placed in layers not more than 150mm thick and be tampered under, around and over the pipe to a height of 600 mm above the crown. Until this level has been reached, the sand shall be placed very carefully. Warning tapes will also be laid prior to the final layers of the backfilling. Excavated sand not to be reused will be transported to sites approved by the Engineer. Areas affected by the excavations will be reinstated to the original condition or improved to suitable condition for appropriate use.

Mechanisms to avoid pipe leakages and groundwater contamination

In the design of the sewer system, allowances will be made for the leakage of groundwater into the sewers and building sewer connections (infiltration) and for other extraneous water entering the sewers from such sources as leakage through manhole covers, drains, roof down spouts, etc. Due to the extremely high peak flows that can result from roof down spouts, they should not, in any circumstances, be connected directly or indirectly via drains, to the sewer system.

Furthermore in order to avoid leakages to ground water, pipe jointing will be carried as per the guideline “Design Criteria and Technical Specifications for Conventional Gravity Sewerage Systems” (EPA n.d.) and techniques such as electro fusion will be used to provide highest quality of pipe jointing. Site engineers will inspect the sewer lines for leakage by carrying out pressure testing for each segment while the pipe laying work is carried out.

Sea outfall pipeline

The sea outfall pipelines are to the western side of the island, which is to the open ocean. Locations of these pipelines are shown in Figure 1. The length of the sea outfall from the northern region is 420m, while that to be laid at the southern region is 340m. It is important to note here that the proposed location for the sea outfall pipeline at the northern region is within close proximity (100m from the boundary) to the protected area of Eidhigali Kilhi, which is a wetland area.

The minimum diameter of the black HDPE pipes used will be 110 mm OD. Outfall pipe will be laid to a depth of 0.6 m on land and placed on the natural sea bed using concrete ballast blocks anchored to the seabed to prevent movement of the pipeline during heavy wave activity. The pipe joints will be HDPE fusion welded. Pipe laying will be done by manual labor, block will be moved to required location on floating rafts or using air bags (underwater).

Outfall ‘T’ diffuser will be fixed at end of pipe outside of the reef which is at a minimum depth of 6 m below lowest tide level. However, it is expected that the end of the outfall pipe to be at 15 m depth below the lowest tide level to ensure maximum environmental benefit and minimize environmental impacts which may arise due to this discharge. Appendix 6 shows bathymetric survey map of proposed and alternative locations for outfall discharge.

For the purpose of minimal impact on shoreline, the depth of pipe portion laid up to beach toe will be placed on same level as the seabed level. Pipe installed on the sea portion will be using concrete ballast blocks anchored to the seabed.

5.6.1.5 Institutional arrangements, operating procedures and project management

The operator of the waste water collection system facility will be FENAKA Corporation Ltd. In addition, an administration building will be located at the plot identified for construction of STP (at later stage) to facilitate the maintenance and operational works. The administration building will also serve as a storage facility with sufficient covered vehicle parking space for a service vehicle.

5.6.2 Operation and Maintenance Requirements

5.6.2.1 Household Infrastructure

Each household will be provided with an inspection chamber inside the boundary. Household sewer to main sewer will be laid at a minimum grade of 1.5-2.5% to facilitate the flow of solids. In case where domestic fixtures do not include a water trap, an ‘S’ bend will be fitted on the outside side. Generally, at the upstream side of the residential connection, a vent pipe will be installed to avoid foul gases entering the network. The household owner shall be responsible for the connection of the house toilet to the inspection chamber. No rainwater down spouts will be allowed to connect to the sewer network. For maintenance purpose, access covers and frames will be incorporated with rubber gasket on the closure capable of restricting ingress of water and emission of odor.

5.6.2.2 Communal Infrastructure

For ease of maintenance works, pre-fabricated circular shafts for manholes will be at a maximum of 60m intervals and at every road junction. Cleanouts or rodding points will also be installed at the start of all main sewers. Hotels/restaurants/industrial places will provide a grease trap for filtration prior to connection with the inspection chamber.

5.6.2.3 Sewer Cleaning

The proponent proposes to use mobile Sewer Jetting Machines for cleaning sewer lines.

5.6.2.4 Sewer System Maintenance Tools

All necessary maintenance tools such as squeegees, wrenches, valve keys, rakes, shovels, spare parts, etc. will be provided (Table 10). A sewer jetting machine is desirable. Readily accessible storage space and workbench facilities will be provided and consideration will be given to provision of a garage for large equipment storage, maintenance and repair.

Table 10. Sewer System Maintenance Tools

Tools	Qty
Squeegees	4 nos
Wrench set	2 nos
Valve key	2 nos
Rake	2 nos
Shovel	2 nos
Impeller	2 nos
Casing	2 nos
Shaft	2 nos
Wearing ring	2 nos
Sewer jetting machine	1 nos

5.6.3 Outputs (development concept and built environment)

5.6.3.1 Site Planning and design

The site plan and design of the gravity type wastewater collection and disposal system to be set up at S. Hithadhoo has been designed by MWSC Pvt Ltd (see Appendix 3 for site plan).

5.6.3.2 Key outputs

The key output of this project is establishment of gravity type wastewater collection and disposal system at S. Hithadhoo north and south regions.

Gravity type wastewater collection and disposal system

The sewerage system comprises of the following:-

- Thirteen zonal pumping stations (4 in the north, 9 in the south) where the wastewater is drained by a gravity pipe system, wastewater collected and then pumped Disposal pump station;
- A sloping pipeline system, typically consisting of a ‘Y’ fixture, lateral connection;
- Two separate sea outfall pipelines for the northern and southern regions
- Sewer mains, cleanouts, manholes, vents, pump stations, outfall pipelines and diffuser with 35 year design flow specifications.

The length of the gravity sewer main required is approximately 32 km.

5.7 **Waste management during the construction work**

5.7.1 **Solid waste**

All solid waste generated during the construction phase will be collected at the end of the days' work and transported to the island's waste disposal site or to Thilafushi once a month for disposal.

5.8 **Emergency plans**

5.8.1 **Emergency Storage**

Pumping stations will be designed with emergency storage capacity to retain the maximum dry weather sewage inflow for a minimum response time of two hours. Backup pumps will be installed at each pump station, while mobile pump will be provided at the operations facility.

5.8.2 **Emergency overflow systems**

5.8.2.1 **Catchment overflow links (LO)**

All catchments will be interlinked via a catchment overflow of 160 mm OD pipe laid at a flat grade at the closest point between two catchments to provide relief during an event where the pump station in a given catchment fails.

5.8.2.2 **Emergency flow relief structures (EFERS)**

Emergency flow relief structures will not be provided since the pumping stations will be designed for the emergency storage to retain two hours peak dry weather flow to provide an adequate response time to a pump station failure. In addition, pumping stations will be provided with an emergency bypass mechanism for use during pump station service and maintenance.

5.8.3 **Emergency power supply**

Backup mobile generators will be in place for use in case of power failures.

6 Methodology

The approach to data collection and compilation of this report includes:-

- Consultation and discussion with the proponent with regard to design and work methodology that would be used to implement the proposed activities of the project;
- Examination of the existing environment to identify significant environmental components which are likely to be affected;
- Consultation with major stakeholders to exchange information on the project and to follow the EIA procedures required for the report; and
- Evaluation of available and relevant literature on environmental impacts associated with similar projects.

Information on existing environment was collected during the field visit to the project site from the 30th March 2017 to 2nd April 2017. General information on the existing environment was based on available secondary data, such as climatic and tide data from the meteorological centre at S. Gan. Oceanographic data and information used to determine the current patterns were also based on monsoonal wind patterns, wind generated waves, tidal flushing and geographic setting.

6.1 Marine Survey

An underwater camera with housing was used to take a series of photographs for assessing reef benthic community. Randomly selected 20 quadrats were sampled within a 10 meter belt along the 100 meter transect line. Quantitative assessment was carried out at 3 sites; site R1 (outfall for southern zone), R2 (outfall for northern zone) and Control site (see Figure 2). Photos were analysed using Coral Point Count with Excel Extensions software (CPCe) to assess the benthic cover.

Assessment of the selected fish community was also carried out at the same sites (R1, R2 and Control) which would also be considered as the baseline for future monitoring of the impact of the project. Fish abundance and density surveys were based on visual fish census techniques described in English, Wilkinson and Baker (1997). The 100 meter long transect line used to assess the coral and other benthic substrate was used to estimate the diversity and abundance of all coral reef fish families that are commonly associated with the reef environment of Maldives and observed in the area.

Figure 2. Reef survey sites at Hithadhoo outer reef (R1: south outfall and R2 north outfall)

6.2 **Water quality analysis**

6.2.1 **Seawater**

In order to assess the sea water quality, seawater samples were taken from the sites proposed for outfall discharge locations and control site (see Figure 2). Both in-situ sampling (Hanna HI9828 multi probe test meter) and laboratory test (by MWSC Water Quality Assurance lab) were carried out.

6.2.2 **Groundwater**

Groundwater was sampled from proposed STP site and 13 pump station locations, in order to establish a baseline for future monitoring work as specified in the TOR (Refer Figure 3 and Table 11 for GPS positions of groundwater sampling sites). Physical parameters were tested in-situ using a Hanna Multiprobe test kit.

Figure 3. Groundwater sampling locations

Table 11. GPS positions of groundwater sampling locations

Sample ID	Longitude	Latitude
PS1	0°36'54.07"S	73° 5'18.50"E
PS2	0°36'46.96"S	73° 5'25.83"E
PS3	0°37'11.04"S	73° 5'26.14"E
PS4	0°37'8.61"S	73° 5'34.04"E
PS5	0°37'27.79"S	73° 5'37.04"E
PS6	0°37'22.67"S	73° 5'47.44"E
PS7	0°37'7.28"S	73° 5'50.57"E
PS8	0°36'50.92"S	73° 5'41.57"E
PS9	0°36'39.89"S	73° 5'34.41"E
PS10	0°35'11.12"S	73° 4'44.88"E
PS11	0°35'28.46"S	73° 4'39.89"E
PS12	0°35'31.51"S	73° 4'52.79"E
PS13	0°35'16.30"S	73° 4'52.48"E
STP	0°37'32.89"S	73° 5'40.21"E

6.3 **Terrestrial vegetation survey**

A visual assessment of the vegetation at the proposed sites for construction of STP facility and the pumping stations was carried out to evaluate the quantity and type of vegetation clearance needed for the proposed project.

7 Existing environment

7.1 Geographic location and geomorphological setting of Hithadhoo

Addu atoll located at 0° 38’S’, 73°10’E is a relatively small atoll (157 km^2) compared to most other atolls in the Maldives. The average area of the Maldivian atolls was calculated to be approximately 855km^2 (Naseer and Hatcher, 2004). Addu atoll has a triangular shape that is dissected by four channels Gan Kandu, Viligili Kandu, Maakanda, and Kodakanda and comprises 16 islands, all of which are formed on the atoll peripheral reef. The atoll lagoon has depths between 30 and 80m. The atoll reef system has two major segments; the reef on the southwestern side of the atoll (Gan – Hithadhoo reef) and the reef that accommodates Hulhudhoo-Meedhoo on the north to the north eastern side of the atoll. The Gan – Hithadhoo reef section represents about 50% of the total perimeter of the atoll. The total area covered by the atoll peripheral reef flats, including the islands is approximately 44km^2. The length of the atoll periphery reef is 60km

The island of Hithadhoo lies at the Northwestern end of Addu atoll approximately 525km north of Capital city Male’ (Figure 4). Measuring approximately 8.4 km in length and around 1.7 km in width (at maximum), the island covers an area of 523 hectare, the island is oriented northwest to southeast. The island is located at 00° 36' 25" N and 73° 05' 19" E. The reef system hosting the island is approximately 29km long and hosts two other inhabited islands, Gan Airport and ten uninhabited islands.

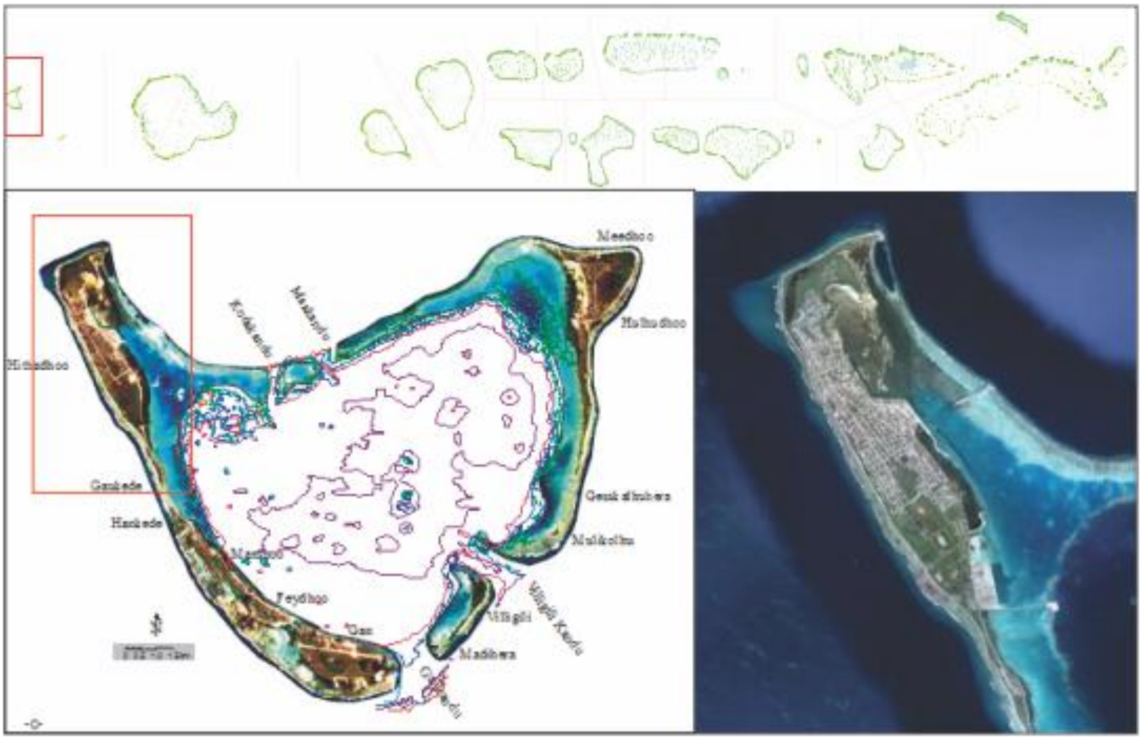

Figure 4. Maldives archipelago depicting location of Seenu Atoll (top), location of Hithadhoo within Seenu Atoll (bottom left) and aerial image of Hithadhoo (2007 image, bottom right)

7.2 **Climatology and oceanography**

7.2.1 **Temperature**

Being an equatorial country, temperature of the Maldives does not fluctuate much throughout the year and remains almost the same. Temperature data recorded by the meteorological station at Gan for the period January 1978 to December 2015 were used to analyze the temperature pattern in the region. Figure 5 shows the minimum and maximum mean monthly temperatures for Addu as per the data recorded by the station for the given period. As evident from the figure, period between March to July recorded the highest temperature at this region, April being the hottest month. The lowest temperatures were recorded for the last quarter of the year.

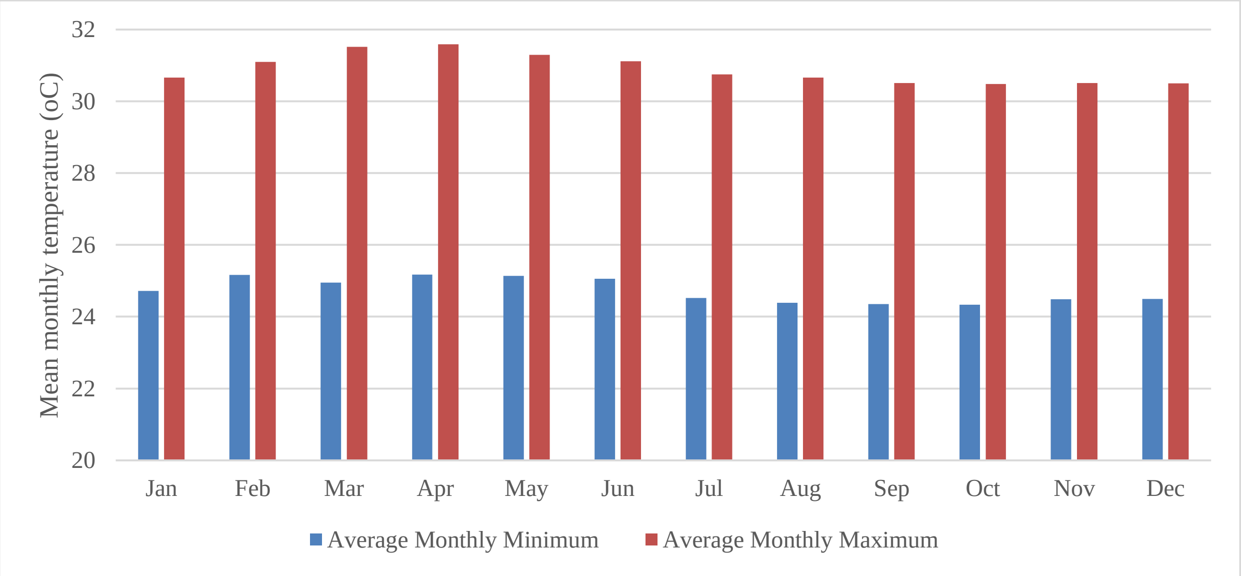

Figure 5. Minimum and maximum mean monthly temperatures for S. Gan (Data from http://statisticsmaldives.gov.mv/yearbook/statisticalarchive/))

7.2.2 **Rainfall**

The rainfall pattern at S. Gan and for the rest of the Maldives is driven by the monsoonal cycles. Wet season mostly spreads from mid-May to November. In general, according to rainfall data from the 4 weather stations, southern atolls (S. Gan) receive about 2,218mm of rainfall and south central atolls (L. Kahdhoo) receive 2,216mm of rainfalls per year, while the average annual rainfalls for northern region (Hdh. Hanimaadhoo) and central area (K. Hulhule) are 1,779mm and 1,966mm respectively (MEE, 2016). It can be observed that south and south central region received higher rainfalls than central and north.

Figure 6 below shows the mean monthly rainfall for S. Gan for the period of January 1978 to December 2015. As evident from the figure highest rainfall is observed during May and October (wet season) whereas the lowest numbers were recorded during February and June (the dry season).

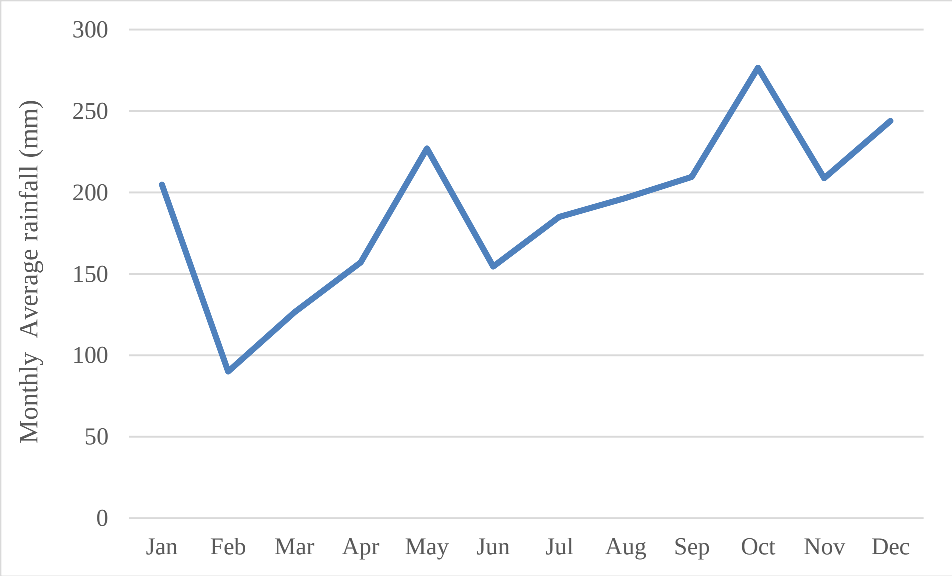

Figure 6. Monthly rainfall patterns for S. Gan for the period: January 1978 to December 2015 (Data from http://statisticsmaldives.gov.mv/yearbook/statisticalarchive/)

7.2.3 Wind climate

Wind climate in the Maldives is dominated by the Indian monsoon climate South West (SW) monsoon and North East (NE) monsoon. The Indian monsoon system is one of the major climate systems of the world, impacting large portions of both Africa and Asia (Overpeck et, al., 1996). The monsoon climate is driven by the atmospheric pressure differences that arise as a result of rapid warming or cooling of the Tibetan Plateau relative to the Indian Ocean (Hastenrath 1991; Fein and Stephens 1987). During the summer of northern hemisphere the Tibetan Plateau warms rapidly relative to the Indian Ocean which results in an atmospheric pressure gradient (Low pressure over Asia and high pressure over the Indian Ocean) between the Asian landmass and the Indian ocean, which drives the prevailing wind from south to westerly directions. The period during which prevailing winds are from south to westerly direction is known as the SW monsoon. In the winter of northern hemisphere the continent cools relative to the ocean. This reverses the pressure gradient (low pressure over the Indian Ocean high pressure over the Asian landmass) and the prevailing winds become northeasterly. The period during which prevailing winds are from northeasterly directions is known as NE monsoon. The transitions from NE to SW monsoon and vice versa are distinctly different from SW or NE monsoon. During these transition periods the wind becomes more variable.

The SW monsoon lasts between May and September while the NE monsoon lasts between December and February. The period between March and April is the transition period from the NE monsoon to SW monsoon known locally as the Hulhangu Halha, while the transition period from SW monsoon to NE monsoon is known as Iruvai Halha. Iruvai halha lasts from October to November (Table 12). The SW monsoon is generally rough and wetter than the NE monsoon. Storms and gales are infrequent in this part of the world and cyclones do not reach as far south as the Maldivian archipelago (Ministry of Construction and Public Works, 1999).

Table 12.The months characterizing the two monsoon periods and the transition periods

Season	**Month**
NE-Monsoon (Iruvai)	December
	January
	February
Transition Period 1 (Hulhangu Halha)	March
	April
SW-Monsoon (Hulhangu)	May
	June
	July
	August
	September
Transition Period 2 (Iruvai Halha)	October
	November

A detailed analysis of the wind climate was carried out using daily averaged wind data from Gan Airport in Addu City for the period of January 1989 to December 2008. In this analysis, wind rose diagram based on wind speed and direction and the frequency of speeds and direction was produced.

Wind rose plot (Figure 7) shows that winds the western quadrant are dominant reaching speeds as high as 30 knots. Winds from the northern and eastern quadrant are less prevalent and with comparatively low speeds. Wind speeds above 18 knots were found to be a rare occurrence, and the instances when it does occur, wind direction was from the western quadrant, thus indicating that this was during the SW monsoon, when winds are generally stronger.

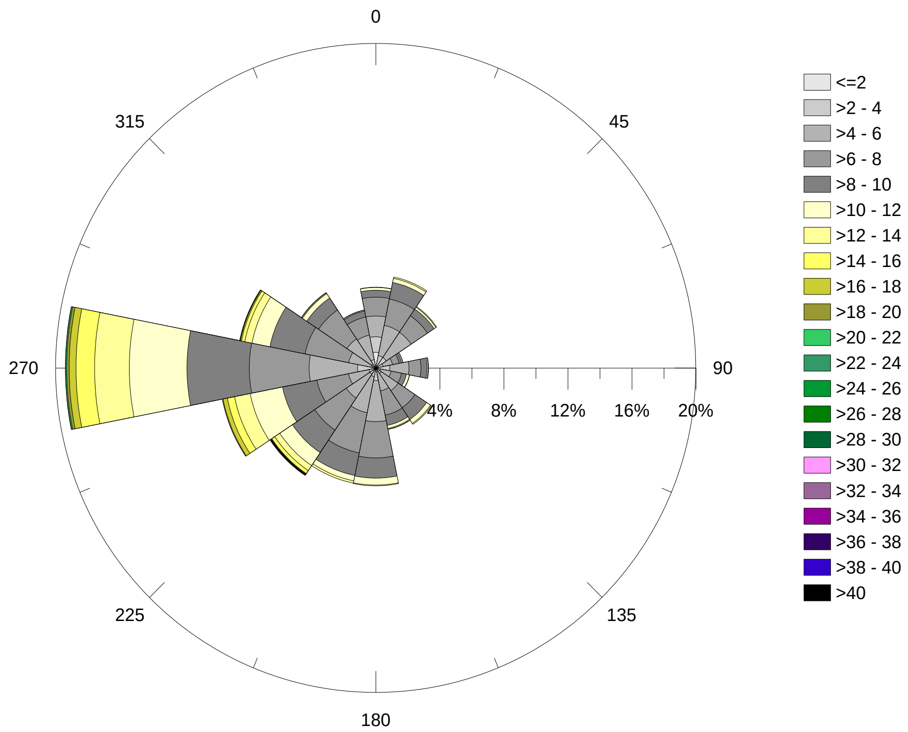

Figure 7.Wind rose plot for Gan Meteorological station, based on hourly wind data for the period of January 1989 to December 2008

7.2.4 Tide

Tides originate from the gravitational forces of the sun and moon acting on the rotating earth. As the earth rotates on its axis, spatially varying gravitational forces from the moon and the sun causes the elevated body of water (tidal wave) to follow the relative motion of the sun and the moon. The most common method of analyzing the water level elevation caused by the tides at any given location is by harmonic analysis of tide data collected from that site.

Nearest tide station to the project site is at Gan in Addu Atoll. Addu Atoll has one of the three sea level monitoring tide stations in the Maldives. Hourly tide data from Addu Atoll is available since 1987 and data can be downloaded from the web site of University of Hawaii (http://ilikai.soest.hawaii.edu/uhslc/htmld/d0109W.html).

7.2.4.1 Harmonic Analysis of Tide Data

Harmonic analysis assumes that tidal motion can be represented by the sum of a series of simple harmonic terms (tidal constituents), each term being represented by an oscillation at a known frequency of astronomical origin. The harmonic method assumes the tide at any location comprises of multiple partial tidal constituents. Approximately 390 tidal constituents have been defined (Doodson, 1922), the most significant of which are formed by the gravitational attraction between the earth and the moon and sun. Table 13 lists the principle constituents and their periods. Sixteen of the 19 constituents listed are diurnal (one cycle per day) or semidiurnal (two cycles per day). Diurnal and semidiurnal constituents are denoted by the subscripts "1" and "2," respectively, in their symbols.

Table 13. Principle tidal constituents (Defant, 1961)

Name	Symbol	Period, solar hr
Principal lunar	M_2	12.42
Principal solar	S_2	12
Larger lunar elliptic	N_2	12.66
Luni-solar semidiurnal	K_2	11.97
Larger solar elliptic	T_2	12.01
Smaller solar elliptic	L_2	12.19
Lunar elliptic second order	$2N_2$	12.91
Larger lunar evectional	ν_2	12.63
Smaller lunar evectional	λ_2	12.22
Variational	μ_2	12.87
Luni-solar diurnal	K_1	23.93
Principal lunar diurnal	O_1	25.82
Principal solar diurnal	P_1	24.07
Larger lunar elliptic	Q_1	26.87
Smaller lunar elliptic	M_1	24.84
Small lunar elliptic	J_1	23.1
Lunar fortnightly	Mf	327.86
Lunar monthly	Mm	661.3
Solar semiannual	Ssa	2191.43

The mathematical expression for a harmonic series of M constituents given by:

$$y(t) = A_0 + \sum_{m=1}^{M} A_m \cos(\omega_m t - \phi_m)$$

Where *y* is the water level; *t* is the time; ω_m is the radial frequency of constituent *m*; A_m is the amplitude, $\O_m$ is the phase, and A_0 is mean sea level.

The number of constituents to be identified, M, is dependent on the length of record available for analysis and the degree of accuracy desired. In typical modelling applications, eight constituents are specified: K_1, O_1, P_1, Q_1, M_2, N_2, S_2, and K_2 because these constituents make up a significant portion of the tidal signal.

The amplitudes of the constituents M_2, S_2, K_1 and O_1 can be used to calculate the tidal form ratio, $F = \frac{K_1 - O_1}{M_2 - S_2}$, which leads to the following subdivisions:

- F = 0.00 - 0.25 : semidiurnal tides
- F = 0.25 - 1.50 : mixed, dominantly semidiurnal tides
- F = 1.50 - 3.00 : mixed, dominantly diurnal tides
- F > 3.00 : diurnal tides

The tidal datum approximating the lowest water level observed at a place is equal to the sum of amplitudes of the harmonic constituents M_2, S_2, K_1 and O_1; usually below that of the lower low water at spring tides.

Harmonic analysis of tide from Addu Atoll was carried out using hourly tide data for the year 2007. The spectrum for these data (Figure 8) enabled determination of the amplitude of the tidal constituents μ_2, N_2, M_2, L_2, S_2, K_2, Q_1, O_1, M_1, P_1 and K_1 (Table 14).

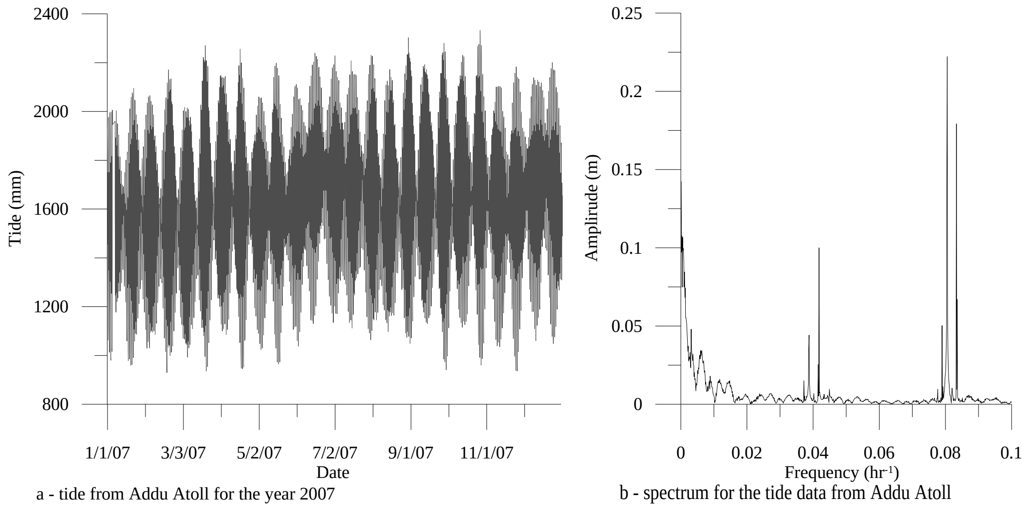

Figure 8.Tide and its spectrum for the hourly tide data from Addu Atoll

Table 14.Amplitudes of tidal constituents for Addu Atoll determined with spectral analysis of tide data

Tidal Constituent	**Period (hr)**	**Amplitude (m)**
μ_2	12.88	0.0095
N_2	12.66	0.0501
M_2	12.41	0.2219
L_2	12.2	0.01
S_2	12	0.1784
K_2	11.97	0.0671
Q_1	26.84	0.0152
O_1	25.79	0.044
M_1	24.86	0.0069
P_1	24.05	0.0256
K_1	23.96	0.0999

The tidal form ratio calculated from the results in Table 14 was 1.95 which means that the tide in Addu Atoll is classified to be a mixed, dominantly diurnal tide. The approximate lowest low water level for Addu Atoll was calculated to be -0.54m (MSL). The approximated tidal range in Addu Atoll is 1.09m.

7.2.5 **Wave and current**

A physical modelling study conducted for the Maldives by the Danish Hydraulic Institute showed that, during NE monsoon the oceanic swells that approach the southern atolls of Maldives are generally from east – south (DHI 1999). The longer period waves of the wave spectrum are from south – southwest directions while the shorter period waves are mainly from east – northeast directions. During the SW monsoon the waves are mainly from south. The longer period waves of the wave spectrum are from south – southwest while the shorter period waves are from southeast – south. It is therefore evident that the incident waves in the southern atolls of Maldives are predominantly from a southerly direction. Table 15 below shows the general offshore wave conditions in the southern regions of Maldives as described in the study (DHI 1999).

Table 15. Seasonal wind and wave climate around the southern atolls of Maldives

Season	Month	Wind	Waves		
			Total	Long period	Short period
NE monsoon	December January February	Predominantly from NW-NE. High speeds from W	Predominantly from E-S. High waves from W	From S-SW	Mainly E-NE. High waves from W
Transition period 1	March April	From all directions. Mainly W. High speeds from W	Mainly from SE-S	From S-SW	Mainly from NE-SE
SW monsoon	May June July August September	Mainly from SE-SW. High speeds from W	From SE-SW. Mainly S. High waves also from W	From S-SW	Mainly from SE-S. High waves from W
Transition period 2	October November	Predominantly from W. High speeds from W	As SW monsoon	From S-SW	Mainly from SE-W. Higher waves from W

The local wind generated waves that are directly related to the wind climate in the region varies with the seasonal changes in the wind velocity. DHI (1999) reported that during the NE monsoon the wind is predominantly from NW – NE and the high speed winds are from west. During Hulhangu Halha (Transition Period 1) the wind varies to all directions but the high winds during this period are from west. Southwest monsoon is marked by winds from SE – SW and high speed winds from west. Iruvai Halha (Transition Period 2) also experiences westerly winds. DHI (1999) reported that the high speed wind in the southern atolls of Maldives throughout the year is from west.

Wave data reported in DHI (1999) shows that the highest waves reaching the southern Atolls of Maldives archipelago are from west direction (Figure 9). Waves of Hs 2.75m with wave periods [Tp] of 8s and 9s have been recorded from west direction. Swell waves with wave periods greater than 9s prevails from South and Southwest directions. Over 80% of the waves from south and southwest directions are long period swell waves.

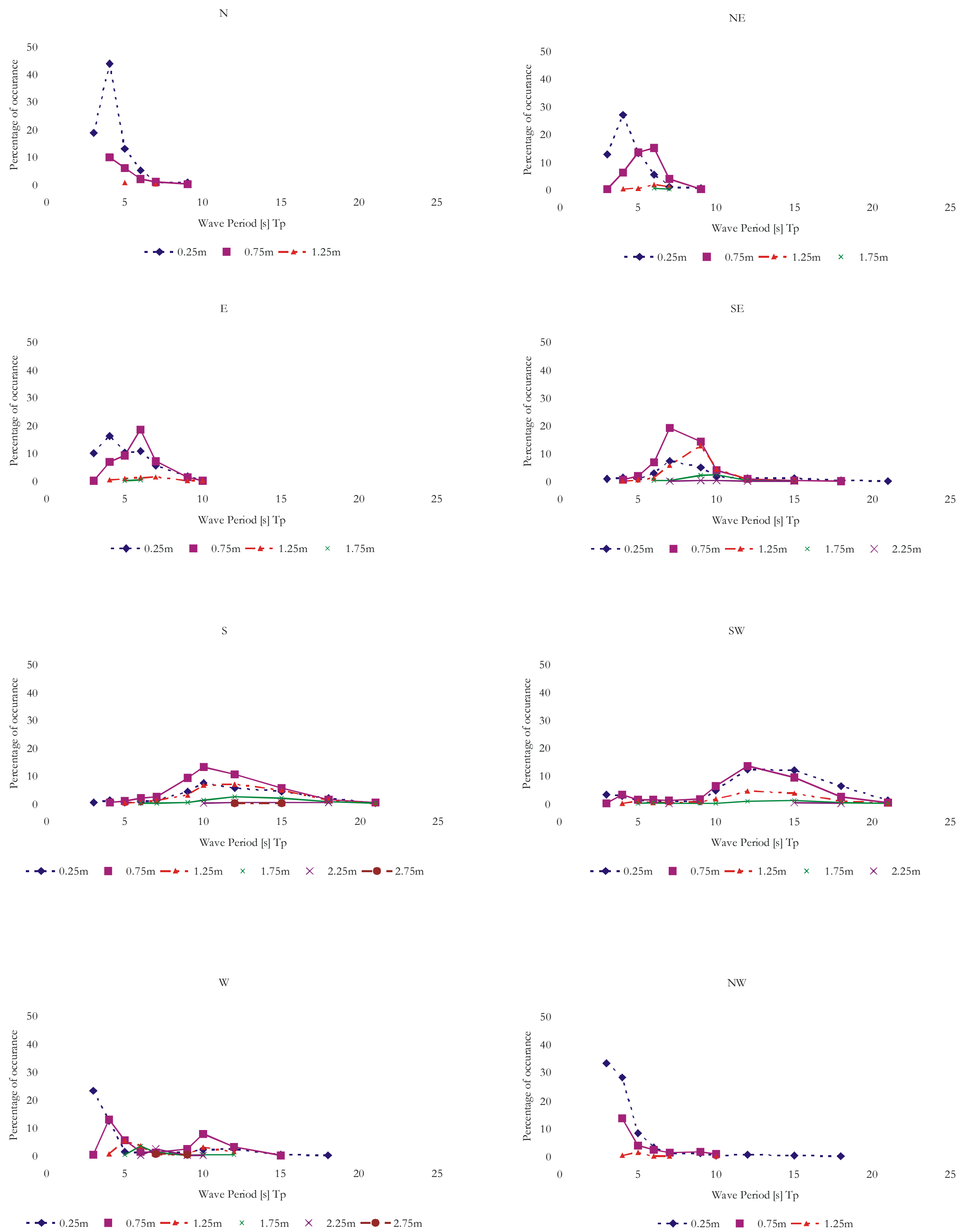

Figure 9. Wave height and period distribution patterns in the southern parts of Maldives (DHI 1999)

The longer period swells (waves with periods between 15 and 21sec) come from SW direction. Over 37% of the waves from SW directions have Tp between 15s and 21s. Out of these long period swells 19.15% of the waves have Hs of 0.25m, 11.5% have Hs of 0.75m, 4.33% have Hs of 1.25m, 1.38% have Hs of 1.75m and 0.31% have Hs of 2.25m.

DHI (1999) data also showed that 51.22% of the waves from SE direction consist of waves with Tp between 9s and 21s, while 48.78% of the waves have Tp between 3s and 7s. Waves from N, NE, E, NW and W are predominantly shorter period waves [Tp between 3s and 7s]. 96.98% of the waves from E direction, 99.6% of the waves from NE direction, 99.36% of waves from N direction, 95.74% of waves from NW direction and 75% of waves from W direction have Tp between 3s and 7s. These data evidently indicates that the local wind generated waves are predominantly confined to northern directions between West and East. The southern directions are predominantly dominated by longer period oceanic swells.

The currents which affect Hithadhoo western side can be expected to be tidal currents, wind-induced currents, and swell induced currents. Wave induced currents in the form of over washing, and in some locations longshore currents due to waves breaking on the reefs, also affect the current regime. As seen above since the tidal range is very small, the tidal currents have a very small role on the overall current patterns within the reefs and around the islands. Tidal component of the current is generally northerly or southerly depending on the tidal phase.

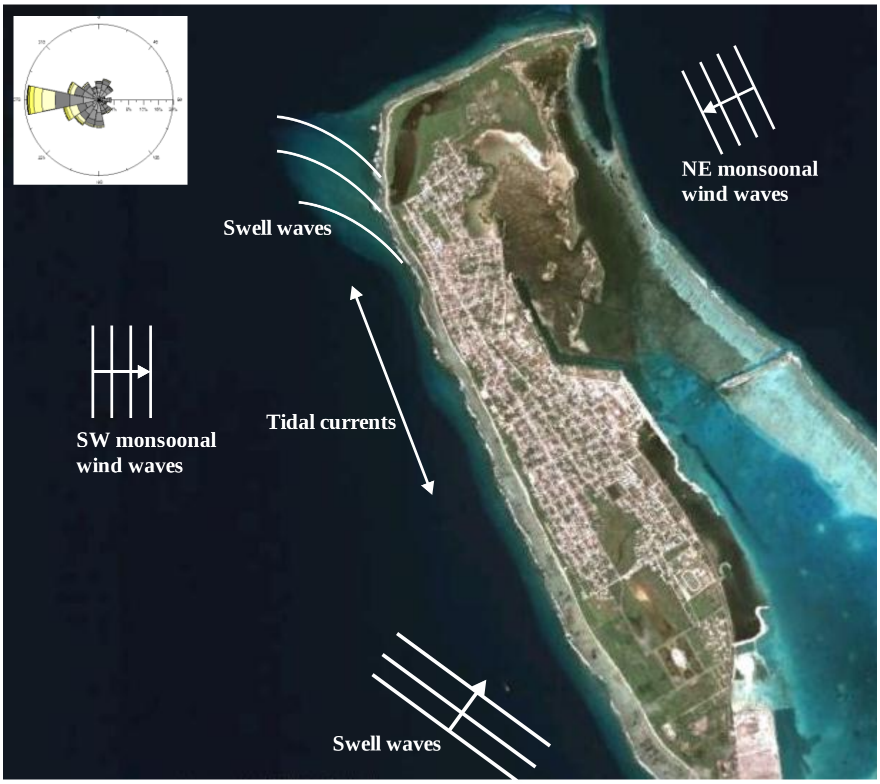

Figure 10. Schematic diagram showing assumed hydrodynamic pattern around Hithadhoo western side outer reef

Current measurements taken under the EIA for the central zone (CDE, 2011) shows that current speed near the proposed southern outfall area is 0.15m/s, while current flow is higher moving northwards. Average speed of water current at reef flat behind wave breaker zone is 0.09m/s according to data present in CDE (2011).

7.3 Marine surveys

The island of Hithadhoo is located on the north western side of Addu atoll. Located on the northern end of the peripheral reef, Hithadhoo shares the same reef with several other islands. The reef platform around the islands at the western side is very shallow (-0.6m MSL) inter tidal flat. Unlike the western side the eastern side is composed of large intertidal flat leading to deep lagoon system. The reef at the western side compose of steep well defined spur and groove formations almost entire length of reef. The north western corner area has large gradual mid outer reef slope, which is more or less flat before reef slope drop off. In comparison to northern end, mid reef slope is narrower. The north western corner area is a high energy zone, where shoaling effect is observed. Since the project area is limited to western reef slope the reef associated ecological investigations were focused to this area and control site 1 km north of this area. The study was focused and limited to the reef flat and upper reef slope at survey locations.

7.3.1 Coral Community

The following section describes the conditions of the reef where quantitative reef substrates surveys were conducted at 3 sites (R1: south outfall, R2: north outfall and control site), 2 of which shall act as a baseline for future monitoring and 1 shall act as a control site for comparison purposes (See Figure 2 for aerial map and GPS Coordinates).

Table 16 shows percent composition of substrate varieties at the 3 surveyed sites. Live substrate cover at all surveyed locations were very poor. Coral rock, dead coral covered in algae and recently dead corals are highly dominant in all surveyed locations. Significantly low covers of live coral cover was encountered, with North outfall site having the highest live coral cover with 8.04%. Presence of algal forms, coralline algae, sand and rubble were also noted. The little live cover that were recorded, mostly comprised of corals in the genera Porites, which are noted for their resilience. Southern outfall site had the highest dead coral cover, this large number of dead coral is perhaps due to the 2016 and 2015 (September 2015) bleaching events.

Table 16. Dominant substrate composition at surveyed sites, as surveyed in April 2017

Substrate type	Survey sites					
	Control	± Std.Err	R2:North Outfall	± Std.Err	R1:South outfall	± Std.Err
Hard Coral	1.01	± 0.01	8.04	± 3.96	1.5	± 1.5
Algae	1.01	± 1.01	2.55	± 2.55	0	
Coralline Algae	0		0		1.52	± 1.52
Dead coral covered with algae and recently dead coral	10.58	± 1.56	34.81	± 4.19	78.37	± 4.63
Rock	83.92	± 0.92	50.04	± 4.04	17.11	± 5.11
Rubble	1	± 1	2.55	± 2.55	0	
Sand	2	± 2	1.5	± 1.5	0	

Figure 11. Photo representation of northern outfall site

Figure 12. Photo representation of southern outfall site

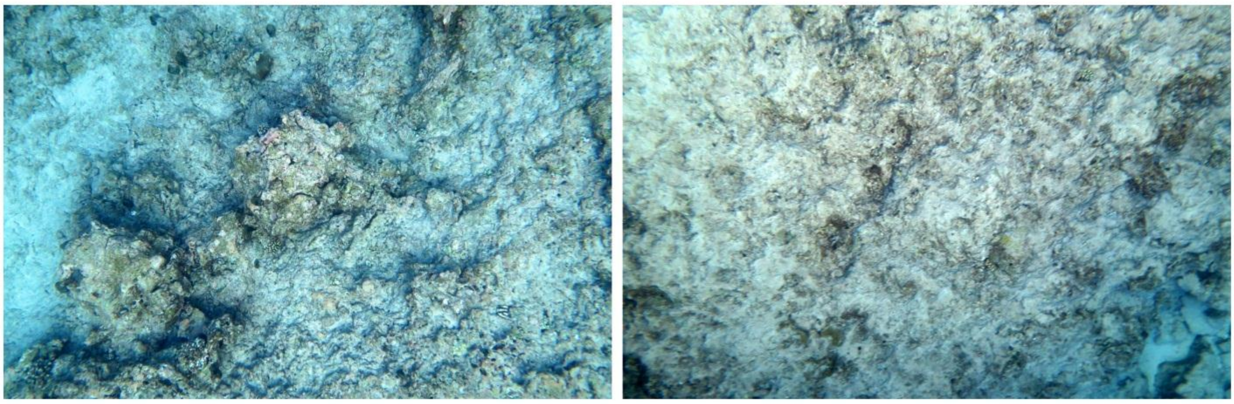

Figure 13. Photo representation of control site

7.3.2 **Reef fish community**

17 families of fishes were recorded during the time of the field survey (north outfall, south outfall and control site). The most abundant group of fishes were of Acanthuridae and followed by Pomacentridae, Acanthuridae and Labridae (Table 17). All the other families each contributed to overall fish community with occasional and rare abundance.

Commercially important food fishes such as groupers (Serranidae) were rare which includes *Cephalopolis argus* and *Ephinephelus merra*. Groupers are targeted fish species that are heavily fished throughout the Maldives. Lethrinides such as sea breams and emperors were also rare in their presence.

Table 17. Dominance of fish families at the survey sites (A=Abundant, C=Common, O=Occasional and R=Rare)

			Locations		
			R2: North Outfall	**R1: South Outfall**	**Control**
Family	**Species**	**Functional group**	**Abundance**		
Herbivores					
Acanthuridae					
	Acanturus leucosternon	Browsers	C	A	A
	Acanthurus lineatus	Browsers	-	R	A
	Acanthurus triostegus	Browsers	-	R	A
	Zebrasoma desjardinii	Grazers/detri	-	-	R
	Ctenochaetus striatus	Grazers/detri	R	R	C
	Naso vlamingii	Grazers/detri	-	-	R
	Naso brevirostris	Grazers/detri	R	R	C
	Naso unicornis	Grazers/detri	R	R	C
	Naso lituratus	Grazers/detri	-	-	C
	Zebrasoma scopas	Grazers/detri	-	R	-
Balistidae					
	Melichthys indicus	Grazers/ detri	R	R	R
	Odonus niger	Grazers/ detri	A	A	A
Caesionidae					
	Caesio lunaris	Browsers	-	R	-
	Caesio varilineata	Browsers	R	A	-

Chaetodontidae					
	Chaetodon guttatissimus	Browsers	C	-	-
	Chaetodon trifascialis	Browsers	-	R	-
	Chaetodon kleinii	Browsers	R	-	-
	Chaetodon collare	Browsers	R	-	C
	Chaetodon auriga	Browsers	-	R	C
Diodontidae					
	Diodon liturosus		-	R	-
Labridae					
	Cheilinus fasciatus	Browsers	-	R	C
	Gomphosus caeruleus	Browsers	R	-	C
	Helichoeres hortulanus	Browsers	C	R	-
	Labroides dimidiatus	Browsers	A	C	R
	Thalassoma lunare	Browsers	-	R	R
	Thalassoma hardwicke	Browsers	R	A	A
Pomacentridae					
	Amphiprion negripes	Grazers	-	R	R
	Dascyllus aruanus	Grazers	R	-	R
	Chromis viridis	Grazers	R	C	R
	Chromis opecularis	Grazers	-	R	R
	Pomacentrus indicus	Grazers	-	R	-
	Pomacentrus philippinus	Grazers	R	-	-
	Stegastes fasciolatus	Grazers	-	R	-
	Amblypomacentrus sp1	Grazers		R	-
	Abundefduf viagiensis	Grazers	C	C	-
Pomacanthidae					
	Pygoplites diacanthus	Grazers/detri	-	R	-
Scaridae					
	Cetoscarus bicolor	Grazers	C	C	R
	Scarus strongylocephalus	Grazers	R	R	C
	Scarus sordidus	Grazers	R	R	R
Zanclidae					
	Zanclus cornatus	Browsers	-	C	C
Carnivores					
Carangidae					
	Caranx melampygus		-	-	-
Cirrhitidae					
	Paracirrhites fosteri		-	-	-
Haemulidae					
	Plectrorhinhus orientalis		-	-	-
Holocentridae					
	Myripristis pralinia		-	R	-
	Sargocentron spiniferum		-	-	C
Lethrinidae					
	Lethrinus erythracanthus		-	-	R
	Gymnocranium sp.		R	-	-
	Lethrinus microdon		-	-	C
Lutjanidae					
	Lutjanus kasmira		R	R	C
	Lutjanus biguttatus		-	-	R
	Macolor macularis		-	R	-
Economically important species					
Serranidae					
	Cephalopholis argus		R	-	R
	Epinephelus merra		-	R	R

7.4 **Seawater quality**

The condition or quality of coastal water is important for ecological functioning of the organisms living in the habitat, for health and safety reasons and also for visual and aesthetic impacts. The water quality is generally determined by the level of nutrients. There are several sources that can lead to increased nutrients in coastal waters, e.g. sewage effluents and terrestrial storm water runoff. Sediment stir-up can also lead to release of nutrients within the sediments especially when there is excavation and dredging involved.

A list of parameters tested and their values for the referred locations are given in Tables 18 to 21. Water testing was done in situ using a Hanna multi-probe water test meter and by sending samples to MWSC Water Quality Assurance Laboratory.

Table 18. Results of in-situ seawater sampling from the proposed location of southern outfall pipe (R1)

Sample	Temperature (°C)	pH	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	Total Dissolved Solids (g/l)	Salinity (ppt)
1	30.04	8.50	0.16	52430.00	26.21	34.36
2	30.11	8.51	0.16	52380.00	26.19	34.33
3	30.13	8.52	0.16	52380.00	26.19	34.32
4	30.13	8.52	0.16	52390.00	26.20	34.33
5	30.10	8.52	0.16	52460.00	26.23	34.39
6	30.06	8.52	0.16	52520.00	26.26	34.43
7	30.02	8.51	0.16	52560.00	26.28	34.47
8	29.98	8.51	0.16	52600.00	26.30	34.49
9	29.97	8.51	0.16	52610.00	26.30	34.50
10	29.97	8.51	0.16	52600.00	26.30	34.49
Average	**30.05**	**8.51**	**0.16**	**52493.00**	**26.25**	**34.41**

Table 19. Results of in-situ seawater sampling from the proposed location of northern outfall pipe (R2)

Sample	Temperature (°C)	pH	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	Total Dissolved Solids (g/l)	Salinity (ppt)
1	29.93	8.56	0.15	53220.00	26.61	34.96
2	29.91	8.55	0.15	53210.00	26.61	34.95
3	29.91	8.55	0.15	53190.00	26.59	34.93
4	29.91	8.55	0.15	53160.00	26.58	34.91
5	29.91	8.55	0.15	53130.00	26.57	34.89
6	29.91	8.55	0.15	53130.00	26.56	34.89
7	29.91	8.55	0.15	53130.00	26.57	34.89
8	29.90	8.54	0.15	53140.00	26.57	34.90
9	29.89	8.54	0.15	53150.00	26.57	34.90
10	29.89	8.54	0.15	53150.00	26.58	34.91
Average	**29.91**	**8.55**	**0.15**	**53161.00**	**26.58**	**34.91**

Table 20. Results of in-situ seawater sampling from the control site

Sample	Temperature (°C)	pH	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	Total Dissolved Solids (g/l)	Salinity (ppt)
1	30.02	8.57	0.15	53160.00	26.58	34.90
2	30.02	8.57	0.15	53160.00	26.58	34.90
3	30.02	8.57	0.15	53160.00	26.58	34.91
4	30.02	8.57	0.15	53160.00	26.58	34.90
5	30.02	8.57	0.15	53160.00	26.58	34.91
6	30.02	8.57	0.15	53160.00	26.58	34.91
7	30.02	8.57	0.15	53170.00	26.58	34.91
8	30.02	8.56	0.15	53170.00	26.58	34.91
9	30.02	8.56	0.15	53170.00	26.59	34.91
10	30.02	8.56	0.14	53170.00	26.59	34.91
Average	**30.02**	**8.57**	**0.15**	**53164.00**	**26.58**	**34.91**

Table 21.Sea water tested by MWSC Water Quality Assurance Laboratory from samples taken from site R1 and R2 (Test results report in Appendix 7)

Parameters	**R1 (outfall - S)**	**R2 (outfall - N)**	**Control**
Physical appearance	Clear with particles	Clear with particles	Clear with particles
Turbidity (NTU)	0.263	0.146	0.136
Nitrate (mg/l)	6.8	4.5	4.7
Nitrogen Ammonia (mg/l)	0.03	0.09	0.02
Sulphate (mg/l)	3000	3150	2900
Phosphate (mg/l)	0.09	0.11	0.09
Biological Oxygen Demand (mg/l)	1	1	1

7.5 Terrestrial environment

7.5.1 Vegetation survey

Vegetation survey was done by visual assessment at the proposed STP facility and at the pump station locations.

The STP and administration building is located at the western side of Hithadhoo near southern end. Since roads are not properly cleared or made, general vegetation at the area is described. Almost half of the plot is vegetated by dense Alexander laurelwood trees, while rest of the plot was observed with mix vegetation (Sea Hibiscus, Tulip tree and Nit pitcha). A part of The Pump stations PS1, PS2, PS3, PS4, PS5 and PS8 is located at vegetated areas; approximately 600sqft of land will be cleared for construction of each pump station. The pump stations PS6, PS7, PS10 and PS11 are located at areas with low and shrubby vegetation (some areas that were previously cleared but presently covered in grass or shrubs). The Pump stations PS9, PS12 and PS13 are located on road, hence no vegetation will clearance is required. Table below provides vegetation at STP and Pump Stations.

Table 22.Vegetation observed at the proposed STP and pump station sites

<table>
<tr><th>Type of vegetation</th><th>STP</th><th>PS1</th><th>PS@</th><th>PS3</th><th>PS4</th><th>PS5</th><th>PS6</th><th>PS7</th><th>PS8</th><th>PS9</th><th>PS10</th><th>PS11</th><th>PS12</th><th>PS13</th></tr>
<tr><td>Coconut palms</td><td>2</td><td>1</td><td>2</td><td></td><td>3</td><td></td><td rowspan="6">Grass and shrubs</td><td rowspan="6">Grass and shrubs</td><td>1</td><td rowspan="6">On road</td><td rowspan="6">Grass and shrubs</td><td rowspan="6">Grass</td><td rowspan="6">On road</td><td rowspan="6">On road</td></tr>
<tr><td>Alexander laurelwood</td><td>36</td><td>2</td><td>3</td><td></td><td>1</td><td>3</td><td>5</td></tr>
<tr><td>Sea hibiscus</td><td>13</td><td>17</td><td>6</td><td>12</td><td>6</td><td>10</td><td>3</td></tr>
<tr><td>Tulip tree</td><td>4</td><td></td><td>2</td><td></td><td>1</td><td></td><td>1</td></tr>
<tr><td>Nit pitcha</td><td>6</td><td>7</td><td>3</td><td>2</td><td></td><td>3</td><td></td></tr>
<tr><td>Country almond</td><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Figure 14. Vegetation at location for PS 1

Figure 15. Vegetation at location for PS 2

Figure 16. Vegetation at location for PS 3

Figure 17. Vegetation at location for PS4

Figure 18. Vegetation at location for PS5

Figure 19. Vegetation at location for PS6

Figure 20. Vegetation at location for PS7

Figure 21. Vegetation at location for PS8

Figure 22. PS9 location

Figure 23. Vegetation at location for PS 10

Figure 24. Vegetation at location for PS 11

Figure 25. PS 12 location

Figure 26. PS 13 location

Figure 27. Vegetation at STP site

7.5.2 **Groundwater**

Groundwater is the primary source of potable water available in the islands of Maldives due to lack of surface running water which is a result of the geomorphologic characteristics of the islands being atoll based. Groundwater or freshwater le ns develops from rain infiltrating the soil of the coral islands and forms as a result of density differences between fresh and saline groundwater. All soil on coral islands are calcareous residual corals derived from weathered corals that form the bedrock coral limestone foundation of the islands. These soil types have a very high vertical permeability and hydraulic conductivity in the order of several meters per day.

The average recharge of groundwater in the islands of Maldives has been estimated from 40% of rainfall. Based on the average rainfall of approximately 2,235.6mm/year, this amounts to

894mm/year which is equivalent to 8,940m3 per hectare per year. Studies on recharge of the groundwater lens from rainwater of Pacific atolls also indicate 30-40% recharge potential (GWP consultants 2006). Studies in Maldives by Falkland have defined a generalized recharge potential as 30% of the rainfall with 10% variation depending on the vegetation cover (Falkland 1993).

7.5.2.1 **Aquifer thickness estimation**

Studies show that the groundwater of coral islands is only of the order of 20m thick (White, 1996). However Falkland (2000) has stated that there is considerable variation in thickness area and volume of freshwater lenses between islands based on extensive investigation of several islands in the Maldives. These factors are;

- Rainfall amount and its temporal and spatial distribution
- Evaporation and transpiration from soil and vegetation
- Size of the island
- Geology of the island
- Hydraulic parameters of the aquifer formation, its porosity and permeability
- Tidal range
- Groundwater extraction from wells and other systems and method of extraction.

Ghyben-Herzberg relation developed from the density differences of sea and freshwater for estimating depth of water lens states that for every 1 meter of freshwater above sea level there is 40 meter of fresh water below sea level forming the freshwater lens. However, as stated by White (1996) the lens in small islands is subjected to tidal forced mixing at the edges and bases. They thus do not exhibit classical sharp interface between freshwater and seawater at its lower boundary; rather the change occurs over a substantial transition zone where the salinity increases with depth from fresh to seawater. In some cases, the transition depth maybe 25% or more of the thickness of the freshwater (White 1996).

Detail assessment of Hithadhoo groundwater system was done under Southern Regional Development project (Falkland, 2001). According to Falkland (2000), the areal extent of Hithadhoo Island area is 544 Ha. This area figure has changed according to CDE, 2011 (EIA report prepared for construction of vacuum system at the central zone of Hithadhoo) 550ha, due to reclamation works. The freshwater lens boundary is estimated at 50 m from the coastline. The total lens area is calculated at 323 Ha which is 3 Ha larger than at the figure calculated by Falkland (CDE, 2011).The freshwater thickness was estimated by Falkland (2000) as 8 m after conducting borehole tests.

Groundwater recharge rate is calculated based on the extent of open area on the island and the yearly total rainfall, Falkland (2000) calculated the value based of 50% of annual rainfall of 1200 based on vegetation cover at the time (CDE, 2011).

Table 23. Average recharge estimate, ML=Million Litres (source CDE, 2011)

	Annual rainfall (%)	Depth (mm/year)	Volume (ML/Day)
Low	40	960	8.5
Medium	50	1200	10.6
High	60	1440	12.7

7.5.2.2 **Groundwater Quality**

In order to estimate the groundwater quality of the island, water samples were taken from 14 locations (see Figure 3 and Table 11 for location and GPS coordinates of survey sites) and tested in-situ using a Hanna multiprobe water test meter. Table 24 shows the results of the different parameters tested.

Table 24. Results of the parameters tested to assess the groundwater quality at the sampling locations at Hithadhoo (average of 10 reading for each site, for the physical parameters)

Sample ID	Temperature (°C)	pH	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	Total Dissolved Solids (g/l)	Salinity (ppt)
P1	30.42	7.87	0.17	838.77	0.42	0.41
P2	28.15	7.56	0.17	888.93	0.44	0.43
P3	30.58	8.30	0.25	781.50	0.39	0.38
P4	29.66	7.94	0.24	2404.55	1.20	1.23
P5	31.60	8.02	0.21	983.09	0.49	0.48
P6	30.47	8.59	0.19	779.33	0.39	0.38
P7	30.16	8.08	0.17	1146.42	0.57	0.56
P8	31.15	8.06	0.17	559.09	0.28	0.26
P9	28.95	8.17	0.16	497.94	0.25	0.24
P10	29.25	8.10	0.17	567.25	0.28	0.27
P11	28.57	7.78	0.24	1308.80	0.65	0.65
P12	28.49	8.26	0.19	603.94	0.30	0.29
P13	30.79	8.09	0.25	772.20	0.39	0.37
STP	28.55	8.14	0.13	498.94	0.25	0.23

7.6 **Shoreline**

The shoreline at the proposed outfall locations are typical of high energy environments. Large prominent island ridge is observed at the western side of Hithadhoo. According to UNDP (2009a) (DIRAM-Hithadhoo) Hithadhoo has one of the highest elevations in the Maldives, along its western shoreline. The ridge system which is believed to be a response to high wave energy in the area, reaches to +3.6 m MSL along the surveyed lines (CDE, 2011). "The average height of the ridge system is estimated at +3.4 m MSL and the average width is estimated at 100m. The height of the ridge decreases southwards and is estimated to be around 1.9-2.4m in the southern half of the island" (UNDP 2009a).

The lagoon area at the out fall locations (both locations) are intertidal with average depth of -0.6 to -0.7m MSL (see Bathymetry maps in Appendix 6). The shoreline at the outfall locations are typical of high energy environments, coarse sand, rubble and rocks. The northern outfall location is mostly composed of beach rock formation and rubble/rock mound berm. The rubble/rock observed were mainly Acroporid origin (tabulate and branching forms).

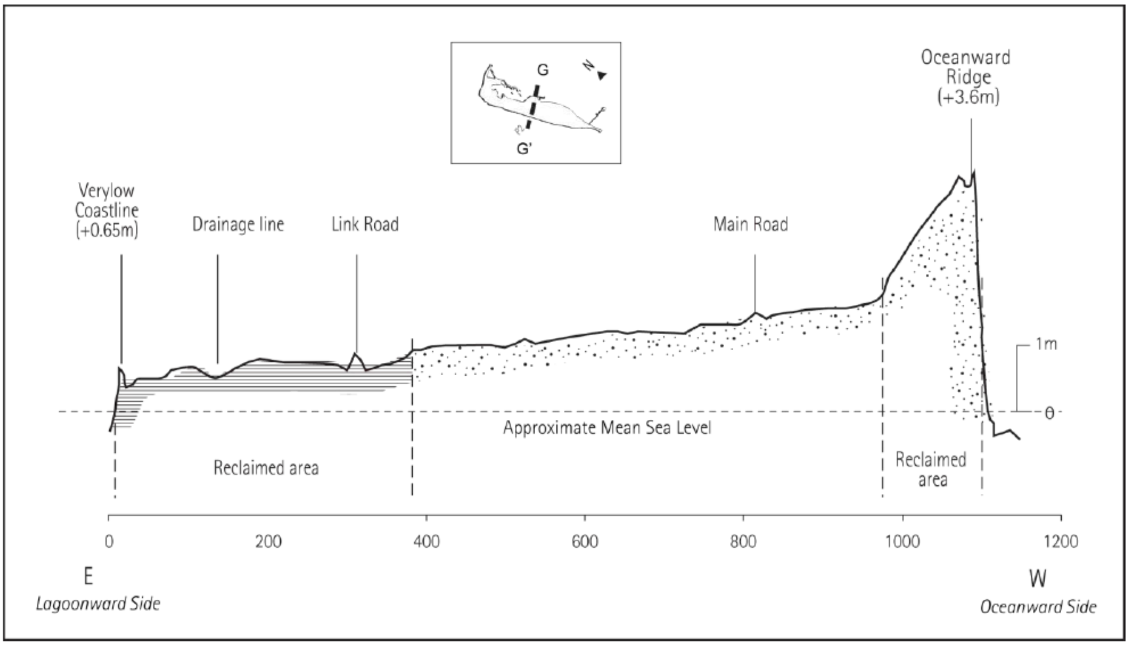

Figure 28. Typical profile of Hithadhoo, showing the prominent island ridge formation at the western side of the island (Image sourced from: CDE, 2011).

Figure 29. Shoreline at Northern side outfall

Figure 30. Shoreline at southern side outfall

7.7 **Existing sewerage infrastructure**

Existing sewerage disposal at Hithadhoo north and southern zones are by means of septic tanks with soak pits. Very few outfall pipes (community constructed) are observed at Hithadhoo unlike many other islands in Maldives, this is perhaps due to large size of the island.

Currently waste water collection system is under construction at the central area of Hithadhoo (see Figure 31). This project was initiated in 2011 by then Southern Utilities Limited and Biwater Maldives Pvt Ltd. According to FENAKA personnel consulted under consultation process of this EIA, most of the work for this project has been completed.

Figure 31. Schematic showing extent of Vacuum waste water collection system that is under construction

7.8 **Marine Protected Areas**

Eidhigali Kilhi was declared as protected site in December 2004, and later on designated as a MPA with two core areas (water bodies) and surrounding land, lagoon and reef areas (Figure 32). Hithadhoo Marine Protected Area (MPA) is approximately 100m from northern zone sea outfall. The pipelines at north segment near the MPA boundary are line starting points. Hence depth of pipeline at this area is shallow, which means less dewatering would be required at the area. All land based components of the project will be out of MPA boundary, but effluent from northern zone outfall will have negative impact on MPA reef area since current phase of the project does not include a STP.

Figure 32. Schematic showing protected area boundary, outfall location and Pump Stations

7.9 Socioeconomic environment

7.9.1 Demography

The population census of 2014 reports the resident population of Hithadhoo as 11,129 with 5,712 males and 5,417 females (NBS, 2014).The current registered population as at 10th April 2017, as reported by the Island Council is 15,822, with 8,163 males and 7,659 females (Secretariat of Addu City Council website accessed, April 2017). Given that recent statistics of households were not available to us, this information has been sourced from the Detailed Island Risk Assessment in Maldives (DIRAM) report done for S. Hithadhoo in 2009 (UNDP, 2009b). As cited in UNDP (2009b), at the time of their surveying there were 1,486 households with average household size of 6.4 persons.

7.9.2 Economic activities, income situation and distribution

Major economic activities of the island community include employment in public administration sector (40%) manufacturing (14%) and wholesale and retail trade (13%). Approximately 8% of the population were involved in the fishing sector (UNDP, 2009b).

7.9.3 **Land use planning, natural resource use and zoning of activities at sea**

Although there is a block level chart which identifies the various residential areas and plots and other infrastructure, there is no approved land use plan for the island.

7.9.4 **Accessibility and transport to other islands**

The easiest means of access to the island is via air transport. Hithadhoo is connected to Gan (International Airport at Addu City) via the link road. Other means of transport to the island, from other atolls is through sea transport.

7.9.5 **Services quality and accessibility**

7.9.5.1 **Water supply**

Rainwater is used as freshwater for drinking and cooking in many houses. Groundwater is also used as a source of potable water to some extent (UNDP, 2009b). At present desalinated water network is under construction at almost commissioning stage.

7.9.5.2 **Solid waste and Wastewater disposal**

A vacuum sewerage network is currently being setup at the central region of the island, as part of a different project. The north and south regions do not have a sewerage network at present and sewage disposal is by means of septic tanks and soak pits to the ground.

Waste management site is set up on the southern end of the island.

7.9.5.3 **Energy supply**

Hithadhoo has 24 hour electricity generated from the FENAKA powerhouse. Total installed capacity at the power house is 9MW, while generating capacity is 5.6MW.

7.9.5.4 **Healthcare**

Hithadhoo houses the Regional Hospital which services both Addu and Fuvahmulah Atoll. There is considerable number of passenger movement between other islands and Hithadhoo specifically for receiving health services from the Regional Hospital.

7.9.5.5 **Education**

As per information sourced from the website of the Ministry of Education, Hithadhoo has three schools; Hithadhoo School, Atoll Education Centre and Islamiyya (Ministry of Education website accessed, April 2017).

7.9.5.6 **Sites of interest**

Marine protected area (Eidhigali Kilhi, which is an internationally declared MPA) is located at the northern side of the island.

7.10 **Hazard Vulnerability, Area vulnerable to flooding and storm surge**

Hazard vulnerability of S. Hithadhoo is assessed based on the literature available and field data collection. Figures for this section of the EIA report have been sourced from the detailed island report for Hithadhoo, prepared by UNDP under the Detailed Island Risk Assessment of Maldives (UNDP, 2009a). Major hazards which were identified for Hithadhoo (based on historical records, meteorological records, field assessment and Risk Assessment Report of Maldives (UNDP, 2006)) in the report were Swell waves and wind waves, heavy rainfall (flooding), wind storms, tsunamis, earthquakes and climate change.

The report also identifies hazard zones on the island. These zones were developed using a hazard intensity index, which is based on a number of variables, namely historical records, topography, reef geomorphology, vegetation characteristics, existing mitigation measures and hazard impact threshold levels. The index ranges from 0 to 5 where 0 is considered as no impact and 5 is considered as very severe (UNDP, 2009a).

Figure 33 shows the hazard zoning map for swell waves and SW monsoon high seas. The proximity of the island to the southern Indian Ocean and the location of the island, leaves the island exposed to southern swell waves. However, the island has not experienced as many flooding events as some of its neighbours. Potential reason for this is the presence of one of the highest ridge systems found in the Maldives, on the island of Hithadhoo, the system reaches 3.6m MSL and is one of the naturally occurring protective features of the island.

The report predicts that the intensity of SW monsoon *udha* will be highest 50m from the eastern coastline, while the intensity of swell waves is anticipated to be highest 50m from the western coastline and 150m from the eastern side (UNDP, 2009a).

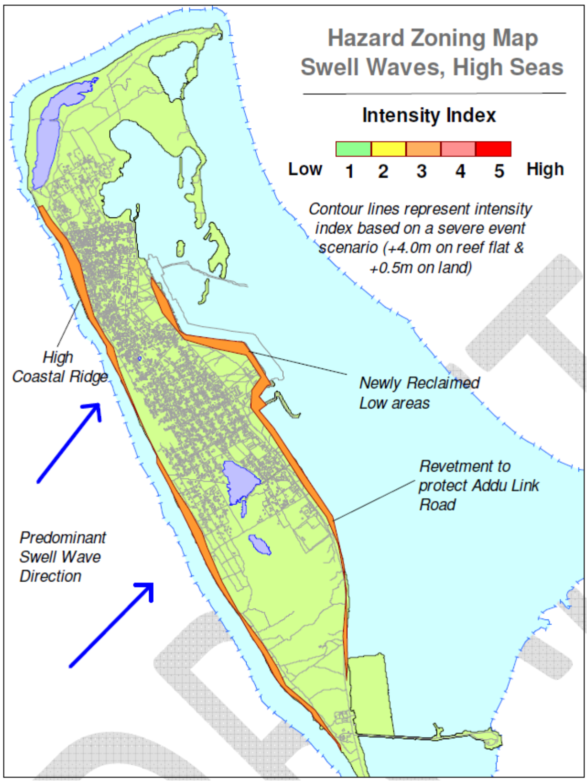

Figure 33. Hazard zoning map for swell waves and SW monsoon high seas (Figure taken from UNDP, 2009a)

Figure 34 shows the hazard zoning map for tsunami flooding on Hithadhoo. Based on this figure, the NE and eastern side of the island is predicted to receive the highest intensity of impact, while the western side is anticipated to have lower impact due to tsunami events.

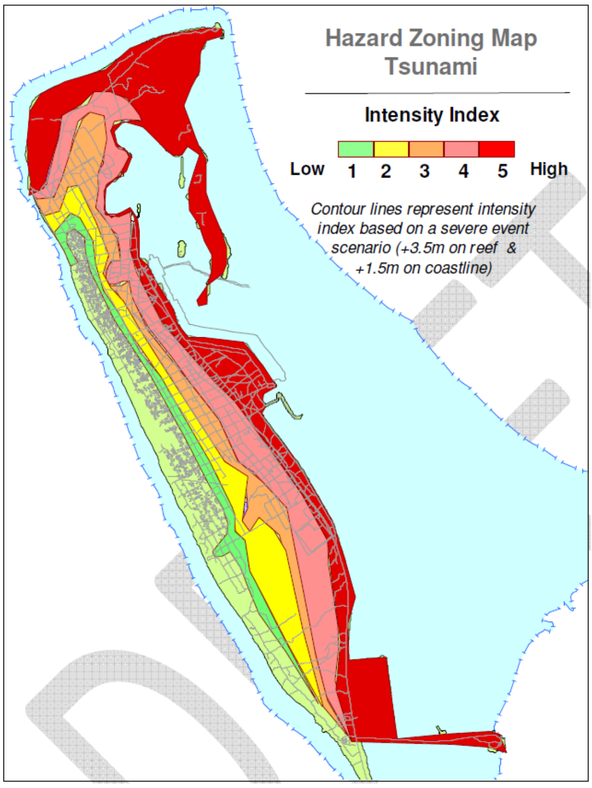

Figure 34. Hazard zoning map for tsunami (Figure taken from UNDP, 2009a)

The report states that heavy rainfall above the severe threshold is expected to flood low lying areas of the island especially near wetland areas, reclaimed wetland areas and reclaimed reef areas (Figure 35). The area around the Addu Link Road was also reported to be particularly susceptible while the inner areas of the island are likely to experience low levels of flooding due to remnants of taro pits and improper road maintenance activities.

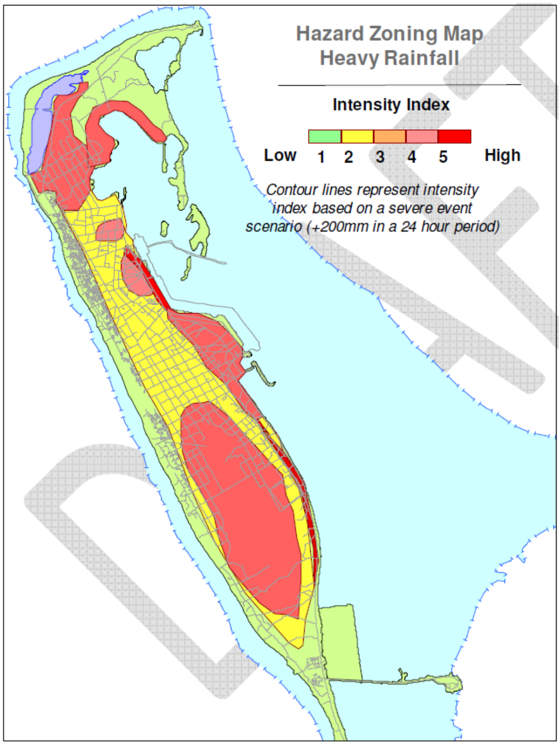

Figure 35. Hazard zoning map for heavy rainfall (Figure taken from UNDP, 2009a)

In general the whole island is predicted to receive strong winds, although the western side of the island is expected to receive the strongest winds, both due to the first point of contact (facing open ocean) and the high ridge. These are depicted in Figure 36 which also shows a narrow strip adjacent to the ridge, which is seen to be protected from the wind and hence receive slightly reduced intensity winds.

The entire island is identified as a hazard zone for earthquakes, though with a low impact intensity of 2. Given the impracticality of hazard zoning due to climate change, this was not done in the report, although they did predict the identified hazard zones and impact patterns to become more prevalent with climate change.

Based on the above predictions, a composite hazard zoning map was formulated for the island of Hithadhoo (Figure 37). This map predicts the coastline on the eastern and western side of the island to have the highest impact intensity, while central areas of the island are also impacted to various degrees by various hazards

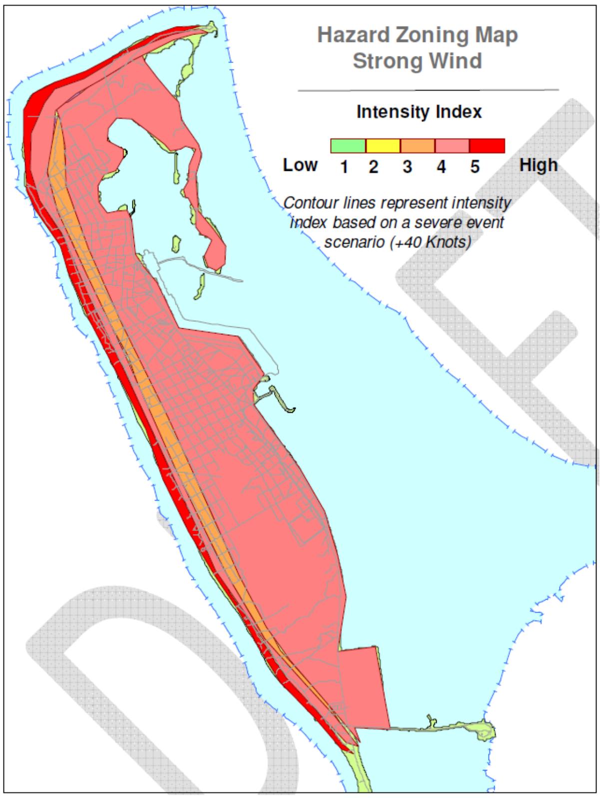

Figure 36. Hazard zoning map for strong winds (Figure taken from UNDP, 2009a)

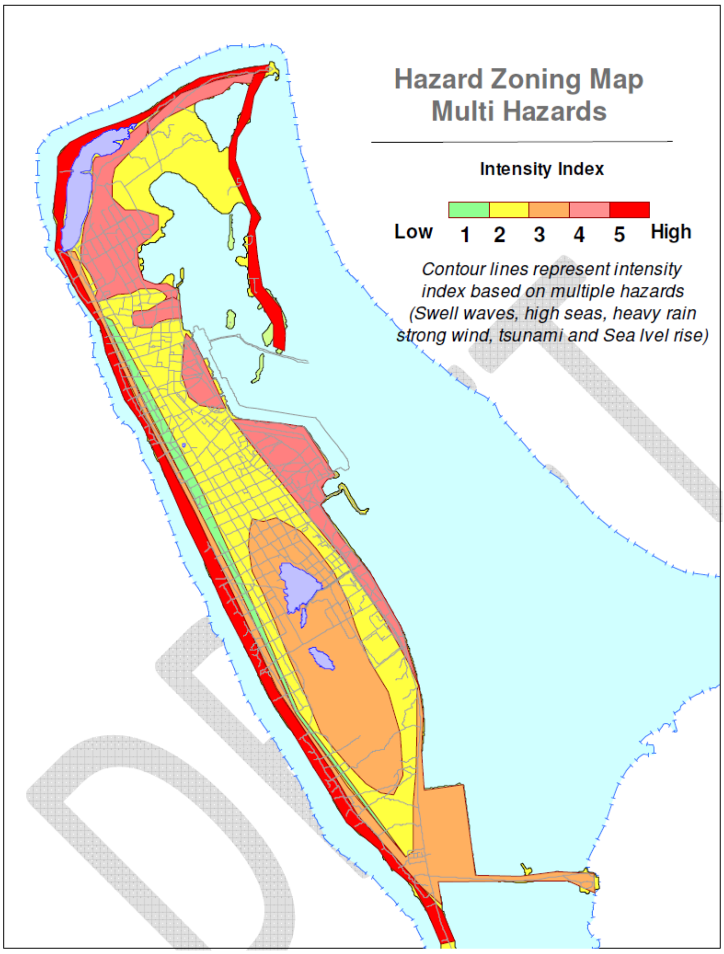

Figure 37. Composite Hazard zoning map for Hithadhoo (Figure taken from UNDP, 2009a)

8 Stakeholder consultation

As per approved TOR, stake holder consultation was done with EPA, MEE, HPA, MHI Addu office, MWSC and Addu City Council regarding the proposed project at Hithadhoo. The following sections provides details of consultation meetings while list of people met is provided in Appendix 8.

8.1 Consultation with Addu City Council

Meeting with Addu Council was held on 2nd April 2017. The representatives of council met during consultation are given in Appendix 8. Consultant briefed the council about the project based on the concept design provided by MWSC.

With current institution powers entitled to the council the project was reportedly not shared with the Council from any of the stakeholders involved in the project except the very initial project appraisal visit in October 2016.

According to the Mayor, they have raised their concerns based on the finding of the appraisal report (survey report prepared by MWSC). The conclusions of the report based on the consultation are reiterated here as follows;

It was observed that ground level in most of the areas is significantly low and therefore water level is shallow. This will result more dewatering and difficulties in lying of gravity mains. City Council raised their concern on the network laying area specified in the project scope since they prefer to lay the network in additional areas at south region. Council requested to lay the network until the south end of the island.

Council also suggested to lay vacuum sewer in both regions and to include installation of Sewage Treatment Plant in the project scope.

They noted that none of their concerns were addressed in the concept that was shared with them. Council is particularly concerned with the proximity of the proposed of sea outfall to the Eidhigali Protected Area, which is regarded as national significance. The effluents are currently proposed to dispose to the sea without any treatment.

8.2 FENAKA Corporation Ltd

Consultation with FENAKA Addu City branch was held on 2nd April 2017 with regard to the project at FENAKA Addu Office. Representative form this service provider include Executive

Director, Mr. Zuhair and other several members. List of people who attended the meeting are given in Appendix 8.

The team was briefed about this project the consultant with regard to the design and power requirement as indicated by the contractor of the project, MWSC. The estimated power requirement for thirteen (13) pump stations is 130KW. FENAKA confirms that they will be able to provide this power requirement through their existing power generating capacity. However, it is important to note that FENAKA does not have any formal communication with regard to their services that may be required for this project; them been the designated service provider of the government for water, sewerage and electricity.

FENAKA is already entitled to operate sewerage network at the central part of Hithadhoo. This network is a vacuum wastewater system which is under construction and close to commissioning stage. Contrary to this, the proposed sewerage system is a gravity system aided with pump stations that to the sea via 2 sea outfalls.

With regard to providing power to the pump stations, FENAKA in principle provide the services to the specific pump station from the power distribution boxes strategically located as part of power supply network. Since 3 phase power supply is required the cost of cables and connections to the pump stations shall be covered by the contractor, according to FENAKA. So far no informal or formal request has been made to FENEKA either by implementing agency (MEE) or MWSC.

With regard to pipelines deployment any issues that may arise during the construction shall be resolved in close collaboration with the contractor and FENAKA, as they already have pipeline and cables deployed underground for water, sewerage and electricity. They would like to see the network (sewerage) drawings and direct communication and contact person during construction works so that they can identify and inform the contractor where existing cables and pipes are to avoid potential damage.

It was clear that there was no appropriate communication with FENEKA with regard to the project as important stakeholder of the project especially when they are in principle the agency to operate and maintain the sewerage system when it is complete. Irrespective of this the executive director's premise is that they are entitled to take over the operation when it is formally handed over to them.

8.3 **Ministry of Environment and Energy**

Consultation with Ministry of Environment and Energy was held on 11th April 2017 10:00 at Ministry of Environment and Energy. Personnel from project management unit participated in the meeting. It was noted that personnel from MEE water department didn't participate in the meeting. Personnel from EPA water section also participated in the meeting. In the meeting EIA consultants inquired about the rationale behind selecting the type of network for the project. Personnel from MEE informed that gravity system was chosen by government since this system is easy to maintain and in terms of cost better than vacuum system. Furthermore rest of the islands in Addu City will have gravity system hence it will be easier for the operator.

EIA consultants inquired regarding the issue of STP, personnel from MEE stated that STP facility will come at a later stage, it is not included in current scope of work of contractor (MWSC). Timing of second phase is not known at present. In regards to compensation of palms/trees at the STP and pump station locations, MEE informed that MHI Addu office will coordinate compensation process.

In regards to outfall issue (located close to the protected area), EIA consultants inquired whether relocation of outfall to 500m offset from boundary is sufficient. Personnel from EPA informed that shifting outfall 500m is ok, but later informed that information regarding outfall location proximity to protected area should be consulted with Environment Research and Conservation (ERC) section of EPA.

The EIA consultants inquired regarding operation fee or tariff for the usage of system, personnel from MEE stated that separate fee will not be taken but usually it is included in the water bill. Hithadhoo water project is also under construction hence it may be included that component.

In regards to alternative locations for STP, MEE informed that alternative STP location is not designated since STP will be common to both gravity and Vacuum system.

8.4 Environment Protection Agency (EPA)

Consultation with EPA was held at Green building EPA meeting room on 17th April 2017 9:30. Personnel form MWSC, MEE (PIU), EIA section of EPA, Environment Research and Conservation (ERC) section of EPA and water section of EPA participated in the meeting.

Personnel from ERC section informed that northern zone outfall is very close to Hithadhoo Marine Protected Area (MPA). He also stated that as per guideline of Marine Protected Area, it has to be ensured that effluent from outfall will have "zero impact" on the protected site.

The EIA consultant informed that concept for the project was approved by MEE, and proximity of outfall pipe to MPA should have been known. Further informed the importance of EIA scoping meeting, where these issue would have been discussed and issues relating MPA included in approved TOR. The approved TOR does not require micro biological test as a parameter for seawater baseline study.

The EIA consultants inquired regarding distance to the MPA and outfall, or minimum distance that has to be maintained. Personnel from ERC section informed that they will not specify a distance but project has to ensure that no impact protected area (zero impact). He further stated that even if STP is proposed the project should demonstrate zero impact on MPA. Also if STP is proposed (which comes at later stage and is not included in the current scope of work), pumping should be done only after installation of STP and treatment.

The EIA consultant inquire with MWSC personnel whether the southern zone outfall can be used, personnel form MWSC stated that it can be done, but due to time limit and stringent scheduling they have already completed detail design. Personnel from MWSC also stated that initially they proposed vacuum system and connecting to vacuum system outfall, but since the project is awarded as design and build, MEE had already made the decision to go for gravity system.

The EIA consultant informed EPA personnel about institutional framework weakness in these projects, and it should have not come to this stage where an outfall is approved (concept stage) at periphery of MPA (approx. 100m). The site is a nationally protected and sensitive site, therefore these issue should be informed to decision makers.

8.5 **Health Protection Agency (HPA)**

As part of the consultation process for the EIA, the Health Protection Agency (HPA) of the Maldives was consulted to discuss their requirements and concerns in constructing a sewerage system. Consultation was done on 11th April 2016 13:30 via telephone conversation. Their main concerns include if population projection was considered in designing the system; issue of maintenance of the system during the implementation phase; location of the wastewater outfall and the condition of working stations during the construction phase.

The EIA consultant discussed these concerns in detail with the representative from HPA. As for population, it was informed to HPA that a 30 year projection is made prior to design of the system. Regarding the issue of maintenance, they raised the issue of the existing problems faced by the people of F. Nilandhoo due to leakage of sewage due to lack of maintenance of the established system if such problems be address in this project. It was discussed that during designing stage and also EIA stage proper mitigation measures are discussed and during implementation close monitoring and maintenance is highly recommended. As the proposed gravity system is easy to manage compared to a vacuum system, maintenance should not be a problem if done as required.

The third concern was if the outfall for wastewater discharge would be located at an area that is used for swimming by the island community. In case of Hithadhoo, the outfall is located at western side of the island which is the outer atoll side and is not used for swimming and recreational activities.

Lastly the condition of the working stations during construction was discussed. Their main concern is the open dents with still water that would lead to increase in mosquitos in the island. This and all other concerns that need to be addressed will be addressed in the mitigation and monitoring section of this report.

8.6 **Male Water and Sewerage Company Pvt Ltd (MWSC)**

Consultation with MWSC was done on 11th April 2017, 14:00 at MSWC head office. Personnel from Projects and Engineering department participated in the meeting. Regarding the issue of relocating or diverting north zone effluent to southern outfall, personnel form MWSC stated that can make the required changes. As per consultation with EPA, MWSC agreed to the changes.

In regards to the network construction at southern zone, areas where roads are not cleared, personnel from MWSC stated that it is not included in their scope to clear roads or making roads. In order to construct network at these areas, relevant authority should provide then with or make available cleared roads. Power connection to pump stations at these areas will be under the project scope.

8.7 **Outcomes of meetings**

Following are the outcomes of meeting;

1. Relocation of northern zone outfall or rerouting pressure line to southern zone outfall
2. Many unwanted issues surfaced due to irregularities in EIA scoping process of the project
3. Better communication is needed between institutes
4. STP is not included in current scope, but STP component will come at a later stage

9 Environmental Impacts

9.1 Impact Identification

Various methods are available to categorize impacts and identify the magnitude and significance of the impact, such as checklists, matrices, expert opinion, modelling etc. Impacts on the environment from various activities of the project construction work (constructional impacts) and post construction (operational impacts) have been identified through interviews with the project management team, field data collection surveys and based on past experience in similar development projects. Data collected during field surveys can be used to predict outcomes of various operational and construction activities on the various related environmental components. This data can also be used as a baseline for future monitoring of the environment.

Impact analysis has been done based on the site plan (Appendix 3). Possible impacts arising from the construction and operation works are described according to their location, extent (magnitude) and characteristics. They are also further categorized by intensity of impacts (negligible, minor, moderate and major) for identifying best possible remedial (mitigation measures) action to be taken. Below are the impact categories (Table 25).

Table 25. Impact prediction categorized

Impact category	Description	Reversible/ irreversible	Cumulative impacts
Negligible	The impact has no significant risk to environment either short term or long term	Reversible	No
Minor	The impact is short term and cause very limited risk to the environment	Reversible	No
Moderate	Impacts give rise to some concern, may cause long term environmental problems but are likely short term and acceptable	Reversible	May or may not
Major	Impact is long term, large scale environmental risk	Reversible and Irreversible	Yes, mitigation measures has to be addressed

The concept of the Leopold Matrix (Leopold et. al., 1971) has been used to classify the magnitude and importance of possible impacts which may arise during the constructional and post constructional stage of the proposed project. This is one of the best known matrix methodology used for identifying the impact of a project on the environment. It is a two dimensional matrix which cross references between the activities which are foreseen to have potential impacts on the environment and the existing conditions (environmental and social) which could be affected.

The matrix has the actions which may cause an impact on the horizontal axis and the environmental conditions which may be impacted on the vertical axis. While the original Leopold matrix lists 100 such actions and 88 environmental conditions, not all are applicable to all projects. Hence the matrix used in the current assessment is a modified matrix customized to this project.

Each action which is evaluated is done so in terms of magnitude of impact on the environmental condition and significance of this impact. In addition to this probability of impact as well as duration of impact is also assessed and shown separately. All probable and significant actions, their magnitude of impact and duration of impact are further described in the text.

This version of the Leopold Matrix has been adopted from Josimovic et. al (2014) and the EIA adopts the grading scales used in the paper referred. Listing of these grading scales are shown in Table 26 below.

Table 26. Grading scales for the four impact evaluation criteria

Evaluation criteria	Designation	Scale
Impact Probability	M	Impact is possible (probability <50%)
	V	Impact is probably (probability >50%)
	I	Impact is certain (probability = 100%)
Impact Magnitude	0	no observable effect
	1	low effect
	2	tolerable effect
	3	medium high effect
	4	high effect
	5	very high effect
Impact significance	P	limited impact on project site (immediate site)
	I	Impact of importance at Island level
	A	Impact of importance at Atoll level
	N	Impact of national character
	M	Impact of cross-border character
Impact duration	P	Occasional/temporary
	D	Long term/permanent

The possible impacts that would be caused by this project of construction of a sewerage system includes the impact to ground water due to dewatering and possible leakages during installation of pipes, impact to vegetation due to land clearance and impact to marine life and marine protected area from the discharge through the sewage outfall. However, given the scale of the project and the location of outfall, most impacts are expected to be moderate.

The severity of impacts is predicted by reviewing the design plans and construction methodologies. Mitigation measures are formulated in light of the information revealed by the project engineers.

9.2 Limitation or uncertainty of impact prediction

Uncertainty of impact prediction are mainly due to the lack of long term data (local currents and wave climate), inherent complexity of ecosystem (reef environment and habitat) and lack of coordinated monitoring programs with consistent methodologies which can be used to predict outcomes or reliability of predictions of previous projects.

The impacts are predicted by reviewing the survey data collected during the field visits and information revealed by the designers and engineers. The data collected during the field visit is limited in terms of number of days to a week, which limits the overall understanding of even the short term environmental conditions.

The time limitation of EIA field data collection and report preparation is also a hindrance to properly understanding the environmental factors dictating the conditions of the habitat.

9.3 Constructional Impacts

In any development project major direct impacts to the environment (either short term or long term) occur mainly during the construction phase. Potential direct or indirect impacts on the environment from the proposed works include:-

- Impact on vegetation due to the need to cut down few mature trees located at the proposed locations for construction infrastructure.
- Impact on groundwater due to dewatering required during trenching works for laying of pipes and construction of pumping stations;
- Impact to the coral cover due to physical damage to live coral due to trampling during pipe laying works;
- Minor impact due to air and noise pollution during construction work
- Impact on marine habitat due to continuous outfall disposal
- Impacts due to odour
- Impacts on natural resources and services due to the proposed project

9.3.1 Mobilization of Equipment and Labour

Heavy machinery, equipment and materials will be transported to the island using barges and heavy cargo dhonis. Materials brought to the island will be unloaded at the harbour at the southern end of the island and stored at the plot allocated for temporary facilities at the harbour front area Materials will be transported to project site as needed using various means of land transport. Mobilization of heavy machinery and equipment such as barges to the site has the potential to physically damage the reef habitat, though this impact is seen to be negligible for the current project since material unloading would be undertaken at the harbour which is an existing facility. However potential impacts from this activity include:-

- Accidental spillage of construction materials; and
- Accidental oil spills

9.3.2 Impacts on Groundwater

The following section discusses potential risks to the freshwater lens during construction of the wastewater collection system.

9.3.2.1 Installation of Collection Pipes, pump stations and water distribution network

It is understood that uPVC collection pipes must be buried at least 0.6 m to 2.5 m below ground level and that with the gravity wastewater collection system the pipes must be laid at a slope of 0.4 %. As the water table of Hithadhoo is at depths around 0.5m to 1.5m on average, a significant proportion of the collection pipes will be laid below the water table over much of the island. This presents two risks to the freshwater lens, which are:-

- The need for dewatering during laying of the collection pipes; and
- Leakage of the groundwater into the pipes over the life of the system, depleting the resource further and increasing the deficit.

Dewatering for pipe laying will lower the water table within the area of the trench being dewatered with the potential for up-coning of the underlying transition zone and saltwater. This potential for up-coning of saltwater will increase the longer the trench is open and dewatering is required. Dewatering will be undertaken in segments and water extracted will be disposed off at nearby areas, hence only a localized impact on groundwater resource will be felt for short period of time.

9.3.3 Impact on marine habitat and ecology

Potential impacts on marine environment during construction phase would be due to laying of outfall pipes from the STP. This involves transport of anchor blocks across the reef for laying and mooring the pipeline to reef bottom. The anchor blocks will be transported manually by workers.

Concrete slabs/blocks deployed to secure the pipe would inevitably damage the reef substrate by local crushing and overshadowing. However, once the blocks are deployed and secure, they become new substrate for marine organisms to settle including coral larvae. Impacts on marine habitat due to pipe line installation is expected to be minimum as the coral cover at the areas for this work is less than 10%. Also, only a narrow width on each side of pipeline will be actively used by the workers causing minimal impacts. Impact due to workers are mostly trampling and physical damage to live coral.

9.3.4 **Impact on protected areas**

Although project components do not fall within the protected area, activities such as dewatering have the potential to have an impact on the MPA. Since pipeline laid near the MPA boundary is the starting point of the pipeline, depth of pipe installation will be shallower, hence requiring lesser degree of dewatering. Furthermore, water extracted would be disposed at nearby areas, thus having negligible impact on the groundwater resource and MPA.

9.3.5 **Air pollution**

There are no major sources that can cause air pollution due to the project implementation works. The likely sources that can change in the air quality are emissions from equipment and machinery used during construction. These include small excavators, dump trucks and concrete machines. Dust may be produced during construction works especially during the earth works for making trenches for pipe networking and during transportation of construction materials such as cement and sand.

Emissions from machinery and vehicles are not anticipated to be significant due to the proposed duration of the project. Machinery and equipment are generally made to meet acceptable adequate air quality standards and if the contractor adheres to these standards, the air quality issues from the project perspectives can be adequately addressed. Dust or air borne particles from construction materials can be minimized through good construction work related practices such as working in restricted to enclosed areas or temporarily enclosing the work area.

It is important to note that there are no air quality standards followed in the Maldives. Generally air quality is regarded as good quality due to the few number of vehicles in the islands (except Male’) and good flushing of air due to small size of the islands. This allows rapid turnover and flushing of any harmful emissions. Major sources of emissions that are likely to deteriorate the air quality are emissions from powerhouses, motor vehicles and fishing boats. These are currently in low numbers at the islands and are not considered as a significant source of air pollution.

9.3.6 **Noise pollution**

Construction work would create noise depending on the nature of the project and the work methodology involved. Operation of the heavy machinery and excavation work would be the main sources of noise. Operation of machinery would be short term and any unfavorable impacts due to this activity would hence be short term. Some level of disturbance to the residential community cannot be avoided since majority of the work would be carried out in the residential areas. However, every measure would be considered to minimize noise level in the residential area during the construction phase.

9.3.7 **Solid Waste**

Solid waste generated during construction phase will be mainly from PVC pipe works of sewer network, empty cement bags and other packing material. Impact due to solid waste generation is anticipated to be minor, as waste will be collected at the end of the work day and taken to solid waste disposal site on the island on a regular basis.

9.3.8 **Impacts due to vegetation clearance**

A number of pump stations and the STP facility fall on vegetated areas which would need to be cleared prior to construction. Main types of vegetation include Alexander laurelwood trees, Sea Hibiscus, Nit pitcha and Coconut palms to some extent. Each pump station requires and area of approximately 600sqft, and based on the survey, plots for 6 pump stations would need to be cleared in addition to the plot identified for the STP facility. Hence vegetation clearance impact due to the project is envisaged to be moderate and irreversible.

9.4 **Post constructional Impacts**

9.4.1 **Impact on marine environment due to outfall disposal**

Disposal of sewage into the marine environment will be through the sea outfall pipes laid at the southwestern side for the southern region and northwestern side for the northern region. The outfall pipes will have a T-head diffuser system and will be laid to a depth of 15m. The use of a T-head diffuser system will aid to achieve increased dilution of the discharge at the point of discharge and is as per the guidelines specified by EPA (EPA, n.d.). Disposal of sewage, especially untreated, is a potential cause of increased nutrient input into the marine environment, especially at the site of discharge. Long term disposal of such materials is a cause of concern, in terms of the effect increased nutrients would have on the seawater quality and reef health and ecosystem. These include increased turbidity, thus reducing sunlight penetration which is vital for growth and survival of many marine organisms including corals and sea grass. Increased nutrients have the potential to trigger algal blooms that directly compete with corals. Increased nutrients can also trigger and assist in proliferation of sea grass communities in shallow coastal waters. This is quite evident in island communities where there is high level of nutrient inputs to near-shore environments (e.g. in fishing villages, nutrients from fish processing on the beaches increases coastal nutrient levels followed by algal or seagrass growth). Suspended solids also have the potential to cover and smother corals leading to "stress" as a result of having to spend increased energy to expel sediments.

The proposed project does not involve construction of a STP facility at the present stage and hence wastewater discharged to sea would be untreated. Release of such high levels of nutrients would inevitably impact the reef environment directly around the outfall diffuser location. Although live coral cover is low at the proposed sites, release of untreated waste over a continuous period of time is anticipated to have moderate impact on the surrounding environment. Furthermore, the northern outfall is approximately 100m from Eidhigali Kilhi which is a marine protected area. Release of untreated waste within such close proximity to the MPA has the potential to have a negative impact on the MPA.

The presence of high current at the area would however, mitigate the impact intensity to an extent. High currents ensure efficient flushing, thus allowing good dispersal of the released product. Furthermore, the construction of a STP facility to cater for this sewerage system (as planned by the proponent) would further mitigate impact due to this activity.

9.4.2 **Impact on ground water**

Leakage of the pipe system or "infiltration" occurs where pipelines are laid below groundwater level or where storm water percolates through the upper soil layers and enters the pipe system through cracks or leaky joints. Direct inflow of storm water into the sewerage system can also occur at manholes, junctions and other surface fixtures through gratings & covers that are not properly sealed. Inflow / infiltration from any source is generally undesirable as it increases the peak loading on the sewerage system and if the capacity of the sewer system is exceeded, sewage overflows may occur as a result. Alternatively if there is a positive pressure in the pipes, there is potential for effluent to leak out and pollute the groundwater. Pipe network is also subject to deterioration over time, which may lead to an increase in infiltration through joints or defects in the pipelines. Hence although the proposed system is a better and more appropriate system than the existing system, impact on groundwater is expected but is expected to be minor.

In addition, in an event of sewer overflow that maybe caused due to a system breakdown or power outbreak, impact on groundwater is expected to be moderate. The provision of a backup generator as proposed, would mitigate this effect and aid with proper functioning of the system during emergencies.

9.4.3 **Socioeconomic impacts**

Social impacts due to the project are projected to be positive. The development of a proper sewage disposal system would facilitate better collection and disposal of sewage from all households and bring an end to further contamination of groundwater resource of the island due to sewage disposal.

This project is expected to improve the sanitation conditions of the island and as a result leave the community and environment in better health conditions. Such improvements to the public health can only be assessed through systematic recording and monitoring of the health of the community. Hospital reports can be used to monitor the number of water borne disease such as diarrhea, certain skin and ear infections.

9.4.3.1 **Odour and noise impacts**

All sewerage systems are a potential source of odours mainly due to the decay of organic constituents of the wastewater being transported. Waste collected from households will pass to the pumping station before being disposed off at sea. Hence there is very little potential for odour to pass through the system into air. It is anticipated that the overall air quality on the island will not be significantly affected through installation of new sewerage systems. In fact, since the need to open up clogged septic tanks and cleaning of existing sewerage facility is no longer necessary, the odors generated from maintenance of existing sewerage facility will be reduced. Nevertheless it is important to note that any sewer overflow due to breakdown of the system or power outbreak would cause foul smell.

9.4.3.2 **Impact on human health**

The construction and operation of the sewerage system is not expected to have any negative impact on the health of people. It is expected to improve the sanitation conditions of the island and as a result leave the community and environment in better health conditions.

9.4.3.3 **Impact on aesthetics**

The construction and set up of the sewerage system is not expected to have a significant impact on the aesthetics of the island. However, any sewage overflows due to power outbreak can cause unpleasant sights, even if their human health and environmental impacts are successfully managed.

9.4.3.4 **Increased demands on natural resources and services**

Power supply necessary for the project works is planned to be sourced from the existing power grid of the island community. Total power required for the sewerage system is 130 kW. Hithadhoo has 24 hour electricity generated from the FENAKA powerhouse. Total installed capacity at the power house is 9MW, while generating capacity is 5.6MW. FENAKA Corporation Ltd who provide the utilities state that the existing capacity is sufficient to meet the needs of the new sewerage system

The project is not expected to have any impact on any of the natural resources and services, such as domestic water supply, solid waste disposal system and power supply. The implementation of a proper sewerage system is however expected to be beneficial to the groundwater resource of the island.

9.5 **Impact Analysis**

An analysis of the impacts due to the project was done using the Leopold matrix. Impacts are assessed according to probability of impact, significance of impact, magnitude of impact and duration of impact. Table 27 27 to 30 gives the assessment for the impacts, and these are further discussed above.

As evident from the tables below, main environmental impacts during the construction phase of this project is on groundwater quality and vegetation. Impacts on groundwater are mainly due to dewatering which will lower the water table, which could allow for potential salinization. Method of dewatering (in segments) minimizes the impact, especially since water extracted will be disposed at nearby areas. The need for vegetation clearance at a number of plots (each of 600sqft) allocated for pump station construction poses a moderate impact on vegetation. This is an unavoidable impact, given that locations have been chosen based on what is optimal for the network.

During the operational phase, impacts are envisaged on both groundwater and seawater, as well as Eidhigali Kilhi which is a designated MPA. Impact on groundwater envisaged is the contamination of groundwater lens due to infiltration in case of pipe leakage. Impacts on seawater is mainly due to nutrient flushing into the open sea (due to release of untreated sewage effluents) which could trigger algal growth which competes with other life forms for sunlight, food and other vital nutrients. Moreover, sewage discharge into the sea increases turbidity thereby decreasing the amount of sunlight penetration for food production and healthy growth of photosynthetic organisms of the reef. Continuous discharge of untreated waste is envisaged to have a moderate impact on the surrounding environment, even with low coral cover. Eidhigali Kilhi, which is a designated MPA is at a distance of 100m from the northern outfall location and the close proximity of these two sites is a cause for potential negative impact on the MPA. However, presence of good currents at the area (facing open ocean) would ensure good flushing.

Social impacts are mainly positive due to improvement in the sewage collection and disposal system, which would bring an reduce or avoid contamination of the ground water resource of the island which is the main source of water used by the island community in their daily life. Hence, establishment of the sewage system is expected to have a major positive impact on the groundwater quality and health and wellbeing of the community.

Table 27. Assessment of probability of impacts from project activities

		Constructional activities						**Operational activities**		
	Envisaged impact factors	**Excavation, trenching & dewatering**	**Construction of outfall pipes**	**Construction of infrastructure**	**Accidental spillages**	**Solid waste generation**	**Operation of heavy machinery**	**Disposal of untreated effluents**	**Leakage of pipe system/ infiltration**	**Establishment of sewerage system**
Physical components	Groundwater	I		I	I	M	M		I	I
	Seawater		I		I	M	M	I		I
	Coastal zone		I		I	M	M	I		I
	Odour	M				M		M	I	V
	Air			M			I			
	Noise	I	I	I			I			
Biological components	Ecosystem quality	M	I	I	I	M	M	I		I
	Diversity of flora		I		I	M	M	I		
	Diversity of fauna		I		I	M	M	I		
Socio-cultural components	Landscape	I		I		M			I	
	Land use	I	V	I						
	Social wellbeing								V	I
	Accidents	M	M	M			M		M	M

Table 28. Assessment of significance of impact from project activities

	Envisaged impact factors	Constructional activities						Operational activities		
		Excavation, trenching & dewatering	Construction of outfall pipes	Construction of infrastructure	Accidental spillages	Solid waste generation	Operation of heavy machinery	Disposal of untreated effluents	Leakage of pipe system/ infiltration	Establishment of sewerage system
Physical components	Groundwater	P		P	I	P	P		I	I
	Seawater		P		P	P	P	P		P
	Coastal zone		P		P	P	P	P		P
	Odour	P				P		P	I	I
	Air			P			P			
	Noise	P	P	P			P			
Biological components	Ecosystem quality	P	P	P	P	P	P	I		I
	Diversity of flora		P		P	P	P	P		
	Diversity of fauna		P		P	P	P	P		
Socio-cultural components	Landscape	I		I		P			I	
	Land use	I	I	I						
	Social wellbeing									I
	Accidents	P	P	P			P		I	I

Table 29. Assessment of duration of impact due to project activities

	Envisaged impact factors	Constructional activities						Operational activities		
		Excavation, trenching & dewatering	Construction of outfall pipes	Construction of infrastructure	Accidental spillages	Solid waste generation	Operation of heavy machinery	Disposal of untreated effluents	Leakage of pipe system/ infiltration	Establishment of sewerage system
Physical components	Groundwater	P		P	P	P	P		D	D
	Seawater		P		P	P	P	D		D
	Coastal zone		P		P	P	P	D		D
	Odour	P				P		D	P	D
	Air			P			P			
	Noise	P	P	P			P			
Biological components	Ecosystem quality	P	D	P	P	P	P	D		D
	Diversity of flora		D		P	P	P	D		
	Diversity of fauna		D		P	P	P	D		
Socio-cultural components	Landscape	D		D		P			P	
	Land use	D	D	D						
	Social wellbeing									D
	Accidents	D	D	P			P		P	P

Table 30. Assessment of magnitude of impact due to project activities

	Envisaged impact factors	Constructional activities						Operational activities				
		Excavation, trenching & dewatering	Construction of outfall pipes	Construction of infrastructure	Accidental spillages	Solid waste generation	Operation of heavy machinery	Disposal of untreated effluents	Leakage of pipe system/ infiltration	Establishment of sewerage system	Sum	Average
Physical components	Groundwater	4	0	3	4	1	1	0	4	4	**21**	**2.33**
	Seawater	0	4	0	4	1	1	5	0	5	**20**	**2.22**
	Coastal zone	0	4	0	4	3	1	3	0	3	**18**	**2.00**
	Odour	1	0	0	0	3	0	3	5	4	**16**	**1.78**
	Air	0	0	2	0	0	1	0	0	0	**3**	**0.33**
	Noise	3	2	2	0	0	2	0	0	0	**9**	**1.00**
Biological components	Ecosystem quality	2	2	2	3	2	2	4	0	3	**20**	**2.22**
	Diversity of flora	0	2	0	2	2	2	3	0	4	**15**	**1.67**
	Diversity of fauna	0	2	0	2	2	2	3	0	0	**11**	**1.22**
Socio-cultural components	Landscape	3	0	2	0	2	0	0	3	0	**10**	**1.11**
	Land use	3	1	3	0	0	0	0	0	0	**7**	**0.78**
	Social wellbeing	0	0	0	0	0	0	0	4	5	**9**	**1.00**
	Accidents	4	2	2	0	0	2	0	3	5	**18**	**2**
Cumulative values of IF according to environmental factors		**20**	**19**	**16**	**19**	**16**	**14**	**21**	**19**	**33**		
Average		**1.53**	**1.46**	**1.23**	**1.46**	**1.23**	**1.08**	**1.61**	**1.45**	**2.54**		

10 Alternatives

Aspects of the project for which an alternative have been considered are:

- Design of wastewater disposal system
- Outfall discharge location

10.1 Considered alternatives

10.1.1 Design of wastewater disposal system

- **Proposed design:** Gravity type wastewater collection, treatment and disposal system
- **Alternative 1:** Vacuum network type wastewater collection and disposal system

10.1.2 Outfall discharge location

- **Proposed location:** proposed location for outfall discharge is off the reef edge on south western side of the island (for southern region) and off the reef edge on the north western side of the island (for the northern region)
- **Alternative 1:** move outfall location at northern region, approximately 200m south from proposed location
- **Alternative 2:** rerouting effluent from northern region, by rerouting pressure line to southern outfall location
- **Alternative 3:** Installation of STP (tertiary treatment) at PS11 (northern region) and outfall pipeline laid to same location as proposed

10.1.3 The no-project scenario

The “do nothing” option or no project would mean that means of sewage disposal for the northern and southern region of Hithadhoo would remain the same, thus leading to further contamination of the groundwater resource on the island, which is not considered as ideal by the community for reasons earlier discussed. Additionally, it would also mean increased health risks faced by the community due to the use of contaminated water.

The environmental impacts predicted for the project are moderate, hence the benefits of establishing the system, though with a cost to the environment is seen to be far more beneficial than the cancellation of the project, as the health risks faced by the community is not something that should and can be overlooked. Therefore the “no-project” scenario is not a feasible solution and it is recommended that the project be continued, but with the proper implementation of all mitigation measures proposed in the report.

10.2 **Selected alternatives**

10.2.1 **Selected system design**

The proposed system design is the use of gravity network waste collection and disposal system which has the following advantages; high level of service provided to the house owner without the need for on-site infrastructure such as septic tanks, sewage is generally retained in a 'fresh' state so there is usually less occurrences of offensive odours, minimal maintenance required where sewer pipes are properly designed and laid at minimum grades to promote self-cleansing (although sewer chokes are still common).

The alternative is to install a vacuum network system which also has some advantages over the preferred system: low chance of exfiltration of sewage into the groundwater system, pipes are generally laid at minimum cover and may closely follow the natural ground profile thereby reducing the cost of excavation and dewatering, minimal pipework maintenance requirements as sewage is transported at relatively high velocities through the vacuum system reducing chances of sedimentation and / or blockages. However, in order to provide the high level service provided by such systems, there is a need to install on-site vacuum collection chambers within the residential properties. This together with the other advantages means an increase in cost. Given the scale of the project, such systems are mostly ideal for bigger islands with larger population.

Although the Central part of Hithadhoo is currently being developed with a vacuum network system through another project, this system and the proposed project would function independently. Hence considering both options the proposed option is thought to be the most appropriate and cost effective for the proposed project. Furthermore, since the project is contracted for designing and building a gravity system (as per tender) changing system is very unlikely.

10.2.2 **Selected outfall discharge location**

The proposed locations of discharge pipe is to the western side of the island (southwest side for southern region and northwest side for the northern region). The discharge pipe on the north western side is near the boundary of Eidhigali Kilhi which is a protected area. The first alternative is to offset this pipeline about 200m southwards so as to have a greater distance between the pipeline and the protected area. The second alternative is to reroute effluent from northern region by rerouting pressure line to southern outfall discharge location. Once the STP is operational, the pipeline from the northern region will also be connected to the STP. Third alternative considered is the installation of a STP facility at PS11 at the northern region and disposal of effluent at same location as at proposed option (refer Figure 38).

In terms of impact on project cost, the first alternative would have a similar impact as the one proposed but in terms of potential environmental impacts, this alternative has will have a lesser negative impact on the environment (especially the protected area), should there be any incidents of pipe leakage or accidents. However, EPA is very clear on the fact that there is to be no impact at all on the protected area. Discharge at same location as southern region outfall (alternative 2) is envisaged to have no impact on the protected area due to the distance between the sites. However, laying the pipeline to the southern region would inevitably increase project cost both for construction and operational phases. Estimated cost for this change in design is MVR 2,000,000.00. Alternative 3 would also increase operational cost, due to installation of STP. Furthermore, although this has been proposed, there is no timeline/confirmation that this would eventuate, hence any effluent disposed of prior to STP installation would be untreated and therefore have a potential impact on the MPA. Therefore, considering all options, the second alternative is thought to be the best and most feasible option and hence this option is selected.

Figure 38. Proposed sea outfall (blue line) and Alternative outfall pipelines for northern region (Green, red and yellow lines) (Refer Appendix 9 for scaled map provided by MWSC)

11 Mitigation Plan

There are a number of actions that can be taken to minimize or avoid impacts altogether. Those that are explored below emerged out of the discussions and consultations during this EIA and from the past experience of the consultant. 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.

Mitigation measures are discussed for the construction and operational stage of the project. One of the most important mitigation measures to be implemented in any project is to utilise a method which will have minimal impact on the environment. Mitigation measures that can be followed and adhered to in order to minimize potential impacts are given below (Table 31).

Table 31. Possible environmental impacts and mitigation measures for construction of Sewerage system at S. Hithadhoo

Phase	Possible Impacts	Mitigation measures	Location	Time frame	Impact intensity	Institutional responsibility	Estimated cost (MRF)
Construction phase (temporary impacts)	Excavation for pipe laying work and construction of pump stations	Trench shoring to be used for maintaining vertical integrity of trench walls.	Land	During construction	Minor to Moderate	Contractor	N/A
		Backfill to the proper grade with coarse sand, or other suitable approved granular material from excavated material					
		Confine disturbance to as small an area as possible during trenching work, maximum of 30 m length at a time					
	Turbidity during anchoring of outfall pipe	Work should be carried out during low tide to minimize sedimentation impacts	Reef	During construction	Minor	Contractor	N/A
	Physical damage to the reef environment during pipe installation	Confine disturbance to as small an area as possible; offset distance to 2 m on either sides of the pipe. Demarcate working area with markers	Reef	During construction	Minor	Contractor	N/A
		Outfall pipe laying area inspected before laying pipe. Adjust location so that live coral colonies are avoided as much as possible					

	Possible contamination by saline intrusion into the soil during dewatering	Not to exceed trench length of 30 m at a given time for pipeline to minimize any saline intrusion	Land/ground water resource	During construction	Minor to moderate	Contractor	N/A
	Loss of freshwater if discharged to sea during dewatering	Attain dewatering permit prior to initiation of dewatering works All water removed during excavation for trenching and construction shall be disposed of inland from the excavation for re-percolation back into the water table as outlined in the EPA guidelines Design Technical Specifications manual for design and construction of sewerage system, and wastewater treatment plant (EPA n.d.)	Land/ Ground water resource	During construction	Moderate to major	Contractor	N/A
	Spillage of oil and other construction chemicals	Monitor spillage of oils and maintain vehicles and machinery	Land/ Ground water resource	During construction	Minor to Moderate	Contractor	N/A
	Vegetation clearance	Ensure only required amount of vegetation is cleared and no mature or protected species are removed. Transplantation of coconut palms at another area of the island, to the greatest extent possible For each coconut palm or tree felled, two or more palms or trees should be planted elsewhere on the island as per stated in the "*By-law on cutting down, uprooting, digging out and export of*	Land	During construction	Moderate to major	Contractor	N/A, should be included in project cost

		trees and palms from one island to another".					
	Air pollution	Minimise use of excavators for all vegetation clearance works and excavation work	Air	Construction phase	Minor/ short term	Contractor	N/A (may increase labour cost)
	Noise pollution	Avoid use of heavy machinery during night hours	Land	Construction phase	Minor/ short term	Contractor	N/A (same as above)
	Accumulation of waste on site for long periods	Daily removal of construction waste from site and transportation to island waste management site	Land	Construction phase	Minor/ short term	Contractor	N/A (same as above)
	Lack of adequate working space in narrow lanes	Provide alternate routes for pedestrians and vehicles Inform island or ward councils and attain permits for temporary road closures.	Land	Construction phase	Minor/ short term	Contractor	N/A
	Disruption to underground services during trenching	Consult service providers for layout maps. In case of damage to power or service lines, immediately stop work and undertake remedial action.	Land	Construction phase	Minor/ short term	Contractor	N/A
	Impact on public safety	Sufficient suitable barricades, warning lights, signs, and similar items shall be provided.	Land	Construction phase	Minor/ short term	Contractor	N/A
Operational phase	Salt water intrusion into the pipes – backflow of salt water through pipes at high tide	Install non-return valves to prevent backflow of salt water	Land	Operational phase	Minor/short term	Contractor	N/A

	Leakage – Infiltration into the sewerage system	Thorough inspection & testing during installation	Land	Operational phase	Minor/short term	Contractor	N/A
		Conduct routine operation and maintenance of the sewer, repair damaged or leaking sections of sewer mains or access fittings	Land	Operational phase	Minor/short term	Contractor	N/A
	Air quality / Odours	Vent stacks of minimum 6.0 m height are provided for all pumping stations to provide controlled release of gases. Building sewer connections are provided with a water trap and vent	Air	Operational phase	Minor/short term	Contractor	N/A
	Possible complete breakdown of pumps or power outbreaks	Provision of standby pumps and generators in case of breakdown or power failure	Land	Operational phase	Minor/Short term	Proponent/ Utility Operator	Included in project cost

11.1 Decommissioning of existing household septic tanks and small bore systems

The existing sewerage system septic tanks and soak pits will be decommissioned after full commissioning of the new system. The decommissioning plan is part of contractor’s scope of works and will be financed from project budget.

11.1.1 Contractors scope of work in decommissioning

A Vacuum (honey sucker) truck should be used to suck the content from septic tanks and soak pits. A jetting machine should be used for cleaning.

The contractor will remove all the existing sludge from the septic tanks and soak wells using the honey sucker and transfer the contents to STP which will be fed into STP process for treatment. Once all the contents have been thoroughly removed, the septic tanks should be backfilled with adequate material and compacted.

In case of small bore sewers, Contractors should asses and with approval of engineer remove the pipes that must be removed to lay the new gravity pipelines. In such case provisions for the temporary sewerage disposal of these households will be made during the construction phase by contractor. Wherever new pipelines can be laid without removal of existing small bores contractor should remove the small bores after providing the new connections.

Table 32 shows estimated rates for decommissioning of the existing sewerage system.

Table 32. Estimated rates for decommissioning

Options	Rate (per household)
Septic tank sludge removal and backfilling	2,000 MRF
Septic tank sludge removal with removal of tank	4,000 MRF
Small bore removal	2,000 MRF

12 Monitoring Program

Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental variables associated with the development impacts. Monitoring is needed to:

- Compare predicted and actual impacts;
- Test the efficiency of mitigation measures;
- Obtain information about responses of receptors to impacts;
- Enforce conditions and standards associated with approvals;
- Prevent environmental problems resulting from inaccurate predictions;
- Minimize errors in future assessments and impact predictions;
- Make future assessments more efficient;
- Provide ongoing management information; and
- Improve EIA and monitoring process.

Impact and mitigation monitoring is carried out to compare predicted and actual impacts occurring from project activities to determine the efficiency of mitigation measures. This type of monitoring is targeted at assessing human impacts on the natural environment. Impact monitoring is supported by an expectation that at some level anthropogenic impacts become unacceptable and action will be taken to either prevent further impacts or re-mediate affected systems.

Tables 33 and 34 show the monitoring which will be carried out during the construction and operational phase of the project. Commitment to carrying out and financing the mitigation and monitoring work is given in the proponent’s declaration at the beginning of the report.

Table 33. Monitoring programme for construction phase of the project

Reef community	Methodology	Sampling frequency	Estimated cost for monitoring
Reef benthos (coral and other benthic cover)	Photo quadrate method at the established baseline locations	Every six months	Rate per field survey MRF 15,000
Reef fish community, diversity and abundance	Fish visual census, at the established baseline locations	Every six months	Rate per field survey MRF 15,000
Sea water quality (physical and microbiological) from proposed outfall locations and control site (located inside MPA boundary)	Water samples sent to competent laboratory for analysis. Following parameters are to be tested; • Temperature • Salinity • pH • Conductivity • Dissolved oxygen • Total dissolved solids • Nitrate • Ammonia • Sulphate • Phosphate • Biological Oxygen Demand • Total Coliform • Feacal Coliform	Every two months	Rate per test set MRF 8,000
Groundwater quality (from all baseline monitoring sites)	Water samples sent to competent laboratory for analysis. Following parameters are to be tested; • Temperature • Salinity • Dissolved oxygen • Total dissolved solids • pH • Conductivity	Every two months	Rate per test set MRF 25,000

Table 34. Monitoring program for operational phase of the project

Reef community	Methodology	Sampling frequency	Estimated cost for monitoring
Reef benthos (coral and other benthic cover)	Photo quadrate method at the established baseline locations	Once every year	Rate per field survey MRf 15,000
Reef fish community, diversity and abundance	Fish visual census, at the established baseline locations	Once every year	Rate per field survey MRF 15,000
Sea water quality (physical and microbiological) from outfall and control site (located inside MPA boundary)	Water samples sent to competent laboratory for analysis. Following parameters are to be tested; • Temperature • Salinity • pH • Conductivity • Dissolved oxygen • Total dissolved solids • Nitrate • Ammonia • Sulphate • Phosphate • Biological Oxygen Demand • Total Coliform • Feacal Coliform	Every two months	Rate per test set MRF 8,000
Groundwater quality (from all baseline monitoring sites)	Water samples sent to competent laboratory for analysis. Following parameters are to be tested; • Temperature • Salinity • Dissolved oxygen • Total dissolved solids • pH • Conductivity	Every two months	Rate per test set MRF 25,000

The EIA monitoring report structure provided in the EIA report bylaw 2012 (2012/R-27) shall be used for the monitoring report preparation. Monitoring reports shall be submitted to EPA as per the monitoring schedules given in Tables 33 and 34.

13 Conclusion and Recommendations

The proposed project at Hithadhoo, Addu City is expected to have moderate impacts on some environmental components, both during the construction and operational phases of the project. This conclusion is based on the evaluation of various components of the proposed project, implementation methods discussed, findings of the existing environment and environmental components that are likely to be affected. The significant environmental components associated with the project are;

- Terrestrial environment, mainly groundwater resource;
- Marine environment including seawater quality

Major impact on terrestrial environment, during the construction phase of the project is expected to be on groundwater resource of the island, due to extensive dewatering required during the trenching works, construction of pump station and associated structures. However, this impact will be minimised with proper implementation of the proposed mitigation measures. Impact on vegetation is envisaged to be moderate due to the requirement for clearance of number of plots for construction of pumping stations.

Major impacts envisaged for the operational phase include impacts on seawater and the marine protected area, Eidhigali Kilhi, which is located within close proximity of the northern outfall location (approximately 100m). The release of untreated sewage on a continuous basis will inevitably have a negative impact on seawater quality, marine habitat and surrounding environment. During consultations, the Environmental Protection Agency has made it very clear that there should not be any impact on the designated MPA and hence after consultation with the Proponent, the Proponent has now opted to select the proposed alternative location for sewage disposal; by connecting the pressure line from the northern region to the southern region so as to dispose sewage from both regions to a single outfall at the proposed outfall location on the south. Although this will inevitably increase project cost, both during the construction and operational phases, the Consultant feels that this is the best option, as this would have no impact on the MPA on the northern side due to the distance between the sites since STP is commissioned at a later stage of the project..

A major positive impact is foreseen during the operational phase of the project, due the establishment of an improved sewerage collection and disposal system, as this will reduce groundwater contamination. Although installation of STP is planned for the project, this will come at a later phase and the Consultant would like to stress the importance of having an STP on site, so as to minimise environmental impacts due to sewage disposal.

The consultant also would like to highlight the issue of concept drawing approval for the project, mainly the issue to approving a sea outfall so close to a designated MPA (which was designated by the Proponent). Furthermore importance of scoping meeting where respective stakeholders give their point of view on the project components that may cause impacts or not aligned with regulations.

With due consideration to the environmental components identified above and the extent of the project activities and their likely and predicted impacts identified, the consultant concludes that the project and its components are only feasible with the proposed appropriate mitigation measures and alternatives have been considered. In this regard the project design shall comply with National Wastewater Quality Guidelines (MWSA-NWWQG, 2006). This will assist to setup of a better sewerage disposal system on the island would aid in improving both the environmental conditions (groundwater resource) and social wellbeing of the island and its community.

The following shall be considered in reference to National Waste Water Quality Guidelines that is followed by EPA as reference for wastewater disposal into marine environment.

1. No raw sewage shall be pumped to the sea at any phase of the project
2. Consider a sewage treatment process that reduce BOD of the effluent to less than 40mg/L among other parameters given in Table 7.1 of the guidelines

Acknowledgements

The consultant acknowledges the contribution provided by the team members in this report for the valuable contribution to the report and at the field. The consultant also acknowledges the assistance provided by Addu City Council, FENAKA, EPA and MWSC Ltd for providing project description related information and data.

CVs of team members are given below.

بسم الله الرحمن الرحيم

CURRICULUM VITAE

1.	**POSITION:**	Environmental Specialist/EIA Consultant
2.	**NAME OF FIRM:**	LaMer Group
3.	**NAME:**	Hussain Zahir
4.	**DATE OF BIRTH:**	10th February 1966
5.	**NATIONALITY:**	Maldives
6.	**EDUCATION:**	*Masters of Philosophy (MPhil) in Coral Reef Ecology* University of Newcastle upon Tyne. Newcastle Upon Tyne, United Kingdom 2006 *Marine Biology B.Sc. (Hon)* University of Newcastle Upon Tyne. Newcastle Upon Tyne, United Kingdom 1993-1996

7. MEMBERSHIP OF PROFESSIONAL SOCIETIES:

8. OTHER TRAINING:

1988. Marine Science Institute, University of Philippines
Certificate of completion of training course on Scleractinian Coral Taxonomy

1989. Chulalongkorn University. Bangkok. Thailand
Certificate of Completion of training Course on Coral Taxonomy, Ecology and Management

1998 Okinawa International Centre, Okinawa, Japan
Certificate of participation on training course on Conservation and Sustainable Management of Coral Reefs

1999 Korean Research and Development Institute, Seoul, South Korea
Certificate of Completion of the Training Course on marine coastal zone conservation and management

1990. Department of Marine Sciences. Chulalongkorn University. Bangkok. Thailand
Workshop on Taxonomy of Soft Bottom Invertebrates (ASEAN-Australian Coastal Living Resources Project)

1991. Mc Master University, Hamilton, Ontario. Canada.
Training on Boring Sponges of Coral reefs in Maldives

1996 Turtle Specialist Group, Convention on the Conservation of Migratory Species of Wild Animal (CMS) and government of India. Bhubaneshwar, India

Workshop and Strategic Planning Session for the Conservation of Sea Turtles of the Northern Indian Ocean

1999. United Nations Environment Program. Environment for South Asia and Pacific, organized by SACEP and Ministry of Home Affairs, Housing and Environment.

National Training for State of the Environment and Data Collection and Reporting

9. COUNTRIES OF WORK EXPERIENCE:

10. LANGUAGE AND DEGREE OF PROFICIENCY:

Dhivehi -Mother Tongue
English -Proficient

11. EMPLOYMENT RECORD:

Nov 2007- Present	Senior Reef Ecologist Marine Research centre, Ministry of Fisheries Agriculture and Marine Resources Male', Maldives.
Feb 2006- October 2007	Reef biologist Marine Research centre, Ministry of Fisheries Agriculture and Marine Resources Male', Maldives.
July 2001- January 2006	Senior Research Officer Marine Research centre, Ministry of Fisheries Agriculture and Marine Resources Male', Maldives.
June 2000 to Present	Marine Biologist/ Director (Part Time) Land and Marine Environmental Resource Group of Pte Ltd
July 1996 to July 2001	Research Officer Marine Research Centre , Ministry of Fisheries Agriculture and Marine Resources
1988 to 1992	Biological Aid Marine Research Centre , Ministry of Fisheries Agriculture and Marine Resources
1986 to 1988	Marine Research Centre , Ministry of Fisheries Agriculture and Marine Resources Trainee

12.	DETAILED TASKS ASSIGNED:	WORK UNDERTAKEN THAT BEST ILLUSTRATES CAPABILITY TO HANDLE TASKS:

Marine Research Centre, Ministry of Agriculture and Marine Resources

National coordinator of Global Coral Reef Monitoring Network
Responsibilities: Including Implementation and management of the programme activities in the country through the GCRMN Regional Node for south Asian Region in Srilanka. Current programme of activities include, establishing and monitoring of coral reefs to assess the recovery processes after the 1998 Bleaching and to monitor the temporal changes to the reef system. Responsibilities also include coordination and implementation of socioeconomic monitoring at designated pilot sites to asses the livelihood and their dependence on coral reef resources. Coordinating the establishment national reef database to share information at national, regional, and global level is also part of the program of activities.

Coral Reef Degradation in the Indian Ocean (CORDIO) Programme
Responsibilities: include implementation and management of the identified projects/ Studies funded by CORDIO. Currently involved biophysical studies designed to understand the reef recovery processes after a severe disturbance in coral reefs

Catalogue of Common Coral Reef of Maldives, 1996
Year: 1996
Location: Maldives.

Task Undertaken
Independent Consultant

Initial Environmental Evaluation, Tsunami Emergency Assistance Project, Maldives
Year: 2006
Location: Ha. Filladhoo, HDH. Nolhivaranfaru, Sh. Maroshi, N. Maafaru, DH. Meedhoo, M. Kolhufushi and Th. Madifushi, Maldives
Client: ADB
Project features: Rehabilitation of damaged infrastructures (electricity)due to the tsunami of December 2004 in the Maldives financed by ADB under Tsunami Emergency Assistance project
Positions held: Domestic Environmental Specialist
Responsibilities: Initial Environmental Evaluation for the Repair and Reconstruction of Diesel powered generator housed in the above 7 island communities. Environmental issues specific of diesel power generation in the local and national context were addressed following ADB environmental guidelines.
I

Initial Environmental Evaluation, Tsunami Emergency Assistance Project, Maldives
Year: 2005
Location: Ugoofaaru, Manadhoo , Dhidhdhoo, Maldives
Client: ADB
Project features: Rehabilitation of damaged infrastructures (harbours)due to the tsunami of December 2004 in the Maldives financed by ADB under Tsunami Emergency Assistance project
Positions held: Domestic Environmental Specialist
Responsibilities: Initial Environmental Evaluation of the project sites; Ugoofaaru, Manadhoo and Dhidhdhoo for the tsunami

emergency assistance project: TA-0001 (MLD). Specific Task include rapid environmental assessment of the project sites, prepare environmental evaluations based on filed data and community Consultants, predict environmental impacts and propose an environmental monitoring plan for the project activities.

Marine Biodiversity assessment, Faafu atoll, Maldives,
Year: 2003
Location: Faafu atoll, Maldives
Client: ADB
Project features: Identification of potential biodiversity hotspots (sites/species) as part of identifying priority areas for an MCPA planning project funded by ADB. Project involves assessment of socioeconomic and biophysical assessment of the short listed sites identified for the project.
Positions held: Biodiversity Environmental Specialist
Responsibilities: Marine Biodiversity assessment Faafu atoll Maldives. ADB regional technical assistance for coastal and Marine resource management and poverty reduction in south Asia. (ADB RETA 5974). A project implemented by Ministry of Fisheries, Agriculture and Marine Resources. Assignment involves detail preparation of marine biodiversity and Coastal management issues with special reference to grouper fishery and resource management.

Environmental Impact Assessment Report for the Development of Fish Processing Plant at Ha. Huvahandhoo, Maldives,
Year: 2002
Location: Maldives
Client: Jausa Fishery Links
Project features: Construction of a tuna processing plant
Positions held: Marine Biologist
Responsibilities: The EIA report involves collection and assessment of baseline and secondary environmental data both at the marine and terrestrial environment of the project site. It also involved a risk assessment and evaluation report. An environmental management plan was also developed as part of the EIA.

Task Undertaken as an employee o f Land and Marine Environmental Resource Group Pte Ltd

Replacement of wastewater collection, septic tanks and disposal systems in Ga.Villingili, Ga.Dhaandhoo, Gdh.Gahdhoo
Year: 2007-Ongoing
Location: Ga.Villingili, Ga.Dhaandhoo, Gdh.Gahdhoo
Client: American Red Cross
Project features: Design and construction of wastewater disposal systems in the specific islands
Positions held: EIA Specialist
Responsibilities: Environmental Impact Assessment research and analysis.
Preparation and submission of the Environmental Impact Assessment Report.

Environmental Impact Assessment for Reethi Rah Resort Redevelopment
Year: 2005
Location: Reethi Rah Resort
Client: Kersner International, Hotel Group
Resort development at Reethi Rah Resort
Positions held: Marine Biologist
Responsibilities: The EIA involves collection and assessment of baseline and secondary environmental data and marine and terrestrial environment of the project site. This is one of the largest reclamation project for resort development and assessment of impact of dredging and reclamation on the coastal marine habitats was a major component of this study

Environmental Impact Assessment Report for Villa Hakatha at Thilafushi, Male Atoll
Year: 2001
Location: Male Atoll
Client: Villa Hakatha,Maldives
Positions held: Project Biologist
Responsibilities: The EIA report involves collection and assessment of baseline and secondary environmental data both at the marine and terrestrial environment of the project site. It also involved a risk assessment evaluation report. An environmental management plan was also developed as part of this EIA.

Development at Baa. Landaagiraavaru, Maldives
Year: 2000
Location: Baa. Landaagiraavaru, Maldives
Client: Club mediterranee *Project features:*
Positions held: Project Biologist
Responsibilities: The EIA involved collection of Oceanographic data, Study of the beach environment, Vegetation, reef quality and reef water quality. The study examined the impacts of the island and mitigation measures where appropriate. The study also forms the baseline data for future monitoring of the environmental changes due to the resort development

Environmental state for the proposed channel dredging & associated Barrier Island at Sun Island Resort.
Year: 2000
Location: Sun Island Resort, Maldives
Client: Tekton Design Associates Pvt. Ltd
Positions held: Project Biologist
Responsibilities: The Study involved assessment of the potential environmental impact on the coastal shoreline of the island and on to the reef environment within close proximity of the proposed project site.

Tasks undertaken as an employee of Riyan Design and Management Pte Ltd

Environmental Statement for the Proposed Redevelopment of Reethi Rah Resort
Year: 2000
Location: Reethi Rah Resort
Client: Reethi Rah Resort
Positions held: Project Biologist
Responsibilities: This Study Involved assessment of the existing

status of the islands environment and identification of potential environmental impact areas related to the proposed redevelopment plans. Formulation of an environmental monitoring plan that would enable the client to record the environmental changes that may be related to anthropogenic activities or natural.

Environmental Statement for the Proposed Redevelopment of Reethi Rah Resort
Year: 2000
Location: Reethi Rah Resort
Client: Reethi Rah Resort
Positions held: Project Biologist
Responsibilities: This Study Involved assessment of the existing status of the islands environment and identification of potential environmental impact areas related to the proposed redevelopment plans. Formulation of an environmental monitoring plan that would enable the client to record the environmental changes that may be related to anthropogenic activities or natural.

Proposed Beach Nourishment at M. Medhufushi. An assessment of Environmental Design Parameters
Year: 2000
Location: M.Medhufushi
Client: Vaaly Brothers Pte.Ltd
Positions held: Project Biologist
Responsibilities: The study involved examination of the beach characteristic
Including the sediment properties, beach profiles. Identification of a borrow site by Comparing the borrow sediment characteristics of the borrow site and the native beach sand.

Environmental Evaluation of Small-bore Sewer System (SBS) in Lh. Hinnavaru and K. Gulhi
Year:1999
Location: Lh. Hinnavaru and K. Gulhi
Client: Maldives Water and Sanitation Authority
Project features: The Study Involved ground water/ Seawater analysis of sewage pollution; reef surveys hydro graphic /oceanographic surveys and survey of the slopes of the sewage lines.
Positions held: Project Environmental Analyst

Assessment of Oil Contamination in Male' Groundwater from Vehicle Garages and Petrol Stations.
Year:1999
Location: Male', Maldives
Client: Maldives Water and Sanitation Authority
Positions held: Project Environmental Analyst
Responsibilities: The study involved Ground water analysis of oil contamination and assessment of general working conditions and practices in the vehicle garages and petrol stations in male'.

Environmental Impact Statement for the Proposed Beach Protection Works at Nika Island Resort
Year:1999

Location: Male’, Maldives
Client: Nika Island Resort
Positions held: Project Biologist
Responsibilities: The project involves assessment of physical environmental condition such as the wave, current sediment characteristics, bathymetry at the project site (Nika Island Resort). Assessment of the status of the reef at the project site and an evaluation of the possible impacts on the reef and the physical environment as a result of the proposed beach protection work.

Environmental Monitoring of F. Filitheyo Resort Development
Year:1999
Location: F.Filitheyo
Client: AAA Trading Company Pvt.Ltd
Positions held: Project Biologist

Environmental Monitoring of M. Medhufushi Resort Development
Year:1999
Location: M. Medhufushi, Maldives
Client: Vaally Brothers Pte Ltd
Position Held: Project biologist

Environmental Monitoring of Lh. Kanuhuraa, Maldives
Year:1999
Location: Lh. Kanuhuraa
Client: SIMDI Hotel Management Pte Ltd
Positions held: Project Biologist

Environmental Monitoring of R. Meedhupparu Resort Development
Year:1999
Location: R. Meedhupparu
Client: Cowrie Investment Pvt Ltd, Maldives
Positions held: Project Biologist
Responsibilities: The Monitoring programmes involved periodic measurements of the beach profiles around the islands, reef quality surveys, ground water/ seawater analysis and environmental auditing

Tasks Under Taken as a Freelance Consultant

Environmental impact Assessment for the F. Filitheyo Resort Development
Year:1998
Location: F.Filitheyo
Client: AAA & Trading Company, Maldives
Positions held: Project Biologist

Environmental Impact Assessment for Lh. Madhiriguraidhoo Resort Development
Year:1997
Location: Lh. Madhiriguraidhoo
Client: Guardian Agency Pte Ltd
Positions held: Marine Biologist

Environmental Impact Assessment for B. Fonimagoodhoo Resort Development
Year:1997
Location: B. Fonimagoodhoo, Maldives
Client: Thasmeen Ali, M. Sheeraazeege, Maldives
Positions held: Marine Biologist

Environmental Impact Assessment for M. Hakuraahuraa Resort Development
Year:1997
Location: M. Hakuraahuraa
Client: Fantasea Pte Ltd, Maldives
Project features:
Positions held: Marine Biologist
Responsibilities: The EIA studies Involved collection of oceanographic data studies of the beach environment, vegetation, reef quality and ground water / Seawater quality. These studies examined the impacts of the development on the island and mitigation measures where appropriate. The studies also form the baseline data for the future monitoring of the environmental changes due to the resort development

13. Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience. I understand that any wilful misstatement described herein may lead to my disqualification or dismissal, if engaged.

______________________________________ Date: 7 May 2008
[*Signature of staff member or authorized representative of the staff]* *Day/Month/Year*

Full name of staff member Hussain Zahir
Full name of authorized representative:

Shahaama Abdul Sattar

Personal Information

Date of birth: 30 September 1980

Address: G. Helengeli Aage, Apt 2 B
Rahdhebai Magu
Male'
Republic of Maldives
Contact No: + 960 7904985 (m)
Email: shahaama@lamer.com.mv (LaMer Pvt Ltd)
shahaama.sattar@gmail.com

Work Address: Currently working independently

Education

Graduate and Postgraduate

Aug 2004 - Jun 2006 Master of Science in Fisheries Biology and Fisheries Management
University of Bergen
Department of Biology
Postbox 7800
N-5020 Bergen, Norway

Feb 1999 - Dec 2001 Bachelor of Science
The Flinders University of South Australia
GPO Box 2100
Adelaide 5001, South Australia

Secondary

Apr 1997 – Jul 1998 G.C.E A'Level (London)
Kolej Damansara Utama
Damansara Jaya
Selangor,
Malaysia

Jan 1994 – Dec 1996 G.C.E O'Level (London)
Aminiya School
Male',
Republic of Maldives

Work experience

Feb 2002 Volunteer work at Seal Bay, Kangaroo Island, South Australia.
Work involved helping researchers with catching seals and removing tracking devices from the seals.

Dec 2001 – Feb 2002 Work experience at the South Australian Aquatic Sciences Centre
Work involved dealing with sea urchins, mainly cleaning their tanks, doing dissections on sea urchins and helping researchers with different aspects of the research.

May 2008 Participated in the Biodiversity Valuation survey of Baa Atoll Maldives carried out by AEC project and IUCN

Employment Record

May 2011 - Present Consultant, Darwin Reef Fish Project
Marine Research Centre, Maldives / Marine Conservation Society, UK

- Consultant to the Darwin Reef Fish Project (4 year joint collaboration between MRC and MCS, UK), which assesses the various reef fisheries (grouper, aquarium and food fisheries) of the Maldives and aims to establish management plans for these fisheries. Provision of technical support and assistance to the project staff and MRC in implementing the project and formulation of the management plans.

June 2011 – Present LaMer Pvt Ltd

- Work part time in report writing for the various Environmental Impact Assessment projects conducted by the group.

July 2011 – Present BOBLME Sharks Working Group Coordinator, Bay of Bengal Large Marine Ecosystem Project

- Coordinator for the Sharks WG of BOBLME project, and work with the focal points in the member countries, to assist in the formulation and implementation of their National Plans of Action for Sharks.

June 2002 – May 2011 Fisheries Biologist (At time of resignation)
Marine Research Centre
Ministry of Fisheries and Agriculture
Male', Republic of Maldives

Line of work at MRC included:

- Conduct field surveys to monitor the reef fishery and fish species behaviour
- Compilation and analyses of the reef fisheries data, in particular the grouper and food fishery data
- Write reports and regular reviews on the status of fisheries including recommendations for management.
- Focal point for the IUCN funded project on identification of reef fish spawning aggregations in the Maldives through fishermen interviews (2007)
- Secretariat – Indian Ocean Cetacean Symposium 2009
- Project Partner for Maldives for the Darwin Initiative Coral Reef Fish Project, Maldives
- MRC Focal point for the Atoll Ecosystem Conservation Programme, Ministry of Housing and Environment (2009 – 2011)

Workshops/Seminars Participated

15-21 March 2003 - Training Workshop on the Implementation of Multilateral Agreements in the Conservation of Biodiversity with special focus on Marine Biodiversity. Kushiro, Japan

14-16 November 2006 – Sixth William R. and Lenore Mote International Symposium – Life history in Fisheries Ecology and Management. Sarasota, Florida

03-05 March 2008 – Olhugiri and Dhigalihaa Protected Areas Management Planning Workshop. Eydhafushi, Maldives

11 March 2008 – Applying the Ecosystem Approach to managing Atoll Ecosystems in the Maldives. Hulhule Island Hotel, Maldives

24-26 March 2008 – Regional Consultation on Preparation of Management Plans for Shark Fisheries. Beruwela, Sri Lanka

17-19 June 2008 – Workshop on Assessment and Management of the Offshore Resources of South and Southeast Asia. Bangkok, Thailand

22-23 March 2009 – BOBP-IGO National Workshop on Monitoring, Control and Surveillance in Marine Fisheries. Male', Maldives

18 – 20 July 2009 – Indian Ocean Cetacean Symposium 2009. Paradise Island Resort and Spa, Maldives.

09-11 August 2009 – Second Regional Consultation on Preparation of Management Plans for Shark Fisheries. Kulhudhuffushi, Maldives

24-25 February 2010 – BOBLME Project – National Inception Workshop, Male', Maldives

2-3 June 2010 – BOBP-IGO Technical Advisory Committee – 5th Meeting, Male', Maldives

13-14 September 2010 – BOBLME Fisheries Assessment Working Group – 1st Meeting, Bangkok, Thailand

14-16 December 2010 – EWS-WWF 2nd Marine Conservation Forum for the Gulf Region In partnership with the Pew Environment Group – Local Actions for Global Challenges, Abu Dhabi, United Arab Emirates

18-19 January 2011 – Bay of Bengal Large Marine Ecosystem Project – Workshop on the Status of Marine Managed Areas in the Bay of Bengal, Penang, Malaysia

5-7 July 2011 –Bay of Bengal Large Marine Ecosystem Project – First meeting of the BOBLME Sharks Working Group, Male', Maldives

7-8 September 2011 – Workshop to formulate the Grouper Fisheries Management Plan, DRFP/MRC, Male', Maldives

15-17 September 2011 – SEAFDEC Special Meeting on Sharks Information Collection in Southeast Asia, Bangkok, Thailand

Publications

Sattar, S. A., Amir, H. and Adam, M. S. (2011) Reef fish tagging programme – Baa Atoll Pilot project (in press)

Sattar, S. A., Andréfouët, S., Ahsan, M., Adam, M. S., Anderson, R. C. and Scott, L (2011) Status of the Coral Reef Fishery in an Atoll under tourism development: the case of Central Maldives (in press)

Saleem, M., Sattar, S. A. (2009) Study on post-tsunami restoration and conservation projects in Maldives, *Prepared for the International Union for Conservation of Nature.*

Tamelander, J., Sattar, S., Campbell, S., Hoon, V., Arthur, R., Patterson E. J.K., Satapoomin, U., Chandi, M., Rajasuriya, A. and Samoilys, M. (2009) Reef fish spawning aggregation in the Bay of Bengal: Awareness and Occurrence, *Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008,* Session 22

Sattar, S. A., Jørgensen, C., Fiksen, Ø. (2008) Fisheries Induced Evolution of Energy and Sex Allocation. *Bulletin of Marine Science*, 83(1): 235-250

Sattar, S. A. (2008) Review of the Reef fishery of the Maldives, Marine Research Centre, Male', Maldives. 62 pp

Sattar, S. A. and M. S. Adam (2005) Review of the Grouper fishery of the Maldives with additional notes on the Faafu Atoll fishery. Marine Research Centre, Male', Maldives. 54 pp

Referees

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References

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Falkland, T., 2000. Report on Groundwater Investigations in Southern Development Region (ADB Regional Development Project). Report for Ministry of Planning and National Development.

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Appendices

Appendix 1 List of abbreviations

BOD – Biological Oxygen Demand

CBD – Convention on Biological Diversity

EIA – Environmental Impact Assessment

EPA – Environmental Protection Agency

GPS – Global Positioning Systems

HDPE – High Density Polyethylene

MHAHE – Ministry of Home Affairs, Housing and Environment

MEE – Ministry of Environment and Energy

MMS – Maldives Meteorological Services

NBSAP – National Biodiversity Strategy and Action Plan

NEAP III – Third National Environment Action Plan

OD – Outer Diameter

PS – Pumping Station

STP – Sewage Treatment Plant

TDS – Total Dissolved Solids

ToR – Terms of Reference

UNDP – United Nations Development Programme

uPVC – Unplasticized Polyvinyl Chloride

Appendix 2 Terms of Reference (ToR)

No: 203-EIARES/438/2017/49

Terms of Reference

Environmental Impact Assessment for The Construction of Sewerage System at Hitadhoo, Addu City

The following is the Terms of Reference (ToR) for undertaking the EIA of the proposed Sewerage System at *Hithadhoo, Addu City*

While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction to the project** – Describe the purpose of the project (wastewater collection system and sewerage treatment system) and, if applicable, the background of the project and the tasks already completed. Clearly identify the rationale and objectives to enable the formulation of alternatives. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked and sequenced with other projects that may be linked or relevant to the project. Identify and outline the institutional arrangements for financing, execution, implementation and operational aspects of the project and how coordination between other consultants, contractors and government institutions will be carried out.

2. **Study area** – Submit a minimumA3 size scaled plan with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location, size and important elements of the proposed water and sewerage system. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites such as coral reef, sea grass and other ecologically important habitats. Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including site preparation, construction and decommissioning phases. The following tasks shall be completed:

Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the project, using maps at appropriate scales where necessary. The following should be provided (all inputs and outputs related to the proposed activities shall be justified):

- Specify materials, equipment, heavy machinery, staff estimate (quantity and period of time), key personnel positions, intermittent technical expertise required;
- Project management: Include communication of construction details, progress, target dates and duration of works, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, water supply, waste management from construction operations (mainly dredged materials), power and fuel supply;

House connection and laterals

- Description of catch pits and expected depth of these catch pits

Collection System

- Type of collection (gravity or forced)
- Road manholes (type and expected number), indicate using site plans
- Sumps and pump stations (numbers ad their specifications)

STP plant facility design:

- Describe treatment technology and capacity (envisage population growth in the next 30 years);
- Specify catchment area: All flows that contribute to the sewer system including flows from the development area to the point of connection to the main line
- Describe operations for dewatering excavations for pump stations and sewer trenches;
- Mechanisms used to avoid pipe leakages protecting groundwater contamination.
- Specify an emergency plan if system fails.

Sea outfall pipeline

- Justify outfall site selection including the distance from the reef and depth of the pipe using oceanographic and ecological information. Currents and waves ought to quickly disperse the discharged water with minimum impacts on marine ecosystems and economic activities. Illustrate the extent of the sediment plume. The design and location of sea outfall shall consider public and stakeholders should views
- Methodology and material used for outfall construction

Task 2. Description of the existing environment – Assemble, evaluate and present the environmental baseline studies/data regarding the *study area and timing of the project* (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction and from at least two benchmarks. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef survey, vegetation survey and groundwater and seawater sampling. Information should be divided into the categories shown below:

General climatic conditions

- Rainfall and temperature

Geology and geomorphology

Offshore/coastal geology and geomorphology (use maps to show major zones or geomorphological features such as reef line, vegetation line);

- Bathymetry(at the proposed outfall location and alternative locations)

Hydrography/hydrodynamics (localized maps)

- Tidal ranges and tidal currents;
- General description of wave climate and wave induced currents (in relation to outfall pipes)
- General description of wind induced currents;
- Seawater quality measuring these parameters: temperature, pH, salinity, turbidity, phosphate, nitrate, ammonia, sulphate and BOD.

All survey locations shall be referenced with Geographic Positioning System (GPS) including sampling points. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. Absence of facilities in the country to carry out the water quality tests will not exempt the proponent from the obligation to provide necessary data. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector. Include map;
- Marine habitat status including coral reef health, seagrass beds and benthic and fish community description at outfall location and a control site. Select a control site far from the outfall location and a test site at representative distance from the outfall discharge site;
- Terrestrial monitoring for selecting the sites for STP facility (See appendix for monitoring guidelines). Include a description of the flora within the STP and pump stations and quantification of the significant vegetation types;
- Groundwater samples from STP location and pump station locations to include Salinity, EC, TDS and pH.

Socio-economic environment

- Demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities at sea;
- Accessibility and (public) transport to other island;
- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Community needs;
- Sites with historical or cultural interest or sacred places (mosques, graveyard).

Hazard vulnerability:

- Vulnerability of area to flooding and storm surge to predict infiltration rates.

Existing Sewerage Infrastructure (if exists)

- Assess the existing sewerage facilities including household septic tanks, soak pits, collection tanks near shore outfalls
- Identify and suggest best possible of mean of de- sludging and cleaning of any such septic tanks and collection tanks
- Suggest and recommend the most environmentally sound method for disposal of any sludge removed from any such system

Groundwater Aquifer

- Estimated volume of groundwater that may be discharged into sea via sewerage system

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Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project.

Task 4. Potential impacts of the proposed project– The EIA report should identify all the impacts (direct, indirect and cumulative) and evaluate the magnitude and significance This shall include:

Terrestrial impacts from construction

- Loss of vegetation and fauna from land clearance activities, STP location, pump stations and pipe works (deployment and dewatering);
- Groundwater quality;

Impact from installing the brine discharge and sewage outfall pipe

- Impacts from marine habitat destruction which may affect fish stocks and species diversity and density of invertebrates,
- Increased turbidity and changes in sediment transport due to pipe introduction when pipe is on the sea bed;
- Equipment, technical and spillage impacts during construction;

Operational phase impacts from outfall discharges

- Sediment plume extent should be delimited so that effects from nutrient inputs (water quality changes) on local reefs, fish and invertebrate communities can be identified;

Sewage waste collection and disposal impacts

- Specify methods of collection and transportation to dump site.

Social impacts:

- Odor and noise impacts;
- Aesthetics on-land and underwater from outfall pipeline and turbidity for recreational users;
- Increased demands on natural resources and services (domestic water supply, waste water disposal, treatment systems, solid waste disposal systems, energy supply, etc);

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternatives for environmental, social and economic considerations. The report should highlight how the location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. Mitigation measures must also be identified for both construction and operation phase. Cost of the mitigation measures, equipment and resources required to implement those measures should be specified. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given.

In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for:

- Physical parameters such as ground and seawater quality assessments and oceanographic studies shall be provided as required by EPA
- Biological parameters such as terrestrial monitoring, coral reef and benthic monitoring, fish community census and terrestrial monitoring shall be provided as per guidelines of EPA.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation – The EIA report should include a list of people/groups consulted and summary of the major outcomes and concerns raised. The following parties should be consulted.

a) Ministry of Housing & Infrastructure (Hithadhoo Branch, Addu City)
b) Addu City Council
c) HPA
d) EPA
e) FENAKA

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

Timeframe for submitting the EIA report – *The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.*

26th March 2017

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Website: www.epa.gov.mv

Appendix 3 Site Plan

بسم الله الرحمن الرحيم

Ministry of Environment and Energy
Male', Republic of Maldives.

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މާލެ، ދިވެހިރާއްޖެ.

Date: 8th March 2017

No.: 438/MWSC/2017/27

Mr. Ibrahim Fazul Rasheed
Managing Director
Male' Water and Sewerage Company Pvt. Ltd.
5th Floor, Fen Building, Ameenee Magu,
Male; 20375,
Republic of Maldives

Dear Sir,

Sub: Design and Build Basis for Sewerage Collection Network, Sewage Pump Stations and Sea Outfall and Allied Works in S. Hithadhoo (North and South Region), Maldives

Reference is made to your letter number: MWSC-C/1/2017/1584 (Received 26th February 2017).

With reference to the concept design report, please find below the comments from MEE.

1. Xylem pumps are proposed to be used in the network and this pump is not readily available in Maldives. Hence, we request for the pumps to be changed to Grundfos or another locally available type of pump.
2. The system has been proposed to be tested using an air pressure system of 0.01 bar. This seems a bit less considering the depth at which some pipes are laid at. Hence, we recommend the system to be tested using a water pressure system of 0.25 - 0.3 bars.

Please incorporate the above two comments and proceed with the detailed design. In this regard, the concept design for the subjected project has hereby been approved.

We would like to kindly remind you that, as per the schedule submitted at the beginning of the project, the project is currently 3 months behind schedule. Therefore, please submit an updated schedule which reflects the actual work progress and please elaborate on how MWSC proposes to make up for the current delay. We urge you to expedite the works without further delay as the completion of this project within the project deadline is of utmost important to the Ministry.

Thank you.

Sincerely,

Mohamed Musthafa
Director

LED SAVES

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Maafannu, Male', 20392, Republic of Maldives.
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+(960) 301 8301
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މާފަންނު، މާލެ، 20392، ދިވެހިރާއްޖެ.
secretariat@environment.gov.mv
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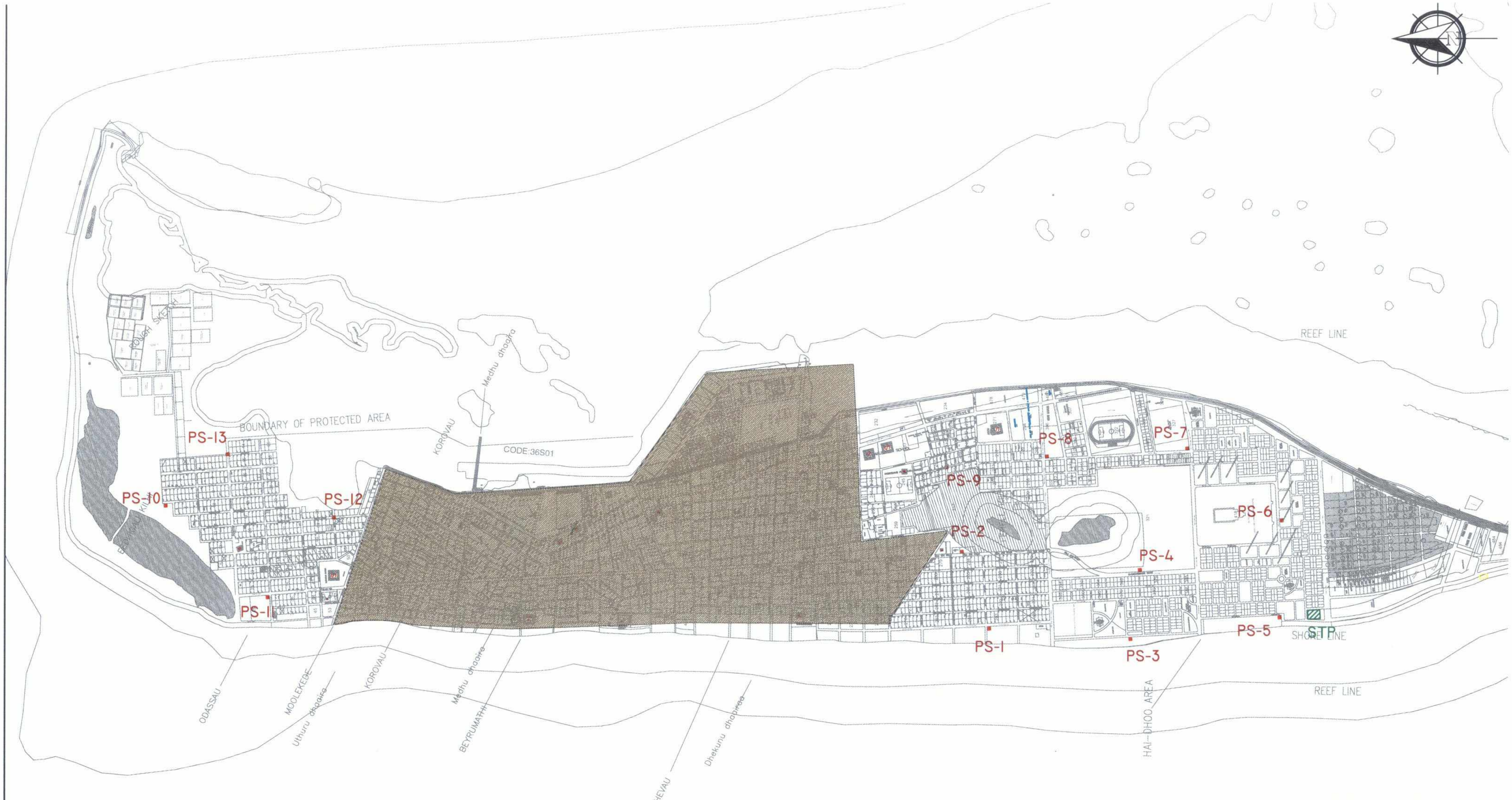
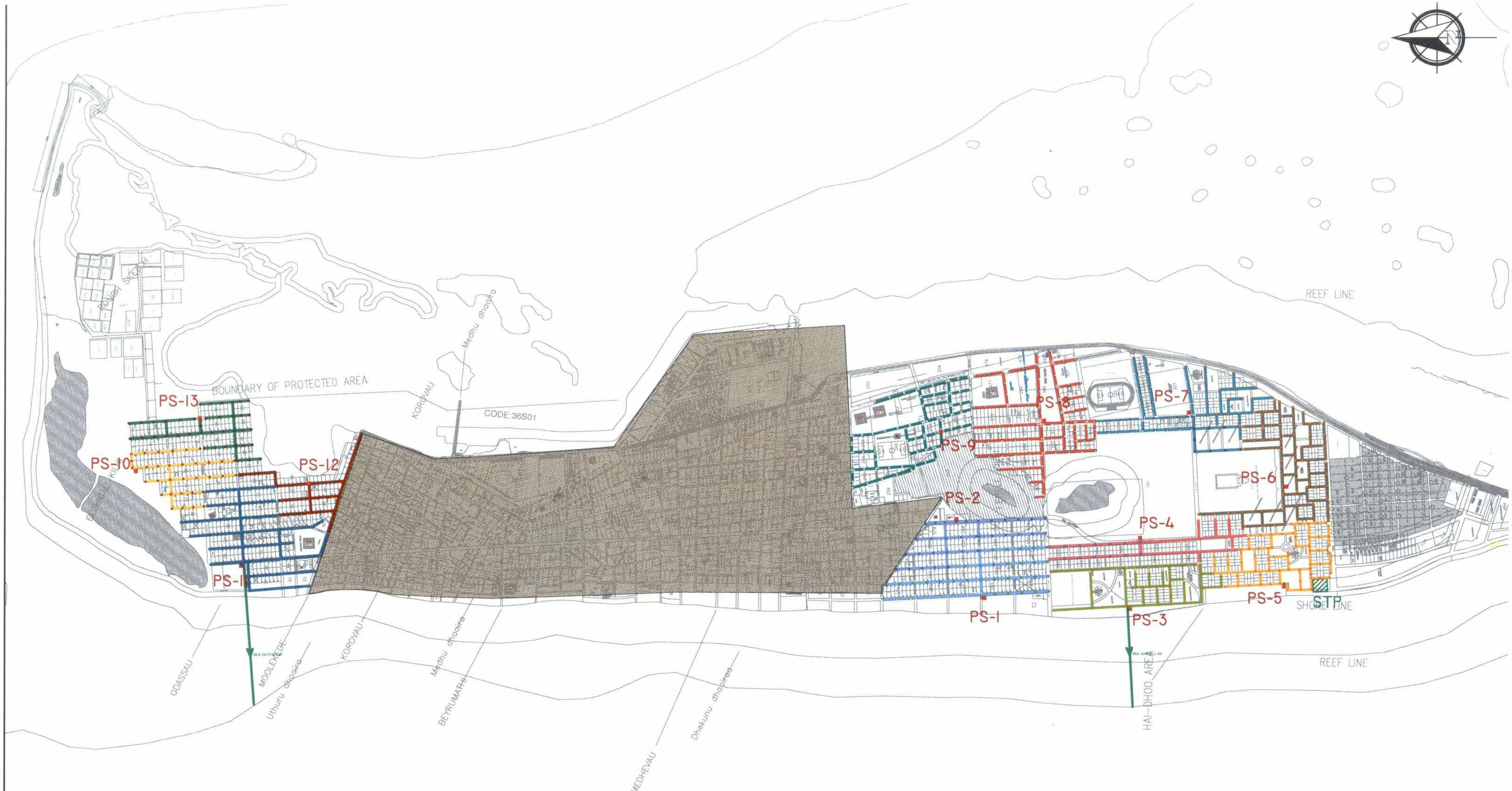


LEGEND

PROPOSED LOCATIONS OF PUMPING STATIONS(7mX8m)

PROPOSED TREATMENT PLANT AND ADMIN BUILDING LOCATION(50mX40m)

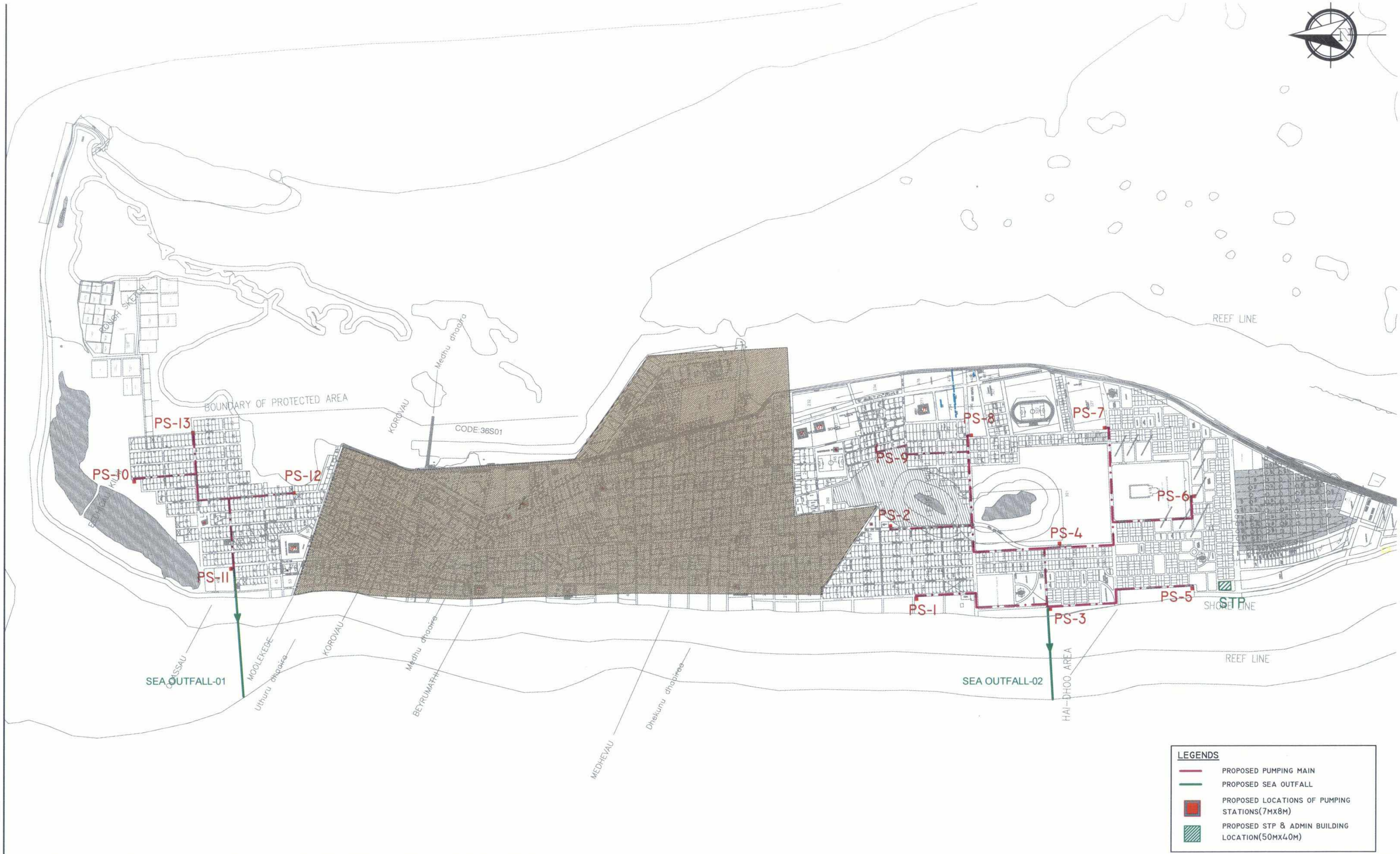
MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY, MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE: NTS	DRW NO. : HITD/PS/LOC-01(R1)	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:	
	CONSULTANT:	CONTENTS: PUMPING STATION LOCATIONS(CONCEPT)	DATE: 21.02.2017	PAGE NO. : 01	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 01 of 7	



LEGENDS

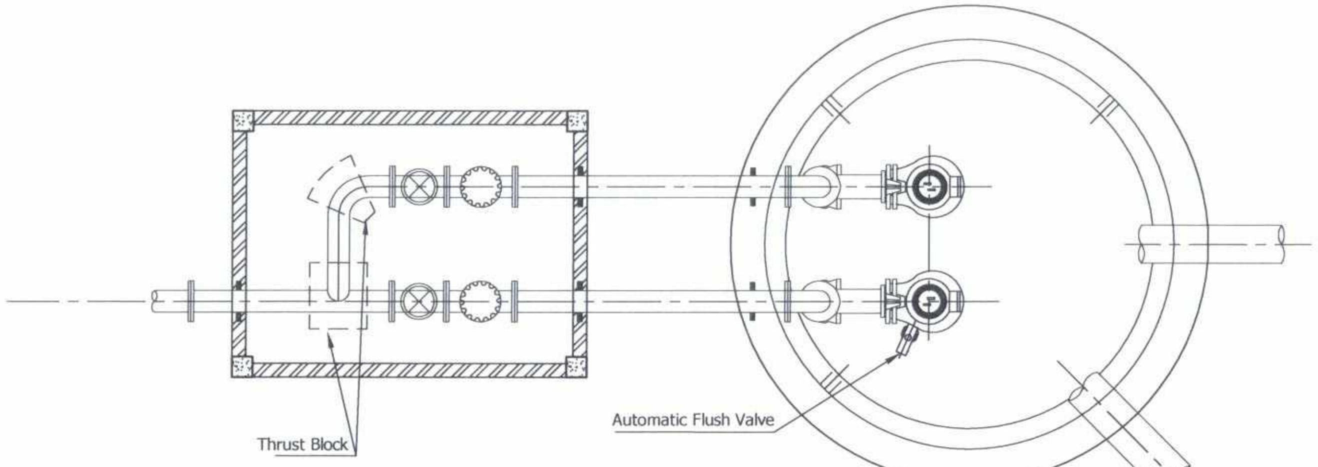
PS-1 AREA	PS-4 AREA	PS-7 AREA	PS-10 AREA	PS-13 AREA	PROPOSED STP & ADMIN BUILDING LOCATION(50MX40M)
PS-2 AREA	PS-5 AREA	PS-8 AREA	PS-11 AREA	SEA OUTFALL	
PS-3 AREA	PS-6 AREA	PS-9 AREA	PS-12 AREA	PROPOSED SEWER MANHOLES	PROPOSED LOCATIONS OF PUMPING STATIONS(7MX8M)

MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY, MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE: NTS	DRW NO. : HITD/SN/LAY-01(R1)	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:
	CONSULTANT:	CONTENTS: PROPOSED SEWER NETWORK LAYOUTS(CONCEPT)	DATE: 21.02.2017	PAGE NO. : 02	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 02 of 7

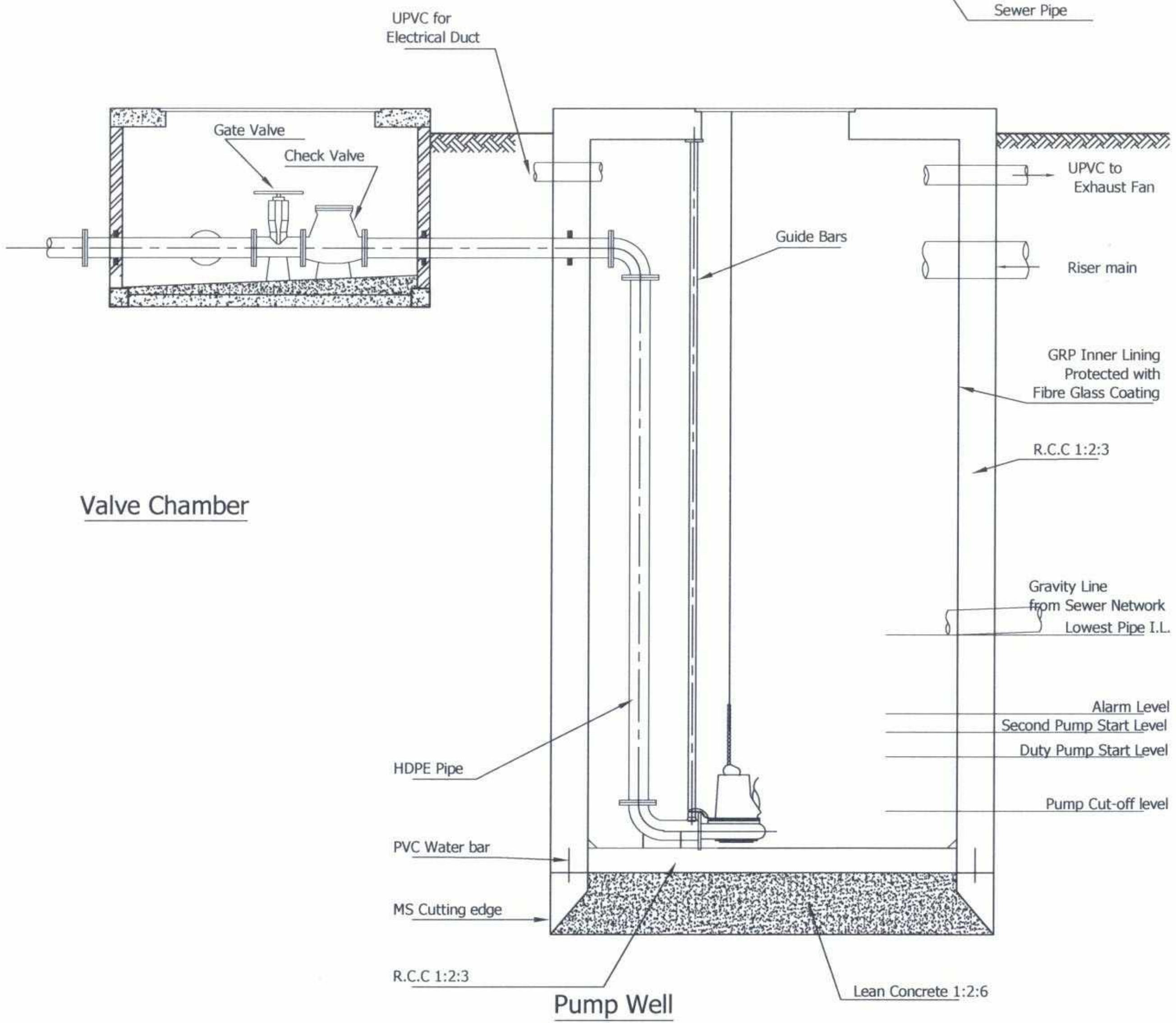


MWSC
MALE' WATER & SEWERAGE COMPANY PVT LTD.
AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES

CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY, MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE: NTS	DRW NO. : HITD/PM/LAY-01(R1)	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:
CONSULTANT:	CONTENTS: PROPOSED PUMPING MAIN & SEA OUTFALL(CONCEPT)	DATE: 21.02.2017	PAGE NO. : 03	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 03 of 7

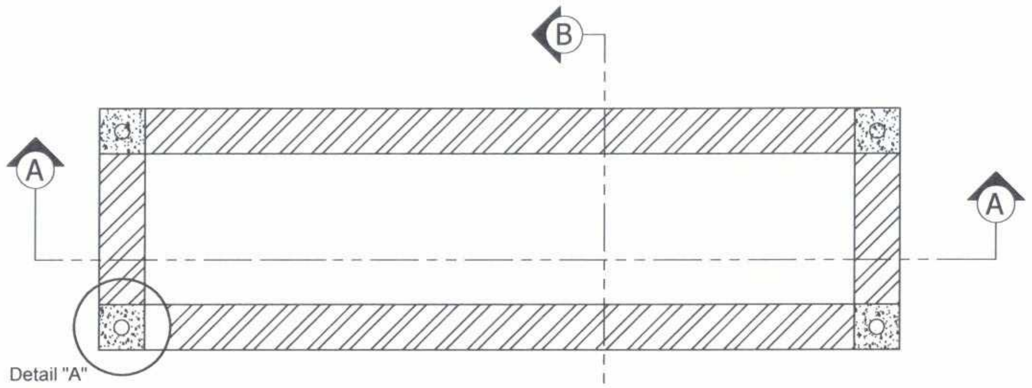


SECTIONAL PLAN



SECTIONAL ELEVATION

MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 3323209, Fax: (+960) 3324306, E-mail: mwsc@dhivehinet.net.mv	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE : NTS	DRW NO. : HTD/PST-1	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:
	CONSULTANT:	CONTENTS: PS-SUMP & CHAMBER SECTIONAL DETAIL (CONCEPT)	DATE : 12-01-2017	PAGE NO. : 04	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 04 of 7



PLAN
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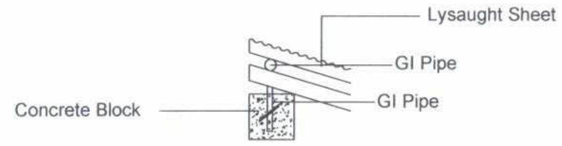

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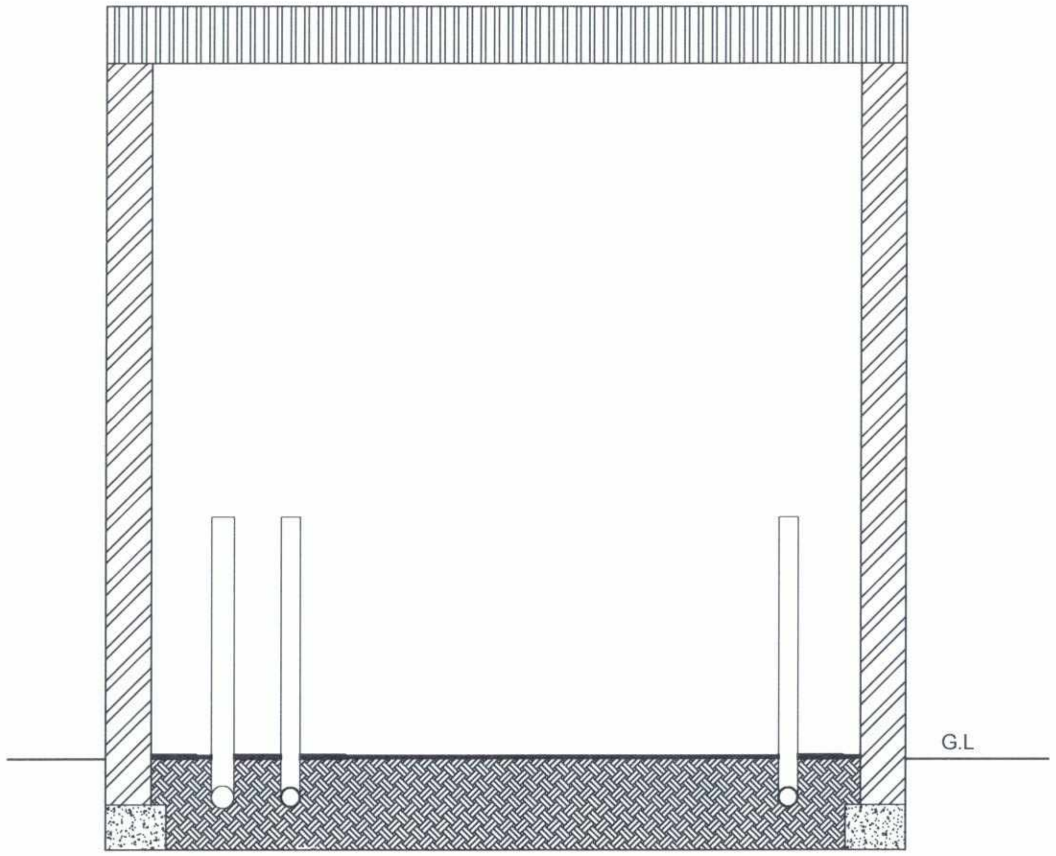

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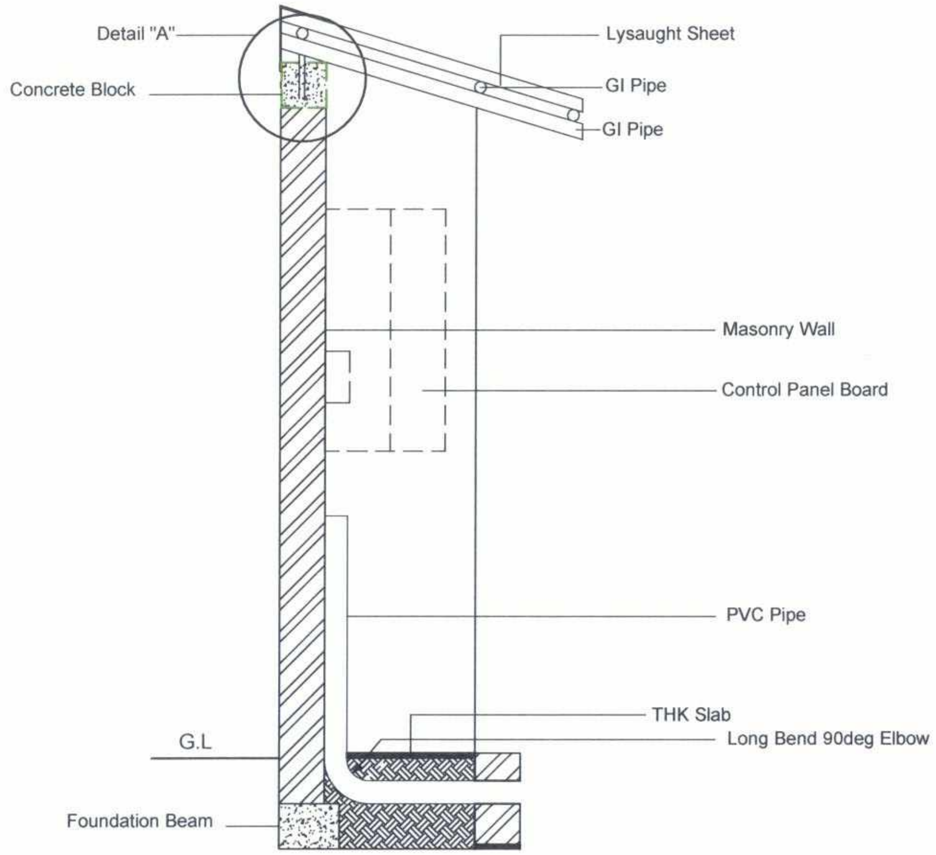
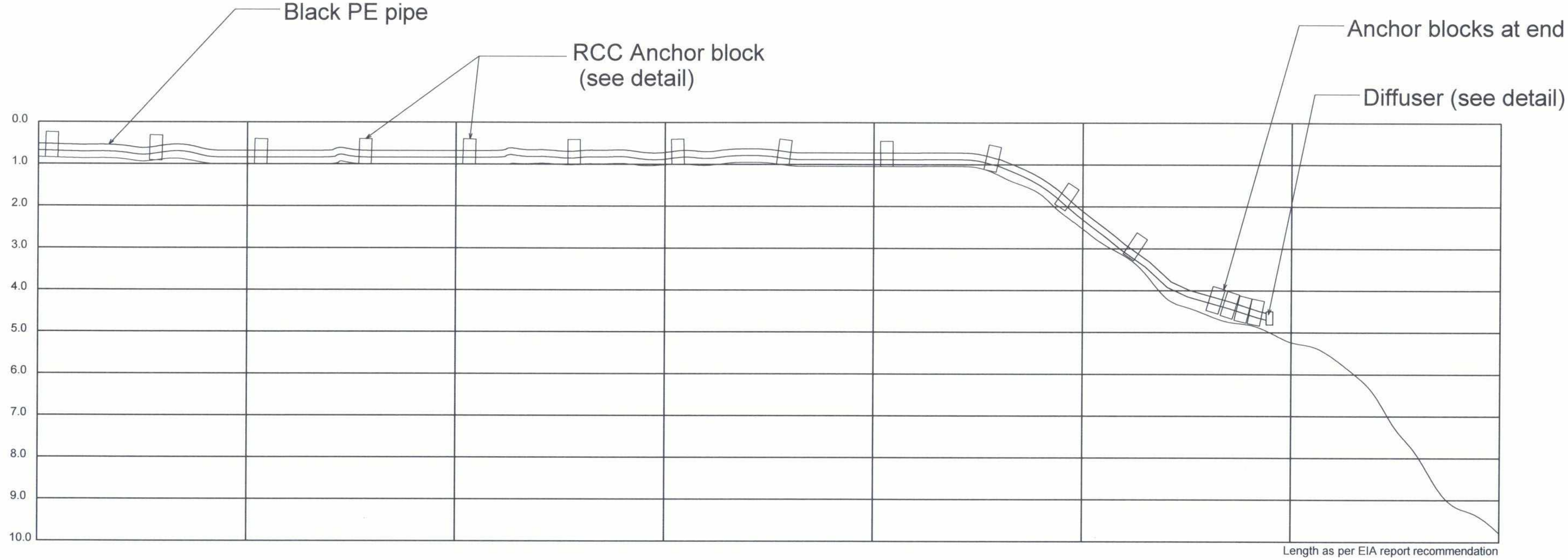


SECTION B-B
SCALE : 1:25

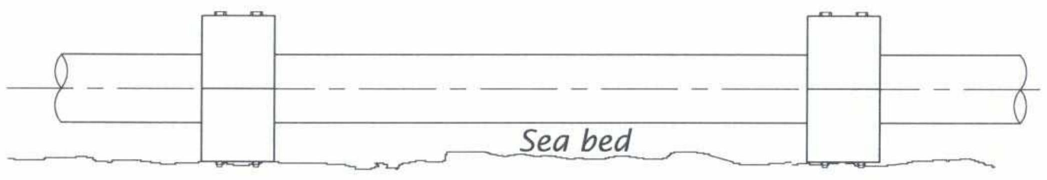
MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 3323209, Fax: (+960) 3324306, E-mail: mwsc@dhivehinet.net.mv	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE : 1:25	DRW NO. : HTD/PST-2	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:	
	CONSULTANT:	CONTENTS: PUMPING STATION- PANEL SHED DETAIL(CONCEPT)	DATE : 12-01-2017	PAGE NO. : 05	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1	
							Page: 05 of 7	



PROFILE
NTS

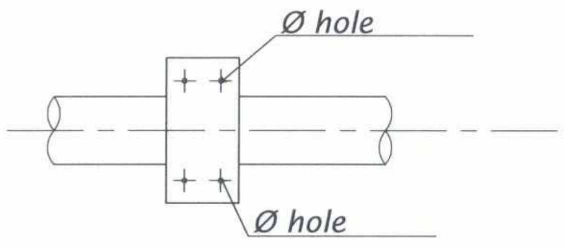
MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 3323209, Fax: (+960) 3324306, E-mail: mwsc@dhivehinet.net.mv	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO	SCALE : NTS	DRW NO. : HTD/SOF-1	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:
	CONSULTANT:	CONTENTS: SEA OUTFALL DETAIL (CONCEPT)	DATE : 12-01-2017	PAGE NO. : 6	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 06 of 7

ANCHOR BLOCK



Side Elevation

Scale - 1:25



Plan

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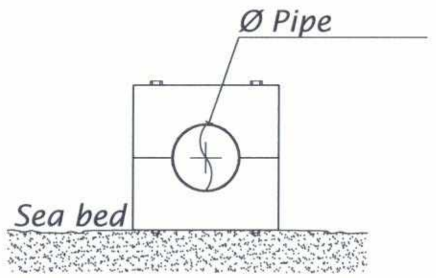

Front Elevation

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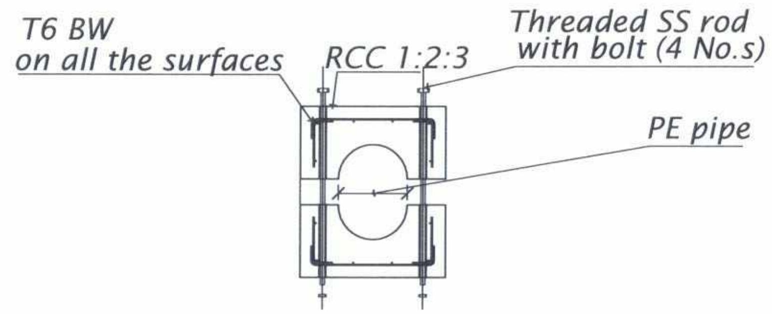


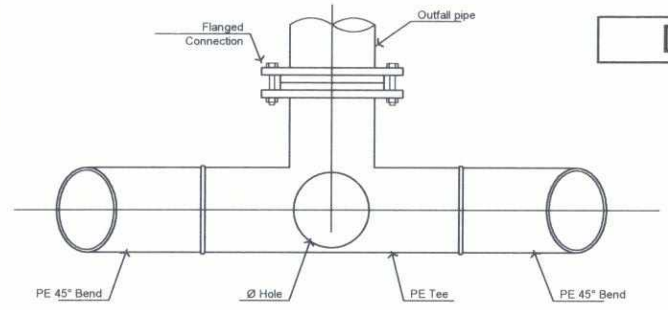
Sectional Elevation

Scale - 1:25

NOTE:

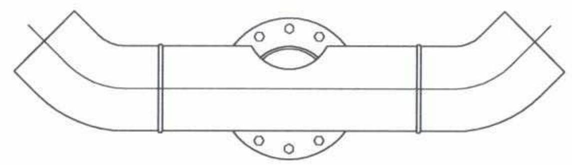
Cover to the reinforcement shall be 75mm

DIFFUSER



Plan

Scale 1:10



Front Elevation

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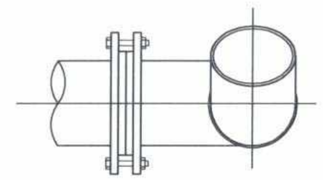

Side Elevation

Scale 1:10

MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 3323209, Fax: (+960) 3324306, E-mail: mwsc@dhivehinet.net.mv	CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY MALDIVES	PROJECT: DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS S.HITHADHOO	SCALE : AS GIVEN	DRW NO. : HTD/SOF-2	DESIGN BY: PAUL	DRAWN BY: ASWATHI	AMMENDMENTS:
	CONSULTANT:	CONTENTS: SEA OUTFALL DETAIL (CONCEPT)	DATE : 12-01-2017	PAGE NO. : 7	STRUCTURAL DESIGN BY:	CHECKED BY:	Revision No: R1 Page: 07 of 7

Land, Building and Municipal Services Department, ލޭންޑް، ބިލްޑިންގ އެންޑް މިއުނިސިޕަލް ސަރވިސަސް ޑިޕާޓްމަންޓް،
Addu City
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Ministry of Housing and Infrastructure
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بسم الله الرحمن الرحيم

Ministry of Environment and Energy
Male', Republic of Maldives.

މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީ
މާލެ، ދިވެހިރާއްޖެ.

Date: 2nd February 2017

No.: 438/MWSC/2017/15

Mr. Ibrahim Fazul Rasheed
Managing Director
Male' Water and Sewerage Company Pvt. Ltd.
5th Floor, Fen Building, Ameenee Magu,
Male; 20375,
Republic of Maldives

Dear Sir,

Sub: Design and Build Basis for Sewerage Collection Network, Sewage Pump Stations and Sea Outfall and Allied Works in S. Hithadhoo (North and South Region), Maldives

Reference is made to your letter number: MWSC-C/1/2016/7800 (dated 7th December 2016) and letter number: MWSC-C/1/2016/7994 (dated 14th December 2016).

Please be informed that the locations proposed for the Pump Stations has been approved. Attached please find the letter from Ministry of Housing and Infrastructure for your information.

Therefore, please proceed to submit the revised concept design and proceed with the EIA for the project

Thank you.

Sincerely,

Shaheeda Adam Ibrahim
Director General

Green Building, Handhuvaree Hingun,
Maafannu, Male', 20392, Republic of Maldives.
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+(960) 301 8301
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މާފަންނު، މާލެ، 20392، ދިވެހިރާއްޖެ.
secretariat@environment.gov.mv
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www.facebook.com/environment.gov.mv

Land, Building and Municipal Services Department, Addu City
Ministry of Housing and Infrastructure

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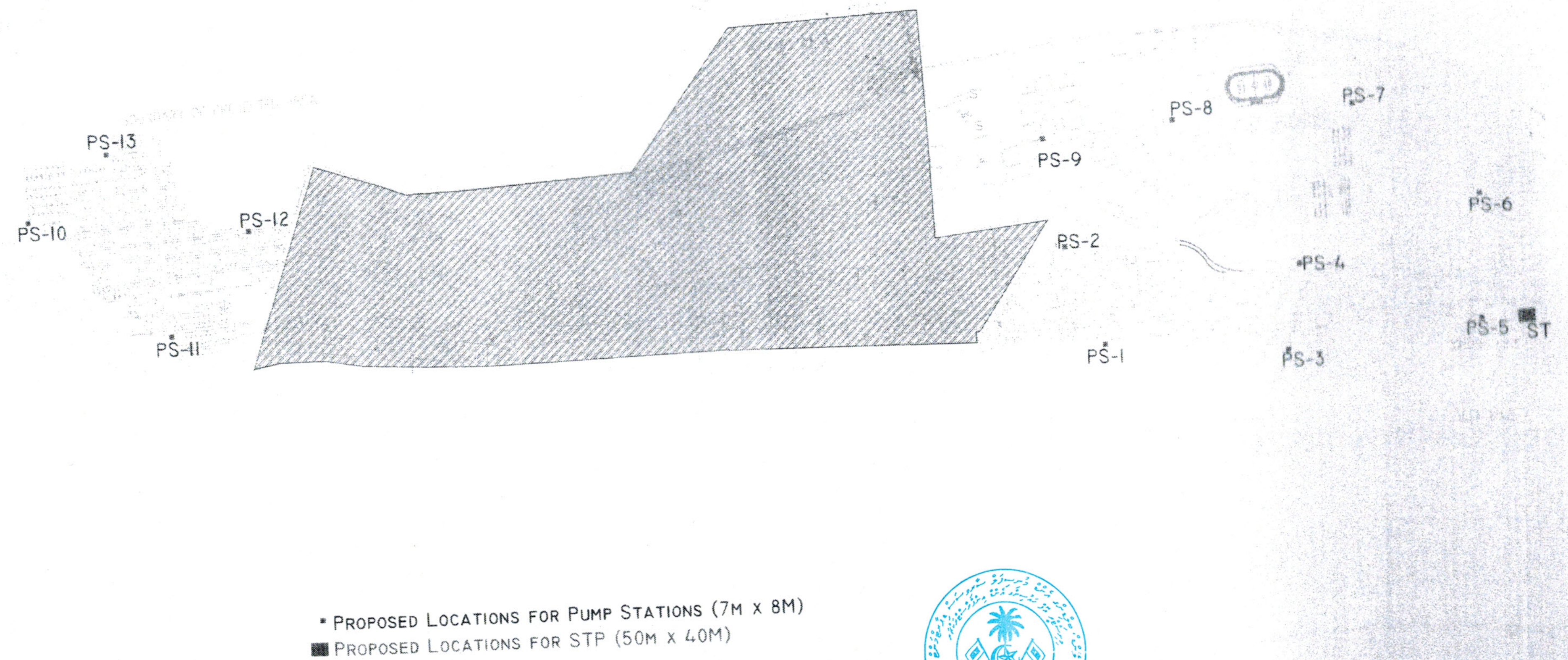
www.twitter.com/HousingGovMv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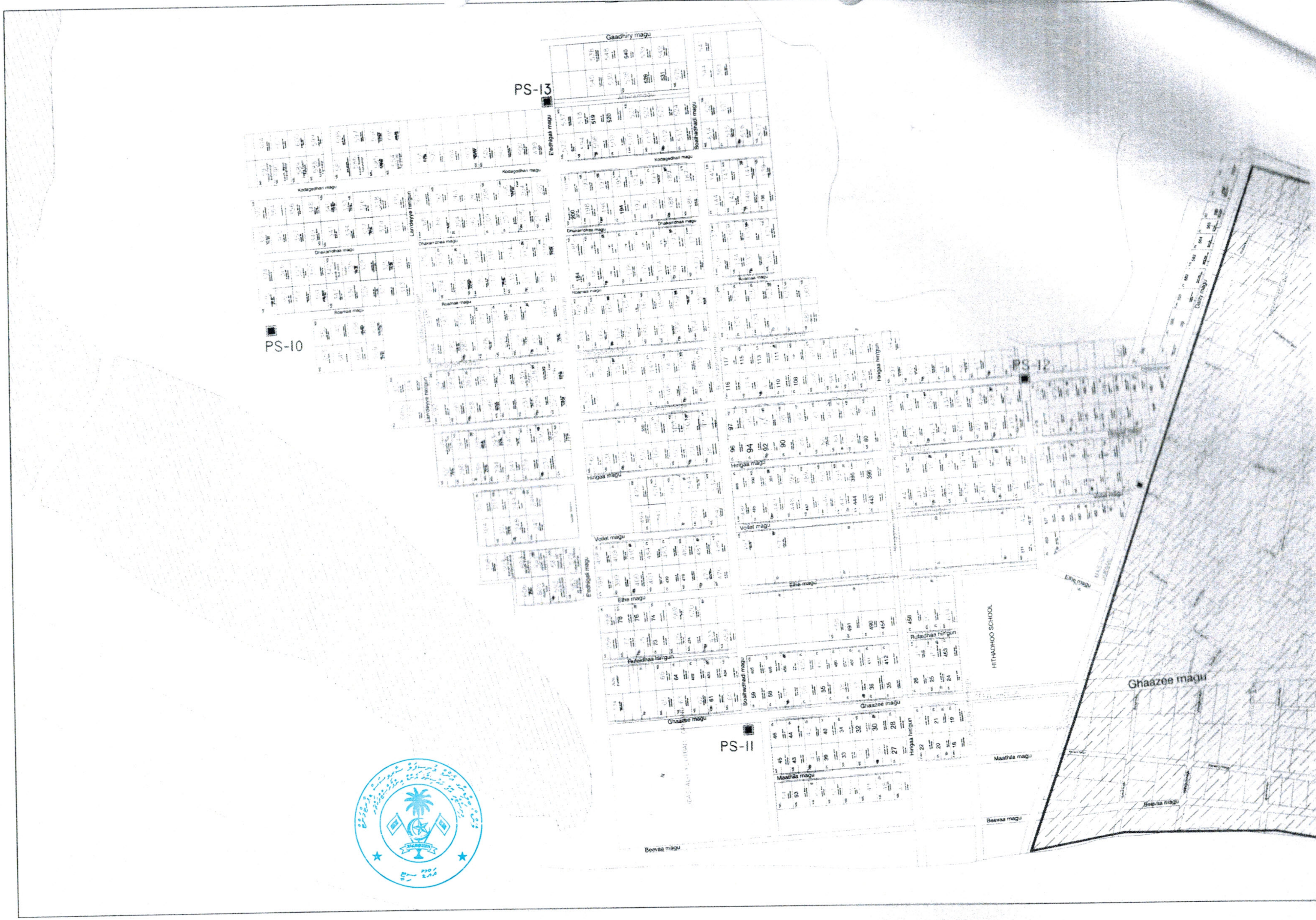
ST
* Proposed Locations for Pump Stations (7M x 8M)
■ Proposed Locations for STP (50M x 40M)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Higaa magu
Violet magu
Elhe magu
Rufaidhaa hin'gun
Ghaazee magu
Maathila magu
Beevaa magu
Dainy magu
HITHADHOO SCHOOL
Ghaazee magu

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Odassau 552 Goathi
Rashuthere 1814 Goathi
Maamendhoo 1428 Goathi
3794
Urban area 3594310 hec
Reserve area 1242541 hec
Total landarea 4836851 hec
East gai hury 417 goathi
West gai hury 510 goathi
Alah dhinumah 186 goathi
Mulhi jumla 1113 goathi
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PS-5
PS-6
PS-7
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Kan'bihaa magu
Feeshimaa magu
Goavaa magu
Aareyfe Magu
Burevi magu
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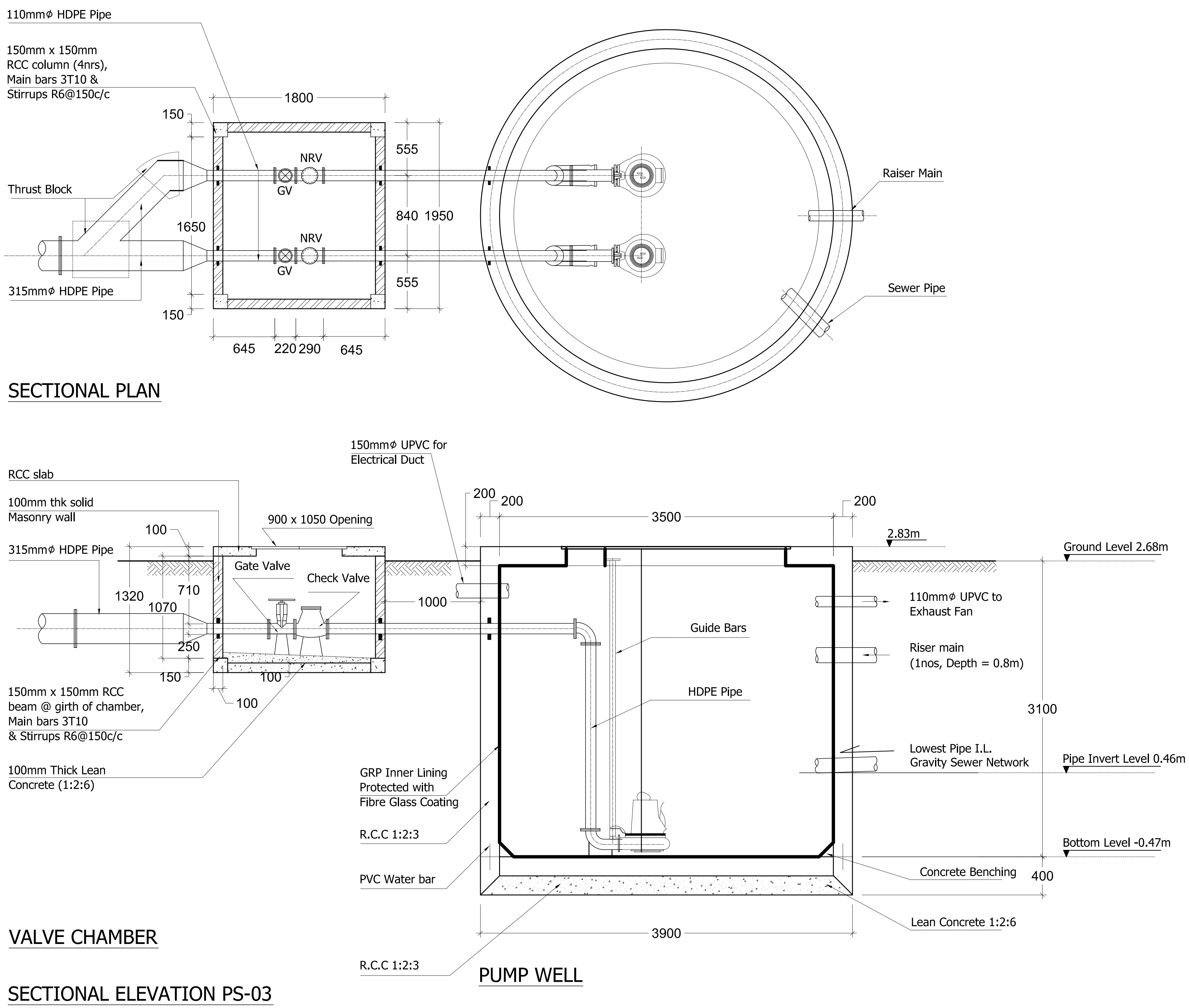
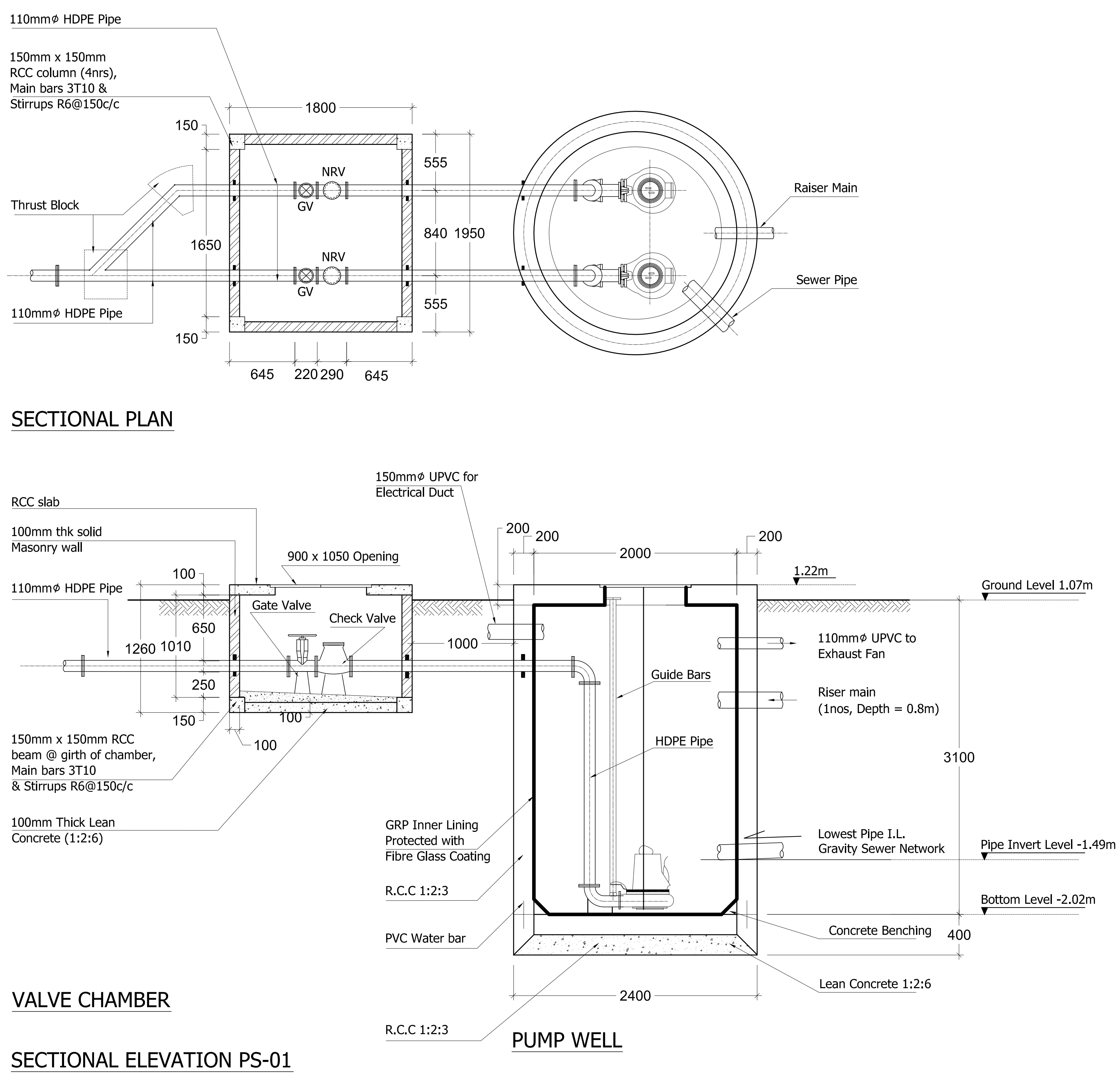


MWSC MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 332 3209, Fax: (+960) 332 4306, E-mail: mwsc@dhivehinet.net.mv	**CLIENT:** MINISTRY OF ENVIRONMENTAND ENERGY, MALDIVES	**PROJECT:** DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO (NORTH & SOUTH)	**SCALE:** 1:50	**DRW NO :** S.HITHA/SN/PS-03	**DESIGN BY:** PAUL	**DRAWN BY:** ASWATHI		**AMMENDMENTS:**
	CONSULTANT:	**CONTENTS:** SUMP & VALVE CHAMBER DETAILS - PS3	**DATE:** 04-APRIL-2017	**PAGE NO :** 134	**STRUCTURAL DESIGN BY:** NASIH	**LICENCE NO:** BDR2014118E	**SIGNATURE:**	



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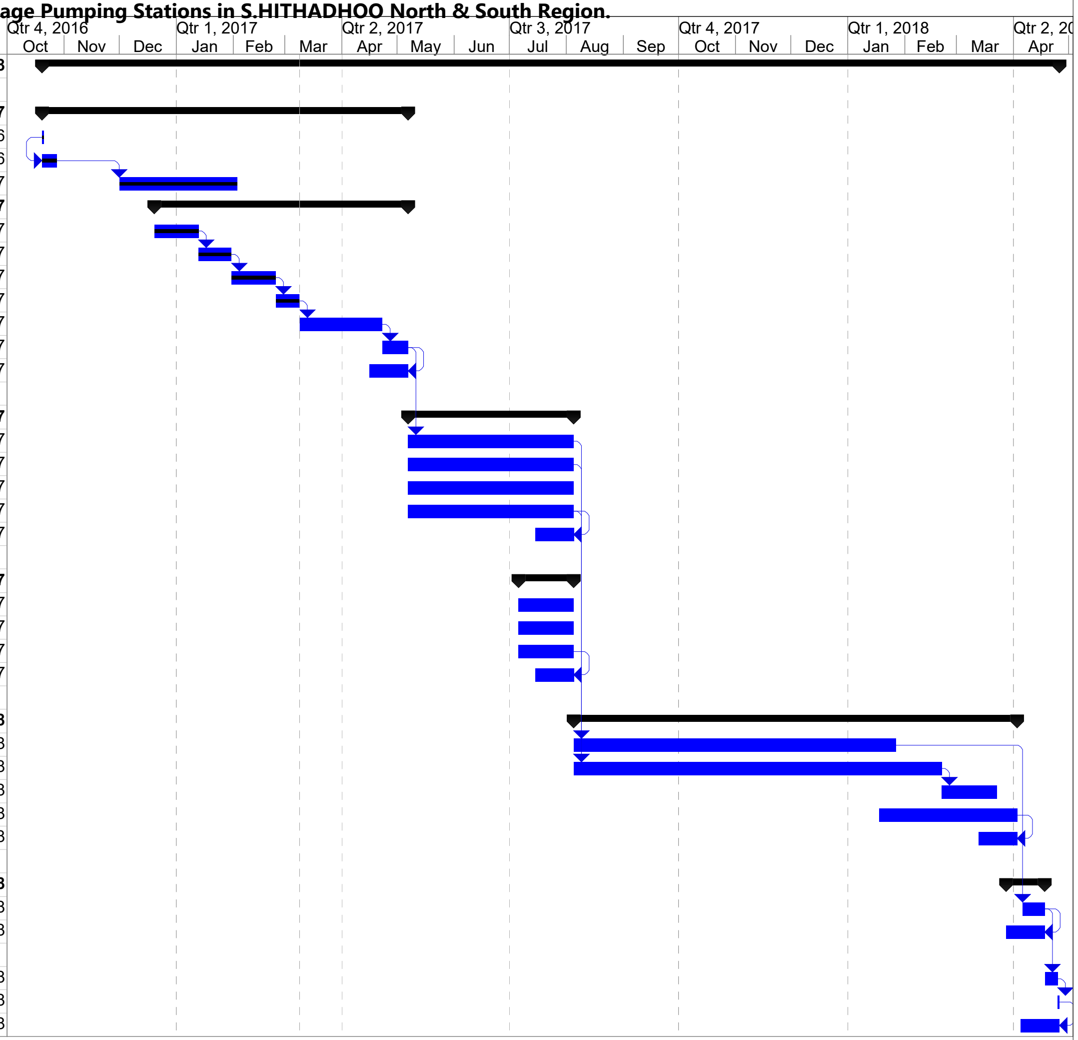
CLIENT: MINISTRY OF ENVIRONMENTAND ENERGY, MALDIVES	**PROJECT:** DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO (NORTH & SOUTH)	**SCALE:** 1:50	**DRW NO :** S.HITHA/SN/PS-01	**DESIGN BY:** PAUL	**DRAWN BY:** ASWATHI		**AMMENDMENTS:**
CONSULTANT:	**CONTENTS:** SUMP & VALVE CHAMBER DETAILS - PS1	**DATE:** 04-APRIL-2017	**PAGE NO :** 132	**STRUCTURAL DESIGN BY:** NASIH	**LICENCE NO:** BDR2014118E	**SIGNATURE:**	

Appendix 4 Construction and work schedule

Design and Built Sewerage Collection Network, Sewerage Pumping Stations in S.HITHADHOO North & South Region.

ID	Task Name	Duration	Start	Finish
1	**Design and Built Sewerage Collection Network,**	**553 days**	**October 20, 2016**	**April 25, 2018**
2				
3	**Survey and Design**	**199 days**	**October 20, 2016**	**May 6, 2017**
4	Commencement of works	1 day	October 20, 2016	October 20, 2016
5	Survey for Pump Station Location	8 days	October 20, 2016	October 27, 2016
6	Approval of Pump Station Location from	64 days	December 1, 2016	February 2, 2017
7	**Sewerage system Design**	**138 days**	**December 20, 2016**	**May 6, 2017**
8	Concept design preparation	24 days	December 20, 2016	January 12, 2017
9	Concept design Review	18 days	January 13, 2017	January 30, 2017
10	Concept design revision	24 days	January 31, 2017	February 23, 2017
11	Concpet design approval	13 days	February 24, 2017	March 8, 2017
12	EIA & Detail Design	45 days	March 9, 2017	April 22, 2017
13	Design & EIA approvals	14 days	April 23, 2017	May 6, 2017
14	Survey & design payment	21 days	April 16, 2017	May 6, 2017
15				
16	**Procurement of Materials**	**90 days**	**May 7, 2017**	**August 4, 2017**
17	Pipes and fittings	90 days	May 7, 2017	August 4, 2017
18	Catch Pits, Manholes, frames	90 days	May 7, 2017	August 4, 2017
19	Pumps, electric Panels. Jetting machine.etc	90 days	May 7, 2017	August 4, 2017
20	SRC cement	90 days	May 7, 2017	August 4, 2017
21	Delivery on site payment	21 days	July 15, 2017	August 4, 2017
22				
23	**Site Mobilization for Construction**	**30 days**	**July 6, 2017**	**August 4, 2017**
24	Establishment of Contractors office	30 days	July 6, 2017	August 4, 2017
25	Establishment of Material Storage	30 days	July 6, 2017	August 4, 2017
26	Establishment of Accomodations	30 days	July 6, 2017	August 4, 2017
27	Site Mobilization payment	21 days	July 15, 2017	August 4, 2017
28				
29	**Civil Works**	**241 days**	**August 5, 2017**	**April 2, 2018**
30	Pumping Stations	175 days	August 5, 2017	January 26, 2018
31	Sewerage Network/House connections	200 days	August 5, 2017	February 20, 2018
32	Pumping Main	30 days	February 21, 2018	March 22, 2018
33	Sea Outfall	75 days	January 18, 2018	April 2, 2018
34	Civil works payment (Note: Interim payment	21 days	March 13, 2018	April 2, 2018
35				
36	**Mechanical & Electric works**	**21 days**	**March 28, 2018**	**April 17, 2018**
37	Pumping Stations	12 days	April 6, 2018	April 17, 2018
38	Electro-mechanic works payment	21 days	March 28, 2018	April 17, 2018
39				
40	Testing & Commissioning	7 days	April 18, 2018	April 24, 2018
41	Project Handover	1 day	April 25, 2018	April 25, 2018
42	Final Payment	21 days	April 5, 2018	April 25, 2018



Date: March 9, 2017

Task		External Tasks		Manual Task		Finish-only	]
Split		External Milestone	◆	Duration-only		Progress	
Milestone	◆	Inactive Task		Manual Summary Rollup		Deadline	⇩
Summary		Inactive Milestone	◇	Manual Summary			
Project Summary		Inactive Summary		Start-only	[		

Appendix 5 Concept design reports

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

The design report is prepared for the "Sewerage Collection Network & Sewerage Pumping Stations for the Island of S. Hithadhoo (North & South Region)". The incorporated system design is complete with the design of Sewerage Network Scheme, Pump Stations and Marine sea outfall.

1.2 SEWERAGE NETWORK SCHEME

The sewerage scheme to be designed for Hithadhoo (North and South region) to accommodate the future population of 14,999 in the year 2051. The north and south region of sewerage system works independently and not incorporate with center region sewerage system. The design is based on the present layouts of buildings and houses on the island and island development master plan provided by the Hithadhoo Island Council. The sewerage network scheme for the island shall be:

1.2.1. Network Statistics

The Type of Sewerage System : Conventional Sewerage System

No. of Pumping stations : 4nos in North region and 9nos in South region (including disposal PS)

Type of Manholes : 425ø and 600ø Prefabricated PE Manhole

Total no. of Manholes : 175nos in North region and 486nos in South region

Total length of Gravity main : 7,955.00m in North region and 24,015.00m in South region

Total length of Force main : 1,288.00m in North region and 4,424.00m in South region

Total No. of Sea outfall line : 1no in each region

Total length of Sea Outfalls : According to EIA and approval from EPA

(Attached layout drawing (concept):

1.2.2. Pump Stations

Pump Stations has been designed for each of the respective catchment zones of the sewerage network scheme. Each pumping stations shall transfer its collected sewage to the disposal pumping station located in each region (North & South region) through the HDPE pressure pipes.

(Attached drawing shows pumping station locations & force main (concept):

1.2.3. Catchment Basins

The sewerage network for Hithadhoo North and South region proposed with fourteen catchment basins (or zones).

North Region:

Total catchment basins (zones) : 4 nos

No. of Pumping stations : 4nos (including disposal pump station)

Maximum depth of Gravity mains : 2.5m from ground level

Maximum depth of Pump stations : 3.5m from ground level

South Region:

Total catchment basins (zones) : 9 nos

No. of Pumping stations : 9nos (including disposal pump station)

Maximum depth of Gravity mains : 2.5m from ground level

Maximum depth of Pump stations : 3.5m from ground level

1.2.4. Salient features of pump stations

Type of Pump stations : Reinforced cement concrete with fiber coated inside

Diameter of the Pump stations : Minimum 2.0m diameter (To be decided upon final design)

Depth of the Pump station : Maximum 3.50m depth (To be decided upon final design)

No. of pumps to be provided : Submersible pump 1 working + 1 stand-by (both pumps will be utilized on rotational basis)

Pump Capacity to be provided : (To be selected upon final design)

(Attached drawing shows typical pumping station (concept):

1.2.5. Sea Outfall

Sewage from the disposal pumping station will be pumped out to the deep sea through sea outfall discharging to at a certain depth which is approved by EPA according to EIA. (EIA will be done before final design and decided the depth of discharge). 2nos of sea outfalls proposed in the island which is to be pumped out separately the sewage from North and South region.

(Attached drawing shows proposed location of sea outfall and typical detail (concept):

1.2.6. Sewerage System Operation and Maintenance

Mobile Sewer Jetting Machine has been proposed for cleaning sewer lines.

For running sewage pumping stations during power-cut situation, a Diesel Generator set has been provided in each of the sewage pumping station.

2.0 GENERAL INTRODUCTION

The purpose of this report is to describe and present the concept design for the sewerage system proposed for Hithadhoo north and south region.

The design parameters will be based on the qualitative and quantitative assessments taken from island and with reference existing guidelines on water and sewerage demand and usage in the Maldives context.

Where possible the report will concentrate on incorporating the required information based on the national guidelines and criteria provided for a project of this nature

3.0 DESCRIPTION OF THE ISLAND

Hithadhoo is located in Addu Atoll at 0° 36’ 0” S and 73° 05’ 0” E and it is the administrative capital of Addu city. Distance from capital Male’ is 530km which can be covered within 1hr 40min by plane. Nearest airport is Gan International Airport which locates at a distance of 12km and linked by a causeway. The natural land area is approximately 525Ha and length is 7.8km. It is the second largest settlement by means of population (approx. 12,000/island record) and also the second largest inhabited island in the Maldives.

A Vacuum sewer network system is under construction in the central region of the island. A water network with overhead tanks are also established and the service in planned to begin in a near future. Electricity is already established in the island and the service is provided by FENAKA Corporation.

A large marsh land called ‘Eedhigali Kilhi’ is located at the north end which is an environmentally protected area. Apart from that there is also another marsh land at the south which is called ECC area.

Ground water level is generally shallow when compared to other islands. A large area at the south of the island is filled with vegetation.

The north and south region of the island also populated (approx. 7,500/according to area) and currently no sewerage system implemented in these two areas.

4.0 SURVEY AND CONSULTATION WITH COMMUNITY

Before preparing the concept, the Island was surveyed to identify the available locations for Pump Station which is needed for the design. The locations were discussed with the Island Council. Further, discussions were made with Utility providers to identify the locations of their cables. This is to avoid/minimize damage during construction on other service provider's line while laying the Sewer line.

Refer Survey report in Appendix 1 for further details on the survey.

5.0 DESIGN METHODOLOGY

5.1 DESCRIPTION OF THE PROPOSED SEWER SYSTEM

5.1.1. SUMMARY

A gravity sewer system is proposed in the north and south side of the Island separately. The gravity sewerage network is divided into four zones in north area with four pumping stations and nine zones in south area with nine pumping stations. Totally thirteen pumping stations are proposed for north and south area of the island. Four Pumping Stations in the south area and nine pumping stations in the north area will be constructed for collection of sewerage which is integrated by pumping mains. From the main Pump Stations sewerage is pumped out by means of the sea outfall.

5.1.2. THE PIPE WORK

The sewer network starts at the household level from the lavatories flowing directly under gravity in to uPVC pipes buried in ground on the roads delivering waste water in to pumping stations and pumped under pressure in to a disposal pumping station.

a. GRAVITY MAIN

The main gravity flow network sections of the piped system will consists of the 160mm OD and 110mm OD uPVC pipes, Inspection chambers and PE Manholes.

b. FORCE MAIN

The force main or pressure flow network will comprise of PE pipes, gate valves, non-return valves, etc. Layout thus described is for the sewage collection system is shown in attached drawing.

c. SEA OUTFALL

The sea outfall will comprise PE pipes, anchor blocks, gate valves, non-return valves, 'T' diffuser, etc. Layout thus described is for the sewage disposal system is shown in attached drawing.

d. PROPERTY /HOUSE CONNECTIONS

The main line installed on the road is to be connected to the private properties by sloping Y-branching pipe which will be laid up to the properties plot boundary and incorporated with a branch connection inspection chamber. The waste water pipe line from the properties will ideally be connected to an inspection chamber which will assist to stop harmful gases from the sewer to enter the fixtures at the property. (Attached method statement for house connection)

5.1.3. PUMP STATIONS

North region

Total four pumping stations are to be constructed to receive the flow from the gravity flow system in North region. Each of the pump stations will have two submersible pumps of appropriate delivery capacities. The flow from three pump stations are to be pumped under pressure in to the forth pump station which is to be designed as disposal pumping station. From disposal pump station the sewage will be pump out to sea via sea outfall-01

South region

Total nine pumping stations are to be constructed to receive the flow from the gravity flow system in South region. Each of the pump stations will have two submersible pumps of appropriate delivery capacities. The flow from eight pump stations is to be pumped under pressure in to the ninth pump station which is to be designed as disposal pumping station. From disposal pump station the sewage will be pump out to sea via sea outfall-02

The force mains are to be designed with carrying capacities that can accommodate future demands and should be laid with HDPE pipes.

The pump controls are to be of appropriate float switches to control pump operations with varying depth of fluid in the chamber. The power source for the pump stations is to be from main power distribution grid on the island. The power control panel board is to be located nearby and under panel shelter.

5.1.4. ODOR CONTROL UNIT

Odor control unit to be provided in the pumping station to expel the foul gas generated in sewer network. PE/uPVC vent shaft of 6m height shall be considered. The vent stack will be constructed with GI pipes.

The vent stacks are used for the release of gases by installing a blower from inside the well and are located at each pump station.

5.1.5. TREATMENT PLANT AND DISPOSAL (IN LATER STAGE)

In later stage one treatment plant shall be constructed with considering both regions sewerage flow and the pumping line shall be bypassed from the disposal pump station to the treatment plant. The treated effluent will then be pumped out to sea via one of the existing sea outfall which is located south and north region.

5.2 DESIGN CRITERIA

5.2.1. Target Population

The volume of wastewater is estimated based on the current population and the projected population for the design life of the project in consideration with the developmental plans for the island.

As per the census 2006 (Department of national planning) the total population of the island was 9,465 persons with growth of 0 .01 and the census 2014 (National bureau of statistics) the total population in the island recorded as 11,129 persons. Hence the population growth considered with the both census and assumed the maximum growth as 2.0 for the sewerage design.

According to the island record the current population of the island is 12,000. As per the area distributed for the three regions, the population in the North region assumed as 1,800 and in the South region assumed as 5,700 persons. During the projected life time of 35years for the project it is expected that the growth rate increase steadily and consideration is given to influx of population for economic activities in addition to the static population. Hence it is estimated that population figure for the design period to be 3,600 in North region and 11,399 persons in South region.

North Region

Table-1: Estimated population growth (north region)

Year	*No. of year*	*Local & Expat growth AVG.(2.0 pa)*	*Progressive growth*
2016	0	1800	1800
2021	5	1987	1987
2026	10	2194	2194
2031	15	2422	2422
2036	20	2674	2674
2041	25	2953	2953
2046	30	3260	3260
2051	35	3600	3600

The population estimation was thus done as follows;

- Existing population = 1800 persons (Island council, October 2016)
- Population growth rate= 2.0 (projected)
- Design life for the project= 35 years
- Estimated Target design population = 3,600 persons
- The design horizon for all the pump replacement considered for 15years

South Region

Table-2: Estimated population growth (south region)

Year	*No. of year*	*Local & Expat growth AVG.(2.0 pa)*	*Progressive growth*
2016	0	5700	5700
2021	5	6293	6293
2026	10	6948	6948
2031	15	7671	7671
2036	20	8470	8470
2041	25	9351	9351
2046	30	10324	10324
2051	35	11399	11399

The population estimation was thus done as follows;

- Existing population = 5700 persons (Island council, October 2016)
- Population growth rate= 2.0 (projected)
- Design life for the project= 35 years
- Estimated Target design population = 11,399 persons
- The design horizon for all the pump replacement considered for 15years

5.2.2. Estimated Design Flow

Maldives Island being populated by ethnically and culturally monotonous groups people with similar habits leading to the characteristics of the daily use of water and daily generation of wastewater quantitatively and qualitatively are somewhat similar in majority of the islands, as far as the design is considered. Hence the absence of reliable records for Hithadhoo on the daily consumption and wastewater generation rates, data from island has been used to estimate the design flows for S. Hithadhoo (North &South region).

For the purposes of estimating Average Dry Weather Flow (ADWF) the flowing waste water flow rates shall be used.

Table-3: Waste water flow rates used for estimating ADWF

Waste water Source	*Unit*	*L/Unit/D*
Domestic	Person	120
Mosque	Person	16
Community Center	Person	12
Product Center	Person	12
School	Person	16
Hospital	Bed	40
Office	1000²ft	400

For the purpose of estimating Average Wet Weather Flows (AWWF) infiltration shall be 10% of ADWF taken as per EPA guidelines.

North Region

Table-4: Wastewater loading estimations for full 35 years design period (north region)

No	*Description*	*Est. Qty*	*Unit*
1	Water Consumption (Daily Average)	150	(l/p/d)
2	Estimated wastewater loading with 80% of total Consumption	120	(l/p/d)
3	Target design population (North region) year2051	3,600	(persons)
4	Wastewater loading (Daily Average) ADWF	432.00	(m3/day)
5	Flow Peaking factor	3	
6	Projected daily Peak flow	1,296.00	(m3/day)
7	Total length of pipe lines	7,955.00	m
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows		
8(a)	Sewage Loading per meter length (average)	0.054	(m3/day)
8(b)	Design Loading per meter length (average)	0.00063	(l/s)
8©	Design Peak Loading per meter length	0.0019	(l/s)
9	Infiltration (10% of ADWF)	43.20	(m3/day)
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	475.20	(m3/day)
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	1,339.20	(m3/day)

Table-5: Wastewater loading estimations for full 15 years design period (north region)

No	*Description*	*Est. Qty*	*Unit*
1	Water Consumption (Daily Average)	150	(l/p/d)
2	Estimated wastewater loading with 80% of total Consumption	120	(l/p/d)
3	Target design population (North region) year2031	2,422	(persons)
4	Wastewater loading (Daily Average) ADWF	290.64	(m3/day)
5	Flow Peaking factor	3	
6	Projected daily Peak flow	871.92	(m3/day)
7	Total length of pipe lines	7955.00	m
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows		
8(a)	Sewage Loading per meter length (average)	0.037	(m3/day)
8(b)	Design Loading per meter length (average)	0.00042	(l/s)
8©	Design Peak Loading per meter length	0.0013	(l/s)
9	Infiltration (10% of ADWF)	29.06	(m3/day)
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	319.70	(m3/day)
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	900.98	(m3/day)

South Region

Table-6: Wastewater loading estimations for full 35 years design period (south region)

No	*Description*	*Est. Qty*	*Unit*
1	Water Consumption (Daily Average)	150	(l/p/d)
2	Estimated wastewater loading with 80% of total Consumption	120	(l/p/d)
3	Target design population (North region) year2051	11,399	(persons)
4	Wastewater loading (Daily Average) ADWF	1,367.88	(m3/day)
5	Flow Peaking factor	3	
6	Projected daily Peak flow	4,103.64	(m3/day)
7	Total length of pipe lines	24,015.00	m
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows		
8(a)	Sewage Loading per meter length (average)	0.057	(m3/day)
8(b)	Design Loading per meter length (average)	0.00066	(l/s)
8©	Design Peak Loading per meter length	0.00198	(l/s)
9	Infiltration (10% of ADWF)	136.79	(m3/day)
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	1,504.67	(m3/day)
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	4,240.43	(m3/day)

Table-7: Wastewater loading estimations for full 15 years design period (south region)

No	*Description*	*Est. Qty*	*Unit*
1	Water Consumption (Daily Average)	150	(l/p/d)
2	Estimated wastewater loading with 80% of total Consumption	120	(l/p/d)
3	Target design population (North region) year2031	7,671	(persons)
4	Wastewater loading (Daily Average) ADWF	920.52	(m3/day)
5	Flow Peaking factor	3	
6	Projected daily Peak flow	2,761.56	(m3/day)
7	Total length of pipe lines	24,015.00	m
8	The sewer sheds selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes is as follows		
8(a)	Sewage Loading per meter length (average)	0.038	(m3/day)
8(b)	Design Loading per meter length (average)	0.00044	(l/s)
8©	Design Peak Loading per meter length	0.00133	(l/s)
9	Infiltration (10% of ADWF)	92.05	(m3/day)
10	Average Wet Weather Flow AWWF (ADWF + infiltration)	1,012.57	(m3/day)
11	Peak Wet Weather Flow PWWF(3*ADWF + infiltration)	2,853.61	(m3/day)

5.2.3. Zone area flow calculation (35 years design period)

The sewer zones selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes considered for calculating the each zone flow.

Table-8: Wastewater loading estimations for full 35 years design period (Zones- North region)

Network area	**Length of Gravity network (m)** (Zone area length)	**Average Dry weather flow (ADWF)** (L*sewage loading per m)	**Average Wet weather flow (AWWF)** (ADWF + infiltration)	**Peak factor**	**Peak wet weather flow (PWWF) Year 2051** (3*ADWF+ infiltration)
		(m^3/day)			
PS10 area/Zone	1544.55	83.41	91.75	3	258.57
PS11 area/Zone	3271.56	176.66	194.33	3	547.66
PS12 area/Zone	1434.61	77.47	85.22	3	240.15
PS13 area/Zone	1704.41	92.04	101.24	3	285.32

Table-9: Wastewater loading estimations for full 35 years design period (Zones- South region)

Network area	**Length of Gravity network (m)** (Zone area length)	**Average Dry weather flow (ADWF)** (L*sewage loading per m)	**Average Wet weather flow (AWWF)** (ADWF + infiltration)	**Peak factor**	**Peak wet weather flow (PWWF) Year 2051** (3*ADWF+ infiltration)
		(m³/day)			
PS1 area/Zone	2131.96	121.52	133.67	3	376.72
PS2 area/Zone	1687.33	96.18	105.80	3	298.15
PS3 area/Zone	2501.99	142.61	156.87	3	442.10
PS4 area/Zone	1862.89	106.18	116.80	3	329.17
PS5 area/Zone	2171.62	123.78	136.16	3	383.73
PS6 area/Zone	3369.70	192.07	211.28	3	595.43
PS7 area/Zone	3466.25	197.58	217.33	3	612.49
PS8 area/Zone	3791.39	216.11	237.72	3	669.94
PS9 area/Zone	3031.98	172.82	190.11	3	535.75

5.2.4. Zone area flow calculation (15 years design period)

The sewer zones selected results in smooth distribution of the residences and institutions resulting in fairly uniform loading of the wastewater each of the pipes laid in the sewer networks. Hence the sewage loading per meter run for gravity main collection pipes considered for calculating the each zone flow.

Table-10: Wastewater loading estimations for 15 years design period (Zones- North region)

Network area	**Length of Gravity network (m)** (Zone area length)	**Average Dry weather flow (ADWF)** (L*sewage loading per m)	**Average Wet weather flow (AWWF)** (ADWF + infiltration)	**Peak factor**	**Peak wet weather flow (PWWF) Year 2031** (3*ADWF+ infiltration)
		(m³/day)			
PS10 area/Zone	1544.55	57.15	62.86	3	177.16
PS11 area/Zone	3271.56	121.05	133.15	3	375.25
PS12 area/Zone	1434.61	53.08	58.39	3	164.55
PS13 area/Zone	1704.41	63.06	69.37	3	195.50

Table-11: Wastewater loading estimations for 15 years design period (Zones- South region)

Network area	**Length of Gravity network (m)** (Zone area length)	**Average Dry weather flow (ADWF)** (L*sewage loading per m)	**Average Wet weather flow (AWWF)** (ADWF + infiltration)	**Peak factor**	**Peak wet weather flow (PWWF) Year 2031** (3*ADWF+ infiltration)
		(m³/day)			
PS1 area/Zone	2131.96	81.01	89.12	3	251.14
PS2 area/Zone	1687.33	64.12	70.53	3	198.77
PS3 area/Zone	2501.99	95.08	104.58	3	294.73
PS4 area/Zone	1862.89	70.79	77.87	3	219.45
PS5 area/Zone	2171.62	82.52	90.77	3	255.82
PS6 area/Zone	3369.70	128.05	140.85	3	396.95
PS7 area/Zone	3466.25	131.72	144.89	3	408.32
PS8 area/Zone	3791.39	144.07	158.48	3	446.63
PS9 area/Zone	3031.98	115.22	126.74	3	357.17

6.0 DESIGN RECOMMENDATIONS

6.1 RECOMMENDATIONS

The sewerage network scheme to be designed for Hithadhoo (north &south region) to accommodate the future population of 14,999 as project of the year 2051. The design is based on the present layout of buildings and houses on the island and the future development scheme prepared by the Island council.

The proposed sewerage network scheme for the Island is a Conventional Sewage System with a gravity flow networks integrated pump stations, a pressure network leading to a disposal pumping station and pumping out the sewerage to the sea via sea outfall. In later stage the pressure lines from disposal pumping station shall bypass to sewerage treatment plant and pump out the effluent through the one of the same sea outfall.

The sewerage system in north and south region will work independently and the networks are divided into separate catchments basins or zones to minimize depth of excavation for the pipes for the given slopes.

The catchment basin is designed with sufficient capacity to cater for the reception of sewage generated at average wet weather flows.

The sewerage system is design with assumption of full flow velocity to be at least 0.60m/sec, with a minimum pipe slope of 1 in 250, and access chamber spacing of not more than 60m, and with inspection chambers within the boundary perimeter of each property. The gravity main sewer pipes to be of uPVC minimum of 160mm. The lateral pipes to be of type uPVC minimum of 110mm OD and force main pipe to be od HDPE material with minimum size 110mm OD.

The sewerage network scheme to be designed according to the regulations and specifications provided by relevant government authorities and without any deviations.

7.0 SEWERAGE SYSTEM DESIGN

7.1 SEWERAGE NETWORK

7.1.1. Peak Factor

Since, population is less than 20,000 and for Conventional Sewerage, Peak Flow Factor shall be 3.0 per capita water supplies is limited to maximum 150 lpcd [Note: 70 to 80 percent of the water consumption rates mentioned shall be used in calculating the sewage flows (ie: 120 lcpd used in this case which is 80% of the maximum per capita)] . These figures are in alignment with the recommendations from EPA for conventional sewerage system in Maldives.

7.1.2 Pipe Material and Size

The Proposed type of material to be used for the sewer pipe is uPVC pipes and fittings are to be used as they are readily available in the Maldives and local know how to using these materials good and it is suggested for all gravity sewers for the project. Hence it is proposed, SN8 solid wall and rubber ring jointed for all gravity sewer mains are to be used. The minimum pipe diameter for house laterals shall be 110mm OD and main gravity sewer size will be 160mm OD as per Maldives EPA recommendation.

Main gravity sewer pipe & pressure line size shall be designed according to sewer flow and velocity. The colour for the pipes is proposed as below;

Gravity line: uPVC non-pressure pipes and fittings (brown/Orange)
Wastewater pumping main: HDPE pipes and fittings (Black)
Sea Outfall: HDPE pipes and fittings (Black)

7.1.3. Infiltration

In this project all the sewer manholes will be installed on the road area and pipes have flexible joints. The infiltration shall be considered to about 10%.

For the purposes of estimating Average Wet weather Flow (AWWF) infiltration shall be taken as 10% of ADWF.

For the purposes of estimating Peak Wet Weather Flow (PWWF) the Average Dry Weather Flow shall be multiplied using a peak flow factor given by Babbit’s formula and plus infiltration.

7.1.4. Hydraulic design

Manning’s Equation will be used to design the sewerage system and defined below.

Design Formula

Sewer network design has to be carried out with help of Manning’s Formula ie;

$Q=AxV$

$V=1/nxR^{2/3}xI^{1/2}$

Q:Designwastewaterflowincl.reservecapacity(m^3/s)

A:Sectionareaofsewageinpipe(m^2)

V:Velocity(m/s)

N: Roughness coefficient

R: HydraulicRadius=A/P(m)

P:Wettedperimeter(m)

I:Slope

7.1.5. Minimum velocity

Velocity of gravity sewer primarily depends upon slope/gradient of sewer and it is influenced by sewer size. The network shall be designed with minimum velocity 0.60m/sec for full flow conditions.

7.1.6. Depth of flow in pipe

For conventional sewer, depth shall be restricted to 80% of full pipe maximum.

7.1.7. Pipe Gradient

The minimum slope required for 160mm conventional sewer is 1 in 250 (0.40%) and this gradient has to be used in design. Since the chosen slope of 0.4% allows the use of only one duty pump and one standby pump per pump station for the Hithadhoo (north & south region) sewerage system. Thus this slope has to be adopted for the gravity line of the sewers consistently throughout the network excluding the lateral connections.
However the flow analysis will be carried out and finalize the gradient during final design.

7.1.8. Minimum and maximum Pipe depth

In order to minimizing the number of pump stations required, the minimum depth of pipe should allow for maximum fall of the pipeline over a specified distances. For pipelines in public roadways in Maldives Islands it is considered that the standard minimum cover requirement is 500mm.

The maximum depth of pipeline excavation should be limited to 2.5m. This will allow for the installation of pump stations to a depth around 3.5m. The principle of gravity sewer shall be followed with respect of ground water table.
Even though the ground water table is high in Hithadhoo Island, excavation and dewatering shall be done with fixing shoring sheets and more wok forces shall apply during construction to avoid work delays due to more dewatering and shoring works.

7.1.9. Sewer bedding

The sewer pipe must be embedded in wet well graded, compacted bedding material. If original soil is unstable, suitable bedding materials should extend at least 100mm below the bottom of the pipe to 300 above the crown of the pipe.

7.1.10. Manhole and Inspection chamber

For conventional system Manhole / Access Chamber spacing of not more than 60m and shall be provided at street crossings, change of slope, change of size/direction of street sewer. The manhole shall be of plastic material like uPVC or HDPE.

In the Main network Manhole/Access Chambers of two sizes are used. They are 600mm diameter manholes (1.20m to 2.50m depth range) and access chamber/inspection chamber of size 425mm (0.50 to 1.20m depth range). The specifications of Manholes/Access Chambers are provided in the table below.

7.1.11. Odor Control

Odor control unit to be provided in the pumping station to expel the foul gas generated in sewer network. PE/uPVC vent shaft of 6m height shall be considered. The vent stack will be constructed with GI pipes. The vent stacks are used for the release of gases by installing a blower from inside the well and are located at each pump station.
The blower shall be selected during final design as per the pump station volume.

7.1.12. House Connections

In this design the House connections to sewer comprise of the pipe work from Household inspection chamber to the main sewer line. The recommended pipe diameter is 110mm. The connection to the sewer main is by 'Y' branch joint. Thus all property connections to the sewer main will include an OD110mm gravity sewer laid a minimum grade of 2.5% to facilitate the flow of solids.

A pre-fabricated catch pit will be placed at the boundary of each property connection prior to downstream connection with a Y fixture, lateral connection. The maximum depth of the connection will be 600mm. The households should provide the provision to connect with connection chamber in this area.

7.2 PUMPING STATIONS

7.2.1. General Conditions

For the Island Hithadhoo, pumping stations are necessary in this sewerage system of due to the high water table and limited depth clear of the water table to allow for the pipe to be laid as further away from the ground water lens. This mainly due to the flat terrain and the expense of deep excavation in soft soil with high ground water table. The pump station will lift the flow from deep sewer and discharge to a disposal pump station through pumping main.

The pumping station generally comprises a wet well, submersible sewage pumps (one duty and one stand by) and an adjacent valve chamber. The pumping station will be below ground level with an adjacent panel shelter for pump control.

7.2.2. Location selection

A comprehensive study was carried out in locating the pump station with respect to the area to be served to ensure entire tributary can be adequately drained with respect to future overall development of the area. The availability of land, scope of expansion, type of equipment and their arrangement, structure, external appearance and general aesthetics were some of the basic consideration in the design of the proposed pumping stations. The site thus been selected generally the agreement with the issues mentioned below

- Proximity to population
- Pumping station should be easily accessible under all weather conditions
- Site should be aesthetically satisfactory
- Site should not be flooded at any time
- Minimum adverse impact considering wind direction
- A bye-pass from pumping station to be easily connected to sea outfall
- Availability of land with respect to further growth and future development

7.2.3. Structure of pumping stations

Total Thirteen pumping stations (including disposal PS) are to be constructed to receive the flow from the gravity flow system in North and south region and are made with reinforced cement concrete with internal FRB coatings. Sulfate resistant cement shall be used for constructing sump wells.

7.2.4. Valve Chambers

Valve chamber will be constructed to the adjacent side of the sump well for fixing valves in an accessible condition. One gate valve and non-return valve shall be fixed on the discharge line on each of the pumps.

7.2.5. Wet Well Capacity

In the case of wet well the volumes of the wells to be estimated based on application of a functional relationship which establishes the minimum capacity of a wet well that is needed to ensure that the maximum cycle time between pump starts and stops is limited to a desired minimum time interval. The relationship is expressed by the following formula

$V = QT/4$
V= Live storage capacity
Q= Maximum peak flow pumping requirement (Equal to max. pump capacity)
T= Pump cycle time (Time between maximum number of starts/hour)
Maximum frequency of starts and stop per hour shall be restricted to 6 and the retention time in wet well shall not exceed 30 minutes at average flow. Cycle of operation of each pump shall not be less than 5 minutes.

7.2.6. Pump Selection

The head required will be equal to the maximum static lift plus friction losses in pipe and other minor loss like from bends, valves, etc.

7.2.7 Pump Technology

7.2.7.1. Pumping system

The proposed sewerage system is gravity system using pumping stations for final effluent disposal to deep sea via disposal pumping station. The individual pumping stations in the network will discharge the wastewater through the pumping main to the sump of the disposal station.

Flygt submersible N series pumps will be used in pump stations. The number of pumps in each pump station will be two (1working + 1 Standby), each having the peak wet weather flow capacity of the catchment zone). The highest efficiency values for typical single vane pumps are around 70% but flygt N pump series deliver 80% or better at 10-15% lower power consumption. And flygt pump maintains this efficiency even in fluids with high solid fibrous content. Required spare parts for operation and maintenance of the pumps will be available from xylem, Hong Kong branch.

7.2.7.2. Pump Station control panel

Standalone onsite operable control panel with adequate incoming power source will be installed at each pumping station together with appropriate system protections. The control cabinet/ enclosure, control cables, instrument protections, indicator meters, switches, lights etc shall be equivalent or comply with standard industry practice and relevant electrical regulations imposed by Maldives Energy Authority.

7.2.7.3 Design and operational features

The control system will be designed to control two pumps of designed capacity. The pump start stops will work on the high and low water level float switches installed in the collection sump.

The pumps will run on alternate basis i.e if pump P1 is running, P2 will be as standby. On the second start cycle P2 will run while P1 will stay as standby.

Operations of the pumps are controlled by level controllers/switches. A float switch is used as emergency float which will be switched on and alarm buzzer and beacon will be activated if both pumps are faulty or if the water level in the sump reaches the Alarm Level.

The control panel is designed with microprocessor based controller for automatic control and monitoring of the system. The system will alert on situation, as detailed below.

- Pump failure / trip alarm for each pump
- Air blower failure / trip alarm
- High water level alarm
- Supply power failure alarm
- Phase failure alarm
- Low Low level alarm (activated after specified period of time – dry run protection)

Control panel will be installed under a shed to protect from direct sunlight and rain. Cables from the pumps and float switches to the control panel will be laid through a cable duct or trench put in place from the sump up to the control panel mounting shed.

7.2.7.4 Pump Control cabinet/ panel and system protection

Control panel will be designed using IP65 enclosures with 3 phase power supply to adequately control and operate pumps and other equipment required for smooth system operation. Required isolation switches/ breakers, overload protection and others will be provided as per the approved drawing from MEA for proposed pump size of the specific pump station.

7.2.7.5 Conductor color codes

Three phase interface marking for the incoming supply and power circuit will be marked following the color codes provided by MEA as detailed below

For control circuit wiring, conductor color code will be used as follows

Control Voltage type & rating	P / +	N/-
230 Vac	Red (P)	Blue (N)
12 Vdc	Gray (+)	Black (-)
Analogs	Brown (+)	Black (-)
24Vdc	White (+)	Black (-)
Earth conductors	Green or green yellow strip	

7.2.7.6 Indicator meters, switches & lights

The system consists of following indicators, switches and lights and shall be as per the technical specification for conventional gravity sewerage system.

Ammeter	indicate individual pump current rating
Hour run meter (7 digit)	Indicate individual pump running hours
Digital power analyzer (DPA)	For monitoring line voltage current, power consumption, power factor and energy

	consumption of the pump station
indicator lights supply power	7 RED for L1 8 YELLOW for L2 9 BLUE for L3 10 RED: for pump stop / fault indicator 11 GREEN:
Other indicator lamps	12 RED – pump stopped and fault indicators 13 GREEN – pump running indicators 14 YELLOW - High high water level alarm indicators
Push button switch	15 BLACK – Alarm / fault reset switch
3 position selector switch	16 MANUAL – OFF-AUTO selection of the pumps
Float switches	17 Control operation of the pump at preset flow levels. 18 Activate alarm annunciator in case of high high water level pump station
Alarm buzzer/ annunciator	19 Audible alarm signal for high high level water at pump station.

7.3 PUMPING MAIN (FORCE MAIN)

The pressure main uses HDPE pipes for discharge from pump stations to disposal pumping station and from there to discharge to sea with appropriate scour valves and anchor blocks.
The discharge velocities shall have a maximum 4.0m/s to prevent scouring of the pipe walls and a minimum velocity of 2.0m/s to aid in the self-cleaning of valves and fittings.
The minimum pipe diameter for Pumping main (force main) will be 110mm OD as per Maldives EPA recommendation. Pumping main (pressure pipes) to be designed for 35 years as single stage installation. The hydraulic design shall be done based on Hazen-William's formula.

7.4 SEA OUTFALL

The outfall pipe line shall be HDPE and flange connected at least 3-4 pipes interval for easy maintenance and replacement in case of damage. Outfall 'T' diffuser will be fixed at end of pipe line (Length of the sea outfall and drop shall be finalized upon completing EIA). The outfall pipe will be laid on natural bed profile. The minimum pipe diameter for sea outfall will be 110mm OD and provided anchor blocks with 316G stainless steel bolts and nuts.

20 SEWERGE TREATMENT PLANT (IN LATER STAGE)

A centralized Sewerage Treatment Plant to be setup to treat the domestic sewerage to achieve the desired effluent parameters. The location of the STP was approved by stakeholders and endorsed by the relevant authorities (MHI and EPA) via an EIA done for the project. Each STP module shall be designed for the estimated Average Wet Weather Flow (AWWF) over its 15 years design horizon and expandable up to 35years design horizon. 2000 M2 land area shall be allocated for STP with 1220K LD expandable up to 1800KLD along with administrative building.

21 ADMINISTRATIVE BUILDING (IN LATER STAGE)

An administrative building at an area of 15m x 10m is proposed for operational and maintenance/ office staffs of the network operation body.

Alternatively to reduce cost, operation staffs could be accommodated in other existing building if there is enough space and if same operator such as electric operators is given the operation and maintenance of the sewerage system.

22 TESTING AND COMMISSIONING OF SEWERAGE SYSTEM

10.1 TESTING /GRAVITY SEWERAGE SYSTEM

10.1.1. General

A gravity sewerage system shall be tested in separate sections, each section being the complete sewer length between manholes. Testing may be either by the application of air or water pressure.

Each section shall be tested progressively by the Contractor during construction, each time two pipes are laid. An air test is the most convenient for this. No backfilling of trenches shall be carried out until a successful test has been completed on the pipes to be backfilled. After backfilling, complete sections between manholes shall be tested under the inspection of the site engineer.

10.1.2. Precautions prior to Testing

All open ends and connecting branches in gravity sewers shall be stopped with suitable plugs or caps, before testing commences.

Prior to testing of sewers, the internal surfaces of pipes and inspection chambers shall be thoroughly cleansed. Previously cleansed and tested sewers, or existing live sewerage systems, shall not be used to drain water and matter from sewers being cleaned.

10.1.3. Acceptance tests

Each reach of sewer shall meet the requirements of the following acceptance tests which shall be carried out by the Contractor before backfilling.

a) Leak tests (Manholes / Inspection chambers/Catch pits)

b) Alignment (Pipe line)

c) Levels (Manholes/Inspection chambers & Pipe line)

d) Conditions and stability of bed.

Testing of sewer pipe line shall be carried out from manhole to manhole. If the test is unsatisfactory, the contractor shall make good any defects and shall retest the pipes until a satisfactory test has been carried out.

10.1.4 Exfiltration

After completing the installation of a sewer line or section of the line, and before backfilling of the line, an exfiltration test shall be carried out on each reach of sewer between manholes. Individual or multiple reaches may be tested at one time.

Exfiltration and shall be conducted by blocking off all manhole and Y branch openings, except those connecting with the reach being tested, filling the line, and measuring the water required to maintain a constant level in the manholes. Each manhole shall be subjected to at least one exfiltration test.

During the exfiltration test, the average water depth above the pipe invert shall be 2000 mm or the full depth of the upper manhole.

The total exfiltration shall not exceed 30 liters per mm of nominal diameter per km of pipe per day for each reach tested. For purposes of determining maximum allowable leakage, manholes shall be considered sections of 1200 mm pipe. The exfiltration tests shall be maintained on each reach for at least 2 hours and as much longer as necessary, in the opinion of the Engineer to locate all leaks.

10.1.5. Air test for Gravity pipes

Air testing shall be carried out using a U -tube connected to the pipeline. A pressure of 100 mm head of water shall be applied for a period of five minutes and the line shall be accepted if the air pressure remains above 75 mm head of water after this time.

Failure to pass the air test shall not preclude acceptance of the pipeline if a successful water test can subsequently be carried out in accordance with the specification.

10.2 PUMP STATION START-UP AND COMMISSIONING

Pump station start-up and commissioning will be carried out as per the below check list,

Note:
- Pump 1 (P1) is on the left and Pump 2 (P2) is on the right when facing the direction of flow
- Refer site layout drawings for pump station (PS) locations
- Due to the condition at the time of commissioning there might be limited water in sump wells for pumping operation, reading will be taken as based on the actual condition available. Functions and activation of float switches will be checked through simulation if not feasible to be based on actual water. Actuation of float switches can be by lifting of switches by hand.

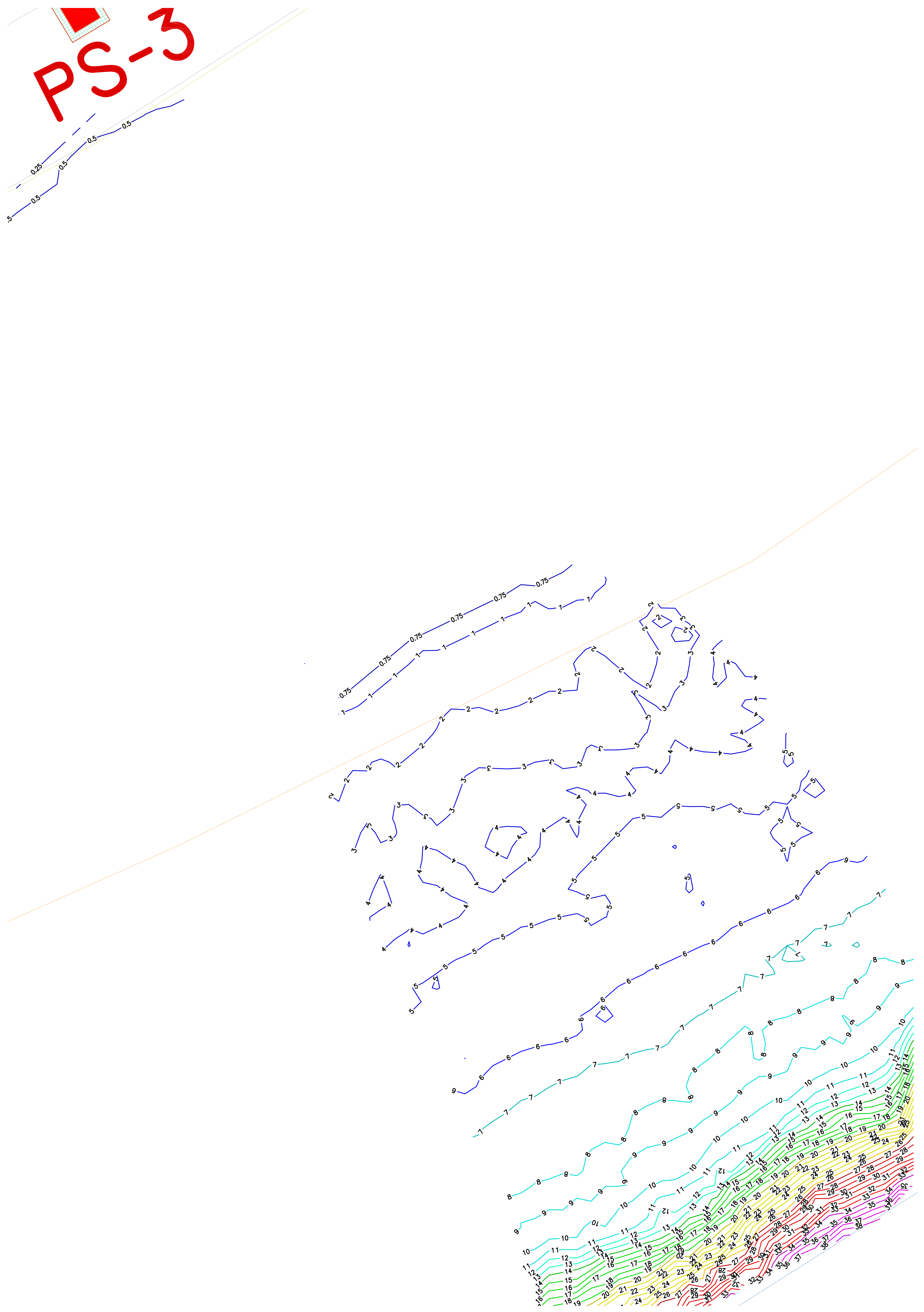
No	Description	Set OR Expected result	Actual result/ Remarks
PART 1: Pre-Start-Up Check			
1.1 Pipe line & Valves			
a	All pipe work, gate valves and check valves within the valve chamber complete, all fasteners and mountings are tightened correctly.	Installed as per the drawings.	
b	Check gate valve of pumping station to be operational and at correct position	Open position following pump checks.	
c	Inspect all check valves from pumping station to the discharge lines are at correct flow direction	Correct flow direction for all check valves.	
1.2 Pump well			
a	All the pipe work within the pump well complete, suitably anchored and guide rails in place	Installed as per the drawings.	
b	Make sure pump well is free of debris that may affect the sewage pump	Wet well is free of rubbish which is likely to damage pumps when it is started.	
c	Check all float switches (FS) have been installed properly and control levels have been adjusted as specified and functional	FS1 ------------------------ FS2 ------------------------- FS3 ------------------------- FS3 -------------------------	

Pumps			
d	Make sure all pumps don't bind when being lifted or lowered		
e	Make sure all pumps sit properly onto the discharge stand		
f	Make sure all pump cables are installed clear of guide rails and not such as to impede removal of the pump		
g	Rotate the pump impeller in hand to ensure they are free to rotate		
h	Confirm correct rotation for all pumps		
PART 2: CONTROL PANEL & ELECTRICAL SYSTEM FUNCTIONAL TEST.			
2.1 Control panel, Power & Control cabling			
a	No sign of visible damage	No visible damage	
b	Control panel secured to mounting structure, earth installed correctly and locks are fitted.	Secured	
c	Conduits installed secured properly.	Secured	
d	Field wiring terminated neatly, labeled and tested for tightness.	Labeled and secured	
e	Check installation and configuration of PLC electrical drawing	Installed properly	
2.2 Power On the control panel and check all incoming and outgoing Voltage			
a	Electrical supply has been connected , energized and meter panels are equipped and wired to supply authority requirement	Incoming power installed	
b	Check operation of phase monitoring relay	Operate properly	
c	Check incoming supply to the control panel is "ON" and has proper voltage and	Incoming supply light "ON" 400V/3Ph/50Hz	Phase R to Y ----------- V Phase Y to B ----------- V Phase Y to B ----------- V

	record		Phase R to N ----------- V Phase Y to N ----------- V Phase B to N ----------- V
d	Check pump No1 Hour run meter	Operational	
e	Check pump No2 Hour run meter	Operational	
f	Check automatic changeover functionality for standby power	Changeover properly	
2.3 Check overload protectors are properly sized			
a	Simulate pump 1 overload trip	Pump 1 fault light ON	
b	Press breaker reset to acknowledge alarm	Alarm acknowledged	
c	Pump 1 overload setting		----------- A
d	Simulate pump 2 overload trip	Pump 2 fault light ON	
e	Press breaker reset to acknowledge alarm	Alarm acknowledged	
f	Pump 2 overload setting		----------- A
2.4 Check pump controller is operational			
a	Activate FS 1 – Low level	No pump runs	
b	Activate FS 2 – duty level	Duty pump runs	
c	Activate FS 3 – Extra high level	Duty & standby pump run	
h	Activate FS 4 – Alarm level	High level beacon activated	
i	De-activate FS3, FS2 & FS1	Both pump stop	
2.5 Pump control and monitor status			
a	Pump 1 run status	Pump 1 run LED ON	
b	Pump 2 run status	Pump 2 run LED ON	
c	Pump 1 Overload trip	Pump 1 Fault LED ON	
d	Pump 2 Overload trip	Pump 2 Fault LED ON	
e	System operation in Utility power	Utility power LED ON	
f	System operation in Standby power	Stand by power LED ON	May not be checked at site if Standby generator is unavailable.
g	Ventilator ON (Optional item)	Ventilator run LED ON	
h	Ventilator tripped or No feedback from ventilator (Optional item)	Ventilator Tripped LED ON	
i	Base line voltage and current during normal operation (with water)	Pump 1 Phase 1 -----V -------A Phase 2 -----V -------A	

		Phase 3 -----V -------A Pump 2 Phase 1 -----V -------A Phase 2 -----V -------A Phase 3 -----V -------A	
PART 3: POST COMMISSIONING			
a	After start-up and commission check, switch all control panels switches, buttons, valves to their normal standby status or as required	System is set to NORMAL	

Appendix 6 Bathymetry Survey map


PS-3


MARINE PROTECTED AREA (EIDHIGALI KILHI)
STP & ADMIN BUILDING
PS-1
PS-2
PS-3
PS-4
PS-5
PS-6
PS-7
PS-8
PS-9
PS-10
PS-11
PS-12
PS-13

Appendix 7 Water Test Results Report from MWSC

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameenee Magu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT
Report No: 500172435

Customer Information:
Land & Marine Environmental
Resource Group Pvt. Ltd

20070

Sample Description	Outfall 1 Hithadhoo	Outfall 2 Hithadhoo	Control Hithadhoo	
Sample Type	Sea Water	Sea Water	Sea Water	
Sample No	83184625	83184626	83184627	
Sampled Date	01/04/2017	01/04/2017	01/04/2017	**TEST METHO**
PARAMETER	**ANALYSIS RESULT**			
Physical Appearance	Clear with particles	Clear with particles	Clear with particles	
Turbidity	0.263	0.146	0.136	HACH Nephelometric Method (adapted from HACH
Nitrate	6.8	4.5	4.7	Method 8039 (Adapted from HACH DR5000 Spec
Nitrogen Ammonia	0.03	0.09	0.02	Method 8038 (Adapted from HACH DR5000 Spec
Sulphate	3000	3150	2900	Method 8051 (Adapted from HACH DR5000 Spec
Phosphate	0.09	0.11	0.09	Method 8048 (Adapted from HACH DR5000 Spec
Biological Oxygen Demand (BOD)	1	1	1	HACH Method 80

Keys: NTU : Nephelometric Turbidity Unit, **mg/L** : Milligram Per Liter

Checked by

Afnan Farooq
Laboratory Executive Gr.1

Approved by

Mohamed Eyman
Assistant Manager, Quality

Appendix 8 List of Stakeholders Consulted

Name	Office / Company	Designation	Contact Number
Ibrahim Naufal	MEE	Project Engineer	3018448
Mariyam Yumna		Project Coordinator	
Ali Mishal	Water Department, EPA	Engineer	3335949
Mohamed Zihan Zuhair	MWSC	Asst. Engineer,	3323209
Ali Sunan		Asst. QS Gr 2	
Mohamed Imran Adnan		Engineering Manager	
Aminath Shaufa	Health Protection Agency	Public Health Program Coordinator	3014496

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ތާރީޚް : 2017-4-2 ގަޑި : 13:15

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1	އަބްދުﷲ ސާދިޤު	މޭޔަރ	އައްޑޫ ސިޓީ ކައުންސިލް	7924030	mayor@adducity.gov.mv
2	މުޙައްމަދު ހިލްމީ	ކައުންސިލަރ	"	7772969	hilmy@adducity.gov.mv
3	ޝިޒްލީނާ އަޙްމަދު	ޑިރެކްޓަރ	"	7782636	shizleena@adducity.gov.mv
4	ޙުސައިން ޒާހިރު	[illegible]	[illegible]	9902143	hussein.zahir@lamer.com.mv
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FENAKA CORPORATION LIMITED
6887559
addu@fenaka.com

#	NAME	DESIGNATION	CONTACT NUM
1	Abdulla Zuhair	Executive Director	7777950
2	Ibrahim Fareed	Senior Engineer	7786433
3	Mohamed Zuhair	Director	9979066
4	Ali Khalid	Deputy Director	7901952
5	Ibrahim Saeed	Asst Manager	7907674
6	Mohamed Naseer	Director	7787197
7	Mausoom Shakoor	Asst.Engineer	7962922
8	Abdulla Naseer	Senior Technician	7978000
9	Mohamed Nazim	Senior Technician	7902922

FENAKA CORPORATION LIMITED

02/04/2017

Environmental Protection Agency
Male', Rep of Maldives

Meeting: Stakeholder meeting with ERC section - EPA
Date: 17-04-2017
Time: 09:00 – 10:00

MEETING ATTENDANCE

	Name	Designation	Office	Email	Phone No.	Signature
01	Rifath Naeem	Senior Environment Analyst	EPA	rifath.naeem@epa.gov.mv	3335949	[signature]
02	Hussain Ibrahim	Asst. Envt. Officer	EPA	hussain.ibrahim@epa.gov.mv	3335949	[signature]
03	Ismail Abidh		Lamer			
04	Hussain Zahir	EIA Consultant	Lamer			
05						
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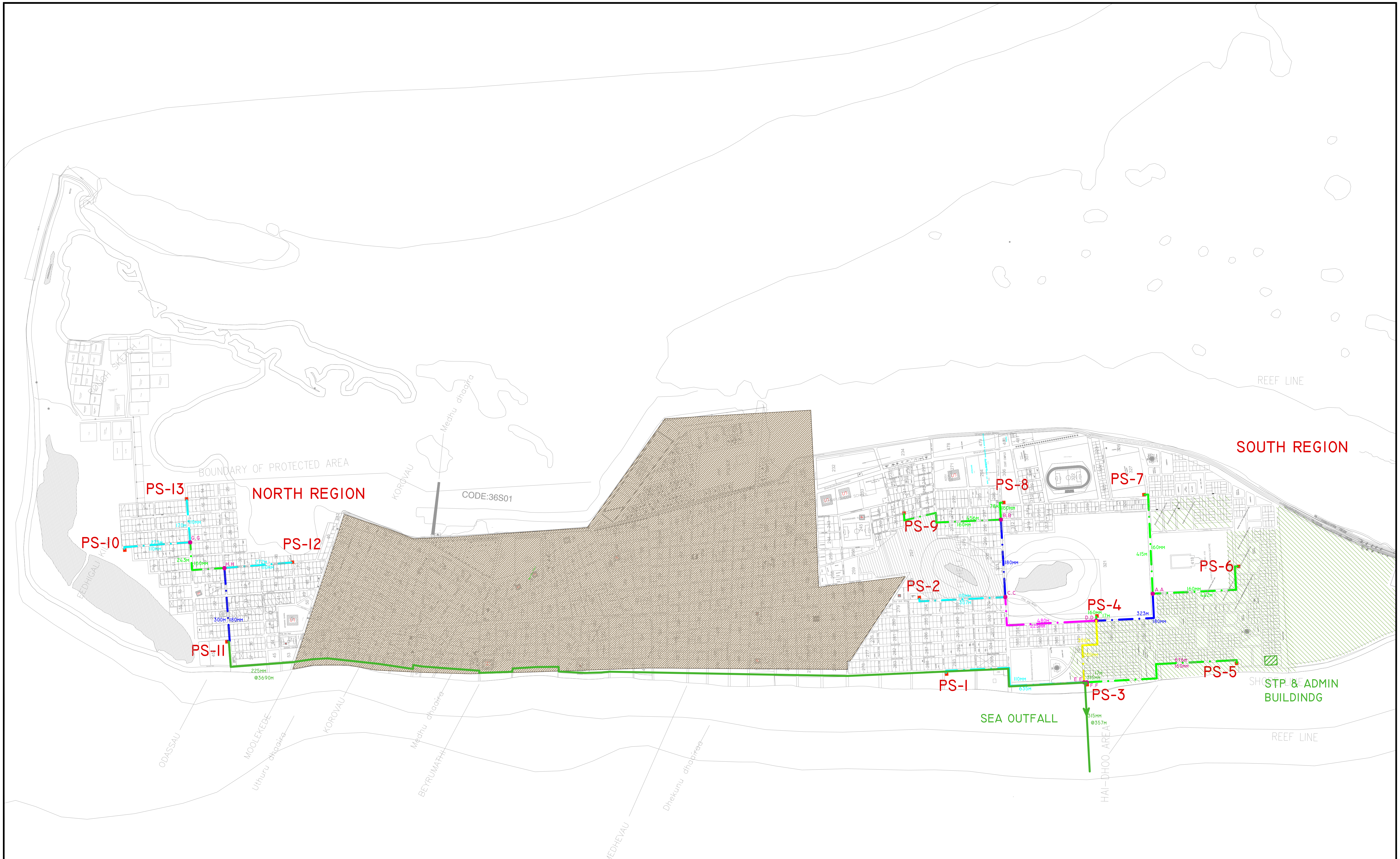
ENVIRONMENTAL PROTECTION AGENCY ★ Male', Rep of Maldives ★

Appendix 9 Scaled map showing alternative outfall location



MALE' WATER & SEWERAGE COMPANY PVT LTD. AMEENEE MAGU, MACHCHANGOLHI MALE' 20-01 REPUBLIC OF MALDIVES Tel: (+960) 332 3209, Fax: (+960) 332 4306, E-mail: mwsc@dhivehinet.net.mv	**CLIENT:** MINISTRY OF ENVIRONMENT AND ENERGY, MALDIVES	**PROJECT:** DESIGN & BUILD BASIS FOR SEWERAGE NETWORK & PS FOR S.HITHADHOO (NORTH & SOUTH)	**SCALE:** NTS	**DRW NO :** S.HITHA/SN/PML-01	**DESIGN BY:** PAUL	**DRAWN BY:** PAUL	**AMMENDMENTS:**
	CONSULTANT:	**CONTENTS:** PUMPING MAIN & SEA OUTFALL LOCATION LAYOUT	**DATE:** 5 APRIL 2017	**PAGE NO :** 131	STRUCTURAL DESIGN BY:	**CHECKED BY:** IMRAN	**REVISION NO:** R-1	**REVISION DATE:** 17 APRIL 2017