ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Water Supply System in Thimarafushi,

Thaa Atoll, Maldives

Proponent:

Ministry of Environment and Energy

Consultant:

Amir Musthafa (EIA 01/13)

November 2016

Table of Contents

Table of Figures

Table of Tables

Consultants Declaration

This EIA has been prepared according to the EIA Regulations 2012. I certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of my knowledge and abilities.

Amir Musthafa (EIA01/13)

Proponent's Declaration

بسم الله الرحمن الرحيم

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

ފަރުގަސްދާއި ތާނަވަރުކަމާއި ތަނާއި ތަރައްގީ ވަޒާރާ
ދަތ، ދިވެހިރާއްޖެ.

Date 23 November 2016

No: 438-PDU/203/2016/110

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

Dear Sir,

Sub: EIA for the Proposed Water Supply System in Th. Thimarafushi

As the proponent of the captioned project, we confirm that we have read the report and hereby confirm our commitment to carry out and bear costs of environmental mitigation measures and monitoring outlined in the EIA report.

Sincerely,

Ajwad Musthafa
Permanent Secretary

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Executive Summary

This Environmental Impact Assessment (EIA) report is prepared in accordance with the Environmental Impact Assessment Regulation 2012 to assess the impacts of proposed development of water supply system at Th. Thimarafushi. This project is proposed by Ministry of Environment and Energy and the impact assessment was carried out by consultants from DCP Pvt. Ltd., lead by lead consultant Amir Musthafa. The construction stage of the project will be undertaken by Puritas Pvt. Ltd.

This impact assessment will identify and determine the significance of potential impact of each major component of the proposed project. Any activity that has a significant impact will be justified and alternatives will be proposed in terms of location and design to mitigate any adverse impact.

The project proposes a water supply system based on desalination and rainwater harvesting. Feed water will be obtained from boreholes drilled over 30m deep. Brine will be discharge in front of the plant facility, 100m away from the beach line. Rainwater will be used to support the RO plant system. The main justification for the project is due to the decrease in quality of the groundwater in the island, as is the case in most islands in the Maldives and therefore to provide continuous supply of freshwater to the public. The integrated water supply system is not designed to cater for the airport facility. The total water production capacity at the facility will be 120 m3/day. The water supply system is designed to cater for 35 years.

Thimarafushi is an island that has undergone significant development in recent history. There has been a major reclamation project as well as airport development. The proposed project will not need to have any significant vegetation removed as there are no such vegetation at the site. Considering the marine environment, there are no significant live corals that could be impacted along the proposed brine discharge location. The proposed site is far away from population center, and therefore will not have any significant impact on the residential environment.

During the stakeholder consultations, all the major stakeholders were quite positive on the project. Their main need was for the project to commence soon. There were other minor concerns that could be attended easily during the implementation of the project. EPA did not that designing the project in such a way that it caters for the airport facility would make the project more feasible and ensure the facility is maintained at a higher level.

Regarding impacts, moderate impacts are expected at the commencement of the project during mobilization and use of heavy machinery and setting up site for the proposed project. Due to the absence of notable environmental features at the site, the construction stage will not have a significant negative impact. However, waste management will be an issue as is always the case. Impacts of note include noise pollution, loss of visual amenity, potential damage to existing cables, health and safety issues, groundwater degradation, marine water quality degradation, impact on marine life, etc. However, most of these impacts were regarded as minor. Major impacts include those due to accidents, for which the probability of occurrence is less.

Mitigation measures were proposed for all impacts. Mitigation measures included following proper safety procedures at site including wearing proper safety clothing, informing the council and community of the project details beforehand, getting information of existing cables from service providers, proper storage of waste and hazardous chemicals, ensuring the quality of water treatment. It is also proposed to place the discharge pipe with ballast blocks to prevent movement of the pipeline during heavy wave activity.

Considering the impacts from the project, it appears that the project would not lead to any long term detrimental impact. On the other hand, the project has several positive impacts to the community including improving the health and lifestyle of the public, improving industries such as tourism and agriculture, thereby facilitating economic growth.

Alternatives for the project including the no project option were also considered. However, it was recommended the project proceeds as proposed based on the feasibility of implementation and the small change to environmental impact that the alternatives will bring.

A monitoring plan has been formulated and will be used to assess the impacts of the proposed system. It is planned that ground water, seawater, and product water will be tested regularly at predefined locations. Findings from the monitoring program will be used to re-evaluate the mitigation measures to reduce any significant negative impact on the environment.

The overall environmental impacts of the project have been assessed using peer reviewed methodology and the results indicated that the proposed project has net positive impact. Given that the project has major socio-economic benefits, minor environmental impacts in addition to improving the health and wellbeing of the community; it is recommended to allow the project to proceed as proposed.

ސާރާ ހުލާސާ

މި ރިޕޯޓަކީ ތ. ތިމަރަފުށީގައި ސާފު ބޯފެން ފޯރުކޮށްދެވޭނެ ނިޒާމެއް ޤާއިމްކުރުން ހިންގަން ފެށުމުން ތިމާވެށްޓަށް އަސަރު ކޮށްފާނެ މިންވަރު ދެނެގަނެ ބަޔާން ކޮށްފައިވާ ކުރެވިފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫޢުގެ އިދާރާއަކީ މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީ އެވެ. މި ރިޕޯޓް ތައްޔާރުކުރެވިފައިވަނީ ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ދެނެގަތުމުގެ ގަވާއިދު 2012 ގައި ހިމެނިފައިވާ ކަންތައްތައް ފުރިހަމަ ކުރެވޭގޮތުންނެވެ. އަދިވެސް މި ރިޕޯޓް ތައްޔާރުކޮށްފައިވަނީ އާމިރު މުޙައްމަދުގެ ދަށުން ޑީ.ސީ.ޕީ ގެ ކޮންސަލްޓަންޓް ޓީމުންނެވެ. މަޝްރޫޢުގެ ކޮންޓްރެކްޓަރުގެ ގޮތުގައި ހަމަޖެހިފައިވާ ފަރާތަކީ ކޮންޓްރެކްޓަރ ކަމުގައިވާ ފުރިހަމަ ބުރިކަ ކޯ އެވެ.

މި ދިރާސާ ރިޕޯޓުގައި ތ. ތިމަރަފުށީގައި ގާއިމްކުރުމަށް ހަމަޖެހިފައިވާ ސާފު ބޯފެން ފޯރުކޮށްދޭ ނިޒާމުގެ މަސައްކަތް ކުރުމާއި އަދި ހިންގުމުގެ ސަބަބުން ތިމާވެށި ވެސް އަސަރުކޮށްދޭ ދެނެގަނެވިފައިވެއެވެ. އެގޮތުން މަޝްރޫޢުގެ އަމަލީ މަސައްކަތް ކުރިއަށް ދާއިރު އެންމެ ބޮޑު ތިމާވެށި ނުރައްކާ އަސަރު ކުރާނީ ތިމާވެށްޓަށް ފޯރާ އަސަރު ކަމަށް ކުރާއިރު ތިމާވެށި ކުރާ އަސަރު ކުޑަކުރުމަށް ގެންގުޅެވޭނެ ފިޔަވަޅު ހިމަނާފައިވެއެވެ. އެގޮތުން މި މަޝްރޫޢު ފޮނުވޭ ކުރުމުގައި ވިސްނާފައިވާ ކަންކަން ފޫހިކޮށްލެވޭ މަޝްރޫޢުގެ މަސައްކަތުގައި ރަނގަޅު ވާނީ ހުރަހެއްވެއެވެ.

ރާއްޖޭގެ ގިނަ ރަށްތަކެއްގެ އެއްފަދައިން ތިމަރަފުށީގައިވެސް އެކަށީގެންވާ ފަދަ ފެން ޕްރޮޖެކްޓް ނިޒާމެއް ގާއިމް ކުރެވިފައިވާ ރަށެއް ނޫނެވެ. އަދި ރަށުގައި ފެނުގެ ބޭނުމަށް ފެންވެރި ނިޒާމެއް ބޭނުން ވަރަށް ބޮޑު ޒަރޫރީ ކަމެކެވެ. މިމަޝްރޫޢުގެ ދަށުން ކަނޑުފެން ބޯފެނަށް ބަދަލުކޮށްދޭ ރިވާސް އޮސްމޯސިސް ޕްލާންޓް ސިސްޓަމް ގާއިމްކުރެވޭނެއެވެ. އަދި ވާރޭފެން ނަގާ ސަޕްލައިކުރަން ފަށާ ސިސްޓަމް ޤާއިމްކުރެވޭނެއެވެ. ރިވާސް އޮސްމޯސިސް ޕްލާންޓަށް ފެން ނަގާނީ 30 މީޓަރު ފުންފެން ވެލްތަކުންނެވެ. އަދި ބޯފެން ރައްކާކުރާ ޕްލާންޓްގެ ކެޕޭސިޓީން 100 ކިއުބިކް މީޓަރު ދުވާލަކު ސަޕްލައިކުރެވޭނެއެވެ. ރިވާސް އޮސްމޯސިސް ޕްލާންޓުން ދުވާލަކު 120 ޓަނުގެ ފެން އުފެއްދޭނެއެވެ. މި ފެން ޕްރޮޖެކްޓު ނިޒާމް ފަރުމާކުރެވިފައިވަނީ 35 އަހަރުދުވަހުގެ މުއްދަތަކަށް ބަލައިގެންނެވެ.

ތިމަރަފުށީގެ ވެށްޓަށް ބަލާއިރު، މިރަށަކީ މިފަދަ ޝަރުތުތަކުގެ ބޮޑު މަޝްރޫޢުތަކެއް ހިންގާފައިވާ ރަށެކެވެ. މިގޮތުން ބިން ހިއްކުމާއި އެއާޕޯޓް ބިނާކުރުމުގެ މަސައްކަތްތަކުގައި ކުރެވިފައިވެއެވެ. އެހެންކަމުން ފުރަތަމަ ތިމާވެއްޓަށް ބޮޑު

ތަފްޞީލްތައް ތިއްބެވެ. ލިބެންދެން ކަނޑައެޅުން ކުރިއަށްދާ ގޮތަށް ކަނޑައެޅުމުގެ ކުރިން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ކަންކަމުގެ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ.

ލ. ކަނޑައެޅުމުގެ ބަދަލުގައި ކަންތައް ހިނގާ ގޮތާ ގުޅޭ ކަންކަމުގެ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ.

ލ. ކަނޑައެޅުމުގެ ބަދަލުގައި ކަންތައް ހިނގާ ގޮތާ ގުޅޭ ކަންކަމުގެ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ.

ލ. ކަނޑައެޅުމުގެ ބަދަލުގައި ކަންތައް ހިނގާ ގޮތާ ގުޅޭ ކަންކަމުގެ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ. ތިން ދުވަހުގެ ތެދުވެރިކަމުގެ ދަށުން ކުރިއަށް ގެންދާ ކަންކަމާ ގުޅޭ ތަފްޞީލް ތިރީގައި ދީފައިވެއެވެ.

1. Introduction

1.1 Introduction

This Environmental Impact Assessment (EIA) report is prepared in accordance with the Environmental Impact Assessment Regulation 2012 to assess the impacts of proposed development of water supply facility at Th. Thimarafushi by Ministry of Environment and Energy. The major components of the proposed project that can be regarded as potentially sensitive to the environment include;

1. Mobilization and site setup
2. Trenching and laying down pipelines,
3. Setting up Desalination plant,
4. Construction of brine discharge outfall.
5. Rainwater harvesting

This impact assessment aims to identify and determine the significance of potential impact of each component of the proposed project. Activities with potential significant impacts will be justified and alternatives will be proposed in terms of location and design to mitigate any negative impact.

This report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be suggested. A mitigation plan and monitoring programme before, during and after the works would also be included. Monitoring would ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

1.2 Need and Justification

The source of potable water in the island are natural sources of water including rainwater and groundwater. The quality of water is well below standards required for human consumption. Rainwater is more than often contaminated at the collection points in the roofs. The water is susceptible to contaminants such as bird droppings, faecal matter of other animals, excessive leaves, etc. Groundwater quality has deteriorated rapidly as with most islands in the Maldives.

The source of groundwater is the thin fresh water lens, which has depleted significantly due to over abstraction. The electronic conductivity, pH and even total coliform and faecal coliform counts are greater than required by international standards and local guidelines. Moreover, protection of the aquifer is vital for the local ecology.

Therefore, recently the government of Maldives has made it a policy to ensure all inhabited islands have safe water supplies that meet basic requirements. There has been several efforts, several projects in numerous islands to better provide water to the communities by improving rainwater harvesting and also by desalinating water.

Desalination is a favorable and feasible option for Maldivian islands, each being surrounded by the sea. Modern day RO plants can be easily installed by a technical team and maintained by the community by following typical guidelines provided by the supplier. In case of any major breakdown, local suppliers are always at hand to replace any components or modules.

The project will therefore provide safe healthy, potable water for the Thimarafushi island community by implementing a feasible and easily maintained water supply system.

The current practice on the island is to discharge the sewage into open pits sometimes with and sometimes without underground septic tanks. Some houses have septic tanks integrated with soak pits and in other situations septic tanks with separated soak ways some distance away from the septic tanks. This practice results in localized and or distributed pollution of the groundwater in the island. The release and spread of pollutants are more noticeable in rainy season although percolation due to rain minimizes rapid salinization of the groundwater.

Majority of the households rely on groundwater for daily non-potable requirements such as bathing, cleaning and to some degree for cooking as well.

1.3 Background to the EIA

This EIA is prepared in accordance with the Terms of Reference (TOR) approved by the Environmental Protection Agency (EPA) on 26th October 2016. It is a legal requirement that new projects having potential for environmental impacts gain environmental clearance or approval prior to construction and operation of such projects.

The principal environmental institution that implements EIA process in the country is Environmental Protection Agency. Additionally, the Ministry of Environment and Energy

provides policy guidance and directions while Atoll Councils and Island Councils also provide approvals before projects are implemented.

1.4 Scope of the EIA and Approach

The main scope of this EIA report is to assess, identify, predict and document potential environmental impacts from the proposed water supply facility development project.

The study will document the whole project proposal in detail, in order to identify the main environmental impacts that are associated with the proposed development, and what component of the development will have the most impact. The study will also cover the legal requirements that need to be taken into consideration while designing and implementing this project.

The environmental impacts can only be understood once the receptor of the impacts are identified and studied. As such, this document also addresses the existing environmental condition of the island and foresees the ways in which potential environmental impacts will be mitigated and/or nullified.

The study further assesses potential alternatives to components of the project and the total project as a whole. These alternatives are studied in terms of how environmentally favorable with respect to the proposed project.

In general, the EIA report has been based upon the following sources of information:

- Project documentation from proponent;
- Preliminary design;
- Discussions with stakeholders;
- Site visits;
- Baseline environmental assessments;
- Legal literature
- Other similar EIAs, and environmental studies undertaken for the site.
- The consultant’s previous experience in similar projects

1.5 Project Tasks completed

The site has been fully surveyed in order to obtain data for design works. Subsequently, preliminary design works have been completed and is now currently in the process of doing detailed design simultaneously with EIA works.

1.6 Project Location and Study Area

Thimarafushi is an island in the Maldives, 222 km South of the capital, Male' and situated at 2.205529°′ north latitude and 73.142935°′ east longitude. The total area of Thimarafushi is 61.2 hectares including the part of the island expanded in 2014 by reclaiming the surrounding lagoon of the island. After the reclamation project, a domestic airport was developed in the newly reclaimed area. Therefore access to the island is convenient.

The closest inhabited island is the capital Veymandoo at just 5.5km towards south west. There is a partially developed uninhabited island called Funaddu just 1.5km south west of Thimarafushi. The only resort island in Th. Atoll is 20km north east of the island. The project site is shown in Figure 1

The closest sensitive areas are in Kanimeedhoo and Veymandoo, which is both more than 5km away from the project site, and will not endure any impact due to this project. There are no designated protected areas in Thaa Atoll.

The proposed study area comprises the island and lagoon and reef areas at proposed and potential outfall locations around the island. The study area/impact area of the project is shown in Figure 2.

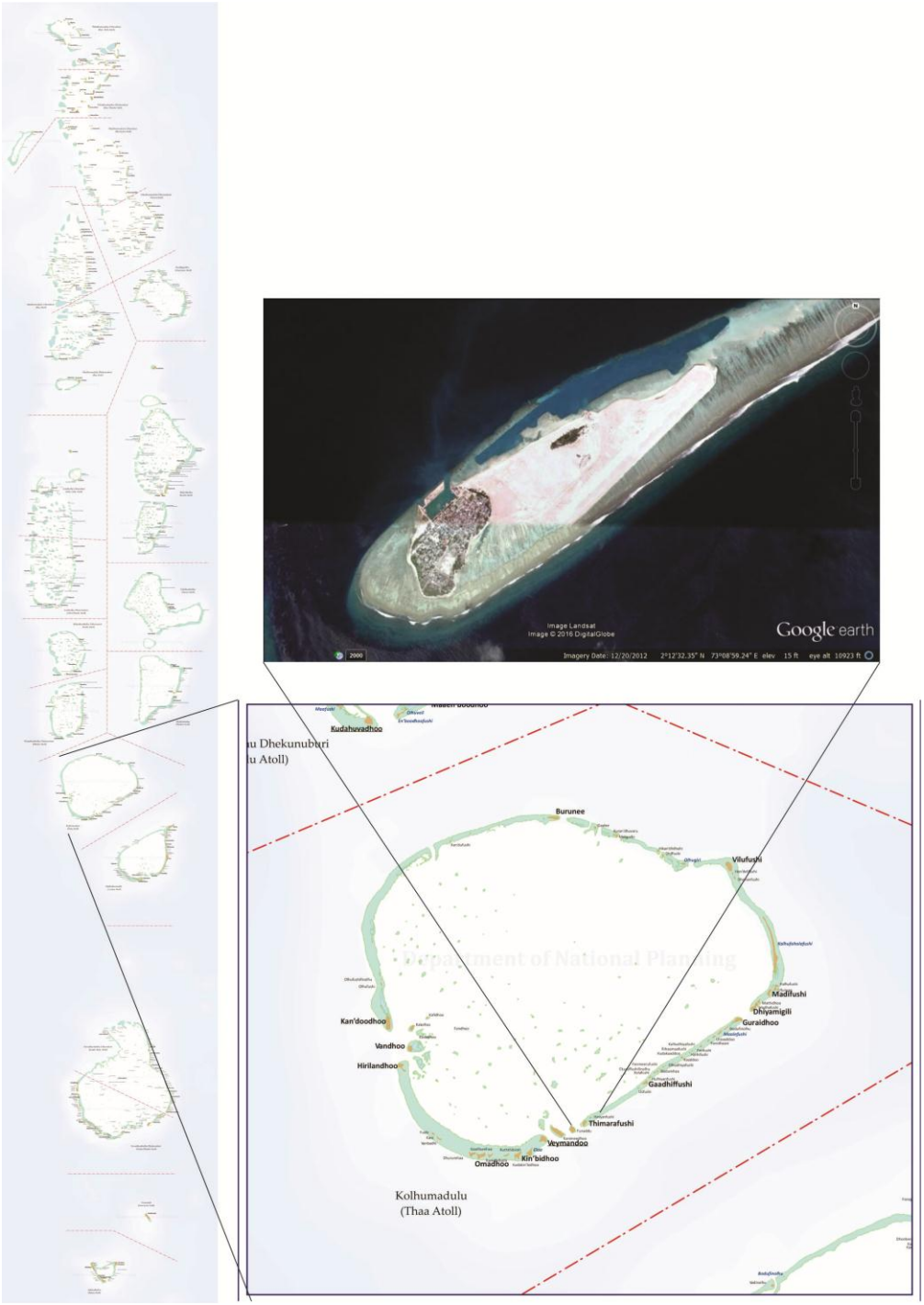


Figure 1 Location of project site

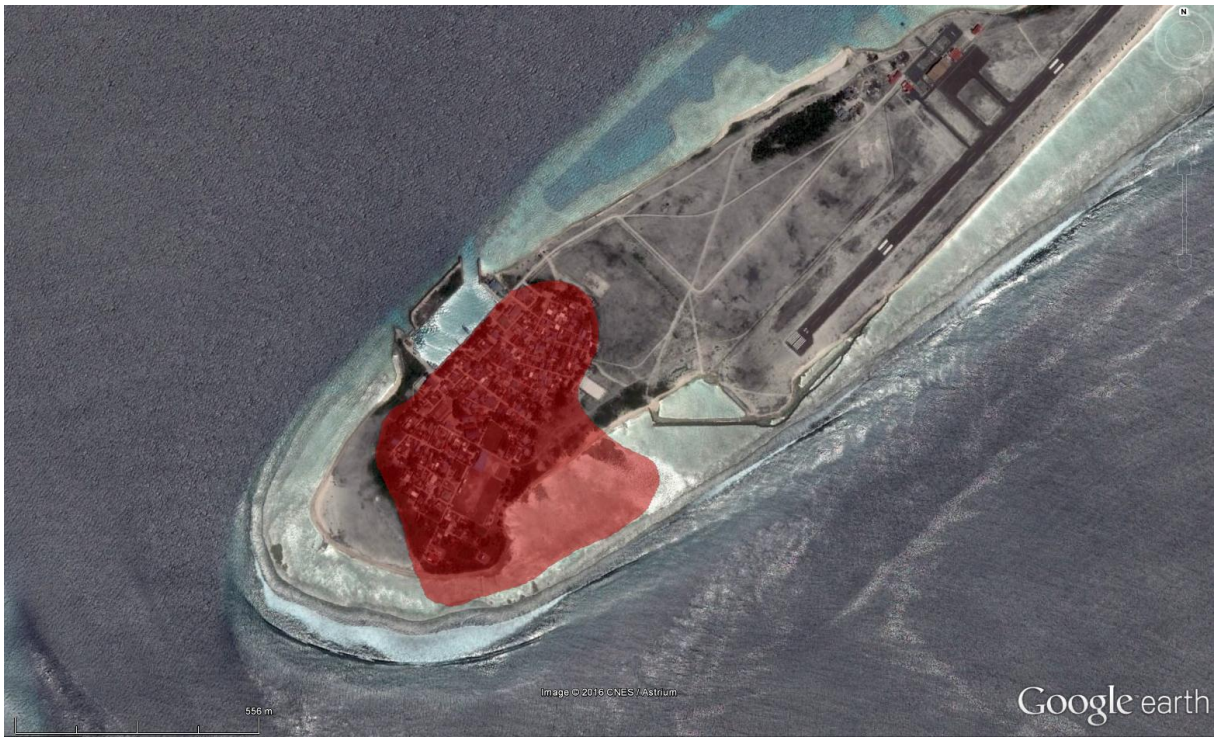


Figure 2 Study Are/Impact Area of the project

1.7 The Proponent & Contractor

The project to develop the water supply system is proposed by Ministry of Environment and Energy (MEE). MEE in the government entity with the mandate for planning and implementing water and sanitation systems in the Maldives. The vision of the Ministry is stated to be *"To ensure that Maldivian's are environment friendly and are aware of environment related issues, and to provide clean water and proper sewerage facilities in a carbon neutral environment for every Maldivian Citizen"*, with an emphasis on clean water. The Ministry is currently implementing numerous water and sewerage projects across Maldives, either through the government budget or through foreign aid.

The project construction works will be undertaken by Puritas Pvt. Ltd. Puritas is an expert environmental service provider, creating solutions for environmental sustainability & management, a developing concern in the modern world. Puritas (Private) Limited was incorporated in 1995 and is renowned for its water and wastewater treatment plants designed and built in Sri Lanka, The Republic of Maldives, Thailand & Indonesia. Puritas is a wholly owned subsidiary of Haycarb PLC and a member of the Hayleys Group of Companies. It is

the exclusive representative of Veolia Water (the world's leading service provider for water and wastewater services) in Sri Lanka and the Republic of Maldives.

1.8 Relevant Studies

In order to prepare this EIA, recent EIA studies for water and sewerage projects undertaken in the Maldives have been carefully studied. Water supply system projects studied include the following;

- EIA for proposed water supply system in L. Fonadhoo (CDE, 2016)
- EIA for proposed water supply system in R. Meedhoo (CDE, 2016)
- EIA for proposed water supply system in Th. Vilifushi (CDE, 2016)

Moreover, previous environmental studies undertaken for the project site, Th. Thimarafushi was also referred. These include the following;

- EIA for the proposed Road construction and coastal protection for Thimarafushi Airport (Sandcays, 2015)
- EIA for the Rehabilitation of the Tsunami damaged harbour at Th. Thimarafushi (Water Solutions, 2008)
- EIA for the proposed reclamation of 24 hactare at Thimarafushi (Water Solutions, 2011)

1.9 EIA Implementation and Methodologies

This study was based mainly on data collected during a field investigation mission on 1 March 2015 by a team from Development Collaborative Partnership Pvt. Ltd (DCP). DCP In association with Puritas Pvt Ltd, contracted by the Ministry of Environment and Energy, is undertaking the design services. Objective of this Design Services is to design the water supply facilities in Th. Thimarafushi Island and to prepare design and generate construction drawings for the actualization of the project, and undertaking Environment Impact Assessment.

The EIA report was compiled by Amir Musthafa, lead environmental consultant for DCP for this project. Amir is a registered EIA consultant with over 5 years of experience who has been involved in numerous water an coastal related projects in the Maldives. Amir was assisted by

Anoosha Hashim, Nafha Aujaaz, and Ibrahim Rashihu, who are all Environmental science graduates with field experience.

Established and widely accepted methods have been applied in this EIA study. Field studies have been undertaken using methods generally employed for EIA studies in the Maldives. The field assessment methodologies are described in Section 4 of this report.

The Terms of Reference (TOR) for this EIA has been attached as Appendix 1. This EIA has been prepared based on this term of reference.

2. Project Description

The project includes 2 main component, which includes;

1. Harvesting and providing clean rainwater
2. Producing and providing desalinated water

Before the project construction works start, a temporary site will be setup at the project site. This section will be divided into the following main sections

1. Project Components
2. Work Methodology
3. Operational activities

The process flow diagram for the whole integrated system is shown in the figure below.

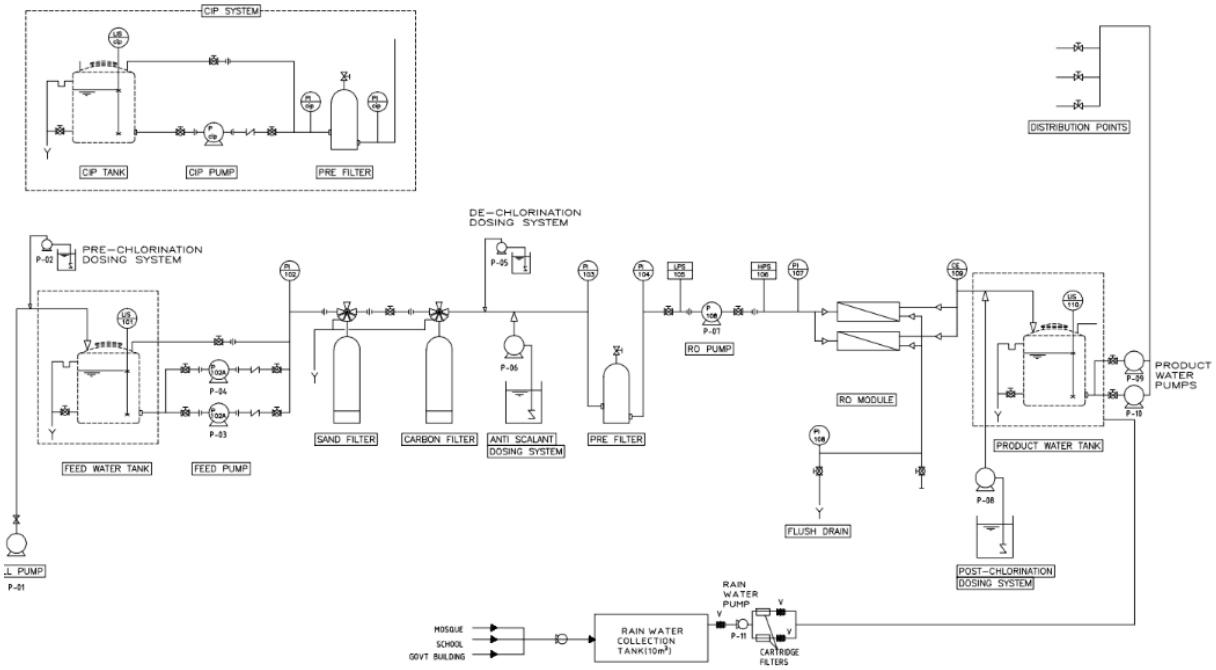


Figure 3 Process flow diagram of the Integrated water supply system (Puritas Pvt Ltd)

2.1 Rainwater Harvesting

A rainwater collection system for public roofs would be built to subsidize and support the water production facility, and introduce saving for the wet months of the year. The rain water collection system consists of collection from existing point of collections, by gravity fed pipeline to a rain water holding tank at the treatment facility.

Rainwater shall provide a backup to the sea water desalination plant during the wet season. The SWRO plants have to be operated only for 4 – 5 hours per day during this period, and this even can be minimized depending on the manufacturer's recommendations.

Key activities of the component include; Preparation of catchment area, temporary storage of water, establishing the rainwater treatment system, establishing water supply network. The rainwater harvesting network is illustrated in the Figure below.

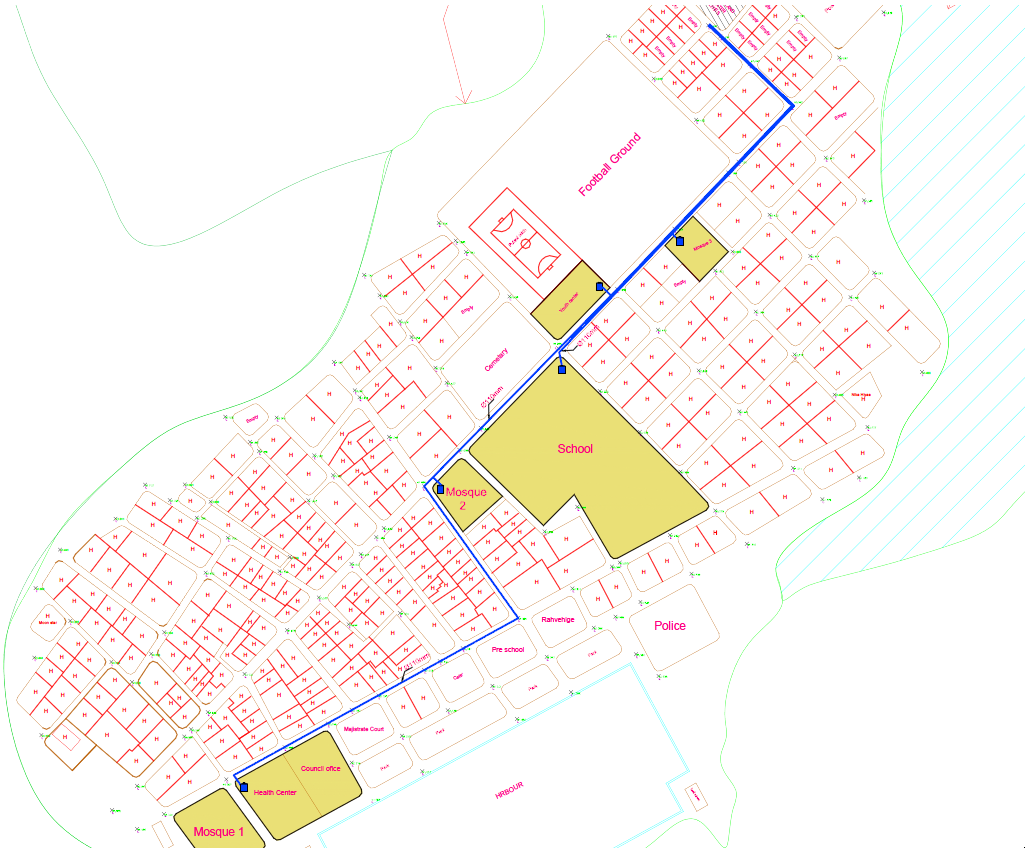


Figure 4 Rainwater harvesting system

2.1.1 Preparation of catchment area

Rainwater will be collected and stored in the following temporary storage facilities:

- Health Centre
- Mosque 2 – 'Masjidul Rahmaan'
- School – Thaa Atoll Education Center
- Youth Center
- Mosque 3 – Masjidul Baagiyath

Existing water storage in the facilities will be used. These are structure where roof are being used for rainwater harvesting and which can be used for this project.

Rainwater from catchment areas and roofs are collected from gutters via PVC downpipes. Leaf screen filters will be installed in the gutters to prevent the debris from entering the network. A first flush device will be installed on the down pipe before it is connected to the rainwater network. The first flush device will prevent debris and other organic matter from entering the network. The First Flush Diverter then ensures that heavy sediments and other finer pollutants are captured in the diverter chamber. A manual or semi-automatic first flush device will be provided on the down pipe, details of which will be finalized during the detailed design stage.

The piping network consists of 75 mm size HDPE pipes according to ASTM standard. The total network is designed such as it should be able to collect rainwater from all the public catchment areas through gravity. The rainwater collected from catchment areas will be first pumped to a 10 m3 GRP tank.

2.1.2 Rainwater Treatment

Rain water will put through a sand filter and treated for particulate matters and will be disinfected prior to storage in the product water and thereafter pumped in to the water distribution network. These actions will mitigate the associated risk and hazard potential and will provide water safety.

2.2 Desalinating water

Water desalination is undertaken by Reverse Osmosis process and is detailed below.

2.2.1 Reverse osmosis plant

The total installed capacity of the RO Plant shall be 120 m^3 per day, with two independent trains. One train shall be in the capacity of maximum 60 m^3/day. The plant shall be a package unit, with two parallel working plants.

Each Plant shall be designed with

- Sand filtration
- carbon filtration
- Anti scalant dosing

- Antioxidant dosing
- Cartridge filtration
- High pressure pump
- SWRO module
- Disinfection – Chlorination
- Instrumentation
- Control panel

The schematic diagram below provides the typical process of the RO Plant.

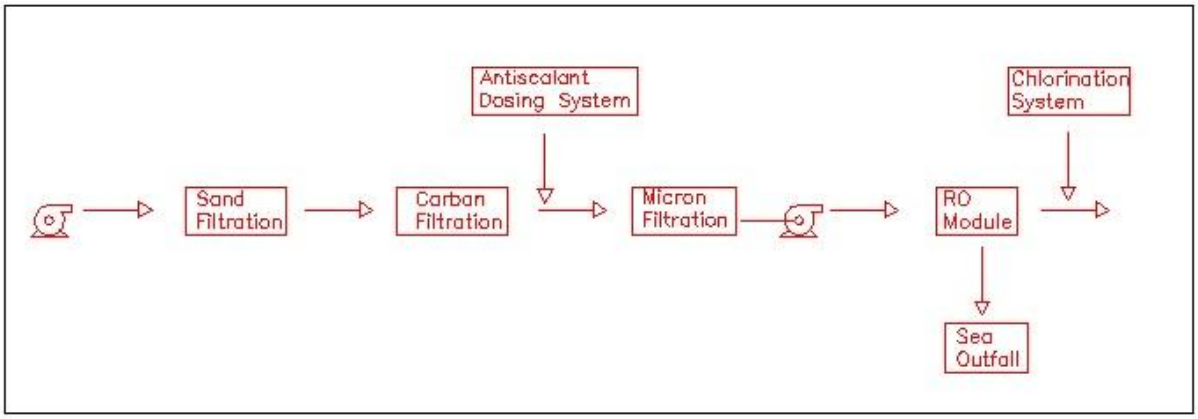


Figure 5 Schematic Diagram of RO plant

2.2.2 *Water Intake*

The designers propose that the brine intake be from bored wells 32m deep at site near the desalination plant. Two wells shall be constructed. One will be sufficient to cater the full demand for the both plants. The other borehole will serve as a backup.

Borehole construction is generally an environmentally sensitive work, and therefore some specific details of the borehole construction methodology is given.

Location of the bore hole shall be worked out from the approved drawing and marked on the top of the existing ground profile. Currently, the locations are tentative and subject to change.

Drilling shall be carried out within the site allocated for the RO plant.

5m X 5m area surrounding the drilling location shall be cleaned before set up of drilling machine. Two mud pits shall be made by using shovel and spade in front of drilling location and connected each other by a drain and canvas lining shall be done to prevent fluid loss.

Drilling mud shall be prepared by mixing of bentonite with water with a proportion of 1:2 before 12 hours of starting of borehole. Thickness of the mud shall be controlled as per the strata.

encountered during drilling. If there is severe caving encountered during drilling through a particular stratum then 150 gm poly-anionic cellulosic polymer shall be used by mixing with 50 Kg bentonite and 100 liter water.

Drilling rig is placed on the drilling spot with proper platform and verticality alignment of the machine is done by using spirit label. During the whole drilling process this is checked frequently to maintain the verticality and alignment of borehole.

After attaching the mud pump and drilling machine with 50 mm hoses drilling shall be started with 250 mm reamer bit up to the loose formation or overburden and 200mm dia PVC casing will be placed inside hole. The depth of outer casing shall be decided as per geological strata encountered at site. After placing of outer casing up to required depth drilling shall be continued with mud circulation, with the help of 200 mm drag & rock roller bit.

Soil samples shall be collected from return water from borehole at every 2 m interval or change of strata. Soil samples will be preserved in polythene bags marked with borehole number and depth and date of collection. Bore Log shall be prepared as per the sample received during drilling from different depth. Soil samples shall be sent to soil testing lab for grain size analysis.

Daily Progress Report (DPR) shall be submitted regular basis. After completion of borehole drilling log along with stratification, ROP, casing details and water analysis at site shall be submitted. Laboratory Water & Soil Testing reports shall be provided after completion of the relevant tests.

The well will be construction with the help of 38 mm gravel feeding, PVC pipe silica gravel shall be placed through the annular space between outer and inner PVC casings and the gravel shall make a layer surrounding inner PVC casing. Gravel feeding pipe shall be raised slowly till the gravel shall be filled up to 20 m from the bottom of the hole. Subsequently, that 3 m thick sand layer shall be placed above the gravel layer. Outer casing shall be removed after placing the sand layer. Bentonite clay layer of 2 m is placed over the sand layer. The bentonite clay layer shall be described as a seal between cement sand concrete layer and gravel pack.

Development of bore well is essential in order to obtain an efficient and long lasting well. After the development, several tests will be undertaken. On completion of constant discharge rate, 12 hours recovery test shall be carried out & water level would be measured for every one minute for first 1 hour and then every 5 minutes for the remaining hours. All test reports shall be submitted in a tabular format after completion of all tests.

After completion of yield test, submersible pump is removed from the bore well and well shall be capped with threaded PVC cap to protect it from any unwanted material from falling inside.

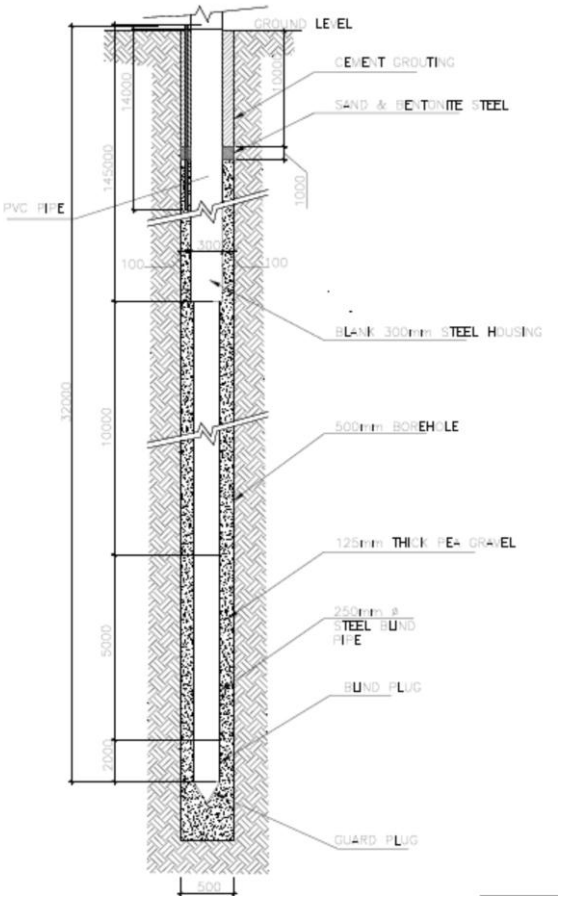


Figure 6 Proposed borehole cross section

2.2.3 Brine Disposal Outfall

An outfall pipeline extending 100m beyond the beach line directly in front of the plant room, as shown in the following Figure as proposed by the designers. The outfall pipe will be placed and anchored to the seabed using anchor blocks carefully placed on the seabed by experienced divers. Encounter with any live corals will be avoided during the installation.

2.2.4 Service Reservoir and Pump House

The anticipated maximum daily demand is 120 m^3/ day; the design is made with a clear water tank of 840 m^3. A Glass Reinforced Plastic (GRP) tank with SMC panels along with necessary base preparation and RCC works are proposed.

This tank shall be constructed strictly according to the manufacturer's recommendations. Special attention shall be paid to avoid any kind of leakage from the tank or from its associated components such as from inserts, manholes, joints, etc

All steel parts shall be galvanised or else shall be given the covering protection against corrosion. Vibration isolators or antivibrants shall be used for critical joints in the plant.

2.2.5 Water Demand and Distribution

The Transmission system is designed for 35 years ending in the year 2050. For the design the population in each house hold is taken as 4.5 in 2050 and to estimate the total population in 2050 land plots allocated for future developments are considered. Also, the actual demand for institutions such as Schools, Hospitals, Office buildings etc. are considered based on field data collected.

GIS software is used to calculate the Population demand and in Calculating the present Population only existing housing units are considered. The total number of existing housing units is 343. The average residents for a house are considered as 6.6. Thus the Total Population will be 2,263 which are in close agreement with the Census population of 2,287 for 2014. For Institutes, actual population is counted.

In a 35 years design horizon there is the need to assess the proposed housing units and other buildings as well. According to the Census Data the assessed population in 2050 will be 2,095. Also for existing institutes actual occupancy is added and for proposed buildings population is added in accordance with the floor area.

For distribution demand calculation, consideration is given to the 2050 Demand. In housing, the average demand is taken as 20 litre/head. For Institutes an average demand is added. Thus in 2050, the Average Demand is 102 m^3/day. Peak factor is 2.25 times the Average Day Demand and the Maximum Day Demand is 229.5 m^3/day.

However, for the transmission network a nominal size of 4" (100mm) HDPE line has been proposed. This diameter is capable of transporting 50 litres/head for 35 years horizon demand as well. In that case, the average demand catered shall be 231 m^3/day and the maximum day demand 519.8 m^3/day respectively.

Similarly, this diameter is capable of transporting 70 litres/head for 35 years horizon demand as well, provided that the distribution head increased by another 1 bar. In that case, the average demand catered shall be 317 m^3/day and the maximum day demand 713.3 m^3/day respectively.

Water flow meter shall be installed at the outlet of the pressureized water booster system. Any loss recorded can be identified as per the summation of the individual household aereawise. Based on the network distribution, isolation valves shal be installed to recognizee the non-revenue water demands and its' areas. All the attempt shall be measured and taken to mitigate non-revenue water.

2.3 Construction work methodology

The Construction activities are sequenced in the following order:

- Site Planning & setup
- Site Clearance

- Groundwork's
- Waste Disposal
- Construction Works
    - Water Treatment Plant
    - Water Distribution Network
- Mechanical and Electrical Works
- Testing and commissioning
- Health and Safety
- Environmental Protection
- Traffic Control
- QA/QC Plan

2.3.1 Site Planning

The site boundary will initially be demarcated. Appropriate signs will be erected to warn the public and to identify the project, construction site and the contractor.

Set up temporary service connections for electricity and water.

The site compound will contain welfare and administrative facilities and a storage area for materials.

Bulk material will be transported and stored in neat safe stacks. Higher value material and small plant and equipment will be stored in secure storage.

Setting out on the ground will be done by a competent person with TBM provided as per approved installation drawings. Correct coordinates and levels shall be taken referring to TBMs. Pipe line trace shall be marked on the ground as per the installation drawings and agreed by the Engineer. After finalizing the trace, trial pit investigation and other studies shall be carried out.

In the construction phase, key activities include mobilization of materials, labor and equipment, material transport, site preparation for installation of pumping station, land surveys for proper leveling, excavations for laying the brine discharge outfall and water network.

2.3.2 Site preparations

Adequate signs will be erected to warn the public and to identify the construction Site and the contractor. Demarcate the site boundaries.

Set up temporary service connections for electricity and water.

The site compound will contain welfare and administrative facilities and a storage area for materials. Bulk material will be transported and stored in neat safe stacks. Higher value material and small plant and equipment will be stored in secure storage.

Setting out on the ground will be done by a competent person with TBM provided as per approved installation drawings. Correct coordinates and levels shall be taken referring to TBMs. Pipe line trace shall be marked on the ground as per the installation drawings and agreed by the Engineer. After finalizing the trace, trial pit investigation and other studies shall be carried out.

2.3.3 Workforce and services

This is one of the key components that need appropriate management on site during the construction phase. In the proposed water supply system in Thimarafushi, an estimated number of 25 staff including labourers, engineers and supervisors will be stationed on the island. Rest of labour force will be obtained locally from Thimarafushi.

2.3.4 Equipment mobilization

The following list of equipment and machinery will mobilise to site.

1. Excavator - 02 nos
2. Bob cat - 01 no
3. Dewatering pumps - 02 nos
4. Motorized pressure pump - 01 no
5. Concrete mixer - 01 no
6. Fusion molds and tools - 02 nos
7. Power drills and grinders - 02 nod
8. Power saw - 02 nos
9. Diesel generator - 01 no

2.3.5 Excavation

Earth moving/ground leveling will be carried out using appropriate plant. Any topsoil will be carefully stripped and stockpiled for re-use. All excavation will be supported as necessary. All excavations will be fenced off to prevent people or plant from falling in.

A significant amount of excavation is expected for laying out the water supply pipe network. However, these excavations are not expected to require dewatering as at most it will be excavated up to 1.5m from surface. Sand from these excavations is to be used for road leveling after pipes have been laid out.

A shore trench will be excavated with the use of an excavator after the exact location of the pump station is confirmed and marked. Excavation works shall commence from the ductile iron/polyethylene flange joint on the outside of the pump station. After completion of the trench work, a pipe will be laid and backfilled. This process will be continued until the shore is reached.

During trenching and piping works, traffic disruptions due to road closures will be handled by coordinating with the island council. Plywood formworks will be used for shoring to prevent accidental collapse. Water removed during excavation will be disposed inland for re-percolation according to Water supply system design guidelines.

2.3.6 Outfall Installation

The outfall will be installed by placing the pipe carefully on the seabed and placing anchor blocks on the pipe at appropriate intervals. The pipe will be fusion-welded and laid to the natural profile of the seabed. Any live corals in the way of the pipe would be transplanted prior to or during the installation process. Anchor blocks will be 1 to 2 tons of reinforced concrete (Precast 2 U-blocks to be bolted in place to form one complete block). The contractor is to undertake a detailed inspection of the outfall site to assess the profile and condition of the reef below sea level and prepare their methodology for installation and fixing.

The pipe will be laid on position by experienced divers. Care will be taken to minimize damage to the reef.

2.3.7 Waste management

Waste generated during the construction phase will include construction material waste such as cement, pieces of PVC pipes, scrap metal and general domestic waste from staff. All the waste generated will be collected at waste management center at the temporary site.

All excess material arising shall be disposed into suitable dumping location. The remainder to be preserved at the site for back filling.

2.3.8 Construction Works

Construction of reinforced and masonry structures related to the Water treatment plant and Water distribution network. Necessary approval will be obtained for each item prior to commencement from the Engineer. Specified test reports and samples will be submitted to the Engineer for prior approvals. At the completion of the each stage required test reports will be submitted as per technical specifications.

- Concrete Formwork; Design and construct, erection and removal, formwork shoring and bracing to confirm to design and code requirements.
- Steel Reinforcement; Bending and laying of steel reinforcement minimum compressive strength of 460 N/mm2 as per the bar schedule.
- Cast in Place Concrete; Mixing and placing of the concrete with required compressive strength according to the design specification and the relevant code of practices.
- Ancillary Building Works; Masonry works, waterproofing, floor, wall and roof finishing works and painting comply with the relevant standards and specifications.
- Plumbing works related to the Water treatment plant and Water distribution network. Necessary approval will be obtained for each item prior to commencement from the Engineer.
- Gravity Mains; Laying and connecting of the gravity lines as per design specification and relevant code of practices.

Pressure Mains; Laying and connecting of the pressure lines as per design specification and relevant code of practices.

2.3.9 Testing and commissioning

All the equipment and accessories that are installed will be checked for its design performance prior to the commencement of commissioning work. All gravity and pressure mains will be inspected and checked as per guidelines given in the technical specifications and testing procedure.

All pipes will be hydrostatically tested according to the approved method. All tests will be conducted on the pipe lines in sections after the trench is backfilled, but before pavement construction.

All pipe lines will be thoroughly checked for foreign particles before testing all wash out valves hydrants will be closed when the pipe line is ready for testing. The pipe line will be slowly filled by water, allowing all air pockets to be released, until the pipe is completely filled and under working pressure at which condition it should be allowed to stand for 24

hours, any apparent defects in the pipeline will be noted and rectified. For this purpose pressure pump and standard equipment will be used with the coordination of the engineer.

After successful completion of pressure testing, sterilizing process will be done for water distribution pipes. The water used for pipeline testing and disinfecting operations will be disposed without causing any damage to adjacent property.

2.3.10 Health and Safety

Health and safety is also an important aspect that needs careful consideration during the implementation phase. Protection of employees from likely adverse effects will be one of the core duties of the proponent or contractor. All machineries and equipment must be operated by trained and experienced personnel wearing necessary safety gears. The care shall be paid for the work underneath electric lines.

Person-in-charge of each group shall be responsible for following every safety measures. Supervisor shall conduct Safety Toolbox Meetings and explain the safety procedure to the employees.

Special attention shall be paid for the pipe laying along the road. Traffic arrangement shall be discussed with the relevant authority prior to the commencement of work. Road Safety shall be among the considerations of the safety precautions.

More health and safety issues are recommended under the Mitigation plan provided in the report.

2.3.11 Traffic Control Plan

Individual traffic arrangement shall be provided with coordination of relevant authority, Traffic Division. Night work shall be introduced to the highly congested roads. For the other roads one lane shall be closed and single lane traffic shall be allowed for the pipe laying work.

Sign boards shall be used for the road users to inform about the pipe laying.

No more than half of the carriageway shall be obstructed due to the pipe laying by the time of single lane traffic is allowed.

2.3.12 Quality Control Plan

Quality of the pipe laying process shall be monitored through the Pipe Laying Trenching Log.

Quality Manual shall be maintained for Quality Assurance for the project.

- The specific QA/QC program will be established so as to ensure that the project requirements will be met for all elements of design, material/service procurement, fabrication, assembly, shipping and installation.
- Document Control

  Document control covering the requirement for the preparation, review, approval and distribution will be established to ensure that those documents and changes thereto are controlled and distributed as required to locations where applicable work is being performed.
- Materials and Equipment Control

  Controls will be established to assure that only correct and accepted items are used and installed
- Inspection/Testing

  The objective of inspection and test is to ascertain that equipment and materials are manufactured and erected strictly in accordance with QA/QC program as well as client document.
- Quality Assurance Records

  Records that furnish documentary evidence of quality, if required by the Client, will be specified, prepared and maintained
- Audits

  Planned and scheduled audits will be performed to verify compliance with all aspects of the QA/QC program to evaluate its effectiveness.

2.4 Project Duration

It has been estimated that the duration of the construction works would take around 28 months. The works will be carried out the following sequence

- Obtaining approvals for the project
- Design works
- Procurement and import of supplies and machinery
- Mobilisation
- Civil construction
- Establishing pipe network
- Eletro Mechanical works
- Testing, commissioning and handing over

Detailed work schedule is attached in the appendix of this report.

2.5 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is effluent. These inputs and outputs are summarised in the following tables

Table 1 Main input of the proposed project

Input resource(s)	How to obtain resources
Construction workers	Laborers mainly from Sri Lanka.
Engineers and site managers/supervisors	Contractor's permanent staff
Construction materials:- timber, cement, electrical cables, reinforcing steel bars, river sand, aggregates, PVC pipes, fuel, etc.	Imported (mainly from India/Sri Lanka/Malaysia) and purchased where locally available at competitive prices – Contractor's responsibility
RO plant components including; sand filers, cartridge filters, RO Pressure vessel, pumps, membranes, checmicals. Storage tanks, etc.	Imported from Sri Lanka
Water (during construction)	Groundwater and RO water for construction, bottled & rain water for consumption for workers
Electricity/Energy (during construction)	Diesel-based electricity- generator at the facility
Protective clothing and gear	Contractor's equipment imported from Sri Lanka
Firefighting equipment	Contractor's equipment imported from Sri Lanka
Firehydrants for the projects	Imported from abroad and installed based on MNDF standards.
Machinery and equipment (excavators, trucks)	Mostly contractors equipment imported from Sri Lanka
Electricity supply during operations	From local utility company, FENAKA
Operational staff	Trained and hired from local community
Feed water	From boreholes.

Table 2 Major outputs from the proposed project

Products and waste materials	Anticipated quantities	Method of disposal
Noise	50 – 80 dbA. Localized	Controlled using effective scheduling and barriers (site fence)
Waste oils from machinery	Small quantities	Collected and store in barrels to be transported to Thilafushi.
Cleared green waste	Minor	Natural decompose at site
Timber, cardboard, gunny bags and scrap metals (construction site waste)	Moderate	Recovered, reused, recycled on site. Those that cannot collected on site to be transported to Thilafushi when project ends.
Excavated sand	Moderate	To be reused to backfill trenched areas
Used oil (waste oil), grease	minute	Reused as lubricants. Those that cannot collected on site to be transported to Thilafushi when project ends.
Brine Discharge	Moderate	Disposed into sea where dilution and dispersion happens
Solid waste (kitchen waste, waste from workers)	1.5 m3 / day	Taken for disposal through island waste management system.

3. Legislative and Regulatory Considerations

1.10 Relevant Laws, Regulations, Guidelines, Standards and Policy Guidance

Table 3 outlines the relevant legal and policy provisions with respect to this project. All components of the project shall give due consideration and abide by to all the legislative requirements provided in this chapter. Moreover, the proponent also shall ensure that the project is in line with any other such requirement brought to their attention throughout the course of the project. The proponent shall be responsible to ensure that all contractors and sub-contractors are informed of these requirements and conform to them accordingly.

Table 3 Key legal and policy provisions of the project

Name	Main area of concern	Key components covered	Relevance to the project	Main regulatory body
Laws				
Environment Protection and Preservation Act (Act no. 4/93)	Environment as a whole	Mandates that Environmental Impact Assessments (EIA) are undertaken for all economic development project that may have an undesirable impact on the environment; addresses the disposal of oil, waste and toxic gas or any substance that may harmful effects on the environment within the Maldivian territory; covers non-compliance penalties.	Apply with respect to the social, economic and environmental impact of the project in the constructional and operational phase of the project. The requirement to undertake an EIA for all economic development projects that may have an undesirable impact on the environment shall be fulfilled by	Ministry of Environment and Energy

			this EIA report.	
Maldivian Land Act	Land	Encompasses the issuing, receiving, owning, selling, leasing, utilizing and using Maldivian land.	Apply with respect to utilization of Maldivian lands	Ministry of Housing and Infrastructure
Regulations				
Environmental Impact Assessment 2012 and Amendments	Sustainability of Development Projects	The regulation sets out criteria to determine whether a development proposal is likely significantly affect the environment and is therefore subject to Environmental Impact Assessment	Apply as this project is included in the *Jadhuvalu R* of the regulation	Ministry of Environment and Energy/ Environmental Protection Agency
Desalination Systems Regulation	Water Supply	Mandates the registration of desalination systems which would either be operated to cater for a 200 plus population or for the purpose of implementing project(s) involving economic or industrial operations and requires an EIA to be approved prior to establishment.	Apply as this project involves the establishment of an SWRO system in combination with a rainwater harvesting and distribution system.	Ministry of Tourism, Arts and Culture
Waste Management Regulation	Waste management	Addresses safe disposal, disposal guidelines and specifications for hazardous materials.	Apply with respect to management of waste during the construction and operational phase	Ministry of Environment and Energy/ Environmental Protection Agency

Regulation on cutting down, uprooting, digging out and exporting of trees and palms from one island to another	Conservation and Biodiversity	Covers the requirements for cutting down, uprooting, digging out and export of trees and palms from one island to another without compromising the environmental integrity of the Maldivian islands.	Apply as vegetation would require to be removed from the proposed water supply facility construction site.	Ministry of Environment and Energy/ Environmental Protection Agency
Dewatering Regulation (2013/R-1697)	Dewatering	Covers measures to ensure the minimization of impact on environment and ecosystem due to dewatering which may be carried out as part of construction works or during other works and also details the procedure for discharging the extracted water and actions to be taken if the dewatering impacts users within a 30m radius.	Apply due to the dewatering component for the water supply facility construction.	Ministry of Environment and Energy/ Environmental Protection Agency
The Environmental Liability regulation (Regulation 2011/R-9)	Environmental Offences	Provide the basis for levying fines on environmentally damaging violations to avoid environmental deterioration, extinction of biological resources, environmental degradation and wastage of natural resources.	Apply with respect to the environmentally relevant aspects of the construction and operation phase	Ministry of Environment and Energy/ Environmental Protection Agency
Guidelines, Standards and Policy Guidance				
Borehole Drilling – Guidelines and Technical	Geotechnical	A set of draft guidelines and technical specifications for borehole drilling which covers drilling of boreholes and installation	Apply as this project involves the drilling of two 30m boreholes for the SWRO plant.	Ministry of Environment and Energy/

Specification		of electric pumps for source water extraction for various water supply development projects including reverse osmosis desalination.		Environmental Protection Agency
Guidelines and Manual for Rainwater Harvesting in the Maldives 2009	Water	Covers detailed manual and standard guideline for each of the rainwater harvesting system components including catchment area, conveyance system, storage, filtering system, distribution, protecting water quality, rainwater harvesting in emergencies and general checklist.	Apply as this project involves the establishment of a rainwater harvesting and distribution network in combination with a SWRO plant.	Ministry of Environment and Energy/ Environmental Protection Agency
Maldives Building Code	Building Construction	Provides the guidelines and standards which shall be used in designing buildings in Maldives.	Apply as this project involves construction of the water supply facility building.	Ministry of Housing and Infrastructure
Guideline for Land Use Planning	Land Use Planning			Ministry of Housing and Infrastructure
Strategic Action Plan (SAP) of National Framework for Development 2009-2013	Development	Incorporates EIA process and EIA monitoring; biological diversity and ecosystem benefits; resilient communities in addressing impacts of climate change, disaster mitigation and coastal protection; adaptation and mitigation for beach erosion and assisting communities where livelihood and property	Apply as a development project with the potential to contribute in the realization of the Action Plan goals especially under corporate social responsibility.	Ministry of Environment and Energy/ Environmental Protection Agency

		are affected by beach erosion; management of solid waste; protection of people and environment from hazardous waste and chemicals; air quality; decentralized environmental governance system; a low carbon economy to achieve carbon neutrality by 2019; environmental values and environmental friendly lifestyle.		
Maldives National Strategy for Sustainable Development 2009-2013	Sustainable development	Seeks sustainable development through appreciation of the true value of natural environment, utilizing natural resources in a sustainable manner for national development, conserving the limited natural resources, building the capacity to learn about the natural environment and leave a healthy natural environment for future generations.	Apply with respect to the construction and operational phase of the project.	Ministry of Environment and Energy/ Environmental Protection Agency
National Biodiversity Strategy and Action Plan	Biodiversity	Aims for the Conservation of biological diversity and sustainable use of biological resources; capacity building for biodiversity conservation through a strong governance framework and improved knowledge and understanding; fostering community participation, ownership and support for biodiversity conservation.	Apply with respect to the construction and operational phase of the project.	Ministry of Environment and Energy/ Environmental Protection Agency
Waste Management	Waste management	Covers polluter pay principles; integrated solid waste management; Best Practice	Apply with respect to management of waste during the construction	Ministry of Environment and

Policy		Environmental Option (BPEO), Best Available Technology Not Entailing Excessive Costs (BATNEEC); proximity principle and private sector participation.	and operational phase	Energy/ Environmental Protection Agency
National Environmental Action Plan	Sustainable development/ Environmental Management	Protect and preserve country's environment and management of natural resources for sustainable development of the country.	Apply with respect to the construction and operation of the project	Ministry of Environment and Energy/ Environmental Protection Agency

1.11 Relevant Permits

The permit or approval for the project is given by the proponent, the Ministry of Environment and Energy.

The permits required for the environmental clearance covered by the scope of this EIA includes desalination plant registration permit and EIA decision note.

1.12 International Conventions and Declarations

Maldives is a signatory to various international conventions and declarations including:

- Un Convention on Law of the Sea – UNCLOS (1982)
- International Convention for the Prevention of Pollution of the Sea by Oil (1982)
- Vienna Convention for the Protection of the Ozone Layer (1985)
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
- Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal (1989)
- The London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990)
- Agenda 21 and the Rio Declaration of the United Nations Conference on Environment and Development (1992)
- Convention on Biological Diversity (1992)
- United Nations Framework Convention on Climate Change (1992)
- The Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1992)
- The Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1997)
- The Beijing Amendment to the Montreal Protocol on Substances that Deplete the Ozone layer (1999)
- Washington Declaration on Protection of the Marine Environment from land-Based Activities
- Kyoto Protocol to the United nations Framework Convention on Climate Change (1998)
- Cartagena Protocol on Biosafety (Maldives acceded on 2 September 2002)
- United Nation Convention to Combat Desertification (2002)

1.13 Regional Plans and Programmes

Maldives is also committed to various regional plans and programmes including:

- SAARC Environmental Action Plan adopted in 1997 in Male'
- SAARC Study on Greenhouse Effect and its Impact on the Region
- South Asian Regional Seas Action Plan and Resolutions concerning its implementation (1994)
- SAARC Study on Causes and Consequences of Natural Disasters, and
- South Asian Seas Programme initiated by SACEP

4. Existing Environment

4.1 General Climate

As most of the islands of Maldives is located within and in very close proximity to the equator, all islands experience monsoonal climate. Towards the North the effect of Seasons are more apparent and hence experience infrequent torrential rain, while towards the South the effect of seasons are negligible and experience frequent rain.

Maldives experiences two distinctive monsoons; the North-East Monsoon or dry monsoon which last from January to March and the South-West monsoon or wet monsoon which lasts from May to November. In both seasons the temperature varies slightly despite the huge difference in rainfall.

4.1.1 Temperature

As the Maldives consists of small islands surrounded by sea even hot days are tempered by cooling sea breezes and mild evening temperatures. Therefore thought the year there is little change in temperature. However the daily temperatures fluctuates between 31 ^{0}C in daytime and 23 ^{0}C at night. However there were rare temperature anomalies recorded; on 19th May 1991 the highest temperature ever recorded in Maldives was recorded at Kahdhoo Meteorological office - 36.8 ^{0}C and on 11th April 1978 the lowest temperature was recorded in National Meteorological Center- 17.2 ^{0}C.

Looking closely at the monthly maximum and minimum temperatures from four different meteorological centers, it becomes clear that there is a very small fluctuation in the maximum and minimum temperatures throughout the year. However as expected there is a considerably huge variation in the maximum and minimum temperature for Hanimadhoo. From February to May, the minimum temperature for Hanimaadhoo rose from 24.5 ^{0}C to 26.5 ^{0}C.

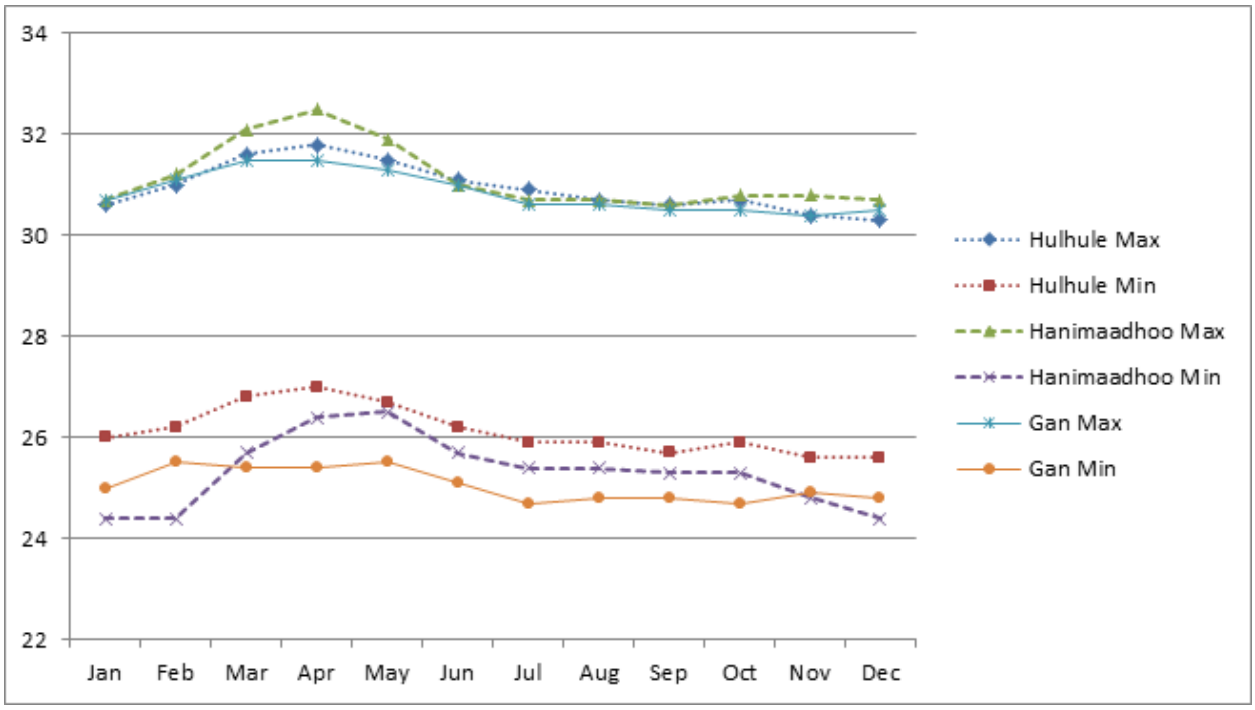


Figure 7: monthly maximum and minimum temperatures(^{0}C) for Maldives throughout the year. Data since 2000, adopted from the National Meterological Centre.

4.1.2 Rainfall

During the South-West monsoon, from mid-May to December heavy rainfall is experienced to all atolls. The highest rainfall ever recorded during a 24 hour period was on 9th July 2002 at Kaadedhdhoo Meteorological office, which was 219.8 mm of rainfall.

Looking at rainfall data since 2000, heavy rainfall is experienced (between 200mm and 250mm of rainfall) from May to December. Lowest rainfall is between February and March, where rainfall is between 25mm and 80mm.

There is a considerable difference in the rainfall pattern between the North and the rest of Maldives during May to July and October to December. For North rainfall is higher during May to July which is at 250mm while for other areas 170mm of rainfall, during October to December rainfall for North declines from 225mm to 100mm while rainfall for other areas remains between 210mm and 240mm.

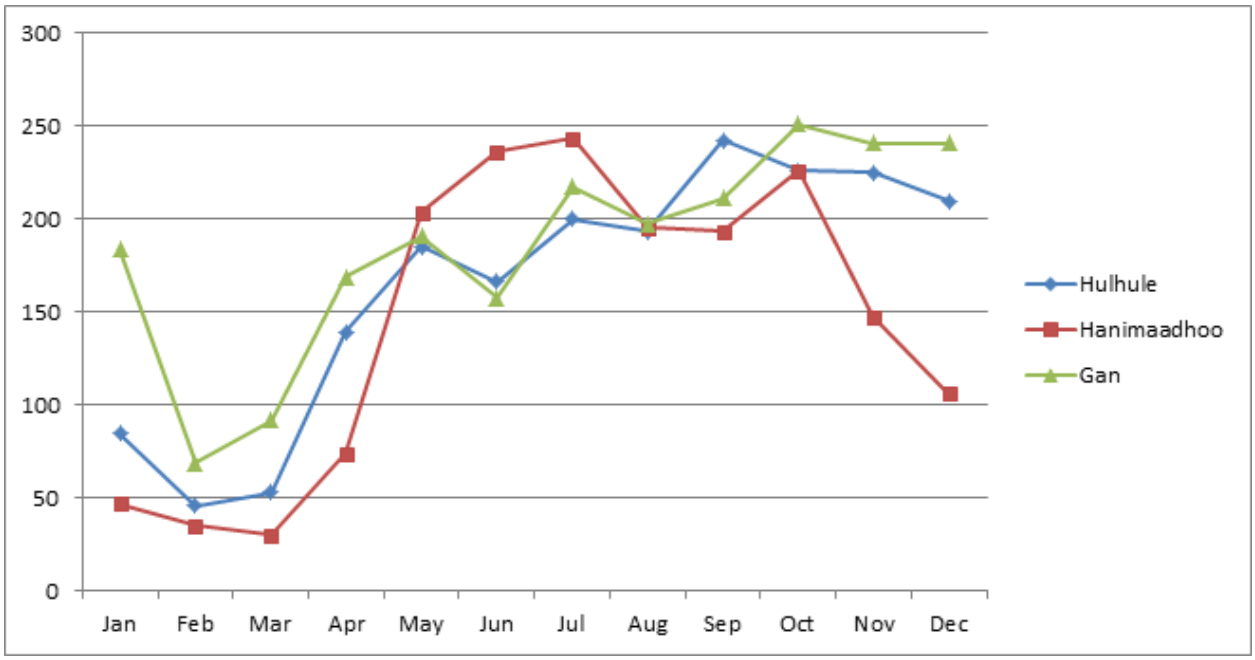


Figure 8: rainfall (mm) data since 2000, adopted from the National Meterological Centre

4.1.3 Insolation

As the Maldives lie within the equator, it received plentiful of sunlight everyday throughout the year. Highest insolation is received between February and April with a peak of 12 hours of daylight. For North, insolation is lower than for the other areas between May and July; 7 hours of insolation for North while for other areas the lowest sunshine was 8.5 hours.

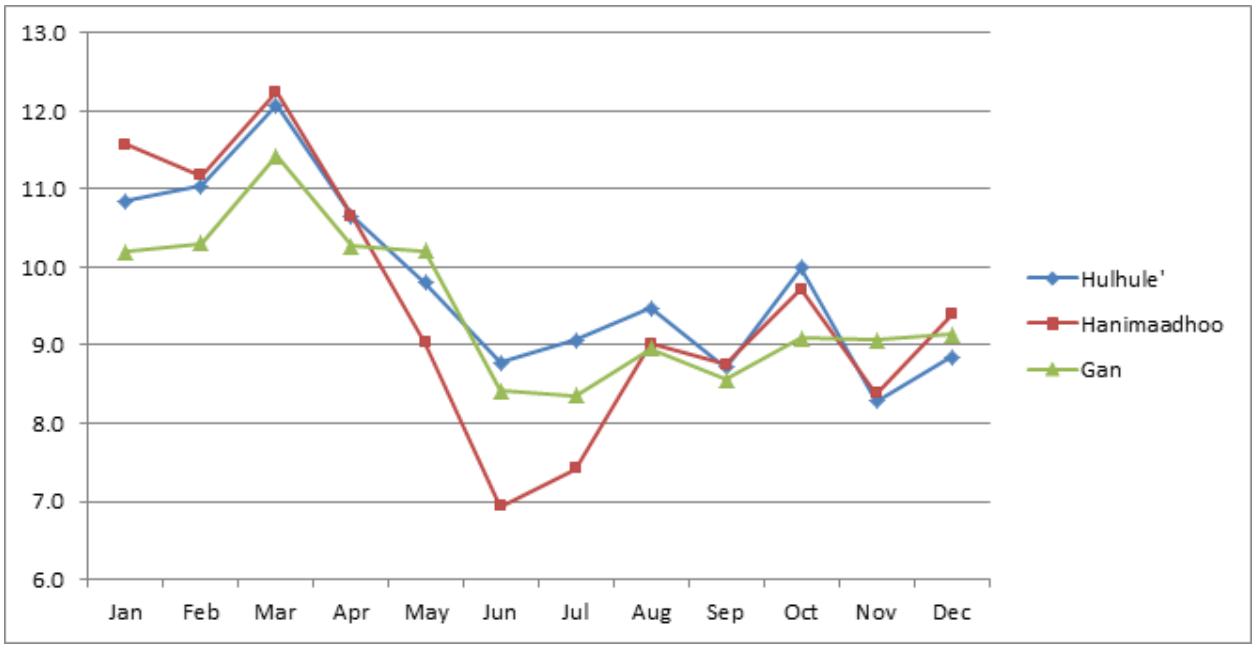


Figure 9: average daily insolation (hours) for different areas

4.1.4 Wind

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

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

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer 2003). Wind speed is usually higher in central region of the Maldives during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975 to

2001. Maximum wind speed recorded in the south was 17.5 m/s during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind speed was in general lower and more uniform throughout the year in the southern region. Wind analysis indicated that the monsoon was considerably weaker in the south (Naseer, 2003).

The Figure below shows the wind direction and speed by month for the year 2013. As can be seen, the speed is highest from June – October from predominantly west.

ތާވަލު 1.3 : ހަފްތަރުގެ ދުވަހުގެ ދަތުރުގެ ދަތުރު ތަކުގެ ތަފްޞީލު، 2013

Table 1.3 : WIND DIRECTION AND SPEED BY MONTH , 2013

Locality	Yearly average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ތަނ
WIND SPEED (MILES/HOUR)														**ދަތުރުގެ ދަތުރު (ފަރާތަކަށް ގޮސް ދާ ދަތުރު)**
Male'	9	10	8	6	6	13	11	8	10	10	11	6	10	ކ.ކ
HDh.Hanimaadhoo	6	5	4	4	5	8	10	8	9	8	7	4	5	ހދ: ހަނިމާދޫ
L.Kadhdhoo	5	6	5	4	5	8	5	4	6	6	7	4	6	ލ: ގައްދޫ
GDh.Kaadedhdhoo	6	6	5	4	6	9	6	5	5	6	7	6	7	ޏދ: ގާދެދޫ
S.Gan	6	5	4	4	6	10	6	6	5	6	7	7	7	ސ: ގާން
WIND DIRECTION														**ދަތުރުގެ ދިމާލު**
Male'		ENE	ENE	E	W	W	WSW	WSW	W	W	W	E	ENE	ކ.ކ
HDh.Hanimaadhoo		ENE	E	NNW	NW	W	W	W	WNW	W	W	E	E	ހދ: ހަނިމާދޫ
L.Kadhdhoo		NE	NNE	VRB	W	WSW	SSW	S	S	W	SSW	W	NE	ލ: ގައްދޫ
GDh.Kaadedhdhoo		NNE	NNE	VRB	W	W	SW	SSE	S	WNW	W	W	NW	ޏދ: ގާދެދޫ
S.Gan		NE	N	W	W	W	SSW	S	S	SSW	W	W	W	ސ: ގާން

Source: Maldives Meteorological Service — ދަތުރުގެ ދަތުރު ދެނެގަތުމަށް ކުރިއަށް ގެންދާ ސަރުވޭ ތަކުގެ ދަތުރު

Note: — ލަފާ :

N - North — *NNE - North-North-East* — *WNW - West-North-West* — N - ތުރު - NNE - ތުރު ތުރު ތުރަށް — WNW - ތުރު ތުރުގެ ތުރަށް

S - South — *NE - North-East* — *SW - South-West* — S - ދުރު - NE - ތުރު ދުރަށް — SW - ދުރު ދުރުގެ ދުރަށް

E - East — *ENE - East-North-East* — *WSW - West-South-West* — E - ހުރަސް - ENE - ތުރު ތުރު ހުރަސް — WSW - ދުރު ދުރުގެ ދުރަށް

W - West — *NW - North-West* — *SSE- South-South-East* — W - ދުރުގެ - NW - ދުރު ދުރުގެ ތުރަށް — SSE - ދުރުގެ ދުރު ހުރަސް

NNW - North-North-West — *SSW - South-South-West* — NNW - ތުރު ދުރުގެ ތުރަށް — SSW - ދުރު ދުރުގެ ދުރަށް

Figure 10 Wind direction and speed by month, (MET 2014)

4.1.5 Waves

Wave energy is important for sediment movement and settlement, and it is also a crucial factor controlling coral growth and reef development. Waves have been attributed to the diversity and the abundance of coral and algal species. These aspects have implications for the type and perhaps the supply of sediment s into the island.

Studies by Lanka Hydraulics (1988 & 1989) on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Maldives has recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than one occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Choi *et al* 2003).

Thimarafushi is exposed to high wind generated waves by SW monsoon and swells from the SE. that travel long distances and meet the island located on the eastern rim of the atoll. The south side of the island is highly exposed to waves during the SW monsoon and there is expected to be a high current along the atoll channel. Waves breaking on the eastern side would be generally weaker because the shorter fetch length to other bodies of mass in the atoll. The overall result of wave influence on the morpho-dynamics of the island during the NE monsoon might be rapid deposition of sediment with shaping the island also taking place mainly during the NE monsoon but also during the SW monsoon. The following figure shows waves data gathered by Young (1999) for a ten year period for each world regional zone.

In terms of dilution of brine discharge, any location out of the SE and SW shoreline would lead to effective dilution.

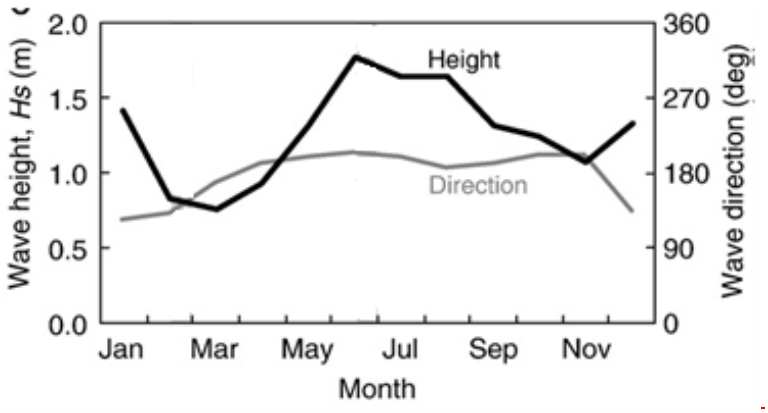


Figure 11: Ten year mean monthly wave height and direction for the central Maldives.

4.1.6 General Currents & Beach Erosion

During the Southwestern monsoon is to be expected that swells will approach the Th. Thimarafushi from the Southwest direction. It was observed that there is more erosion experienced on the western side of the island than in the east. This can be due to swells which approaches the island from the southwestern side has less obstacles in their path compared to the northeastern swells, reducing chances for refraction and dropping of swell strength. The erosion areas are shown in Figure 13 below. The erosion is not very significant and the

location the plant site is proposed is not under immediate threat of erosion. In the study undertaken by Sandcays Pvt. Ltd. in Thimarafushi in 2015, the location shown on the east was also identified as an erosion area.

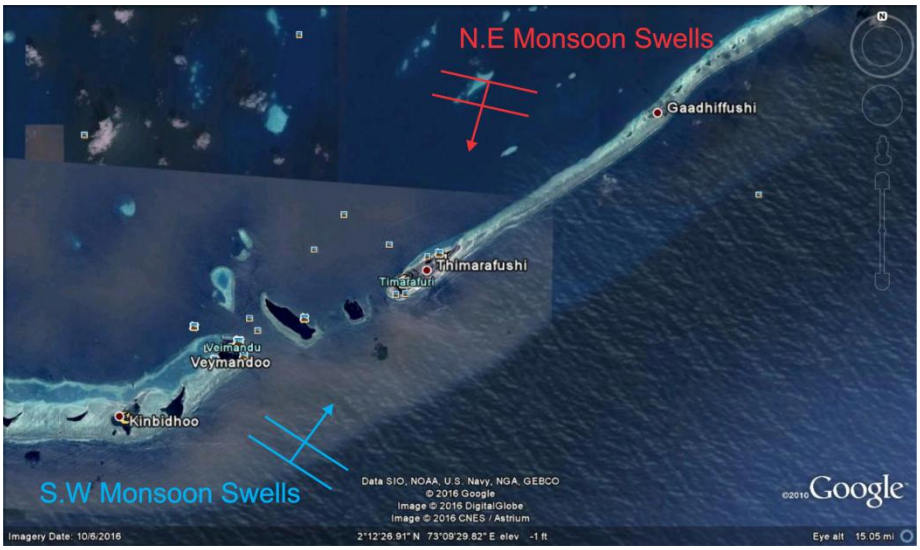


Figure 12: shows south-western and North-eastern swells around Th.Thimarafushi

Figure 13: locations where erosion is currently experienced

4.2 Marine Environment

4.2.1 Benthic Cover

Method

The benthic survey and fish community survey was carried out by means of snorkeling and photography. Snorkeling was done covering most part of the lagoon area southern side of the island. Photographs and videos were taken during the survey to analyze the current condition of the existing environment.

Figure 14: Shows the area surveyed by snorkeling.

Results

It was observed that only rubble and rocks where present on the Southern side of the island where the proposed outfall will be located. Rubble covering the lagoon was also found on the coastline in abundance. No live coral was observed on this side. As at low tide the sea level very low to the extent where majority of the southern lagoon area were exposed to the surface which reduces any chance to coral growth within the area. The condition of the area can be seen in the figure below.

Figure 15:Shows the condition of the Southern lagoon.

The lagoon area southeastern side of the island was covered by rocks and rubble and hardly any fish was seen near the outfall area. Live corals were very low in abundance and were observed to be significantly low in diversity.

Figure 16: Shows the condition of the southeast lagoon.

A few of coral massives such as *Siderastrea siderea* was encountered during the survey but they were far between and young when compared in size. Porites furcate was the most abundant species in the lagoon when it came to live corals having as small patches scattered on the eastern side of southern lagoon.

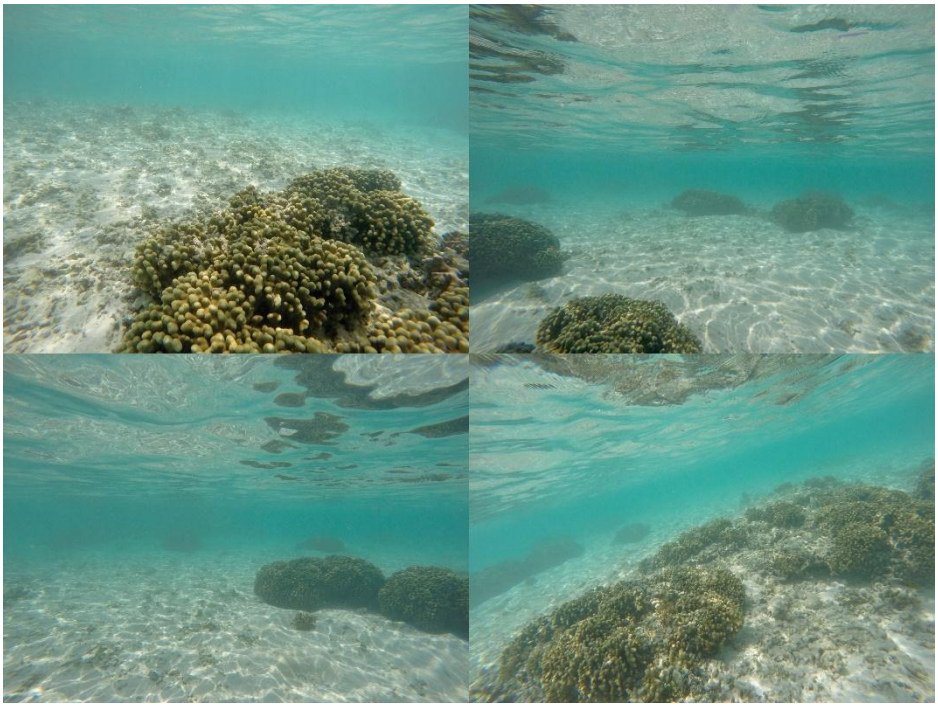


Figure 17: Shows the scattered *Porites furvate* patches in the lagoon.

4.2.2 Fish Community

The small patches had small juvenile fish communities with species like *Canthigaster valentini*, *Ctenochaetus Striatus*, *Chaetodon auriga* and Chrysiptera cyanea dominating the patch. The table below shows the common names for these juvenile fish spieces. As rock and rubble dominated the southeastern lagoon fish diversity was low along with the scarcity.

Table 4 Fish species observed at site

Common Name	**Scientific Name**
Saddled Puffer	*Canthigaster valentini*
Threadfin	*Chaetodon auriga*
Striated surgeonfish	*Ctenochaetus Striatus*

Blue Damselfish	Chrysiptera cyanea

Currents

Method

Current measurements were taken by allowing a 500 mL plastic water bottle (half filled with sand) tied to a rope 5 meters in length to drift for 5 meters and timing how long it took to calculate the speed. Measurements were taken at 5 different locations around the island.

Results

Table and figure below shows current measurements and locations around the island during the field visit.

Figure 18: Shows current pattern on Southeast lagoon.

Table 5: Shows current data for the Southern lagoon area.

Current data for Th.Thimarafushi					
Site	Location		Distance Traveled (m)	Duration (sec)	Current (m/sec)
	Latitude	Longitude			
C1	2.203633848609437	73.14361544013241	5	222	0.023
C2	2.204377472744222	73.14446984803067	5	107	0.047
C3	2.204929102972903	73.14532767722209	5	175	0.029
C4	2.20532834326733	73.14613371209848	5	139	0.036

It can be determined from the results that there is small current flowing from east to west along the southeast shoreline with the occasional wave induced current towards open ocean.. The weak swell current flow was easily disturbed by the incoming waves reducing accuracy in terms of current direction. No currents were taken from the southwest side as the only current present in the area are wave induced currents due to the shallow lagoon flat as previously highlighted.

Figure 19: Shows the southern side at low tide.

4.2.3 Water Samples

Method

Seawater samples were collected from 2 locations; one from the West side of the Island and one from the South side of the island. A 1.5L bottle and sterilized 400mL glass bottle was filled in every location. Water sample was collected by dipping the water sample bottle below sea water surface to about 1m from sea level. Sampling bottle was rinsed 3 times with sea water before sampling.

Seawater quality is generally not good. At both sites tested, the total coliform and faecal coliform values were regarded as 'too numerous to count' by the laboratory. This is likely due to the fact that the sewage pipeline has been damaged and is running under a temporary solution. Other parameters are as expected in sea water.

Groundwater samples were collected from 4 different locations for analysis. The locations were selected in a manner where the overall condition of the islands groundwater supply can be determined. The bottles are filled until it over flows before placing the cap on tight. After placing the cap it was made sure that the bottle had the least possible level of air bubble in it.

The groundwater quality at Site 4 down south is remarkably good with conductivity at 186 µs/cm, while quality at site 3 is quite bad. It has a very high total hydrocarbon value of 153 mg/L. pH is generally alkaline in all the locations.

The water quality test results from the laboratory is provided in the Annex.

Sample locations

Figure 20: Shows water sample locations for sea and groundwater.

Table 6: Shows the GPS coordinates of the sample locations.

Site	GPS Locations	
	Latitude	Longitude
GW1	2.208126140922757	73.14398940245191
GW2	2.205982837302621	73.14313223224239
GW3	2.207175997380432	73.1443544867787
GW4	2.205080078344471	73.14213030018227
SW1	2.202248063345838	73.14254848252391
SW2	2.205271932525643	73.13953464584547

4.3 Terrestrial Environment

4.3.1 Water Supply Facility

The site for the proposed water supply facility is located in the southern corner of the island coast. As shown in the figure both the electricity service providing facility and the sewerage

treatment facility of FENAKA is situated near the site. The proposed site had some common trees and shrubs found in abundance in Maldives. The Table 7 provides the plant varieties generally found near the proposed construction site which includes Sea hibiscus, Mexican sunflower, Sea lettuce, Wild screw pine and Tulip tree.

Generally the foremost line of coastal vegetation is left intact in the area and the same is expected for the proposed facility as well. The Figures below shows the proposed site and current condition of the area.

The block opposite also has overgrown shrubbery and similar vegetation and consisted of plots already given for housing. No boundary wall or demarcation had been yet made to the plots by the owners.

Table 7: The general plat types found in the vegetation cover of the proposed site

Local Name	Common Name	Scientific Name
Dhigga	Sea hibiscus	Hibiscus tiliaceus
Bodu mirihi	Mexican sunflower	Tithonia diversifolia
Magoo	Sea lettuce	Scaevola taccada
Boa Keyo	Wild screw pine	Pandanus tectorus
Hirun'dhu	Tulip tree	Thespesia populnea

Figure 21: Location of the proposed water supply facility from google map

Table 8: Geo-coordinates of the proposed site for water supply facility

Site	GPS Locations	
	Latitude	Longitude
STP (Sewerage Treatment Plant)	2.202780380840851	73.14288349181146
Electrical power station	2.202837113169955	73.14179446232356
Nearest resident household	2.20312513807221	73.14268743453071
Water supply plant	2.202779281092105	73.14219940924193

Figure 22: Shows photographs of the proposed site for the water supply facility and the vegetation of the site location.

4.3.2 Noise levels

Method

Noise was measured in the area of the proposed water supply facility site using a application called “Science Journal”. The reading were taken in the adjacent STP building and the nearest occupied household with and without the noise from the generators. The details are shown below.

Results

It was observed that the noise level was significantly contained considering the close proximity of the households and the STP. The only occasion where the noise level when beyond 60 decibels was when the reading was taken from the STP when the generators were. The details of the results obtained are shown below.

Table 9: Shows noise level results.

#	Location	Noise (dB)	Remarks
1	Sewerage Treatment Plant Facility	55	Generator of STP off/ Sound of breaking waves can be heard
2	Sewerage Treatment Plant Facility	73	Generator of the STP on
3	Corner of the nearest house	48	Generator of the STP off
4	Corner of the nearest house	50	Generator of the STP on

4.3.3 Historic Places and Biodiversity of the Island

According to the islanders, the banyan tree (*Ficus benghalensis*) on the South-west side of the island (2.204712481549567, 73.14096856574085) is the oldest tree of the island and there are no other notable places or biodiversity of significance to the island.

Figure 23: Shows the location of the Banyan tree

Figure 24: Shows a photograph of the oldest tree of Thimarafushi (A Banyan tree)

4.4 Socio-economic environment

Thaa atoll is a relatively small atoll with a maximum length of 50km in the southern regions of the country. It had been a relatively undeveloped atoll compared to other atolls in the South. However, currently many ongoing projects are focused on Thaa Atoll. These include Reclamation projects, harbor development, airport development, road development, housing and water supply.

4.4.1 Demography

According to census of 2014, the population of Thimarafushi is 1,190 and consists of 12.3 % of Thaa Atoll's population. The sex ration of the island's population is given as 111 males per 100 females (National Bureau of Statistics, Ministry of Finance and Treasury, 2015).

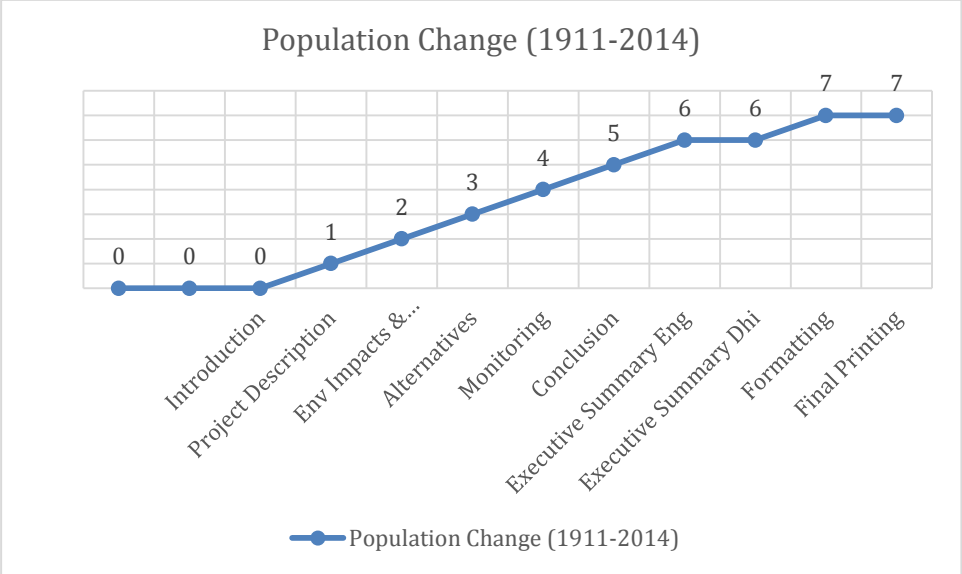


Figure 25: Population changes of Th.Thimarafushi in absolute figures from 1922 to 2014 (Source: 2014 Census, National Bureau of Statistics, Ministry of Finance and Treasury)

4.4.2 Economic Activities and Employment

The main economic activity in which the island is engaged is fishing. The community is also involved in contract work, business and office jobs from public and private sector.

4.4.3 Services & Resources

4.4.3.1 Education

The island consist of one community preschool, Thimarafushi Preschool and one government school, Thaa Atoll Thauleemee Marukazu. The government school provides education up to the lower secondary or O'level. According to School Statistics 2015 report published by the Ministry of Education, there were a total of 326 students enrolled in different levels including pre-primary, primary and lower secondary. 217 students were enrolled in grade 1 to 10 while 109 were enrolled in the preschool. The government school had a total of 39 teachers teaching the classes of grade 1 to 10. Total 4 teachers taught in the community preschool. The overall percentage of male students of the island is 53.1% and that of female students is 46.9% (Ministry of Education, 2015).

4.4.3.2 Healthcare

Healthcare is provided by the Thimarafushi Health Centre and the island has one pharmacy.

4.4.3.3 Water Resources

The main sources of water used in the island is rainwater and groundwater. Most of the households have 1 to 3 rainwater harvesting tanks. While mostly rainwater is used for drinking and cooking purposes, some households and office buildings uses bottled water for drinking. For other purposes such as washing groundwater is used.

4.4.3.4 Energy and Sewerage

Power and sewerage of the island is managed by FENAKA Corporation Limited. The island is provided with 24 hour electricity. The sewer is treated in the Sewerage Treatment Facility prior to being released to the open sea. The discharge pipe originally extends to a distance of 200m from the shore. However, currently due a breakdown in the pipe, the refuse water is being discharged over the reef edge by a temporary fix. The supervisor of the facility ensured it is being discharged in a manner that it would not be carried towards the shore with the changing currents.

4.4.3.5 Waste Management

Currently the island has no designated area for waste disposal. Hence at present, waste is disposed at various locations around the island to the shore side in the absence of any demarcated area or dedicated management.

4.4.3.6 Transportation and Infrastructure

The island has a 730 x 260 harbor and a domestic airport which was opened in 2013 is in operation. According to first quarter report of 2015 by Maldives Civil Aviation Authority, the arrivals to Thimarafushi airport is recorded as 859 and the departure as 964. The report also states that Thimarafushi airport experienced a sharp fall of passenger arrival and departure (-210.48% and -189.63% respectively) compared to the first quarter of 2014 (Maldives Civil Aviation Authority, 2015).

4.4.3.7 Tourism Activities

There is currently not much tourism related activities in Thimarafushi. Thaa Atoll is among the few atolls that tourism had not been introduced to until very recently. The atoll now has 1 resort, Male'fushi.

4.5 Natural hazard vulnerability

The following information on the vulnerability of the islands in the Maldives are taken from published literature such as Developing a Disaster Rick Profile for Maldives by UNDP (2006) as site – specific information on vulnerability of Thimarafushi was not available. Previous literature reviews undertaken by CDE Pvt. Ltd., Sandcays Pvt. Ltd., Water Solutions Pvt. Ltd. and Amir Musthafa with respect to general hazard vulnerability in the Maldives has been used in this Section.

According to the UNDP (2006) the natural vulnerability of the islands and atolls of the country to potential hazards have been modelled to understand the risk factors of the country.

The disaster risk scenario for Maldives can be described as moderate in general. Despite this, Maldives was among the most severely affected countries hit by the Asian tsunami on December 26th, 2004. Maldives experiences moderate risk conditions due to a low probability

of hazard occurrence and high vulnerability from exposure due to geographical, topographical and socio-economic factors.

Following are some of the risks that have been identified and potential areas that may be within the range of risks based on its sensitivity, location, exposure, historic events, etc.

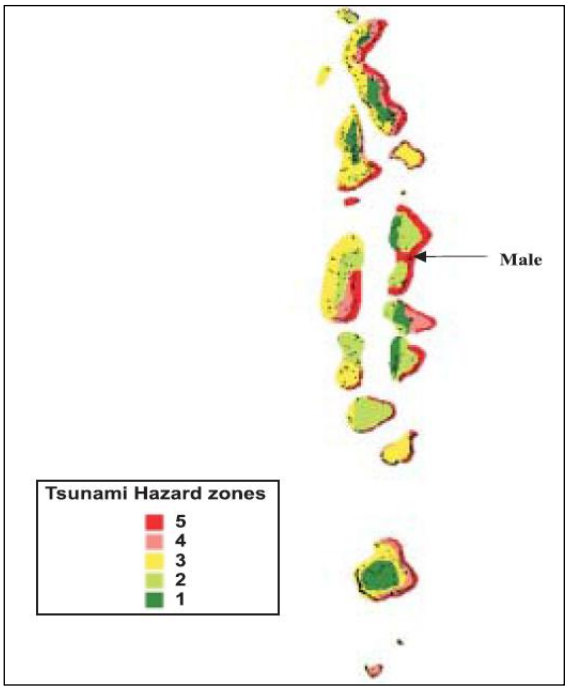


Figure 26 Tsunami Hazard Zones

Figure 26 show that Maldives faces tsunami threat largely from the east and relatively low threat from the north and south. So, islands along the eastern fringe are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe experience a relatively low tsunami hazard. This map is produced based on the experience of the tsunami in 2004 and also occurrence of historic tsunami events in the greater region where most of the events have identified to have occurred from the Sumatra Region (UNDP 2006).

Besides heavy rains and strong winds during monsoons, hazardous weather events which regularly affect Maldives are tropical storms or 'tropical cyclones', and severe local storms. At times, tropical cyclones hitting Maldives are destructive due to associated strong winds that exceed a speed of 150 kilometres per hour, rainfall of above 30 to 40cm in 24 hours and storm tides that often exceed four to five meters (UNDP 2006).

It has to be noted that under a study done by the Ministry of Environment and Energy, Maldives, it demonstrated that there would be an increase in temperature and rainfall over the entire country in the future due to climate change events (MEE, 2012). The projections from the study for the year 2100 is shown in Figure 27. Based on this study, extreme events of rainfall are to increase over the entire country. Considering Thimarafushi specifically, the island is in a zone, which is projected to endure relatively high increase in temperature and high rainfall percentage.

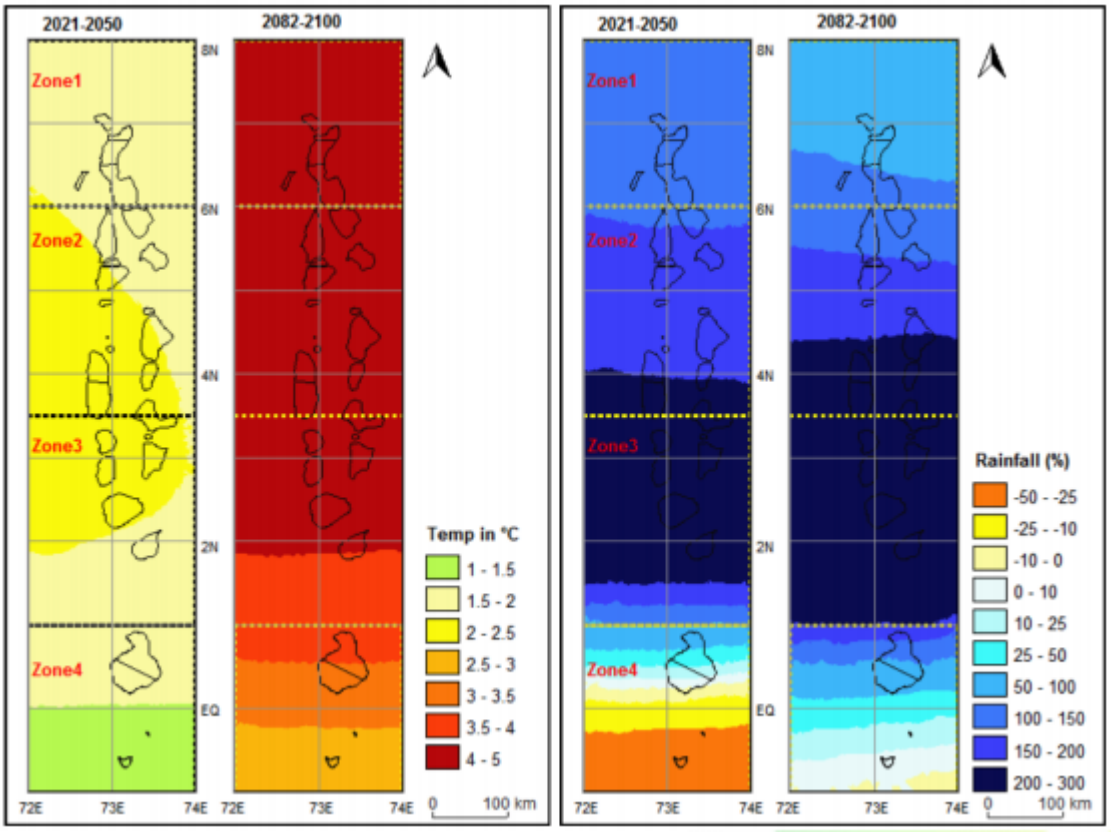


Figure 27 Downscaled future projects of temperature and rainfall for Maldives (MEE, 2012)

Cyclonic winds sometimes can cause a sudden rise in sea-level along the coast, leading to a storm surge. The combined effect of surge and tide is known as 'storm tide'. Storm tides can cause catastrophe in low-lying areas, flat coasts and islands such as Maldives.

Maldives is also affected by severe local storms- thunder storms/ thunder squalls. Hazards associated with thunder storms are strong winds, often exceeding a speed of 100 kilometres per hour, heavy rainfall, lightning and hail; they also give rise to tornadoes in some regions. In general, thunderstorms are more frequent in the equatorial region than elsewhere, and land

areas are more frequently hit by thunderstorms as compared to open oceans. However, thunder storms close to the equator are less violent when compared with those in the tropical regions and beyond. Strong winds generated by severe local storms generate large wind-driven waves which are hazardous for Maldives (UNDP 2006).

The islands of Maldives are less prone to tropical cyclones. The northern islands of the country were affected by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. Figure 28 shows the tracks of cyclones affecting Maldives during the period 1877-2004. The number of cyclones directly crossing Maldives is small.(UNDP 2006).

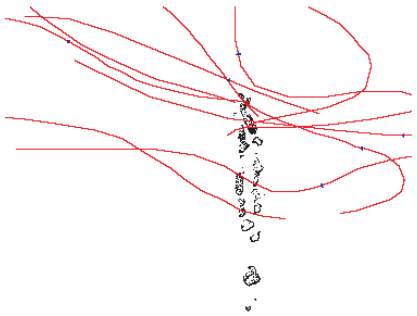


Figure 28 Tracks of Cyclones affecting Maldives, 1877-2004

UNDP (2006) stated that there were 21 cyclonic disturbances within the 500km radius during 1877-2004, of which 15 were depressions with an average wind speed of about 28 knots. The highest wind speed due to cyclonic disturbances that affected the islands during that time was about 65 knots.

Based on the above information, Maldives is divided into zones with varying scales of cyclone hazards based on based on a qualitative judgment based on the gradient of the storm tracks from north to south.

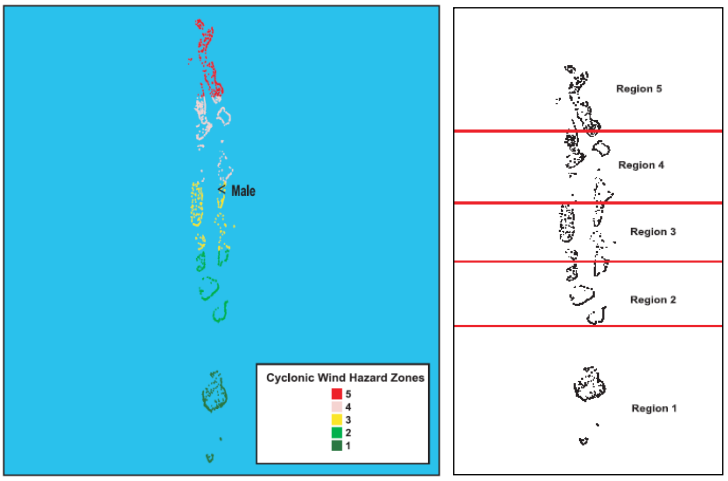


Figure 29 Regions to capture Cyclones passing through Maldives for Hazard Zoning

Figure 29 shows the regions used to compute the highest wind speed of each cyclone captured within the region. Majority of the cyclonic disturbances crossed the northern region. The frequency and wind speed decreases from northern region to southern region. Region 1 is not affected by any storm. Thus, Maldives can be divided into three cyclone hazard zones – the northern zone with high cyclone hazard, central zone with moderate cyclone hazard and the southern zone with very little cyclone hazard.

With regards to the storm surge potential, the bathymetry around the Maldives shows that the ocean slope close to the east coast is steeper than the west coast, hence it can be generalized that the eastern islands of the Maldives are vulnerable to higher surge hazard compared to the western islands. Figure 30 shows the bathymetry around Maldives. Figure 31 shows storm surge hazard zones based on computed model with maximum pressure drops for 100 year return period and with historical data (UNDP 2006).

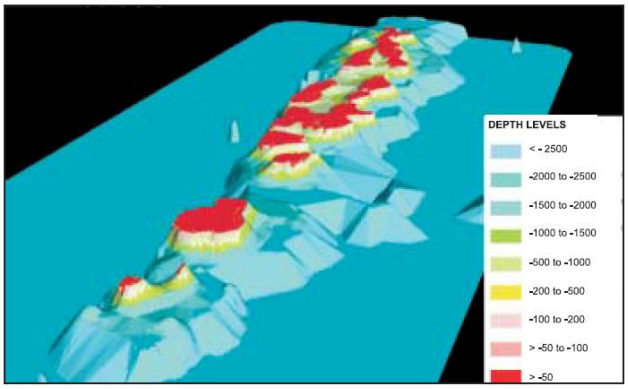


Figure 30 Three Dimensional View of Bathymetry of Maldives

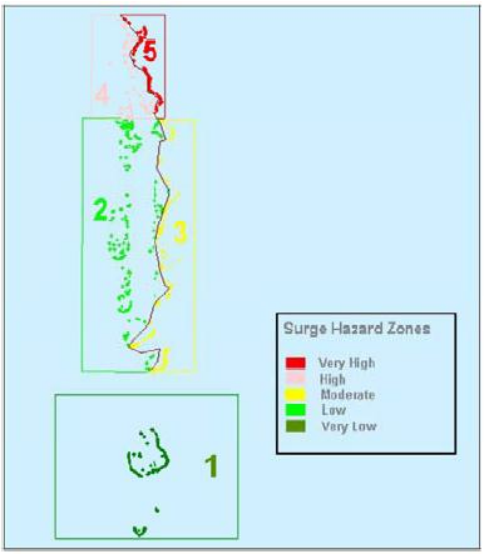


Figure 31 Storm Surge Hazard Zones with Cyclones Affected

Based on the above figure, it can be said that the north-eastern parts of the country are very vulnerable to storm surges.

Based on historical catalogues of earthquakes in the region, identifying seismic sources based on this historical information and based on numerical models, it was found that except for Seenu, Gnaviyani and Gaafu Atolls, earthquake hazard is low across the country. (UNDP 2006).

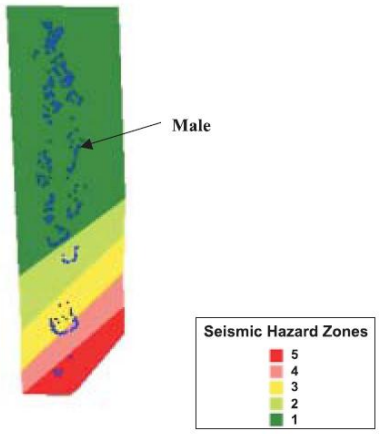


Figure 32 Maldives Seismic Hazard Zones

It can be summarized that the northern parts of the country are vulnerable to cyclones and storm surges while southern parts of the country are vulnerable to seismic activity. The eastern side of the country is more exposed to potential tsunamis and surges.

Overall, the hazard vulnerability of Thimarafushi for the immediate future is low.

5. Stakeholder Consultations

5.1 Introduction

Key stakeholders were identified based on the location and type of the project. Consultations were undertaken with various groups including;

- Th. Atoll Council
- Th. Thimarafushi Council
- Th. Thimarafushi Community
- Th. Thimarafushi Airport
- FENAKA Corporation Limited
- Thimarafushi Cable TV Service Provider

5.2 Methodology

The consultations were carried out as meetings, interviews, mail or phone consultations.

In the meeting held, to begin with, the familiarity of the stakeholder regarding the project is clarified and based on their understanding, a brief description of the project is shared. Then the relevant information, concerns and recommendations of the stakeholder were clarified and discussions were made based on the key areas relevant to this project.

The one on one interviews with the public were based on a set of close ended and open ended questions in order to draw a general baseline of the current water consumption practices and derive understanding of the public perception and comments in relevance to the proposed water supply project. The interviews were conducted from public spots (*Joalifathi)* and at first after an introduction on the nature and purpose of the interview, it is clarified that their participation shall be voluntary and anonymous. To make the participants more open and communicative, the interviews were conducted in a conversation like manner and were kept brief. At the beginning their understanding, of the project was clarified and the scope of the project was briefed accordingly. Then it was proceeded to the questions and finally any additional remarks were taken if any.

For the phone consultations initially a project description and key layouts are shared through mail and some time is given to familiarize with the project. Then the consultation is carried

out at a time convenient for the stakeholder. First it is checked whether they have any questions regarding the project scope and if clear they are asked regarding the concerns/recommendation in relevance to the key areas of the project concerning them. Finally any general comments or recommendations are taken if any.

5.3 Thaa Atoll Council

Date: 16 November 2016

Consultation Type: Mail/ Phone

- Information regarding the scope of the project was shared with Thaa Atoll Council through mail and Phone.
- It was communicated by the Council that they are satisfied with the project
- The main need of the council was to initiate the project soon.
- The council noted some general issues such as information regarding development projects in Th. Atoll not being shared with them.
- They specifically raised issues on some EIAs not being received.
- They were informed that due process will be undertaken for this project and the EIA document will be sent to them before submission to EPA

Name	Designation	Phone Number	Mail
Abdulla Shareef Abdul Fahthaah	Thaa Atoll Council President	7792605	-
Moosa Muthafa	Thaa Atoll Council Member	7791523	-
Ahmed Shareef	Thaa Atoll Council Director General	9969609	hirisharyf@hotmail.com

5.4 Th. Thimarafushi Council

Date: 7 November 2016

Consultation Type: Phone

Information regarding the project were shared with the council before the site visit. However, due to time availability from the council, much details were not exchanged. During the site visit, all the council members had departed the island, and none could be met for a one to one consultation.

The initial impression we received was that the council was supportive of the project and wanted the project to commence as soon as possible, with the proper environmental safe guards in place.

Name	**Office**	**Designation**	Phone number
Hussain Shareef	Thimarafushi Island Council	Council President	7874595
Ahmed Ali	Thimarafushi Island Council	"Zinmaa Dhaaru Veriya"	7947969

5.5 Th. Thimarafushi Community

Date: 12 November 2016

Consultation Type: One on one interviews

Random interviews were conducted among the residents of the island.

- Most of the households had 1 to 3 tanks for rainwater harvesting. The participants from households with rainwater harvesting tanks assured that they connected the roof to the tanks after cleaning the roof and letting it rain for some time and they trusted that most other households collected in such a manner as well. However, people did note that the water collection standards would differ in different households and not all are up to standards.
- Although most of those interviewed used rain water for drinking and cooking purposes and ground water for other purposes such as washing, mineral water is also used for drinking by some households. While some households use mineral water when the rainwater reserve is exhausted and some households use only mineral water for drinking. Some use rain water for drinking after boiling it.

- One of the household with their own rain water harvesting tanks stated that they were not comfortable about the safety of water collected from the roofs and hence used only mineral water for drinking. They believed that the roofs were not sufficiently clean with the frequently collected rubbish and constantly roaming animals such as cats.
- The people noted that mostly the water collected is sufficient unless 3 to 4 month passes by without rain. It was noted as a common practice to share the water reserve of a household with the neighboring households either without reserve tanks or those that have run out of their own reserve.
- When asked regarding their willingness to pay a monthly fee for the maintenance of the water supply system, most said that they are willing to pay a reasonable amount to enable a reliable and quality service.

  While some stated that the amount they would be willing to pay would depend on the cost they have to be borne for the service itself. Among those that stated a specific amount, the amount generally ranged between **100 to 150 MVR per month**. However, some of the participants were totally against an additional fee and stressed that it would an added burden to the monthly expenses.

- All participants agreed that it was important that the quality of the water collection and distribution is assured to them through practices such as standard maintenance and monitoring of the roofs of the households connected to the system.
- The groundwater was rated as good by most people and it was highlighted by many that the odor of the groundwater improves with the rain. However, a trend was observed where the groundwater quality gets lower towards the shore, to which the participants near the coastline agreed to. A participant from a western household nearer to the coast have noted that the condition of groundwater in that area was very low and they are being able to use it by installing an oxygen pump to remedy the bad odor.
- All participants agreed that this project is important for Thimarafhushi community as a whole. However, there were few that stated that although they support the project for the common good of the community, they personally plan to continue using water by existing means and would prefer not to engage in a charging service.

5.6 Th. Thimarafushi Airport Office

Date: 16 November 2016

Consultation Type: Phone

- Currently the airport purchases drinking water from a local supplier in bulk and groundwater is used for other purposes.
- It was noted that the airport has not been handed over to Island Aviation and hence the current administration is not informed of the overall plans for the place.

Name	Designation	Mail	Contact
Rifash Waheed	Senior Airport Services Officer	sm.tmf@iasl.aero	91400454

5.7 FENAKA – Electricity Service Providing Unit

Date: 16 November 2016

Consultation Type: Phone

- The main concern of the electricity service providing unit is the risk of damage to the electric network cables during the works of this project.
- The electricity unit of Thimarafushi has generated the layout of the main distribution cable network for purposes such as this project to reduce the risk of damage. However, it was highlighted that they do not have the details of consumer cables. But it was noted that the consumer cables would be easy to identify while the work is ongoing.
- Also staff will be specifically allocated for the monitoring and supervision of the networking works of this project to minimize the risk of any damage.
- They informed that they were not entirely sure if they would be in charge of operating the water supply system once it is in operation

Name	Designation	Mail	Contact
Mohamed Shareef	Manager	ashamohamedshareef@gmail.com thimarafushi@fenaka.com.mv	9970037

Date: 12 November 2016

Location: Th. Thimarafushi Sewerage Treatment Plant Facility

- The STP system is temporarily disconnected for servicing the system. The outfall pipe originally has been laid to a distance of 200m from the shoreline into the sea. However, the pipe has harbored damages and is being operated with a temporary solution. It is still ensured that the pipe goes over the reef edge and the discharges are not carried towards the shore with the current.
- The most challenging problem that the facility faces is that of unavailability of spare and servicing equipment for the proper maintenance of the system. Hence it was highlighted that it was important that the water supply project take to if possible include such provisions within the project to ensure the efficiency and sustainability of the service.

Name	Designation	Contact
Ismail Madheehu	Supervisor	9550442

5.8 Thimarafushi Cable TV Service Provider

Date: 21 November 2016

Consultation Type: Phone

- It was stated that the main concern from the cable TV network was their cables as any damage to them is more critical than the consumer cables.
- It has been decided that a staff of the cable TV service would be assigned to monitor the networking works of the water supply project.
- Also it was noted that a layout of the cable TV network has already been provided to facilitate the process.
- It was also highlighted that they are well informed of this project and is ready to collaborate closely during the physical works.

Name	Designation	Contact
Mohamed Nimaal	Incharge	7992990

6. Environmental Impacts & Mitigation

Infrastructure development project in island environments are believed to generate a series of environmental impacts, of different magnitudes and occur at different scales. The most significant environmental impacts are those that are felt on the immediate environment and have long term effects. For this project, marine environment in the lagoon and terrestrial environment on the island is the 2 vulnerable receptors., in addition to socio economic environment. Terrestrial environment is directly affected during building construction and trenching works.. Marine environment impacts are felt on coral reef environments during placement of the brine discharge pipeline. There are many socio ecnomic benefits from the project due to the continuous availability of fresh water that project will provide.

Below is some of the methodology used to identify impacts and their significance. A lot of work has already been done by environmental consultants in the Maldives to provide the best methodology to assess impacts. Therefore knowledge from these studies are used. Identification is done qualitatively based on previous experience and studies already undertaken, while significance is determined quantitatively so that decision makers can be aware of the particular activities which cause the most impacts and how they are offset by other positive impacts.

6.1 Limitations and Uncertainty

The methods used to predict and evaluate the environmental impacts are mainly from experience. It is not entirely subjective, as experience from other consultants in similar projects have been considered. Most notably, the impacts that were recently identified by CDE during their studies in L. Fonadhoo, R. Meedho and Th. Vilifushi have been referred. These are compared the consultant's judgment in order to reduce errors. However, it should be noted that follow up monitoring reports from the studies are not available and this could have provided empirical data to further reduce limitations and uncertainty.

Furthermore, the degrees at which these impacts are either accurate or inaccurate as well as uncertainties and natural variability are the key factors that affect the accuracy of these methods. Nonetheless, the methods used are concise and provide a general overview as well as the range of impacts that can affect the environment.

Environmental impact assessment always involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. The level of uncertainty, in the case of the proposed development, may be expected to be low due to the experience of similar projects in similar settings in the Maldives. Implementing desalination plants, sewerage systems, powerhouses, etc. in remote islands, for instance, is common especially in the past few years and the know-how to minimize the impacts exists. Nevertheless, it is important to consider that there are elements that are new and that there will be uncertainties and to undertake monitoring as described in the monitoring program given in the EIA report.

These uncertainties applies to the determination of existing environment as well.

6.2 Methodology

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

- A consultative process within the EIA team and important stakeholders including the proponent and potential contractors.
- Purpose-built checklist
- Existing literature and reports on similar developments, especially in L. Fonadhoo, R. Meedhoo and Th. Vilifushi
- Baseline environmental conditions described in Chapter 4
- Consultant's experience of projects of similar nature and similar settings

In order to assess the significance of the impacts identified through the above methods, 2 separate methodology has been adapted and amalgamated.

The impacts of the project activities have been evaluated according to the framework proposed by Posford Haskoning (2004). The decision framework is illustrated in following Fgure. The main factors used to evaluate impacts under the framework are as follows:

- Sensitivity of Receptor
- Recoverability of Receptor
- Importance of Receptor
- Spatial Distribution of impact

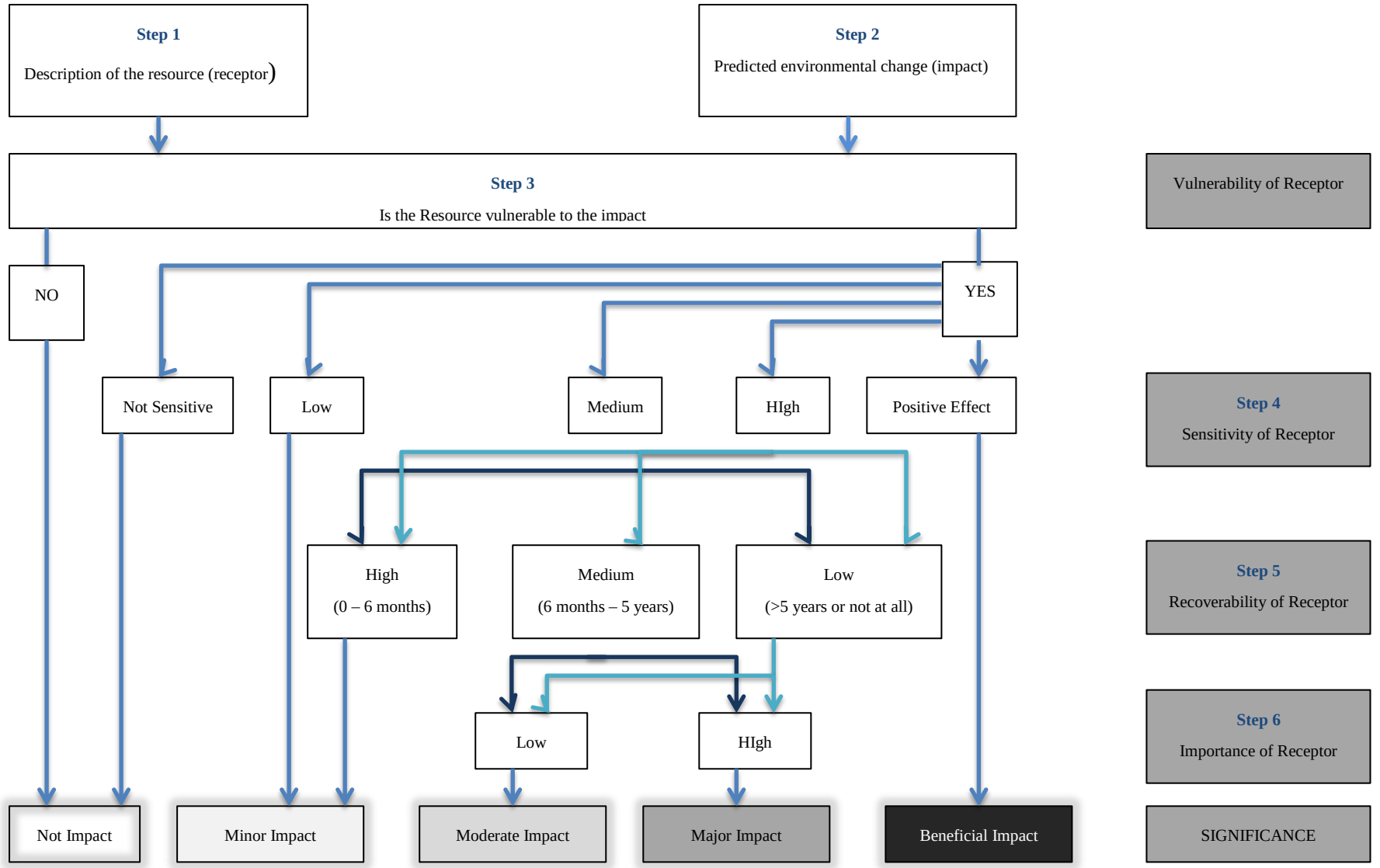


Figure 33 Impact Assesment Diagram (Haskoning 2004)

This lets decision makers view each project activity that may cause impacts individually and determine what type of impact they have on the environment, and whether they are of significant concern.

6.3 Identification of Impacts & Mitigation Measures

The construction phase of the proposed project involves operation of machineries, vehicles and building construction. This would be carried out by a fairly large work fleet. Hence there will be a considerable amount of social and environmental impacts; both negative and positive. For instance, amongst the potential environmental impacts include disturbances due to loss in visual amenity, noise pollution, health and safety issues. However, there will be an increase in job opportunities for the locals of the area. The following subsections include a detailed assessment of impacts from all the components of the construction & operational phase of the project.

Construction Phase

6.3.1 Equipment Mobilization and material transport

Impacts from the activity include;

- Generation of noise
- Reduction of sea water quality
- Deterioration of visual amenity
- Direct impact on reef

Based on the experience of several projects of this nature that has been undertaken in the region and elsewhere in the Maldives, this project is expected to have minor negative impacts of **noise pollution**. During mobilization, noise is expected to rise in the range of 60 – 80 dbA. However, this will be for a very short time, expected to be 3 - 5 hours during each mobilization round.

Sea water quality can deteriorate locally due to mobilization activities. During the unloading of materials and equipment, Suspended Particulate Matter is expected to be the critical pollutant and may increase due to leaks and potential impact on sea bed. Usually, in projects involving heavy machinery, it carries the risk of spills. Such spills are not a cause for concern in the case of the construction equipment as fuel prevention measures are in place. The impact on the quality of soil and groundwater is not going to be significant as proper storage facilities will be maintained for construction materials, construction waste and oil and grease.

Significant impact may occur due to unforeseen conditions where the materials are not able to be unloaded using the existing harbor. This would lead to creation of a temporary sand bund, thereby increasing sedimentation and turbidity of the water locally.

The sudden influx of machineries will have minor temporary impact on **visual amenity**. Thimarafushi is not an island alien to massive development projects, as recently the island has been reclaimed and the airport development project has also been undertaken. Therefore the community is familiar with heavy machinery operating in the island.

Reefs also get damaged due to boating activities including mooring, loading and unloading of materials. Recently, there have been several incidents of boats and barges getting wrecked and grounded due to **direct impact on reefs**. This causes huge financial losses in addition to the environmental damage to all parties concerned, including the developer, contractor and the community. Additionally, the project gets significantly delayed. The damage to reef is irreversible, as it leads to immediate mortality of the corals in the impact zone. The sudden change in the environment also has negative effects on other organisms dependent on the corals directly and indirectly. The impact is regarded as major.

Mitigation measures for the discussed impacts are the following:

- Inform the council and the community of the mobilization within at least 1 week from mobilization date
- Finalise all arrangement for the unloading point, and material and equipment storage at least 1 week before mobilsation commences
- Ensure mobilization is completed with as few trips as possible. This can be done by having a large barge/landing craft carry all the required machinery in one or two attempts.
- However, the barge should not be bigger than can be easily accessed to site
- Ensure all equipment and machinery are mobilized to site during day time
- Arrange mobilization in such a way that equipment and material are unloaded as soon as possible. Make arrangements for material pick up at the port or unloading site beforehand
- The route from the port of origin to Thimarafushi should be mapped and bathymetric charts should be studied beforehand to ensure the vessel does not encounter any shallow reefs en route to the site. Extra precaution should be taken during inner atoll travelling.

- Ensure the mobilization vessel and the equipment and material are insured
- Have an emergency plan in place in the event of an impact on the reef. Establish contact with vessel salvage groups operating in the Maldives beforehand. Inform the authorities immediately upon such an incident.
- Inform these mitigation measures to all suppliers that may mobilise to site independently from the developer/contractor.

6.3.2 Temporary site set up

Impacts from the activity include;

- Generation of wastes
- Health and safety impacts
- Generation of noise
- Loss of visual amenity

Significant amount of **waste will be produced**, both during the initial setup and once the work force is settled. Type of waste produced includes building and construction waste, green waste and household wastes. Household waste types produced at the temporary site will include paper, plastic, wood, food waste, glass and metallic waste. Hazardous waste will also be produced in minute amounts along with waste oil. The impact of the waste will be confined to the site under normal circumstances. However, if the waste is not managed and not removed from site periodically, there is potential for waste to accumulate at other areas of the island.

Construction materials stored at the site such as cement and fuel for machineries have the potential to damage the marine and terrestrial environment. Both terrestrial and coastal activities can pollute the environment including soil, aquifer and coastal water due to accidental spill of oil and chemicals. Sometimes these materials are thrown into the environment due to absence of appropriate supervision at work sites. Waste disposal also has the potential to cause contamination of groundwater from leachate while waste is stockpiled.

Construction of large development projects such as establishment of water supply network require a large number of construction workforce and a number of risks related to construction activities. Key impacts predicted for the construction workforce is related to health and safety issues. Often in such construction environments, workers are prone to injuries and diseases. Also, if precautionary measures on **health and safety** are not taken into

serious consideration, the entire operation may be affected as a result of accidents and subsequent injuries.

Noise will be continuously generated at the site due to equipment and machineries including cement mixers, excavators, dump trucks, etc. Power generator at site will also be usually noisy, emiting noise in the range of 60 – 80 dbA. If workers are exposed to noise consistently, it will have an impact on their health and well-being.

Temporary sites such as proposed for this project are usually set up rapidly without much concern for **visual amenity.** The location of the proposed site is far away from residential areas and the general community. Therefore the impact will be minor.

Mitigation measures for the discussed impacts are the following:

- Inform the council and the community of the site setup and finalise the locations at least 1 week before mobilization.
- Establish a temporary waste management which segregates wastes to at least the following categories; organic food wastes, metal/steel, plastics, green wastes, hazardous wastes, waste oil.
- Waste site to have a concrete base to ensure there is no ground water impact at the site due to leachates.
- Place bins for biodegradable and non biodegradable wastes at different locations of the site, especially near the staff accommodation and/or canteen.
- Pre-inform all the staff on importance of waste management and inform on penalties that will be informed for poor practice. Increase the penalties if any waste is disposed off site.
- Establish contact with the health facility on the island before mobilization. Make an emergency plan on how a staff with serious injury can be transported within minimum amount of time.
- Have first aid kits available on site, especially at the staff accommodation.
- Have about 2-5 staff trained in first aid techniques before mobilization to site.
- Although the site will not be at the highest standards, ensure basic hygiene is followed, especially with regards to open wastes and sewage.
- Enforce hand washing at the canteen, and make drying towels and hand sterilizers available.

- The site has to be fully demarcated and fenced with a gate for personal entry. Fencing should be at least at a height of 6ft. Double padded insulated fencing is not necessary. However, fencing should be done using one material, and should not be randomly placed.

6.3.3 Operation of Heavy duty vehicles and Machinery

Impacts from the activity include;

- Health and safety impacts
- Generation of noise
- Air pollution
- Damage to road and existing structures

Health and safety impacts need to be considered for both workers and the local community. Excessive driving on uneven terrain will cause chronic pain to drivers. There are other similar minor cumulative impacts. More direct impact are accidents that may occur. There have been numerous incidents in recent past in local communities where reckless driving and negligence of proper safety measures have led to serious injury and even untimely death to workers and members of community.

The machinery is expected to generate **noise** well in excess of 75 dbA at the height of their work. Cement mixers, batching plants, and even dump trucks will inevitably create such noise. While mobile machinery will create noise over a larger area, the noise will be distributed and not concentrated to a particular location and therefore the impact would be lesss. Static equipment such as cement mixers will generate significant noise at point locations.

The use of fuel in vehicular engines and operation of machines such as trucks cause emissions of carbon dioxide, sulphur dioxide and nitrogen oxides with fine particulate matter causing **air pollution.** For the proposed project, carbon emissions are considered to be negligible, as the amount generated from vehicles from a project of such scale will be minute. However, at a local level, thick smoke generated from incomplete combustion from poorly serviced vehicles will be an issue and have direct impact on the residents.

Continuous operation of heavy machinery on roads may put excessive load on **roads**, thereby reducing the road level at locations. Sudden dip in road levels will make it very difficult for continuous flow of traffic. Travelling regularly in such 'bumpy' roads can be regarded as a health issue for the local community as well. Furthermore, these locations will later create large pot holes for water to collect during rainy seasons. There have been situations in islands where such situations have lead to the road being inaccessible at times.

Mitigation measures for the discussed impacts are the following:

- Establish main routes for the machinery before mobilization. These routes should be the larger roads in the island and all heavy machinery should travel on these roads, unless it is inevitable. Shorter smaller roads should not be used as short cuts. There should be a buffer of at least 1m from each side from the vehicle width.
- Provide back support aids to drivers and heavy lifters
- Enforce protective clothing to be worn during work hours. These include fluorescent vest, safety helmets, and safety shoes. Staff operating loud equipment should wear ear muffs.
- Members of the public, and especially children not allowed access to heavy machinery under any circumstances.
- Ensure the vehicles are in good working order before mobilization. All back mirrors and side mirros, lights, brake should be in excellent condition.
- Ensure all the equipment and machinery are serviced before mobilization to site.
- Do an assessment of road conditions before mobilization to ensure existing condition.
- If any significant damage to the roads or a significant decrease in road level, contractor should back fill the roads to original level (the level before mobilization)

6.3.4 Building construction and dewatering

Impacts from the activity include;

- Groundwater quality degradation.
- Generation of noise
- Air pollution
- Water pollution

Groundwater quality is impacted due to dewatering and spills and leakages during building construction. Groundwater aquifer will be exposed during excavation and dewatering to lay

pipes and during other construction activities. Any accidental spill of oil and toxic substances has the potential to contaminate groundwater especially if the aquifer is exposed. Likewise, during construction, significant quantities of waste will be generated where any mishandling of solid and hazardous waste could also pollute the aquifer. Impacts from dewatering will be felt on the groundwater aquifer at a very local level. The impacts are primarily salinisation and reduction in volume of water in the aquifer. These impacts will be very short term and expected to be recharged during rainfall (CDE, 2016). Therefore, the impacts are minor.

Air pollution is mainly from dust and emissions from machinery engaged in construction and from concrete works. The location of the site indicates that the wind will predominantly blow any particulates towards the island population center from south west. Machinery exhausts may degrade the air quality leading to long term health risks to the community. However, due to relatively small size of islands that allow rapid turnover and flushing of harmful emissions, impacts from air pollution due to operation of machinery and construction works is minor (CDE 2016)

Noise impact from building construction works is inevitable. Noise in excess of 75 dbA is expected, however intermittently. The site is located away from population center and the public will not have to endure this nuisance and therefore the impact is minor.

Water pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction. However, the likelihood of this occurring at a significant level is very low.

Mitigation measures for the discussed impacts are the following:

- All building and construction works should start only after the site is properly demarcated and fenced. Fencing should be done along the side facing the coastline as well.
- Dust screens should be placed around heavy construction areas
- Building wastes should not be placed along the coast line, unless otherwise requested by the council as temporary shore protection measures; if required.
- Any hazardous liquids including paint to be stored in concealed locations
- Project should be planned in such a way that foundation works start immediately after dewatering.

- Priority should be given to dewater to the adjacent land. However, dewatering to the lagoon in front of the site is also acceptable.
- Dewatering to occur at low tides

6.3.5 Construction of Brine discharge Outfall

Impacts from the activity include;

- Impact on corals and marine life
- Sea water quality degradation

There could be direct **impact on the corals** and benthic organisms due to the outfall pipe works. However, there does not appear to be significant marine life at this location. Furthermore, the pipe and anchor blocks will provide a substrate for further growth in the near future as is usually the case with such pipelines. Therefore, there is a minor negative and minor positive impact from laying the pipe in the chosen location.

Regarding water quality, sedimentation will occur at a very small level during the pipe works. A slight increase in turbidity is expected, but will be highly localized. The impact is therefore minor.

Mitigation measures for the discussed impacts are the following:

- Study the weather conditions during the course of the project, and schedule the works for the calmest period.
- Lay down the pipe during low tide
- The work to be carried out with a small team. The team should not venture out of the work area.

6.3.6 Trenching and Construction of water network

Impacts from the activity include;

- Groundwater quality degradation
- Impact on traffic flow
- Impact on vegetation
- Visual amenity
- Damage to existing cables

Groundwater quality degradation will be minor, as significant dewatering is not expected if at all. However, there is probability for wastes to be deposited in the trenches, leading to local contamination.

To establish the network, quite an extensive amount of trenching would need to be undertaken all around the island. There will be a moderate impact on **vehicle and pedestrian traffic**. Some traffic may need to be diverted at small roads. However, it is not expected pedestrian access will be blocked at any road. Temporary closures may occur to setup equipment at site. In larger roads, vehicle obstruction is also not expected.

Trenching works may lead to **vegetation** removal on some occasions. However, from the existing environment survey it was identified that no significant vegetation will have to be removed.

Visual amenity at populated neighbourhoods will decrease during trenching works. The significance of impact will depend on how long the area is trenched without being backfilled. It is expected the impact will be minor.

From the stakeholder consultation, it was put forward by both FENAKA and the TV cable company that they have concerns regarding **damage to their cables** during trenching works. Damage to electricity cables will have a greater impact as sections of the community may have to endure blackouts for a period of time until any potential damage is fixed.

Mitigation measures for the discussed impacts are the following:

- In case of trenching in smaller roads, plan it in such a way that continuous flow of traffic is not impeded. The works will need to be divided in regions and access to popular public locations should be provided at all times.
- Place warning and notice boards at trenched roads
- Inform the community through the council on the water network and where trenching will occur.
- If under any scenario a tree has to be removed, ensure it is transplanted rather than removed and discarded.
- Works to be carried in the shortest time possible. Ensure all materials and equipment are available and in working order before commencing work.
- Get updated cable drawings from all utilities and services before commencing works. Invite utilities and services to be present at the site and supervise the works during trenching (especially in more sensitive areas).

6.3.7 Construction of borehole

Impacts from the activity include;

- Groundwater quality degradation
- Air pollution
- Noise generation

Drilling of the tube well may require dewatering, temporarily decreasing the **ground water** condition at the location. This impact is minor. The drilling liquids may contaminate the ground water if not properly disposed. There will be a short term impact on marine water as well if disposed to the sea, which is not recommended.

Regarding **air pollution**. Dust nuisance may be caused if bentonite used in the drilling process is discharged on land and when the discharged bentonite is dried up in the sun. Given the small quantity of bentonite and with proper disposal, dust nuisance from bentonite is insignificant (CDE 2016).

Noise pollution during drilling works will be excessive. This will be a moderate impact

The overall impact from borehole construction is minor. However, the impact would increase in many folds if the borehole collapses under any circumstances.

Mitigation measures for the discussed impacts are the following:

- Members of the public should not be allowed on site during drilling works
- Staff engaged in drilling should wear ear muffs for the entire duration
- Drilling fluids and drill cuttings should be buried in either excavated pit (excavated above the water table) or mixed with top soil at a ratio of 1:1.

Operational Phase

6.3.8 Waste generation and management

Impacts identified include:

- Contamination of soil and groundwater from oil and chemical spill

- Generation of solid waste from plant site, including worn out equipment and materials such as storage containers, RO membrane, filter membrane, etc, causing public nuisance and/or health hazards.
- Generation of liquid waste from plant site, including hazardous chemicals. Leaching to the ground, causing groundwater pollution.

Likely oil and chemical spills from operation of desalination plant will pollute the air, groundwater and soil. This pollution usually occurs either due to accidental spill or unregulated emissions into atmosphere due to absence of appropriate measures to manage such operations.

Inappropriate handling of solid waste and garbage and its disposal into the surrounding environment can have impacts on the marine environment including pollution of coastal waters.

Solid wastes can have adverse impacts on the marine environment ranging from reduced aesthetic beauty of the surrounding area to degraded water quality as well as potential ecological disturbances. Environmental impacts associated with solid waste disposal into the marine environment include reductions in fish populations due to water pollution, as well as killing corals and other marine organisms by smothering by plastic bags.

Other waste types such as waste oil, hazardous wastes, plastics will be segregated and transported to Thilafushi and therefore minimum impact in anticipated.

Mitigation measures include the following:

- Minimize waste generation
- Maximize the opportunity for reusing/ recycling/ recovering materials
- Ensure that all treatment and disposal options comply with all relevant guidelines and standards.
- Segregate waste materials according to types to facilitate re-use;
- Co-ordinate material deliveries to minimize storage times on site to avoid damage
- Provide training to site staff in waste minimization practices

6.3.9 General operations of the plant

Possible impacts include:

- Air pollution
- Noise pollution
- Light pollution

The proposed method of using diesel generators for production water will release pollutants such as carbon dioxide, sulfur dioxide and nitrogen oxides to the atmosphere, creation **air pollution**. These emissions will not be significant; even considering the cumulative nature, this impact is considered minor.

The RO plant facility will continue to generate **noise** during operation. However, the impact would be minimal as the plant would be concealed in a building. Generally, the plant noise outside of such buildings are within the acceptable range of 50 – 60 dbA.

There will not be any significant **light pollution** due the existence and operation of the facility.

There are no further mitigation measure apart from wearing ear muffs inside the plant house.

6.3.10 Feed water intake

Impacts include

- Groundwater quality degradation

For desalination, water will be pumped at a depth of 32 metres at the rate of approximately 17 m3 per hour. the proposed pumping may have some drawdown effect due to the unconfined nature of the freshwater lens,. Considering the depth at which water is withdrawn, the pumping rate and the location of the borehole on the edge of the freshwater lens near the coast, it is considered that the drawdown effect on groundwater lens will be minimal.

Therefore the impact would be minor. However, if there is an accident and the borehole collapses, there will be short term major impacts on the ground water.

There are no mitigation measures other than monitoring feed water volume daily.

6.3.11 Brine Discharge

Impacts include

- Sea water quality degradation

Wastewater will not get discharged into surrounding waters without treatment. Direct contamination of surrounding water causing degraded water quality is therefore highly improbable. Brine discharge from seawater desalination is not expected to affect the environment. Brine is discharged 100m away from the beachline. The impact of such small discharges is negligible. Almost all audits and EIA reports carried out in the past indicate that there is no impact of hyper-salinization from brine discharge in the lagoon, especially for such small scale operations (Sandcays 2013).

Outfall pipe damage due to rough weather. This would be a major impact as it would halt the operation of the plant.

Mitigation

- Outfall pipe should be placed on the sea bed with concrete ballast blocks of a mass sufficient to prevent the movement of the pipeline during heavy wave activity

6.3.12 RO Product water

Impacts include

- Degradation of water quality
- Causing public unrest and illness
- Plant operations breakdown

It is absolutely critical that the plant and network is properly supervised and maintained. Drop in product water quality will lead to initial aesthetic issues, which may further worsen to an outbreak of disease within the public.

Decrease in product water quality is an indication of plant systems not working according to design. This is usually due to failure of some component of the plant. The membranes or filters for examples will deteriorate gradually and thus it is important continuously monitor the product water quality.

Mitigation measures include the following:

- All chemicals to be stored in a locked area with concrete floors and walls

- Ensure daily supervision of RO plant including checking for vibration and leaks
- Monitor and log electronic conductivity and production volume
- Follow membrane back washing schedule as given in the RO plant manual
- Ensure sedimentation tank, and water storage tanks are sealed
- Clean water storage tanks at least biannually.
- Pressure vessel membranes to be serviced regularly

6.3.13 Rainwater harvesting

Impacts include

- Degradation of water quality
- Causing additional stress to the filters.

Open gutters at the rainwater harvesting locations will welcome foreign particles and sometimes even organisms such as mice to enter the gutter and the water network. This would lead to a degradation of the product water quality which will be mixed at the final storage tank. Likewise, the rainwater holding tank condition may also lead to contamination of the collected rainwater. This would initially cause stress to the filters and if the situation continuous may damage the filters rapidly, thereby leading to water quality degradation.

Mitigation measures include the following:

- Roofs in structures chosen for rainwater harvesting to undergo scheduled cleaning at least once a month. Weekly or fortnightly during heavy rainy seasons.
- Gutter openings should be covered with a mesh to prevent foreign particles and organisms entering the gutter. The mesh should be supervised and maintained.
- Rainwater collecting tanks should be cleaned.

6.3.14 Socio-Economic Impacts

The socio-economic impacts from the proposed project are positive in general, in terms of job opportunities and other income generating opportunities for local island communities and the nations economy as a whole. These include opening new markets for the locals and providing support to existing industries such as:

- Agriculture: opportunity to get fresh water required to grow fruits and vegetables in large scale

- Construction: concrete casting, cement mixing, and other construction related works can be undertaken more conveniently. Moreover, providing good quality drinking water to laborers will be easier. These changes would reduce the time and cost for construction projects

- Tourism: The availability of continuous supply of fresh water will be a boost to the tourism sector. While tourism is not a highly developed industry in the island, there is potential with the existence of the airport. Availability of fresh water can enable to market the isl and more favorably. Satisfaction of guests will also improve. Guests in general will be more willing to travel to islands with convenient fresh water supplies. The subsequently applies to investors willing to invest in the tourism sector in the island Furthermore, big tourism development such as city hotels can only be developed in islands with fresh water supply networks in place.

- Job opportunities at the island: Few jobs will be created to maintain and monitor the system in the island.

In addition to improving the economic status of the island, the water supply network will provide safe drinking water to the community, thereby improving their health and lifestyle.

6.4 Assessment of significance of impact

Table 10 Assessment of significance of impacts

		Nature of impact		Significance Evaluation Criteria				
Project Activities	**Potential Impact**	Direct/Indirect	Immediate/Cumulative	Vulnerability	Sensitivity	Recoverability	Importance	**Significance**
CONSTRUCTION STAGE								
Mobilization & Site setup	Generation of noise	Direct	Immediate	Yes	Low	High	-	Minor
	Reduction of sea water quality due to oil spills, sedimentation and increase in turbidity	Direct	Cumulative	No	-	-	-	No impact
	Loss of visual amenity	Immediate	Immediate	Yes	Low	-	-	Minor
	Direct impact on reefs (due to accident)	Direct	Immediate	Yes	Med	Low	High	Major*
Temporary site setup	Generation of waste leading to pollution	Direct	Cumulative	Yes	Low	High	-	Minor

	Health and safety impacts (due to accidents)	Direct and indirect	Immediate and Cumulative	Yes	High	Med	High	Major*
	Generation of noise	Direct	Immediate	No	-	-	-	No impact
	Loss of visual amenity	Direct	Immediate	Yes	Low	Med	High	Minor
Operation heavy duty vehicles/machinery	Health and safety impacts	Direct	Immediate	Yes	Med	High	-	Minor
	Generation of noise	Direct	Immediate	Yes	Med	High	-	Minor
	Air pollution	Indirect	Cumulative	Yes	Low	-	-	Minor
	Damage to roads and existing structures	Immediate	Cumulative	Yes	Med	Med	Low	Moderate
Building construction and dewatering	Groundwater quality degradation	Direct	Cumulative	Yes	Low	-	-	Minor
	Generation of noise	Direct	Immediate	Yes	Med	High	-	Minor
	Air pollution	Indirect	Cumulative	Yes	Low	-	-	Minor
	Water pollution	Indirect	Cumulative	Yes	Low	-	-	Minor

Construction of brine discharge outfall	Impact on corals and marine life	Direct	Immediate	No	-	-	-	No impact
	Sea water quality degradation	Direct	Immediate	Yes	Low	High	-	Minor
Trenching and construction of water network	Groundwater quality degradation	Indirect	Cumulative	No	-	-	-	No impact
	Impact on traffic flow	Direct	Immediate and cumulative	Yes	Low	-	-	Minor
	Loss of visual Amenity	Direct	Immediate	Yes	Med	High	-	Minor
	Damage to existing cables	Direct	Immediate	Yes	Med	Med	Low	Moderate
Construction of borehole	Groundwater quality degradation	Direct	Cumulative	Yes	Med	High	-	Minor
	Air pollution	Indirect	Cumulative	No	-	-	-	No impact
	Noise Generation	Direct	Immediate	Yes	Med	High	-	Minor
OPERATION STAGE								
Waste generation	Water pollution from leaks	Direct	Cumulative	Yes	Low	-	-	Minor

and management								
	Oil spills	Direct	Cumulative	Yes	Med	High	-	Minor
	Air pollution	Indirect	Cumulative	No	-	-	-	No impact
General plant operations	Air Pollution	Indirect	Cumulative	No	-	-	-	No impact
	Noise pollution	Direct	Cumulative	Yes	Low	-	-	Minor
	Light pollution	Indirect	Cumulative	No	-	-	-	No impact
Feed water intake via borehole	Groundwater quality degradation	Indirect	Cumulative	No	-	-	-	No impact
Brine Discharge	Sea water quality degradation	Direct	Cumulative	Yes	Low	-	-	Minor
RO Product water	Degradation of product water quality	Direct	Cumulative	Yes	High	Med	High	Major*
	Plant operations breakdown leading to unavailability of fresh water	Direct	Immediate	Yes	High	Med	High	Major*
Socio Economic changes	Impact on agriculture	Direct	Cumulative	Yes	Positive	-	-	Beneficial
	Impact on construction industry	Direct	Immediate	Yes	Positi	-	-	Beneficial

					ve			
	Impact on tourism	Indirect	Cumulative	Yes	Positive	-	-	Beneficial
	Creation of job opportunities	Direct	Immediate	Yes	Positive	-	-	Beneficial
	Impact on public health	Direct	Immediate	Yes	Positive	-	-	Beneficial

6.5 Mitigation management plan

Table 11 Details of Mitigation measures

Mitigation measures	Implementing Responsibility	Implementing Stage	Cost
Site Mobilization			
Inform the council and the community of the mobilization within at least 1 week from mobilization date	Contractor – project manager	Mobilization	0
Finalize all arrangement for the unloading point, and material and equipment storage at least 1 week before mobilization commences	Contractor – project manager	Mobilization	0
The route from the port of origin to Thimarafushi should be mapped and bathymetric charts should be studied beforehand to ensure the vessel does not encounter any shallow reefs en route to the site. Extra precaution should be taken during inner atoll travelling.	Contractor – Project Manager & Supplier – Manager, Vessel Captain	Mobilization	In project costs
Ensure the mobilization vessel and the equipment and material are insured	Contractor & Supplier	Mobilization	In project costs
Have an emergency plan in place in the event of an impact on the reef. Establish contact with vessel salvage groups operating in the Maldives beforehand. Inform the authorities immediately upon such an incident	Contractor – Project Manager	Mobilization	In project costs
Inform these mitigation measures to all suppliers that may mobilise to site independently from the developer/contractor	Contractor – Project Manager	Mobilization	0
Carry out mobilization during Off peak hours during day time	Contractor – Project Manager	Mobilization	0
Reduce frequency of mobilization trips	Contractor – Project Manager	Mobilization	In Project Cost
Temporary site setup			
Establish a temporary waste management which segregates wastes to at least the following categories; organic food wastes, metal/steel, plastics, green wastes, hazardous wastes, waste oil	Contractor – Project Manager	Design and Construction	
Waste site to have a concrete base to ensure there is no ground water impact at the site due to leachates	Contractor – Project Manager	Design and Construction	35,000 MVR
Place bins for biodegradable and non-biodegradable wastes at different locations of the site, especially near the staff accommodation and/or canteen	Contractor – Project Manager	Design and Construc	15,000 MVR

Pre-inform all the staff on importance of waste management and inform on penalties that will be informed for poor practice. Increase the penalties if any waste is disposed off site	Contractor – Project Manager	Pre-construction	0
Establish contact with the health facility on the island before mobilization. Make an emergency plan on how a staff with serious injury can be transported within minimum amount of time	Contractor – Project Manager	Pre-construction	0
Have first aid kits available on site, especially at the staff accommodation	Contractor – Project Manager	Construction	In project costs
Have about 2-5 staff trained in first aid techniques before mobilization to site	Contractor – Project Manager	Pre-construction	In project costs
ensure basic hygiene is followed, especially with regards to open wastes and sewage	Contractor – Project Manager, Site supervisor	Construction	0
Enforce hand washing at the canteen, and make drying paper towels and hand sterilizers available	Contractor – Project Manager, Site supervisor	Construction	In project costs
The site has to be fully demarcated and fenced with a gate for personal entry. Fencing should be at least at a height of 6ft	Contractor – Project Manager, Site supervisor	Construction	In project costs
Stockpile material and sites to be covered to prevent washout and erosion during heavy rainfall.	Contractor – Project Manager, Site supervisor	Construction	In project costs
Avoid cleaning and washing of oily tools, equipment and parts (e.g. engine parts, machines) on bare ground	Contractor – Project Manager, Site supervisor	Construction	0
Operation of heavy duty vehicles and machinery			
Establish main routes for the machinery before mobilization	Contractor – Project manager	Pre-construction	0
Members of the public, and especially children not allowed access to heavy machinery under any circumstances	Contractor – Project Manager, Site supervisor	Construction	0
Ensure the vehicles are in good working order before mobilization. All back mirrors and side mirros, lights, brake should be in excellent condition	Contractor – Project Manager, Mechanical Engineer	Pre-construction	In project costs
Do an assessment of road conditions before mobilization to ensure existing condition	Contractor – Project Manager	Pre-construction	0
If any significant damage to the roads or a significant decrease in road level, contractor should back fill the roads to original level	Contractor – Project Manager	Construction	Depends on damage
Building construction and dewatering			
All building and construction works should start only after the site is properly demarcated and fenced	Contractor – Project Manager	Construction	**0**
Dust screens should be placed around heavy construction areas	Contractor – Project Manager	Construction	In project costs
Building wastes should not be placed along the coast line	Contractor – Project Manager	Construction	**0**

Any hazardous liquids including paint to be stored in concealed locations	Contractor – Project Manager	Construction	In project costs
foundation works to start immediately after dewatering.	Contractor – Project Manager	Construction	**0**
Priority should be given to dewater to the adjacent land	Contractor – Project Manager	Construction	**0**
Dewatering to occur at low tides	Contractor – Project Manager	Construction	**0**
Construction of brine discharge outfall			
schedule the works for the calmest period	Contractor – Project Manager	Design and Construction	**0**
Undertake the works during low tide	Contractor – Project Manager	Design and Construction	**0**
work to be carried out with a small team	Contractor – Project Manager	Design and Construction	**0**
Place ballast blocks along the outfall pipe	Contractor – Project Manager	Design and Construction	In project costs
Trenching Construction of water network			
Ensure continuous flow of traffic is not impeded.	Contractor – Project Manager	Design and Construction	10,000 USD
Place warning and notice boards at trenched roads	Contractor – Project Manager	Construction	In project cost
Inform the community through the council on the water network and where trenching will occur	Contractor – Project Manager	Pre-construction	0
Works to be carried in the shortest time possible	Contractor – Project Manager	Construction	0
Get updated cable drawings from all utilities and services before commencing works.	Contractor – Project Manager	Pre-construction and during construction	**0**
Invite utilities and services to be present at the site and supervise the works during trenching (especially in more sensitive areas).	Contractor – Project Manager	Pre-construction and during construction	**0**
Construction of borehole			
Restrict public access to site	Contractor – Project Manager, Site supervisor	Construction	0
Staff engaged in drilling should wear ear muffs for the entire duration	Contractor – Project Manager	Construction	In project costs
Drilling fluids and drill cuttings should be buried in either excavated pit	Contractor – Project Manager	Construction	In project costs
Waste Management during operations			
Minimize waste generation by Maximize the opportunity for reusing/ recycling/ recovering materials	Plant operator	Operations	In project costs
Ensure that all treatment and disposal options comply with all relevant guidelines and standards.	Plant operator	Operations	0
Segregate waste materials according to types to facilitate re-use;	Plant operator	Operations	0
Co-ordinate material deliveries to minimize storage times on site to avoid damage	Plant operator	Operations	0

Provide training to site staff in waste minimization practices	Project operator	Operations	In Project cost
Rainwater harvesting			
Roofs in structures chosen for rainwater harvesting to undergo scheduled cleaning at least once a month. Weekly or fortnightly during heavy rainy seasons.	Utility company and/or council – Plant operator	Operations	Approx. 1000 – 3000 MVR / month for cleaner
Gutter openings should be covered with a mesh to prevent foreign particles and organisms entering the gutter. The mesh should be supervised and maintained.	Utility company and/or council – Plant operator	Operations	Can accommodate within the cost above
Rainwater collecting tanks should be cleaned at least biannually.	Utility company and/or council – Plant operator	Operations	Can accommodate within the cost above
Desalination Plant and Water production			
All chemicals to be stored in a locked area with concrete floors and walls	Project Engineer	Design and Operations	In Project cost
Ensure daily supervision of RO plant including checking for vibration and leaks	Plant operator	Operations	Approx. 10,000 MVR/month as wages for plant operator
Monitor and log electronic conductivity and production volume	Plant operator	Operations	Can accommodate within the cost above
Follow membrane back washing schedule as given in the RO plant manual	Plant operator	Operations	Can accommodate within the cost above
Ensure sedimentation tank, and water storage tanks are sealed	Project Engineer & Plant operator	Design and Operations	In Project cost
Clean water storage tanks at least biannually or annually.	Plant operator	Operations	Within plant operator wages
Pressure vessel membranes to be serviced regularly	Plant operator	Operations	In Maintenance costs

6.6 Conclusion

The project in general has few impacts that can be regarded as significant. As with any major developer in island environments, the initial impacts come from mobilization and site setup activities, which are usually done in a hurry without proper planning and regard for the

environment. In such cases, there are moderate to major impacts that may occur during this stage. However, with the proper planning as recommended under mitigation measures, these impacts can be reduced and even fully nullified.

The possible major impacts from the project including accidents during mobilization, heavy machinery usage, degradation in product water quality, and plant breaking down, are all from highly improbable scenarios. These scenarios can easily be avoided with proper mitigation measures as proposed in place. Therefore these impacts will also be nullified.

Project specific impacts predominantly include noise pollution, aesthetic impacts, pollution due to waste generation, etc. These impacts are minor and can be easily mitigated and localized. Impacts during operation are most concerning the groundwater, sea water, and product water quality. The project will have a positive impact on the groundwater aquifer and the highly localized minor change in sea water quality is not a cause for concern.

Regarding implementation of the mitigation measures, it can be seen from the above table that most mitigation measures can be put in place without incurring any additional costs. Most are based on proper planning with knowledge on impacts that may occur due to negligence. There may be indirect costs associated with these mitigation measures such as having a larger project management team or a more qualified team, with personnel trained in specific attributes such as health and safety, vessel maneuvering, etc. It is estimated that having the mitigation measures in place would not cost 1% of the total project cost and is therefore economically feasible.

Overall, the project have numerous positive impacts including its impact on the ground water, improving public health, improving the lifestyle of the community, and creating new economic opportunities in agriculture, tourism, and business sectors.

7. Project Alternatives

This section looks at different alternatives for the proposed project. The main alternative is the no project option. After extensive discussion of this alternative, then alternatives for the project components are investigated. Alternatives are given for each component based on location and design. Each alternative is discussed based on economic, social, and environmental factors. Finally, the recommended alternatives are suggested to assist in the project decision-making process.

These alternatives are not as intensively investigated as the original scope of the project. However, investigating and discussing alternatives is important so that it is ensured that the best available option(s) is/are chosen to solve the issues/problems of the project.

7.1 No project option

Initially the no project option is discussed in order to hypothesize whether the project should be taking place first of all. Sometimes, projects are proposed at a whim without much thought given to the socio-economic motivation of such development and the unnecessary impacts it may have on the environment, especially those that are long term. Therefore carrying out this practice is important to avoid such a scenario and to ensure that undertaking this project at this stage makes good socio-economic sense without much, if any, impact on the environment.

The advantages and disadvantages of not undertaking the project is given below.

Table 12 Advantages and disadvantages of the no project option

Advantages	Disadvantages
No additional environmental impact due to construction works	Negative impact on health and well being of the community due to lack of continuous fresh water supply will persist.
Do not have to invest for the new project, and can be used for other facilities	Long term economic implication may have to be encountered if groundwater is completely depleted at current rate.
Other less intensive options to provide fresh water can be explored	Groundwater aquifer will continue to be under stress.
Can continue to rely on more natural sources of water, which is properly and	Would need to develop a sophisticated and large rainwater collecting and storage system system and/or have large areas of

intensely designed can be argued to be more sustainable.	the ground allocated for groundwater recharge
New type of waste that will be produced from the RO plant, such as membranes, filters, chemicals can be avoided.	New indirect opportunities that will arise after the project such as in tourism and agriculture will not materialize.

A comparison of the no project option with the recommended and other evaluated options indicate that the no-project option is practicable but involves long-term costs, and will lead to current environmental issues in the island persisting. The major disadvantage of the no project option is that the operations will have to continue with the current issue of receiving inconsistent fresh water to the public. There are major economic and social implications of the project not going ahead.

The main advantage of the no project option is that there will not be any heavy machinery works at site, and natural state of the island can be preserved to an extent. However, this does not really apply as there have been several major construction works already undertaken in the island.

7.2 Project Alternatives

Considering the scale of operations carried out as part of this project, the no project option is not viable. However, there are some alternatives that can be considered in terms of backup water supply and location of the discharge pipeline.

The Proponent initially decided that the best option not encompassing excessive costs would be adopted after evaluating different options. Therefore, the different alternatives for the project components were considered before finalizing a particular option.

7.3 Alternative treatment options

The current system proposed a chlorination system to disinfect water. UV sterilization will achieve the same purpose by sterilizing the water using UV radiation.

Advantages of UV treatment as opposed to Chlorination is as given below:

- killing of bacteria, viruses, and yeasts within seconds
- neither the taste nor odor of the water are impaired
- no formation of by-products hazardous to health
- no chemicals need

- no ecological damage
- method with low maintenance and easy handling

The main advantages of the chlorination system are the residual protection against recontamination. In addition to this, its low cost and scalability compared to UV treatment, makes this a more favorable option.

UV filtration can be further explored to be incorporated to this project if bottling is considered to commercially sell drinking water. This could be a way the project is made more feasible. However, it does not seem this would be necessary at this stage.

7.4 Alternative Outfall Location

The only possible alternative to the proposed outfall location is as shown in the Figure below.

Any other alternative location will not be feasible given the distance from the RO plant house. The alternative location is not particularly favorable compared to the proposed location. The proposed location ensures the water is diluted to its maximum possible and the water is taken away from the island. However, the alternative option is not recommended as there is

probability the wave impact in the area will lead to high saline water moving towards the shoreline of the newly reclaimed area.

In terms of marine environment impact, there will not be any significant impact in either option. The existing environment at the site was investigated and discussed in Section 4..

8. Environmental Monitoring

This section deals with the Environmental Management and Monitoring plan for the Water supply facility in Th. Thimarafushi. The proposed monitoring plan is for the construction and operational phase of the project components including; vegetation clearance, trenching, construction and use of pump stations and sewage outfall. The data collected for this assessment and previous assessments will be used as baseline data while undertaking the monitoring plan. Undertaking environmental monitoring is essential for several reasons including:

- To ensure that potential impacts are minimized and to mitigate unanticipated impacts.
- To aid in impact management,
- To improve impact prediction and mitigation methods.
- To gather long term data to minimise uncertainty
- To ensure sustainable development

Environmental monitoring has traditionally been a component that has been overlooked by most proponents. Proponents claim that this is mainly due to difficulty in making arrangements with the environmental consultants on a long-term basis and making arrangement for each monitoring is difficult since monitoring plans are given for a long term. Currently, environmental monitoring does not appear to be cost effective from the proponent's point of view and is generally viewed as a burden. However in order to make the best use of this report and for the aforementioned reasons, carrying out the monitoring plan as outlined is vital.

The proposed monitoring programme will yield beneficial results if it is undertaken for a long period. As required in the TOR, the monitoring is to take place during construction, after project completion, every 3 months thereafter up to 1 year, and then on a yearly basis for 5 years.

The proponent expressed their full commitment to carry out the monitoring program outlined in this report. The proponent's commitment to undertake the environmental monitoring and mitigation measures is given in the **Proponents Declaration.**

8.1 Monitoring Methodology and Costs

The methodology used for monitoring will be similar if not the same as those used in this environmental assessment. However, field water quality testing equipment can be employed to decrease the uncertainties of the results as they can be compared to those obtained from the National Health Laboratory or MWSC. To carry out field water testing, such equipment needs to be procured and available on site, which will be feasible for the proponent of this project.

Cost estimates for environmental monitoring were usually given in previous EIAs based on the components that require monitoring. However, this was not seen as an efficient method and it tended to give high overall cost estimates to proponents and how much the proponent would need to spend to generate an annual monitoring report was not clear. As a result, more often than not, it discourages the proponent from attending to the environmental monitoring. Generally the components that require monitoring can be done simultaneously and therefore estimated costs are given based on the activities that need to be carried out to compile an effective monitoring report.

The costs given in Table 13 and Table 14 are calculated for monitoring to be undertaken by hiring environmental consultants for each monitoring program. However, field data collected for the proposed environmental monitoring program can be carried out by an in house team of engineers and/or technical assistants since most of the parameters are to be investigated quarterly, and therefore hiring a consultant for each occasion may not be feasible. Nevertheless, if the client does not employ an environmental expert among its staff, it is highly recommended that an arrangement is made with an environmental consultant on a long term basis to carry out and supervise the execution of the monitoring program.

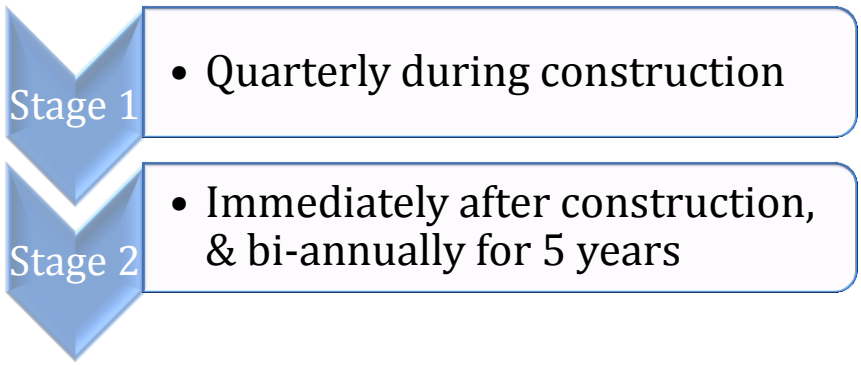
The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. Therefore, the monitoring programme will cover the following aspects of the proposed project:

- Ground water quality
- Marine water quality
- Marine environment quality
- Waste generation and management
- Environmental health and safety
- Product water quality
- Public opinions and concerns

For all the measurements, it is important that the samples are taken from exactly the same locations as done for this EIA study.

8.2 Recommended Monitoring Programme

As instructed in the TOR, the monitoring programme will be divided into 3 stages.



Stage 1 (during construction)

- Ground water quality for pH, Salinity, Electrical Conductivity, and Total hydrocarbon. (from G1, G2, G3, G4)
- Marine water quality for pH, Salinity, Electrical Conductivity, TSS, Turbidity, BOD and total coliform and faecal coliform. (S1, S2)
- Qualitative coral reef and benthic monitoring (at brine discharge location) to look for any major deterioration of reef health compared to that of initial EIA.
- Supervision of maintenance and management of health and safety hazards (at temporary site). Note down reports of accidents and injuries that has occurred within the past quarter.
- Qualitative monitoring/supervision of waste management on site. (at temporary site). Note down the amount of space by volume each type of waste takes at site, and note down loose waste elsewhere at the site. Also consult with council regarding any reports of waste from the project outside the site boundary.

Stage 2 (during operations)

- Ground water quality for pH, Salinity, Electrical Conductivity, and Total hydrocarbon. (from G1, G2, G3, G4)
- Marine water quality for pH, Salinity, Electrical Conductivity, TSS, Turbidity, BOD and total coliform and faecal coliform. (S1, S2)

- Brine discharge water quality for pH, Salinity, Electrical Conductivity, Salinity, Dissolved oxygen, TDS, and BOD (at temporary brine discharge collection tank/pipe)
- Intake water quality for pH, Salinity, Electrical Conductivity, Salinity, Dissolved oxygen, TDS, Faecal coliform, total coliform. (at sedimentation tank)
- Qualitative coral reef and benthic monitoring (at brine discharge location) to look for any major deterioration of reef health compared to that of initial EIA.
- Product water quality for pH, Salinity, Electrical Conductivity, TDS, Free Chlorine, Chlroide, Boron, Copper, Flouride, Iron, Total Hardness, Iodine, Nitrate, Nitrite, Ammonia, Phosphate, Sulphate, Sulphite, Total Coliform, Feacal Coliform. (from 4 sites including; plant site/storage tank, main hospital, main school, main mosque)

8.3 Cost of monitoring

The following tables outline the cost estimate for each stage of the monitoring plan given. The costs are calculated assuming the monitoring will be undertaken by hiring environmental consultants on a project basis.

Table 13 Estimated costs of Stage 1 of the Monitoring Programme

Item No.	Details	Unit cost (US$)	Frequency	Total (US$)
1	Field allowance for 2 consultants for 2 day	100.00	9	900.00
2	Surveying and monitoring equipment depreciation.	50.00	9	450.00
3	Laboratory charges	400.00	9	3600.00
4	Compliance reporting	750.00	2	1500.00
	Total			**6450.00**

The monitoring is to be undertaken quarterly for a 28-month duration (once every 3 months), during which the project is expected to be completed. The report is produced once each year. If in any case the project prolongs, this monitoring phase should be extended to the full stretch of the construction period.

Table 14 Estimated costs of Stage 2 of the Monitoring Programme

Item No.	Details	Unit cost (US$)	Frequency	Total (US$)

1	Field allowance for 2 consultants for 2 days	100.00	10	1000.00
2	Surveying and monitoring equipment depreciation	100.00	10	1000.00
3	Laboratory charges	1000.00	10	10,000.00
4	Compliance reporting (annual report)	1000.00	5	4000.00
	Total for 5 years			**16,000.00**

Considering the 2 stages of monitoring, monitoring costs in the first phase, during which construction takes place is estimated to be **USD 6450.00**, which amounts to USD 230.36 per month.

In the 2nd Phase, the total costs are expected to amount to **USD 16,000.00.** In each of the next 5 years, it is estimated that the proponent would need to spend **USD 3,200.00** to undertake proper environmental monitoring.

Please note that the costs are subjective. It may vary depending on the consultant and also due to changes in price with time. Also, in the case that a long-term arrangement is made with a consultant, the price may considerably decrease and may be more feasible for the proponent.

8.4 Monitoring Report

Monitoring report should be compiled based on the baseline data collected. The report is to be compiled annually. This report should be submitted to the EPA and any other relevant government agencies for compliance, if requested. The report structure may include but not limited to;

- Introduction
- Details of the site at the time of investigation,
- Data collection and analysis,
- Details of methodologies and protocols followed
- Quality control measures,
- Sampling frequency and monitoring analysis
- Conclusion and recommendations

In addition to the proposed monitoring program, the desalinated water will be required to test more frequently, under the desalination plant registration requirement. Product water will need to be tested for microbes on a weekly basis. This monitoring plan is outside the scope of this EIA. However, some of the monitoring data collected under this monitoring requirement can be used for that purpose as well.

9. Conclusions

In conclusion, the project of establishing a water supply system in Thimarafushi is justified from a technical as well as environmental and especially a social point of view. In fact, the project is being undertaken in order to improve the livelihood of the people of Thimarafushi, especially their health and wellbeing and protect the groundwater aquifer of the island, and is therefore environmentally beneficial.

The main negative impacts of the proposed development includes small, short-term changes in local groundwater quality due to de-watering, impacts associated with increased operation of machinery and vessels during mobilization and construction period, impact marine environment from construction of the outfall. These are usually minor or short term environmental impacts and spread across a small spatial extent and can be mitigated easily. Major impacts due to accidents are improbable and can be avoided with good operations procedures in place.

The mitigation measures proposed for the construction phase are general construction controls such as dust, noise and emission control measures for land-based civil works and sediment minimisation and reef protection during laying the outfall pipeline. In addition, dewatering shall be kept to a minimal by way of appropriate design and dewatering impacts monitored and impacts on vegetation in dewatering areas addressed promptly. Some of the mitigation measures proposed for the operational phase include employment of trained personnel or training personnel to maintain and service the water supply system and related facilities, regular maintenance of the RO plant, including replacing membranes when required, regular monitoring of the product water quality. It had been recommended to proceed works with caution while laying down the outfall pipe.

With the implementation of the mitigation measures outlined in this EIA, severe or irreversible environmental impacts are not expected for the proposed project. However, it is very important for a suitable monitoring programme to be in place to ensure there is no detrimental impact on the groundwater quality of the island and no unexpected impacts would occur during the operational phase of the project. It is therefore recommended to proceed with this environmentally beneficial project with the said safeguards in place.

10. Acknowledgements

The author wishes to acknowledge the work of several people who have contributed to this report. Thanks are also due to those who participated in the different meetings, interviews, discussions although their names have not been specifically mentioned here.

The technical team of organized for this study who gathered field data, analyzed the data and presented some of the data in this report as well as the previous report are worthy of credit for the important work they did. Thanks to Nafha Aujaaz, Anoosha Hashim, and Ibrahim Rashihu for undertaking field work and assisting in the data processing and field data representation.

The field team wishes to express their appreciation for the assistance provided by the Island council and community.

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12. Team members who participated in the EIA study

Chapter	Page No.	Participants	EIA Registration no.	Signature
Introduction	1	Amir Musthafa	EIA 01/13	
Project Description	9	Amir Musthafa	EIA 01/13	
Legislative and Regulatory considerations	26	Nafha Aujaaz	EIA T02/16	
Existing Environment	33	Ibrahim Rashihu Adam	EIA T04/15	
Stakeholder consultation	60	Nafha Aujaaz	EIA T02/16	
Environmental Impacts and Mitigation	66	Amir Musthafa	EIA 01/13	
Project Alternatives	94	Amir Musthafa	EIA 01/13	
Environmental Monitoring	97	Amir Musthafa	EIA 01/13	
Conclusion	103	Amir Musthafa	EIA 01/13	

1. Team members who participated in the EIA study

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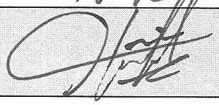
Introduction	1	Amir Musthafa	EIA 01/13	
Project Description	9	Amir Musthafa	EIA 01/13	
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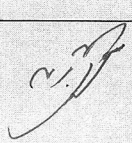
		Nafha Aujaaz	EIA T02/16	
Stakeholder consultation	60	Nafha Aujaaz	EIA T02/16	
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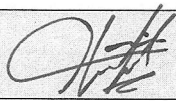
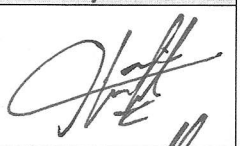
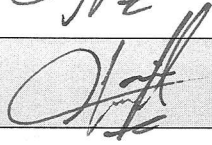
Project Alternatives	94	Amir Musthafa	EIA 01/13	
Environmental Monitoring	97	Amir Musthafa	EIA 01/13	
Conclusion	103	Amir Musthafa	EIA 01/13	

Annex 1: Terms of Reference

بسم الله الرحمن الرحيم

ToR: 203-EIARES/438/2016/179

Terms of Reference for Environmental Impact Assessment for the Water Supply System in Thimarafushi, Thaa Atoll

The following is the Terms of Reference (ToR) following the scoping meeting held on *24/10/2016* for undertaking the EIA of the proposed Water Supply System in Thimarafushi, Thaa Atoll. The proponent for the project is Ministry of Environment and Energy.

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.

Even though a single TOR is issued for the development of water supply system in seven islands, a separate EIA report for each island has to be submitted to the EPA and each report should address all the components of this ToR.

1. **Introduction and rationale** – Describe the purpose of the project with the rationale and, if applicable, the background information of the project/activity and the tasks already completed. Objectives of the development activities should be specific and if possible quantified. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked to other activities that are carried out or that is being carried out within the defined project boundary. Identify the donors and the institutional arrangements relevant to this project.

2. **Study area** – – Submit a minimum A3 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 and size. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds) if deemed significant for the stuy. 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 preparation, construction and decommissioning phases.
   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 provided):

Desalination plant design

- Submit an A3 size site plant of the RO plant house with labelled drawings
- Submit a process flow diagram of the RO system
- Describe the technology and production capacity and how it is justified
- Water storage capacity and how it relates to predicted water consumption
- Water quality monitoring systems
- Dewatering and excavation/trenching for pump station and pipeline installations if required
- Specify materials, equipment, heavy machinery, staff estimate, key personnel, positions, technical expertise required.
- Overall landscaping (transplanting trees from other locations will not be part of the scope of this study)

Rainwater Collection

- Describe rain water collection potential in the proposed project site
- Description of the proposed rainwater collection system and the total area required

Borehole water Intake, brine discharge pipe, and distribution network

- Justify pipe locations, provide depth and distance from shore using oceanographic and ecological information.
- Currents and waves ought to disperse the discharged water with minimum impacts on marine ecosystems and economic activities
- Description of borehole design and location of boreholes
- Description and justification of boreholes
- Description of borehole construction methodology including equipment used.
- Detailed description of the distribution network including pipe materials, house connections, water metring, trenching required and pumping facilities

Temporary facilities:

- Construction methods, scheduling and operation of temporary facilities including power generation, oil storage, water supply, wastewater treatment, accommodation facilities, waste management and decommissioning.
- Labour requirements;
- Material storage
- Housing of temporary labour
- Waste management at the temporary facility

Project Management

- Include communication of construction details, progress, target dates, duration of works, access to site, safety, power and fuel supply.
- Waste management practices during the construction stage of the project.

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 transects, vegetation transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

Climate

- Temperature, rainfall, wind, waves, evaporation rates
- Risk of hurricanes and storm surges;

Hydrography/hydrodynamics (use maps)

- Tidal ranges and tidal currents;
- Surface water currents
- Depths at brine discharge locations

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; and significant inland flora
- A qualitative assessment of coral reef environment (benthic coral fauna and fish fauna cover) at the proposed brine concentrate discharge area.
- Vegetation survey including type of vegetation and number of extent of vegetation to be cleared, if vegetation clearance is required as part of the project.

Physical Parameters

- Sea water quality measuring these parameters: temperature, pH, salinity, Electrical conductivity, turbidity, total suspended solids, BOD, total coliform and faecal coliform from a minimum of 2 locations.
- Ground water quality assessment of desalination plant site and at borehole locations, measuring these parameters, temperature, pH, salinity, conductivity, and total hydro carbon
- Noise measurement near proposed desalination plant area

Socio-economic environment

- Demography: total population, sex ratio, density, growth, and pressure on land and marine resources.
- Economic activities of both men and women
- Land use planning and natural resource use
- Accessibility and public transport within and to other islands
- Services quality and accessibility including health care facilities
- Community needs
- Sites with historical or cultural interest or sacred places

Hazard vulnerability:

- Vulnerability of area to flooding, storm surge and tsunami events.

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 (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- Impacts on marine habitats including damages to coral reefs, seagrass communities, fish stocks, protected areas and protected species during pipe installation;
- Impact on marine water quality
- Temporary sediment dispersal in water column (turbidity at the pipe installation areas).
- Impacts on ground water table and quality as a result of construction and operation activities (if any);
- Impact due to equipment and vehicle leaks and spillage
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment

- Impacts on employment and income, potential for local people to have (temporary or long term) job opportunities (and what kind) in the execution of the works;
- Disturbance to local natural resource users such as fishing areas, other tourism ventures nearby;
- Impact equity (economic activities, employment, income);

Construction related hazards and risks

- Pollution of the natural environment (e.g. oil spills, discharge of untreated waste water and solid waste, including construction waste);
- Risk of accidents and pollution on workers and local population.
- Impact due to any traffic diversions
- Impacts of noise, and work related safety issues.

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

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

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". 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.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures. Measures for both construction and operation phase shall be identified. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given. Mitigation measures shall be detailed to include expected costs of implementation and the personnel responsible for undertaking the mitigation measures. In cases where impacts are absolutely unavoidable, arrangement to compensate for the environmental effect shall be provided.

Task 7. Development of monitoring plan (see appendix)– Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for ground water and sea water quality. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction, after project completion and every three months thereafter, up to one year and then on a yearly basis for five years after. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities, government agencies, NGOs, engineers/designers and development managers, along with island council and community. The EIA report should include a list of people/groups consulted and summary of the major outcomes.

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 2012

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 October 2016

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Annex 2: Document Receipt by Council

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ފ.ތަރ.ގ ތިމަރަފުށި ތަކެއް:

ތ. ތިމަރަފުށި ފެނުގެ ގަލްވަނި ސަބްލައި ނެޓްވަރކް ހަދައިދިނުމުގެ ފަރާތުން ކަނޑައެޅިފައިވާ ފ.ތަރ.ގ ތަކެއް

EIA for the proposed Water Supply System in Thimarafushi, Thaa Atoll, Maldives

ހަވާލުވެގަންނަ ތަކެއް: ـــ

ދަށްވި: ـــ

ތިރުއްވާ ތަކެއް: ـــ

ތާރީޚް: ـــ 24 ނޮވެމްބަރ 2016

ސޮއި: ـــ

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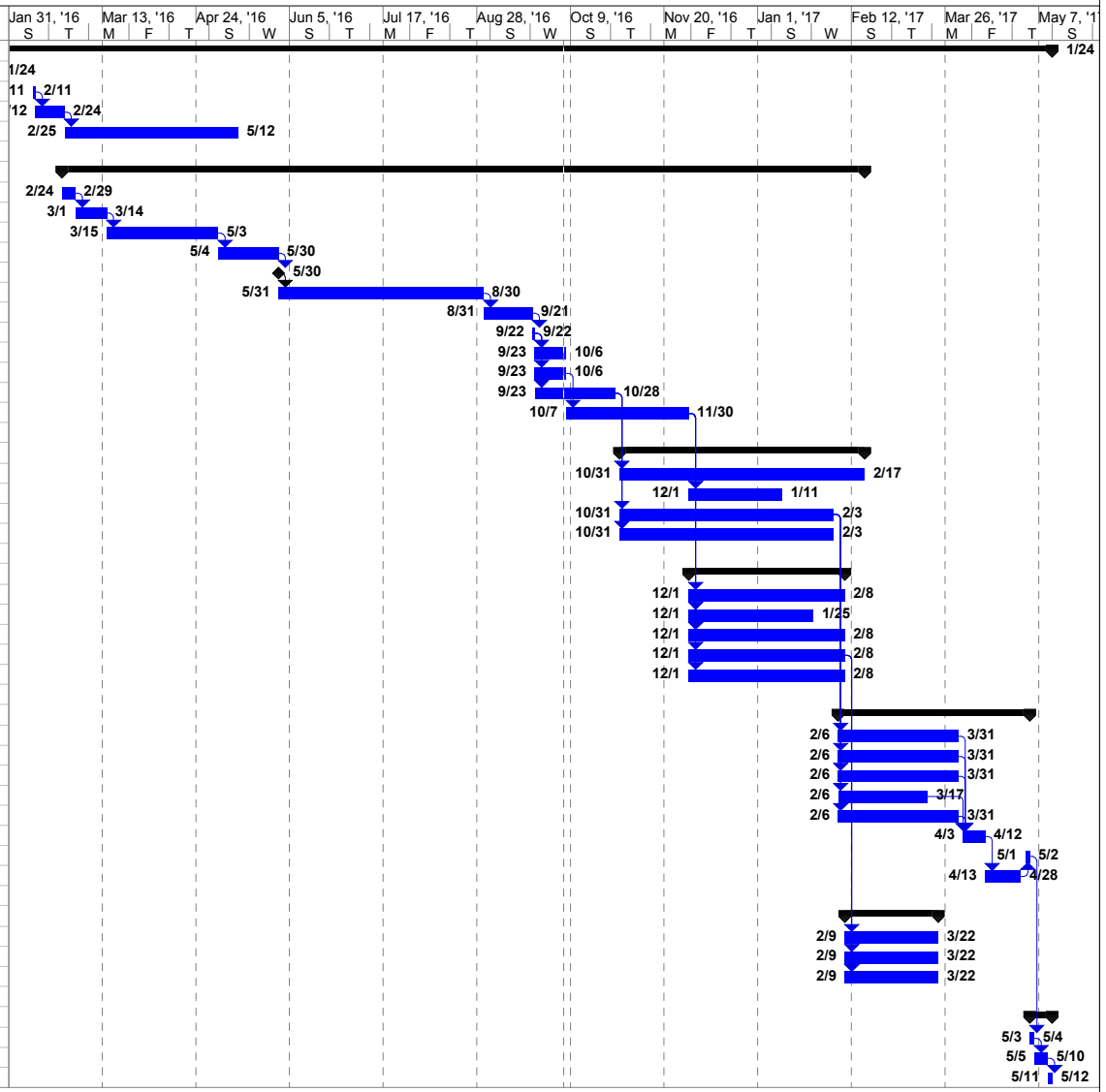
Annex 3: Work Schedule

Design and Build Basis for Water Supply Network, Water Storage Tanks and Reverse Osmosis Plant and Allied Works Based on Intergrated Water Resources Management

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Water Supply Project**	**340 days**	**Sun 1/24/16**	**Fri 5/12/17**	
2	Reciept of Letter of Acceptance	0 days	Sun 1/24/16	Sun 1/24/16	
3	Contract signing date	1 day	Thu 2/11/16	Thu 2/11/16	
4	Submission of Advance payment guarantee,	9 days	Fri 2/12/16	Wed 2/24/16	3
5	Reciept of 15% Advance payment	56 days	Thu 2/25/16	Thu 5/12/16	4
6					
7	**Design Works**	**258 days**	**Wed 2/24/16**	**Fri 2/17/17**	
8	Site inspection and planning	4 days	Wed 2/24/16	Mon 2/29/16	
9	Mobilization for preliminary survey and update of	10 days	Tue 3/1/16	Mon 3/14/16	8
10	Submission of updated land use plan	36 days	Tue 3/15/16	Tue 5/3/16	9
11	Concept Design	19 days	Wed 5/4/16	Mon 5/30/16	10
12	Submission of Concept Design (R-0)	0 days	Mon 5/30/16	Mon 5/30/16	11
13	Submission of Concept Design (R-1)	66 days	Tue 5/31/16	Tue 8/30/16	12
14	Submission of Concept Design (R-2)	16 days	Wed 8/31/16	Wed 9/21/16	13
15	Approval for Concet Design	1 day	Thu 9/22/16	Thu 9/22/16	14
16	Submission of Concept Report Clarifications	10 days	Fri 9/23/16	Thu 10/6/16	15
17	EIA Application - Submission to EPA	10 days	Fri 9/23/16	Thu 10/6/16	15
26	Project Design	26 days	Fri 9/23/16	Fri 10/28/16	15
18	Approval of EIA Report	39 days	Fri 10/7/16	Wed 11/30/16	17
19					
20	**Procurement Procedure & Imports**	**80 days**	**Mon 10/31/16**	**Fri 2/17/17**	
21	Plant & Machinery	80 days	Mon 10/31/16	Fri 2/17/17	26
22	Civil Construction Items	30 days	Thu 12/1/16	Wed 1/11/17	18
23	Pipes & fittings	70 days	Mon 10/31/16	Fri 2/3/17	26
24	Storage Tanks and structures	70 days	Mon 10/31/16	Fri 2/3/17	26
25					
27	**Civil Construction**	**50 days**	**Thu 12/1/16**	**Wed 2/8/17**	
30	Storage tank structures	50 days	Thu 12/1/16	Wed 2/8/17	18
31	Bore Hole construction	40 days	Thu 12/1/16	Wed 1/25/17	18
32	Rain Water harvesting system	50 days	Thu 12/1/16	Wed 2/8/17	18
28	Plant Room	50 days	Thu 12/1/16	Wed 2/8/17	18
29	Admin Building	50 days	Thu 12/1/16	Wed 2/8/17	18
33					
34	**HDPE Pipe Network**	**62 days**	**Mon 2/6/17**	**Tue 5/2/17**	
35	50mm HDPE Line	40 days	Mon 2/6/17	Fri 3/31/17	23
36	110mm HDPE Line	40 days	Mon 2/6/17	Fri 3/31/17	23
37	125mm HDPE Line	40 days	Mon 2/6/17	Fri 3/31/17	23
38	construction of Sea outfall line	30 days	Mon 2/6/17	Fri 3/17/17	23
39	75mm HDPE Line	40 days	Mon 2/6/17	Fri 3/31/17	23
40	Pressure Testing	8 days	Mon 4/3/17	Wed 4/12/17	37,35,36,38,39
41	Disinfection of Pipes	2 days	Mon 5/1/17	Tue 5/2/17	42
42	House conection	12 days	Thu 4/13/17	Fri 4/28/17	40
43					
44	**Electro Mechanical Works**	**30 days**	**Thu 2/9/17**	**Wed 3/22/17**	
45	RO Plant Installation	30 days	Thu 2/9/17	Wed 3/22/17	28
46	Generator Installation	30 days	Thu 2/9/17	Wed 3/22/17	28
47	Pump Installations	30 days	Thu 2/9/17	Wed 3/22/17	28
48					
49	**Testing, Commissioning & Handing Over**	**8 days**	**Wed 5/3/17**	**Fri 5/12/17**	
50	Test running	2 days	Wed 5/3/17	Thu 5/4/17	41
51	Commissioning	4 days	Fri 5/5/17	Wed 5/10/17	50
52	Project Handing Over	2 days	Thu 5/11/17	Fri 5/12/17	51



Contract No: (AGR) 438-PDU/PRIV/2016/4

Annex 4: MEE approval letter

بسم الله الرحمن الرحيم

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

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ދަތުރު، ތިރީގަމުގެ.

Date: 22nd September 2016 No: 438-POLPU/PRIV/2016/1121

Ms. Sharmilla Ragunathan,
Director,
Puritas PVT,
No.25, Foster Lane
Colombo 10
Srilanka.

Dear Madam,

Subject: Concept Design approval of Th.Thimarafushi Water Supply Project

Reference to your concept design submission on 21st September 2016.

We hereby grant you a conditional approval to the concept design of Th.Thimarafushi Water System provide that the attached comments are thoroughly incorporated into the detail design. In addition, we request you to complete and report Environmental Impact Assessment (EIA) and detailed design works in accordance to Environmental Protection Agency's (EPA) Guidelines.

Yours sincerely,

Shaheeda Adam Ibrahim
Director General
Ministry of Environment and Energy

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Maafannu, Male', 20392, Republic of Maldives.
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+(960) 301 8301
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ދަތުރު، ތިރީގަމު، 20392، ދިވެހިރާއްޖެ.
secretariat@environment.gov.mv
www.twitter.com/ENVgovMV
www.facebook.com/environment.gov.mv

Concept design to review

Comments on Th. Thimarafushi Preliminary Design Report submitted by Puritas Pvt Ltd.

No: 438-POLPU/PRIV/2016/1087
Date: 18th September 2016.

(a) In Part III , Preliminary design outline, provide a writ up subtitled PROPOSED WATER SUPPLY SCHEME describing the Water SCHEME concept used with clear references to drawing described in (c) below, covering water quality, sources and their part contribution in this scheme in terms of volume.

(b) Technology proposed needs to be justified based on technical feasibility with a perspective on water safety and associated risk and potential hazard mitigation in the way of building backup systems and appropriate redundancy considering financial and environmental issues. There is a write up on environmental feasibility however discussion on the former is lacking in the report which is expected to cover **energy efficiency and operational issues** addressed to ensure water safety and security of the scheme.

GRP tanks have been selected for water storage, it is recommended to provide an assessment of such tanks based on operational experience in the Maldives.

This part shall address prevention of vibration in plant, plant leakages at interconnections, corrosion, control of non revenue water, endurance and stability of the selected water storage systems or tanks, level of data acquisition, monitoring and control measures provided. Health and safety with respect to selection of material in contact with drinking water such as paint, coatings and chemicals etc. In addressing operational issues, the contractor may refer to handling, robustness and endurance of systems and test methods selected; the contractor may refer to recent water schemes commissioned in 2015 by MEE. The objective here is to identify significant issues as well as quality control and test methodology in order to address them adequately in the detailed design, construction and hand over process.

(c) Include schematic drawings of the water scheme layout showing the linkages to catchments, production systems, storages, pipe network showing the preliminary pipe sizes discussed in the report.

(d) Water quality mentioned in (a) shall cover discussion on raw water quality as well as the product and brine water quality of the desalination process selected. The objective is to ensure that detailed design addresses the specific issues arising from such general assessments.

(e) Include revised work schedule: In reference to the schedule of works discuss strategies being adopted to avoid delays and manage risks such that the project is completed and operational as planned.

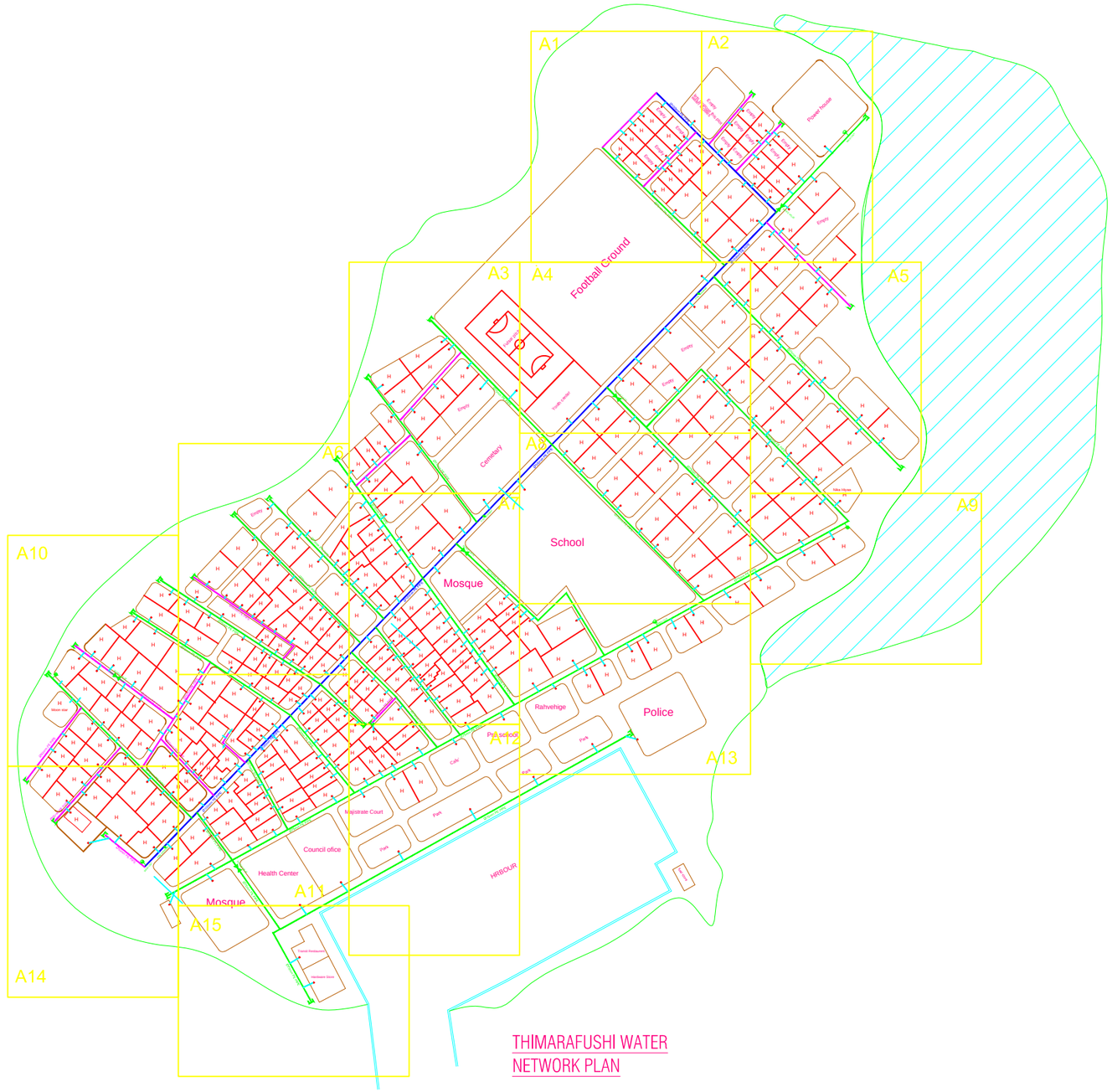
(f) Provide a one page executive summary of the preliminary or concept design proposed at the beginning of the report.

END

Annex 5: Project concept drawings

PROJECT NO

PROJECTION



THIMARAFUSHI WATER NETWORK PLAN

FIRE HYDRENT

25mm DIA SINGLE ORIFICE AIR VALVE

50mmDIA LARGE ORIFICE AIR VALVE

80mm DIA DOUBLE ORIFICE AIR VALVE

SLUICE VALVE

WASH OUT

END CAP

100mm PIPE

75mm PIPE

50mm PIPE

HOUSE CONNECTION

DIAMETER	DEPTH
100mm PIPE	0.75m
75mm PIPE	0.70m
50mm PIPE	0.60m

QTY : –NOs

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

REV.NO	ITEM	DESCRIPTION	DATE
1			2016.10.06

UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS
SCALE	N/S	CHECKED	MLW/HTK
GENERAL TOLERANCE		APPROVED	PS
SAVE NAME	TFM_LAY_29_00		

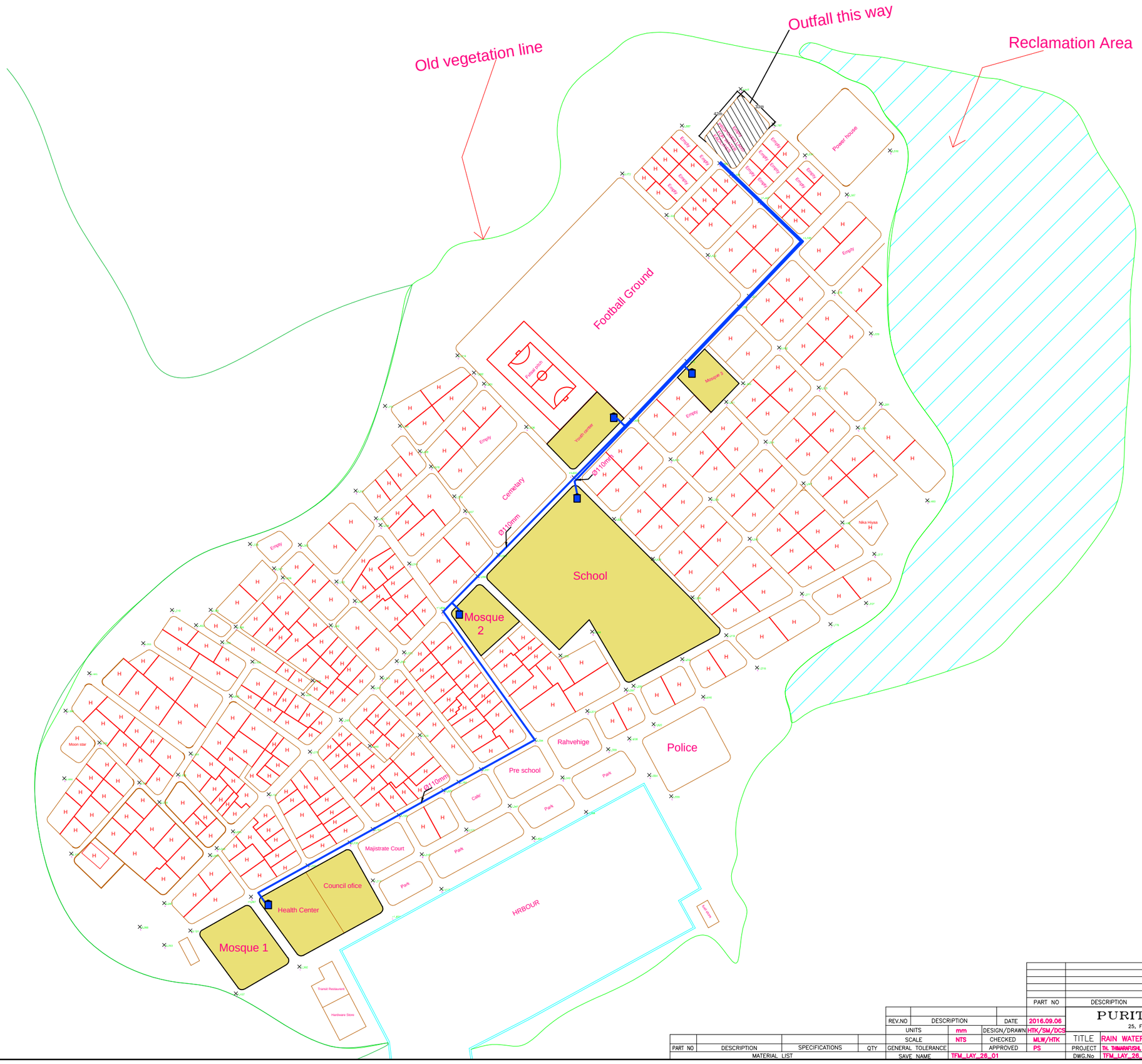
PART NO	DESCRIPTION	REF.DRAWING NO.

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

TITLE	WATER NETWORK LAYOUT
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_29_00
REV.	MA MI

PROJECT NO

PROJECTION



PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION	DATE
		2016.09.06

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GENERAL TOLERANCE		APPROVED	PS
SAVE NAME	TFM_LAY_26_01		

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

TITLE	RAIN WATER HARVESTING SYSTEM
PROJECT	TH, THANARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_26_01
REV.	01

PROJECT NO

PROJECTION

CIP SYSTEM

LIS cip

PI cip

PI cip

P cip

CIP TANK

CIP PUMP

PRE FILTER

DISTRIBUTION POINTS

DE—CHLORINATION DOSING SYSTEM

PRE—CHLORINATION DOSING SYSTEM

P-02

LIS 101

PI 102

P 102A

P-04

P 102A

P-03

P-05

PI 103

PI 104

LPS 105

P 108

P-07

RO PUMP

HPS 106

PI 107

CE 109

LIS 110

P-09

P-10

PRODUCT WATER PUMPS

RO MODULE

P-06

SAND FILTER

CARBON FILTER

ANTI SCALANT DOSING SYSTEM

PRE FILTER

PI 108

FEED WATER TANK

FEED PUMP

PRODUCT WATER TANK

P-08

FLUSH DRAIN

POST—CHLORINATION DOSING SYSTEM

WELL PUMP

P-01

RAIN WATER PUMP

V

P-11

CARTRIDGE FILTERS

MOSQUE

SCHOOL

GOVT BUILDING

RAIN WATER COLLECTION TANK($10m^3$)

PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	ITEM	DESCRIPTION	DATE
			06.10.2016

PURITAS LTD
25, FOSTER LANE, COLOMBO 10.

UNITS	mm	DESIGN/DRAWN	HTK/MLW/DCS
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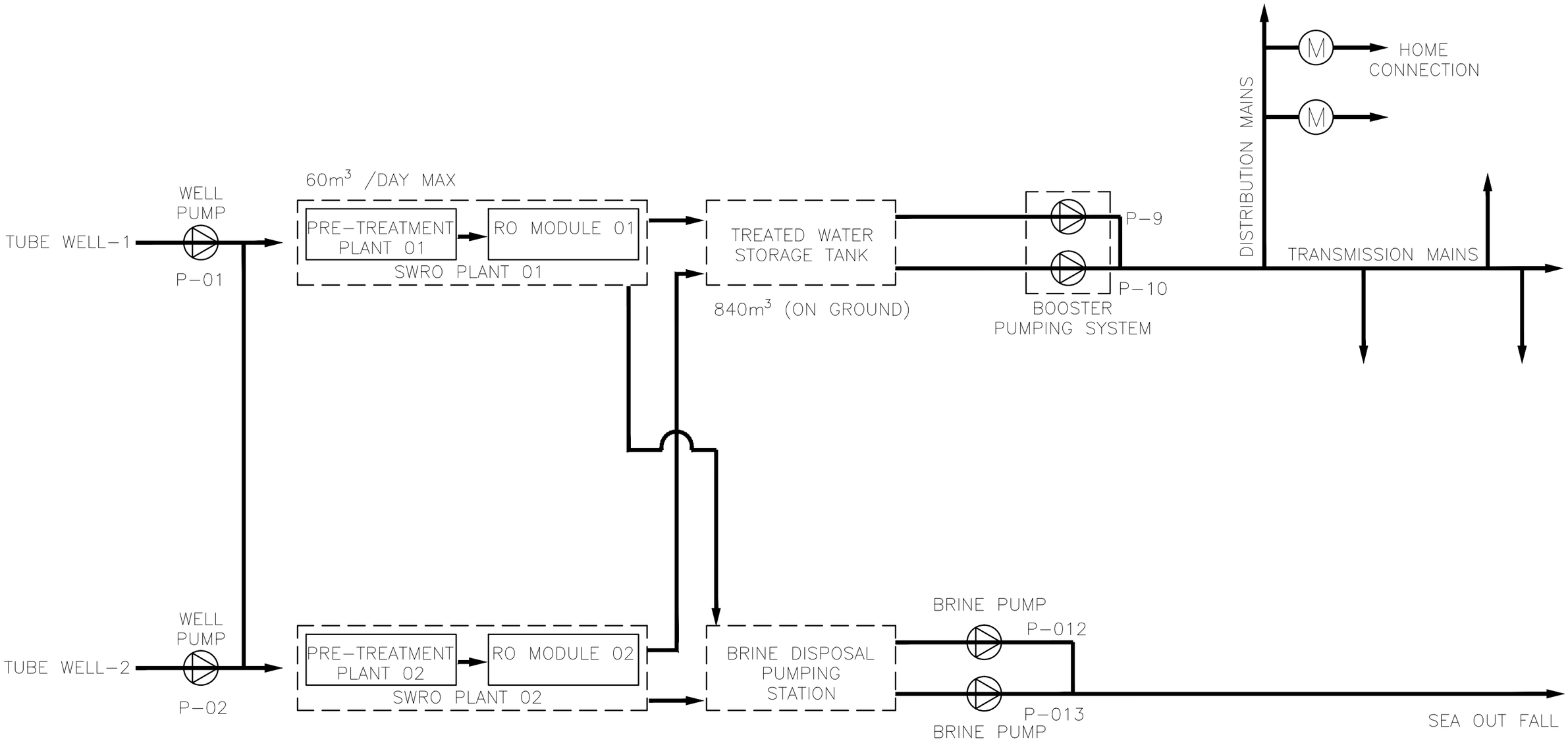
GENERAL TOLERANCE		APPROVED	PS
SAVE NAME	TFM_PFD_10_00		

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

TITLE	PROCESS FLOW DIAGRAM -RO PLANT
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_PFD_10_00
REV.	00
	MA / MI

PROJECT NO

PROJECTION



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	SCALE	NTS	CHECKED MLW/HTK
	GENERAL TOLERANCE		APPROVED PS
	SAVE NAME	TFM_LAY_23_01	

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

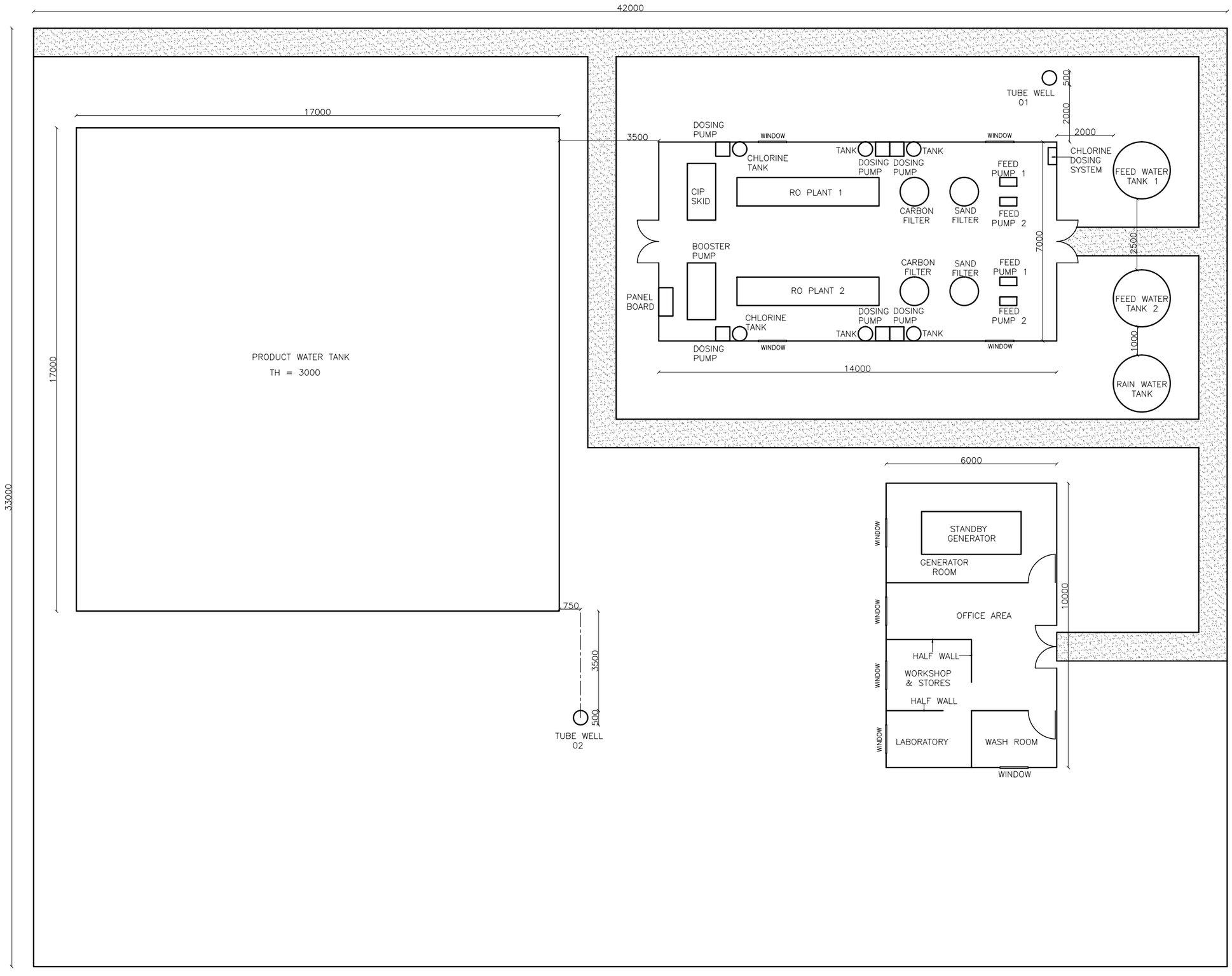
TITLE	INTEGRATED WATER SUPPLY SCHEMATIC
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No.	TFM_LAY_23_01
REV.	01

PART NO	DESCRIPTION	SPECIFICATIONS	QTY

MATERIAL LIST

PROJECT NO

PROJECTION



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REV.NO	DESCRIPTION	DATE	2016.09.06
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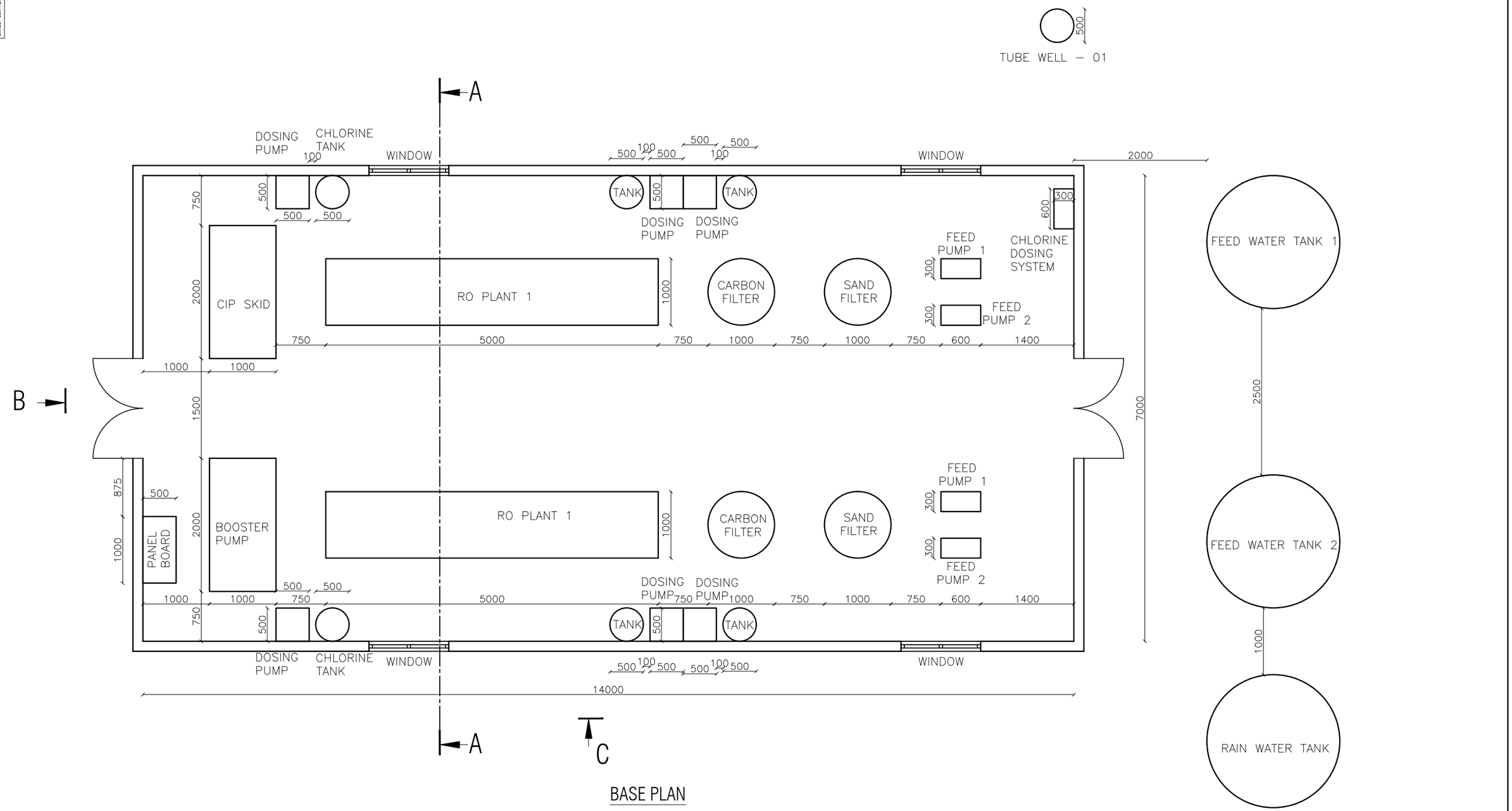
PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

TITLE	SITE LAYOUT PLAN
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
REV.	01

PROJECT NO

PROJECTION



BASE PLAN

PART NO	DESCRIPTION	REF.DRAWING NO.
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GENERAL TOLERANCE		APPROVED PS
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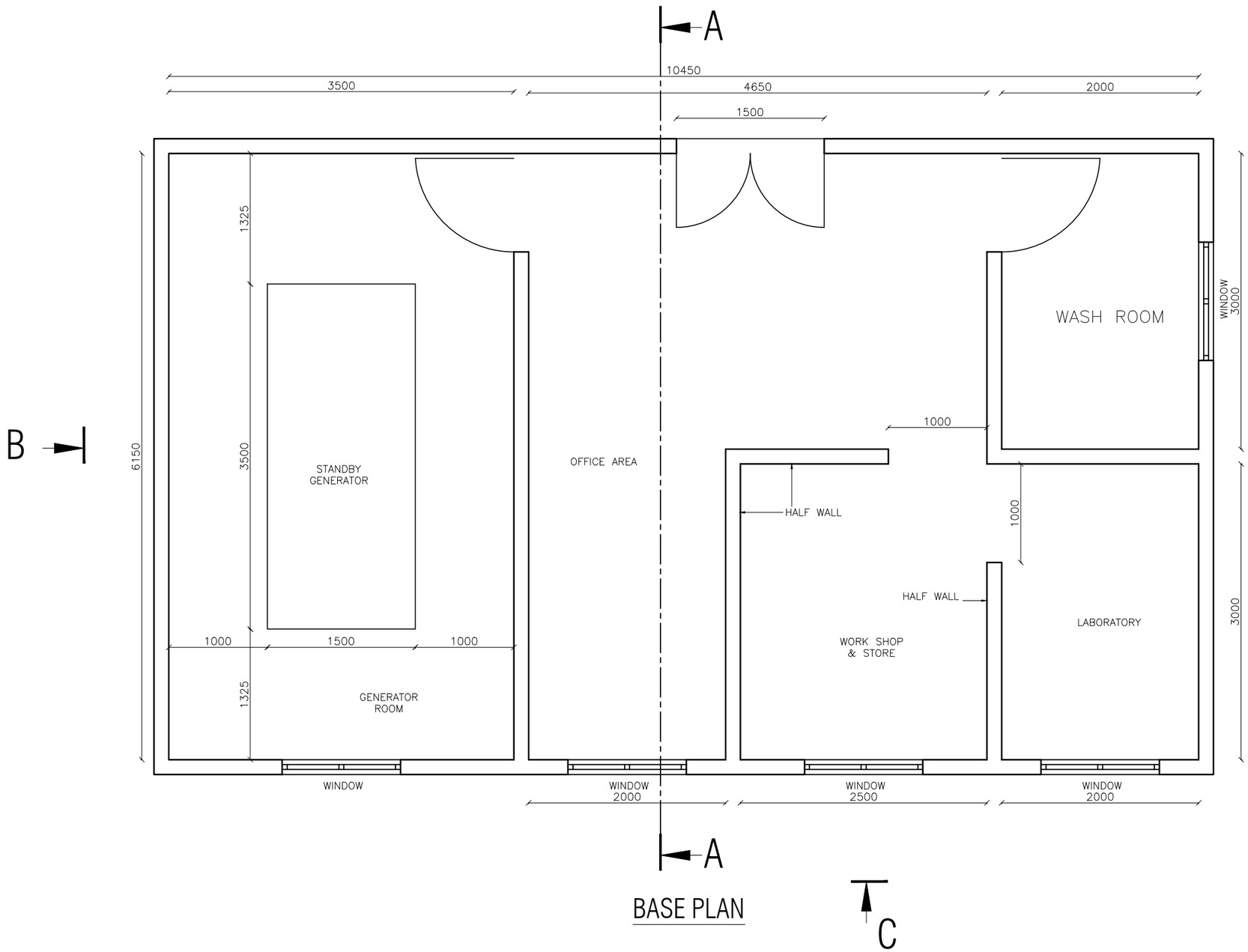
PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

TITLE	RO PLANT BUILDING BASE PLAN
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_21_02
REV.	02

PROJECT NO

PROJECTION



BASE PLAN

PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION	DATE
		2016.10.06

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

				UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS
				SCALE	NTS	CHECKED	LK/MLW
PART NO	DESCRIPTION	SPECIFICATIONS	QTY	GENERAL TOLERANCE		APPROVED	PS
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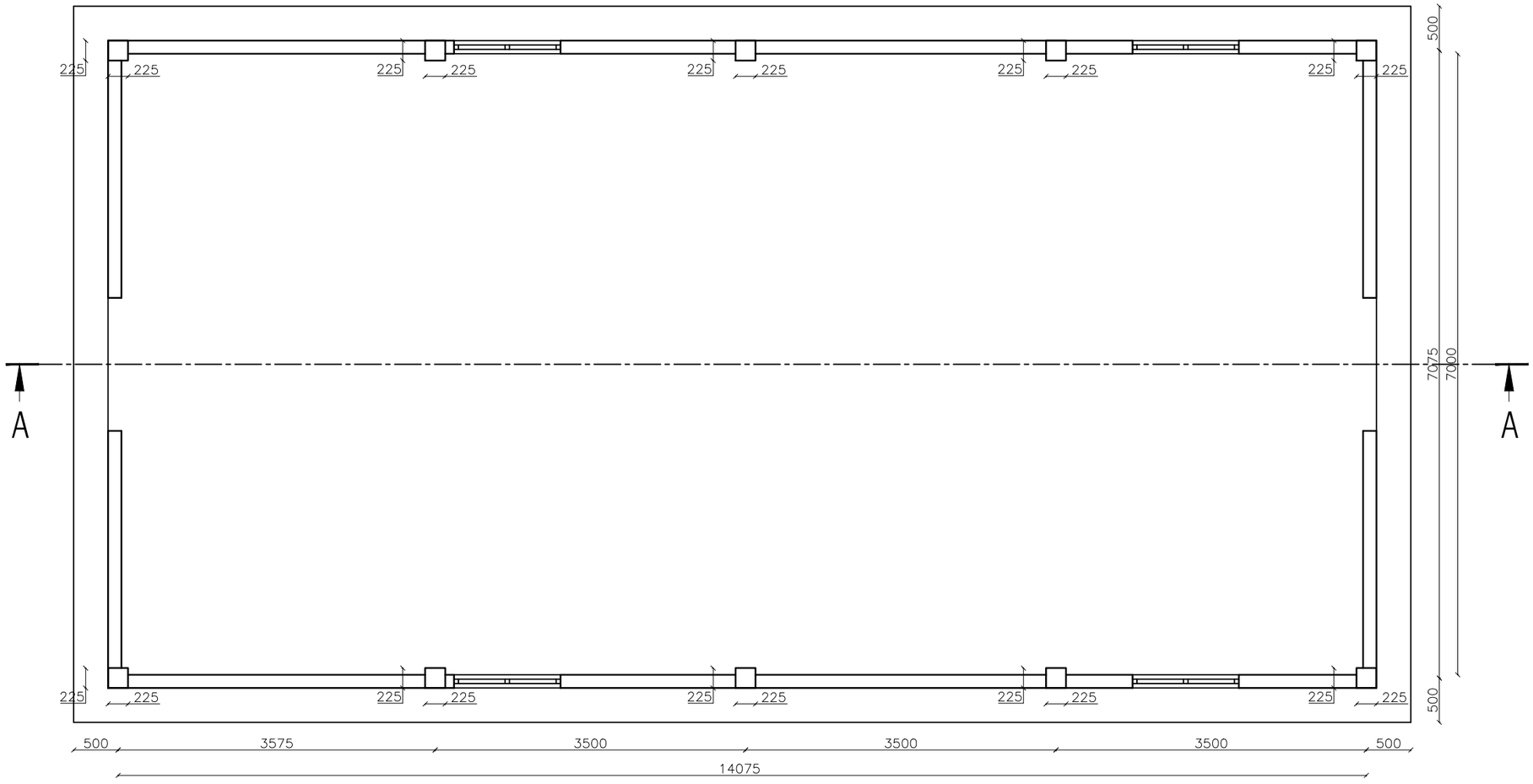
TITLE	RO PLANT ADMIN BUILDING BASE PLAN
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_22_01
REV.	00

PROJECT NO

PROJECTION

SECTION A-A



BASE PLAN

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REV.NO	DESCRIPTION	DATE
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PART NO	DESCRIPTION	SPECIFICATIONS	QTY	GENERAL TOLERANCE		APPROVED PS
MATERIAL LIST				SAVE NAME	TFM_LAY_49_00	

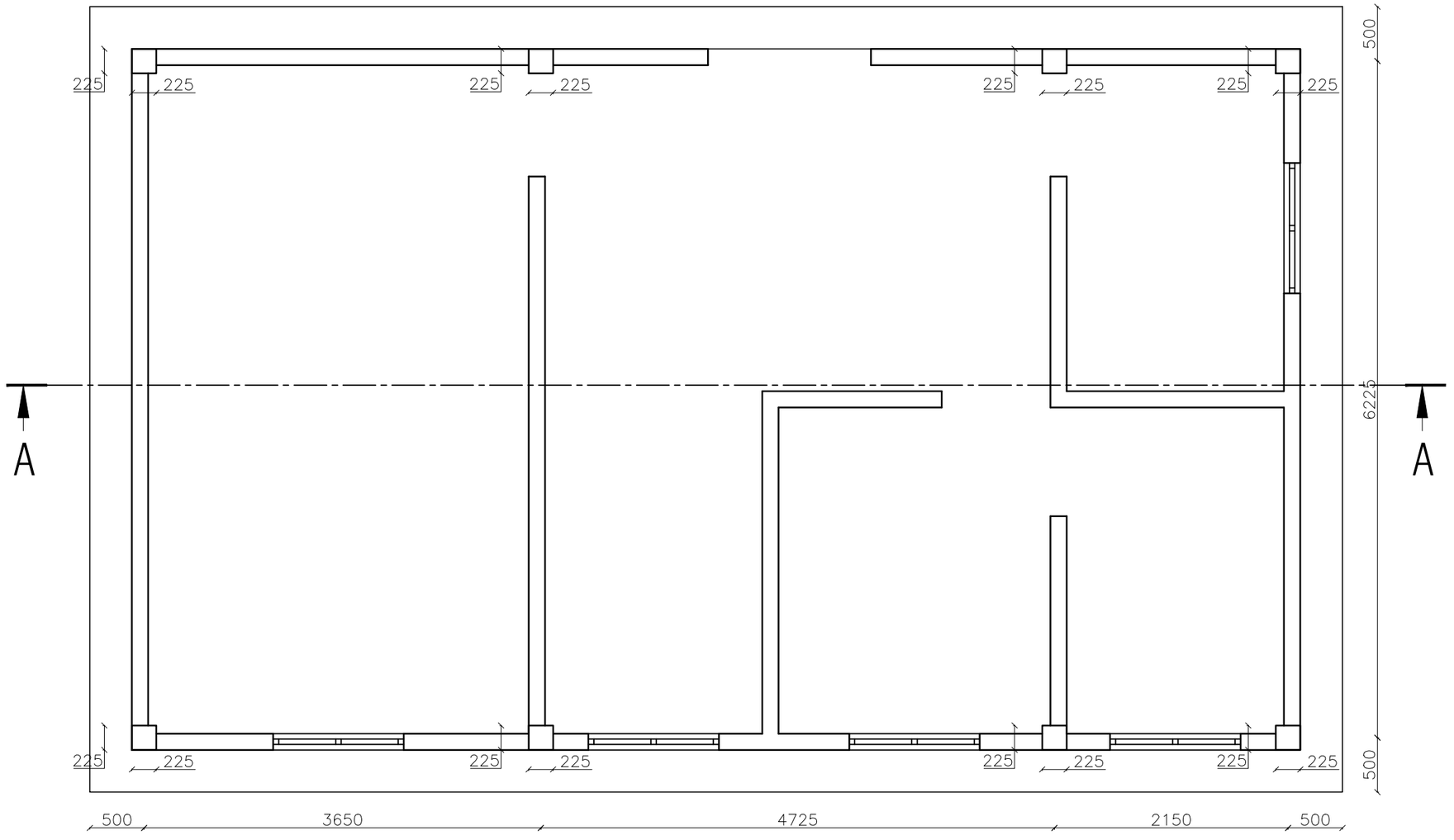
PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

TITLE	RO PLANT BUILDING STRUCTURAL PLAN
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_49_00 REV. 00

PROJECT NO

PROJECTION

SECTION A-A



BASE PLAN

PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION		DATE	2016.10.06	PURITAS (PVT) LTD
	UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS	25, FOSTER LANE, COLOMBO 10.
	SCALE	NTS	CHECKED	LK/MLW	TITLE: ADMIN BUILDING STRUCTURAL PLAN
	GENERAL TOLERANCE		APPROVED	PS	PROJECT: TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
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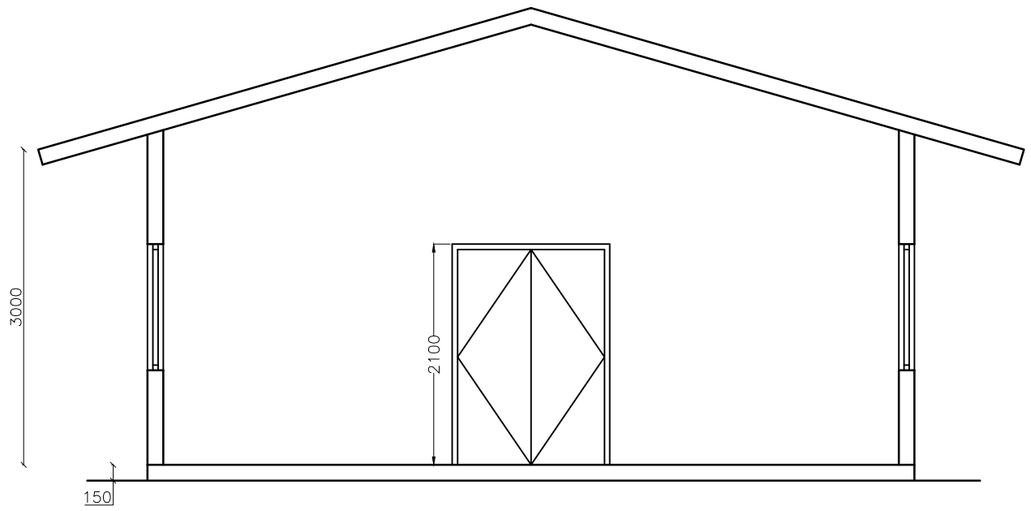
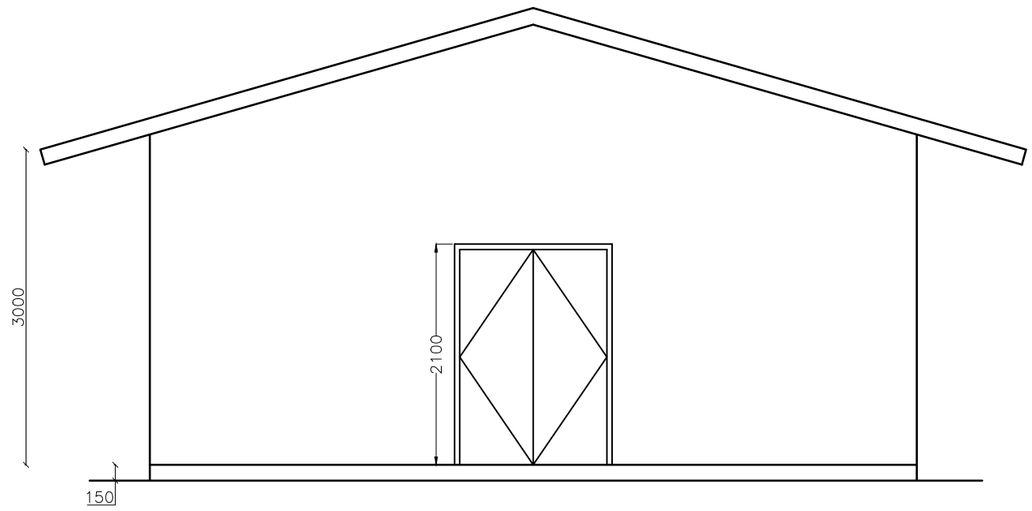
PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

PROJECT NO

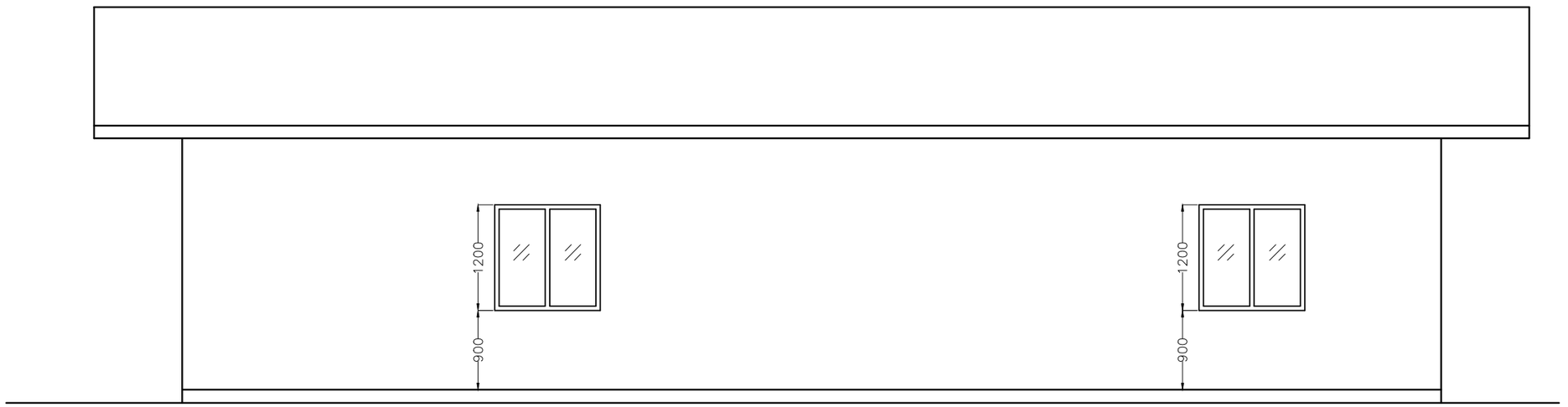
PROJECTION



SECTION A-A



ELEVATION AT -B



ELEVATION AT -C

PART NO	DESCRIPTION	REF.DRAWING NO.

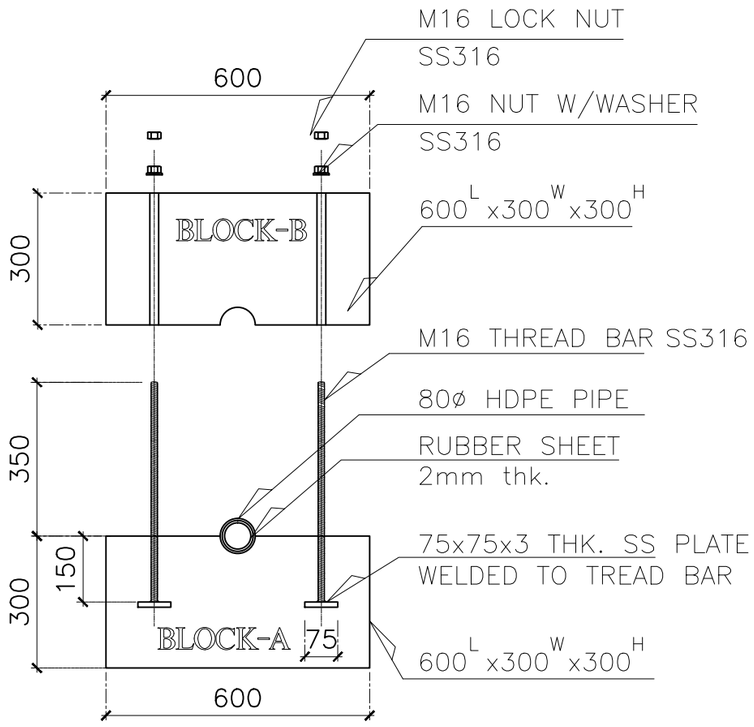
REV.NO	DESCRIPTION	DATE
		2016.10.06

UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS	PURITAS (PVT) LTD	
SCALE	NTS	CHECKED	LK/MLW	25, FOSTER LANE, COLOMBO 10.	
GENERAL TOLERANCE		APPROVED	PS	TITLE	RO PLANT BUILDING ELEVATION & SECTION
SAVE NAME	TFM_LAY_34_00			PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
				DWG.No	TFM_LAY_34_00 REV. 00

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

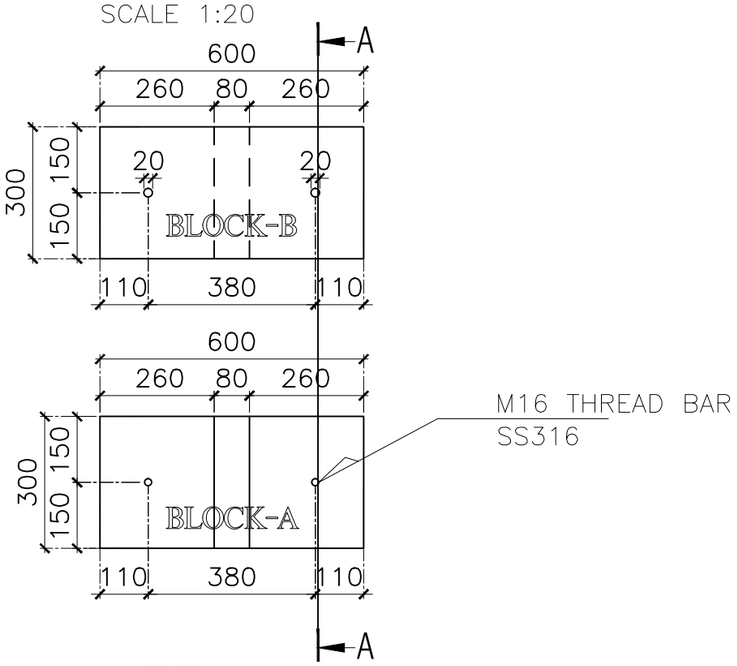
PROJECT NO

PROJECTION

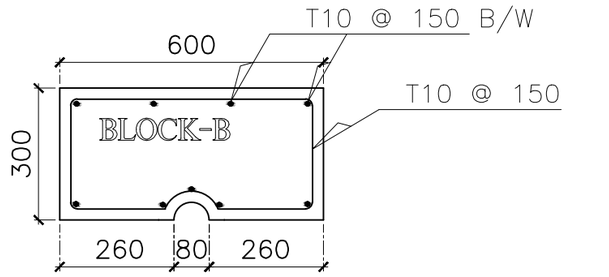


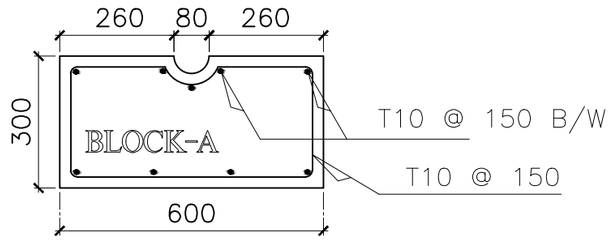
SECTION
DETAILS OF DIFFUSER BLOCK

SCALE 1:20



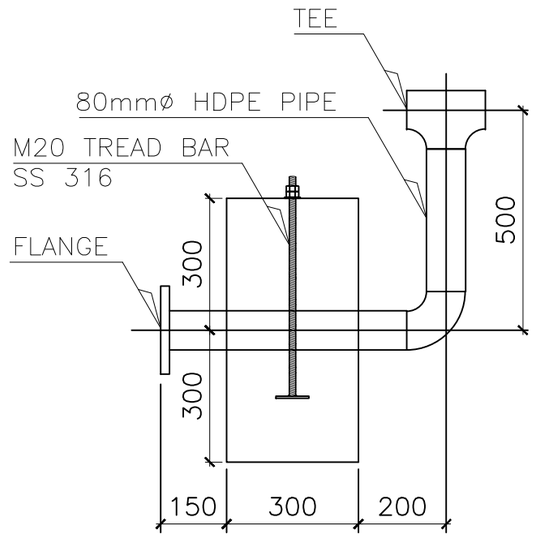
PLAN
FOR DIFFUSER BLOCK





REINFORCEMENT DETAIL
FOR DIFFUSER BLOCK

SCALE 1:20



DIFFUSER DETAIL
SECTION - AA

SCALE 1:20

PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION	DATE
		2016.10.13

UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS
SCALE	NTS	CHECKED	LK/MLW
GENERAL TOLERANCE	±5	APPROVED	PS
SAVE NAME	TFM_LAY_48_00		

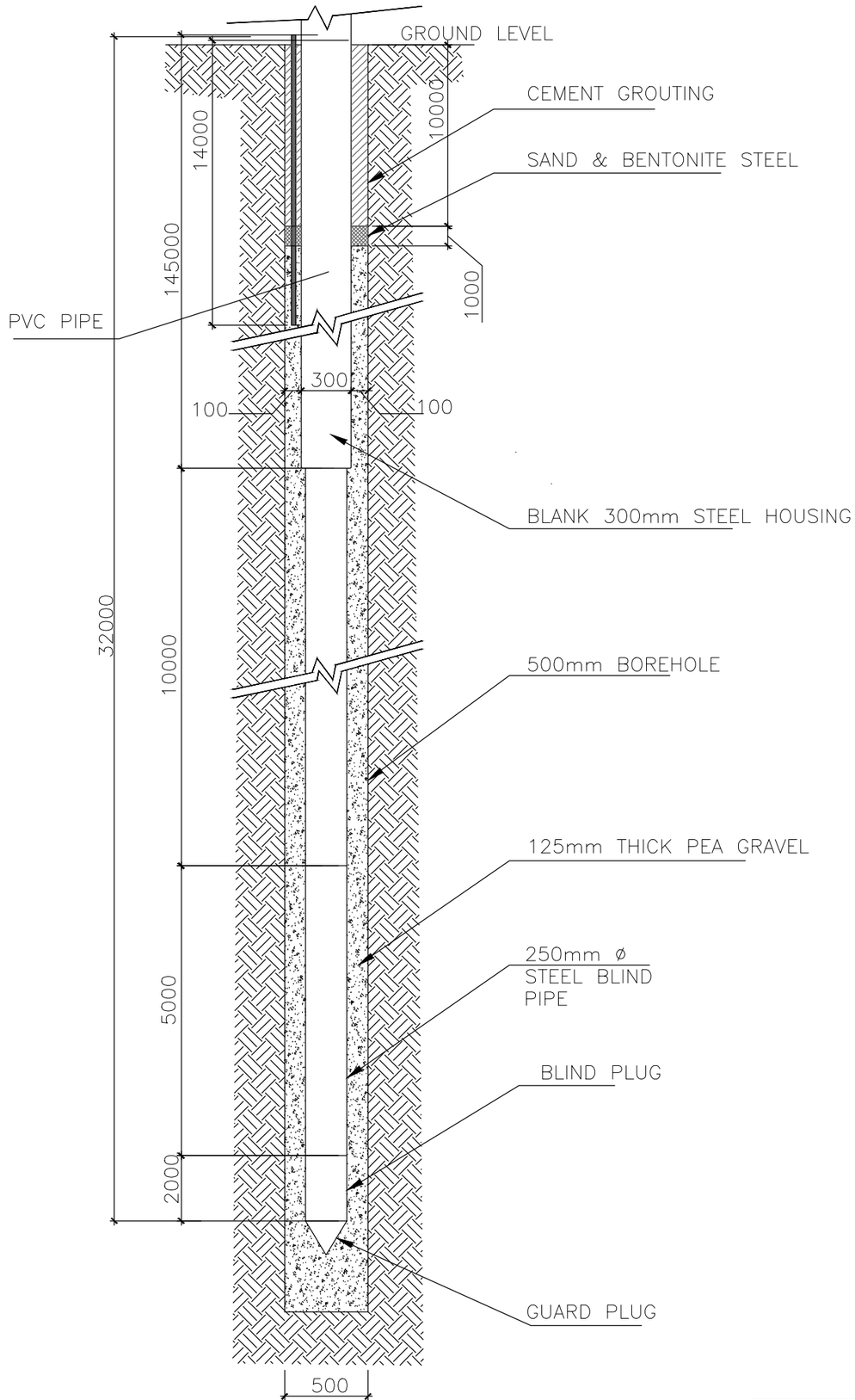
PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

PURITAS (PVT) LTD
25, FOSTER LANE, COLOMBO 10.

TITLE	BRINE OUTFALL DETAILS
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_48_00
REV.	01

PROJECT NO

PROJECTION



PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION	DATE
		2016.10.13

PURITAS (PVT) LTD

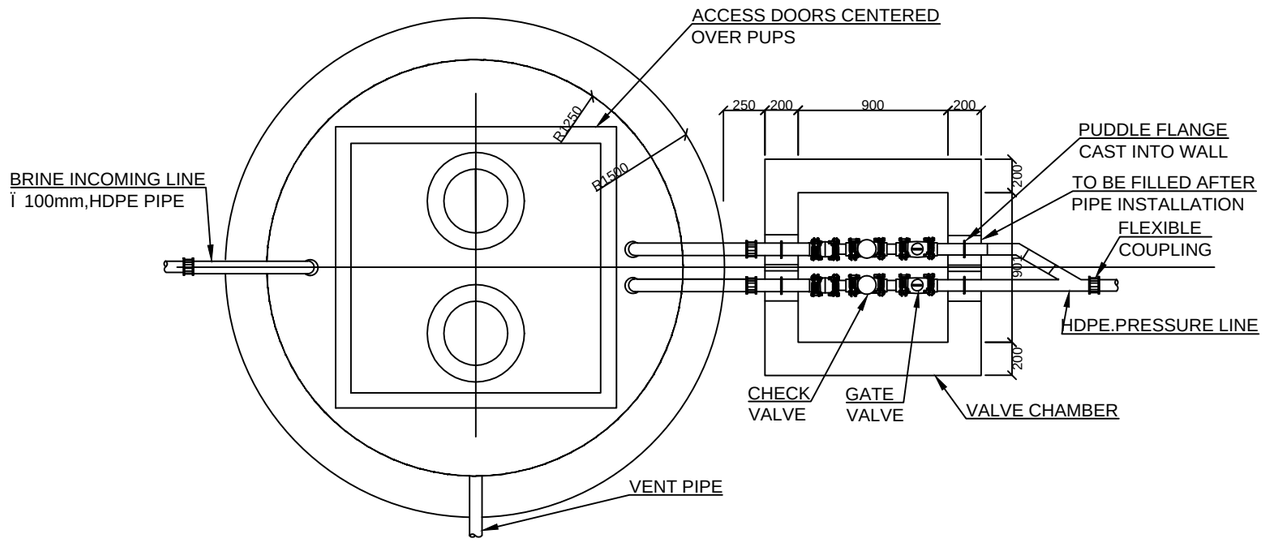
UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS
SCALE	NTS	CHECKED	LK/MLW
GENERAL TOLERANCE	±5	APPROVED	PS
SAVE NAME	TFM_LAY_47_00		

PART NO	DESCRIPTION	SPECIFICATIONS	QTY
MATERIAL LIST			

TITLE	TUBE WELL DETAILS
PROJECT	TH. THIMARAFUSHI. WATER SUPPLY SCHEME. MALDIVES
DWG.No	TFM_LAY_47_00
REV.	00

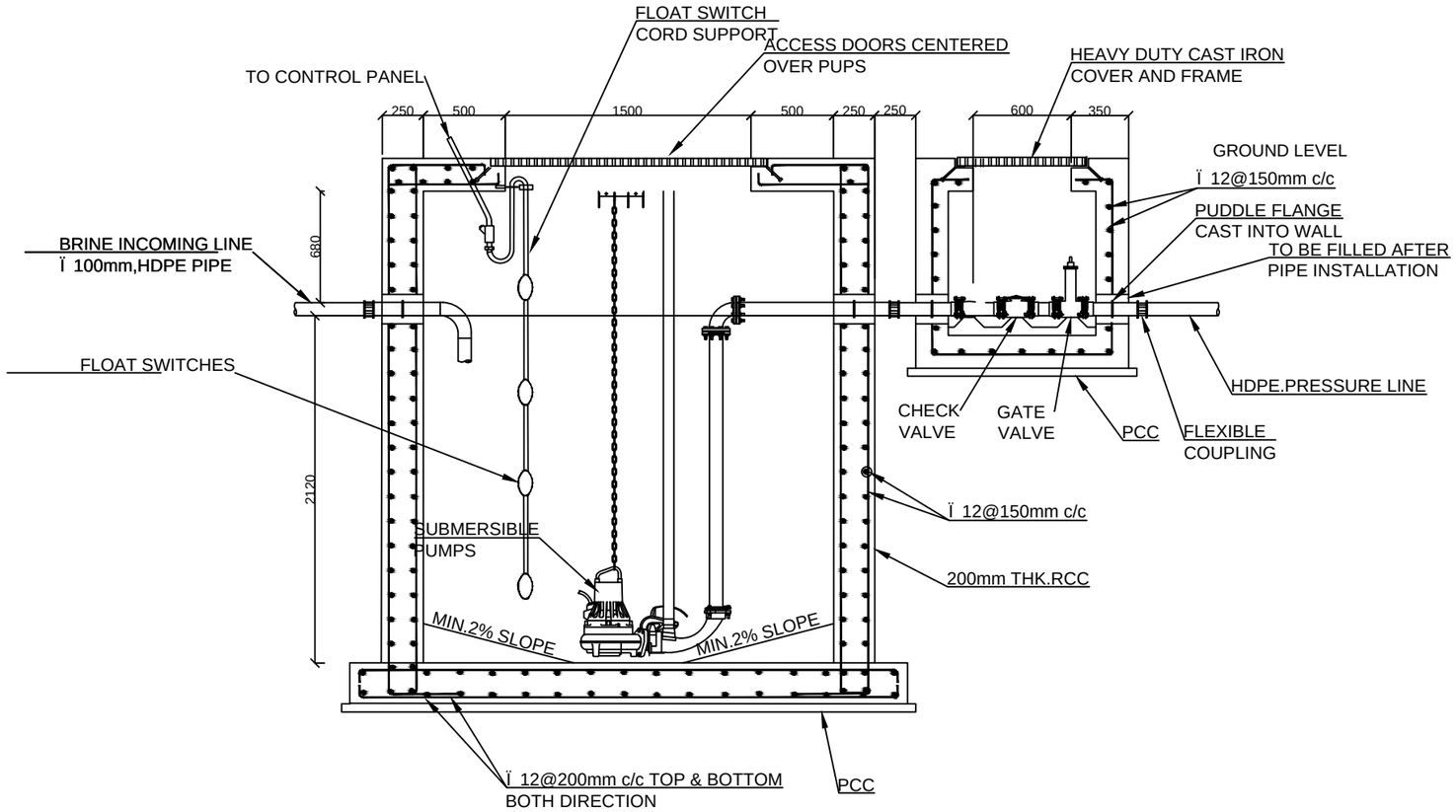
PROJECT NO

PROJECTION



BRINE PUMP DETAILS - PLAN

Scale 1:50



BRINE PUMP DETAILS - SECTION

Scale 1:50

PART NO	DESCRIPTION	REF.DRAWING NO.

REV.NO	DESCRIPTION	DATE
		2016.10.13

PURITAS (PVT) LTD

				UNITS	mm	DESIGN/DRAWN	HTK/SM/DCS
				SCALE	NTS	CHECKED	LK/MLW
PART NO	DESCRIPTION	SPECIFICATIONS	QTY	GENERAL TOLERANCE	±5	APPROVED	PS
MATERIAL LIST				SAVE NAME	TFM_LAY_46_00		

TITLE	BRINE PUMP WELL DETAILS
PROJECT	TH. THIMARAFUSHI, WATER SUPPLY SCHEME MALDIVES
DWG.No	TFM_LAY_46_00
REV.	00

Annex 6: Water quality test reports

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

بسم الله الرحمن الرحيم

MWSC

WATER QUALITY TEST REPORT

Test Report No: 300827/2016/32

Customer Informations : ***Mr. Amir Musthafa***
Flat 11-2-3,
Hulhumale'
Rep. of Maldives

Date: 20/11/2016

Sample Description / Location~	Thimarafushi				TEST METHOD	UNIT
	Ground water 1	Ground water 2	Ground water 3	Ground water 4		
Sample Type~	Ground water					
Sampled Date~	12/11/2016					
Sample Received Date	13/11/2016					
Test Requisition Form No.	900168770					
Sample No.	829753	829754	829755	829756		
Date of Analysis	13/11/2016 - 15/11/2016					
PARAMETER	ANALYSIS RESULT					
Physical Appearance	Clear	Clear	Clear	Clear	Visual	-
Conductivity	629	561	500	185.6	Method 2510 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	µS/cm
pH	7.39	8.04	7.43	7.72	Method 4500-H+ B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	-
Salinity	0.31	0.27	0.24	0.09	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	‰
Temperature	19.7	19.7	19.7	19.7	Electrometry	°C
Total Petroleum Hydrocarbon	7.7	9.9	153	8.8	UV Fluorescence	mg/L

Keys:
µS/cm: Micro Seimen per Centimeter, **‰:** Parts Per Thousand, **mg/L:** Milligram Per Liter, **°C:** Degree Celcius

Checked by:	Approved by:
Nihaz Ali Zahir Laboratory Executive	Mohamed Eyman Senior Technical Officer

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory
This report shall not be reproduced except in full, without written approval of MWSC
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information Supplied by the customer

**********END OF THE REPORT**********

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

بسم الله الرحمن الرحيم

MWSC

WATER QUALITY TEST REPORT

Test Report No: 300827/2016/33

Customer Informations : ***Mr. Amir Musthafa***
Flat 11-2-3,
Hulhumale'
Rep. of Maldives

Date: 20/11/2016

Sample Description / Location~	Thimarafushi		TEST METHOD	UNIT
	Sea Water 1	Sea Water 2		
Sample Type~	Sea water			
Sampled Date~	12/11/2016			
Sample Received Date	13/11/2016			
Test Requisition Form No.	900168770			
Sample No.	829757	829759		
Date of Analysis	13/11/2016 - 19/11/2016			
PARAMETER	**ANALYSIS RESULT**			
Physical Appearance	Clear with particles	Clear with particles	Visual	-
Conductivity	52600	52800	Method 2510 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	µS/cm
pH	8.42	8.45	Method 4500-H+ B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	-
Salinity	34.46	34.64	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	‰
Temperature	18.8	18.7	Electrometry	°C
Biological Oxygen Demand	1	1	HACH Method 8043	mg/L
Total Suspended Solids	<5 (LoQ 5mg/L)	<5 (LoQ 5mg/L)	Electrometry	mg/L
Turbidity	0.320	0.380	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Coliform, Total	TNTC	TNTC	HACH Method 10029	CFU/100ml
Coliform, Faecal	TNTC	TNTC	HACH Method 8074	CFU/100ml

Keys:

µS/cm: Micro Seimen per Centimeter, **‰:** Parts Per Thousand, **mg/L:** Milligram Per Liter, **°C:** Degree Celcius, **NTU:** Nephelometric Turbidity Unit, **CFU:** Colony Forming Unit

LoQ: Limit of Quantification

TNTC: Too Numerous to Count

Checked by:	Approved by:
Nihaz Ali Zahir Laboratory Executive	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

**********END OF THE REPORT**********

Annex 8: Curriculum Vitae

CURRICULUM VITAE

1. Personal information

Name:	Amir Musthafa
Date of Birth:	24 August 1984
Permanent Address:	Dhashukubaige, Gn. Fuvahmulah, Republic of Maldives
Contact Address:	Flat 11-2-03, Hulhumale', 23000, Republic of Maldives
Marital Status:	Married
E-mail:	amir.musthafa@gmail.com
Cell phone:	+960 7981711

2. Key Qualifications

2010 Bachelor of Engineering (Hons) in Environmental Engineering – University of New South Wales

Courses undertaken include but not limited to the following:

- Ecology, Sustainability and Environmental Science
- Transport Engineering and Environmental Sustainability
- Engineering surveying and GIS
- Environmental Principles and Systems
- Water and Atmospheric Chemistry
- Environmental Frameworks, Law and Economics
- Environmental Engineering Practice
- Coastal Resource Management
- Coastal Engineering (post-grad module)
- Coastal Management (post-grad module)

3. Other Certificates and Licences

1. **EIA Licence. No. (2013 – 2018)**
2. **International English Language Learning Systems (IELTS)**

Listening 8.0. Reading 8.5. Writing 7.0. Speaking 8.0 Overall Band 8.0.

3. **Project Management online course (2014) via www.udemy.com**

4. **Programming for Everybody – Python online course (2014) via www.coursera.org**

5. **GCE Advanced Level, Cambridge**

4. Work Experience

1. **Environmental Impact Assessment Consultant : 2009 – to date**
   Freelance
   Have provided consultancy and involved in EIA documentation for the following projects as an assistant and as a registered consultant:

   - EIA addendum for ADh. Thundufushi Redevelopment (2009)
   - EIA for the ADh. Athuruga Redevelopment (2009)
   - EIA for K. Olhahali Redevelopment (2010)
   - IEE for beach nourishment works at Dh. Velavaru (2011)
   - IEE for powerhouse expansion works at K. Kudahuraa (2011)
   - EIA for K. Kudahuraa Reef Club Development and Coastal Works (2012)
   - EIA for the Coastal Protection Works at K. Ihuru (2012)
   - EIA for Mariculture project for Sea cucumber harvesting in HDh. Makunudhoo (2013)
   - EIA for B. Kihavah Beach nourishment project (2013)
   - EIA for Sewerage systems project in HDh. Hanimaadhoo (2013)
   - EIA for shore protection project at Emboodhoo Island (2014)
   - EIA for R. Lundhufushi Resort Development Project (2015)
   - EIA for K. Dhiyaneru Mooring Area Development Project (2015)
   - EIA for Male' West Area Redevelopment Project (2015)
   - EIA for Dh. Maagau Resort Development Project (2015)
   - EIA for HA. Filladhoo Sewerage System Development Project (2015)
   - EIA for Th. Dhiyamigili Sewerage System Development Project (2015)
   - EIA for Building Construction at Manaage, Male' (2015)
   - EIA for Building Construction at Andalus, Male' (2016)
   - EIA for Borehole Construction for desalination plant at Helengeli Island Resort (2016)
   - EIA Addendum for Maadhoo Resort Development (2016)
   - EIA for the proposed project to Reclaim and Develop 3 Resort Islands on the lagoon located at North Male' Atoll (4°40'28.8"N 73°32'02.2"E and 4°40'18.4"N 73°32'24.6"E) (2016)
   - EIA for deep sea dredging for proposed project to Reclaim and Develop 3 Resort Islands on the lagoon located at North Male' Atoll (4°40'28.8"N 73°32'02.2"E and 4°40'18.4"N 73°32'24.6"E) (2016)

Have provided consultancy for Environmental Audits for Desalination plant registrations and Environmental Screening for several more projects including for;

- Fourseasons Kudahuraa Island Resort
- M. Medhufushi Island Resort
- The Beach house at Iruveli
- Viceroy Hotels at Sh. Vagaru Island resort
- F. Filitheyo Island Resort
- K. Fihalhohi Island Resort
- Jumeirah Medhufushi at Meradhoo island resort
- Jumeirah Vittaveli at Bolifushi Island Resort
- Ozen by Atmosphere at Maadhoo Island Resort
- Ozone by Atmosphere at Helengeli Island Resort
- Malahini Island Resort at Kudabandos

2. **Environmental Impact Assessment Evaluator : 2011 – to date**
   Freelance
   Have evaluated Environmental Impact Assessment reports for over 20 projects. Including;

   - Coastal Protection Projects
   - Sewerage and Water network projects
   - Agriculture Projects
   - Building Construction Projects
   - Resort Development Projects
   - Beach Nourishment Projects
   - Airport Development Projects

3. **Project Engineer : July 2015 – to date**
   Islamic Development Bank: Tsunami Harbour Reconstruction Project Phase II – 10 Harbours
   - Environmental Management of Projects
   - Evaluate Environment Impact Assessments and ensure the environmental performance of the projects
   - Coordinate with project management team
   - Project status follow up
   - Provide engineering solutions in coordination with Project Consultants

4. **Engineer : December 2013 – July 2015**
   Ministry of Housing and Infrastructure
   - Developing project plan,
   - Preparing tender documents,
   - Managing communication between project stakeholders,
   - Managing project team,
   - Monitoring and reporting progress,
   - Undertake site visits to monitor quality of work,
   - Environmental management of projects
   - Evaluate Environment Impact Assessments and environmental performance of projects

   Name of Project: GA. Kanduhulhudhoo Harbour Breakwater Construction Project
   Contractor: MTCC
   Project Value: 20.5 million MVR
   Year: 2015

   Name of Project: Lh. Naifaru Harbour Construction Project
   Contractor: MTCC
   Project Value: 67.5 million MVR
   Year: 2015

   Name of Project: HDh. Nellaidhoo Harbour Construction Project
   Contractor: MTCC
   Project Value: 24.0 million MVR
   Year: 2013 – to date

   Name of Project: HDh. Kurinbi Harbour Construction Project
   Contractor: MTCC
   Project Value: 17.7 million MVR
   Year: 2013 – to date

5. **Assistant Engineer: 2011 – 2013**
   Ministry of Housing and Infrastructure

   Project Manager for following harbour construction projects:

   Name of Project: Dh. Kudahuvadhoo Harbour Breakwater Construction Project
   Contractor: MT Hojgaard
   Project Value: 30 million MVR
   Year: 2012 - 2013

   Name of Project: Dh. Meedhoo Harbour Construction Project
   Contractor: MT Hojgaard
   Project Value: 35 million MVR
   Year: 2012

Name of Project: Construction of Harbour at AA. Ukulhas & Channel Dredging work in AA. Bodufulhadhoo
Contractor: MT Hojgaard
Project Value: 32 million MVR
Year: 2011 - 2012

Name of Project: GDh. Gahdhoo Harbour Project (Design and Build)
Contractor: Amin Construction Pvt. Ltd.
Project Value: 32 million MVR
Year: 2011 - 2013

Name of Project: Th. Kibidhoo Harbour Project
Contractor: Amin Construction Pvt. Ltd.
Project Value: 29.5 million MVR
Year: 2011 - 2013

Name of Project: Sh. Noomara Harbour Project (Design and Build)
Contractor: MT Hojgaard
Project Value: 30 million MVR
Year: 2011 - 2012

Name of Project: F. Feeali Harbour Construction Project
Contractor: MTCC
Project Value: 16 million MVR
Year: 2012 - 2013

Name of Project: M. Mulah Harbour Construction Project
Contractor: MTCC
Project Value: 14.8 million MVR
Year: 2012 - 2013

Responsibilities:
Developing project plan, making cost estimations, preparing tender documents, managing communication between project stakeholders, managing project team, managing project schedule, managing project budget, monitoring and reporting progress, undertake site visits to monitor quality of work, maintain documentation, Evaluate Environmental Impact Assessments and environmental performance of projects.

Project Engineer for following harbour construction projects:
Name of Project: K. Huraa Harbour Reconstruction Project (Design and Build)
Contractor: MT Hojgaard
Project Value: 26.0 million MVR
Year: 2012 – 2013

Name of Project: GA. Maamendhoo Harbour Construction Project
Contractor: MT Hojgaard
Project Value: 49.6 million MVR

Year: 2013 – 2014

Name of Project: GA. Gemanafushi Harbour Construction Project
Contractor: MTCC
Project Value: 46.0 million MVR
Year: 2013 – to date

6. **Environmental Engineer (intern) : 2009**
   Water Solutions Pvt. Ltd.

7. **Computer Technician : 2006 - 2007**
   Faculty of Engineering Technology

8. Major Trainings/Workshops and Meetings attended

1. **WODCON XX – The Art of Dredging (2013), Brussels, Belgium.**

2. **Training workshop on Maintenance of Infrastructure (2011), Hyderabad, India.**

9. Referees

Mr. Abdullah Muththalib
Deputy Minister
Ministry of Housing and Infrastructure
Maldives, Male'
Mobile: +960 7958100
E-mail: abdullah.mutholib@housing.gov.mv

Dr. Stuart Khan
Bsc (Hons), PhD
Senior Lecturer
University of New South Wales
Kensington, NSW, Australia
E-mail: s.khan@unsw.edu.au

10. Certification

Certification
I, the undersigned, certify that to the best of my knowledge and belief, the information given above correctly describes my qualifications and experience:

Amir Musthafa

2016

PERSONAL INFORMATION

Nafha Aujaaz

Commercial Flat/H-Block/4C, Sheikh Abdul-Rahmaan Magu,K.Villingili, 16020, Maldives

(+969) 7721554

nafha.aujaz@gmail.com

Sex Female | Date of birth 28/07/1990 | Nationality Maldivian

WORK EXPERIENCE

26 Apr 2015 to present

Environment Analyst

Ministry of Housing and Infrastructure, Maldives (Ameenee Magu,Male' Maldives, http://www.housing.gov.mv/v1/)

- Manage and take part in the preparation of EIA s for civil and infrastructure development projects and oversee the monitoring works as committed with the approved EIA reports in collaboration with external environmental consultancies and relevant internal and external stakeholders.
- Provide technical counsel necessary in the processes for hiring environmental consultancy and procurement to Project Planning and Development unit.
- Participate and provide technical counsel in stakeholder and community consultations of all the project managed by Infrastructure Department.
- Ensure the mitigation measures as required by the approved EIA report are being practiced during the implementation of the responsible projects through conducting inspection trips and share the inspection reports with relevant units.
- Be responsible to enhance the general awareness of the department on the environmentally relevant local laws and regulations which needs to be observed for the purposes of the works undertaken by the department.
- Provide assistance to other units in corresponding to Environmental Protection Agency (EPA) regarding environmental issues of the projects undertaken by the department
- Carry out research on improving the project designs in relation to sustainability, adaptation and impact minimization and share the information with relevant units.
- Manage the materials of the unit in a systematic manner.

Sector: Housing and Infrastructure Developments

22 Apr 2015 to 25 Apr 2015

Assistant Project Officer

Ministry of Housing and Infrastructure, Maldives (Ameenee Magu,Male' Maldives, http://www.housing.gov.mv/v1/)

- Update and implement the preparation of Environmental Impact Assessments of the Infrastructure Department projects
- Keep an update of the environmental monitoring requirements of the project EIAs
- Plan and implement the environmental monitoring requirements of post construction period of projects.
- Provide project information to relevant stakeholders
- Responsible for the administrative management of the unit through preparing necessary documents, filing and organisation.

Sector: Housing and Infrastructure Developments

5 Feb 2014 to 22 Apr 2015

Assistant Project Monitoring Officer

Office of Programmes and Projects, Maldives -currently disbanded under a structural reform made within the government institutions

- Prepare the contract document of projects
- Prepare project related documents and communicate them with relevant stakeholders
- Ensure the quality of the work and compliance to set standards and the contract
- Arrange and participate in monitoring trips and prepare relevant reports
- Coordinate project related meetings and keep the minutes of the proceedings
- Monitor the progress of projects through progress reports by island councils and contractor and regularly update the monitoring unit on overall progress
- Check and verify the invoices made for the projects

Sector: Housing and Infrastructure Developments

11 Aug 2013 to 5 Sept 2013

Internship

Ministry of Housing and Infrastructure, Maldives (H. Alihuras, Lonuziyaaraiy Magu, Male', Maldives, http://www.sandcays.com/)

- Prepare environmental monitoring reports
- Participate in the preparation of Environmental Impact Assessments
- Participation in data analysis and compilations

Business: Environmental Consultancy

EDUCATION AND TRAINING

2011 to 2014

Bachelor of Environmental Management

The Maldives National University

- Global Environmental Issues in a Local Context
- Introduction to Earth and Marine Science
- Environment and Community Health
- Statistical Methods
- Plants and Ecology
- Monitoring and Reporting Environmental Quality
- Sustainable Human Development
- Population and Demography
- Marine Biology
- Fundamentals of Environmental Chemistry
- Environmental Impact Assessment(EIA)
- Integrated Waste Management
- Marine Biology, Ecotourism and Environmental Interpretation
- Development of an Environmental Management System
- Integrated Marine and Coastal Management
- Pollution Prevention and Control
- Community Development and Environmental Education
- Environmental Economics
- Policy and Law
- Climate Change and Society
- Strategic Environmental Assessment and Planning
- Fisheries Management and Aquaculture
- Conservation Biology
- Environmental Affiliation Project (Internship)
- Independent Research Project

21 May 2015 — **First National Dialogue on Intended Nationally Determined Contributions (INDCs) of the Maldives**
Ministry of Environment and Energy

10th September 2015 — **Intended Nationally Determined Contributions (INDCs) of the Maldives - Endorsement Workshop**
Ministry of Environment and Energy

61 November 2015 — **Supporting SNAP on short lived climate pollutants in the Maldives**
Ministry of Environment and Energy

20th May 2013 to 25th May 2013 — **Youth Exchange Programme to Japan– JENESYS 2.0 (Japanese Learners from SAARC Countries)**
Japan International Cooperation Center (JICE)

Mother tongue(s): Dhivehi

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	Proficient user(C2)	Proficient user(C2)	Proficient user(C2)	Proficient user(C2)	Proficient user(C2)
	Certificate of Proficiency in English.C2.				

Levels: A1/A2: Basic user - B1/B2: Independent user - C1/C2 Proficient user
Common European Framework of Reference for Languages

Digital competence

SELF-ASSESSMENT				
Information processing	Communication	Content creation	Safety	Problem solving
Independent user	Proficient user	Independent user	Independent user	Independent user

Levels: Basic user - Independent user - Proficient user
Digital competences - Self-assessment grid

CURRICULUM VITAE of IBRAHIM RASHIHU ADAM

PERSONAL DETAILS

Name: Ibrahim Rashihu Adam
Nationality: Maldivian
Gender: Male
Date of Birth: 5th March 1991

Present address for communication: 3rd FL/ M. Honey Dew
IzzudheenMagu
Malé
Republic of Maldives
Tel: (960) 3331626 (W)
(960) 7785434 (M)
Fax: (960) 3336575
Email: rashihu@seamarc.com

EDUCATIONAL QUALIFICATION

SECONDARY EDUCATION: **High School Diploma**
2008-2010 Centre for Higher Secondary Education, Male', Maldives

GCE O' level
2005-2007 Majeedhiya School, Malé, Republic of Maldives

TERTIARY EDUCATION: **Bachelor of Environmental Management**
2012-2014 Maldives National University, Male', Maldives

Certificate II in Information Technology
Cyryx College, Male', Maldives

Scubapro Level 2 Service Seminar
Scubapro Education Association, Male', Maldives

EMPLOYMENT HISTORY

01.01.15 – Ongoing	Marine Research Officer	Seamarc Pvt. Ltd.
01.06.14 – 31.12.14	Trainee Marine Research Officer	Seamarc Pvt Ltd
01.06.11 – 01.01.12	Assistant surveying Technician	Survey Section Ministry of Environment and Energy

EXPERIENCE

EIA for Submarine Platform Development, March 2016. The project was to determine the environmental impacts arising from submarine platform which was composed with a walkway, 2 docks and a pavilion. I was

involved in the survey and the formulation of the EIA report to assess the environmental impacts that can surface from the project.

EIA for partial renovation and upgrade works for Six Senses Laamu, Octorber 2015. The project was to determine the environmental impacts arising from the renovation and upgrade works at Six Senses which involves construction of pools at existing villas and extending dive and arrival jetties. I was involved in the survey and the formulation of the EIA report to assess the environmental impacts that can surface from the project.

EIA for the partial renovation and upgrade works of Four Seasons Kuda Huraa, August 2015. The project was to determine the environmental impacts arising from the renovation works at Kuda Huraa water villas and walkway jetties. I was involved in the survey and the formulation of the EIA report to assess the environmental impacts that can surface from the project.

EIA for the relocation of Trees from B.Kihaadhoo to B.Voavah, August 2015. The project was to relocate 50 trees from B.Kihaadhoo housing plots to B.Voavah which is going to be developed as a Luxury Tourist Resort. I was involved in the survey and the formulation of the EIA report to assess the environmental impacts that could arise from the project.

EIA for the development of B.Voavah as a Luxury Tourist resort in July 2015. The project was to determine the environmental Impact arising from the development of B.Voavah as a tourist resort. I was involved in the survey and the formulation of the EIA report to assess the environmental impacts arising from the project.
EIA for Coral Frame Project at Maalifushi, Thaa Atoll in May 2015. The project aims to rehabilitate the coral reef of Maalifushi by deploying coral frames around the reef. I was involved in the survey and the formulation of the EIA report to evaluate the environmental impacts arising from the project.

Coral Frame Project at Cocoa Island by Como. Monitoring of the coral frames in April 2015 under the project.

Coral Frame Project at Kanifushi, Kaafu Atoll. Monitoring of the coral frames in April 2015 under the project.

Coral Frame Project at Kuda Huraa, Kaafu Atoll. Monitoring of the coral frames in March 2015 under the project.

EIA for Coral Frame Project at Kanuhuraa, Lhaviyani Atoll, October 2014. The project aims to rehabilitate the coral reef of Kanuhuraa by deploying coral frames around the reef. I was involved in the survey and the formulation of the EIA report to evaluate the environmental impacts that can arise from the project.

Coral Frame Project at Kanuhuraa, Lhaviyani Atoll. I was involved in the launching of the project in August 2014. This involved transplantation of corals to the frames and its consecutive deployment in Kanuhuraa reef. In addition, the initial monitoring of the frames after transplantation.

Coral Frame Project at Landaa Giraavaru, Baa Atoll. Monitoring of the coral frames in August 2014 under the project.

CURRICULUM VITAE

PROFILE

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ACADEMIC QUALIFICATIONS

2012-2014 Bachelor of Environmental Management, Faculty of Science, Maldives National University.

2011 Foundation Studies in Environmental Management, Maldives National University.

2008-2010 General Certificate of Education, Advanced Level, Centre for Higher Secondary Education, Male', Maldives.

2005-2007 General Certificate of Education, Ordinary Level, Irushadhiyya School, S.Maradhoo, Maradhoo Feydhoo.

WORK EXPERIENCE, TRAINIGS AND WORKSHOPS

- **March 2016 to present** Assistant Project Officer at Ministry of Housing and Infrastructure
    - *Prepare EIA related documents and communicate with relevant stakeholders*
    - *Responsible for administrative works of the unit through organization, filing, preparing of documents and updating sheets.*
    - *Coordinate EIA project related meetings and keep records of it.*
    - *Assist, plan and implement environmental monitoring requirements of EIA projects.*
- **December 2012 to January 2015** Volunteer member of the Maldives National University Project, mangroves for the future, guided by IUCN and UNDP.
    - *Field Surveys of K.Huraa Mangrove*
    - *Data entering to excel sheets*
- **16 August to 04 September and 04 December to 24 December 2014** Intern in Maldives Marine Program for IUCN
    - *Undertaking door to door surveys*
    - *Data entering to excel sheets*
    - *Data mapping using GIS ArcView.*
- Participated in the Data collection survey of Enabling Activities to Facilitate Early Action on the Implementation of the Stockholm Convention on Persistent Organic Pollutants in 2013.
- Completed Basic First Aid course conducted by Faculty of Health and Sciences in 2011.

- **30 -31 August 2016**
  - *Promoting Bilateral Mechanisms in Asia and the Pacific- A Workshop on the Joint Crediting Mechanism*

REFEREE

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