ENVIRONMENTAL IMPACT ASSESSMENT

Proposed Mixed Residential Building Development at Hulhumale’, Plot No. D1-1

Proponent:
Sandal Mauritius Pvt. Ltd.

Consultant:
Amir Musthafa (EIA01/13)

February 2017
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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 (EIA 01/13)

20th February 2017
Proponents Declaration

(attached in the following page)
21st February 2017

Dear Mr. Ibrahim Naeem,

Project: EIA for the proposed mixed residential apartment building in Hulhumale' Plot No D1 - 1

Sub: Proponents Declaration

As the proponent of the project, we guarantee that we have read this EIA report and to the best of our knowledge, all non-technical information provided here are accurate and complete. We are aware that this report has been prepared in accordance with the EIA regulations.

Thanking you

Yours Sincerely

For SANDAL MAURITIUS PVT LTD.,

Narayana Mynampati
Director.
Non Technical Summary

This report is based on the proposed 12 storey social mixed residential luxury building construction in Hulhumale’, in Plot No. D1-1. The project is being developed by Sandal Mauritius Pvt. Ltd. A contractor has not been chosen yet. Upon completion of construction, the building will be handed over to the Ministry of Housing and Infrastructure, to be leased out to tenants as part of the social housing program.

An Environmental Impact Assessment was necessary for the works due to the fact that the structure exceeds 10 storeys as specified in the EIA regulation ‘Jadhuvalu R’ in the list of type of projects for which EIAs are required. In addition to meeting the regulatory requirements, the report would further assist the proponent and important stakeholders to make decisions based on favourable environmental conditions with the main focus on sustainability. The project also adheres to several other rules and regulations in the Maldives and has obtained permit from HDC to proceed. HDC is a 100% government entity being given the responsibility to set guidelines and oversee all developments in Hulhumale’.

The project is in addition to the larger program by the Ministry of Housing and Infrastructure and HDC to enable housing opportunities for people living in the Greater Male’ area. Apartments in this particular building is to be targeted towards social housing scheme. The project will contribute to the grand plan of reducing congestion in Male’ by providing more housing opportunities in Hulhumale’.

The existing environment at the project site does not consist of any significant vegetation and the water test result shows normal water quality. There are no residents living in close proximity to the site and there is no other structure at the site as well. However the structure faces the Central Park, albeit the undeveloped section of the park. There are also upcoming projects adjacent to the proposed development.

During the construction stage, health and safety standards of the workers at site, and waste generation is the major areas of concern. With proper planning and project management, this can be easily mitigated. Waste is the main concern during the operational stage of the project as well. Since this will be developed as a condominium with multiple tenants owning the rights of the building, it has to be ensured that the tenants are held responsible to properly manage the waste in addition to maintaining the building.

Regarding alternatives, there are no viable alternatives available for the project with respect to location. The no project option is also not plausible at this stage and possibilities are outside the scope of this study. Other alternatives including material, foundation type, construction
methodology are not necessarily recommended. Recommendations had been made to proceed with the project as planned.

An environmental monitoring plan is proposed to be carried out with 2 phases; one for the construction stage, and one for 2 years post construction. Factors to investigate include surveying the amount of waste generation, noise pollution, traffic flow, health and safety at site and water quality.

All the impacts as highlighted in the project can be mitigated. The socio-economic benefits to Greater Male’ City from projects such as these is high. It also provides additional housing opportunities, which would contribute to alleviating the housing issues in Male’ City, and therefore mitigating the issues related to congestion. Thus, after consideration of all these perspectives, it is recommended that this project proceed as planned, after incorporating the mitigation measures given in this study with the commitment to implementing the monitoring plan given.
EIA for the proposed mixed residential building development project at Hulhumale', Plot No. D1-1

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1. Introduction

1.1 Background

This Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts of the proposed mixed residential building construction in Plot D1-1.

The report will look at the justifications for undertaking the proposed project components and it will identify and determine the significance of the potential impacts of the proposed works. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be suggested along with measures to mitigate any negative impact on the environment. Environmental monitoring programme is vital in order to demonstrate the long-term sustainability of the proposed project as well as to undertake mitigation measures before any impact leads to long-term significant effects. Long term monitoring helps to understand uncertainties in impact analysis improving future impact predictions and project implementation. Therefore, a building monitoring and management plan would be suggested.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site visits in October 2016. Available long-term data were collected from available sources, such as long-term data on meteorology and climate from local and global databases. Long-term data on the project site is lacking. However, to compensate for this, data collected over the years in Hulhumale’ for similar projects will be used.

1.2 Aims and Objectives of the EIA

This report addresses the environmental concerns of the building construction works and also those that will occur during the operational stage of the development. The report attempts to achieve the following objectives.

- Describe the project components to the relevant authorities and to the public
- Allow better project planning and decision-making based on the sustainable development.
- Identify environmental impacts that will occur and gauge their significance for such a project undertaken in the particular location.
- Mitigating impacts caused due to the works outlined in the project
- Promote informed and environmentally sound decision making
To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.

1.3 Methodologies

This EIA has been prepared by Amir Musthafa, a registered permanent EIA consultant with a few years of experience in Environmental Impact Assessment in the Maldives and has been actively involved in numerous coastal protection projects and building construction undertaken in the country. The consultant was assisted by the developer’s staff throughout the project, most notably for water sample collection from the site.

Internationally recognized and accepted methods have been used in this environmental evaluation and assessment. This EIA is based mainly on data collected during field investigation missions in February 2017. The data collection methods are described in detail under the following Section.

1.4 Methods of data collection

Conditions of the existing environment of the study area were analysed by using various surveying techniques and scientific methods. Field surveys were carried out to get a further understanding of the existing conditions at the project location, and were carried out during February 2017 to collect baseline data.

The following investigations were carried out on site.

- Groundwater quality parameters
- Existing noise levels on site
- Traffic flow at the project site
- Socio-economic conditions in the area

As the area does not include any structures or vegetation of notes, vegetation and structural surveys were not required.

1.4.1 Groundwater quality

Groundwater quality was measured at the project location. Groundwater was collected by dipping into groundwater wells using 1500ml glass bottles. The containers were filled and taken for testing at the MWSC laboratory within 3 hours for sampling.

1.4.2 Noise Pollution
Noise pollution at the project area was measured using a handheld noise measurement device using Decibel 10th 3.8.1 software. Noise measurements were undertaken for 60 seconds at the locations shown under Existing Environment section.

### 1.4.3 Traffic flow

Traffic flow was measured by visual observation of traffic within a predetermined area at the project location within a specified period of time using a stop-watch. The no. of heavy duty vehicles, cars, motor-cycles, and pedestrians at the area in a 15 minute period were noted down by visual inspection, and extrapolated to 60 minutes. Traffic surveys were undertaken at different times and due to the low traffic flow in the area, the maximum flow is presented in the report.

### 1.4.4 Stakeholder consultations

Stakeholder consultations was initially carried out in the EIA scoping meeting. The EIA scoping meeting gave the opportunity to consult with the Environmental Protection Agency, project developer and contractor, and Housing Development Corporation (HDC) in one sitting. Additionally, consultation with the Ministry of Housing and Infrastructure, STELCO, MWSC, HPA, WAMCO and Project engineer, were carried out throughout this study, via mail, telephone and in person. Meetings were held with the listed organisations before this study to discuss similar developments in Hulhumale’. Minutes of these meetings are also included in this EIA, as they are very relevant to the scope of this project.

### 1.4.5 Built Environment

An overview of the built environment around the project site was undertaken by visual inspection with the aid of photographs. A structural defect inspection study is not recommended as is the case for structures usually built in high congestion areas in Male’.

Once the EIA has been submitted it is expected that the review process will not take more than 2 weeks. The review process may result in the request for additional information before issuing a decision statement. However, all efforts have been made to ensure that adequate information has been provided with specific attention paid to meet all requirements of the Terms of Reference (TOR). The TOR for this EIA is given in Annex 1.

### 1.5 References to similar studies

As there have been several muti-storey building projects undertaken in Male’ City recently by various consultants, several of them were studied. These include the following:
1.6 The Proponent

The project is being proposed by Sandal Mauritius Pvt. Ltd, which is a group based in India. A contractor for the project has not been decided at the time of report drafting.

1.2 The Project Location

The project is based in Hulhumale’, Plot No. D1 – 1. Location coordinates are at around 4°13’7.04”N, 73°32’25.48”E. As can be seen from the Figure below, it is in close proximity to Central Park.

There are no buildings in the direct vicinity of the proposed site. However, other similar developments are proposed in the neighbourhood.

The precise location is shown in the following image (Figure 1). A more detailed site plan is given in Annex.
EIA for the proposed mixed residential building development project at Hulhumale’, Plot No. D1-1

Figure 1 Location of proposed site in Hulhumale'

Figure 2 Location of Plot D1 - 1 in Hulhumale’

Proponent: Sandal Mauritius Pvt. Ltd.
1.3 Need and Justification

Hulhumale’ has been regarded as the main residential area in the greater Male’ region future and as such all upcoming housing projects are being proposed to be developed in Hulhumale’. Hulhumale’ is currently a hub for development and is very much intended to play an integral role to drive the housing industry forward. There are additional housing projects being proposed, while a yacht marina, IT city, tourism zones, and others. All these developments are believed to generate a number of employment opportunities and therefore will attract additional migration to the area.

With the development of Hulhumale’ Phase 2, it appears that there is an urgency to complete the entire Phase 1, and as such there has been a flurry of housing projects proposed. The proposed project in this study has been proposed earlier than the recent developments. The completion of these buildings would greatly alleviate the housing issues in the region, and also provide a much needed relief to the congestion in Male’. The need for such a relief has never been greater, as the living conditions in Male’ have deteriorated with each passing year.

The population in Male’ has steadily increased with respect to the total population in the Maldives. In 1985, data shows about ¼ of the total population was residing in Male’, which
increased to 1/3 of the total population according to 2006 census. Moreover, this includes a large percentage of immigrants living in the capital city. The percentage of people living in Male’ area compared to the rest of the country is illustrated in the following graph. The data has been given up to 2006. However, the trend has continued up to the present year.

![Graph showing percentage of people living in Male with respect to total population](image)

**Figure 4 Percentage of people living in Male with respect to total population**

In 2006 there were 14,107 households in Male’ compared to just 9,700 in 2000. The average household size was 7.4 persons per household. The increase in number of households over the 6 year period is regarded as a result of subdivision of housing plots and families sharing a single housing unit.

It has been common for a 2-3 bedroom houses in Male’ to have 15 to 20 people. The proportion of people living in houses with 40 square feet or few of housing area per person has increased from 17 to 22 and percentage of houses without compounds has decreased from 52 to 39 percent. Large households combined with relatively small size of houses create morbid living conditions, with people often sleeping in shifts. It is common to find whole families living in single rooms, which doubles as kitchen and living room. Such living conditions place great strain on families, sometimes leading to social issues including break up of families, above average drug usage among the youth, behavioural problems in children and young adults, etc. (Faisal, n/a)

In order to alleviate these issues, a major housing scheme was underway for the past 2 years titled ‘Gedhoruverikurun’, to provide housing opportunities to residents in Male’. As it is a social housing scheme, the recipients of the scheme is targeted to those that are in need of
government subsidised housing. While most of the recent mixed residential developments are targeted towards middle income members of the society, this project is part of the social housing scheme, and will provide decent quality housing for the community.

2. Project Description

The project proposes to develop 120 housing units in 1 tower. It will be an 11 storey building with the ground floor dedicated to shops and each of the remaining floors will consists of 12 units. There will not be any basement. The total height of the building will be 37.50m.

There will not be additional amenities such as swimming pools, restaurant, gyms or cinemas as part of the development. The method of construction will be typical of similar structures with a raft foundation, concrete structures and masonry walls.

The drawings are shown below. It is given in more detail in the Annex.
Figure 6 First Floor plan
2.1 Site setup

HDC has allocated the plot behind plot D6 – 1C for the developer. This plot will be used to store all the materials and accommodate all the construction staff. Materials will be transported from here to the proposed site on a needs basis.
2.1 Excavation and Foundation Protection

It has been established that the depth of foundation will be over 1.6m below the existing ground level. The estimated depth of water table in the area is 1.50m from ground level, dewatering will have to be continuous until casting of the foundation. Excavation will be undertaken with a backhoe excavator. Total excavation quantity is approximately 4,000.00 cum. Part of this this will be used for back filling

When all the necessary excavation is complete, a 50 mm thick lean concrete (Grade C15, 15MPa) layer will be laid to provide a level surface to assemble the reinforcement of foundation raft slab and beams.

The lateral pressue on the material adjacent to the excavation could be prevented materially by ‘I’ Section concrete panel shoring will be to protect road way around the land and adjacent land. Grouting and welding will be done at all joints to minimise water seepage to provide lateral stiffness.

Onsite close observation, frequent measurements and recording of the vertical and lateral movements and behaviours of the sheeting and bracing will be done to provide early warning of unfavourable development which might cause settlement of the adjacent road/property.

2.2 Dewatering

Dewatering is the localized lowering of the ground water table from its natural level, in order to create a dry environment for construction works. This is a critical process for creating the correct working conditions to establish the building substructures.

Dewatering will be a continuous process and will be on-going simultaneously while excavation is being undertaken. The process will be continued throughout until casting of the foundation. It is envisaged that 5 or 6 pumps each with the flow rate of 30 litres per second will be located at specific locations to pump out the water to the sea, north of the site. The dewatering works will be done entirely by the contractor. Water will be dewatered to a site close to the project site as identified by HDC. Dewatering will not take place towards the lagoon.

2.3 Building Foundation

For the foundation works, a raft foundation be used. This is currently the most commonly adopted method of construction in Maldives. It enables to spread the load from a structure over a large area, minimizing the pressure exerted on the base. Beams will then be incorporated into the structure to stiffen the foundation.
Excavation in loose sand requires continuous support, and therefore supports will be placed immediately as excavation commences. Sheets would be closely spaced and horizontal support bracings provided as excavation progresses. Supports and bracings will be placed concurrently with excavation, moving along the periphery of the plot successively. The concrete works for the raft foundation will be done using C30 Grade concrete.

### 2.4 Construction materials and machinery

The heavy construction materials to be used are

- Excavators
- Concrete Mixers
- Dump Trucks
- Concrete Pump
- Cranes
- Tower crane

All the materials such as cement, aggregate and sand will be delivered to site based on consumption. Steel and Plywood will be stored at the contractor’s warehouse. Barb bending and carpentry work will be prefabricated at company work yard or given to sub-contractors and transported to site.

### 2.5 Utilities

Water and sewerage facilities will be provided by the MWSC water and sewerage network. Therefore water will be desalinated water from the main supply. And sewage will be disposed untreated along the main water outfall.

Electricity will be provided by STELCO. STELCO has assured that they will be able to provide up to the requirements of the site. Backup generator will be placed on site during construction activities. A Sound Proof Diesel Generator, with specifications of 100 KW, 125/140 kva may be in place.

It is anticipated that the project site will require approximately 30 kW of power during the construction phase, while 25 m3 per day of desalinated water in anticipated during the construction stage of the development.

During the construction, the amount of wastewater generated would be relatively low compared to its generation during the operation phase of the development.
2.6 Project Management

The project is managed by the developer Sandal Mauritius Pvt. Ltd. Construction works is to be undertaken by a contractor chosen by the developer. Laborers are mostly going to be from Bangladesh and India, who are already established with the contractor for previous construction projects. All labourers will be accommodated at Company Labour Quarters at the allocated temporary site. There will be a consulting engineer hired in addition to an in-house site engineer and site supervisor to manage the project.

All operations, work planning for the on-going construction work will be done at Site Office; Major operations will be done at company head office. Heavy machinery such as excavator, dump truck, tower crane, cement mixer, cement pump, and crane will be used during excavation and casting. Most of the machineries are expected to be owned by the contractor while some heavy duty machinery may be rented.

2.7 Waste Management

Sand excavated during foundation work will be stockpiled at the site. Upon completion of foundation works, sand will be reused for back filling. Excess sand can be transported to a stockpile as instructed by HDC, likely to be in the newly reclaimed Phase 2.

It is estimated that during the construction phase, the project will generate wastes around 4 – 5 tons per day which will be collected on site, and stockpiled at the site. Organic household type waste will be transported to Hulhumale’ waste management center. The contractor will arrange the transportation of waste outside of Hulhumale’ to Thilafushi on a weekly or fortnightly basis. None of the waste will be placed outside the project boundary at any time. Temporary waste storage will be within the project-demarcated area.

All waste generated during concrete works phase and finishing phase will be collected at the end of each work day and temporarily stored in the ground floor. Hazardous waste such as empty oil-cans (lube-oil), paint cans or strainers will be kept separate and disposed according to the standards established by relevant government authority. They will also be transported to Thilafushi in separate containers.

For waste generated during operations, waste collection bins will be kept at ground floor garage area. There will not be a waste chute in these proposed buildings. Instead, waste will be collected and transferred downstairs either by tenants or maintenance team. The waste will be collected by WAMCO vehicles daily and transported to the waste management site in Hulhumale’.
2.8 Road closure and traffic re-routing

Road closure and traffic rerouting will not be necessary as part of this project, as there will not be any significant obstruction to the main road. The temporary site will store all the required materials there will not be any issue with material storage. The tower crane will also be fixed at the site. Therefore, there will not be any need for road closures. However, there may be temporary closures during slab concrete works. The traffic can easily be rerouted via the South curved road facing Central Park.

2.9 Work Schedule

The project is expected to take about 2 years to complete. The project is expected to commence soon after the approval of this EIA report, which should take approximately 2-3 weeks from submission. Dewatering permit will then be obtained.

Initially the architectural and structural design works had been completed and approved before undertaking the EIA. The is already been cleared by HDC. Dewatering is scheduled to commence next, which will be carried out by contractor. Upon completion of dewatering, foundation works will begin and soon thereafter structural works will be carried out. Masonry work and interior works will commence afterwards. The work schedule is given below.

Table 1 Work Schedule for the project

<table>
<thead>
<tr>
<th>S.NO</th>
<th>DESCRIPTION</th>
<th>DURATIONS</th>
<th>START DATE</th>
<th>END DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>SHPM</td>
<td>702.00</td>
<td>27-Jan-17</td>
<td>30-Dec-18</td>
</tr>
<tr>
<td>A</td>
<td>Approval Drawings</td>
<td>28</td>
<td>27-Jan-17</td>
<td>24-Feb-17</td>
</tr>
<tr>
<td>1</td>
<td>Structural Dwg</td>
<td>15</td>
<td>27-Jan-17</td>
<td>11-Feb-17</td>
</tr>
<tr>
<td>2</td>
<td>Submission of Structural Drawings</td>
<td>3</td>
<td>12-Feb-17</td>
<td>15-Feb-17</td>
</tr>
<tr>
<td>3</td>
<td>Fire Drawing</td>
<td>16</td>
<td>27-Jan-17</td>
<td>12-Feb-17</td>
</tr>
<tr>
<td>4</td>
<td>Submission of Fire Drawings</td>
<td>3</td>
<td>12-Feb-17</td>
<td>15-Feb-17</td>
</tr>
<tr>
<td>5</td>
<td>Electrical &amp; Plumbing Drawings</td>
<td>15</td>
<td>5-Feb-17</td>
<td>20-Feb-17</td>
</tr>
<tr>
<td>6</td>
<td>Submission of Electrical &amp; Plumbing Drawings</td>
<td>3</td>
<td>21-Feb-17</td>
<td>24-Feb-17</td>
</tr>
<tr>
<td>A</td>
<td>Tender Drawings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Structural Dwg</td>
<td>15</td>
<td>27-Jan-17</td>
<td>11-Feb-17</td>
</tr>
<tr>
<td>2</td>
<td>MEP- Electrical, FF &amp; Plumbing</td>
<td>15</td>
<td>11-Feb-17</td>
<td>26-Feb-17</td>
</tr>
<tr>
<td>B</td>
<td>Tendering &amp; Award of work- Civil &amp; MEP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Technical specifications/Special Conditions/Tender Drawings /boq</td>
<td>16</td>
<td>25-Feb-17</td>
<td>13-Mar-17</td>
</tr>
<tr>
<td>2</td>
<td>Vendor List/Approval/GSCC/Approval</td>
<td>5</td>
<td>8-Mar-17</td>
<td>13-Mar-17</td>
</tr>
</tbody>
</table>
2.10 Safety on site

All precautions will be taken for safety of workers during the construction stage. Barricades, warning signs or devices will be placed on the road during casting or road works (connection of water lines and sewer lines) for safety of pedestrians and vehicles.

All workers are given instructions about the health and safety at Site. The Site Engineers and Supervisors will give a brief on daily basis before the work starts to all workers and all proper health and safety precautions will be implemented on site. Safety signs will be used on site, some of which are shown in the following Figure 6.

Personal protective equipment will be available for all the workers, for falling objects, hazardous dust or chemicals, or high working areas. Emergency first aid kit will be at site for minor injuries. First aid kit will be provided in the temporary office on the ground floor, after completion of ground and first floor slab where all safety clothing and equipment will be held. All workers and personnel entering the premises will be given hard hats and safety shoes.
2.11 Accident and hazard scenarios

Assessment for accident and Hazard is given below.

The following hazard and accident assessment is based on the following 3 stages of the building lifecycle, including construction, use, and maintenance of building. Risk levels & probability are qualitatively assessed based on the following parameters; High, Moderate and Low.

Table 2 Accident and Hazard Risks

<table>
<thead>
<tr>
<th>Performance Consideration</th>
<th>Risk Level</th>
<th>Risk Probability</th>
<th>Responsible Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of hazardous substances, which impact on construction work eg: asbestos, SMF, hydrogen chloride, etc.</td>
<td>High</td>
<td>Low</td>
<td>Project manager, Site Supervisor</td>
</tr>
<tr>
<td>Provision</td>
<td>Rating 1</td>
<td>Rating 2</td>
<td>Responsible Officer</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Sufficient access / space around new section or building for use of cranes, scaffolding during construction</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Project Engineer</td>
</tr>
<tr>
<td>Construction workers will be protected from / proximity to HV electrical, high risk energy sources</td>
<td>High</td>
<td>Moderate</td>
<td>Site Supervisor</td>
</tr>
<tr>
<td>Traffic / pedestrian risks are minimised for planned loading &amp; unloading for construction vehicles</td>
<td>High</td>
<td>Moderate</td>
<td>Site Supervisor, Project Manager</td>
</tr>
<tr>
<td>Neighborhood construction considerations eg:, school vicinity, site location</td>
<td>Low</td>
<td>Low</td>
<td>Project Manager, HDC</td>
</tr>
<tr>
<td>Roof design will reduce /eliminate the risk of falls from height during construction</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Project Engineer</td>
</tr>
<tr>
<td>Sufficient space is planned for access &amp; to install / major fixed plant or equipment or specialised equipment, plant rooms</td>
<td>Low</td>
<td>Moderate</td>
<td>Project Engineer</td>
</tr>
<tr>
<td>Floor loading design has been assessed by engineer to be able to accommodate heavy equipment / plant to be installed in future</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Project Engineer</td>
</tr>
<tr>
<td>Floor surfaces – even level with no sudden changes in levels – floor coverings non slip, suitable for levels of traffic use and suitable for type of tasks to be done</td>
<td>Moderate</td>
<td>High</td>
<td>Project Engineer</td>
</tr>
<tr>
<td>Stairs and balcony – edge delineation, slip resistant (SR) stair nosing, construction / design suitable for</td>
<td>Moderate</td>
<td>High</td>
<td>Project Engineer</td>
</tr>
</tbody>
</table>
2.12 Project Inputs and Outputs

Each component of the project has inputs and outputs based on human resources, economics, and the environment. However, since the operation is carried out in house, project inputs and outputs are greatly conserved and limited.

The major inputs and outputs associated with the project encompassing all the components, are tabulated below. Table 3 highlights the main inputs, while Table 4 highlights the major outputs.

**Table 3 Main inputs from the proposed project**

<table>
<thead>
<tr>
<th>Input resource(s)</th>
<th>Estimated Quantity</th>
<th>Main sources of resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>intended use, handrails, non-horizontal railings in balcony</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window positioning and solar glare</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Safe Access to lighting fixtures to change fitting, bulbs</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Safe Access to plant rooms – locked, lighting</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Access to roof tops – safe access to within safety zone, minimised manual handling of material, equipment tools.</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Accessible window cleaning methods</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Accessible roof cleaning methods</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Accessible dirt or rubbish collection points</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Maintenance Officer
| Construction workers | Management staff – 2  
Technological supervision – 4  
Quality Control – 3  
Design and supervision and development of shop drawing – 2  
Skilled Labor – 45  
Unskilled labor – 15  
Security Staff – 2 | Contractor’s permanent staff. Project staff. Labourers mostly registered workers from Bangladesh, India. |
|----------------------|---------------------------------------------------------------|
| **Machinery and equipment** | Tower crane – 2nos  
Excavator – 20 tons  
Concrete mixing plant – 1nos  
Transit mixtures – 2nos  
Dewatering pumps – as per the requirement  
Power generators – 100kW 2nos  
Soil boring machine – 1nos  
Skid loader – 2nos  
1.5 cube tipper 1nos  
Crane truck 1nos  
Scaffoldings – as per the requirement about 400 sets  
GI Pipes 50mm – 1000nos  
Arco jacks and based (U Formwork system | Sourced from contractor’s own equipment/machinery. If new machinery required, sourced from local rentals. |
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete stationary pump with required length of pipe</td>
<td>1</td>
</tr>
<tr>
<td>Material and passenger hoist</td>
<td>2 nos</td>
</tr>
<tr>
<td>Bar bending machine</td>
<td>4 nos</td>
</tr>
<tr>
<td>Pre-stressing jacks</td>
<td>4 nos</td>
</tr>
<tr>
<td>Grout pumps</td>
<td>2 nos</td>
</tr>
<tr>
<td>Compressive testing machine</td>
<td>1 nos</td>
</tr>
<tr>
<td>CBR testing apparatus</td>
<td>1 nos</td>
</tr>
<tr>
<td>Rebound hammer</td>
<td>2 nos</td>
</tr>
<tr>
<td>Water proofing membrane welding machine</td>
<td>2 nos</td>
</tr>
<tr>
<td>Arc welding plants</td>
<td>2 nos</td>
</tr>
<tr>
<td>Lighting generators</td>
<td>2 nos</td>
</tr>
<tr>
<td>Silent hammer</td>
<td>1 nos</td>
</tr>
<tr>
<td>Mobile crane</td>
<td>1 nos</td>
</tr>
<tr>
<td>Backhoe loader</td>
<td>2 nos</td>
</tr>
<tr>
<td>Plastering Machine</td>
<td>2 nos</td>
</tr>
<tr>
<td>Small concrete mixture</td>
<td>4 nos</td>
</tr>
<tr>
<td>Mobile concrete pump (as per the requirement)</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Quantity/Detail</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Energy supply (during construction)</td>
<td>~30kW</td>
</tr>
<tr>
<td>Cement (Ordinary Portland cement)</td>
<td>+2,000 bags</td>
</tr>
<tr>
<td>Water</td>
<td>25 cbm/day</td>
</tr>
<tr>
<td>Sand</td>
<td>+6,000 bags</td>
</tr>
<tr>
<td>Aggregates</td>
<td>+15,000 bags</td>
</tr>
<tr>
<td>Ply wood (12mm thick)</td>
<td>+1000 No.</td>
</tr>
<tr>
<td>Timber (Hard wood)</td>
<td>+7500 No.</td>
</tr>
<tr>
<td>Steel</td>
<td>+50 tons</td>
</tr>
<tr>
<td>Painting</td>
<td>Not yet determined</td>
</tr>
<tr>
<td>Exterior (Seamaster, or Equivalent Emulsion)</td>
<td></td>
</tr>
<tr>
<td>Interior (Seamaster or Equivalent Emulsion)</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4 Major outputs from the proposed project

<table>
<thead>
<tr>
<th>Products and waste materials</th>
<th>Anticipated quantities</th>
<th>Method of disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste generated during construction</td>
<td>2-3 tons per day</td>
<td>Collected and sorted at site, and taken to Thilafushi waste collection area.</td>
</tr>
<tr>
<td>Waste water</td>
<td>60 litres/second</td>
<td>Water flow towards the lagoon on the west of Hulhumale’ via established MWSC system</td>
</tr>
<tr>
<td>Waste oil and grease</td>
<td>Minute quantities</td>
<td>Collected in used containers and transported to waste site</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Debris in minute quantities</td>
<td>External influence minimised by site demarcation temporary boundary walls.</td>
</tr>
<tr>
<td>Noise pollution</td>
<td>&gt;80 db(A)</td>
<td>Minimised by site demarcation barriers. Ear muffs and safety equipment for workers on site.</td>
</tr>
<tr>
<td>Waste generated during operations</td>
<td>2 – 5 tons per day</td>
<td>Collected on site and transported to waste collection site in Hulhumale’</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Waste water generated during operations</td>
<td>300 tons per day</td>
<td>Via MWSC sewerage network</td>
</tr>
</tbody>
</table>
3 Description of the Existing Environment

This section covers the existing environmental conditions of the project site. Since this is a housing project, the key components with respect to the project under consideration are described below.

- Climate
- Existing structures
- Vegetation
- Traffic flow
- Noise pollution
- Water quality
- Hazard vulnerability

Data was collected using methods discussed in Section 1.4.

3.1 Climate

This section deals with the regional and local climate of the study area.

Data has been taken from the weather station at Hulhule’, the island which accommodates the International Airport, and adjacent to Hulhumale’. Long-term meteorological data for Hulhulé is available and being less than a kilometre away from the project location, the station is at an ideal location.

The Maldives, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,924.7mm in the central parts of Maldives, where Male’ is located. (Department of Meteorology, 2012).

The climate of the Maldives is dependent upon the Indian Ocean Monsoons. Monsoon wind reversal plays a significant role in weather patterns.

The two monsoon seasons observed in the Maldives include the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The northeast monsoon is the dry season that occurs from December to February and the southwest monsoon is the rainy season, which lasts from May to September. The transition period of northeast monsoon occurs from October to November while that of southwest monsoon occurs between March and April. The ‘four seasons’ of the Maldives is highlighted in the following Table 4.
### Table 5 Four Seasons of the Maldives

<table>
<thead>
<tr>
<th>Seasons</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>South West Transition</td>
<td>March to April</td>
</tr>
<tr>
<td>South West</td>
<td>May to September</td>
</tr>
<tr>
<td>North East Transition</td>
<td>October to November</td>
</tr>
<tr>
<td>South West Transition</td>
<td>December to February</td>
</tr>
</tbody>
</table>

#### 3.1.1 Wind

Wind is an important indirect process affecting formation, development and seasonal dynamics 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 an important factor, as being the dominant influence on the hydrodynamics in most coastal areas.

The two monsoon seasons have a dominant influence on winds experienced across Maldives. Since Maldivian islands are spread across the equator, monsoons are relatively moderate while strong winds and gales are rare. However, during South West monsoon gusts of up to 60 knots have been recorded at Male’. Wind is an important indirect process affecting the formation, development and seasonal dynamics of the Maldivian islands. Reversal of winds in the Maldives means change of seasons from North East monsoon to South West or vice versa.

General wind surface wind pattern over the country during North East monsoon is north-easterly direction whereas during South West monsoon mean wind flow is westerly.
3.1.2 Waves

Wave climate is not as important for a structure situated directly at the coast. Therefore, for the purpose of the EIA, there were no measurements carried out for the wave generation on a local scale. However, regional data has been studied and visual observation on site was used to analyse the environment, as even though there is low probability that direct wave impact will occur at the project site, inundation due to larger swells is possible for the area.

Two major types of waves are formed on the Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves, which are typically strongest during May-July in the aforementioned southwest monsoon period. During this period, 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.

The project site is well protected from any potential wave impact. In an event of flooding, there is a massive ground water recharge in front of the site in the form of the Central Park.

3.1.3 Rainfall

The average annual rainfall for the archipelago is 1,937mm. There are regional variations in average annual rainfall. Southern atolls receive more rain compared to the northern atolls (MEC, 2004). Mean monthly rainfall also varies substantially throughout the year with the dry season getting considerably less rainfall. The north east monsoon is known as the dry season and the south west monsoon the rainy season. It is not expected that the project team
will have to endure heavy rainfall during the excavation and foundation works based on the current schedule.

Figure 10 Annual Seasonal rainfall variation in Hulhule'

3.2 Existing structures

There are no other buildings on the same block as the proposed development. There are however proposed project in the same area including Rainbow Ocean front building and an upcoming 14 storey building by Jausa Investment Pvt. Ltd. This is the main site at the vicinity of the project site, which is about 15m away from the project site. It is not envisaged the project will have any significant impact on the upcoming structure.

Condition of the road near the project location was also observed to be good. There were no significant cracks and defects that could be observed near the site. The general condition of the roads are shown in the following images.
Figure 11 General condition of the road near the project site
3.3 Vegetation

This is a site that has not been used for any purpose. The vegetation that was planted after reclamation of the island, has been cleared from this area and therefore there is no vegetation of note to be found at the site, except for grass. Roadside vegetation will be removed to provide better access to site during the course of the project. However, The vegetation belt between the main road on the site is proposed to remain.

Figure 12 Vegetation at the project site

3.4 Traffic Survey

Traffic load at Bageecha Hingun was expected to be moderate relative to the busier roads of Hulhumale’. However, Bageecha Hingun is the main road that connects the ferry terminal to the rest of Hulhumale’. The road is divided into 2 arcs. The proposed project is on the northward arc. Taking the Ferry terminal as a reference point, majority of the traffic flow
directly towards east and is divided roughly equally among the 2 arcs. Therefore, the no. and frequency of vehicles in this area is currently moderate with respect to general Hulhumale’ traffic. It is low compared to general Male’ traffic.

A traffic survey was undertaken on Bageechaa Higun infront of the project site. The survey results can be seen below.

Throughout the survey, the traffic in the area was moderate with spikes when a ferry arrives.

In this regard traffic counts were carried out on 11\textsuperscript{th} February 2017 from, 17:00 – 18:00 and 0700 – 0800 respectively. Summary of data recorded is provided in the following figure.

![Traffic Flow Chart](image)

**Figure 13 Traffic flow from 17:00 – 18:00 (top) and 07:00 - 08:00 (bottom) in front of project site.**
3.5 Noise Pollution

Noise pollution can be an environmental and health hazard. However, there are no currently no guidelines for noise levels at residential areas in general. Examples of guidelines with regard to noise for residential areas as set World Bank Environmental Health and Safety guidelines for noise at residential areas are:

Daytime reference value for noise as set by the bank is 50 dBA while night time value is set at 45 dBA. For industrial area the noise reference level is set at 70dBA. Figure 14 gives the noise levels measured at the selected sites in the vicinity of the project area. These measurements were taken during evening from the 2 locations as illustrated in the figure to include ambient noise from traffic that is present in the area in general. As stated in the traffic flow section, this area undergoes very low traffic throughout the day and therefore noise pollution is generally low, with sudden spikes, usually when a motorcycle or heavy vehicle occasionally passes by. The noise on Test 1 is high as there were more traffic passing through within that time period.
The average noise level as can be seen is about 55 to 62 dB, and the lowest go down to 48 dB, which is moderately low. Spike maximum goes to about 77 dB. Noise levels were almost entirely determined by traffic, with the spikes occurring during loud occasional motorcycle or heavy vehicle transport.

### 3.6 Water quality

Ground water in the location was sampled and sent for testing to MWSC, Results of this test are shown in Table 5 below (see Annex 4 for results sheet).
It is noted that the groundwater quality of Hulhumale’ has deteriorated slightly over the past several years due to extraction of groundwater for several development projects such as water and sewerage and road construction projects, along with major building infrastructure project. However, the quality is much better relative to that of Male’. Moreover, the proposed site does not have any significant development thus far.

Table 6 Groundwater quality

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Project Site 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS Location</td>
<td></td>
<td>4°13'7.07&quot;N, 73°32'25.48&quot;E</td>
</tr>
<tr>
<td>Electronic Conductivity</td>
<td>μs/cm</td>
<td>777</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.72</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>21.4</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>mg/L</td>
<td>389</td>
</tr>
<tr>
<td>(TDS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>MPN/100ml</td>
<td>261</td>
</tr>
<tr>
<td>Salinity</td>
<td>%</td>
<td>0.38</td>
</tr>
</tbody>
</table>

As seen from the results, the parameters from the project site shows moderately bad water quality compared to most sites previously tested. However, quality is good with respect to sites in Male’ and some other sites previously tests in Hulhumale’. Electrical Conductivity is a very important parameter with regards to groundwater over extraction and increase in groundwater salinity. The EC value is at a moderate level. The water was collected from about 1.6m below ground level. A detailed soil test has also been carried out for the project, the result of which is attached in the Annex.
2.1 Socio-economic Environment

1.2.1 Population

The population of Hulhumale’ based on most recent official results is 15,769 divided to 8,175 males and 7,594 females. Total no. of foreigners residing in Hulhumale’ is about 1200. However, HDC data shows current residential population in Hulhumale as 65,520 people.

Hulhumale’ population is growing rapidly and is the fastest growing in the country. In 2006 census the total population of Hulhumale was only 2866 people. Therefore the exponential growth is set to continue. The population is projected to rise up to about 100,000 in 2020. There are many housing projects proposed in the island, and migration from Male’ and even from other island is anticipated to increase at a greater rate. Moreover, Male’-Hulhumale’ bridge project is currently ongoing and will complete in 2018. This gives incentives to residents in Male’ to move away from the congestion in the capital island.

1.2.2 Transport

Access to Hulhumale’ is by ferry operated by the Maldives Transport and Contracting Company Plc Ltd (MTCC). Ferry is available throughout the day except between 3am to 5am. The average carrying capacity of the ferries are about 100 people per boat. Regular bus is available to travel from the Ferry terminal to the several location in the residential areas.

There is also a regular bus traveling between Hulhumale’ and Hulhule’ every 30 minutes. There are more options to travel between Hulhumale’ and Hulhule’ currently; by private vehicles of guest houses operating in Hulhule’. The vehicles, usually vans provide taxi services to locals.

Traveling within Hulhumale’ is by taxi services and also private motorcycles. Currently bicycles are also getting increasingly popular. The island is designed in a pedestrian friendly manner with big pavements available through the island, especially in the main roads.

1.2.3 Education

Hulhumale’ currently have 3 secondary and higher secondary schools, namely; Ghaazee School, Rehendhi School and Gateway International School.
Pre-schooling options in Hulhumale’ currently consists of Little Gems Preschool and Gateway International School. A new preschool is currently being built and is anticipated to be operational sometime during 2017. While most of the local residents obtain schooling from the local schools, some do travel to Male’ daily. There are fewer occasions where students from Male’ come to Hulhumale’ schools.

### 1.2.4 Health

There is a main public hospital in Hulhumale’ on the main road. It is the central health care provider in the island. The hospital was previously run by the Ministry of Health and recently management has been shifted to Medical Insurance Provider ‘Aasandha’. Due the relatively less congestion at the site relative the Male’, the hospital does get patients from Male’ in addition to Hulhumale’ residents. Currently, there are some major renovation works being undertaken at the hospital.

A multi speciality international hospital has been proposed for Hulhumale’ and is nearing completion. The hospital is expected to be operational sometime in 2017. When fully developed, the hospital will have a capacity of 600 beds and will have private access to emergency facilities.

Additionally, there are few clinics currently being opened in Hulhumale’, including dental clinics and general clinics.

### 1.2.5 Utilities

Utility services are provided by the biggest utilities in the Maldives; STELCO and MWSC. Both companies inform they have the capacity to deal with the current developments in Hulhumale’ and are poised for expansion as new developments come in. Current power generating capacity at STELCO, Hulhumale’ is 12MW, while there are plans to upgrade to an additional 3MW in the coming months.

Regarding waste management, HDC has recently signed the contract with WAMCO to undertake all waste management in Hulhumale’, including waste pick up and transport from households, management of the waste site, transporting waste to Thilafushi. Currently WAMCO is in the process of establishing their waste management system, and is not fully operation at the time of this study.
1.2.6 Tourism

Hulhumale’ has been a hub for budget tourism and guest house development. Currently it is estimated there are about 100 guest houses in the island, with the total capacity to cater for about 2000 guests at any one time. International visitors numbers provided by HDC states that in 2016 alone over 126,385 guests visited the island and is projected to rise exponentially to over 650,000 guests in 2020.

Hulhumale’ is also a popular destination for local tourism with many locals travelling to the island on weekends and on holidays, mainly from Male’. In 2016, about 820,144 locals visits are accounted for and the number is projected to rise to over 1,200,000 in 2020. However, this could be a gross over estimate.

2.2 Hazard Vulnerability

Maldives in general does not experience natural disasters and hazards on a frequent basis. However, the Indian Ocean Tsunami in 2004 was a historic reminder on potential hazardous threats the country faces. The islands across Maldives face similar type of threats and hazards to varying degrees and magnitude depending on several factors.

The vulnerability of islands to natural hazards depends on geological and more importantly geographic aspects of the island. As such, the location of the island, with respect to the country and atoll is quite important. Likewise, the level of protection the island is offered from neighbouring islands, and the house reef, shape and orientation of the island are also important factors.

Based on the UNDP Disaster Risk Assessment Report of Maldives in 2006, Hulhumale’ is located in an area that has been designated as a low-risk hazard zone. However, as stated in the report, sea level rise due to climate change is a uniform hazard throughout the country, and will have high impact on Hulhumale’ as well. Figure profiling the Maldives based on the hazard zones are given in Figure 20.

The proposed development being located virtually in the center of the island, any impact at the project site will be minimum compared to those at eastern and western sides more exposed to the coastline. However, in an event of a disaster such as a tsunami, where the impact will be felt throughout the island, the project site will also be vulnerable. It should be considered that the impact from the 2004 Indian Ocean Tsunami, was felt more on the eastern side rather the west.
Figure 15 Disaster risk profile of the Maldives (UNDP, 2006)
3 Legislative and Regulatory Considerations

The legislative and regulatory consideration the project adheres to is mostly at a national level, since it takes place on a local scale within the Maldivian environment. The extent to which the project conforms to existing plans, policies, guidelines, regulations and laws of the Maldives are considered in this Section. Some of the more important regulations are stated within the context of this project scope. The regulatory context in which the project activities take place and the legal and policy aspects relevant to those activities will be discussed in the Section.

3.1 Environmental Protection and Preservation Act (Law No. 4/93)

The major legal instrument relating to environmental protection is the Environmental Protection and Preservation Act (Law No. 4/93) of the Maldives passed by the Citizen’s Majlis in April 1993. This Act provides the Ministry of Environment with wide statutory powers of environmental regulation and enforcement. This umbrella law covers issues such as environmental impact assessment, protected areas management and pollution prevention. The following clauses of the Environmental Protection and Preservation Act (Law No. 4/93) are relevant to the project:

Clause 5a: An impact assessment study shall be submitted to the Ministry of Environment, and Energy before implementing any development project that may have a potentially detrimental impact on the environment.

Clause 5b: The Ministry of Environment, and Energy shall formulate the guidelines for EIA and shall determine the projects that need such assessment as mentioned in paragraph (a) of this clause.

Clause 6: The Ministry of Environment, and Energy has the authority to terminate any project that has an undesirable impact on the environment. A project so terminated shall not receive any compensation.

Clause 9a: The penalty for minor offences in breach of this law or any regulations made under this law, shall be a fine ranging between Rf5.00 (five Rufiyaa) and Rf500.00 (five hundred Rufiyaa), depending on the actual gravity of the offence. The fine shall be levied by the Ministry of Environment, and Energy or by any other government authority designated by that Ministry.
Clause 9b: Except for those offences that are stated in (a) of this clause, all major offences under this law shall carry a fine of not more than Rf100,000,000.00 (one hundred million Rufiyaa), depending on the seriousness of the offence. The fine shall be levied by the Ministry of Environment, Energy and Water.

Clause 10: The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment. This includes all activities mentioned in Clause No. 7 of this law as well as those activities that take place outside the projects that are identified here as environmentally damaging.

3.2 Regulation on Aggregate and Sand Mining

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

Coral mining from the house reef and the atoll rim has been banned through a directive from the President’s Office dated 26th September 1990. Under Article 7 (c) of the Regulation on Sand and Coral Mining issued by the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) on the 13th of March 2000, it is an offence to mine sand or coral from the beach, lagoon or reef of any inhabited island and islands leased for the purpose of building a tourist resort.

This regulation would not have any implication on the project, as manufactured sand will be used for the construction works.

3.3 EIA Regulations

The EIA Regulations, which initially came into force in May 2007 has been amended and republished in May 2012 based on the Environmental Protection and Preservation Act. The EIA Regulations have been the basis for Environmental Impact Assessment in the Maldives and since its inception; it had helped to improve the quality of EIAs undertaken in the country. Today, registered consultants are required to sign EIAs and the reports are subsequently reviewed by two independent reviewers and a final decision is made by EPA based on the
reviews. Likewise, this EIA report would also be subject to these requirements and review criteria.

‘Jadhuvalu Raa’ of the new EIA Regulations lists the different environmental projects that require an Environmental Impact Assessment study. High rise building construction works is among this list and thus a full Environmental Impact Assessment was needed to be carried out for this project. It is specifically stated that buildings with foundation deeper than 5ft / 1.5m will require Environment Impact Assessments to be carried out. This project proposes a foundation 2.77m deep.

The EIA Regulations sets out the requirements for the contents of Environmental Impact Assessment reports in ‘Jadhuvalu Baa’ and format for monitoring reports have been given in ‘Jadhuvalu Laamu’. Therefore, these requirements have been taken into consideration in preparing this EIA report.

On 9th April 2013, a further amendment to the EIA Regulation 2012 has been published, which deals with repeated offenders of the regulation. Under Clause 20 of the regulation, the amendment proposes a new Schedule. ‘Jadhuvalu Taviyani, which lists penalties for repeated offenders. Under ‘Jadhuvalu Taviyani’, repeated offenders of the regulation will be fined based on the following criteria

- For Initial offence: 20,000 MVR
- If an offence is repeated for the 2nd time: 60,000 MVR
- If an offence is repeated for the 3rd time: 120,000 MVR
- If an offence is repeated for more than 3 times: 200,000 MVR for each offence.

On 11th August 2016, a third amendment was published, which mainly deals with revised criteria for EIA evaluators, environmental consultants and their performance evaluations.

On 19th January 2017, a fourth amendment was published, which mainly amends the type of projects for which EIA exemption can be given. As such, one of the main changes was that developments in newly reclaimed lands can be carried out without undertaking an EIA for the first 5 years after reclamation completion, unless the area has been populated. There were projects exempted from this exceptions including projects involving fibre works, dealing with oil or hazardous chemicals/pollutants/material, and incinerators. The contents of this amendment does not apply to this project.
3.4 Maldives National Building Act 2010 draft

The Maldives National Building Act is currently at the draft stage. The building Act discusses compliances issues and procedures, providing disability access, details of procedures for building consent, supervision of buildings, roles and duties of all parties concerned with developments including the regulatory authority, building owners, developers and contractors, occupation of the buildings, licensing of building practitioners, and refers to the building code for more detailed guidance on construction procedures and best practice.

3.5 Maldives National Building Code 2008 draft

Maldives National Building Code is also still at a draft stage, and is awaiting the Building Act to come in place. The Code intends to regulates on the duties of the contractors, It recommends best practices, in addition to regulations to be adhered to during construction work. It covers aspects such as structural stability, fire safety, access, moisture control, durability, services and facilities, and energy efficiency. Once the building act is published, the Coder will be enforced and all contractors will need to adhere to the regulations provided. Currently the contents are followed as a guideline. The proposed development will conform to the guidelines provided in the Building Code draft.

3.6 Environmental Guidelines for Concrete Batching plants 2014

The guideline has been prepared by EPA as a guide for developers/contractors regarding installation and operation of batching plants. It is proposed to ensure that the operations are environmentally friendly and has minimum impact on neighbouring communities. Some of the key points outlined in the guideline are as follows:

Generation of wastewater from the plant must be minimised and measures to re-use wastewater should be in place such that it mitigates potential groundwater impacts.

Materials used for the plan such as cement, sand and aggregates should be stored in such a way that they are covered and not exposed to rain or excessive sunshine.

Material dispersal to the natural environment should be minimised during transportation

Noise reduction measures should be in place during plant operations
The plant should be located at the site in such a way as to reduce spread of dust and/or debris by incorporating existing trees, or constructing fences and landforms to maintain a minimum of 100m buffer distance from sensitive land uses.

### 3.7 Waste Management Regulation, 2013

Waste Management Regulation (No. 2013/R-58) came into effect on 6 February 2014. The Regulation was gazetted on 05 August 2013. The regulation provides a set of comprehensive guidelines and on collecting, storing, transporting and managing waste as well as management of hazardous waste. The waste management regulation prohibits dumping of waste on to parks and roads; protected areas under the Environmental Protection and Preservation Act. Moreover, waste management regulation states that those involved in waste management must be permitted by the Environmental Protection Agency.

Clause 11 of the regulation deals with terrestrial wastes and states that waste should be deposited and managed only at sites allocated by the relevant authority.

Clause 26 of the regulation deals with the transportation of wastes.

Clause 34 of the regulation states the procedure for penalties for those that do not abide by the regulation.

Jadhuvalu (annex) Haa 1.1 states the regulation applicable to household wastes.

- Waste should be stored within the household in a container with a lid, such that there is no opening for any leakage. This is the responsibility of the household dwellers.
- There should not be any leakage of waste from waste storage to waste transport vehicle
- Any waste that can potentially leak out liquid should be properly sealed
- Waste should be sealed such that no insect or animal will be able to access the contents of the stored wastes

Jadhuvalu (annex) Haa 1.4 of the regulation states the conditions applicable to building and construction waste. From the clause, the notable points are as given below:

- Construction projects should be planned and managed in such a way to ensure minimum amount of waste is produced.
- Steps should be in place to ensure minimum waste generation during building and construction
- Building and construction waste generated from demolition should be reused as much as possible
- Building and construction waste should be within the site boundary of the project and should not cause any disturbance to the public
- All building and demolition works shall be arranged in such a way to ensure that during the course of the project, there shouldn’t be any disturbances to the neighbouring entities and public due to the generation of wastes

It should be noted that demolition is not part of this project, as there is no structure in the area currently. Moreover, the way the site is setup, it is virtually guaranteed that waste will be contained within the site and will not pose any nuisance to the public or any potential neighbour.

Jadhuvalu (annex) Haa 2.1 states the conditions applicable to land transport of waste.

- Waste should be properly concealed during transportation such that any waste or smell of waste will not be exposed to the surrounding environment
- Waste transporting vehicle should be properly washed and cleaned regularly
- If waste is to be transported on a wheel burrow, it has to still be ensured that the burrow is able to handle the entire content of the waste and that there is no chance for waste to spill out
- If waste is transported by individuals personally, still the condition as stated in this clause is applicable.

During the operational stage of the project, waste management of the building will be handled by the building monitoring board members, whom are unanimously elected among the tenants. Waste management will likely be outsourced to a third party by the board, which is the intended process by the developer.

**3.8 Dewatering Regulation, 2013**

A Dewatering Regulation (No. 2013/1697) came into effect in December 2013. The main purpose of the regulation is to protect groundwater resources found in the islands from impacts of dewatering, pollution and protect the environment from release of groundwater by
dewatering. As per the regulation, a dewatering permit shall be obtained from EPA prior to any dewatering operations required for all development projects.

Further, the regulation states that 30m radius boundary shall be considered as impact area from all dewatering operations and any entities within the boundary shall be informed 24hrs before the dewatering operation. EPA approved dewatering signage must be placed during the process of dewatering. There are no structures or any development within a 30m radius from the project site.

Dewatering can only be to be carried out, after gaining approval by submitting “the dewatering approval form” in the annex 1 of the Regulation to the enforcing body for approval with all the required documents expressed and with an administrative fee of 500 MVR. Water quality tests results also have to be submitted as one of the required component.

The regulation also guides on where and how the extracted water shall be disposed of, and how it has to be handled. According to the regulation, permission can be granted for dewatering at a stretch for a maximum of 28 days, for which a sum of 500 MVR should be paid per day. This amount is liable to be increased with the number of days increased.

### 3.9 Management, Use and Control of HCFC Substances Regulation, 2010

The HCFC Regulation is developed under the Environmental Protection and Preservation Act (4/93) towards regulating phasing out of import, use, selling of HCFC substances by 2011 and completely eliminating use of HCFC substances in the Maldives by 2020 through controlling importers, registering importers, establishment of a quota system, control mechanisms for selling, maintenance of import, selling, purchase and service providers statistics. This regulation is more relevant to the operational stage of the project.

### 3.10 Maldivian Land Act, 2002

The Act governs the allocation of Maldivian land for different purposes and uses and other issues regarding the issuing of land, issuing of state dwellings for residential purposes, conduct regarding state dwellings or private dwellings constructed for residential purposes and the sale, transfer and lease of Maldivian Land.
In accordance with section 3 of this Act, land shall be allocated for the following purposes and uses: for the construction of households and buildings for residential purposes, for commercial use, for social use, for environmental protection and for government use.

Clause 38 of the Act states the conditions for Articles found during excavation of land. Sub-clause A states Except for coconut palms owned by the person, all other natural resources and gold, silver, jewellery, money, utensils, historical artefacts and metals that do not have a legal owner shall be a property of the government. Sub-clause B states Any jewellery, vessel or money or artefacts or metal as mentioned in subsection (a) of this section, if found in the soil of Maldives then the party who found the articles. As the project is being undertaken in Hulhumale’, an artificially reclaimed land, it is highly unlikely the clause will come into effect.

### 3.11 Land Use Plan and Implementation Regulation

Under the Maldivian Land Act of 2002, all lands in the islands under the lands development policy, a Land Use Plan shall be developed and approved from Ministry of Housing and Infrastructure prior to use of the lands. The regulation outlines key aspects that need to considered while preparing land use plans as well as describes guidelines on developing and allocating lands for various purposes. In this regard, various categories of lands are identified under which a government agency shall implement the land use plan.

The project falls under Category D, which are described as islands reclaimed as special projects. The land use plan will be made for such islands by the developer as stated in the regulation, which in this case is HDC.

### 3.12 Condominium Law 2006

Condominium Law or ‘Emmedhu Imaaraathaa behey Qavaaidhu’ came into effect on 21st May 2006. The law states that a Condominium is defined by buildings in which in different tenants own floor areas/apartments in the same building, as would be the case in this project.

Clause 18 of the law states that Public Spaces and Services in Condominiums will have to be maintained by the tenants.

Clause 19 of the law states that It has to be stated in the contract on how Public Spaces and Services in Condominiums will be monitored and maintained.
Clause 20 of the law states that apartments in condominiums can only be owned by local citizens of the Maldives.

The tenants would need to be contractually obliged to maintain the building.

The law is very brief and is in need up revision considering the many upcoming condominiums projects.

### 3.13 Mosquito Control Regulation 2007


Clause 3 of the regulation provides responsibilities of landlords and developers on prevention of mosquito growth in households and buildings. These include prevention of open water logged areas, cleaning gutters, and pipes

Clause 4 is on prevention of mosquito growth during building construction and repair/maintenance works.

These are the clauses most relevant to this project. The penalties for not adhering to the Clauses of the regulation as stated by the regulation very small, and is almost negligible. Heavier penalties may be imposed by HPA if mosquito breeding becomes a persistent issue in the building area, and if not controlled after several inspections and warnings. As such Clause 9.3 states HPA can take legal action against developers under such a scenario.

### 3.14 Permits required for the Project

#### 3.14.1 Design Approval

The floor plans and design has to be currently approved by Housing Development Corporation (HDC). The approval is attached in the Annex 3. There need not be any approvals required from the Ministry of Housing Infrastructure to implement the project.

#### 3.14.2 Dewatering Permit

A dewatering permit shall be obtained from EPA prior to undertaking any dewatering works. Before dewatering approval is given, an EIA would need to be done if the project falls under ‘Jadhuvalu R’ of the EIA regulations.
3.14.3 EIA Decision Statement

A decision regarding this EIA from the Environmental Protection Agency (EPA) need to be obtained before construction commences. The EIA Decision Statement, as it is referred to, shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Statement may only be given to the Proponent after a review of this document following which the EPA may request for further information or provide a decision if further information is not required.

3.14.4 Building Use Permit

A building use permit is required to be obtained from HDC upon completion of the proposed building. HDC projects and/or engineering team will undertake a final inspection of the development to determine if there are any defects and if the building conforms to the development guidelines as provided by HDC.
4 Identification of Impacts & Significance

This section is based on the potential environmental impacts due to the project components including:

- Demolition
- Excavation and Dewatering
- Material sourcing, transport and storage
- Construction of the foundation
- Super structure construction and masonry works
- Waste management
- Establishment of utilities
- Building operation
- Building maintenance

The section describes the mitigation measures for each identified impact. Since the components are all building related some impacts are general to all the components of the project, and some are specific. Likewise, the same applies for the mitigation measures. Methods of identification of potential impacts and assessing the significance of the impacts are described in the following sections.

4.1 Identification of Impacts and their Significance

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

- Public consultation with important stakeholders. Including during the scoping of the project and formulation of the Terms of Reference for the EIA.
- Using decision frameworks for assigning significance to impacts
- Existing environmental studies carried out similar developments in other similar environments
- Research data that has been accumulated specific to the Maldivian context.
- Baseline environmental conditions collected.
- Experience of the consultants with similar projects.
Possible negative impacts on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in the implementation phase.

The impacts highlighted in the TOR for this EIA has been used as a guideline in identifying important impacts. However, this was not used as a strict instruction for the identification. Once new impacts not highlighted in the TOR were foreseen, they were given equal importance.

Following are the major types of negative impacts that commonly occur due to the implementation of building construction projects in Greater Male’ City.

- Loss of visual amenity during demolition and construction
- Loss of vegetation and impact on terrestrial habitats
- Groundwater degradation
- Mosquito growth
- Noise Pollution
- Air Pollution
- Traffic disruption leading to congestion
- Generation of building and construction waste
- Impact on adjacent structures
- Health and safety of workers and neighbours
- Generation of household waste during operational phase
- Building maintenance issue

The project impact area is the project site as shown in the following figure, with no significant impact anticipated beyond the area.

### 4.2 Description of Impacts

#### 4.2.1 Loss of visual amenity during demolition and construction

There is no existing building at the site and therefore there is no impact from demolition. However, during construction, the area will be an eye sore for public using the central park area. The area is especially close to the open gym area in the park. The impact would be short in nature and would not be direct as there are few obstructions between the developed area in the park and the site. Considering the importance and reversibility, the significance is minor to moderate.

#### 4.2.2 Loss of vegetation and impact on terrestrial habitats
The site has already been cleared by HDC. It is highly likely that there were no significant vegetation in the area. The area was generally known to consists of bushy vegetation. There will thus be no significant impact on vegetation. Care must be taken to avoid harming the roadside vegetation during construction activities.

4.2.3 Groundwater degradation

The major cause for concern with regards to groundwater is the water extraction process, dewatering, to lay the foundation. Dewatering would remove a moderate volume of water from the project site. This water will be disposed nearby the project site on land to be used for groundwater recharge. The impacts of the operation are short term.

The short-term impacts due to dewatering is mainly the impact on the groundwater lens due to saline intrusion resulting from coning and the impact of such sudden increase in salinity on the freshwater lens near the site. As stated previously, there are no mature trees that will undergo an impact from this. Desalinated water from MWSC water network is widely used by the residents in Hulhumale’. The sudden increase in salinity in the area will not have any impact.

It is not expected that the impact will be significant on the surrounding infrastructure in accordance with the permit given by Environmental Protection Agency. In any case, dewatering is an unavoidable component of the project.

4.2.4 Mosquito growth

Mosquito growth has become a significant issue at all major construction sites, due to potential spreading of dengue among other reasons. Mosquito growth at construction sites mostly occur due to negligence. After foundation is laid, and construction takes place at ground floor and beyond, the elevator pit is usually left without any such construction. Mosquito growth occurs at dewatering sites as well. Water sometimes tend to get accumulated in the area; and if left without intervention, provides a favourable environment for mosquito growth.

4.2.5 Noise Pollution

As stated previously under Description of the Environment, ambient noise pollution in the area is low - moderate due to relatively low traffic. Construction activities will increase the amount of noise, especially during the concrete mixing operations. Also, there will be consistent noise emitted from Stationary equipment such as air compressors, cranes, and generators. They generally run continuously at relatively constant power and speed, although
sound levels may vary according to the work cycle (e.g., loading). These types of noises are temporary and are relatively intermittent. The users of the open gym area may have to endure some noise impacts. But this will be intermittent and virtually negligible.

### 4.2.6 Air Pollution

Air pollution is an issue during construction when debris maybe seen accumulating in the project area. Impact of debris on human health is significant. Pollutants will include dust from demolition, excavation, movement of transportation vehicles, loading and unloading of materials, earthwork and during concrete mixing work. Dusts may also be transported to surrounding areas by wind, affecting residents and workers of surrounding areas.

In addition to dusts and debris, harmful gases released by heavy machineries and vehicles and other construction work include carbon monoxide, carbon dioxide, hydrocarbons, and nitrogen oxides. Other harmful gases can be released from vapors of oils, glues, thinners, paints and wood treatment during construction and interior finishing. These are all atmospheric pollutants and can also cause respiratory problems and other detrimental health issues upon repeated inhalation.

### 4.2.7 Traffic Congestion

From the nos. obtained during the observation of traffic, and how the project has been planned this project will have low impact in the area. Some traffic may need to be diverted at work intensive times, which will last from 1 – 2 days. If the area needs to be closed under any circumstances, the other side of the arc towards central park can always be used, and therefore there will not be any major disruption of traffic.

### 4.2.8 Lead based paints

Using lead based paints could have very serious cumulative long term impacts on the residents of the apartment building during operation stage. Children and Pregnant woman are especially vulnerable to the effects of lead. Prolonged exposure to lead based solvents also lead to high blood pressure, hypertension, issues with the kidney and reproductive system in healthy adults. Furthermore, the impact on children include mental and growth issues.

### 4.2.9 Generation of building and construction waste

There will be a significant volume of building and construction waste generated from the construction area. This would result in a negative input to the environment and can be a nuisance to the surrounding areas. Construction waste such as wood, concrete, metals, bricks,
plastic and domestic waste will be generated in addition to excavated waste and municipal waste. The impact of the waste will be localised as waste should not be placed outside the site under any circumstances.

### 4.2.10 Impact on adjacent structures

There are no structures nearby at the time of construction. Therefore there will be no impact. However, other structures are proposed to be developed close to the project site. The foundation protection method ensures there will not be any significant impact.

### 4.2.11 Health and Safety of workers and neighbours

Health and safety of workers and neighbours have been discussed to some extent under noise pollution and air pollution. As stated in the preceding sections, the construction site will indeed be a health hazard and care must be taken always while at or near the site. Moreover, in addition to impacts arising from noise and air pollution, there is also the significant possibility of direct impact from accidents from the work area. This could occur due to falling objects, misplaced equipment and materials, temporary structures not properly fixed, etc.

### 4.2.12 Alleviating congestion issues in Male’

Male’ is already among the most densely populated island cities in the world. Based on the 2006 census, the population density of Male’ is 18,000/km². Currently over one third of the total population lives in Male’. It is a widely held belief that projects of these types in Male’ contribute to alleviating the ever increasing population in Male’. More housing has traditionally resulted in more migration to the Male’, and the process has continued to grow exponentially.

Decentralisation is a key policy for all the major government stakeholders and policy makers and this has resulted in reducing the increase in the population density. One of the key actions for this has been the development of Hulhumale’, which has resulted in people moving to the island away from Male’.

Hulhumale’ offers more public spaces, better ventilation, and an overall better environment compared to Male’, and therefore it is a positive impact to offer more housing in the area, albeit with some controls in place to preserve the current environment. From a planning perspective, there are important factors to consider as constructing large buildings will lead to congestion issues.

### 4.3 Impact Significance Assessment
This section provides a summation of the impacts of the project components discussed above. The impacts of the project have been evaluated as per the criteria proposed by Posford Haskoning (2004). The decision framework is given in the following figure.

In order to make the evaluation quantitative, the framework proposed by Haskoning has been modified. Spatial distribution of impact is also added in order to make the significance of the impacts more realistic. Scores are given for each impact once it is identified that the resource is vulnerable to the impact. Scores are based on the following factors.

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

The scales associated with the above criteria are given in the Table 6.
EIA for the proposed mixed residential building development project at Hulhumale’, Plot No. D1-1

**Step 1**
Description of the resource (receptor)

**Step 2**
Predicted environmental change (impact)

**Step 3**
Is the Resource vulnerable to the impact

- **NO**
  - Not Sensitive
  - Low
  - Medium
  - High

- **YES**
  - Positive Effect

**Vulnerability of Receptor**

**Step 4**
Sensitivity of Receptor

**Step 5**
Recoverability of Receptor

**Step 6**
Importance of Receptor

**SIGNIFICANCE**

- Not Impact
- Minor Impact
- Moderate Impact
- Major Impact
- Beneficial Impact
Table 7 Impact Evaluation Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Scale</th>
<th>Attribute</th>
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<tbody>
<tr>
<td>Sensitivity</td>
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<td>Positive Effect</td>
</tr>
<tr>
<td><em>How sensitive the receptor is to the impact</em></td>
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<td>Not sensitive</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>High</td>
</tr>
<tr>
<td>Recoverability</td>
<td>1</td>
<td>Short</td>
</tr>
<tr>
<td><em>How long it would take for the receptor to recover from the impact</em></td>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Non-recoverable</td>
</tr>
<tr>
<td>Importance</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td><em>The importance of the receptor to the environment</em></td>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>High</td>
</tr>
<tr>
<td>Spatial Distribution</td>
<td>1</td>
<td>local scale</td>
</tr>
<tr>
<td><em>Distribution of impact</em></td>
<td>2</td>
<td>regional scale</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>global scale</td>
</tr>
</tbody>
</table>

If the impact receives a -1, it deems the impact to have a positive effect on the receptor and the other criteria is then not applied. The impact is referred to as a Beneficial impact as is done by the Haskoning framework.

The significance of the negative impacts will be given based on the following range:

- 1 – 5 : Minor Impact
- 6 – 9 : Moderate Impact
- 10 – 12: Major Impact
### Table 8: Analysis of potential impacts and their significance

<table>
<thead>
<tr>
<th>Potential Impact</th>
<th>Nature of Impact</th>
<th>Significance Evaluation Criteria</th>
<th>Spatial Distribution</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of visual amenity during demolition and construction</td>
<td>Direct</td>
<td>Immediate</td>
<td></td>
<td>4 (Minor)</td>
</tr>
<tr>
<td>Air pollution during demolition and construction</td>
<td>Indirect</td>
<td>Cumulative</td>
<td></td>
<td>5 (Minor)</td>
</tr>
<tr>
<td>Groundwater degradation during dewatering</td>
<td>Direct</td>
<td>Immediate</td>
<td></td>
<td>5 (Minor)</td>
</tr>
<tr>
<td>Mosquito growth during dewatering stage, and at locations where structural construction is scheduled at a later stage</td>
<td>Direct</td>
<td>Cumulative</td>
<td></td>
<td>6 (Moderate)</td>
</tr>
<tr>
<td>Environment Impact</td>
<td>Type</td>
<td>Timing</td>
<td>Direct</td>
<td>Cumulative</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>Noise pollution during construction.</td>
<td>Direct</td>
<td>Immediate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Disruption of regular traffic and traffic congestion</td>
<td>Direct</td>
<td>Immediate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Generation of waste oil and building and construction wastes</td>
<td>Direct</td>
<td>Cumulative</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Impact on residents due to use of lead based paints</td>
<td>Direct</td>
<td>Cumulative</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Structural impact on adjacent structures</td>
<td></td>
<td></td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Health and safety of workers</td>
<td>Direct</td>
<td>Cumulative</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Health and safety of neighbours</td>
<td>Indirect</td>
<td>Cumulative</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Indirect contribution to alleviating congestion in Male’</td>
<td>Indirect</td>
<td>Cumulative</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Waste Generation during the operational stage of the project</td>
<td>Direct</td>
<td>Cumulative</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
### Indirect Economic impact on the community, by creating additional jobs for construction and building maintenance

<table>
<thead>
<tr>
<th>Indirect</th>
<th>Cumulative</th>
<th>-1</th>
<th></th>
<th></th>
<th>Beneficial</th>
</tr>
</thead>
</table>

The potential impacts, their significance and mitigation measures to be undertaken are given in Section 6 for the construction and operation phase together since the components of the project are all continuous processes.

In conclusion, the project will generally have minor impact on the environment. While some moderate impacts are important, probability of these impacts occurring is rather low. Waste management best practices in both construction and operation is highly important to keep impacts at a minimum.

4.4 Uncertainties in Impact Prediction

The impact prediction has been carried out based on literature and tested methods. However, the prediction relies heavily on the judgement of the consultant, and would therefore lead to uncertainties. Alternatively, such projects as has been described in this report has been carried out on numerous occasions in Male’ and Hulhumale’. Therefore, observing past literature on a local context, the uncertainty would be severely reduced. However, the issue is that no long term monitoring exists for such developments, and therefore there are major unknowns as to the direct impact due to the project.

Based on this, the level of uncertainty in the case of the proposed project may be expected to be moderate as similar projects in similar settings is ongoing. The uncertainty can be further reduced once some of these projects are completed and a final assessment of the impacts that has occurred is made in a comprehensive monitoring stage.

Uncertainties will be significantly reduced by undertaking the monitoring program and re-analysing impacts, after comparing the monitoring data with the baseline data in this report and previous recent environmental studies done for Hulhumale’.

5 Environmental Management and Mitigation Measures

Mitigation measures are proposed where significant impacts are expected. Once an impact is identified to have ‘moderate’ or ‘major’ impact, appropriate mitigation measures are given for the project, if possible.

Successful implementation of the measures given would lead to a major reduction and/or nullification of the impacts on the environment and thereby ensuring that the project is environmentally sustainable.
5.1 Loss of visual amenity during demolition and construction

Some impacts from demolition and construction generally arises due to poor project planning. To avoid loss of visual amenity and other such minor impacts, it is recommended that the project site be hidden to the public by means of a temporary boundary wall straight as soon as possible. Warning signs should be placed which states that only staff is allowed within the boundary wall. The wall height should not be less than 10ft, and it could be made of wood or roofing materials. More consumer friendly designs on the fencing/boundary wall could be used to reduce aesthetic impact, however is not necessarily recommended. It must be ensured that absolutely no waste or temporary storage of materials occur outside the project boundary.

5.2 Mosquito growth

As a mitigation measure, some project managers put an oil layer on top to make the area inaccessible for mosquito growth. However, this also leads to groundwater contamination. For small pockets of unavoidable open water areas, it is recommended to put a lid or wax layer on top of the area. This practice is already carried out by some contractors and results have been positive. Alternatively, regular monitoring of any water logged area at the site can be carried out and removed or lidded with immediate effect. Daily inspection of the project site is required and any open stagnated water area should be removed or covered.

5.3 Noise Pollution

Noise protection gears such as ear muffs are to be used by workers on site. Components that require heavy vehicles such as casting of the slabs and columns are scheduled to be undertaken on weekends, during morning or at noon as to minimize the impact of noise to the park, shops, mosque. Works emitting noise at high decibels should not to be undertaken during night hours. Furthermore, the boundary wall should be able to contain some amount of noise within the project site.

5.4 Air Pollution

For mitigation, dust screens and regular water spraying and dampening should also be practiced to reduce the spread of dust to surrounding areas. All heavy machineries should be inspected and fine-tuned to make sure the harmful gases released to the atmosphere do not exceed allowed standards. Building materials should be covered or contained during loading, unloading and storage. The boundary wall or fence should
also be able to restrict the movement of dusts and debris within the project site. It should especially ensure no such debris passes northwards towards Central Park. Construction workers should wear dust masks during dust sensitive work always.

**5.5 Lead based paints**

Use of lead free paints is recommended. If under any circumstances, lead based paint is used, the tenants should be well informed and the painted surfaced in the housing units should be inspected and maintained regularly. The better option is to not use any lead based paints altogether.

**5.6 Generation of building and construction waste**

It is recommended to re-use as much construction waste as possible, although this may be difficult to manage. The reusable waste includes wood and blocks. Metals can be recycled, and a recycling group can be contacted to remove such materials. WAMCO will assist on this. Reusing formwork material as much as possible is another measure that can be taken to reduce waste. All such recyclable or reusable wastes should be segregated on site. Waste that cannot be reused or recycled (which will be in the majority) are to be taken away from site for disposal. The contractor has to collect and store the waste at site. These include any waste oil and other hazardous type waste, which all should be collected separately. They are to be transported to Thilafushi on a regular basis; likely weekly.

**5.7 Impact on upcoming structures**

For potential mitigation, soft/silent piling can be used, which would be approximately 6m of piles at regular intervals around the land plot for retaining the earth to a depth of 10 metres below the ground level. The piles would be driven into the ground to hold the boundary wall that would be constructed for the shoring of the foundation. As added horizontal protection, the compacted soil should be placed along the periphery of the construction area, preferably in gunny bags, to minimize stress and risk of overturning. The construction methodology adopted for the proposed project has been decided in order to minimise the impact on any upcoming buildings nearby. Unlike the deep pile foundation, the raft foundation is shallow and does not require deep piling.

Furthermore, it is recommended that dewatering will be timed when rainfall is less or there is no rainfall (NE monsoon). This is to avoid rainwater percolating into the soil beneath the foundations. If rain does occur, measures should be taken to reduce the
amount of water to the site, as the water particles may loosen the soil reducing its shear strength.

**5.8 Health and Safety of workers and neighbours**

Awareness of the works on site is the first and foremost mitigation measure that can be taken to reduce any risk of accidents and other minor health impacts. For awareness, the commonly used method is to put up warning signs around the project area. These include:

‘Caution: Construction works in progress!”.

“Warning: No entry beyond this point!”.

“Wear Safety Hats at all times!”, etc.

Aside from awareness, second method is to encourage wearing safety cloths and equipment at the construction site always. This applies more to construction workers. As such, they should be instructed to wear safety helmets always, dust masks during sensitive work, conspicuous fluorescent cloths, earmuffs, safety shoes, etc.

**5.9 Waste Management**

Waste management is the main issue during the operational stage of the project. A large number of wastes will be generated from over 100 apartments in a concentrated area. Currently the proponent has stated that this is a service that would likely cost the tenants in addition to the rental of apartments. The maintenance of the building will fall under the responsibility of the Ministry of Housing and Infrastructure and will be handled by a contractor assigned by the Ministry and/or HDC. Daily collection and disposal services is expected to be offered by the developer. The group that would be undertaking the maintenance works including waste management will be made by the steering committee selected among the tenants. A separate waste management plan should be made for the operations and submitted to EPA.

In addition to the general waste management method, recyclables from non-recyclables should be segregated at the source. Tenants should be informed on the type of waste that are regarded as recyclables and non recyclables. They should be informed on how the waste are to be collected in their units. The waste should be collected on a daily basis and transported to the waste management area in the ground floor, and placed in appropriately labelled bins for recyclables and non-recyclables. Images such as given
in the Figure below could be used. This will reduce the total no. of waste produced and the system will be easier to manage ensuring sustainability.

![Acceptable recycling items](image)

![Unacceptable recycling items](image)

**Figure 16** Indicative image for recyclables and non recyclables (source: [http://www.huonvalley.tas.gov.au/services/waste-2/](http://www.huonvalley.tas.gov.au/services/waste-2/))

Furthermore, it is recommended for the developer to put in place a system for hazardous wastes such as batteries and large waste collection. It is important to inform tenants to not dispose hazardous wastes including batteries along with normal household wastes. It is recommended to collect large wastes on a quarterly basis and upon demand. The developer would need to coordinate with WAMCO to schedule to remove such waste as per the generation volume.

**Table 9 Mitigation management plan summary**

<table>
<thead>
<tr>
<th>Mitigation measures</th>
<th>Implementing Responsibility</th>
<th>Implementing Stage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground water degradation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispose water to site as shown by HDC for ground water recharge</td>
<td>Project Engineer</td>
<td>Construction</td>
<td>65,000 MVR</td>
</tr>
<tr>
<td>Regular monitoring of groundwater condition on site</td>
<td>Project Engineer</td>
<td>Construction</td>
<td>750 MVR/test</td>
</tr>
<tr>
<td><strong>Mosquito Growth</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ensure still water does not remain on site</td>
<td>Site Supervisor</td>
<td>Construction</td>
<td>na</td>
</tr>
<tr>
<td><strong>Noise Pollution</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Put lids or Place layer of wax on top of area in which water is prone to accumulate.</td>
<td>Site Supervisor</td>
<td>Construction</td>
<td>10,000</td>
</tr>
<tr>
<td>For workers, use of earmuffs at construction site.</td>
<td>Project Manager</td>
<td>Design</td>
<td>In project cost</td>
</tr>
<tr>
<td>Construction to be scheduled in such a way that noise pollution will be at a minimum to the public.</td>
<td>Project Manager &amp; Site supervisor</td>
<td>Design and Construction</td>
<td>In Project cost</td>
</tr>
<tr>
<td>Ensure proper site demarcation and boundary wall condition before commencing such work</td>
<td>Site supervisor</td>
<td>Construction</td>
<td>In Project cost</td>
</tr>
</tbody>
</table>

| **Air Pollution** |  
| --- | --- | --- |
| Workers should be made to wear dust marks during dust sensitive work. | Project Manager | Construction | In Project cost |
| Place dust screens demarking the concrete mixer | Project Manager | Construction | In project cost |
| Daily water spraying and dampening to reduce spread of dust to surrounding areas. | Site Supervisor | Construction | In Project cost |
| Inspect and fine-tune all machinery and vehicles before work commencement to ensure harmful gases released to atmosphere are at a minimum. | Site Engineer | Construction | In Project cost |
| Cover building materials such as cement and sand, and should be contained during loading, unloading and storage. | Site Engineer | Construction | In project cost |
| Surfaces in the housing units should be painted with lead free paints. | Project Manager | Construction | In Project cost |

| **Traffic Congestion** |  
| --- | --- | --- |
| Schedule transport of heavy-duty vehicles to site during off peak hours such as the morning. | Project Manager | Construction | 0 |

| **Generation of building and construction waste** |  
| --- | --- | --- |
| Re-use construction waste where possible. | Project Engineer | Construction | 0 |
| Metals are to be collected separately and handed over or sold to a metal recycling group. | Site supervisor | Construction | 0 |
| All waste should be segregated on site. | Site supervisor | Construction | 5,000 |
| During and straight after demolition works, all waste that cannot be recycled or reused, are to be transported daily to the waste disposal site in Thilafushi. | Site supervisor | Construction | In Project cost |
| Reusing formwork material as much as possible. | Site supervisor | Construction | 0 |

| **Health and safety of workers and neighbors** |  
| --- | --- | --- |
| Undertake health and safety training for workers before project commencement. | Project Manager | Pre-Construction | In Project cost |
Put up warning signs around the project area including signs indicating ongoing works, and restricting entry into the project area, and signs reminding the use of safety gear at site.  

<table>
<thead>
<tr>
<th>Project Manager</th>
<th>Construction</th>
<th>In Project cost</th>
</tr>
</thead>
</table>

Encourage use of safety cloth and equipment at the site at all times. These include safety helmets, dust masks, conspicuous fluorescent cloths, earmuffs, safety shoes, etc.  

<table>
<thead>
<tr>
<th>Project Manager</th>
<th>Construction</th>
<th>In Project cost</th>
</tr>
</thead>
</table>

### Generation of household wastes

- Separate collection of recyclables and non-recyclables at the building and transport the waste  
<table>
<thead>
<tr>
<th>Site Supervisor</th>
<th>Operation</th>
<th>In Project cost</th>
</tr>
</thead>
</table>

- Collect hazardous wastes in separate containers.  
<table>
<thead>
<tr>
<th>Site Supervisor</th>
<th>Operation</th>
<th>In Project cost</th>
</tr>
</thead>
</table>

- Have a quarterly large waste collection schedule in place  
<table>
<thead>
<tr>
<th>Site Supervisor</th>
<th>Operation</th>
<th>In Project cost</th>
</tr>
</thead>
</table>
6 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 options 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.

6.1 No project option

Initially the no project option is discussed to hypothesise whether the project should be taking place first of all. Sometimes, projects are proposed 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 exercise is important to avoid such a scenario and to ensure that undertaking this project at this stage makes good socio-economic sense without any significant impact on the environment.

The no project option is analysed on the basis that no such project is to take place in Male’ City, and not specifically for this development. As this development is part of a larger program, discussing no project option for this specific project alone will not make much sense. The no project option is therefore not very much applicable as the project has been given the go ahead in the planning stage, and the decision does not seem reversible at this stage.

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

Table 10 Advantages and Disadvantages of the no project option

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will not lead to health and safety concerns at project site</td>
<td>Will not be able to alleviate the issue of people living in small crowded places in Male’</td>
</tr>
</tbody>
</table>
Will not cause any noise and air pollution at project location | Will decrease economic opportunities for construction companies and their employees
--- | ---
Will not cause any traffic disruptions | Will be a missed opportunity for upper class still looking for their individual housing options in Male’ City.
Will offer greener quasi-natural public areas without built areas | Will hinder the development of Hulhumale’
Will not lead to production of waste at a concentrated site as the apartment building. | Easier to collect waste from a single point source rather than housing units dispersed over a wide land area.

A comparison of the no project option with the project going ahead as proposed, indicate that the no-project option is practicable, but involves losses to the developers and to the development of Male’ City in general.

There are a few advantages of the no project option from an environmental perspective, although they are not strong as impact from the project is minor. Local environmental impact from this project is small in nature, and the advantages stated is not significant, since most of the environmental impacts can be properly mitigated. Alternatives for components of the project are discussed further.

### 6.2 Project Alternatives

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 finalising an option. Alternative options; mainly based on design and methodology for the construction are given below.

#### 6.2.1 Project Location

Alternative locations are not as important for this project, as the location cannot be changed under any circumstances. The plot was awarded to the developers by the
Ministry of Housing and Infrastructure, and at this stage changing the plot would not be an option.

### 6.2.2 Building Height

Building height has also been approved at the planning stage. Initially, it was proposed that the building heights cannot exceed 4 storeys. But Hulhumale’ development plan has recently changed to accommodate these 12 – 14 storey mixed residential apartment buildings. While it will lead to congestion of population at a point source, there are advantages such as easy management of housing units. As an example waste management will be more convenient for the municipal service provider as collection from the point source would be easier than collecting waste from dispersed housing units. However, there are social issues that will arise from a large number of people living together as well. These will need to be properly managed by the developer.

### 6.2.3 Project design

Several component of the project design can be changed, taking the community more into consideration, such as:

Making space for a mini mall or office space for the first 4 or 5 floors so that it would provided activities in the area. Vertical development is important since it would encourage shop/office goers to get concentrated to particular areas, rather than spread out into the streets as the case in Male’ thereby making them crowded & disrupting traffic. Providing more of such amenities in the building will have a further advantage as discussed in the following sub section.

Provide a larger parking space within the building. The current parking space proposed will likely be sufficient for the tenants of the building. But a larger public parking space would alleviate potential parking issues for Hulhumale’. Providing such a space in the building will be an important service to the community.

Design for a rooftop garden area and incorporate green walls, which will contribute to making the city greener, while continuing with the infrastructure development in the given area.

These project designs are given as suggestions, the feasibility of which the developer should take into consideration before implementation.

### 6.2.4 Building maintenance
Currently the proposed plan in similar developments is to take a monthly fee from the tenants, which would likely be the case in this situation as well. The fees will be pooled into a fund to undertake building maintenance. This include waste management operations at the building as well. An alternative would be to increase the amenities such as proposed in 6.2.4 which could be used to generate some income to the building maintenance office by renting out these facilities. Furthermore, added luxury facilities such as kids play area, catering services to the apartments, child care centers, etc. will contribute further by taking fees from those who obtain these services.

This would alleviate the burden on the tenants somewhat to keep providing monthly payments and increase the chances of accumulating consistent amounts each month, which would in turn help to maintain the building more effectively than simply depending on individual tenants payments.

Waste management can be better facilitated by incorporating mechanical waste chutes in the building. This will reduce the impact from waste being transported in the common areas of the building. The negative impact from the change will be those associated with the maintenance of the chute system. If not properly maintained, it would be a hub for pollution leading to bad smell and further health issues for the tenants.

6.2.5 Foundation

A deep pile foundation can be constructed, which will likely provide more stability to the structure in the long term. However, the methodology have endured negative reception in Male’, most notably that of the Traders building (formerly Holiday Inn) at Athireege Aage. For the structure, metal load bearing piles were driven to depths of 30 to 40 metres. The deep piling, lead to several neighbours complaining of tremors and cracks in their walls. Due to the close proximity of buildings structures, use of deep pile technology may not be ideal for high rise buildings in Male’, although it is a different case in Hulhumale’. Nevertheless, with only 14 storeys developed over a large enough land area, it is not a necessity for this project.

7 Stakeholder Consultations

Stakeholder consultations were carried out with the construction management team of Sandal Mauritius Pvt. Ltd. Officials from the Environmental Protection Agency were also met for consultation. The EIA scoping meeting held at Environmental Protection Agency (EPA) provided a good opportunity to discuss issues with all the major stakeholders present. Further consultations were carried out with the Project Manager
for the project, and other stakeholders such as STELCO, WAMCO, MWSC, HPA, Ministry of Housing and Infrastructure and Housing Development Corporation were consulted. General discussions relevant to all similar developments that are currently being undertaken in Hulhumale’ were discussed previously and specific information on this project were also shared.

### Table 11 Important stakeholders met during the consultation process

<table>
<thead>
<tr>
<th>Name</th>
<th>Office</th>
<th>Contact</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narayana Mynampati</td>
<td>Sandal Mauritius Pvt. Ltd</td>
<td><a href="mailto:narayana.mynampati@assotech.in">narayana.mynampati@assotech.in</a></td>
<td>Project Manager</td>
</tr>
<tr>
<td>Mohamed Azim</td>
<td>MHI</td>
<td><a href="mailto:mohamed.azim@housing.gov.mv">mohamed.azim@housing.gov.mv</a></td>
<td>Director General</td>
</tr>
<tr>
<td>Ahmed Sofwan</td>
<td>HDC</td>
<td><a href="mailto:sofwan@hdc.com.mv">sofwan@hdc.com.mv</a></td>
<td>Senior Municipal Officer</td>
</tr>
<tr>
<td>Aminath Shaufa</td>
<td>HPA</td>
<td><a href="mailto:shaufa@health.gov.mv">shaufa@health.gov.mv</a></td>
<td>Public Health Program Cordinator</td>
</tr>
<tr>
<td>Ali Irushad</td>
<td>MWSC</td>
<td>+960 7968987</td>
<td>Business development manager</td>
</tr>
<tr>
<td>Azzam Ibrahim</td>
<td>STELCO</td>
<td>+960 7782574</td>
<td>Senior Engineer</td>
</tr>
<tr>
<td>Ismail Ubaid</td>
<td>WAMCO</td>
<td><a href="mailto:Ismail.ubaid@wamco.com.mv">Ismail.ubaid@wamco.com.mv</a></td>
<td>Facilities Manager</td>
</tr>
</tbody>
</table>

#### 7.1 Consultations with the Developer
Numerous consultations were undertaken with the developer to ensure the details of the project components. Consultations were also important to identify the most environmentally sensitive components and discuss potential mitigation measures.

The developer informed as per their contract with HDC, general maintenance of the building along with waste management will be the responsibility of the Ministry of Housing and Infrastructure. They informed that the project will fall under the social housing scheme and the tenants will be chosen by the Ministry.

The developer informed that the project has been delayed considerably and gave their assurance that this project will not encounter any further delays during the project. Assurance was given that the funding for the project was also secured.

7.2 Ministry of Housing and Infrastructure

Consultation with the Ministry personnel was initially held at a more general level discussing all the developments in Hulhumale’.

The Ministry informed that under recent changes, Male’ City Council currently has no role to play in infrastructure developments in Male’. The unit that was undertaking building and land approvals now come under the Land and Building Department under the Ministry of Housing and Infrastructure. The structure and architectural works for the project are to be undertaken by consultants registered at the Ministry. The foundation protection method along with other structures will need to be certified by these registered licenced consultants.

The Ministry informed that they do not have any further concerns if the necessary approvals for the project have been obtained. They also further informed that the Ministry does not give approvals for such projects undertaken in Hulhumale’. HDC is solely responsible for giving planning approvals and detail drawing approvals. It was informed that Hulhumale development falls under ‘Binaaveshi Qavaaidh’ Clause 2.2.4, which refers to islands that are developed as a special project. Clause 3.1.3 of the Regulation states Planning for such islands will be carried out by the developer of the island, which in this case is HDC. It was further informed that Hulhumale’ is also by law regarded as a land owned by HDC.

Regarding the specific project, the Ministry informed that the project will indeed fall under the social housing scheme, as it was initially designed as such. The project was initially planned to be undertaken in Male’ and was later moved to Hulhumale’. The tenants will be chosen based on the governments criteria. The commercial units will however be leased by the project developer.
7.3 State Electric Company (STELCO)

All similar projects being undertaken within the same timeline were discussed with STELCO in a face to face meeting. Project specific details were later communicated.

STELCO was consulted as the main power supplier for Hulhumale’ for residential, industrial and commercial areas as well. The company informed that they had not received previous information about the projects until recently. However, it was informed that there will not be any issue in providing power/electricity to the area, as there have been other developments in the area, namely the Rainbow Oceanfront site setup area.

It was informed in the general meeting the difficulty STELCO faces in accommodating new developments, when the plans for the upcoming developments are not shared with the company pre-emptively. If such a system is in place, STELCO can be even more efficient in accommodating their services for new development projects in Hulhumale’.

It was also informed that STELCO has the capacity to provide electricity to such new developments, and that the power plant will be gradually upgraded with new gen-sets as more developments come in.

They further informed that they can provide electricity connection up to 300A to all projects. For more than 300A, the developer has to install a transformer at site with his/her own cost, weather it is a temporary or permanent connection.

7.4 Male’ Water and Sewerage Company (MWSC)

Meeting with MWSC was held to discuss all similar developments in Hulhumale’. The specific project was informed via email as was agreed in the meeting.

MWSC provides water and sewerage services to the whole of Hulhumale’. MWSC also provides dewatering services to similar developments in Male’. However, it was informed that for such developments based in Hulhumale’, currently MWSC does not provide any such services.

It was informed on the difficulty in obtaining valid information in a timely manner on the new developments in Hulhumale’. MWSC team had shared a map where the most immediate new developments were noted.

Information was provided on the current water and sewerage network in Hulhumale’. There was no confirmation on the connection to the proposed development area.
currently. Confirmation was not received at the time of final compilation of the report. However, it was informed that connection can be made as soon as it is requested. Both water and sewerage lines were nearby the area, and as such a connection can be made without much difficulty. A meeting specifically for this project was not held as it was not required. However, during the final drafting of the report, a potential future meeting to discuss the current status and plans of MWSC for their network was discussed.

7.5 Health Protection Agency (HPA)

HPA had informed that information regarding upcoming projects were not shared with them previously. The main concern from HPA side is with respect to workers health and safety on site, and issues with respect to hygiene. However, they mentioned that there were no local regulations or guidelines currently specifying the standards for health and safety of workers.

The other main concern from HPA was regarding mosquito control at construction sites. They informed that a survey had been undertaken recently in Male’ and the condition was quite bad at most site and they had notified numerous developers on the issue of mosquito growth at their sites. Details of the survey has not been published at the time. HPA informed that they do carry out inspections at site, and that some work had already been undertaken in Hulhumale’ as well.

HPA further stated that they are currently in the process of making regulations and guidelines which would enforce and assist certain standards within construction sites with respect to both mosquito control and worker health and safety.

HPA later informed regarding this specific project that they wish to recommend the contractors to use lead free paint in the buildings as lead is a toxin known to have many impacts to the human health, and lead based paint is something they wish to phase out completely.

7.6 Waste Management Corporation ltd. (WAMCO)

WAMCO informed that all waste management has been handed over to them starting from January 2017. This includes waste collection, pickup and sorting, management of the waste site, and transporting waste to Thilafushi. However, they informed that they were at the very early stages currently and have not resumed full operations in Hulhumale’ yet.

Regarding construction waste, WAMCO advised to undertake the same process as had been carried out thus far. For the contractor to collect and sort waste at their site and
transfer to Thilafushi on a regular basis. Organic household type wastes can be transported to the waste center in Hulhumale’.

Regarding waste generated post construction, WAMCO informed that they will likely have a good setup running in Hulhumale’ at that stage. They are currently planning to pickup waste from sites on a daily basis. The waste collection nodes in the residential area that currently exists will be removed soon and all waste will be collected in the vehicles as per the time table that will be formulated soon. They informed that waste have to be sorted at the buildings to at least recyclable and non-recyclable wastes. Separate bins must be in place at the waste collection area in the buildings. Large bulky wastes will be removed on demand. A call and pickup service will be provided to collect such wastes. There is also plans to have a scheduled monthly or quarterly round of picking up bulky wastes from households and apartment buildings such as these.

WAMCO did not have any specific concerns for this particular project.

8 Environmental Monitoring

This section deals with the Environmental Management and Monitoring plan for the proposed development with respect to the developments proposed in this EIA. The proposed monitoring plan is for the construction and operation phase of the project. The data collected for this assessment 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

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 the construction phase once every 3 months up to 1 year, and then on an annual basis for 2 years. Further monitoring will be undertaken by the developer as long as building monitoring and maintenance is under their control. However, this is not obligated by this EIA.
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 Annex 7.

### 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 Laboratory from MWSC. To carry out field water testing, such equipment needs to be procured, which may not be feasible based on this project alone.

The costs given in Table 11 and Table 12 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 maintenance team since most of the parameters are to be investigated monthly and quarterly, and therefore hiring a consultant for each occasion may not be feasible. Nevertheless, if the developer does not employ environmental experts 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 waste generation data have to be undertaken by the maintenance team setup at the site.

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

- Ground water quality
- Generation of wastes
- Noise pollution
- Traffic congestion

### 8.2 Recommended Monitoring Programme

As instructed in the TOR, the monitoring programme will be divided into 2 stages.
Stage 1

- Ground water quality for pH, temperature, electronic conductivity, total hydrocarbon and salinity at project site

- Determine number, type and respective quantity of waste produced within the past quarter. Assistance from the contractor’s project management team will be required. Waste types and respective quantities present at site during inspection should be noted at each visit.

- Noise measurement. Measure noise at the locations as was studied in the EIA.

- Survey the traffic within the same area as undertaken for this EIA

- Inspect the use of health and safety equipment on site. Take a head count on the number of staff at site not using proper health and safety equipment including safety shoes, fluorescent vest, safety helmets.

Stage 2

- Ground water quality for pH, temperature, electronic conductivity, total hydrocarbon and salinity at project site

- Determine number, type and respective quantity of waste produced (on daily basis, extrapolated to monthly data). Long term data can be taken in coordination with the maintenance office set up at the building. During monitoring, general inspection of the building common areas should take place to take note of any loose wastes in the common areas. Will have to depend on secondary data collected by building monitoring officers based at the site.

- Noise measurement

- Survey the traffic within the same area as undertaken for this EIA
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. Since this monitoring is in Hulhumale’ and does not involve expensive surveying equipment, and most are based on visual observation and consultation, the overall cost is low relative to most monitoring programs.

Table 12 Estimated costs of Stage 1 Monitoring Programme

<table>
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<tr>
<th>Item No.</th>
<th>Details</th>
<th>Unit cost (US$)</th>
<th>Frequency</th>
<th>Total (US$)</th>
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<td>Field allowance for 1 consultants for 1 day</td>
<td>75.0</td>
<td>8</td>
<td>600.00</td>
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<td>2</td>
<td>Surveying and monitoring equipment depreciation</td>
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<td>8</td>
<td>400.00</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory charges</td>
<td>110.00</td>
<td>8</td>
<td>880.00</td>
</tr>
<tr>
<td>4</td>
<td>Compliance reporting (annual report)</td>
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<td>2</td>
<td>1600.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>7,430.00</strong></td>
</tr>
</tbody>
</table>

The monitoring is for a period of 2 years (duration of construction phase), where data is collected quarterly.

Table 13 Estimated costs of Stage 2 Monitoring Programme

<table>
<thead>
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<th>Item No.</th>
<th>Details</th>
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<th>Frequency</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>2</td>
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</tr>
<tr>
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<td>Surveying and monitoring equipment depreciation</td>
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<td>2</td>
<td>100.00</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory charges</td>
<td>110.00</td>
<td>2</td>
<td>220.00</td>
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</tbody>
</table>
This monitoring is for a period of 2 years, where data is collected annually. Therefore for each year the cost will be approximately USD 1310.00, not taking into account any effects of inflation and other such economic scenarios.

Considering the 2 stages of monitoring, monitoring costs in the first year would be approximately USD 3715.00. The proponent has to endure the greatest cost during stage 1 monitoring, as frequency of monitoring is greater.

### 8.4 Monitoring Report

Monitoring report should be compiled based on the baseline data collected. This report should be submitted to the EPA and any other relevant government agencies for compliance annually or at a greater frequency, 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

### 9 Conclusion

The project can be regarded to complement the larger program by Housing Development Corporation to establish mixed residential buildings in Hulhumale’. Apartments in the proposed building is targeted towards lower income market. The project will contribute to the grand plan of reducing congestion in Male’ by providing more housing opportunities in Hulhumale’. The project is part of the social housing program by the Government. The project will provide medium quality apartments for the social housing program. The eventual plan is to provide a wide range of accommodation option to all members of the community living in greater Male’ area.

The existing environment at the project site does not consist of any significant vegetation and the water test result shows good water quality. There are no residents living near the site and there is no other structure at the site as well. There are other
buildings that are proposed to be developed near the area, and the central park is right in front. However, it is not anticipated that there will be any significant impact on these areas due to this.

During the construction stage, which takes about 2 years, health and safety standards of the workers at site, and waste generation is the only areas of concern. With proper planning and project management, this can be easily mitigated. Waste is the main concern during the operational stage of the project as well. The buildings will be developed as a social housing condominium with multiple tenants owning the rights of the building. It is likely the management of the building will fall under the responsibility of the tenants. Considering the relative remote location of the project site, the impacts will be at a minimum.

Regarding alternatives, there are no viable alternatives available for the project with respect to location. The no project option is also not plausible at this stage and possibilities are outside the scope of this study, as the non-development of this building is a question to be considered at the planning stage. The same applies to the height of the building. Other alternatives including material, foundation type, construction methodology are not necessarily recommended. Recommendations had been made to proceed with the project as planned.

All the impacts as highlighted in the project can be mitigated. The socio-economic benefits to Greater Male’ City from projects such as these is high. It also provides additional housing opportunities, which would contribute to alleviating the housing issues in Male’ City. Therefore, after consideration of all these viewpoints, it is recommended for the project to proceed as planned after incorporating the mitigation measures given in this study with the commitment to implementing the monitoring plan given.
10 References

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www.meteorology.gov.mv

Faisal, M. (n/a), Living on a crowded island: Urban Transformation of the Maldives – background to a research in progress, Victoria University of Wellington

Horodecki, G.A. and Dembicki, E. (2012), Impact of deep excavation on nearby urban area


Ministry of Housing, Transport and Environment (2009), Third National Environment Action Plan - 2009-2013,


Musthafa, A. (2013), EIA for proposed 14-storey building at G. Hudhukokaa, Malé

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Sandecays 2015, Environment Impact Assessment Multi Storey Building at H. Point Villa, Male’ City, Maldives

Rincon Consultants Inc 2004, Viginia Court Condominium Project Final Environment Impact Report

Pal, B. K., Dey, K. and Tandia, P. K. (2010), Vibrations on structures and soils due to industrial activities: unique case studies. In Journal of Environmental Research And Development 4 (3)
Annex 1 – Terms of Reference
Terms of Reference for Environmental Impact Assessment for Proposed mixed residential building development project at Hulhumale’ plot D1-1

The following is the Terms of Reference (ToR) following the scoping meeting held on 5th February 2017 for undertaking the EIA of the Proposed Mixed Residential Development in Plot D1 1, Hulhumale’. The proponent of the project is Sandal Mauritius Private Limited.

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

1. **Introduction to the project** – Describe the purpose of the project and, if applicable, the background of the project and the tasks already completed. Clearly identify the rationale and objectives to enable the formulation of alternatives. Define the arrangements required for the environmental assessment and if relevant, including how work carried out under this contract is linked and sequenced with other projects executed by other consultants, and how coordination between other consultants, contractors and government institutions will be carried out. List the donors and the institutions the consultant will be coordinating with and the methodologies used.

2. **Study area** – Submit an A3 size scaled plan with indications of all the proposed land infrastructures. Specify the boundaries of the study area for the environmental impact assessment highlighting the location and size of the proposed construction. The study area should include nearby environmentally sensitive areas. Justification for site selection is required. Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including site preparation, construction and decommissioning phases.

**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. All inputs and outputs related to the proposed activities shall be justified.

1. Provide a clearly labeled concept design and scaled site plan of the project boundary.
2. Submit a detailed description of the components of the project and how the project activities will be undertaken.
3. A project schedule should be included.
4. A matrix of inputs and outputs related to the proposed activities shall be included.
5. Need and justification for the proposed project.
6. Waste management during construction period including construction waste, demolition waste, and green waste where applicable.
7. Dewatering plan.
8. Description of any underground structures such as basement or wells.
10. Details of vegetation clearance if any.
11. Use of any energy conserving utilities.
12. Details of the back-up generator to be installed.
13. Estimated consumption of water and electricity and their sources.

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Environmental Protection Agency

Grosvenor Building, 3rd Floor, Handhuveroo Street

Malé, Rep. of Maldives, 20392

Tel: (+960) 333 5949 (+960) 333 5951

Fax: (+960) 333 5953

Email: secretariat@epa.gov.mv

Website: www.epa.gov.mv

No: 203-EIARES/PRIV/2017/196
Project management: Include communication of construction details, progress, target dates and duration of works, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, water supply, waste management from construction operations, power and fuel supply for backup generators;

**Task 2. Description of the environment** – Assemble, evaluate and present the environmental baseline study/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 including water-sampling points.

**Physical and Biological Environment**

- Noise levels in the vicinity of the site including any noise sensitive location
- Traffic flow (size and direction) around the project site
- Vegetation in the project site and major trees around it, if any
- Water quality of groundwater wells in project site. Following parameters are to be tested: Conductivity, pH, Salinity, Temperature, TDS, and Turbidity

**Built Environment**

- Nature of adjacent buildings if any
- Condition of the surrounding roads
- Existing structure/uses of the proposed site
- Public facilities nearby

**Socio-economic Environment**

- Demographic data for Hulhumale’ area.
- Brief description of social environment of Hulhumale’ in general and adjacent residential units in particular
- Identify types of vehicles and peak traffic hours in or near the project site

**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. Legal requirements:
  - Building Approval from the Housing Development Corporation
  - Architectural drawing approval from Housing Development Corporation

**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:

- Loss of vegetation if any
- Loss of visual amenity
- Land preparation and piling works if any
- Impacts on ground water table and water quality
- Impacts related to construction works on land including materials sourcing, transport and storage, building construction methodology and piling
- Mosquito growth
- Noise, fugitive dust, traffic obstruction and other impacts related to traffic due to the project
- Impacts due to generation of waste
• Potential impacts of the development on adjacent properties and residential areas, especially sensitive areas like schools, pre-schools and mosques.
• Safety and security of the building
• Risk of accidents to workers and public
• Impacts on employment and income such as job opportunities
• Disturbances to residents and public facilities/activities nearby

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

Task 5. Alternatives to proposed project – Describe alternatives including the “no action option” should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the “no action alternative”. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures. Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan (see appendix) – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for ground water as well as defects in neighbouring structures. 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, Housing Development Corporation, STELCO, WAMCO, MWSC, engineers/designers, development managers, staff and members of the general public. The EIA report should include a list of people/groups consulted, their contact details 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 for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 45 days from the date of this Term of Reference.
Annex 2 – Approved Site layout and Concept
HDC(161)-EM/MIS/2017/98

24th January 2017

Narayana Mynampati
Dy. General Manager (International Projects)
Sandal Mauritius Pvt. Ltd.,
M.Roselin, Janmbu Magu,
Male', Maldives

Dear Sir,

SUBJECT: APPROVAL OF THE CONCEPT DRAWING OF PLOT D1-1

Reference is made to the Concept Drawings sent by Sandal Mauritius Pvt. Ltd. for the Social Housing development in Plot D1-1 on 22nd January 2017 for the approval of HDC.

Please be informed that the referred concept drawing has been approved and stamped.

The stamped copied (3 copies) are attached herewith.

Yours sincerely,

Ahmed Faathih
Director
Human Resource
Annex 3 – Water test results
# WATER QUALITY TEST REPORT

**Report No:** 50917623

**Sample Description:** Ground Water Plot D1-1

## Sample Information

- **Customer Information:**
  - Name: Amir Musthafa
  - Flat: 11-02-03
  - Address: Hulhumale', Maldives

- **Test Requisition Form No:** 900170987
- **Sample(s) Received Date:** 02/02/2017
- **Date of Analysis:** 02/02/2017
- **Report Date:** 06/02/2017

## Sample Details

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<th>Parameter</th>
<th>Analysis Result</th>
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<tr>
<td>Physical Appearance</td>
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<td>Conductivity</td>
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<td>Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 21st edition)</td>
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</table>

**Keys:** μS/cm: Micro Siemens per Centimeter, %: Parts Per Thousand, °C: Degree Celsius, mg/L: Milligram Per Liter, NTU: Nephelometric Turbidity Unit

**Checked by:** Afrin Farooq  
**Approved by:** Adam Rasheed  
**Laboratory Executive Gr.1**  
**Manager, Quality**

**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 provided by the customer.

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

Page 1 of 1
Annex 4 – Proponents Commitment for Monitoring and Mitigation
Dear Mr. Ibrahim Naeem,

Project: EIA for the proposed mixed residential development in Hulhumale' Plot No. D1 - 1

Sub: Proponents Commitment for Monitoring and Mitigation

As the proponent of the project, we confirm our commitment to undertake all mitigation measures and carry out the monitoring program as specified in the report.

Thanking you

Yours Sincerely

For SANDAL MAURITIUS PVT LTD,

Narayana Mynampati
Director.
Annex 5 – Soil test report
JOSMAR CONSULTING ENGINEERS

Geotechnical Engineering Division

Geotechnical Investigation Report

For

Sandal Mauritius Pvt. Ltd.,

Site:

Plot D1-1,
Hulhumale,
Maldives.

REPORT NO: JCE/GEOTECH/2016/MALE/003

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Client File # 16-I-Male/003

Sandal Mauritius Pvt. Ltd.,

Site:
Plot D1-1,
Hulhumale,
Maldives.

SUB: FINAL GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING AT HULHUMALE, MALDIVES.

Dear Sir,

We are pleased to hereby transmit one (01) original and two (02) photocopy of our final Geotechnical Investigation Report for the above captioned project.

Should you have any questions, please do not hesitate to contact this office.

Please note that our final report is deemed acceptable to you, if we do not hear from you in writing within 10 calendar days from the date that you received it.

It has been a pleasure being of service to you on this project. Assuring you of our continued co-operation, we remain.

Yours Truly,

FOR JOSMAR CONSULTING ENGINEERS
(Geotechnical, Structural & Materials Consultant)

[Signature]

Er.P.KALPANA. M.E.
Geotechnical Engineer
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Appendix - A  
- Key plan & Bore hole locations plan

Appendix - B  
- Borehole Logs & Cross sectional area of borelogs

Appendix - C  
- Laboratory Test Results

Appendix - D  
- Bearing capacity calculation
  - Immediate Settlement calculation

Appendix - E  
- Analysis of Raft Foundation (Flexible)

Appendix - F  
- Pile Capacity Calculation
INTRODUCTION - MALE

The Republic of Maldives is comprised of a chain of coral atolls extending about 860 km north to south and 80 to 120 km east to west. There are 26 atolls of varying sizes consisting of reefs and islands. A total of 1,192 low-lying coral islands have a total land area of approximately 300 km². Although the area with the highest elevation is approximately three meters above the mean sea level, about 80% of the nation's total area is less than one meter above the mean sea level. The 26 atolls are grouped into 20 administrative regions. Among the islands, 199 are inhabited and 87 are used as tourist resorts. The geographic coordinates are 3.20 degrees N, 73.22 degrees E.

An atoll is an island made from coral that surrounds a lagoon either completely or partially. Each atoll has around five to 10 inhabited islands and from 20 to 60 uninhabited islands. There are also atolls that are a single island with a surrounding coral beach. The terrain is flat, white sandy beaches. The coastline is 644 kilometers. For clear picture shown in the Google map in Maldives was attached in this report (Figure - 1).

INTRODUCTION – HULHUMALE

Hulhumale Island is an island in the Maldives, connected with airport by the causeway. Island beach is rather mediocre. Beach: sand. Seabed: sand, stones. For clear picture shown in the Google map in Hulhumale, Maldives was attached in this report (Figure - 2).
GEOGRAPHICAL BACKGROUND

The geographic locations of certain group of islands are such that they are protected from tsunami waves. The group of islands lying along the eastern side of Maldives, are most prone to tsunami waves (zone 4-5), as 95 % of tsunamis that affected Maldives generated from eastern source zone - three segments of Sumatra subduction zone. Situated on the Indo-Australian plate, the Maldives is tectonically very stable and aseismic. It is located far away from high-seismicity regions. And attention is given to the possibility of a tsunami generated from the active seismic zones around Sumatra, Western India and in the waters west and south west of Maldives. The Waters of ocean lying south of Maldives and the Carlsberg oceanic ridge zone, which has a high level of seismic activity. The seismic hazard Zone in Maldives was shown below

Seismic Hazard Zone
Earthquake is a shaking of the ground caused by the sudden dislocation of material within the earth’s outer layer, or crust. When forces pushing on a mass of rock overcome the friction holding the rock in place and blocks of rock slip against each other an earthquake may occur. Some earthquakes are so slight, and some occur in such remote areas, that they are barely felt. Others are so violent that they cause extensive damage. The earthquake prone areas in Maldives are shown in below.

Earthquake prone areas in Maldives

The Seismic Hazard Zone and Earthquake prone areas are shown in varies zones are marked in the above figures. In this figure, we understood that the proposed construction site is located in Hulhumale; Maldives is occurring in zone -5 in Seismic Hazard Zone and zone- 1 in Earthquake prone area. The structural engineer should take care of design consideration for the proposed structure.
INTRODUCTION

This report presents the results of the geotechnical investigation work carried out by JOSMAR Consulting Engineers—Geotechnical & Foundation Engg. Division, for the proposed construction of (G+12) Residential Building, located at Plot No: D1-1, Hulhumale, Maldives.

This work was authorized by the Client, (Sandal Mauritius Pvt Ltd.), vide their acceptance through mail dated on 25.11.2016.

Standard Penetration Tests were carried out six boreholes have been drilled at the captioned project up to an appropriate depth. BH-1, BH-2 & BH-3 to BH-6 was drilled up to a depth of 15.00m, 18.00m & 15.00m below the existing ground level respectively.

The investigation consists of drilling six boreholes, soil sampling, field and laboratory testing and preparation of a Geotechnical Report for the Proposed Construction of (G+12) Residential Building, located at Plot No: D1-1, Hulhumale, Maldives.

PURPOSE & SCOPE OF WORK

The scope of this investigation is to:

i) Determine the soil profile at the site, with ground water observation.

ii) Recommend a suitable foundation system and safe bearing pressures at the foundation level for the proposed project at Hulhumale, Maldives.

Six (6) boreholes were drilled to a maximum depth of 18.00m. Soil samples were collected for visual identification, classification and laboratory testing.

The key plan & borehole location plan are presented in Appendix-A. The borehole logs and the cross sectional bore logs are presented in Appendix-B. The laboratory tests results are presented in Appendix-C. The bearing capacity, settlement calculations are presented in Appendix-D. Raft foundation (Flexible) calculation is presented in Appendix-E. Pile capacity calculations are presented in Appendix-F.
DESCRIPTION OF THE SITE & PROJECT

Proposed project would be constructed at Plot No: D1-1, Hulhumale, Maldives.

The top surface of the site is 0.50m above the adjacent road level. The site is located by Bageechaa Hingun road at South direction, Reethigas Magu road at East direction, vacant land at West direction, while at North direction there is a Road.

Proposed construction would consists of (G+12) Residential Building.

EXPLORATION PROGRAM & TECHNIQUES

After the visual inspection of the site, the subsurface investigation was performed from 30th November 2016 to 04th December 2016. Using a rotary drilling rig the Six(6) exploration boreholes were drilled for the captioned project and each borehole drilled date at the site was mentioned below.

BH - 1 was started on 30th November 2016 and completed on 30th November 2016
BH - 2 was started on 01st December 2016 and completed on 01st December 2016
BH - 3 was started on 01st December 2016 and completed on 02nd December 2016
BH - 4 was started on 02nd December 2016 and completed on 02nd December 2016
BH - 5 was started on 02nd December 2016 and completed on 03rd December 2016
BH - 6 was started on 04th December 2016 and completed on 04th December 2016

Boreholes were drilled at the site as shown in the auto cad drawing in order to obtain the average soil properties of the site. Rotary drilling was performed using (wash boring techniques) water as drilling fluid in the sub soil the boreholes was drilled up to the required depth. Field tests and sampling were conducted in accordance with BS/ASTM standards.

Standard Penetration Test (SPT) was conducted using split barrel sampler at top layers to determine the "N" value of the soil layers. SPT was conducted at every 1.50m depth intervals in each borehole to determine penetration resistance as per BS 1377-9: 1990. Number of blows was recorded for every 15cm penetration for a total of 45cm penetration. The number of blows required to drive the sampler for 30 cm apart from the seating drive is termed as penetration resistance "N". The SPT value at the top layers in each borehole at different depths has been recorded in the bore logs.
Coralline Limestone samples were extracted by rotary drilling techniques using double tube core barrel of 73mm diameter, fitted with a diamond bit. The extracted cores are very soft and small pieces. The extracted cores are very soft and small pieces (Heterogeneous layer). However the recovered sample was measured T.C.R. as well as R.Q.D values. The appropriate estimation of the properties of the encountered rock strata can be obtained by referring to the borehole logs and the following description.

<table>
<thead>
<tr>
<th>R.Q.D %</th>
<th>ROCK QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 25</td>
<td>Very Poor</td>
</tr>
<tr>
<td>25 - 50</td>
<td>Poor</td>
</tr>
<tr>
<td>50 - 75</td>
<td>Fair</td>
</tr>
<tr>
<td>75 - 90</td>
<td>Good</td>
</tr>
<tr>
<td>90 - 100</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOVERY %</th>
<th>DESCRIPTION OF ROCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 20</td>
<td>Rock is treated as soil</td>
</tr>
<tr>
<td>20 – 35 with SPT&gt;50 blows/30cm</td>
<td>Soft or disintegrated rock</td>
</tr>
<tr>
<td>35 - 50</td>
<td>Intermediate rock</td>
</tr>
<tr>
<td>50 - 85</td>
<td>Medium rock</td>
</tr>
<tr>
<td>&gt;85</td>
<td>Sound rock</td>
</tr>
</tbody>
</table>
The SPT soil test was conducted in the site, the photos are shown below.

BH-1
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

BH-2
GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING AT HULHUMALE, MALDIVES

BH-3
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

BH-4
The fieldwork was carried out under the close supervision of our geotechnical engineer.
LABORATORY TESTING PROGRAM

All the extracted soil/rock samples were brought to the Geotechnical & Materials Testing Laboratory of JOSMAR Consulting Engineers for further examination in accordance to ASTM D2488. Selected samples were subjected to the physical and chemical tests in accordance to relevant ASTM & BS Standards. The relevant tests carried out include the following.

1) Natural Moisture Content
2) Sieve Analysis (ASTM D422-63)
3) Direct Shear Test
4) Chemical Analysis of soil

The laboratory test results are given in Appendix "C".

SUBSURFACE SOIL DESCRIPTION

Based on boreholes information, sub surface soil profile at the proposed construction of (G+12) Residential Building is given below:

**BH-1**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 6.50</td>
<td>Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM)</td>
</tr>
<tr>
<td></td>
<td>(Reclaimed fill)</td>
</tr>
<tr>
<td>6.50 - 9.50</td>
<td>Whitish, poorly graded sands, gravelly sands with fines (SP)</td>
</tr>
<tr>
<td>9.50 - 15.00</td>
<td>Coralline, lime stone highly fractured and very dense to rebound</td>
</tr>
</tbody>
</table>

**BH-2**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 6.50</td>
<td>Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM)</td>
</tr>
<tr>
<td></td>
<td>(Reclaimed fill)</td>
</tr>
<tr>
<td>6.50 - 9.50</td>
<td>Whitish, poorly graded sands, gravelly sands with fines (SP)</td>
</tr>
<tr>
<td>9.50 - 18.00</td>
<td>Coralline, lime stone highly fractured and very dense to rebound</td>
</tr>
</tbody>
</table>

**BH-3**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 6.50</td>
<td>Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM)</td>
</tr>
<tr>
<td></td>
<td>(Reclaimed fill)</td>
</tr>
<tr>
<td>6.50 - 9.50</td>
<td>Whitish, poorly graded sands, gravelly sands with fines (SP)</td>
</tr>
<tr>
<td>9.50 - 15.00</td>
<td>Coralline, lime stone highly fractured and very dense to rebound</td>
</tr>
</tbody>
</table>
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

BH-4
0.00 – 6.50m  Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM) (Reclaimed fill)
6.50 – 9.50m  Whitish, poorly graded sands, gravelly sands with fines (SP)
9.50 – 15.00m Coralline, lime stone highly fractured and very dense to rebound

BH-5
0.00 – 6.50m  Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM) (Reclaimed fill)
6.50 – 9.50m  Whitish, poorly graded sands, gravelly sands with fines (SP)
9.50 – 15.00m Coralline, lime stone highly fractured and very dense to rebound

BH-6
0.00 – 6.50m  Grayish, Whitish, silty sands, poorly graded sand silt mixture (SM) (Reclaimed fill)
6.50 – 9.50m  Whitish, poorly graded sands, gravelly sands with fines (SP)
9.50 – 15.00m Coralline, lime stone highly fractured and very dense to rebound

This area has been reclaimed in the past and filled by dredging material, consists of coralline sand, cobble, boulder and silt, along with sea sediments.

In view of the borehole information, the BH-1 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates medium dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates medium dense to dense relative density. This layer is followed by Coralline, lime stone highly fractured and very dense to rebound found up to a depth of 15.00m. Further drilling was stopped due to refusal strata.

In view of the borehole information, the BH-2 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates loose to medium dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates medium dense to very dense relative density. This layer is followed by Coralline, lime stone highly fractured and
very dense to rebound found up to a depth of 18.00m. Further drilling was stopped due to refusal strata.

In view of the borehole information, the BH-3 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates medium dense to dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates dense relative density. This layer is followed by Coralline, lime stone highly fractured and very dense to rebound found up to a depth of 15.00m. Further drilling was stopped due to refusal strata.

In view of the borehole information, the BH-4 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates loose to medium dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates dense relative density. This layer is followed by Coralline, lime stone highly fractured and very dense to rebound found up to a depth of 15.00m. Further drilling was stopped due to refusal strata.

In view of the borehole information, the BH-5 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates loose to medium dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates dense relative density. This layer is followed by Coralline, lime stone highly fractured and very dense to rebound found up to a depth of 15.00m. Further drilling was stopped due to refusal strata.

In view of the borehole information, the BH-6 was noticed that top layer consists Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m where its standard penetration test result indicates loose to medium dense relative density. This layer is followed by Whitish, poorly graded sands, gravelly sands with fines (SP) found up to a depth of 9.50m where its standard penetration test result indicates dense relative density. This layer is followed by Coralline, lime stone highly fractured and very dense to rebound found up to a depth of 15.00m. Further drilling was stopped due to refusal strata.
GENERALIZED SOIL PROFILE

In view of the above borehole (BH-1 to BH-6) information, it is noticed that the top layer consists of Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to 6.50m below the existing ground. The following layer consists of Whitish, poorly graded sands, gravelly sands with fines (SP) from the average depth of 9.50m. The following layer consists of Coralline, lime stone highly fractured and very dense to rebound found up to an average depth of 15.00m in all the six bore logs except BH-2 the depth of bore log is 18.00m. For foundation analysis, we analyzed Coralline, lime stone up to a maximum depth of 24.00m. Detailed description is given in borehole logs. The rock pieces are not encountered in all six bore logs. The soil samples in all the six bore logs at different depths are shown below.
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

B.H - 1
Top soil to 6.00m Depth

7.50m to 15.00m Depth
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

B.H - 2
1.00m to 7.50m

9.00m to 18.00m
GEOTEchnical Investigation Report for the
Proposed Construction of (G+12) Residential Building
At Hulhumale, Maldives

B.H - 3
1.00m to 7.50m

9.00m to 15.00m
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

B.H – 4
1.00m to 7.50m

9.00m to 15.00m
GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING AT HULHUMALE, MALDIVES

B.H – 5
1.00m to 6.00m

7.500m to 15.00m
B.H – 6
Top soil to 6.00m Depth

7.500m to 15.00m
GROUND WATER
Ground water was encountered at 1.60m below the existing ground level during the time of field investigation. However it may fluctuate due to the tidal variations, slightly.

FOUNDATION ANALYSIS
Out of the above six bore holes, at BH-1 to BH-6, the top layer is Grayish, Whitish, silty sands, poorly graded sand silt mixtures (SM) (Reclaimed fill) found up to a depth of 6.50m. The variations in soil strength parameters between the boreholes as there are lower N values were recorded. The Spread / Strip footing is not feasible for the proposed (G+12) Residential Building as the expected settlement for Spread / Strip footing is not within the allowable limits. The analysis of spread/strip footing is presented in Appendix-D.

By considering the type of structure, which is a high rise building and based on the borehole information & laboratory test results the foundation calculation was attached. Raft foundation (Flexible) calculation is presented in Appendix – E. Pile capacity calculations are presented in Appendix- F.

FOUNDATION DESIGN:
Analysis of Raft Foundation (Flexible)
The proposed (G+12) Residential Building the settlement of raft foundation (Flexible) calculation is presented in Appendix-E.

Bearing capacity calculations indicate very high bearing value however that needs to be restricted by settlement criteria. The settlement calculation and allowable bearing pressure is carried out for raft foundation. Initially, bearing pressure calculations were carried out using average soil properties of the founding strata, as there are three layers considered for the Raft analysis. Appropriate net bearing pressure shall be selected from the calculation sheet based on allowable settlement criteria. Using Steinpro software based on settlement calculations are carried out for Raft foundation (Flexible). Bearing capacity calculations were carried out initially and found that the settlement controls the design.

The ground water table was observed at 1.60m below the ground level during the time of investigation. Dewatering will be needed due to shallow ground water conditions.
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

Settlement calculations were carried out by estimating the modulus of elasticity of soil, using appropriate corrected N values for subsoil layer up to a depth of 24.00m below the ground level. The modulus of elasticity 'E' values considered is shown in the calculation sheets.

For raft foundations allowable settlement on sand soils shall be up to 100mm as per IS:3 Code. But as per J.E.Bowles 60mm is allowed. Being the founding soil as a reclaimed fill it's recommended to follow J.E.Bowles. Structural Engineer shall choose the appropriate net bearing pressure from the calculation sheet provided in the report.

The subgrade modulus was calculated from the below mentioned formula (Ref Author Mr.K.R.Arora page no.659, 660)

\[ k = \frac{q}{z} \text{ (kN/m}^3\text{)} \]

where,
\[ k = \text{Coefficient of subgrade reaction (kN/m}^3\text{)} \]
\[ q = \text{Pressure (kN/m}^2\text{)} \]
\[ z = \text{Settlement (m)} \]

Raft Foundation (Flexible)
- Raft foundation (Flexible) shall be adopted for the proposed structure.
- Foundation shall be placed at a depth of 2.00m below the ground level and before laying the foundation, the surface is compact and leveled properly.
- The maximum width of foundation considered is 35.00m.
- A PCC (Plain Cement Concrete) layer of 15cm thickness is recommended below the foundation.
- Grade beams shall be adopted in order to minimize differential settlements
- In case of finding any loose pockets found during excavation then 40mm gravel filling shall be done
- Gravel bedding of 50mm would be helpful in distributing the tower building loads to wider area thus reducing differential settlements.
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

- If Necessary Dewatering shall be carried out during construction since the ground water
table is occur at 1.60m below the ground level.
- Expected settlements shall be less than the permissible limits for the foundation and the
differential settlement shall be considered up to 75% of the expected total settlement.

Soil Parameters

The top layer (0 to 6.50m), the modulus of elasticity was considering for this depth is 27.50 MPa
and gamma value is 19kN/m³. The second layer at 6.50 to 9.50m, the modulus of elasticity was
considering for this depth is 28.70MPa and gamma value is 20 kN/m³ .The third layer at 9.50 to
24.00m, the modulus of elasticity was considering for this depth is 91 MPa and gamma value is
20kN/m³.

PILE FOUNDATION (BCIS)

Pile foundation system shall be adopted for the proposed structure by terminating the
Piles in the deep strata. It is a normal practice to adopt same Pile lengths, for better interaction
and to achieve uniform settlements.

Under each column there should be a pile cap to transfer the support load to the carrying
piles. The bottom level of the all pile caps shall be kept at 1.0 m below the ground level. The
plan and dimensions of pile caps could be estimated according to the required number of piles
and considered centre to center spacing between piles.

Bored In situ Pile Foundation

A Pile length of 14.00 m has been analyzed below and the corresponding pile capacities are
given. Selection of Pile length was estimated according to soil profile and soil stiffness as
obtained from SPT values.

PILE CAPACITIES

Bedrock was not encountered up to a maximum explored depth. Hence, the Piles
utilizing friction and also end bearing capacities shall be adopted for the proposed structures.
The Pile capacities of the bored, cast in situ piles are worked out considering a depth of 14.00
meter below ground level as the top of pile level. Estimation of Pile capacities are given below with reference to the boreholes drilled at site.

<table>
<thead>
<tr>
<th>Pile Depth (m)</th>
<th>Pile Diameter (mm)</th>
<th>Factor of Safety = 2.5 Allowable Pile Load Capacity (kN)</th>
<th>Lateral load bearing capacity (kN)</th>
<th>Uplift Resistance (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.00</td>
<td>500</td>
<td>535</td>
<td>42.8</td>
<td>270</td>
</tr>
<tr>
<td>14.00</td>
<td>600</td>
<td>705</td>
<td>56.4</td>
<td>325</td>
</tr>
<tr>
<td>14.00</td>
<td>800</td>
<td>1110</td>
<td>88.8</td>
<td>435</td>
</tr>
</tbody>
</table>

Note:
The above recommendation is given by assuming similar soil strata in the whole site area. In case of any variations in the soil profile the above recommendation need to be validated.

In view of the ground water which is expected to have salts that could corrode the steel bars and affect the concrete strength, necessary measures can be considered by the designer of the building.

PILE GROUPING
The group efficiency shall be worked out based on number of Piles in a group. Piles shall have a minimum spacing of 2.5 times diameter centre to centre or minimum 1.5 times diameter as clear spacing in order to mobilise frictional resistance, which is a key factor in achieving better Pile capacities. Larger spacing is always preferable, in case of bored piles.

PILE GROUP EFFICIENCY
Pile group efficiency will depend on the pattern of arrangement of piles and number of piles in a group. An efficiency of about 60 to 70% shall be considered for the onsite soil condition, in general. However, it shall be decided based on pile load tests. Sequence of casting of Piles shall be such that the adjacent Piles do not get affected during Pile drilling. Tremmie concrete shall be carried out in order to minimize segregation. Water-cement ratio shall also be controlled in order not to be affected by water, existing inside the Pile boring. Gradual pull out of Pile casing is necessary, to avoid necking of Piles.
UPLIFT CAPACITY

Uplift capacity of piles shall be considered as 50% of the ultimate frictional capacity of Piles.

PILE TESTING

The group efficiency shall be worked out based on number of Piles in a group. However, Pile load tests are recommended to observe the performance of the Piles and to re-confirm the theoretical Pile capacities. Load tests to be carried out after a minimum period of 1 week after driving of Pile.

Pile load tests should be conducted by loading up to 1.5 times the service load on working Pile, while minimum two (2) times the service load on Pilot Piles. A minimum of (two) 2 pile load test can be conducted for this project.

FOUNDATION CONSIDERATIONS

All fill material should be removed till appropriate depth and replaced by rock/gravel fill material/ or A PCC (Plain cement concrete) till reaching the recommended foundation level.

Ground water was encountered at 1.60m below the existing ground level during the time of field investigation. Hence dewatering will be required while excavation below 1.60m depth. Necessary measures shall be taken to control the flow of water at the foundation excavations during foundation concrete.

A PCC (Plain Cement Concrete) layer of 15cm thickness is recommended below the foundation. Any over excavation in the foundation trenches should be re-filled by plain concrete or gravel and any disturbed and loose materials found in the foundation trenches should be removed before placement of P.C.C.

CHEMICAL ANALYSIS OF SOIL

In the proposed site, the sub soil consists of sulphates in the range of 0.0006 to 0.0008 % & chlorides in the range of 0.01921 to 0.0193 % and the pH value in the range of 9.65 to 9.73 (10% solution). Hence, it is suggested to use Ordinary Portland cement (Type – 1) for the construction of all underground members, because it will resist the chloride attack better than other type of cement. A minimum cover of 50mm is recommended for the steel reinforcement with minimum cement content of 350 kg/m$^3$ for foundation concrete.
UPLIFT CAPACITY

Uplift capacity of piles shall be considered as 50% of the ultimate frictional capacity of Piles.

PILE TESTING

The group efficiency shall be worked out based on number of Piles in a group. However, Pile load tests are recommended to observe the performance of the Piles and to re-confirm the theoretical Pile capacities. Load tests to be carried out after a minimum period of 1 week after driving of Pile.

Pile load tests should be conducted by loading up to 1.5 times the service load on working Pile, while minimum two (2) times the service load on Pilot Piles. A minimum of (two) 2 pile load test can be conducted for this project.

FOUNDATION CONSIDERATIONS

All fill material should be removed till appropriate depth and replaced by rock/gravel fill material/ or A PCC (Plain cement concrete) till reaching the recommended foundation level.

Ground water was encountered at 1.60m below the existing ground level during the time of field investigation. Hence dewatering will be required while excavation below 1.60m depth. Necessary measures shall be taken to control the flow of water at the foundation excavations during foundation concrete.

A PCC (Plain Cement Concrete) layer of 15cm thickness is recommended below the foundation. Any over excavation in the foundation trenches should be re-filled by plain concrete or gravel and any disturbed and loose materials found in the foundation trenches should be removed before placement of P.C.C.

CHEMICAL ANALYSIS OF SOIL

The proposed site, the soil consists of the sulphates contain in the range of 0.0006 to 0.0008 % & chlorides contains in the range of 0.01921 to 0.0193 % and the pH value in the range of 9.65, to 9.73 (10% solution). However, it is suggested to use Ordinary Portland cement (Type – 1) for the construction of all underground members. A minimum cover of 50mm is recommended for the steel reinforcement with minimum cement content of 350 kg/m³ for foundation concrete.
GEOTECHNICAL INVESTIGATION REPORT FOR THE
PROPOSED CONSTRUCTION OF (G+12) RESIDENTIAL BUILDING
AT HULHUMALE, MALDIVES

BACKFILLING AND COMPACTION
Back filling materials around the foundations of building should be granular with durable
particles free of deleterious matter, meeting the graduation requirement as described for groups
A-1-a or A-1-b or A=2=4 according to ASTM D3282 classification system.

Back filling material shall be placed in horizontal layers not exceeding 25 cm thickness and each
layer shall be compacted to at least 95% of the maximum dry density in accordance to ASTM
D1557.

The (reclaimed fill) is not recommended as such. However, upon excavation and screening, it
shall be tested again to verify the suitability.

EXCAVATION

Excavation through at the overburden can be carried out by conventional equipment such as
dozers and poclain or rock dippers. As the water was encountered at 0.80m below ground level,
there will be a groundwater inflow during excavation and construction of foundations.
Dewatering shall be carried out as necessary. Well point system would be more appropriate.

GENERAL COMMENTS
The above allowable bearing pressure and the comments have been made based on the
borehole information obtained from the boreholes and laboratory tests, which were carried out
on the samples collected from the site. Number and location of boreholes were specified by the
client. The investigation and commentary are necessary ongoing as new information on
subsurface conditions becomes available. When foundation construction is underway, the
recommendations of this report should be checked through field inspection, to validate the
information for use during the construction stage. Any variation in underground conditions
revealed by the borehole should be brought to our attention for alternate recommendations, if
needed.

Yours Truly,

FOR JOSMAR CONSULTING ENGINEERS

Er.P.KALPANA, M.E.
Geotechnical Engineer
APPENDIX A

KEY PLAN & BOREHOLE LOCATION PLAN