

# Environmental Impact Assessment Report for Villa Hakatha - Thilafushi, Male atoll



Prepared for:  
Villa Hakatha, Maldives

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December, 2001

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## EXECUTIVE SUMMARY

### 1.0 INTRODUCTION

The Villa Shipping and Trading Company Ltd. (Villa Group) is proposing to establish a green field project for bulk fuel and cement storage and filling services in the Maldives. The project is named as Villa Hakatha Pvt. Ltd. (Villa). The facility is proposed to be located in Thilafushi Island which is 5.7Km miles to the west of Male, the capital of the Republic of Maldives. This island has been earmarked for industrial development by the Government of Maldives

This project consists of LPG Horton Spheres and bottling facility, petroleum storage tank farm and cement silos and packing plant and Nitrogen/Oxygen production plant. The proposed facility will be comparable to the best in the world through the use of state of the art technology, control systems, highly trained manpower and an effective Environmental Management System.

#### Terms of Reference

An Environmental Assessment (EA) is required by the Government of Maldives, for development projects such as the one being proposed by Villa. An EA is also required by the International Finance Corporation (IFC), whom the Villa Group has approached for finance.

Villa has engaged the services of Land & Marine Environmental Resource Group (Lamer) Maldives for carrying out the EA. Lamer has been assisted by Serene Environmental Services (SES), India for carrying out this EA. The Scope of Work of this EA includes:

- Determination of baseline environmental status at site locations for environmental parameters.
- Identification of various polluting sources and quantification of pollution loads.
- Determination and evaluation of environmental impacts.
- Environmental Mitigation measures for the adverse environmental impacts.
- Developing an Environmental Management Plan for the facility

### 2.0 PROJECT JUSTIFICATION

#### LPG (Liquefied Petroleum Gas)

At present only a small proportion of the Maldivian households use LPG for cooking. Almost all of the consumers are located in the capital Male' (where approximately 27 percent of the population resides) and resorts. At present the household consumption rate of LPG in the capital Male, is approximately 6670 metric tons per year, which has to be imported in both storage tankers and cylinders. Cooking gas cylinders are not readily available in the atolls (where 73% of the population lives). Recently, the demand for cooking gas has increased considerably in the Maldives

With this recent demand, the proposed storage facility of 3 LPG Horton Spheres (1750 m<sup>3</sup> each), Villa can realize the potential of providing LPG at an affordable price for the

majority of the households throughout the country, thereby replacing firewood and kerosene as the main fuel source for domestic and industrial use.

### Fuels (Diesel & Petrol)

Similar to the LPG business, Villa has been in the business of both fuels (diesel, petrol and kerosene) and building material including cement since its inception. Like LPG, fuel storage too was on board tankers, which by any means is a very costly method. Villa is one of the suppliers of fuel oil to the resort islands and owns a fleet of distribution tankers.

Villa has been trying to acquire land in the vicinity of Male (The largest consumer-Island & commercial Hub) for a long time. This diesel & petrol, facility at Thilafushi will reduce the cost to the extent where a healthy competition in the domestic market can be created, bringing down the retail prices significantly. Fuel storage at Thilafushi consists of 21000 metric tons of diesel, 3000 metric tons of petrol and 6000 metric tins of heavy oil.

### Cement (Bulk storage with Bagging facility)

Cement used to be imported in small bags (50 kg) and stored in Male'. However, with the increased scarcity of land Government of Maldives does encourage cement storage in Male for health and safety reasons, where Male is very much over crowded.

There is high demand for cement and other construction material with developed construction industry booming throughout the country and the current market trend increase in consumption of cement is expected to continue for years. There is an existing bulk storage & bagging facility situated in Thilafushi Island and has been in business for few years catering to less than 40% of the national demand. The rest of the supply is in imported bags, but stored in and distributed from Thilafushi Island.

The Cement storage and packaging facility at Thilafushi has been anticipated to meet the ever increasing demand and to cater for the construction industry. The cement storage structures consist of 4 silos of 2000 metric ton capacity each, with 2 packaging plants (900 bags/min) total.

## **3.0 PROJECT SITE**

Thilafushi Island has been created by reclamation by the Govt. of Maldives. The reclamation activity started as a land fill site to dispose the large amount of waste generated from Male, the capital near by has been continuing since 1991. Recently (1999) this land fill site has been expanded through reclamation of the lagoon by excavation and suction dredging. The initial land fill area (Thilafushi 1) has been designated by the government as a landfill site for garbage from Male and other islands including tourist resorts. Thilafushi 1 and 2 (areas expanded through reclamation and consists of reef sediments) have been made available for industrial activity.

The existing area of Thilafushi is 2.3sqKm. The nearest inhabited island is Villigili located 3.7km away in the east direction. Thilafushi 2 and 3 consists of a few industrial facilities including LPG storage and bottling facility (Owner; State Trading Organization), Fibreglass boat construction and motor boat service facility (Owner; Gulf Craft Pvt. Ltd.)

## 4.0 PROPOSED PROJECT INFRASTRUCTURE & UTILITIES

### 4.1 Major Installations

The major installations of the Villa facility are given below in Table A.

Table A: Major Installations of Villa Hakatha

Building Details	Description	Major Equipments To Be Installed
Main Installations	LPG Spheres	3 LPG Horton Spheres – 1700 m <sup>3</sup> /tank
	Fuel Farm	Diesel : 2 tanks x 9000 tons/tank 1 tanks x 3000 tons/tank Petrol : 1 tank x 3000 tons Heavy : 2 x 6000 tons/tank Oil
	Cement Silo & Packing facility	2000 MT/Silo x 4 Silos +2 cement packing plants – 900 bags/minute/plant
	Oxygen & Nitrogen Production and filling plant	Oxygen at a rate of 63 Sm <sup>3</sup> /hr Nitrogen at a rate of 60 Sm <sup>3</sup> /hr.
	LPG Filling Hall	300 bottles of 12 kg per hour.
Utility Building	A single storey building from where electricity, water and air is supplied to the whole site.	Generators: 1 x 450kVA, 1 x 750kVA & 1 x 1000kVA Desalination Plants: 1 x 10m <sup>3</sup> /day and 1 x 100m <sup>3</sup> /day  Air Compressors & Water Pumps.
Store/Kitchen/ Dining and Accommodation Building	A multi-storey building for Kitchen/ Dining with 38 single-bed-capacity for accommodation. Ground floor is allocated for General store area.	Kitchen Equipments
Refilling Station	Hut with Fuel Dispensers (Diesel & Petrol)	Road side Filling Station: A small hut with sales counter & few sales items
Administrative and Senior Staff Accommodation Building	A multi-storey building with 28 rooms in 1st & 2nd floor for accommodation, office & admin area in the ground floor. and a control room on 4 <sup>th</sup> floor.	Control & Monitoring Panels for LPG, Oil and Cement. Fire Panel for the site.

### 4.2 Project Infrastructure and Utilities

Land and Area: The facility is spread over 300,000sqft.

Coastal Structures: The facility comprises of a sheet pile quay wall of length of about 300m installed on the northern coast.

**Manpower:** A total of 80 personnel will be employed for all activities. This manpower includes 7 operators, 73 staff and casuals.

**Water Supply and Treatment:** Water will be mainly required for domestic use. A total of 20 m<sup>3</sup>/day of water will be required. Water will be drawn from bore well and treated in the Reverse Osmosis unit and then used for drinking purpose.

**Power:** Power requirement of the plant will be met by way of 3 Diesel Power Generating (DG) sets - 1 x 450kVA, 1 x 750kVA & 1 x 1000kVA

**Fuel :** Diesel will be the only fuel required for the facility operation for running the DG sets.

**Compressed Air:** The compressed air system consists one air compressors of capacity 281 m<sup>3</sup> at 10bar and associated equipment such as air dryers, filters etc. Compressed air will be used for the pneumatic systems for LPG bottling, Cement packing and Silo operations.

**Material Storage Facilities and Warehouses:** Empty and filled LPG cylinders will be stored in the loading area of LPG filling room. Cement bags will handed over to the customer directly and surplus will be stored in the stores.

**Material Transport and Jetty Operations:** There will be 3 jetty landings for unloading and conveyance of LPG, Cement and Oil.

**Sanitary Wastewater Treatment:** Sewage from toilets and canteen effluent will be conveyed to a Sewage Treatment Plant (STP) of 50m<sup>3</sup>/day capacity for treatment. Treated water from STP will be conveyed for horticulture purposes. STP unit operations and layouts are given in Section 7 on Environmental Management Plan.

**Scrap Storage Yard:** A dedicated scrap storage yard will be constructed to separate store used oil drums and miscellaneous wastes such as packaging waste, domestic garbage etc.

**Drainage:** Dedicated storm water drains will be provided along the paved roads. The drain will finally discharge into the lagoon area adjacent to the facility to the north.

**Fire Protection Systems :** Fire fighting systems will be installed as per NFPA requirements.

**Water Treatment:** Raw water from the bore wells will be treated in the reverse osmosis (RO) plant of 90 KL/day capacity. This water will be chlorinated and supplied for drinking. The RO reject water will be discharged via pipeline outside the reef area.

### **4.3 PROCESS DESCRIPTION**

#### **LPG handling Operations**

Supply vessels and Tankers will station on the north side and flexible hoses on floats will be used to connect vessels cargo delivery pipe to the supply lines. LPG will be transferred via the supply lines to LPG Horton spheres. LPG will be filled in LPG bottles

in the state of the art 8 head carousel system. The design capacity is 300 bottles of 12 kg per hour.

The specially developed harbour for LPG cylinder handling will be used to load empty and filled cylinders, combining manual handling and conveyor belts that will take the cylinders through the filling hall and back. In addition to this, provision is also made for filled cylinders to be loaded to trucks so that they can be sent for in-land use or storage. This facility will also be used to take away cylinders for repair and bring back.

### Fuel Handling Operations

Here too, the supply vessels and tankers will station on the north side and flexible hoses on floats will be used to connect vessels cargo delivery pipe to the supply lines. The fuels (Diesel, Petrol and Heavy fuel oil) will be transferred to the respective tanks in the Fuel Oil Tank Farm.

Diesel and fuel oil will be sold mainly in bulk and petrol will be sold in drums. The drum transfer operations will be carried out in the calmer waters in the south side lagoon. The traditional transport boats "Dhoni" (with drums) and landing craft with Fuel Tank Trucks will have easy access to this special harbour in all weather conditions as this harbour is situated opposite the storage site and inside the protected & calm lagoon. Appropriately sized fuel dispensing units will be situated conveniently at this site for filling drums and tankers. In addition to this, higher capacity filling will be provided in this site as well as the main harbour side to fill small fuel tankers that are engaged in transporting fuel for tourist resorts and or others of higher consumption. These facilities may also be used to fill up the inter-atoll transport boats, if necessary.

### Cement Handling Operations

Bulk Cement Carrier will be stationed at the dedicated north side jetty and flexible hoses on floats will connect vessels cargo delivery pipe to the supply lines. The cement will be discharged pneumatically by the ship into cement silos.

Bulk Cement supply from the silos will be taken to the 2 packing plants of 900 bags/minute/plant capacity. Cement will be packed into 5 kg and 1-ton Jumbo bags. A Tower Crane will be installed to lift these bags directly form the packer and put on to the transport vessels / Carriers either alongside the Cement Harbour or at the main Jetty.

## **5.0 LEGAL AND ADMINSTRATIVE FRAME WORK**

### **5.1 Environmental Requirements of Republic Of Maldives**

There are many sectors of the Government of Maldives (GoM) which have a role to play in the management of the environment in the Maldives. Following are some of the government agencies who have a key role to play in the management of environment:

Ministry of Home Affairs Housing and Environment (MHHE) is central agency for environmental protection and related matters. This is mainly manifested at the level of policy, but since environmental law (Law No. 4/93) is essentially about the taking of discretionary, political decisions, this means that the MHHE has an enormous impact, which is apparent from the statements of the Law. Generally, the ministry is responsible

for monitoring the activities of the public and private sector to ensure that their activities and their management are consistent with government policies and a developed set of guidelines and procedures

Relevant Requirements under Environmental Protection and Preservation Act are;

Environmental Impact Assessment study shall be submitted to MHHE for any new developmental project. Process includes submitting a project proposal to MHHE. After review, MHHE will decide if an EIA is required. MHHE has the authority to terminate any project that has any undesirable impact on the environment. A project so terminated shall not receive any compensation.

Any waste, oil, poisonous gases or any substance that have harmful effect on the environment shall not be disposed within the territory of Maldives. In case disposal is necessary, they shall be disposed only within areas designated by the Government. MHHE or a designated Ministry(s) can impose a fine for breach of these laws. Fines range from 5 Rufiyaa to 500 Rufiyaa for minor offences under this law. Fines up to MRf One Hundred Million Rufiyaa can be levied for major offenses.

Ministry of Fisheries, Agriculture & Marine Resources (MoFAMR) is solely responsible for the management of living marine resources in the Maldives. Coral reefs and associated species are managed by MoFAMR. Laws and regulations concerning the management of coral reefs are formulated by MoFAMR.

Ministry of Construction and Public Works (MCPW) implements all major building and civil works projects carried out by the GoM. MCPW is also responsible for the management of solid waste in Male.

Ministry of Tourism (MoT) All aspects of tourism in the country are the responsibility of MoT. MoT has a number of regulations for management and preservation of the environment of the resort islands. Portions of the tourism regulations are applicable to these types of industrial facilities.

## ***5.2 International Finance Corporation (IFC) Requirements and Guidelines for Environment, Health and Safety***

### ***Environmental Assessment***

IFC requires environmental assessment (EA) of projects proposed for IFC financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making.

IFC undertakes environmental screening of each proposed operation to determine the appropriate extent and type of EA. IFC classifies the proposed project into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.

Category A: projects that are likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented.

Category B: A proposed project is classified as Category B if its potential adverse environmental impacts on human populations or environmentally important areas—including wetlands, forests, grasslands, and other natural habitats—are less adverse than those of Category A projects.

Category C: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.

Category FI: A proposed project is classified as Category FI if it involves investment of IFC funds through a financial intermediary, in subprojects that may result in adverse environmental impacts.

In addition to this, IFC rules and regulations that may be applicable to this project are;

Environmental, Health and Safety Guidelines Oil and Gas Development (Offshore)  
Environmental, Health and Safety Guidelines – Port and Harbour Facilities  
Environmental, Health and Safety Guidelines for Hazardous Materials Management  
Life and Fire Safety Guidelines  
Environmental, Health and Safety Guidelines for General Health and Safety. These includes;  
Workplace Air Quality  
Workplace Noise  
Work in Confined Spaces  
Health - General  
Safety - General  
Drinking Water  
Training

## **6.0 POLLUTION SOURCES, CHARACTERISTICS AND QUANTIFICATION**

Environmental pollutants are expected both during the construction and operation stages of the project. Several operations of the Villa Hakatha project will generate pollution in the form of air emissions, wastewater and solid wastes. Accidental scenarios such as oil spills from fuel handling operations and fire/explosions from LPG handling and fuel handling operations are also possible. The following operations of the Villa facility's bulk material handling operations have the potential to generate various environmental pollutants :

Cement transfer operations  
Cement packing plant  
Oil storage and transfer operation  
Compressors  
Diesel Generators  
Canteen  
Raw Water Treatment  
Sewage treatment Plant

The pollutant loads from these operations have been quantified.

## **7.0 EXISTING ENVIRONMENT**

### **7.1 General Setting**

The island of Thilafushi lie at coordinates 73°26'E and 4°11' N on Thilafalhu which lies on the southern periphery of North Male Atoll. Thilafalhu is a long ribbon shaped faro that has an enclosed deeper lagoon (vilu). To the east at about 1km from Thilafushi is Gulhifalhu, which is a round shaped faro. These two faros are separated by a narrow and deeper pass. The island is not a naturally formed island but originates from the dumping of solid waste from Male and the nearby resort islands. The land fill operation at Thilafalhu started during 1991 and since that time up till now an area of 2sqkm have been reclaimed from Thilafalhu by dumping solid waste

### **7.2 Geology of Thilafushi**

Thilafalhu is a reef that consists of live coral, coral fragments and coral fine sand. The soil investigation works for the proposed project (May 2000) indicates the thickness of the reclaimed layer has depths about 2.33m. This is a layer consists of a loose, well graded, fine graded sand.

Underlying the reclaimed layer of sand is the coral reef formation. The soil samples obtained from this formation indicated that the original coral reef has been exposed to weathering. This weathering is a destructive or disintegrating process by which rocky material on exposure to atmospheric agents such as atmospheric oxygen or circulating seawater, changes in colour, texture, structure, composition and form.

### **7.3 Climate And Oceanography**

The climate of Maldives is dominated by the monsoons the North East (NE) monsoon from December to February and the South West (SW) monsoon from May to September. Strong winds and gale force winds are infrequent in the Maldives and cyclones do not reach Maldives because of the negligible Coriolis force in these latitudes. However, storms and line squalls can occur, typically in the period May to July: gusts up to 50–60kts have been recorded at Malé during these storms

Tides in the Maldives are diurnal-semidiurnal type with a tidal range about a meter. The tide station at Hulhule is the closest station to Thilafushi where the tidal data have been recorded for over 30 years. It has been assumed because of the close proximity of Rasfaree to this tide station that the tidal behaviour at Thilafushi would not differ much from that at Hulhule. Seasonal variations in Mean Sealevel in the Maldives are very small.

Thilafalhu is exposed to two main types of waves, the oceanic swells from the south of the reef and the local wind generated waves from a northerly direction. The oceanic swells approaching the shores of Thilafushi originates in the storm in the Indian Ocean. The oceanic swells reaching Male Atoll have been recorded to have wave periods of about 10sec (Seawall Study). These waves have an average wave heights of about 0.5 – 1.0m.

Currents in and around Thilafalhu could be generated by the tides, winds or by wave. Tidal currents on the reef flat are not expected to be very strong because of the limited tidal range. Wind induced currents however, could be significant during times of strong winds usually during the SW monsoon.

#### **7.4 Marine Environment**

##### Reef and Fishes

The marine environmental conditions at the project site were studied in December 2001, using standard marine survey methodologies. These include line intercept survey method for the assessment of reef benthic community and the visual census methodology for the assessment of the fish community.

This ecological study is an attempt to describe the existing marine environmental condition at Thilafushi 2, specifically at the proposed project site. It has been recognized that the proposed project implementation would have little impact on ecological functioning of the reef. It is evident that significant environmental impact has already been resulted due to reclamation of the reef flat, where the ecological condition there, has been altered from a marine ecosystem to a land based terrestrial system. This has directly resulted in elimination of the immobile reef benthic organisms particularly corals and their habitat on the reef flat. It is also evident that some modification has been resulted to the reef ecosystem in the vicinity.

The project site is located on the northern coastal periphery of Thilafushi 2 and this environmental evaluation is based on the reef environment immediately adjacent to this site.

##### Significant findings of the Reef Benthic Community survey:

Live coral cover was relatively low for all transects surveyed.

Coral cover ranged from very low 0.4% to 13.4% on the reef areas surveyed.

There is no significant difference in live coral cover between the two depth contours.

Over 90% of the reef substrate consisted of coral rock, rubble and sand.

Coral rubble and sand contributed to 30 – 95% of the reef substrate. These rubbles have originated from branching coral forms that may have been part of the coral community in these locations.

Filamentous algae and turf algae also forms a significant part of the reef benthos however, highly variable between the transects.

Previous studies as part of the reclamation for Thilafushi 2 has reported similar results on reef benthos.

From the results of the present study and the previous studies, it can be concluded that the reef environment around Thilafushi has experienced some inevitable damage to the reef as result of the reclamation. The physical alteration of the reef flat from a shallow water reef to a dry terrestrial habit has consequentially caused this damage together with

other factors that may contribute to reef damage. Among these, the most significant damage to the reefs has been caused by mass coral bleaching event, which severely affected the reefs in Maldives. Live coral cover in shallow reef areas around Maldives was reduced from 40-60% (average value for a healthy reef) to less than 5%.

Fish census surveys showed similar trends in terms of abundance of fish at the two sites surveyed. Between 20 and 33 species of fishes belonging to 13 groups of fish were recorded. Butterfly fishes and angel fishes are frequent despite the low live coral cover but the reef slope is characterized by relatively high topographic relief which may have been the reason for the diversity and abundance of fish species.

Commercially valuable food fishes such as jacks and snappers are also recorded here though not in abundance.

Fusiliers, a popular baitfish species are also observed schooling in the vicinity. Damselfishes and surgeon fishes are abundant at the two depths surveyed and more conspicuous in algal dominated areas in the reef.

#### Protected Sites and Species

There are 25 marine protected dive sites in the Maldives mainly in the tourism zone atolls. Many of these sites are located in Male atoll. "Lion Head" is one such protected dive site in North Male atoll and is located on the southern side of Thilafushi reef. Significant features of this site include Grey reef sharks, Napoleon wrasses and many other pelagic fish life.

Many marine species are legally protected in the Maldives. These include whale and dolphins, sharks (in the tourism zone atolls), sea turtles, Napoleon wrasses, black coral, giant clam and many others. A small number of protected species were observed at the project site. These included Napoleon wrasses and a small green turtle. Napoleon wrasses are territorial and hence appear as residential to this reef area.

#### Seawater Quality

The parameters tested for showed typical values as that of standard seawater indicating good quality of the water samples. Similar results were also reported for the water quality tests carried out in the vicinity in different surveys (1993-1997) and 1998 (JICA report 1998). This is indicative of the high level of dispersal and dilution ability in the surrounding waters of Thilafushi despite the continued solid waste dumping in the vicinity.

It should however be noted that the samples taken are targeted from the project site and does not include adequate samples to quantify the effects of Thilafushi waste disposal effects on the reef environment. Therefore it should not be generalized and considered conclusive that the on going solid waste disposal and the related dredging activities and its constituents would not contribute to some level of contamination.

### **7.5 Terrestrial Environment**

#### Ambient Air Quality

Baseline ambient air quality data is not available. However, visual assessment of the site did not indicate any problems with air quality. This is due to large open areas on all

sides. However, Thilafushi is a dumpsite for all sorts of waste emanating from Malé, resorts and some of the other islands. Open burning of all kinds of waste takes place on Thilafushi, as a result of which, depending on the direction of the wind, smoke containing hazardous substances may be present at times on the Villa Hakatha site as well. One of the main concerns would be the production of ground level ozone due to reaction of nitrogen oxides and volatile organic compounds in the presence of sunlight. Burning of plastics at low temperatures would also produce carcinogenic toxins that may impair health of those working in the vicinity. In addition to health impacts, ecological and material damage due to some of the pollutants and soot is of concern.

### Ambient Noise

Sound levels were measured at different locations around the office complex and the generator house using a digital sound level meter. The source of the noise is the diesel generator sets during construction and even during the operational phase. At the time of sampling the windows of the generator house was open. Hence the noise levels were above acceptable standards around the powerhouse and inside the office. Behind the office complex on the opposite side of the road is a small powerhouse of Gulf Craft Motor Boat Yard. The noise from this powerhouse also has a cumulative impact on the noise levels near the office building and perhaps inside the office.

Since the island is a landfill and industrial island, there are no residential and recreational receptors on the island. The site office is basically the only noise sensitive area in the facility boundaries. However, the noise level inside the site office conforms to acceptable standards.

## **8.0 ENVIRONMENTAL IMPACTS**

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes, present information and monitor actual changes.

### **8.1 Impacts On Ambient Air Quality**

Maldives does not have any air emission and ambient air quality (AAQ) standards or guidelines. Thus emissions from the proposed operations have been estimated and a qualitative impact assessment on AAQ has been made based on engineering judgments, inherent process safeguards and existing site conditions.

During the construction phase, air emissions are mainly expected from earth moving activity and exhaust from the diesel generator. These emissions will not have any significant negative impact on Ambient Air quality (AAQ).

The Villa Hakatha facility is not expected to have any significant negative impact on the AAQ due to the following reasons:

Use of fuel-efficient DG sets. The emissions from DG sets will be discharged through a single 18m high stack. This stack height is adequate to disperse the pollutants sufficiently. Fuel used will be of good quality with about 0.5 % sulphur content.

The emissions from cement silos and packing plant will be vented through dedicated high efficiency bag filters (Efficient +99%). Cement transport from ship to silos and thereafter to packing plant will be through enclosed pipelines. Plant roads will be largely asphalted thereby minimising dust entrainment from roads into the atmosphere due to vehicle movement.

## **8.2 Impacts On Ambient Noise**

During the construction phase, high noise generation emissions are mainly expected from the diesel generator. The impacts from these emissions are insignificant due to the following:

The day and night time noise level monitored at the facility boundaries varied between 50 and 65 dB (A) during operation of DG sets. This is within 70 dB (A) and 75 dB (A) night and day noise guideline value prescribed by the IFC EHS guidelines for Construction, Material and Plants.

Also, Thilafushi Island has been designated as an industrial zone. There are no public and residential areas on the island, apart from the plant personnel residential facilities. Thus it is concluded that there will be insignificant negative impact on community noise due to construction at site.

## **8.3 Water Availability And Drinking Water Quality**

The water requirement for operations will not exceed 20 m<sup>3</sup>/day. Water requirement will be met from bore well on site and by seawater after treatment in reverse osmosis facility. There are no public areas in the island sourcing groundwater. Also industries on Thilafushi are similar to that proposed at Villa Hakatha and are not water intensive. Thus adequate amount of water is available for the project activities and no negative impact on water availability is expected.

Treated water quality after RO treatment (Manufacturer Specifications) will comply with the WHO guideline values for drinking water.

## **8.4 Surface & Ground Water Quality**

Coral island aquifers are vulnerable to many pollutants and contaminants because of high permeability. The poor nature of the soil in many islands, which is generally poor in organic contents, has not the adequate structure to attenuate pollutants most effectively. The depth to the surface of the groundwater is also another factor that poses potential threats to its pollution. In the case of many islands, this is only a couple of meters. Thilafushi over time has now developed a thin freshwater lens on top of the seawater beneath the reclaimed land.

Small amounts of suspended solids are likely to be discharged into the reef area during rains, however, this quantity will be insignificant due to presence of sheet piles and boundary structure. Impacts are not likely to be significant.

Sanitary wastes from labour camps could contaminate surface and groundwater resources if discharged untreated. The wastewater will be treated in septic tanks and

discharged through soak pits away from any well locations. Thus impacts due to sanitary wastewater discharge will be insignificant.

#### Impacts Due to Accidental Petrol/Diesel and Cement Spills

Credible spill quantities in the marine area due to unloading operations are 10 m<sup>3</sup> of petrol, 20 m<sup>3</sup> of diesel and about 1 m<sup>3</sup> during fuel dispensing into drums loaded on boats. 5 to 7 tons of cement is also likely to spill into the marine environment in case of rupture or snapping of cement unloading line.

The diesel and petrol storage tanks would be secured with a bund wall to contain potential leakages in case of accidents. When and if such incident happens the amount of leakage onto ground and contaminate groundwater would be minimal.

When such spills and leakages occurs the mobility of the fuel depends on the viscosity of the fuel and the nature of the hydrocarbons. Crude oil derivatives such as diesel and petrol are significantly soluble in water and can contaminate water quite quickly. Oil leakages would be easily detected by taste and odor at concentrations less than 0.005 mg/l.

In situations where oil penetrates the water table zone and then spreads out, the effect of water table fluctuation would become important for its dispersal. The migrating oil film created by a spill or leakage would spread towards sea with falling tide and this would be significant in small coral islands.

### **8.5        *Impacts On Marine Environment***

#### *Impact due to sheet piling*

The shallow reef flat on the northern side of Thilafushi has already been physically modified and altered from the reclamation of this area carried by the Ministry of Public Works (GOM). This reclamation extended up to the reef slope. The entire northern periphery (water front) of the project side has been constructed by steel sheet piling. This has evidently modified the reef in this area quite considerably, which would have inevitably caused irreversible damage to benthic flora and fauna. Sedimentation from this operation would also have caused smothering of corals and other benthic organisms but the extent and impact from this would be considerably less compared to the impact from the reclamation.

#### *Impacts due to accidental spill of fuels and cement*

Fuel (petroleum based) and cement spill can have a serious impact on the reef environment depending on its magnitude and scale. The effects of a particular oil spill depends on many factors not least the properties of the oil. Complex processes of oil transformation in the marine environment starts developing from the first moment of oil's contact with seawater. The progression, duration and the result of these transformations depend on the properties of the composition of oil itself and the environmental conditions. Diesel and petrol fuels are of low viscosity in its properties and have relatively high evaporation rates. The most toxic constituents of oils are often the most volatile and hence evaporate rapidly. Because of this lethal concentration of toxic components leading to large-scale mortalities of marine life are relatively rare, localised and short-lived. It is also noted that the water depth in the vicinity of the fuel unloading area is relatively deep (no intertidal area), thus contamination of the benthos from oil would be

rare unlike shallow reef area where clean-up processes are few and difficult. Therefore, given the nature of the fuel handled in the facility and its potential accidental spill would also be short-lived and localised. An oil spill response plan has been prepared (Separate Report) and all response actions will be as per this plan.

Cement spill and its effects would also be localised when and if it happens. Smothering of benthic organisms would be inevitable but the severity of the impact would be related to the hydrology of the receiving water body. Cement smothering would have some lethal to sub-lethal effects on coral and other benthic organisms. These would range from total mortality of the organism impacted, to impairment of physiologically important processes such as respiration and reproduction. Although these impacts may be severe in case of any spill, it would be very localised

### **8.6 Impacts On Topography And Geology**

As mentioned earlier, Thilafushi Island has been formed by reclamation activity. The reclamation was done to create a place for solid waste disposal for the city of Male' and surrounding islands. This activity has altered the very ecosystem of the area transforming it from a reef flat to large terrestrial ecosystem.

The site construction activity of Villa is not modifying the land mass of the project area significantly and this would be insignificant compared to what has already been modified at the site at large.

Soil quality in the study area is not expected to have any significant negative impact due to the following reasons:

All solid and hazardous wastes will be handled and stored in designated containers and locations. Strict adherence to the Environmental Management Plan described in this document

Major process areas will be asphalted and thus there will be no leaching of contaminants in case of accidental spills.

Tank farms areas and other areas prone to spills have dikes for spill control and thus there will be no uncontrolled soil contamination due to accidental spills.

All plant areas will have good housekeeping, thereby minimising material losses, which may find its way into storm water drains and contaminate soils.

### **8.7 Impacts On Terrestrial Ecosystem**

As Thilafushi, especially the industrial zone, is a recently reclaimed area, there are no native flora and fauna on the island. Thus, this project will not have any negative impact on the terrestrial ecosystem.

### **8.8 Impacts On Socio-Economy And Community**

Thilafushi has been designated as the island for industrial activity and disposal of wastes. The island was formed by reclamation for the above purpose and did not consist of any human population. No rehabilitation and resettlement of people is required. The project is the second industrial venture in the country and likely to boost the economy of the region.

Most of the staff will be staying on site and adequate sanitation and health facilities will be available on site including residential accommodation, water supply, medical facilities etc. Thus a major positive impact is expected on socio-economic front in the area.

### **8.9 Historical, Archaeological Or Architectural Sites Compatibility**

Historical, archaeological or architectural sites in the area form another important aspect of aesthetics. Such monuments need to be preserved and maintained, and care should be taken to ensure that there are no adverse impacts resulting from the project operations, if located in their proximity. There are no architectural monuments of any significance on Thilafushi Island and hence no negative impact is expected.

## **9.0 ANALYSIS OF ALTERNATIVE PROJECT SITES**

Thilafushi Island has been created by reclamation by the Govt. of Maldives. The island has been subdivided into 3 major sections – Thilafushi 1, Thilafushi 2 and Thilafushi 3. Thilafushi 1 has been earmarked as a landfill site for garbage from Male. The land filling activity had commenced from the year 1991. Thilafushi 1 and 2 have been made available for industrial activity.

Government of Maldives (GOM) is currently permitting industrial activity of this nature, only on Thilafushi Island. Thus there is no alternative, but to establish the Villa facility at Thilafushi and environmental assessment for possible alternative sites was not carried out for this project.

## **10.0 ENVIRONMENTAL MANAGEMENT PLAN**

### **10.1 Environmental Mitigation Measures**

Adequate environmental management measures need to be incorporated during the entire planning, construction and operating stages of the project to minimize any adverse environmental impact and assure sustainable development of the area. The EMP presented below should be followed and regular monitoring of concerned parameters should be done. The EMP should be proactive in nature and should be upgraded if new facilities or modification of existing facilities, with environmental concerns, come up at a later stage. The mitigation measures presented below covers various environmental parameters such as :

- Air Pollution Control and Management
- Effluent Treatment and Management
- Hazardous and Solid Waste Management
- Occupational, Safety and Health issues
- Emergency Response Plans for emergency scenarios
- Plans for managing other operational issues
- Environmental monitoring
- Environmental Management System at Villa

Action plan for mitigating the adverse affects of the above are given as Action Plans in the EA report. A summary of waste generated from various activities, the mitigation measures taken, safety and occupation health issues etc. are given in Table B.

TABLE B READY-RECKONER OF WASTE MANAGEMENT

ACTIVITY AREA / CONCERN	WASTE / ISSUE	HANDLING AND DISPOSAL	PROCEDURE	MONITORING / Inspections	RECORDS
LPG Storage/Filling	No significant wastes	--	--	--	--
	Accidental fire /explosion	--	Procedure for periodic inspections/checks as per vendor specs.  Work Instructions for Emergency Response to be made (as per Emergency Response Plan)	Safety audits Fire drills Equipment inspections as per specs.	Maintenance records. Incident records.
	Occupational Safety and Health	PPEs for fire fighting such as fire jackets, SCBAs etc.	--	All equipment to be calibrated and inspected as per vendor specs.	--
Oil Storage / Oil Jetty/ unloading and dispensing.	Oily storm water discharge from dyke areas.	Oil interceptor pit.. Oil will be removed and pumped back.	--	--	--
	Oil spills from storage tanks/pipelines on land	Clean up as per procedure.	SOP for un-loading and dispensing. SOP for spill clean-up.	Maintenance/ Inspections of Pipelines/valves etc. as per vendor specs.	Spill incident records
	Oil spills in marine areas.	As per oil spills contingency plan	SOP for un-loading And dispensing. SOPs for response as per plan. Insist on strict compliance with international codes such as MARPOL etc.	Spill response drills. Maintenance/ inspections of spill control equipment and gear as per vendor specs.	Spill incident records. Drill records. Inventory of dispersants for spill control.

	Sludge from storage tanks	Will be collected in sludge tank and sent to Thilafushi1 in Govt. landfill site.	Work Instruction for sludge handling.	--	Sludge disposal records.
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TABLE B Cont.

ACTIVITY AREA / CONCERN	WASTE / ISSUE	HANDLING AND DISPOSAL	PROCEDURE	MONITORING / Inspections	RECORDS
	Occupational Safety and Health	PPEs for fire fighting such as fire jackets, SCBAs etc.	--	All equipment to be calibrated and inspected as per vendor specs.	--
Oil Storage / Oil Jetty/ Oil dispensing etc.	Accidental fire /explosion	As per Emergency Response Plan.	Procedure for periodic inspections/checks. Work Instructions for emergency response.	Safety audits Fire drills Equipment inspections as per specs.	Maintenance records Incident records
DG POWER GENERATORS	Used oil during oil change operations	To be stored in designated drums in the Room. Oil to be reused or sent to Thilafushi 1 disposal site.	SOP for handling used oils to avoid spills	--	Used Oil generated and disposal records
	Oily rags and other used spares from maintenance	To store in designated area in DG room and to be disposed along with other wastes to Thilafushi1.	Work Instructions for waste handling, storage and disposal.	--	--

	Air Emissions	To be let out from 18 m Stack. Use of low sulfur clean fuel.	--	Periodic Fuel quality inspection	Records of fuel quality
	Noise	Operators to use ear plugs.	--	--	--
WATER TREATMENT PLANT	RO rejects	To sea via marine outfall	--	--	--
STORES/ Administrative block/ Residential block	Packaging and office waste – Cartons, paper, plastic etc., Domestic garbage	To be stored in dedicated Waste Storage area and Sent to Thilafushi1 for disposal .	Work instruction for storage and handling.	--	Waste generation and disposal records.

TABLE B Cont.

ACTIVITY AREA / CONCERN	WASTE GENERATION /Issue	HANDLING AND DISPOSAL	PROCEDURE	MONITORING / Inspections	RECORDS
Cement Storage and Packing Plant	Air Emissions from Silos and packing plant	Filtered in Bag Filters.	SOP for Bag-Filter maintenance.	Bag-filter inspections as per vendor specs. Monitoring of pressure drops to assess filter performance.	Maintenance records including number of bags, solenoid valves etc. replaced.

	Occupational Safety and Health	Face masks, goggles for operators.	--	Work-place air monitoring for PM <sub>10</sub> inside packing plant every 6 months. Bag-filter differential pressure checks and maintenance as per vendor specs.	Work place monitoring records.
STP	Treated effluent	To be used for horticulture.  In case of STP break down, effluent after primary treatment will be discharged into sea via marine outfall.	As per O & M Manual	Monthly analysis of SS, O&G.	O & M manual Vendor Specs. Monitoring records. STP Operating Hours
	STP sludge	Sent to Sludge drying beds and used for horticulture	As per O& M Manual	As per O& M Manual	As per O& M Manual
DRAINAGE AND HOUSEKEEPING	Contamination in storm water discharge	Storm water inside premises collected in separate storm water drains and discharged outside plant. Through screens to trap trash etc.	Develop Storm Water Management Plan to minimise leaks/spills etc. entering storm drains.	As per Plan	Work instructions for house-keeping.

### Plantation and Landscaping

The plantation will have several benefits on the environment of the project area, such as :  
Control of wind blown fugitive dust and dust due to vehicular movement.  
Plantation will also help in binding the soil and in turn reduce soil erosion.

Due to space constraints, a small area near the facility boundary will be available for plantation. The following considerations will be made before selecting plant species:

Tall growing, evergreen trees, native to the area  
Easy and quick early growth and establishment.  
Uniform spreading crown habit.  
Evergreen habit, if possible, or at any rate short deciduous period  
Ability to withstand conditions like inundation, salinity and draught  
Soil improving plants (Nitrogen fixers, rapidly decomposable leaf litter).  
Attractive appearance with good flowering and fruit bearing.  
Sustainable green cover with minimal maintenance

### Requirements for Vessels Carrying Fuel OIL/ LPG/Cement

All vessels carrying bulk fuel oil, LPG and Cement to the Villa Hakatha site, will be required to comply with various international requirements for safety and marine environment protection. The vessels will be required to comply with the applicable codes such as

MARPOL 73/78, including requirement of Shipboard Oil Pollution Emergency Plan (SOPEP)  
Requirements of the ISM Code and for issuing the appropriate certificates.  
Cargo ship Safety Construction Certificate  
International Load Line Certificate  
Cargo Ship Safety Equipment Certificate  
Certificate of Class  
Cargo Ship Safety radio Certificate  
Certificate of Fitness (Under SOLAS) for LPG carriers

## **10.2 Environmental Management System**

The Environmental Management System (EMS) will be developed for the Villa Hakatha Project.

The EMS will be driven by:  
An Environmental management cell  
EMS Documentation – SOP's, management plans, records.  
Regular Environmental Audits and Corrective Action

In general, all plant personnel connected with tasks which could have a significant environmental impact will be made aware/trained in environmental issues. As the facility is not yet in operation the team for EHS cannot be confirmed. The EHS responsibilities will be handled by the plant personnel. As the facility area is not extensive, a dedicated Environmental Professional is not envisaged. The environmental manager will be designated from the plant operation management. Safety officer, however, will be employed for co-ordinating all safety aspects of the facility.

The EMS documentation will consist of :

Standard Operating Procedures (SOP's) for significant environmental issues and tasks,  
Environmental records and logs.

Good Environmental Practice guidance documents

External/internal EHS correspondence.

Fire fighting, monitoring equipment and other critical equipment calibration and maintenance records.

Records of Vessels used for bulk transport of LPG, Fuel Oil and Cement – Their Names, capacity, Owner/Operator, Copies of various certificates.

### **10.3 Environmental Monitoring And Reporting**

#### Reporting Parameters

Environmental monitoring is an important on-going activity, which helps in tracking environmental performance. Monitoring requirements such as monitoring parameters, locations, frequency etc. are described in the Action Plan of the document in this section.

Reporting of Environmental Performance results is an important element for keeping various stake holders such as IFC, Villa Group, Govt. of Maldives and other investors. The following parameters need to be documented at the Villa site and reported periodically to the various stake holders:

Consolidated summary of analysis results for groundwater, marine water quality.

Summary of treated sewage water quality and final use.

Summary of marine surveys for reef benthos, fish habitat.

Workplace monitoring results for PM<sub>10</sub> in Cement Plant.

Number of incidents and causes of fire, explosions, marine oil spills and sewage treatment plant failures. Reported impacts of such incidents should be enumerated. Corrective actions suggested and implemented should also be reported.

Environmental and safety audit findings and corrective action plans.

Cost of operation and maintenance of pollution control equipment such as STP, Bag-filters etc.

#### Reporting

Detailed formats for reporting of the above data will be prepared by Villa within 2 months of start of operations. Review of the actual operations will allow preparation of practical reporting formats. These will then be sent to IFC for approval.

The frequency of reporting will vary depending upon the requirements of individual stake holders:

For the first year after commencing operations, 6 – monthly reports of the above data will be sent to IFC. Thereafter for subsequent years, annual reports shall be submitted.

The period of reporting to GOM, will be as specified in their Environmental Permit or Permission to operate the facility.

## **11.0 RISK ASSESSMENT AND EMERGENCY RESPONSE**

Separate <sup>1</sup>HAZOP study <sup>2</sup>Risk Assessment Study have been carried out and <sup>3</sup>Emergency Response Plans have been made for the Villa Hakatha Project. These studies are presented in separate reports. Recommendations for hazard minimization, occupational health and safety, emergency response action plans for fire/explosions/oil spills etc. are given in these studies. These recommendations will be strictly implemented.

## **12.0 PUBLIC CONSULTATION**

Public consultation for developmental projects are required by International Finance Corporation (For Category A and B Projects). As per the requirement of IFC, Environmental Review Summary (ERS) will be prepared by the Environment and Social Development Department of IFC, after review of the EA report. The ERS will then be circulated to the public by the Project Proponent (Villa) and the public consultation process will be conducted as per IFC procedure.

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<sup>1</sup> HAZOP Study Report for LPG, Oil and Cement Facility of Villa Hakatha, December 2001, Serene Environmental Services.

<sup>2</sup> Risk Assessment Report for Villa Hakatha Project, December 2001, Serene Environmental Services

<sup>3</sup> Emergency Response Plan (ERP) for Villa Hakatha Project, December 2001, Serene Environmental

## 1.0 PROJECT DESCRIPTION AND OPERATIONS

### 1.1 INTRODUCTION

Republic of Maldives is an archipelago of some 1190 islands that span the equator about 650 km south-west of Sri Lanka. The islands are distributed among 26 atoll formations and are spread over an area of 90,000 square kilo-meters. Only 199 islands are inhabited and another 74 islands are set aside exclusively for tourist resort development. The islands are surrounded by shallow crystal clear lagoons enclosed by coral reefs. All atoll islands in the Maldives are small and low (1-3 meters above sea level).

Villa Hakatha Pvt. Ltd. (Villa) is establishing a green field project for bulk fuel and cement storage and filling. The plant is located in Thilafushi Island of Maldives. The island is located at 5.7Km miles to the west of Male, the capital of the Republic of Maldives. This island has been earmarked for industrial development by the Government of Maldives. Figure 1 shows Map of Maldives showing Location of Thilafushi.

The project consists of LPG Horton Spheres and bottling facility, petroleum tank farm and cement silos and packing plant. The proposed plant will be comparable to the best in the world through the use of state of the art technology, control systems, highly trained manpower and an effective Environmental Management System.

Figure 1 Geographic location of Thilafushi



## 1.2 PROJECT JUSTIFICATION

### **LPG (Liquefied Petroleum Gas)**

Demand for cooking gas has increased considerably in the Maldives. The LPG storage facility at Villa Hakatha at Thilafushi has the capacity to store 2284 metric tones (5250m<sup>3</sup>) of cooking gas. At present the household consumption rate of LPG in the capital Male, is approximately 6670 metric tons per year, which has to be imported. This amounts to approximately 555,830 bottles of 12 Kg. It is believed that at least an equal amount of cooking gas would be required by the tourism sector.

With the proposed storage facility of 3 LPG Horton Spheres (1750 m<sup>3</sup> each), Villa can realize the potential of providing LPG at an affordable price for the majority of the households throughout the country, thereby replacing firewood and kerosene as the main fuel source for domestic and industrial use. At present only a small proportion of the Maldivian households use LPG for cooking. Almost all of the consumers are located in the capital Male' (where approximately 27 percent of the population resides) and resorts. Cooking gas cylinders are not readily available in the atolls (where 73% of the population lives).

### **Fuels (Diesel & Petrol)**

As for diesel & petrol, the land-based facility will cut down cost to the extent where a healthy competition in the domestic market can be created, bringing down the retail prices significantly. Villa is one of the suppliers of fuel oil to the resort islands and owns a fleet of distribution tankers.

Same as the LPG business, Villa has been in the business of both fuel and building material (Cement etc.) business since it's inception. Like LPG, fuel storage too was on board tankers, which by any means is a very costly method. Villa has been trying to acquire land in the vicinity of Male (The largest consumer-Island & commercial Hub) for a long time.

### **Cement (Bulk storage with Bagging facility)**

Cement used to be imported in 50kg bags and stored in Male', which was not only a costly proposition but a very unhygienic process with higher environmental damages. Furthermore, the Government does not permit it now. According to present regulations, cement warehouses cannot be located in Male' for health and safety reasons.

The only bulk storage & bagging facility (situated in Thilafushi Island too) has been in business for few years catering to less than 40% of the national demand. The rest of the supply is in imported bag, but stored in and distributed from Thilafushi Island.

With new constructions booming throughout the country and with the upcoming "Hulhu-Male' Project" the current market trend increase in consumption of cement is expected to continue for years.

## 1.3 PROJECT SITE AND SURROUNDINGS

### 1.3.1 SITE HISTORY

Thilafushi Island has been created by reclamation by the Govt. of Maldives. The reclamation activity started in the year 1999 and has been continuing in phases. The island has been subdivided into 3 major sections – Thilafushi 1, Thilafushi 2 and Thilafushi 3. Thilafushi 1 has been earmarked as a landfill site for garbage from Male. The land filling activity had commenced from the year 1991. Thilafushi 1 and 2 have been made available for industrial activity. **Figure 2** shows a map of the Thilafushi and its major subdivisions.

### 1.3.2 SITE SURROUNDING AND LOCATION

The existing area of Thilafushi is 2.3sqKm. The nearest island is Viligili located 3.7km away in the east direction. Thilafushi 2 and 3 consists of a few industrial facilities.

Map of Thilafushi in **Figure 3** shows the location of the Villa facility and the surrounding industries. The names and type of industry are given in **Table 1** below:

**Table 1 List of Facilities Surrounding the Project Site**

Name of Industry	Type
Villa Hakatha (Proposed Villa Site)	LPG storage and bottling, Bulk petroleum, Bulk cement storage and packing.
State Trading Organisation (STO) to the East	LPG storage and bottling, Bulk cement storage and packing.
Gulf Craft Pvt. Ltd. (South)	Motor boat service station

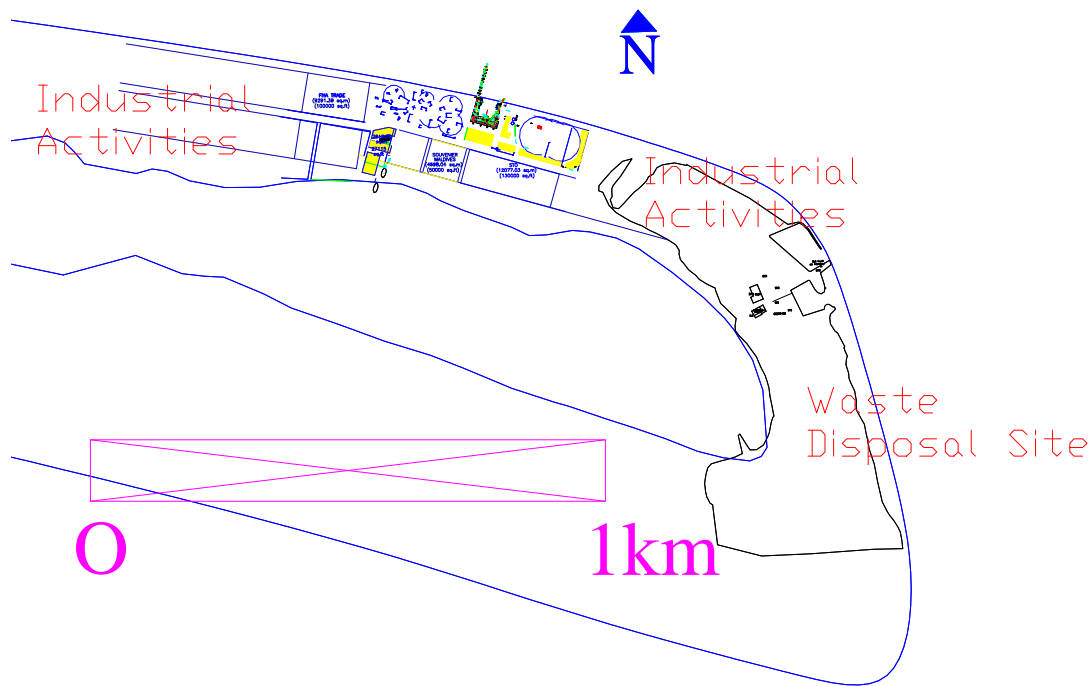
**Photo 1 – 5 in Annex 1**, shows the Villa site and the land use in the different directions of the Villa facility.

### 1.3.3 TOPOGRAPHY AND DRAINAGE PATTERN

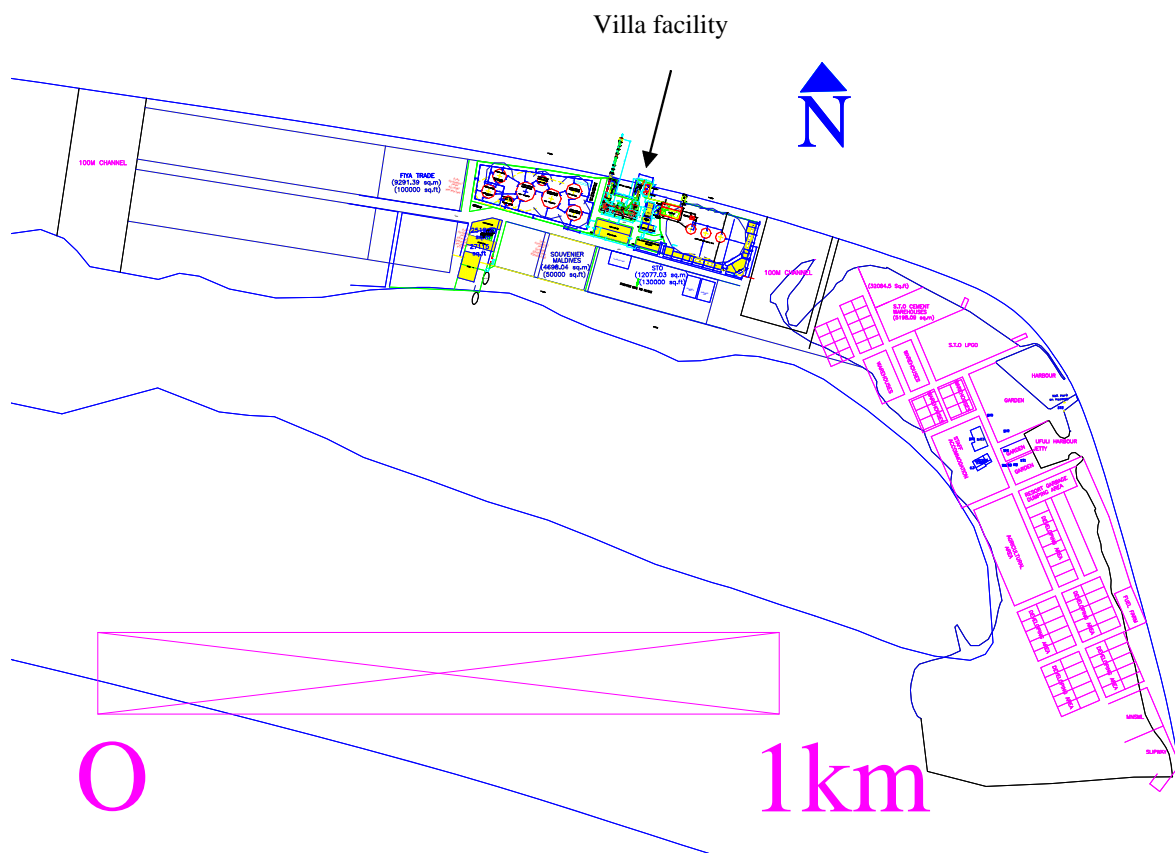
As seen in the above photographs, the area is flat and does not consist of any topographical feature of interest. Storm water collected in the dedicated storm water drains will be discharged in the sea. The entire land is reclaimed and does not consist of any water body. The groundwater is available at a depth of about 1 – 1.5m.

Geology and soil tests done at various locations on plant site by Taisei Corporation, indicate reclaimed sand of light yellowish brown colour, up to an average depth of 2.33m. This is followed by sand from weathered coral reef formations.

**Figure 2 Map showing the major developments at Thilafushi**



**Figure 3 Location of Villa facility and the surrounding industries**



## 1.4 PROJECT COMPONENTS

### 1.4.1 INSTALLATIONS AND FACILITIES

A facility layout Map is given in **Figure 4**. Details of the various components of the project are given in **Table 2**.

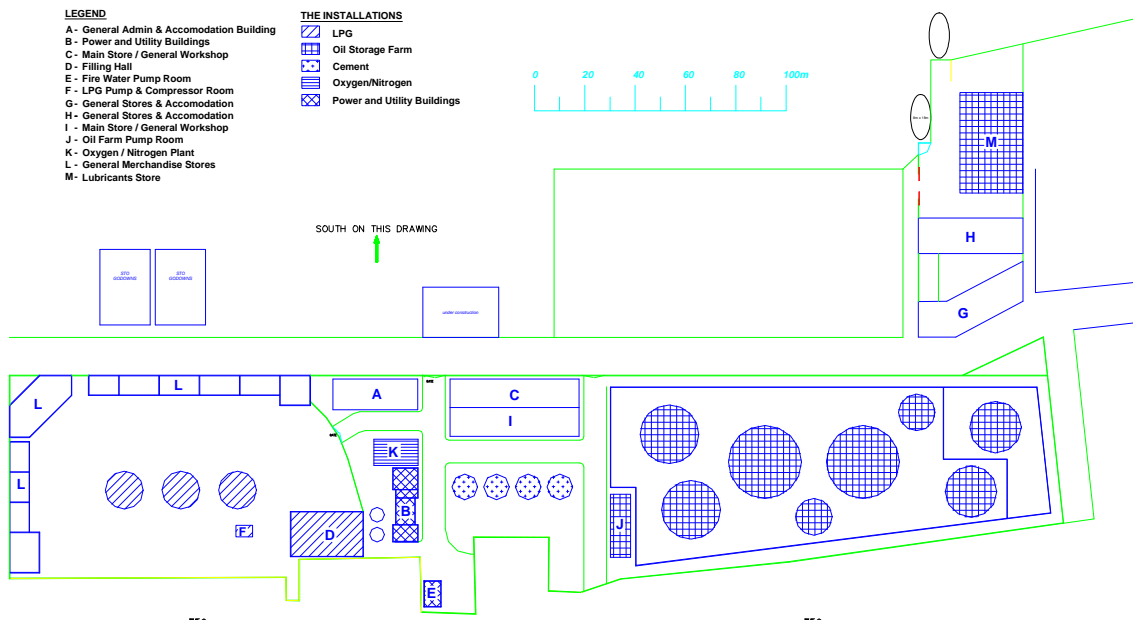
A perimeter wall will enclose the entire plant boundary. A network of storm water drains will be provided. The storm water outfall will discharge into the adjoining sea in the north.

**Table 2 Installations & facilities of Villa Hakatha**

Building Details	Description	Major Equipments To Be Installed
Main Installations	LPG Spheres (Layout Drawing in <b>Annex II</b> )	3 LPG Horton Spheres – 1700 m <sup>3</sup> /tank
	Fuel Farm (Layout Drawing in <b>Annex II</b> )	Diesel : 2 tanks x 9000 tons/tank 1 tanks x 3000 tons/tank Petrol : 1 tank x 3000 tons Heavy : 2 x 6000 tons/tank Oil
	Cement Silo & Packing facility (Layout Drawing in <b>Annex II</b> )	2000 MT/Silo x 4 Silos +2 cement packing plants – 900 bags/minute/plant
	Oxygen & Nitrogen Production and filling plant (Layout Drawing in <b>Annex II</b> )	Producing: Oxygen at a rate of 63 Sm <sup>3</sup> /hr Nitrogen at a rate of 60 Sm <sup>3</sup> /hr.
Main Installations	LPG Filling Hall  Boats (Dhonis) will berth along side of this building to load the LPG cylinders from the chain conveyor system.	300 bottles of 12 kg per hour.  Chain Conveyor System, 8 head Filling Carousel with automatic induction/ejection unit, Filling machines with electronic check scale, Electronic leak detector, Manual leak detector, evacuation system with evacuation rack, Pneumatic cylinder clamp, Pressure Testing machine including tank.
Utility Building	A single storey building from where electricity, water and air is supplied to the whole site.	Electrical Control & distribution Panels  <i>Generators:</i> 1 x 450kVA, 1 x 750kVA & 1 x 1000kVA  <i>Desalination Plants:</i> 1 x 10m <sup>3</sup> /day and 1 x 100m <sup>3</sup> /day  Air Compressors & Water Pumps.

<b>Building Details</b>	<b>Description</b>	<b>Major Equipments To Be Installed</b>
Fire Pump Room	A single storey building, which accommodates 2 nos of diesel firewater pumps.	2-engine driven fire pumps (capacity = 750m <sup>3</sup> /hr per pump)
LPG Pump Room	A pump house, which deals in pumping of LPG to the tanks from the ship.	2 Nos. LPG pumps and a compressor.
Store/Kitchen/ Dining and Accommodation Building	A multi-storey building for Kitchen/ Dining with 38 single-bed-capacity for accommodation. Ground floor is allocated for General store area.	Kitchen Equipments
Storage Building	A single storey building for general storing and a common mechanical workshop for LPG, Oil, Cement, etc.	Mechanical equipments
Oil Pump Room/ Bag tank module room	All the pumps involved in the Oil depot will be accommodated in this building	Pumps for Diesel, Petrol, Heavy oil, Sludge. Bag Tank module etc...
General Stores buildings	Single story buildings	No plants or equipments: Will be used for storing general goods
Lub Oil Stores buildings	Single story buildings	Will be used for storing Lubricating Oil, Grease and related Oils in Drum & Cans
Refilling Station	Hut with Fuel Dispensers (Diesel & Petrol)	Just a road side filling Station: A small hut with sales counter & few sales items
Administrative and Senior Staff Accommodation Building	A multi-storey building with 28 rooms in 1st & 2nd floor for accommodation, office & admin area in the ground floor and a control room 4th floor from where facilities will be monitored & controlled.	Control & Monitoring Panels for LPG, Oil and Cement. Fire Panel for the site.
Store/Accommodati on Building	A multi-storey building planed for accommodation, storage & other multi-purpose activities.	No major equipment.

**Figure 4 Layout map of Villa Hakatha facility on Thilafushi**



## 1.4.2 INFRASTRUCTURE & UTILITIES

### **Land and Area**

The facility is spread over 300,000sqft. The Plant Layout in **Figure 4** depicts the major operational and non-operational areas.

### **Coastal Structures**

The facility has a sheet pile quay wall of length of about 300m installed on the northern coast.

### **Manpower**

A total of 80 personnel will be employed for all activities. This manpower includes 7 operators, 73 staff and casuals.

### **Water Supply and Treatment**

Water is mainly required for domestic use. A total of 20 m<sup>3</sup>/day of water will be required. Water will be drawn from bore well and treated in the Reverse Osmosis unit and then used for drinking purpose.

### **Power**

Power requirement of the plant will be met by way of 3 Diesel Power Generating (DG) sets - 1 x 450kVA, 1 x 750kVA & 1 x 1000kVA

### **Fuel**

Diesel will be the only fuel required for the facility operation for running the DG sets.

### **Compressed Air**

The compressed air system consists one air compressors of capacity 281 m<sup>3</sup> at 10bar and associated equipment such as air dryers, filters etc. Compressed air will be used for the pneumatic systems for LPG bottling, Cement packing and Silo operations.

### **Material Storage Facilities and Warehouses**

Empty and filled LPG cylinders will be stored in the loading area of LPG filling room. Cement bags will handed over to the customer directly and surplus will be stored in the stores.

### **Material Transport and Jetty Operations**

There will be 3 jetty landings for unloading and conveyance of LPG, Cement and Oil.

### **Sanitary wastewater Treatment**

Sewage from toilets and canteen effluent will be conveyed to a Sewage Treatment Plant (STP) of 50m<sup>3</sup>/day capacity for treatment. Treated water from STP will be conveyed to horticulture for gardening purposes. STP unit operations and layouts are given in **Section 7** on Environmental Management Plan.

### **Scrap Storage Yard**

A dedicated scrap storage yard will be constructed to separate store used oil drums and miscellaneous wastes such as packaging waste, domestic garbage etc.

### **Drainage**

Dedicated storm water drains will be provided along the paved roads. The drain will finally discharge into the lagoon area adjacent to the facility to the north.

### **Fire Protection Systems**

Fire fighting systems will be installed as per NFPA requirements.

## **1.5 PROCESS DESCRIPTION**

### **1.5.1 LPG HANDLING OPERATIONS**

Supply vessels and Tankers will station on the north side and flexible hoses on floats will be used to connect vessels cargo delivery pipe to the supply lines. LPG will be transferred via the supply lines to LPG Horton spheres. LPG will be filled in LPG bottles in the state of the art 8 head carousel system. The design capacity is 300 bottles of 12 kg per hour.

The specially developed harbour for LPG cylinder handling will be used to load empty and filled cylinders, combining manual handling and conveyor belts that will take the cylinders through the filling hall and back. In addition to this, provision is also made for filled cylinders to be loaded to trucks so that they can be sent for in-land use or storage. This facility will also be used to take away cylinders for repair and bring back.

### **1.5.2 FUEL HANDLING OPERATIONS**

Here too, the supply vessels and tankers will station on the north side and flexible hoses on floats will be used to connect vessels cargo delivery pipe to the supply lines. The fuels (Diesel, Petrol and Heavy fuel oil) will be transferred to the respective tanks in the Fuel Oil Tank Farm.

Diesel and fuel oil will be sold mainly in bulk and petrol will be sold in drums. The drum transfer operations will be carried out in the calmer waters in the south side lagoon. The traditional transport boats "*Dhoni*" (with drums) and landing craft with Fuel Tank Trucks will have easy access to this special harbour in all weather conditions as this harbour is situated opposite the storage site and inside the protected & calm lagoon. Appropriately sized fuel dispensing units will be situated conveniently at this site for filling drums and tankers. In addition to this, higher capacity filling will be provided in this site as well as the main harbour side to fill small fuel tankers that are engaged in transporting fuel for tourist resorts and or others of higher consumption. These facilities may also be used to fill up the inter-atoll transport boats, if necessary.

### **1.5.3 CEMENT HANDLING OPERATIONS**

Bulk Cement Carrier will be stationed at the dedicated north side jetty and flexible hoses on floats will connect vessels cargo delivery pipe to the supply lines. The cement will be discharged pneumatically by the ship into cement silos.

Bulk Cement supply from the silos will be taken to the 2 packing plants of 900 bags/minute/plant capacity. Cement will be packed into 5 kg and 1-ton Jumbo bags. A Tower Crane will be installed to lift these bags directly from the packer and put on to the transport vessels / Carriers either alongside the Cement Harbour or at the main Jetty.

### **1.5.4 WATER TREATMENT**

Raw water from the bore wells will be treated in the reverse osmosis (RO) plant of 90 KL/day capacity. This water will be chlorinated and supplied for drinking. The RO reject water will be discharged via pipeline outside the reef area.

## **2.0 LEGAL AND ADMINISTRATIVE FRAME WORK**

### **2.1 ENVIRONMENTAL REQUIREMENTS OF REPUBLIC OF MALDIVES**

#### **General Sitting Requirements**

- Tourist resorts may be developed only in uninhabited islands with permission from Ministry of Tourism (MoT).
- Under no circumstances should buildings be allowed to disrupt the natural facade of the island.
- Enough trees and vegetation should be left during clearing and site works to block views of the buildings to be constructed.
- No buildings should stand above tree tops.
- Guest rooms and units must be set back at least 5m from the beach vegetation line so that vegetation covers the structures.
- Each room or unit should be separated by at least 2m, with at least 12% of the total beach length allocated to this purpose.
- Water bungalows erected on jetty piles must be in keeping with the natural look of the island
- Use of Open pile structures to maintain natural wave, current and sand movement regimes are encouraged.

### **2.2 KEY ENVIRONMENTAL GUIDELINES IN THE MALDIVES:**

#### **Ministry of Tourism Laws (Relevant portions will also be applicable to other Projects)**

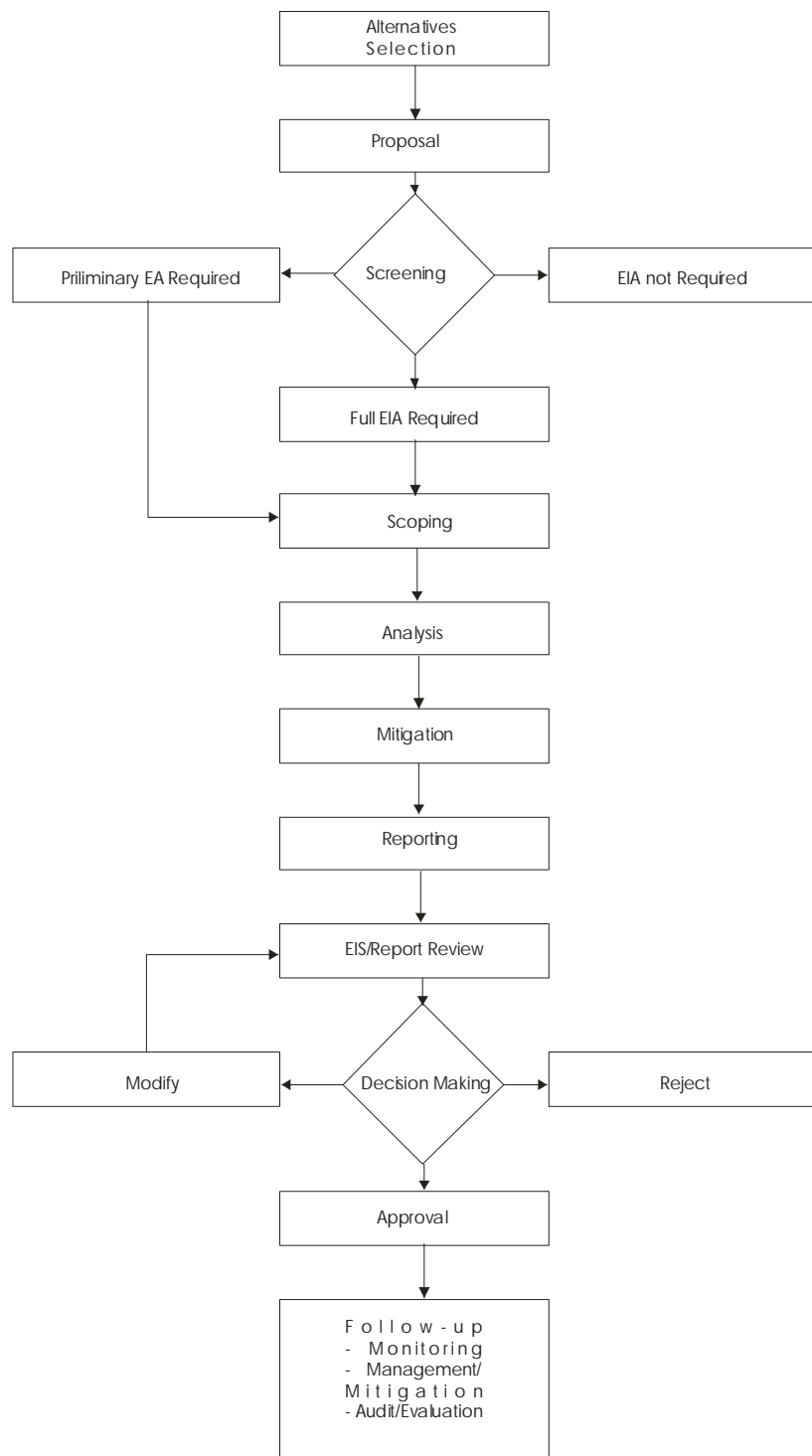
- Garbage should be disposed of in a manner that would not cause any damage to the environment.
- Tourist resorts are required to have incinerators, bottle crushers and compactors. All such wastes should be disposed into deep sea. (Thilafushi Island has been designated as a place where all garbage can be disposed, however, official documentation on this is not present)
- One competent person should be engaged to oversee proper functioning of water supply, wastewater treatment and disposal, beach and other facility housekeeping, medical attention for staff and guests.
- Adequate treatment and disposal of sewage to prevent pollution of water supplies, pollution of beached and other areas, nuisance, ugly sights and unpleasant odours, contact with animals, humans and food.
- Tourists are prohibited catching of turtles, removal and collection of corals and rocks from the sea and from beaches etc. These requirements should be displayed at a

prominent place in the resort. (Detailed fishing regulations are given by Ministry of Fisheries)

**Relevant Requirements under Environmental Protection and Preservation Act and (Ministry of Home Affairs Housing & Environment (MHHE))**

- Environmental Impact Assessment study shall be submitted to MHHE for any new developmental project. Process includes submitting a project proposal to MHHE. After review, MHHE will decide if an EIA is required. Flowchart in **Figure 5** shows the generally practiced process of making EIA's in the Maldives.
- MHHE has the authority to terminate any project that has any undesirable impact on the environment. A project so terminated shall not receive any compensation.
- Any waste, oil, poisonous gases or any substance that have harmful effect on the environment shall not be disposed within the territory of Maldives. In case disposal is necessary, they shall be disposed only within areas designated by the Government.
- MHHE or a designated Ministry(s) can impose a fine for breach of these laws. Fines range from 5 Rufiyaa to 500 Rufiyaa for minor offences under this law. Fines up to MRf One Hundred Million Rufiyaa can be levied for major offenses.

**Figure 5 Flowchart showing the generally practiced EIA process in the Maldives**



## 2.2 INSTITUTIONAL ARRANGEMENT FOR ENVIRONMENTAL MANAGEMENT

There are many sectors of the Government of Maldives (GoM) which have a role to play in the management of the environment in the Maldives. Following are some of the government agencies who have a key role to play in the management of environment.

### **Ministry of Home Affairs Housing and Environment (MHHE)**

As its name implies, the ministry plays the main role within the Government for environmental matters. It has central control over environmental protection and related matters. This is mainly manifested at the level of policy, but since environmental law (Law No. 4/93) is essentially about the taking of discretionary, political decisions, this means that the MHHE has an enormous impact, which is apparent from the statements of the Law. Generally, the ministry is responsible for monitoring the activities of the public and private sector to ensure that their activities and their management are consistent with government policies and a developed set of guidelines and procedures (NDP,1997)

### **National Commission for the Protection of the Environment (NCPE)**

The NCPE was appointed by the President in 1989 and restructured in 1993, with the rise of Law No 4/93, to broaden the consultative process on environmental protection. The NCPE is mandated to advice the government on environmental assessment, planning and management and to ensure that environmental protection is a vital component of all development projects. The NCPE is a high level commission whose members include Ministers, Deputy Ministers and Director Generals from various government offices.

### **Ministry of Fisheries, Agriculture & Marine Resources (MoFAMR)**

The Ministry of Fisheries, Agriculture & Marine Resources (MoFAMR) is solely responsible for the management of living marine resources in the Maldives. Coral reefs and associated species are managed by MoFAMR. Laws and regulations concerning the management of coral reefs are formulated by MoFAMR.

### **Ministry of Construction and Public Works (MCPW)**

The Ministry of Construction and Public Works implement all major building and civil works projects carried out by the GoM. MCPW is also responsible for the management of solid waste in Male.

### **Ministry of Tourism (MoT)**

All aspects of tourism in the country are the responsibility of MoT. MoT has a number of regulations for management and preservation of the environment of the resort islands.

## 2.4 INTERNATIONAL FINANCE CORPORATION (IFC) REQUIREMENTS AND GUIDELINES FOR ENVIRONMENT, HEALTH AND SAFETY

### **OP 4.01: Environmental Assessment**

- IFC requires environmental assessment (EA) of projects proposed for IFC financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making.
- IFC undertakes environmental screening of each proposed operation to determine the appropriate extent and type of EA. IFC classifies the proposed project into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.
  - a) *Category A:* A proposed project is classified as Category A if it is likely to have significant adverse environmental impacts that are sensitive,<sup>1</sup> diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works. EA for a Category A project examines the project's potential negative and positive environmental impacts, compares them with those of feasible alternatives (including, the “without project” situation), and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance.
  - b) *Category B:* A proposed project is classified as Category B if its potential adverse environmental impacts on human populations or environmentally important areas—including wetlands, forests, grasslands, and other natural habitats—are less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and in most cases mitigatory measures can be designed more readily than for Category A projects. The scope of EA for a Category B project may vary from project to project, but it is narrower than that of Category A EA. Like Category A EA, it examines the project's potential negative and positive environmental impacts and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance.
  - c) *Category C:* A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.
  - d) *Category FI:* A proposed project is classified as Category FI if it involves investment of IFC funds through a financial intermediary, in subprojects that may result in adverse environmental impacts. In addition, in some capital markets projects, IFC funds are not targeted to specific subprojects (e.g. equity in a financial institution such as a commercial bank), but the financial institution has operations which may have adverse

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<sup>1</sup> A potential impact is considered “sensitive” if it may be irreversible (e.g., lead to loss of a major natural habitat) or raise issues covered by OP 4.10, *Indigenous Peoples (forthcoming)*; OP 4.04, *Natural Habitats*; OP 4.11, *Safeguarding Cultural Property* in IFC-Financed Projects (forthcoming); or OP 4.12, *Involuntary Resettlement*.

environmental impacts (e.g. project finance). In such cases, IFC may also classify the project as Category FI.

### **International Finance Corporation, Environmental, Health and Safety Guidelines Oil and Gas Development (Offshore)**

- An Environment, Health and Safety Management System (EHSMS) is required for Category B projects in sensitive environment.
- Environmental Action Plan consisting of the set of mitigation measures for adverse environmental impacts and management, monitoring, and institutional measures for EMP implementation.
- Risk analysis to identify and quantify hazards and determination of consequences.
- Preparation of Emergency Response Plan including procedures for evacuation, command and control structure, training of personnel, response infrastructure etc.
- Oil spill response plan including quantification of probable spills and response procedure, infrastructure required etc.
- Occupational Safety and Health issues including Personal Protective equipment (PPE) for hazardous tasks, workplace air quality and noise, Procedures for carrying out hazardous tasks and working in confined spaces, appropriate sanitary facilities and ventilation etc.
- Monitoring, recording and reporting procedures for critical environmental, health and safety parameters.

### **International Finance Corporation, Environmental, Health and Safety Guidelines – Port and Harbour Facilities**

- Site to be selected after consultation with Govt. agencies and affected communities.
- In case dredging is required, a dredging program should be selected to minimize environmental impacts.
- All construction activities in accordance with general health and safety guidelines and general environmental guidelines to minimize impacts on air quality, water resources, ambient noise levels and sensitive natural environment.
- **General Environment Requirements:**
  - Identification of potential impacts on shoreline vegetation, wetlands, coral reefs, fisheries etc. Develop a mitigation plan for such impacts.
  - Emergency response for fires, explosions oil spills etc.
  - All hazardous and solid wastes to be disposed off as per international conventions and other local waste management requirements.
  - Waste generation characteristics study to be done and assessment of pollution control options for solid wastes, sanitary wastes and process wastewater streams. Collection and environmentally sound disposal of ship generated wastes according to requirements of international conventions such as MARPOL (73/78). Examples include oily wastes, tank washings, garbage, sanitary wastes etc.

- **Port/Harbour Safety:**
  - Coordination with Government agencies responsible for port and harbour safety including emergency response.
  - Coordination of ship traffic.
  - Operational measures such as signals, wind direction instruments, emergency response etc.
  - Security – restricted areas.
  - Procedures for handling and transport of hazardous material.
  - Location of facility to minimize risks from earthquakes, tidal waves, floods and fires.
- Construction and operation personnel to be trained on hazards, safety procedures, emergency response plans.
- Records of significant environmental issues, monitoring data, incidences of oil spills, accidents, fires etc. to be kept. Regular review of such data and submission of annual summary reports to IFC.

### **International Finance Corporation, Environmental, Health and Safety Guidelines for Hazardous Materials Management**

- Preparation of Hazardous Materials Management Program (HMMP) for all identified hazardous materials.
- Undertake community involvement and awareness activities for identified hazards.
- HMMP to include:
  - Worker health and safety – Provision of Personal Protective Equipment (PPEs), ventilation and sanitation facilities, pre-employment and scheduled medical examinations, workplace monitoring etc.
  - Monitoring, Record Keeping and Reporting – Monitoring of employee exposure, workplace environment monitoring etc. Monitoring plan to include monitoring locations, frequency, methods used, responsibilities, schedule etc.
  - Training – All employees working with Hazmats should be trained in hazard identification, safety operating procedures, appropriate materials handling procedures, safe work practices, basic emergency procedures, and special hazards unique to their jobs. Training should incorporate information from Material Safety Data Sheets (MSDSs) for Hazmats being handled. MSDSs should be readily accessible to employees in their local language.
  - Hazmat Risk Management Plan – Hazard assessment, incident investigation, process safety information, operating procedures for hazardous tasks, HAZOP analysis, Emergency Preparedness and Response Plan, Hazardous Waste Management plan including

### **International Finance Corporation, Life and Fire Safety Guidelines**

- All new and existing buildings must be designed and operated in compliance with local building codes, Fire Department regulations, Internationally acceptable L&FS standards such as NFPA 101.

- L&FS plan identifying the major risks, applicable codes, standards, regulations and mitigation measures. Plan should include fire prevention, means of egress, detection and alarm systems, compartmentalization, fire suppression and control, emergency response plan and operation and maintenance.

### **International Finance Corporation, Environmental, Health and Safety Guidelines for General Health and Safety**

#### ○ **Workplace Air Quality**

- Periodic monitoring of workplace air quality should be conducted for air contaminants relevant to employee tasks and the plant's operations.
- Ventilation, air contaminant control equipment, protective respiratory equipment and air quality monitoring equipment should be well maintained.

#### ○ **Workplace Noise**

Reduce average noise level in work areas by employing sound insulation, engineering controls etc. Use of hearing protection when exposed to noise levels above 85 dBA.

#### ○ **Work in Confined Spaces**

Prior to entry and occupancy, all confined spaces (e.g., tanks, sumps, vessels, sewers, excavations) must be tested for the presence of toxic, flammable and explosive gases or vapors, and for the lack of oxygen and adequate precautions should be taken before entry such as adequate ventilation, use of air-supplied respirators etc.

#### ○ **Health - General**

- Sanitary facilities should be well equipped with supplies (e.g., protective creams) and employees should be encouraged to wash frequently, particularly those exposed to dust, chemicals or pathogens.
- Ventilation systems should be provided to control work area temperatures and humidity.
- Pre-employment and periodic medical examinations should be conducted for all personnel, and specific surveillance programs instituted for personnel potentially exposed to toxic or radioactive substances.

#### ○ **Safety - General**

- All installations shall be designed and operated to protect the health and safety of employees and the community. Safety procedures and practices for the workplace include guard railing at appropriate places, use of safety shoes, face masks, ear-plugs, safety helmets, gloves etc. as appropriate.
- A safety program should be established for construction and maintenance work.
- A fire prevention and fire safety program should be implemented and include regular drills.

#### ○ **Drinking Water**

Drinking water should conform to the standards published by the World Health Organization in "Guidelines for Drinking Water Quality, Health Criteria and the Supporting Information".

○ **Training**

- Employees should be trained on the hazards, precautions and procedures for the safe storage, handling and use of all potentially harmful materials relevant to each employee's task and work area.
- Personnel should be trained in accident prevention, safe lifting practices, the use of MSDSs, safe chemical handling practices, and proper control and maintenance of equipment and facilities, emergency response procedures as per emergency response plan. Occupational Health and Safety Monitoring

○ **Records and Reporting**

Records should be maintained of significant environmental matters, including monitoring data, accidents and occupational illnesses, and spills, fires and other emergencies. An annual summary of the above information should be provided to IFC.

### **3.0 POLLUTION SOURCES, CHARACTERISTICS AND QUANTIFICATION**

#### **3.1 POLLUTION SOURCES**

Environmental pollutants are expected both during the construction and operation stages of the project. Several operations of the Villa Hakatha project will generate pollution in the form of air emissions, wastewater and solid wastes. Accidental discharges of pollutants are also probable such as oil spills from fuel handling operations. The following operations of the Villa Hakatha bulk material handling operations have the potential to generate various environmental pollutants :

- Cement transfer operations
- Cement packing plant
- Oil storage and transfer operation
- Compressors
- Diesel Generators
- Canteen
- Raw Water Treatment
- Sewage treatment Plant

#### **3.2 POLLUTION LOAD QUANTIFICATION**

Characteristics and quantification of pollutants from the Villa facility is summarized below in **Table 3**.

**Table 3 POLLUTANT SOURCES AND CHARACTERISTICS**

Sr. No.	Activity / Area	Pollutant Media	Pollutant Characteristics	Pollutant Loads	Frequency
1.	Fuel transfer (From Ship to Tanks and vice versa)	Petrol, Diesel	Oil spills on marine and land due to accidental leaks during loading operation	10 to 15 m <sup>3</sup> (Petrol) 20 to 25 m <sup>3</sup> (Diesel)	Accidental episodes. Bulk unloading from ship to tanks will be 1 to 2 times per month.
2.	Fuel dispensing into drums.	Petrol	Oil spills on marine and land due to accidental leaks.	1 m <sup>3</sup>	Accidental episodes and minor leaks
3.	Fuel Storage	Sludge	Sludge from tank cleaning operation.	6 to 7 m <sup>3</sup>	Occasional (5 years)
		Petrol, Diesel	Minor leaks from valves	Negligible	Periodic
		Wastewater	Oil contaminated rain water from dyke area	Small Quantities	During rainy seasons
		Air emissions	Fugitive fuel vapour emissions from storage tanks.	2 tons/hour	Including Tank breathing, loading, tanker filling. This will occur only during tank loading. Smaller emissions expected during only storage and dispensing operations.
4.	Cement Unloading from Ship to Silos	Air	Cement discharge into marine area due to accidental decoupling of marine hose line.	5.3 tons of cement	Accidental
	Silo	Air	Cement dust after bag filter on silo top	Negligible	During silo filling. (Once a month)
	Packing plant	Air	Cement dust emissions from packing plant bag filter.	Negligible 0.9 kg/hr	Continuous
5.	Diesel power generators	1. Air emissions	SO <sub>2</sub> , NO <sub>x</sub> , SPM, CO <sub>2</sub> from fuel burning	0.17 gm/sec (SPM) 1.24 gm/sec (NO <sub>x</sub> ) 0.08 gm/sec (SO <sub>2</sub> )	Continuous
		2. Noise	Noise due to running of equipment	100 – 106 dB(A)	Continuous
		3. Waste oil	Waste engine oil during oil change.	360 lit/month	Periodic, during oil changes

Sr. No.	Activity / Area	Pollutant Media	Pollutant Characteristics	Pollutant Loads	Frequency
6.	Compressor Room	1. Noise	Noise due to running of equipment	80 – 95 dB(A)	Continuous
7.	Residential area / office / Canteen	1. Wastewater 2. Solid waste	Wastewater containing waste food matter.  Garbage / Food waste / misc. office waste	16 KL/day  40 kg/day	Continuous  Continuous
9.	Raw water treatment	Wastewater	RO reject wastewater	70 kl/day	Continuous
10.	Sewage treatment Plant	Solid waste	Settled sludge during cleaning operation	3 kg/day	Periodic during cleaning
11.	Air conditioners	Air emission	CFC release	Negligible	Continuous
12.	Storm water drains	Wastewater	Contamination discharge from site	--	During rainy season

### 3.2.1 AIR EMISSIONS AND NOISE

Air emissions are generated as either point emissions or are fugitive in nature. Point emissions are emitted through a stack, pipe or any definite outlet. Fugitive emissions refer to those air pollutants that enter the atmosphere without first passing through a stack or duct designed to direct or control their flow.

### 3.2.2 POINT EMISSIONS FROM DIESEL POWER GENERATOR SETS

The Diesel generator sets (3 Nos.) will use a maximum of 100 lit/hour of diesel oil. Major pollutants include SO<sub>2</sub>, NO<sub>x</sub> and SPM. Fuel efficient DG sets from the DG manufacturer "Cummins (India)" will be used. The emissions will meet the US EPA (MOH) Tier 1 emission norms. The 3 DG sets will be connected to one stack of 18 m height from the ground level. This height will ensure adequate dispersion of air emissions and is not expected to have adverse ground level air impacts. Air emission quantities and concentrations of SO<sub>2</sub>, NO<sub>x</sub> and SPM expected from the DG stacks at peak capacities for the 750 KVA generator are given in below in **Table 4**.

**Table 4 EMISSION RATES FROM DG sets**

Stack	SPM gm/sec	NO <sub>x</sub> gm/sec	SO <sub>2</sub> gm/sec
Common Generator Stack	0.17	1.24	0.08

- Emissions for generators are based on information provided by DG suppliers - Cummins India

### 3.2.3 POINT EMISSIONS FROM CEMENT SILOS AND PACKING PLANT

Cement dust (particulate) emissions will be generated during the following operations and conditions:

#### Cement Transfer from Ship to Silos

Accidental discharge of cement into the marine environment could occur due to snapping of the unloading line. Two floating unloading lines will be used, each with unloading capacity of 80 tons/hr or 1.33 tons per minute. Assuming a 2 minute response time for shutting the operation, about 5.3 tons of cement could be discharged into the marine environment, if both lines snap.

#### Dust emission during silo filling

During silo filling, the displaced air in the silos will pass through a high efficiency bag-house filter, before being discharged into the atmosphere. Emissions will be negligible and are expected only during silo filling operations, which will be done only once or twice a month.

#### Dust emissions from packing plant operation

Both packing plants are connected to individual high efficiency bag filters. Fugitive dust at packing nozzles are drawn through hoods and filtered in the bag filters before atmospheric discharge. The discharge rate for the bag filters are based on actual emission data of 125 mg/Nm<sup>3</sup> observed in other similar packing plants. The discharge rate for each bag filter will be about 9 kg/day as follows:

$$7200 \text{ m}^3/\text{hr} \times 125 \text{ mg/ m}^3 \times 10 \text{ hr operation} = 9 \text{ kg/day.}$$

### **3.2.4 EXHAUST EMISSIONS FROM SUPPLY VEHICLES**

About 5 to 6 vehicles are expected to be present inside the premises during the operation phase of the project. These vehicles will be mainly used for transport of material to stores when needed. As seen in the process description, the material movement is mainly by way of pneumatic pipelines and direct loading through flexible hoses. Thus exhaust emissions will be negligible.

### **3.2.5 FUGITIVE EMISSIONS**

Fugitive emissions will occur from the following sources:

#### Vehicular movement

Dust is entrainment from roads due to vehicular movement. Most plant roads will be asphalted thereby minimizing dust entrainment. Also, the soil consists of coral sands, whose particles being heavy will settle down faster. Thus these emissions are expected to be negligible.

#### Fugitive dust from Cement handling area

This is also expected to be negligible due to pneumatic transport of cement, enclosed operations and high level of housekeeping proposed for the area.

#### Vapour losses from Fuel Storage Tanks

Evaporative losses from the 2 x 9000 tons Diesel tanks and a 3000 tons petrol tank will be major sources of hydrocarbon emissions from the project. The major factors that affect evaporative losses are vapour pressure, temperature changes, tank filling and emptying schedules, tank type, type of tank seal etc.

The two significant emissions from fixed roof tanks are storage and working losses. Storage loss is the expulsion of vapour from a tank through vapour expansion and contraction, which are results of changes in temperature and barometric pressure. This loss occurs without any liquid level change in the tank.

The combined loss from filling and emptying is called working loss. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled

from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.

**Using AP-42 and California Air Resources Board (CARB) emission factors , the maximum hourly vapour losses from a fixed roof tank can work out to about 2 tons/hour as follows:**

$E_h = T \times EF$  ( $E_h$  = Max. hourly gasoline vapour emissions,  $T$  = Max. 1-hr, gasoline delivery)  
 $E_f$  = Emission factor )

$E_h = 600 \text{ m}^3/\text{hr} \times 1.87 \text{ lbs/ 1000 gallons transferred}$   
 **$E_h = 2 \text{ tons/ hour}$**

(The emission factor of 1.87 / 1000 gal. Includes emissions from tank loading, tank breathing, tanker dispensing etc.)

### **3.2.6 NOISE**

Major noise generating sources inside the plant are the DG sets and the air compressors. Noise monitoring results in similar areas, indicate that noise in the generator room will be in the range of 100 to 106 dB(A) and in the compressor room will be between 85 to 95 dB(A).

### **3.2.7 EFFLUENT AND OTHER LIQUID WASTE DISCHARGES**

#### **3.2.7.1 INDUSTRIAL EFFLUENT**

None of the operations require water and source of continuous effluent generation are not present in the Bulk terminal operations of Villa Hakatha.

##### Water Treatment Plant

Reverse Osmosis (RO) plant will be used for raw water treatment. Capacity of RO plant is 4 KL/hr (100 KL/day). About 70 KL/day of RO discharge (brine water) is expected. This will be discharged about 30 m into the sea on the north side via an outfall pipeline.

#### **3.2.7.2 SANITARY AND CANTEEN WASTEWATER**

Wastewater will be generated from toilet usage and canteen facilities. Approximately 16 m<sup>3</sup>/day of sanitary wastewater and canteen wastewater will be generated. Sewage and canteen wastewater will be treated in a separate sewage treatment plant of 50 m<sup>3</sup>/ day capacity. The treated water will be used for horticulture and flushing in toilets. Typical expected characteristics of raw and treated sanitary effluent are given in **Table 5**.

**Table 5 Raw and Treated Domestic Effluent Characteristics**

Parameter	Untreated Characteristics	Treated Characteristics	Permissible Standards* for discharge into surface water.
PH	6.5 - 8.5	6.5 - 8.0	6 -9
BOD	300	20	60
Suspended Solids	500	30	50
Oil and Grease	8 – 30	<10	20
Coliforms MPN/100 ml	10 <sup>6</sup> to 10 <sup>9</sup>	< 400	<400

\* World Bank EHS guidelines for Hotels and Resorts.

### **3.2.7.3 STORM WATER**

Dedicated storm water drains laid all round the site will drain storm water from the plant site into the sea . Storm water can carry substantial amounts of contaminants from the site such as spilled oils and suspended solids into the surrounding environment. Thus effective housekeeping is very essential to prevent storm water contamination. Storm water drains have been designed for maximum flood levels.

The collected storm water will be discharged into the sea adjoining the north boundary of the plant. the plant premises. The outlet will have a suitable screen mesh to minimise discharge of suspended solids and trash into the reef area.

### **3.2.7.4 OIL SPILLS AND OTHER PERIODIC DISCHARGES**

Impacts on the marine environment from accidental spills of petrol and diesel is an area of concern. The following are the envisaged scenarios and estimated spill/discharge quantities:

#### Snapping of Fuel Discharge Line during unloading of Fuel (Diesel/Petrol) From ship to storage tank

Ship will be anchored about 40-60 m away from land (depending upon the ship size- planned up to 25000 M<sup>3</sup>) and connected to land via mooring lines and to buoys and the other end (sea side).Flexible hose will be about 80m in length and this will be hooked up to the jetty pipeline (8 inch line, check MOC) and on towards the tanks.

In case of petrol, discharge rate will be 300m<sup>3</sup>/hr. In case of snapping of hose line and a response time for shut off of 2 minutes, about 10 to 15 m<sup>3</sup> of petrol is likely to spill in the marine area.

In case of diesel, discharge rate will be 600m<sup>3</sup>/hr. In case of snapping of hose line and a response time for shut off of 2 minutes, about 20 to 25 m<sup>3</sup> of petrol is likely to spill in the marine area.

Fuel spills during manual dispensing of fuel into drums on ships

Petrol will be dispensed through dispensers into small carriers (dhonis) into drums of 200 litres and also tank trailers (road tankers or bowsers), small shipping vessels, speedboats etc. Discharge rate will be about 25m<sup>3</sup>/hr. In case of line snapping and response time for shut off of 2 minutes, about 1 m<sup>3</sup> is likely to spill in the marine area.

### 3.2.8 SOLID AND HAZARDOUS WASTES

*These wastes will be generated from industrial and domestic sources. The waste generated will be as follows:*

- Domestic garbage including food wastes
- Miscellaneous office wastes such as plastic, paper, metals etc.
- Sludge from tank cleaning operation
- Waste engine oil from D.G. sets.

The characteristics and quantities of these wastes are described in **Table 6**.

**Table 6 SOLID AND HAZARDOUS WASTE GENERATION**

Sr. No.	Waste	Activity / Area	Pollutant Characteristics	Quantity	Current Mode of Disposal
1.	Domestic Garbage	Residential and Canteen	Food waste, plastic, paper etc.	0.5 kg/day/person x 80 persons = 40 kg/day	To be sent to Thilafushi Garbage landfill close by.
2.	Waste oil from DG's and compressors	DG room	Used engine oil.	360 litre / month	To be sent to Thilafushi waste disposal site
3.	Oily Sludge	Fuel storage tanks.	Settled sludge during tank cleaning	6.6m <sup>3</sup> / 5yrs	To be sent to Thilafushi waste disposal site
4.	STP Sludge	Sewage Treatment Plant	Settled Sludge from Clarifier	Negligible	Used for manure after drying.

## 4.0 EXISTING ENVIRONMENT

### 4.1 GENERAL SETTING - MALDIVES

The Republic of Maldives consists of a double chain of 26 coralline atolls that are situated in the Indian Ocean between latitudes N 07° 6' 30"– S 00° 41' 48". The country has a length of 860km and a width of 130km at its widest point. The double chain of atolls lie on either side of an Inner Sea, tapering to single atolls to the north and south. There are 23 geographical atolls grouped into 20 administrative units. These atolls rise from an aseismic submarine ridge which is 300 – 350m deep to the south and 700m deep to the north. The country comprises of about 1,200 small low lying islands, which are lying less than 2m above MSL. The physical setting of the Maldivian atolls vary from open structures with numerous islands, faros (ring-shaped reefs) patches and knolls in the atoll lagoon and around the rim to almost closed structures with few lagoons, knolls and patches.

In North and South Male Atolls, as in the northerly atolls, the islands are found predominantly on the faros on eastern periphery of the atoll. These islands have broad, shallow reef flats on their eastern edges, some with shingle ramparts at the seaward limit of the reef flat. The islands and the shingle ramparts owe their origin to the deposition of shingle or coral debris during "storms".

Maldives experiences a tropical climate and weather is characterised by two monsoonal periods. The average maximum annual temperature ranges between 28° and 32° C. The average minimum temperature rarely drops 25°C. There are very little seasonal variations in the temperature. The average annual rainfall is around 1900mm and there is an increase in the amount of rainfall in the south having 2470mm, while the north having around 1977mm of rainfall).

### 4.2 GENERAL SETTING – STUDY AREA

The island of Thilafushi lie at coordinates 73°26'E and 4°11' N on *Thilafalhu* which lies on the southern periphery of North Male Atoll (fig 1, 6 and 7). The island is not a naturally formed island but originates from the dumping of solid waste from Male and the nearby resort islands. The land fill operation at *Thilafalhu* started during 1991 and since that time up till now an area of 2sqkm have been reclaimed from *Thilafalhu* by dumping solid waste.

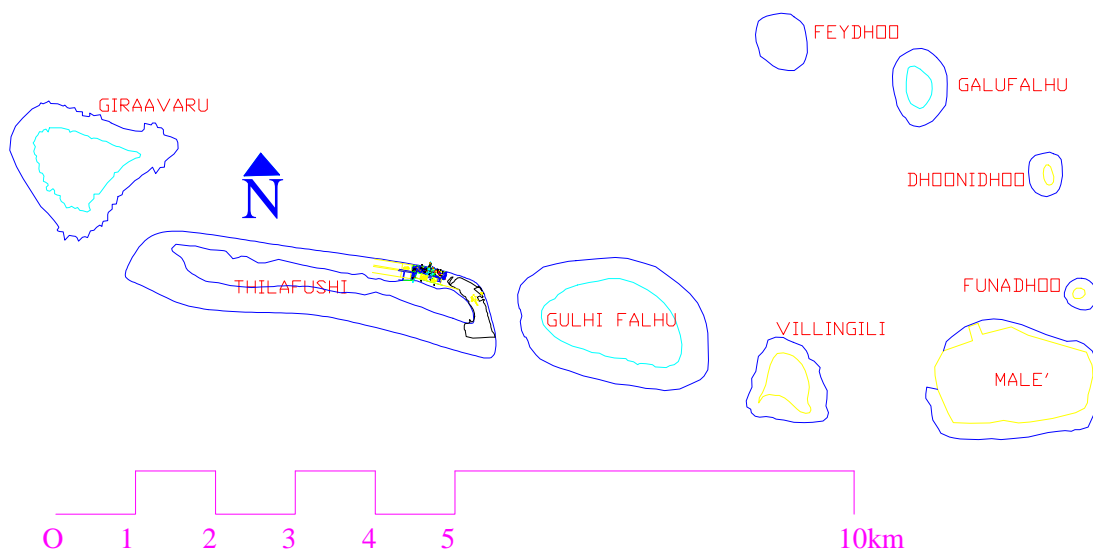
*Thilafalhu* is a long ribbon shaped faro that has an enclosed deeper lagoon (*vilu*). To the east at about 1km from *Thilafushi* is *Gulhifalhu*, which is a round shaped faro. These two faros are separated by a narrow and deeper pass. The resort hotel Giraavaru Island lies at about 2km northwest of *Thilafalhu*. The island of Giraavaru and *Thilafalhu* are also separated by a narrow pass *Giraavaru Irumathee KAndu*. The closest inhabited islands, Viligili, and Male lies at about 5km and 6km respectively to the east of Thilafushi. The typical depth within North

and South Male Atolls is about 45 – 50m. Vaadhoo Kandu to the south of Thilafushi that separates North and South Male Atoll is a relatively deep channel. This channel has an average depth of about 400m and a width of about 10Km. This channel is well known to be a rough channel during the southwest monsoon.

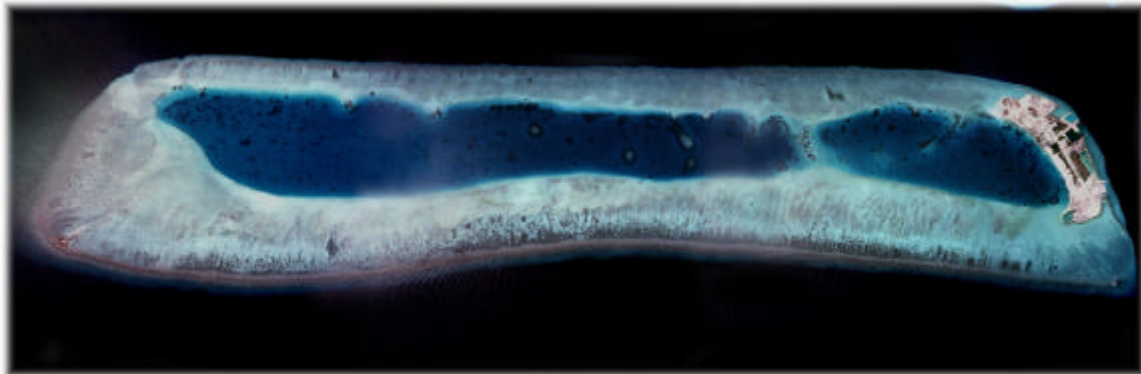
As aforementioned, Thilafalhu has been exposed to high levels of anthropogenic impacts since 1993. A man made island, Thilafushi, was created by dumping solid waste onto the shallow reef flat and this operation is still continuing, creating more land as time goes by. In addition to the landfill operation, a large area of Thilafalhu has also been reclaimed by pumping marine sand onto the shallow reef flat. The land reclamation with marine sand started during 1999 and is still continuing. This operation is carried out by the Ministry of Construction and Public Works who is also the implementing agency for the landfill operation at Thilafushi. The newly reclaimed land at Thilafalhu is called Thilafushi II. This land was created from sand borrowed from the deeper lagoon (vilu) of Thilafalhu by using a cutter suction dredger that pumped the sand directly to the reclamation site. The shallow reef flat on which Thilafushi and Thilafushi II are created has an average depth of about 0.2 – 1m whilst the deeper vilu has an average depth of about 4 – 5m below MSL.

“Lions Head” which is an area on the southern side of Thilafalhu is a marine protected area and another marine protected area “Hans Hass Place” lies on the southern side of Gulhifalhu. These marine protected areas are popular dive site to which many tourists from the nearby tourist resorts visit almost daily.

**Figure 6 Thilafushi and the Nearby Islands**



**Figure 7 Aerial photo of Thilafushi island and the reef (April 1998)**



### **4.3 GEOLOGY OF THILAFUSHI**

Thilafushi is a reef that consists of live coral, coral fragments and coral fine sand. This reef is situated on the atoll rim of north Male Atoll. According to the Maldives Coral Mining Study of 1991 the atoll rim sedimentary environments can be subdivided into two categories: 1- above wave base and 2- below wave base. The source of sediment above wave base environment is predominantly massive coral and branching corals and coralline algae that live on the reef edge. The major force that produces sediment in this environment would be the waves while the tides, wave and wind generated currents in the area would play an important part in transporting the sediment produced here.

The soil investigation works for the proposed project in May 2000 indicate the thickness of the reclaimed layer has depths about 2.33m. This layer consists of a loose, well graded, fine graded sand.

Underlying the reclaimed layer of sand is the coral reef formation. The soil samples obtained from this formation indicated that the original coral reef has been exposed to weathering. This weathering is a destructive or disintegrating process by which rocky material on exposure to atmospheric agents such as atmospheric oxygen or circulating seawater, changes in colour, texture, structure, composition and form. Thus, through this weathering process, this formation is further classified into two weathered zones (*In: Report on Soil Investigation works for Proposed LPG, Cement & Oil Storage Facilities Project at Thilafushi Island, Republic of Maldives – May 2000*).

**Zone 1:** This zone consists of a loose coral sand that has an average SPT value of 12. This layer has an average thickness of 13.67m.

**Zone 2:** This layer underlies the above Zone 1. This layer consists of a consolidated coralline formation. The layer has an average SPT value of 78.

#### 4.4 CLIMATE AND OCEANOGRAPHY

The climate of Maldives is dominated by the monsoons the North East (NE) monsoon from December to February and the South West (SW) monsoon from May to September. The period between March to April is the transition period from the NE monsoon to SW monsoon known locally as the Hulhangu Halha, while the transition period from SW monsoon to NE monsoon known as Iruvai Halha is from October to November. The SW monsoon is generally rough and wetter than the NE monsoon. Generally the winds of SW monsoon are stronger than that of the NE monsoon and precipitation is higher during SW monsoon. Wind rose diagrams for the year 1994 are given in **Annex 3**.

Strong winds and gale force winds are infrequent in the Maldives and cyclones do not reach Maldives because of the negligible Coriolis force in these latitudes. However, storms and line squalls can occur, typically in the period May to July: gusts up to 50–60kts have been recorded at Malé during these storms (Environmental/Technical Study for Dredging/Reclamation works under the Hulhumalé project, Maldives, 1999).

##### 4.4.1 TIDE

Tides in the Maldives are diurnal-semidiurnal type with a tidal range about a meter. The tide station at Hulhule is the closest station to Thilafushi where the tidal data have been recorded for over 30 years. It has been assumed because of the close proximity of Rasfaree to this tide station that the tidal behaviour at Thilafushi would not differ much from that at Hulhule.

Seasonal variations in Mean Sealevel in the Maldives are very small. GITEC Consult et al., 1991 – In Environmental/Technical Study for Dredging/Reclamation works under the Hulhumalé project, Maldives, 1999 indicates that there is a seasonal variation at Malé of +0.1m from February to April and –0.1m from September to November.

The highest water level caused by the astronomical tides at Hulhule falhu when referred to MSL, which is about 0.56m above the chart datum is 0.64m (**Table 7**).

**Table 7 Tide levels at Hulhule (from Environmental/Technical Study for Dredging/Reclamation works under the Hulhumalé project, Maldives, 1999)**

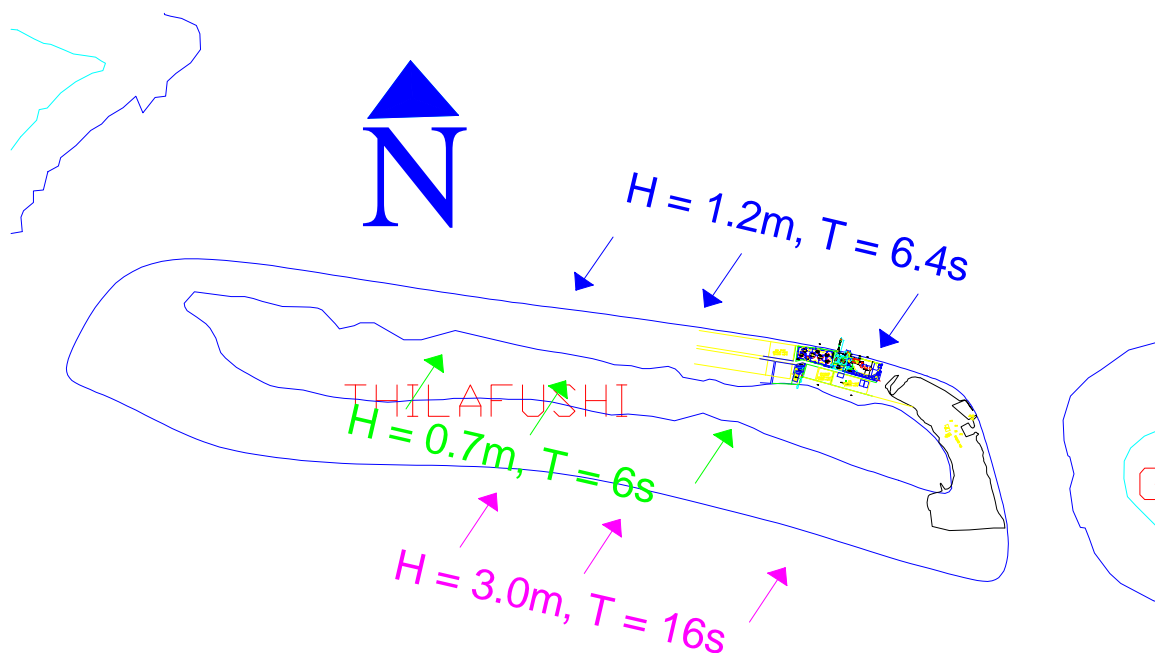
Tide level	Referred to MSL
Highest Astronomical Tide (HAT)	+0.64m
Mean Higher High Water (MHHW)	+0.34m
Mean Lower High Water (MLHW)	+0.14m
Mean Sea Level (MSL)	0.0m
Mean Higher Low Water (MHLW)	-0.16m
Mean Lower Low Water (MLLW)	-0.36m
Lowest Astronomical Tide (LAT)	-0.56m

#### 4.4.2 WAVES

Thilafalhu is exposed to two main types of waves, the oceanic swells from the south of the reef and the local wind generated waves from a northerly direction. The oceanic swells approaching the shores of thilafushi originates in the storm in the Indian Ocean. The oceanic swells reaching Male Atoll have been recorded to have wave periods of about 10sec. These waves have an average wave heights of about 0.5 – 1.0m.

The local wind generated waves originating from within North Male Atoll have wave periods about 2 – 4sec. The Male seawall study has used an offshore design wave for the northern side seawall at Male to be 0.6m in height and to have a wave period of 4.6sec. Whilst for the south coast the offshore design wave height have been determined to be 3.0m and the period 16sec. Due to the close proximity of Thilafushi to Male it has been assumed that these wave conditions could be applied at Thilafushi with reasonable accuracy. **Figure 8** indicates the characteristics of waves that could be employed for design of coastal structures around Thilafushi.

**Figure 8** Characteristics of waves approaching Thilafushi (The study on Solid Waste Management for Male City in the Republic of Maldives (1998)).

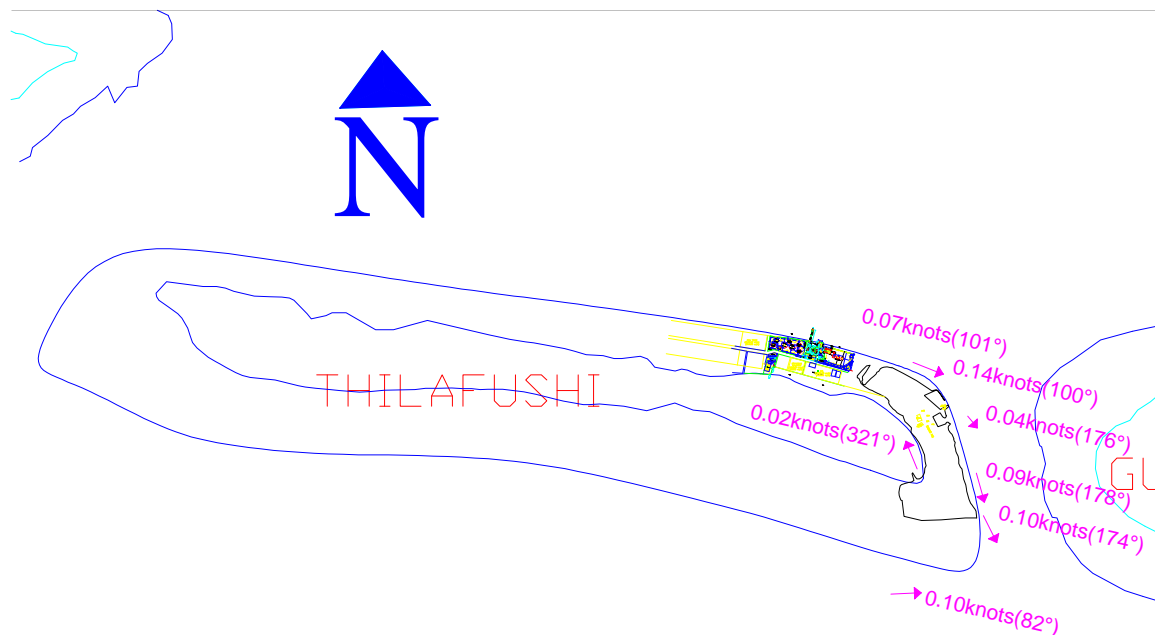


#### 4.4.3 CURRENTS

Currents in and around Thilafalhu could be generated by the tides, winds or by wave. Tidal currents on the reef flat are not expected to be very strong because of the limited tidal range. Wind induced currents however, could be significant during times of strong winds usually during the SW monsoon.

The study on Solid Waste Management for Male City in 1998 included measurement of current patterns around Thilafalhu. These current data indicated that the currents around Thilafushi are greatly influenced by the oceanic currents. The oceanic currents flowing in the Maldives are driven by the monsoon winds. In the northern part of Maldives, the current flows westwards during the NE monsoon and eastward during the SW monsoon. This study also indicated that during the SW monsoon currents around Thilafushi could reach speeds upto 0.14 knots (**Figure 9**).

**Figure 9** Current records around Thilafushi (August 1998) – Direction are given in degrees starting from south and counting clockwise.



## 4.5 MARINE ENVIRONMENT

The marine environmental conditions at the project site were studied using standard marine survey methodologies. These include line intercept survey method for the assessment of reef benthic community and the visual census methodology for the assessment of the fish community.

The reef comprising Thilafushi 2 (also part of Thilafushi 1, solid waste disposal facility for Male and nearby islands) is an atoll rim ring reef on the southwestern end of North Male atoll (Figure 1). This reef is separated from the other reefs by two channels on its west and east. On the east is the Medhufalhu (commonly referred to as Dhefarudheythere) channel and to the west end lies Giraavaru channel. The southern side of Thilafushi reef is exposed to Vaadhoo channel separating South and North Male atoll. Reef morphology here is characteristic of typical atoll outer reefs with poorly developed spur and groove formation at the wave break zone. On the north side the reef is characterized by a typical atoll inner reef.

Thilafushi was developed to meet the demand for a proper waste disposal site for Male. As such, the existing land of the present Thilafushi 1 emerged partly from solid waste and partly from reclamation of the shallow lagoon in the vicinity. Thilafushi 2 has been developed as an area to build industrial infrastructure. The land required for this infrastructure development was reclaimed by material dredged from the shallow lagoon. As such the landmass developed for this, on the shallow reef flat and the reclamation extended to the reef edge on this side. Because of this reclamation the outer reef flat and reef slope have been considerably modified.

This ecological study is an attempt to describe the existing marine environmental condition at Thilafushi 2, specifically at the proposed project site. It has been recognized that the proposed project implementation would have little impact on the ecological functioning of the reef. It is evident that significant environmental impact has already been resulted due to reclamation of the reef flat, where the ecological condition there, has been altered from a marine ecosystem to a land-based terrestrial system. This has directly resulted in the elimination of the immobile reef benthic organisms, particularly corals and their habitat on the reef flat. It is also evident that some modification has been resulted to the reef ecosystem in the vicinity. The project site is located on the northern coastal periphery of Thilafushi 2 and this environmental evaluation is based on the reef environment immediately adjacent to this site.

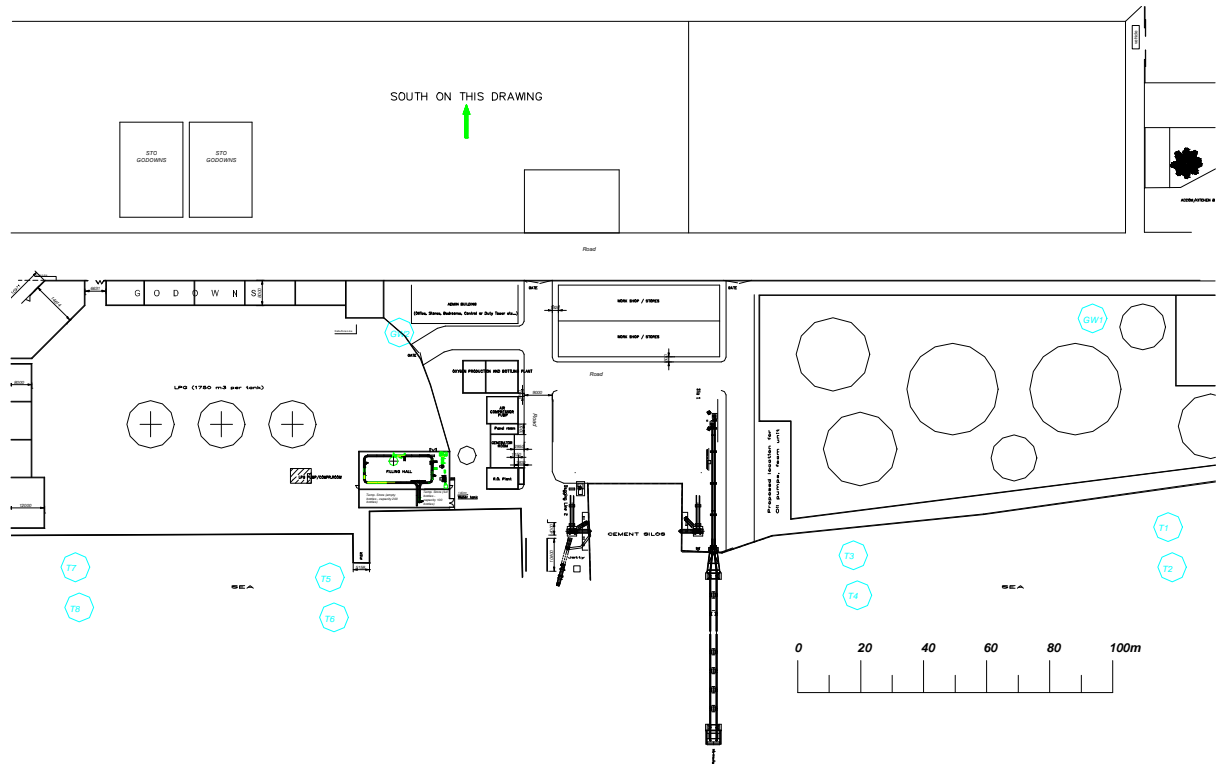
### 4.5.1 METHODOLOGY

#### **Line Intercept Transect (LIT)**

A measuring tape was laid on the reef along two depth contours, 5 and 10 meters on the east and west end of the project site (**Figure 10**). Two twenty-meter transects were surveyed along each depth contour. The purpose of this survey was to assess the condition and health of the reef at these locations. This method provides information on the reef benthic community at these sites. Key parameters include:

- o Live coral cover
- o Number of species
- o Cover of other benthic groups

**Figure 10** Locations of reef survey



## **Visual Census Survey**

This survey involves counting of fish species at a given location to estimate its abundance and species diversity. A recorder swam slowly along the transect counting all the fish encountered within a five meter belt transect of 50 meters in length were surveyed at the same locations where the LIT surveys were carried out. Fish belt transects were the first surveys completed after the transect lines were deployed. The purpose of the fish census was to collect information on:

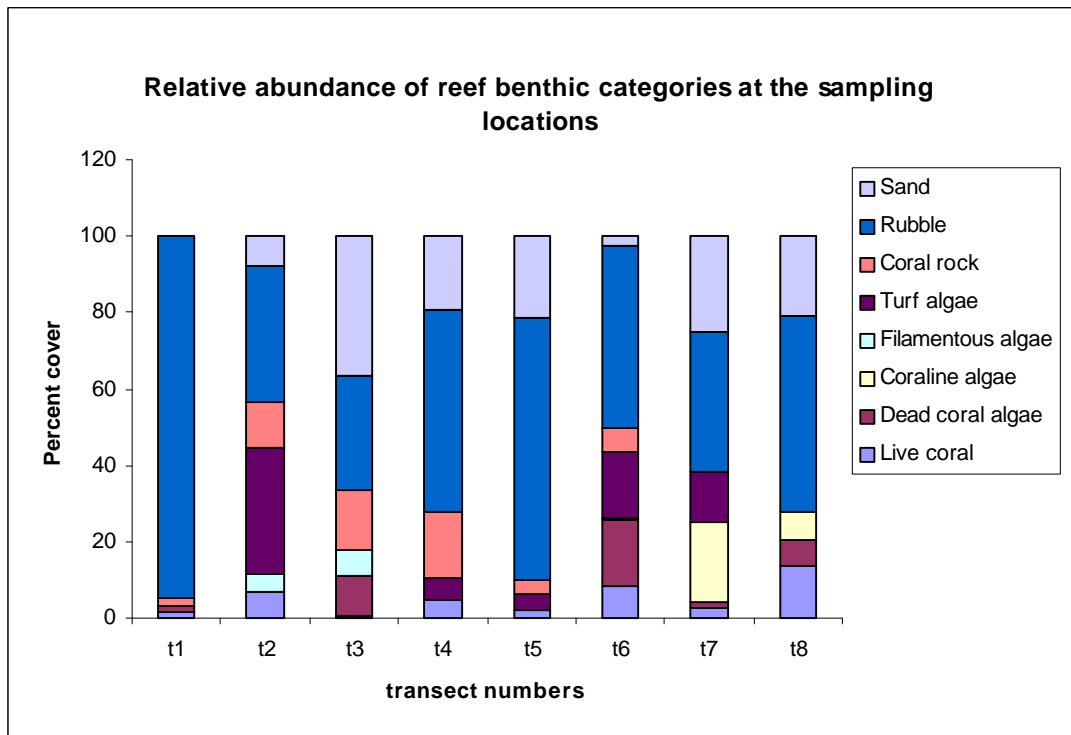
- Coral reef fish abundance
- Diversity of fish
- Number of species

### **4.5.2 SURVEY FINDINGS**

#### **4.5.2.1 REEF BENTHOS**

Live coral cover was relatively low for all transects surveyed (**Figure 11**). Coral cover ranged from very low 0.4% (T3, reef slope (10meters) west end reef) to 13.4% (T8, reef slope (10meters) east end reef). There is no significant difference in live coral cover between the two depth contours. Over 90% of the reef substrate consisted of coral rock, rubble and sand. Coral rubble and sand contributed to 30 – 95% of the reef substrate. These rubbles have originated from branching coral forms that may have been part of the coral community in these location. Filamentous algae and turf algae also forms a significant part of the reef benthos however, highly variable between the transects.

**Figure 11 Percent cover of all benthic groups for all the transects surveyed. See map for survey locations.**



Previous studies as part of the reclamation for Thilafushi 2 has reported similar results on reef benthos. A large-scale survey around the reef system of Thilafushi conducted in 1998 to collect some baseline information on coral cover and other benthic groups formed the basis for basic ecological information on this reef and its vicinity. Live coral cover for the outer reef stations varied from 12-27% and these values were similar for both reef slope and reef flat stations. However, coral cover in the atoll inner sites (close to project site) was reported higher in the reef slope compared to the corresponding reef flat stations. Live coral cover then (1998 study) at approximately same location of the present study reported approximately 7-15% live coral cover. Based on this information and the results of the present study it can be concluded that the reef environment around Thilafushi has experienced some inevitable damage to the reef as result of the reclamation. The physical alteration of the reef flat from a shallow water reef to a dry terrestrial habit has consequentially caused this damage together with other factors that may contribute to reef damage. Among these, the most significant damage to the reefs have been caused by mass coral bleaching event which severely affected the reefs in Maldives. Live coral cover in shallow reef areas around Maldives was reduced from 40-60% (average value for a healthy reef) to less than 5%.

Reef sedimentation is also evident in the survey sites. Partial mortality to live corals especially to large coral boulders by chronic settlement of heavy sediments was common (see **Photo 6 – 8 in Annex 1**). This has evidently caused partial mortality to live coral species specially those of laminar and massive growth forms. Large colonies of *Diploastrea* corals were covered with sediments and their persistent settlement has caused partial tissue damage to

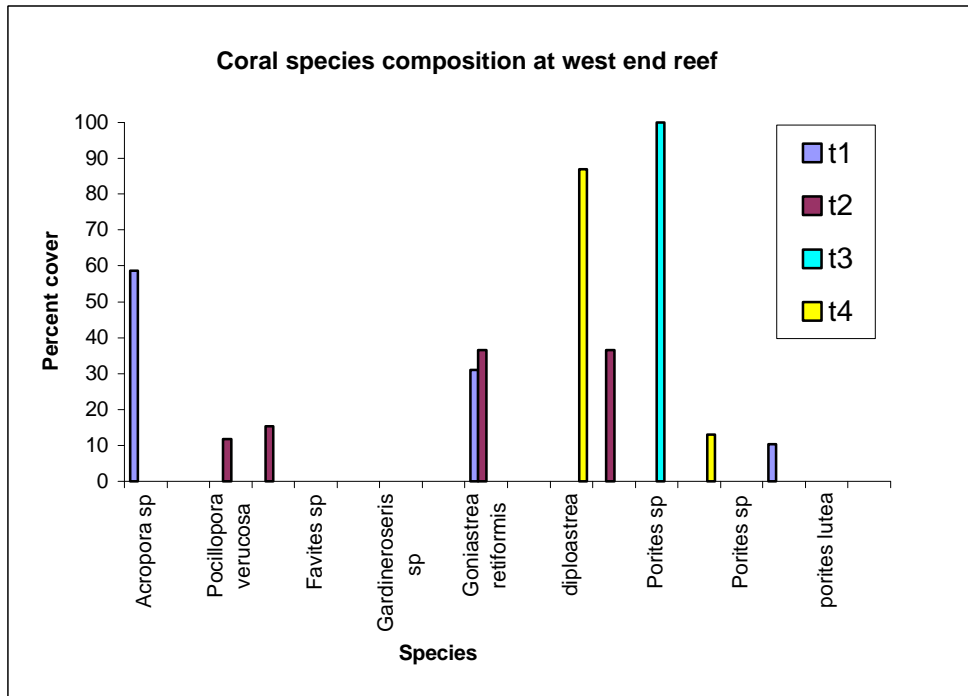
these colonies. This was also evident in other massive growth form species such as Favids and Poritids.

Based on the present survey observations and by comparing the findings of 1998 reef benthos surveys it is evident that altering the ecological condition of the reef flat has considerably altered the reef benthos due to the reclamation.

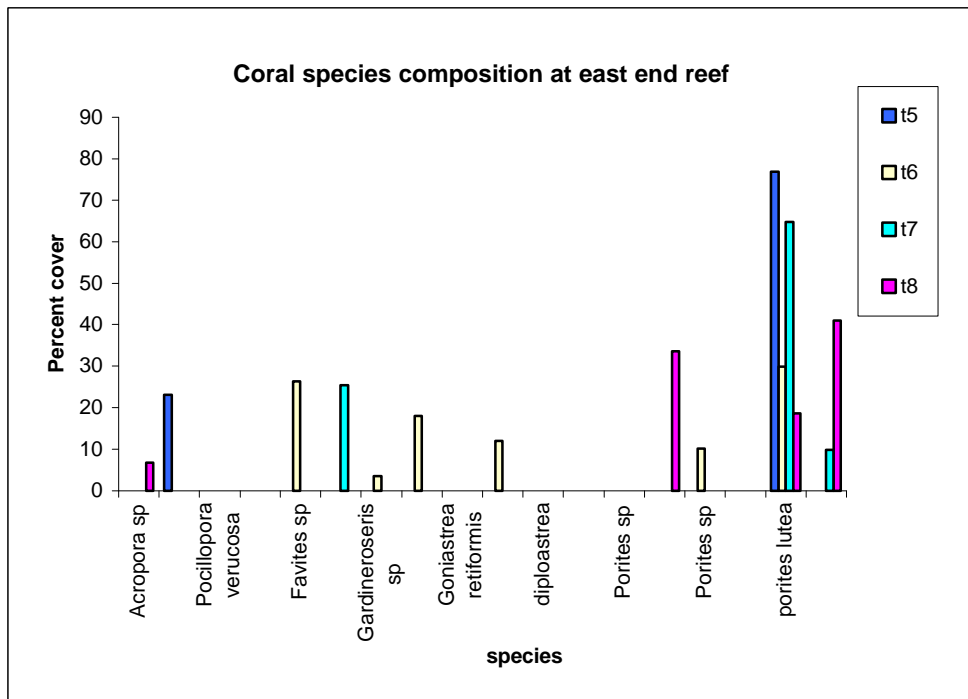
Coral species diversity was low for all the surveyed transects and was similar to both sites and depths surveyed (**Figure 12**). Branching coral species (mainly *Acropora sp*) were few and recorded in only two transects (t1 in west end reef and t8 in east end reef. All the *Acropora* colonies were less than 40 cm in diameter indicating recent growth of these corals. These branching corals often grow fast compared to massive species and are more sensitive to environmental stress. Sedimentation depending on its intensity and duration would have chronic effects on coral and *Acropora* species are the first to suffer. Recently settled corals are not common in the survey area. The presence of adult colonies in the area indicates that it potentially would be the source of larvae as new coral settlement however, in the presence of environmental stress such as sedimentation, mortality of newly settled corals would be high. Smothering of newly settled corals and its death would be therefore be high on horizontal surfaces compared to vertical surfaces. This argument is supported by the presence of new coral settlement of the vertical surfaces of sheet piles (**Photos 9 – 13 in Annex 1**)

**Figure 12 Species composition of live coral cover for the transects surveyed. a) West end reef. Plots are for two depths (t1-t2 = 5meters) t3-t4 = 10meters). b) East end reef. Plots are for two depths (t5-t6 = 5 meters), t7-t8 = 10 meters)**

a



b



#### 4.5.2.2 FISH SURVEYS

Fish census surveys showed similar trends in terms of abundance of fish at the two sites surveyed. Between 20 and 33 species of fishes belonging to 13 groups of fish were recorded (**Table 8**). Butterfly fishes and angel fishes are frequent despite the low live coral cover but the reef slope is characterized by relatively high topographic relief which may have been the reason for the diversity and abundance of fish species. Commercially valuable food fishes such as jacks and snappers are also recorded here though not in abundance. Fusiliers, a popular baitfish species are also observe schooling in the vicinity. Damselfishes and surgeon fishes are abundant the two depths surveyed and more conspicuous in algal dominated areas in the reef.

**Table 8 Fish census survey results**

	Western reef site				Eastern reef site			
	Reef slope (5meters)		Reef slope (10meters)		Reef slope (5meters)		Reef slope (10meters)	
Name	Species	Numbers	Species	Numbers	Species	Numbers	Species	Numbers
Butterflyfishes	4	21	3	12	3	9	3	6
Angel fishes	2	5	3	6	1	5	3	5
Parrot fishes	5	39	3	15	4	13	4	20
Snappers	2	8	3	7	2	6	2	7
Jacks	1	12	2	7	1	2	2	6
Emperors	1	4	1	2	0	0	2	7
Damsel fishes	3	schools	1	schools	3	schools	4	schools
Surgeon fishes	5	schools	2	18	2	35	3	schools
Fusiliers	2	schools	2	schools	0	0	0	0
Sweetlips	1	6	0	0	1	3	1	5
Groupers	2	2	3	7	1	2	3	12
Wrasses (others)	4	27	3	21	2	12	2	31
Sea turtles	1	1	0	0	0	0	0	0
Napolean wrasse	0	0	1	3	0	0	1	2
Total	33	125	27	98	20	87	30	101

#### 4.5.3 MARINE PROTECTED DIVE SITES AND PROTECTED SPECIES

There are 25 marine protected dive sites in the Maldives mainly in the tourism zone atolls. As such, many of these sites are located in Male atoll. "Lion Head" is one such protected dive site in North Male atoll and is located on the southern side of Thilafushi reef. Significant features of this site include Grey reef sharks, Napoleon wrasses and many other pelagic fish life.

Many marine species are legally protected in the Maldives. These include whale and dolphins, sharks (in the tourism zone atolls), sea turtles, Napoleon wrasses, black coral, giant clam and many others. A small number of protected species were observed at the project

site. These included Napoleon wrasses and a small green turtle. Napoleon wrasses are territorial and hence appear as residential to this reef area **(Photos 14 – 18 in Annex 1)**

## 4.6 WATER QUALITY

### 4.6.1 GROUNDWATER

In order to assess and establish baseline condition of the ground water at project site water samples were taken from the two existing well in the site (see figure ). One source of groundwater was from the old well on the western end of the project compound and the other is a new well that would be fully used during the operation of the project.

The results of the groundwater analysis are shown in **Table 9** The parameters included here are analyzed by the Public Health Laboratory (PHL) in Male and are limited to tests available at this laboratory at the time of the study. From the analysis of the groundwater samples it is noted that the conductivity of the both samples are less than 2.0 ms/cm indicating very low salinity for both samples. Chemical oxygen demand (COD) levels are well below detection level for both these samples indicating the water been virtually pollution free. Similarly, the concentration of metals in the water including heavy metal lead (only heavy metal test available at DPH at the time of study) is very low (< 5µg/l).

Similar studies in the vicinity of project site were carried out in 1998 (The study on Solid Waste Management for Male City in the Republic of Maldives (1998)).

**Table 9 Groundwater sampling results**

Parameters	units	GW1	GW2
Physical appearance		Clear	Clear
Temperature	° Celsius	23.6	23.5
Conductivity	Ms/cm	1.02	0.8
Salinity	ppt	2	1
PH		7.7	10
Total dissolved solids	g/l	339	178
Phosphate	mg/l	0.11	0.52
Nitrite	mg/l	3	1
Nitrate	mg/l	1.7	1.5
Ammonia	mg/l	0.07	0.08
Dissolved oxygen	mg/l	9.1	8.3
Iron	mg/l	0.01	0.01
Copper	mg/l	0.04	0.03
Lead	µg/l	3	5
Chemical oxygen demand	mg/l	0.00	0.00
Oil (hydrocarbons)	ppm	0.00	0.00

#### 4.6.2 SEAWATER

Similar to groundwater sampling seawater samples were collected from the lagoon where the reef surveys were carried out. This is also to establish a benchmark for the seawater quality at the project site. This baseline information could be useful in determining changes that may occur if any accidental or operational damage to marine environment occur.

**Table 10** shows the results of the water quality analysis for all the samples tested. It is noted that the parameters tested and available from PHL showing typical values as that of standard seawater indicating high quality of the water samples. Similar results were also reported for the water quality tests carried out in the vicinity in different surveys (1993-1997) and 1998 (In: The study on Solid Waste Management for Male City in the Republic of Maldives (1998)). This is indicative of the high level of dispersal and dilution ability in the surrounding waters of Thilafushi despite the continued solid waste dumping in the vicinity (Thilafushi I, solid waste disposal area for Male and nearby islands).

It should however be noted that the samples taken are targeted from the project site and does not include adequate samples to quantify the effects of Thilafushi waste disposal effects on the reef environment. Therefore it should not be generalized and considered conclusive that the on going solid waste disposal and the related dredging activities and its constituents would not contribute to some level of contamination. It should also be noted this water quality is only a broad scale means of assessing the health of the seawater and it alone would not be sufficient to out rule micro level nutrients in the water body due to the above mentioned activities.

**Table 10 Seawater quality results**

Parameters	units	Sw1	Sw2	Sw3	Sw4	Sed1	Sed2
Physical appearance		Clear	Clear	Clear	Clear	Clear	Clear
Temperature	° Celsius	24.3	24.3	24.9	25.1	25.6	24.3
Conductivity	ms/cm	63.5	62	64	63	64	63.8
Salinity	ppt	34	34.5	34	35	35.2	35.1
pH		7.9	7.9	7.7	7.6	7.7	7.8
Total dissolved solids	g/l	36800	35300	38400	37300	3230 0	35500
Phosphate	mg/l	0.05	0.06	0.15	0.07	0.13	0.13
Nitrite	mg/l	6	2	2	5	0.00	0.00
Nitrate	mg/l	1.5	0.9	1.4	1.4	0.4	1.0
Ammonia	mg/l	0.75	5.75	3.25	2.0	5.75	3.25
Dissolved oxygen	mg/l	11.4	11.6	9.8	11.1	9.3	6.5
Iron	mg/l	0.00	0.00	0.01	0.01	0.00	0.01
Copper	mg/l	3.76	3.52	3.71	3.57	2.32	4.21
Lead	µg/l	1	1	1	1	5	0
Oil (hydrocarbons)	ppm	0.00	0.00	0.00	0.00	1.00	1.00

### 4.6.3 AMBIENT AIR QUALITY

Baseline ambient air quality data is not available. However, visual assessment of the site did not indicate any problems with air quality. This is due to large open areas on all sides. However, Thilafushi is a dumpsite for all sorts of waste emanating from Malé, resorts and some of the other islands. Open burning of all kinds of waste takes place on Thilafushi, as a result of which, depending on the direction of the wind, smoke containing hazardous substances may be present at times on the Villa Hakatha site as well. One of the main concerns would be the production of ground level ozone due to reaction of nitrogen oxides and volatile organic compounds in the presence of sunlight. Burning of plastics at low temperatures would also produce carcinogenic toxins that may impair health of those working in the vicinity. In addition to health impacts, ecological and material damage due to some of the pollutants and soot is of concern.

It would, therefore, be necessary to have proper waste management procedures in place for Thilafushi and also have air quality monitoring systems in place to ensure health of the people working or literally 'living' in Thilafushi.

Thilafushi is also growing with several industries, each with their own power plants. Power generation often produces gaseous pollutants such as sulphur dioxide and nitrogen oxides along with particulate matter. Particulates can be composed of inert or extremely reactive materials of size varying from 0.0002 to 500 microns, and the fraction below 10 microns are often inhaled into the deepest parts of the human respiratory tract causing acute respiratory symptoms. For this reason, it is important to reduce the number of small power plants on the island and provide central electricity to all industries. It may be for this reason that the government is considering the provision of common utilities on the Thilafushi, which may reduce the impacts of individual utilities.

On average, a person breathes about 22,000 times a day, and in the process takes in about 16kg of air each day, which is much more than the daily consumption of food and water (AL Aggarwal). Therefore, it is important that the air that we breathe is kept to the best possible standards, relatively free from all sorts of pollutants. The effects of air pollution on human beings are mainly on eyes and respiratory system. Air-borne gases, vapours and dust come in contact with the organs of the body, and first cause irritation or even damage the exposure routes of eyes, nose, throat, skin, etc. Further, continued exposure of short term (acute) or long term (chronic) pollutant concentrations may lead to various ailments, which are pollutant specific. The range of health effects may vary from a temporary recoverable nature, like carboxy-haemoglobin rise to permanent fatal type, like lung cancer. The prime factors affecting the human health are nature and concentration of pollutants, duration of exposure, health of the person and age group.

Villa Hakatha may consider carrying out a dust sampling programme or air quality monitoring programme in the future in collaboration with Thilafushi management or Waste Management Section of the Ministry of Construction and Public Works.

#### 4.6.4 AMBIENT NOISE

Sound levels were measured at different locations around the office complex and the generator house using a digital sound level meter that meets IEC 651 type 1 specifications and conforms to A and C decibel weighting scales. **Table 11** gives the A-weighted sound pressure levels (spot readings) for the selected locations. The A-weighted scale was used for ease of reference using the USEPA standards, which are followed in the country at present. Since the noise levels were measured while the diesel generator that would be used during the operation of the facility was working, an estimation of the noise levels were not required or necessary.

**Table 11 Noise levels near the powerhouse and around the Villa Hakatha Office complex, Thilafushi**

Location	Sound level in dB(A), slow response	Remarks
Inside the Office Compound	57	Can be heard
Outside Office Compound (Northern Side)	75	
Inside DG Room	106	Room Windows Open
Panel Room (DG)	79	
Compressor Room	71	Compressor off

These noise readings indicate that the source of the noise is the diesel generator sets during construction and even during the operational phase. At the time of sampling the windows of the generator house was open. Hence the noise levels were above acceptable standards around the powerhouse and inside the office. Behind the office complex on the opposite side of the road is a small powerhouse of *Gulf Craft Motor Boat Yard*. The noise from this powerhouse also has a cumulative impact on the noise levels near the office building and perhaps inside the office.

Since the island is a landfill and industrial island, there are no residential and recreational receptors on the island. The site office is basically the only noise sensitive area in the facility boundaries. However, the noise level inside the site office conforms to acceptable standards.

By all standards a maximum of 70dB(A) is often allowed for an industrial area such as Thilafushi. However, it is important to note that workers who are constantly working in areas with SPL above 85 dB(A) must wear hearing protection devices.

## **5 IMPACT ASSESSMENT**

### **5.1 INTRODUCTION**

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes, present information and monitor actual changes. Environmental impacts could be positive or negative, direct or indirect, local or regional and also reversible or irreversible. This chapter discusses the incremental environmental impacts on these environmental parameters due to the proposed project activities of Villa Hakatha.

### **5.2 POTENTIAL IMPACTS ON AMBIENT AIR QUALITY**

#### **5.2.1 CONSTRUCTION PHASE**

During the construction phase, air emissions are mainly expected from earth moving activity and exhaust from the diesel generator. These emissions will not have any significant negative impact on Ambient Air quality (AAQ) for the following reasons:

- Use of fuel-efficient DG sets.
- The soil on the site consists of coarse coral sand, which generates minimal fugitive dust during excavation and dumper operations.
- No public-residential areas on the island and other sensitive receptor likely to be affected by air-borne dust.

#### **5.2.2 OPERATION PHASE**

Air emissions during the operation phase of the project consists of:

- Point emissions from Diesel Power Generator Sets
- Point and fugitive emissions from Cement Silos and Packing Plant
- Emissions from Supply Vehicles
- Fugitive dust emissions from cement handling area
- Vapour losses from fuel handling and storage tanks.

Maldives does not have any air emission and ambient air quality (AAQ) standards or guidelines. Thus emissions from the proposed operations have been estimated and a

qualitative impact assessment on AAQ has been made based on engineering judgement, inherent process safeguards and existing site conditions.

*The Villa Hakatha facility is not expected to have any significant negative impact on the AAQ due to the following reasons:*

- Use of fuel-efficient DG sets. The emissions from DG sets will be discharged through a single 18m high stack. This stack height is adequate to disperse the pollutants sufficiently. Fuel used will be of good quality with about 0.5 % sulphur content.
- The emissions from cement silos and packing plant will be vented through dedicated high efficiency bag filters (Efficient +99%). Cement transport from ship to silos and thereafter to packing plant will be through enclosed pipelines.
- Plant roads will be largely asphalted thereby minimising dust entrainment from roads into the atmosphere due to vehicle movement.

## 5.3 IMPACTS ON AMBIENT NOISE

### 5.3.1 CONSTRUCTION PHASE

During the construction phase, high noise generation emissions are mainly expected from the diesel generator. The impacts from these emissions have been categorised as **insignificant negative** due to the following:

- ◆ The day and night time noise level monitored at the facility boundaries varied between 50 and 65 dB (A) during operation of DG sets. This is within 70 dB (A) and 75 dB (A) night and day noise guideline value prescribed by the *IFC EHS guidelines for Construction, Material and Plants*.
- ◆ Also, Thilafushi Island has been designated as an industrial zone. There are no public and residential areas on the island, apart from the plant personnel residential facilities. Thus it is concluded that there will be **insignificant negative impact** on community noise due to construction at site.

### 5.3.2 OPERATION PHASE

During the operation phase, noise will be generated from operation of diesel generator and compressors. The impact on community due to plant operation will be **insignificant negative** due to same reasons as in the construction phase.

## 5.4 IMPACTS ON WATER RESOURCES

### 5.4.1 WATER AVAILABILITY AND DRINKING WATER QUALITY

The water requirement for operations will not exceed 20 m<sup>3</sup>/day. Water requirement will be met from bore well on site and by seawater after treatment in reverse osmosis facility. There are no public areas in the island sourcing groundwater. Also industries on Thilafushi are similar to that proposed at Villa Hakatha and are not water intensive. Thus adequate amount of water is available for the project activities and no negative impact on water availability is expected.

Treated water quality after RO treatment (Manufacturer Specifications) will comply with the WHO guideline values for drinking water. Raw and treated water values for critical parameters are given below in **Table 12**.

**Table 12 Drinking Water Quality**

Parameter	Typical Sea Water	RO Product Water	WHO Guidelines
Chlorides	19300	121.2	250
Sulphate	3100	13	400
Electrical Conductivity	58600 us/m	405 us/cm	--
Sodium	10837	70.2	200
TDS	35540	217	1000
Total coliform	--	< 10	10

### 5.4.2 SURFACE & GROUND WATER QUALITY

Coral island aquifers are vulnerable to many pollutants and contaminants because of high permeability. The poor nature of the soil in many islands, which is generally poor in organic contents, has not the adequate structure to attenuate pollutants most effectively. The depth to the surface of the groundwater is also another factor that poses potential threats to its pollution. In the case of many islands, this is only a couple of meters. Thilafushi over time has now developed a thin freshwater lens on top of the seawater beneath the reclaimed land.

Similarly, contaminant free coastal water body is important for associated coral reefs and reef organisms health and functioning. Even though the project does not have planned to use groundwater or seawater directly for facility during the operation, the potential areas of impact

during construction and operation phase of the project for both surface and groundwater are discussed here.

#### **5.4.2.1 CONSTRUCTION PHASE**

Construction phase impacts on ground and surface water quality are expected from:

- Sheet piling activity
- Site development
- Sanitary wastewater from labour camps.
- Minor oil and grease leaks from construction equipment.

Small amounts of suspended solids are likely to be discharged into the reef area during rains, however, this quantity will be insignificant due to presence of sheet piles and boundary structure. **Impacts are not likely to be significant.**

Sanitary wastes from labour camps could contaminate surface and groundwater resources if discharged untreated. On an average about 80 to 120 construction staff and labour will be residing in temporary quarters. The wastewater will be treated in septic tanks and discharged through soak pits away from any well locations. Thus impacts due to sanitary wastewater discharge will be insignificant.

Open dumping of garbage on Thilafushi 1 by Ministry of Public Works has got a potential of contaminating the adjacent sea water. Garbage has been observed to be spilling out into the adjacent seawater. Therefore, leachate from waste materials have the potential to contaminate the surrounding surface water. However, chemical analysis of seawater and groundwater to establish the baseline condition did not indicate any significant contaminant from these sources. No faecal coliform were accounted for the samples tested either the ground or seawater and this was consistent with similar water sample studies carried out in 1998. The fine seawater quality around Thilafushi can be interpreted as effective in diluting and dispersing contaminants into the water body to an undetectable level due to the hydrodynamic regimes experienced by these waters.

#### **5.4.2.2 OPERATION PHASE**

##### **Impacts During Normal Plant Operations**

The process area does not have any source of continuous wastewater generation. Domestic wastewater (about 16 m<sup>3</sup>/day) will be treated in a Rotating Immersion Disc (RID) biological sewage treatment plant (STP) consisting of primary and secondary treatment units and used for gardening and flushing purposes inside the premises. This plant would have a capacity of handling a total hydraulic load of 300 m<sup>3</sup>/day. The characteristics of the effluent are given in **Tables 13.**

**Table 13 Treated water quality (effluents from sewage treatment plant)**

Parameters	Unit (mg/l)
PH	6.5 – 8.0
Biological Oxygen demand (BOD)	<15
Chemical Oxygen Demand (COD)	<200
Suspended Solids (SS)	<30
Oil and grease	<10

As seen from the Tables, wastewater will be treated to more stringent levels than the requirements of World Bank. ***No negative impact*** is expected on groundwater or surface water quality for the following reasons:

- a. All treated wastewater (less than 16 m<sup>3</sup>/day) is reused for gardening inside the premises and used for secondary uses such as toilet flushing. In case of unlikely event of STP breakdown, sewage will be treated in the primary treatment section to separate out the suspended solids and discharged via marine outfall where it would be dispersed and diluted effectively
- b. Critical site areas will be asphalted and thus there will be minimal leaching of contaminants in case of accidental spills.
- c. Tank farms areas and other areas prone to spills will have dikes for spill control and thus there will be no uncontrolled marine, soil and ground water contamination due to accidental spills.
- d. All plant areas will have good housekeeping, thereby minimising material losses, which may find its way into storm water drains.

### **Impacts Due to Accidental Petrol/Diesel and Cement Spills**

Credible spill quantities in the marine area due to unloading operations are 10 m<sup>3</sup> of petrol, 20 m<sup>3</sup> of diesel and about 1 m<sup>3</sup> during fuel dispensing into drums loaded on boats. 5 to 7 tons of cement is also likely to spill into the marine environment in case of rupture or snapping of cement unloading line.

The diesel and petrol storage tanks would be secured with a bund wall to contain potential leakages in case of accidents. When and if such incident happens the amount of leakage onto ground and contaminate groundwater would be minimal storage.

When such spills and leakages occurs the mobility of the fuel depends on the porosity of the fuel and the nature of the hydrocarbons. Crude oil derivatives such as diesel and petrol are significantly soluble in water and can contaminate water quite quickly. Oil leakages would be easily detected by taste and odor at concentrations less than 0.005 mg/l.

In situations where oil penetrates the water table zone and then spreads out, the effect of water table fluctuation would become important for its dispersal. The migrating oil film created by a spill or leakage would spread towards sea with falling tide and this would be significant in small coral islands.

## **5.5 IMPACTS ON MARINE ENVIRONMENT**

### **5.5.1 IMPACT DUE TO SHEET PILING**

The shallow reef flat on the northern side of Thilafushi has already been physically modified and altered from the reclamation of this area carried by the Ministry of Public Works (GOM). This reclamation extended up to the reef slope. The entire northern periphery (water front) of the project side has been constructed by steel sheet piling. This has evidently modified the reef in this area quite considerably, which would have inevitably caused irreversible damage to benthic flora and fauna. Sedimentation from this operation would also have caused smothering of corals and other benthic organisms but the extent and impact from this would be considerably less compared to the impact from the reclamation.

### **5.5.2 IMPACTS DUE TO ACCIDENTAL SPILL OF FUELS AND CEMENT**

Fuel (petroleum based) and cement spill can have a serious impact on the reef environment depending on its magnitude and scale. The effects of a particular oil spill depends on many factors not least the properties of the oil. Complex processes of oil transformation in the marine environment starts developing from the first moment of oil's contact with seawater. The progression, duration and the result of these transformations depend on the properties of the composition of oil itself and the environmental conditions. Diesel and petrol fuels are of

low viscosity in its properties and have relatively high evaporation rates. The most toxic constituents of oils are often the most volatile and hence evaporate rapidly. Because of this lethal concentration of toxic components leading to large-scale mortalities of marine life are relatively rare, localised and short-lived. It is also noted that the water depth in the vicinity of the fuel unloading area is relatively deep (no intertidal area), thus contamination of the benthos from oil would be rare unlike shallow reef area where clean-up processes are few and difficult. Therefore, given the nature of the fuel handled in the facility and its potential **accidental spill would also be short-lived and localised.**

Cement spill and its effects would also be localised when and if it happens. Smothering of benthic organisms would be inevitable but the severity of the impact would be related to the hydrology of the receiving water body. Cement smothering would have some lethal to sublethal effects on coral and other benthic organisms. These would range from total mortality of the organism impacted, to impairment of physiologically important processes such as respiration and reproduction. Although these impacts may be severe in case of any spill, it would be very localised

## **5.6 IMPACTS ON TOPOGRAPHY, GEOLOGY AND SOILS**

### **5.6.1 IMPACTS ON TOPOGRAPHY AND GEOLOGY**

As mentioned earlier, Thilafushi Island has been formed by reclamation activity. The reclamation was done to create a place for solid waste disposal for the city of Male' and surrounding islands. This activity has altered the very ecosystem of the area transforming it from a reef flat to large terrestrial ecosystem.

The site construction activity of Villa is not modifying the land mass of the project area significantly and this would be insignificant compared to what has already been modified at the site at large.

### **5.6.2 IMPACTS ON SOILS**

Soil quality in the study area is not expected to have any significant negative impact due to the following reasons:

- a. All solid and hazardous wastes will be handled and stored in designated containers and locations. Strict adherence to the Environmental Management Plan described in **Section 7.**
- b. Major process areas will be asphalted and thus there will be no leaching of contaminants in case of accidental spills.
- c. Tank farms areas and other areas prone to spills have dikes for spill control and thus there will be no uncontrolled soil contamination due to accidental spills.

- d. All plant areas will have good housekeeping, thereby minimising material losses, which may find its way into storm water drains and contaminate soils.

## 5.7 IMPACTS ON TERRESTRIAL ECOSYSTEM

As Thilafushi, especially the industrial zone, is a recently reclaimed area, there are no native flora and fauna on the island. Thus, this project will not have any negative impact on the terrestrial ecosystem.

## 5.8 IMPACTS ON SOCIO-ECONOMY AND COMMUNITY

Social impact assessment is a process of estimating the social consequences that are likely to follow from specific project development.

Thilafushi has been designated as the island for industrial activity and disposal of wastes. The island was formed by reclamation for the above purpose and did not consist of any human population. No rehabilitation and resettlement of people is required. The project is the second industrial venture in the country and likely to boost the economy of the region.

Most of the staff will be staying on site and adequate sanitation and health facilities will be available on site including residential accommodation, water supply, medical facilities etc. Thus a **major positive impact** is expected on socio-economic front in the area.

## 5.9 HISTORICAL, ARCHAEOLOGICAL OR ARCHITECTURAL SITES COMPATIBILITY

Historical, archaeological or architectural sites in the area form another important aspect of aesthetics. Such monuments need to be preserved and maintained, and care should be taken to ensure that there are no adverse impacts resulting from the project operations, if located in their proximity.

There are no architectural monuments of any significance on Thilafushi Island and hence **no negative impact** is expected.

## 5.10 IMPACT MATRIX

A summary matrix of all impacts, their sources, significance and mitigation measures are given in **Table 14**. Details of mitigation measures are given in Section 6.

**Table 14 Impact Matrix**

ENVIRONMENTAL COMPONENTS AFFECTED	Sr. No.	PROBABLE SOURCES OF IMPACT	POTENTIAL IMPACTS	MITIGATIVE MEASURES	REMARKS
Marine Water quality And biota	1.	Accidental Spills of diesel/petrol due to snapping of ship to shore unloading floating flexible hose.	Major Negative Impact - Damage to coral reefs and marine biota.	<ol style="list-style-type: none"> <li>1. Strict adherence to Procedures for fuel handling. Regular maintenance of pipelines and other equipment.</li> <li>2. Preparation and regular drills of <sup>2</sup>Spill Response Plan.</li> <li>3. All ships will be certified to MARPOL and other conventions- See <b>Section 7.2.3.3.</b></li> </ol>	Impacts will be localized due to rapid evaporation of petrol/diesel. Water depth at fuel unloading area (north side) is substantial.
	2.	Accidental uncontrolled discharge of spilled fuel from storage area	No negative impact	<ol style="list-style-type: none"> <li>1. Secondary containment (Dykes) around the fuel tank farm of 100% capacity of the largest tank.</li> <li>2. Tanks are designed in accordance with API standard. Design, fabrication and erection covered under 3<sup>rd</sup> party inspection by Lloyds Register.</li> </ol>	

<sup>2</sup> Emergency Response Plan for Villa Hakatha Facility

**Table 15 Cont table 14.**

ENVIRONMENTAL COMPONENTS AFFECTED	Sr. No.	PROBABLE SOURCES OF IMPACT	POTENTIAL IMPACTS	MITIGATIVE MEASURES	REMARKS
Marine Water quality And biota.	3.	Continuous discharge of RO brine rejects.	Negative impact on marine biota (coral, fisheries etc.) No negative impact expected	RO reject water will be discharge via marine outfall extending 20 m. , away from known coral formations for quick dilution.	Very small quantities – 2 m <sup>3</sup> /day of concentrated brine - Will be diluted and discharged via marine outfall.
	4.	Sewage discharge (in case of STP break-down only)	Minor negative impact Expected	In case of STP failure, sewage will be discharged after primary treatment via marine outfall away from known coral formations for quick dilution.	This will happen only in the unlikely event of STP mal-function requiring major repairs.
	5.	Storm water discharge from drains draining into sea near north boundary of the facility.	No negative impact expected	1.Oil separation pit at drain outlet from oil storage dyke to collect trace oils in storm runoff. 2.Adequate screen mesh at storm water outlet to collect suspended matter and other trash. 3.High level of housekeeping and maintenance in oil storage area	Small quantities expected.
	6.	Accidental release of cement, due to snapping of ship to shore pneumatic unloading floating line.	Smothering of coral formation likely. However, impact will be localized.  Moderate negative impact	1. Strict adherence to Procedures for cement handling. Regular maintenance of hose lines and connections. 2. Preparation and regular drills of Spill Response Plan.	In case of snapping of cement line, about 3 to 5 tons of material spill is expected. This will however, immediately get air borne and spread over a large area and disperse quickly due to high blower speeds.

**Table 16 Cont table 14.**

ENVIRONMENTAL COMPONENTS AFFECTED	Sr. No.	PROBABLE SOURCES OF IMPACT	POTENTIAL IMPACTS	MITIGATIVE MEASURES	REMARKS
Ground water quality	7.	Oil spills on ground.	Groundwater contamination  Insignificant negative impact	1.All major roads and oil storage areas will be Asphalted. 2.Fuel leak minimisation by strict adherence to maintenance schedules and good housekeeping	
Air quality	8.	SO <sub>2</sub> , NO <sub>x</sub> and SPM emissions from DG sets.	Deterioration of air quality Insignificant negative impact	1. Adequate stack height for dispersion. 2. Installation of Fuel efficient DG sets from Cummins 3. Use of good diesel (sulfur content of 0.5 % )	Thilafushi Island is ear-marked for industrial use by Govt. No public-residential areas on the island. Large dilution factor available from sea breezes.
	9.	Point emissions from cement silos during unloading and from packing plant.	Deterioration of air quality Insignificant negative Impact	Bag filters installed on silo tops and on the 2 packing plants.	Silo filling will take place only about once a month.
	10	Vapour losses from petrol/diesel bulk storage tanks	Human health impact Moderate negative impact	--	Vapour recovery systems recommended.
	11.	CFC release from air conditioners	Ozone depletion Insignificant negative impact	Use of CFC free air conditioners	--
Noise	12.	Diesel generator and compressor operation	Insignificant negative impact on Community ambient noise. Workplace noise impacts possible on personnel in high noise areas.	DG set and compressors will be housed in dedicated rooms. Staff will be required to wear ear-plugs.	No public-residential areas in Thilafushi. Noise level at facility boundaries during DG operation are not significant.

**Table 17 Cont table 14.**

<b>ENVIRONMENTAL COMPONENTS AFFECTED</b>	<b>Sr. No.</b>	<b>PROBABLE SOURCES OF IMPACT</b>	<b>POTENTIAL IMPACTS</b>	<b>MITIGATIVE MEASURES</b>	<b>REMARKS</b>
Terrestrial Environment	13.	Site development	No significant impact.	--	Thilafushi island is a fully reclaimed land, earmarked for industrial development. Reclamation done by GOM. Reef has been significantly affected by changing the marine ecosystem to a largely terrestrial ecosystem.
	14.	Discharge of wastewater and disposal of solid wastes, air pollution deposition	Soil contamination - Insignificant negative impact	No discharge of wastewater outside premises. To be used entirely for horticulture and other uses. All solid waste will be collected and immediately be taken to the Govt. garbage landfill site on Thilafushi 1 located 1.5 km away, in enclosed containers.	--
	15.	Disposal of sludge and waste oil from DG sets and other equipment.	Soil contamination – Minor negative impact	Will be sent to Thilafushi 1 Government landfill site for disposal. All material will be stored in sealed drums with secondary containment to avoid land contamination.	--

**Table 18 Cont table 14.**

<b>ENVIRONMENTAL COMPONENTS AFFECTED</b>	<b>Sr. No.</b>	<b>PROBABLE SOURCES OF IMPACT</b>	<b>POTENTIAL IMPACTS</b>	<b>MITIGATIVE MEASURES</b>	<b>REMARKS</b>
Disasters and Occupational health and Safety	16.	Exposure to high cement dust levels in packing plant.	Worker health and safety – Insignificant impact on health.	<ol style="list-style-type: none"> <li>1. Hoods with high efficiency dust collectors near filling area.</li> <li>2. Face masks will be provided to workers.</li> <li>3. Work place monitoring as per monitoring plan in EMP (Section 7)</li> </ol>	--
	17.	Explosions in LPG handling and storage area and fire in fuel oil handling area.	Property damage, personnel injury, loss of lives.	<ol style="list-style-type: none"> <li>1. Plant design as per NFPA standards. 3<sup>rd</sup> party inspection or design and installation by Lloyds Register.</li> <li>2. HAZOP and HAZAN have been conducted to identify hazards and mitigation measures.</li> <li>3. Risk Assessment (RA) studies have been carried out for hazardous installations such as LPG, Petrol, Diesel handling and storage.</li> <li>4. Site specific Emergency Response Plan (ERP) has been prepared, including Oil Spill Contingency Plan.</li> </ol>	

**Table 19 Cont table 14.**

<b>ENVIRONMENTAL COMPONENTS AFFECTED</b>	<b>Sr. No.</b>	<b>PROBABLE SOURCES OF IMPACT</b>	<b>POTENTIAL IMPACTS</b>	<b>MITIGATIVE MEASURES</b>	<b>REMARKS</b>
Disasters and Occupational health and Safety	18.	Explosions in LPG handling and storage area and fire in fuel oil handling area.	Property damage, personnel injury, loss of lives.	5. Findings and recommendations of the RA will be strictly implemented. 6. All personnel will be trained for safe operations and fire fighting and emergency response. Regular drills as per ERP.	--
	19.	Exposure to high noise levels	Human health impacts	Provision of ear-plugs to employees.	--
	20.	Hazards in construction phase – working at heights, welding etc.	Human injury	Provision of Personal Protective Devices – Safety belts, shoes, helmets, face masks etc.	--

## **6.0 ANALYSIS OF ALTERNATIVES**

### **6.1 BACKGROUND**

Republic of Maldives (Maldives) is an archipelago of some 1190 islands that span the equator about 650 km south-west of Sri Lanka. The islands are distributed among 26 atoll formations and are spread over an area of 90,000 square kilometers. Only 199 islands are inhabited and another 74 islands are set aside exclusively for tourist resort development. The islands are surrounded by shallow crystal clear lagoons enclosed by coral reefs. All atoll islands in the Maldives are small and low (1-3 meters above sea level).

Thilafushi Island has been created by reclamation by the Govt. of Maldives. The island has been subdivided into 3 major sections – Thilafushi 1, Thilafushi 2 and Thilafushi 3. Thilafushi 1 has been earmarked as a landfill site for garbage from Male. The land filling activity had commenced from the year 1991. Thilafushi 1 and 2 have been made available for industrial activity.

### **6.2 ALTERNATIVE SITES FOR THE PROJECT**

As stated above in Section 6.1, Government of Maldives (GOM) is currently permitting industrial activity of this nature, only on Thilafushi Island. Thus there is no alternative, but to establish the Villa facility at Thilafushi and environmental assessment for possible alternative sites was not carried out for this project.

## 7.0 ENVIRONMENTAL MANAGEMENT PLAN

### 7.1. INTRODUCTION

Adequate environmental management measures need to be incorporated during the entire planning, construction and operating stages of the project to minimize any adverse environmental impact and assure sustainable development of the area. The EMP presented below should be followed and regular monitoring of concerned parameters should be done. The EMP should be proactive in nature and should be upgraded if new facilities or modification of existing facilities, with environmental concerns, come up at a later stage.

### 7.2. ENVIRONMENTAL MITIGATION MEASURES

The mitigation measures presented below covers various environmental parameters such as :

- Air Pollution Control and Management
- Effluent Treatment and Management
- Hazardous and Solid Waste Management
- Occupational, Safety and Health issues
- Emergency Response Plans for emergency scenarios
- Plans for managing other operational issues
- Environmental monitoring
- Environmental Management System at Villa

The section below gives an **Action Plan** for mitigating impacts from generation of various pollutants. Other relevant issues such as occupational health and safety, environmental monitoring are also referenced in the Action Plans. An activity wise ready- reckoner of wastes generated and their management, procedures for handling, records etc. are given in **Table 24**.

#### 7.2.1 AIR POLLUTION CONTROL AND MANAGEMENT

The major sources of air emissions at Villa during the operating phase of the project include:

- Exhaust emissions from the generator sets - Continuous emissions
- Cement dust emissions from cement silos during filling - During silo filling (Monthly)
- Cement dust emissions from packing plant - Continuous emissions
- Gasoline vapour loss from Petrol and Diesel Storage tanks – During Filling

Action plan for air pollution mitigation is given in **Table 20**.

**Table 20 ACTION PLAN FOR AIR POLLUTION MANAGEMENT**

<b>EMISSIONS</b>	<b>MITIGATION MEASURES</b>
Emissions from DG sets.	<ul style="list-style-type: none"> <li>• Dispersion through 18 m high stack.</li> <li>• Use of low sulphur fuel (0.5%).</li> <li>• Strict adherence to maintenance schedule for generators, as specified by vendors.</li> </ul>
Dust emission from cement silos.	<ul style="list-style-type: none"> <li>• Silos equipped with valves to check pressure build-up.</li> <li>• Excess air with dust is released to atmosphere only through high efficiency pulse-jet bag filter (25000 m<sup>3</sup>/hour capacity). Dust collected in bag-filter discharged back into silo.</li> <li>• Strict adherence to bag-filter maintenance and housekeeping schedule.</li> </ul>
Dust emission from cement packing plant.	<ul style="list-style-type: none"> <li>• Cement dust generated during packing sucked through hoods by negative pressure pulse-jet bag filters (7200 m<sup>3</sup>/hour capacity, 1 bag-filter per plant).</li> </ul>
Vapour loss from fuel tanks. (all fixed roof tanks, even for petrol).	<ul style="list-style-type: none"> <li>• Vapor recovery system not present. It is recommended to install a vapour recovery and condensation system (presently PV valve only).</li> <li>• Strict adherence to Operation Control Procedure (OCP) for fuel dispensing to avoid spills.</li> </ul>
Monitoring	<ul style="list-style-type: none"> <li>• Workplace air monitoring inside packing plant for PM<sub>10</sub> and Total Suspended Particulate matter (SPM). Monitoring to be done every 6 months, during peak operation of packing plant.</li> <li>• Monitor tank losses and maintain records through daily logs and collect explosimeter readings from time to time.</li> </ul> <p>Physical monitoring of air emissions not recommended for the following reasons:</p> <ul style="list-style-type: none"> <li>• Operations at Villa facility do not involve generation of significant amounts of air pollutants.</li> <li>• Adequate infrastructure Air Monitoring and analysis not available in the Maldives.</li> </ul>

**TABLE 20 Cont.**

Occupational Safety and Health	<ul style="list-style-type: none"> <li>• Face masks for workers inside packing plant and other areas with high particulate emissions.</li> <li>• Use of safety shoes, helmets and goggles.</li> <li>• LPG and oil tanks vessel entry once a few years. Petrol tanks may contain lead residues- proper protective clothing at the time, pre entry and post entry checks etc.</li> <li>• Slight exposure to LPG fumes in the LPG bottling plant- not significant.</li> <li>• Petrol fumes in petrol dispensing units- not significant. Use standard dispensers (low vapour loss).</li> </ul>
Records	<ul style="list-style-type: none"> <li>• Generator maintenance records/logs</li> <li>• Fuel quality - sulfur content for each lot used.</li> <li>• Bag-filter maintenance records, including logs of incidences of bag rupture in cement section.</li> </ul>

### 7.2.2 NOISE CONTROL AND MANAGEMENT

Noise emission sources include DG sets and compressors. Work place noise is of concern in these areas. Action plan for noise mitigation is given in **Table 21**.

**Table 21 ACTION PLAN FOR noise control & MANAGEMENT**

EMISSIONS	MITIGATION MEASURES
Noise from DG and compressor room	<ul style="list-style-type: none"> <li>• Strict adherence to maintenance schedule for generators and compressors, as specified by vendors.</li> </ul>
Monitoring	<p>Physical monitoring of noise not recommended for the following reasons:</p> <ul style="list-style-type: none"> <li>• Operations at Villa facility do not involve generation of significant noise.</li> <li>• Noise monitoring at facility boundary during DG operation indicated noise levels lower than IFC ambient noise requirements.</li> </ul>
Records	<ul style="list-style-type: none"> <li>• DG/Compressor maintenance records.</li> </ul>
Occupational Safety and Health	<ul style="list-style-type: none"> <li>• Ear-plugs for DG operators.</li> </ul>

### 7.2.3 WATER POLLUTION CONTROL AND MANAGEMENT

As see in **Table 15**, the surrounding marine water quality and groundwater quality can be affected by the following:

- Sewage discharge into marine environment in case of STP failure
- Canteen effluent discharge
- Accidental fuel (Petrol/Diesel) and cement spills into marine area, during loading/unloading operations and from storage areas.
- RO reject discharge into marine area
- Discharge of storm water into marine area

Action plan for mitigating the impacts from these sources are given below and are summarized in **Table 22**.

#### 7.2.3.1 SEWAGE TREATMENT PLANT

The maximum wastewater flow from the entire facility will be 16 m<sup>3</sup>/day. Domestic wastewater including canteen effluent will be treated in a Sewage Treatment Plant (STP). This plant would have a capacity of handling a total hydraulic load of 300 m<sup>3</sup>/day. The STP will treat the effluent to meet the World Bank surface water discharge standards (**See Table 5**). The STP consists of the following main units:

##### a. Primary Treatment

- Screening
- Settling tank

##### b. Secondary Treatment

- Bio-treatment by Rotating immersion Disks
- Clarification by Lamella separator
- Dis-infection

##### c. Sludge Drying Beds

Treated effluent after secondary treatment will be used for horticulture. Sludge after drying will be used as manure. Some of the advantages of this system are low area requirement, low power consumption, low maintenance.

#### **Operation and Maintenance of ETP**

Only one operator will be required for the system per shift. STP Operation and Maintenance (O&M) procedure will be provided by the manufacturer/supplier of the system.

The O&M manual will consists of:

- ◆ STP Design Basis
- ◆ STP operation procedures under various scenarios
- ◆ Operational Trouble shooting guide
- ◆ Shutdown and Start-up procedures
- ◆ Preventive maintenance schedules
- ◆ Sampling locations, parameters and procedures
- ◆ Vendor manuals for various equipment

A plan for STP management and mitigation measures for discharge from other small sources are given in **Table 22A**

**Table 22a. ACTION PLAN FOR Sewage Treatment And Management And Mitigation of Discharges from Other Sources**

<b>DISCHARGE</b>	<b>MITIGATION MEASURES</b>
Canteen effluent	Effluent will be taken through a grease trap for removal of oil and grease. The treated water will then be taken to a Sewage Treatment Plant for further treatment along with sewage.
Domestic sewage	<ul style="list-style-type: none"> <li>• STP to treat sewage and canteen effluent to levels, lower than those required by World Bank surface water discharge standards.</li> <li>• Secondary treated effluent to be used for horticulture.</li> <li>• All effluent to be used inside premises. – NO DISCHARGE PERMITTED OUTSIDE PREMISES.</li> <li>• In case of STP breakdown, effluent will be discharged into sea via a marine outfall after primary treatment, till repairs are carried out.</li> <li>• Preparation of O&amp;M Manual. Strict adherence to O&amp;M procedure given in STP O&amp;M manual</li> <li>• Good housekeeping at STP area and sludge drying beds.</li> <li>• The STP vendor will give STP O&amp;M training to Villa operation team.</li> </ul>
RO discharge	RO reject (brine) water will be discharged into the sea away from reef area, only through a marine outfall.
Storm water discharge	<ul style="list-style-type: none"> <li>• Storm water discharge into sea from north boundary. A screen will be provided to arrest trash</li> <li>• All Dyke outlets at fuel storage area will have oil separation pit to trap oil carried over with storm water from dyke area.</li> <li>• Storm water drains and 2 meter area on either side to be kept clear of all chemical and other storage.</li> </ul>

**TABLE 22A CONT.**

<b>DISCHARGE</b>	<b>MITIGATION MEASURES</b>
Monitoring	<ul style="list-style-type: none"> <li>• Monthly analysis of treated effluent for pH, BOD, S.S and Oil &amp; Grease. Quality should meet vendor specified levels. Should not exceed World Bank discharge standards (<b>See Table 5</b>)</li> <li>• Corrective action plan will be prepared for instances when, discharge standards are not met.</li> </ul>
Records	Records to be maintained for the following: <ol style="list-style-type: none"> <li>1. Monthly monitoring results for pH, BOD, SS, O&amp;G</li> <li>2. Logs of STP operating hours</li> <li>3. Instances of STP stoppage.</li> <li>4. Incidents of large oil spills/leaks</li> </ol>

**7.2.3.2 OIL/CEMENT SPILL PREVENTION AND MITIGATION**

Material spills can occur in marine and land area due to the following incidences:

- Fuel spill in marine area due to snapping of Fuel Discharge Line during unloading of Fuel (Diesel/Petrol) from Ship to tanks. A maximum credible scenario of 10 to 15 m<sup>3</sup> Petrol Spill and 20 to 25 m<sup>3</sup> Diesel Spill into the marine area is envisaged.
- Fuel spills during manual dispensing of fuel into drums on ships. A maximum credible scenario of 1 m<sup>3</sup> fuel spill in the marine area is envisaged.
- Fuel Spills due to tanker/ship mishap.
- Cement spills into the marine are during pneumatic unloading of cement from ship to silos. A maximum credible scenario of 5.3 tons of cement spill in the marine area is envisaged.
- Minor fuel spills on land due to valve/ line failures and leaks.

The mitigation measures proposed for these incidences are given in **Table 22B** below:

**Table 22b. ACTION PLAN FOR material spills**

INCIDENTS	MITIGATION MEASURES
Fuel/Cement spills in marine area during unloading operation.	<ul style="list-style-type: none"> <li>• <sup>3</sup>HAZOP study carried out for the entire system. Recommendation of the study will be strictly implemented.</li> <li>• Strict adherence to maintenance schedule specified in <sup>4</sup>Risk Assessment (RA) Report for the facility</li> <li>• <sup>5</sup>Oil spill contingency plan has been prepared for the facility. Facilities for spill clean-up and regular drills will be carried out as per the plan.</li> </ul>
Marine Spills from tanker/ship mishap.	<ul style="list-style-type: none"> <li>• All ships will be certified to MARPOL and other requirements. See <b>Section 7.2.3.3</b> for a list of compulsory certifications for all vessels used for Villa Hakatha project..</li> <li>• Annual 3<sup>rd</sup> party safety audit (including spill control capability) of Villa vessels to be used for loading and transport of fuel to and from Villa facility at Thilafushi.</li> <li>• Very low incident base probability (10 hours per year of unloading envisaged).</li> <li>• Waters near the jetty unlikely to result in groundings- traffic is very low hence collision frequency could be very low. In addition, other vessels to be stopped in the area during LPG and petrol/ diesel unloading- NB OTHER OPERATIONS ALLOWED AT THE TIME.</li> <li>• Facility of Booms, Skimmers, dispersants etc. at the jetty catering to a major oil spill to be ensured.</li> <li>• Strict O &amp;M procedures for marine unloading, hose empty out (for LPG through compressor etc.), connection and disconnection etc.</li> <li>• Clean-up procedure of spills as per ERP, which includes detection of spill, surveillance of spill and mitigation plan.</li> </ul>

<sup>3</sup> HAZOP Study Report for LPG, Oil and Cement Facility of Villa Hakatha, December 2001, Serene Environmental Services.

<sup>4</sup> Risk Assessment Report for Villa Hakatha Project, December 2001, Serene Environmental Services

<sup>5</sup> Emergency Response Plan (ERP) for Villa Hakatha Project, December 2001, Serene Environmental

**Table 22b Cont.**

<p>Fuel spills on land from storage tanks, valve leaks etc.</p>	<ul style="list-style-type: none"> <li>• Dyke around Fuel tank farm to contain spills.</li> <li>• Mechanical seals for pumps provided</li> <li>• 3<sup>rd</sup> party inspection of design, fabrication and installation of fuel storage tanks by Lloyds Register, UK.</li> <li>• All tanks made as per API specifications.</li> </ul>
<p>Occupational Safety and Health</p>	<p>Neither LPG nor Oil have significant health impact - their fires may release un-burnt hydrocarbons and toxic products. Fire fighters, those inhaling vapours must have respiratory protection</p>
<p>Monitoring/Inspections</p>	<ul style="list-style-type: none"> <li>• Annual monitoring and analysis of marine ecosystem - Reef benthos including corals and fish diversity. The locations and methodology of monitoring will be the same as that for the baseline monitoring <b>(See Section 4.5)</b> of this EA report.</li> <li>• Annual monitoring and analysis of ground water on the site and marine water surrounding the site. Monitoring locations and parameters to be monitored will be the same as those for baseline study <b>(See section 4.6)</b></li> <li>• Storage tank/ LPG sphere inspections by third party , inspection/ hydro test of hazardous pipelines, periodic thickness surveys etc. Unloading Hoses vendor suggested inspection/ maintenance schedule.</li> <li>• Regular O&amp;M logs including vibration, thickness, operating conditions etc.</li> </ul>
<p>Records</p>	<ul style="list-style-type: none"> <li>• Ecological and water monitoring records.</li> <li>• Vessel and equipment history cards/ passports showing maintenance works carried out, design and operating data, failure data, inspection reports, Non Destructive Testing records etc.- this must be maintained for all critical equipment.</li> <li>• Operating data available on Data Acquisition System of the DCS in memory- printouts to be taken and studied and kept in safe custody.</li> <li>• Trends analysis through DCS/PLC may be done periodically.</li> </ul>

### 7.2.3.3 REQUIREMENTS FOR VESSELS CARRYING FUEL OIL/ LPG

All vessels carrying bulk fuel oil, LPG and Cement to the Villa Hakatha site, will be required to comply with various international requirements for safety and marine environment protection. The vessels will be required to comply with the following:

(a) **MARPOL 73/78**

Marpol 73/78 (The International Convention for the Prevention of Pollution From Ships) is the international treaty regulating disposal of wastes generated by normal operation of I vessels. 88 Countries are parties as of November 1, 1994 and Republic of Maldives is one such country. An International **Oil pollution Prevention (IOPP)** certificate for Annex 1, Marpol compliance is issued by the Ministry of Transport and Civil Aviation, Govt. of Maldives.

The treaty consists of 20 Articles and 5 Annexes. Annexes I and II are mandatory on all parties, whereas, Annexes III, IV and V are optional and are not binding unless the party has specifically accepted those Annexes. The Annexes are as follows:

<b>Annex</b>	<b>Subject</b>	<b>Entry into Force</b>
Annex I	Oil	10/2/83
Annex II	Noxious Liquids carried in Bulk	4/6/87
Annex III	Harmful substances in packaged Form	7/1/92
Annex IV	Sewage From Ships	Not yet in Force
Annex V	Garbage from Ships	12/31/88

Apart from other requirements, **Regulation 26, Annex I of MARPOL** requires every oil tanker of 150 tons gross tonnage and above, and every ship other than an oil tanker of 400 tons gross tonnage and above, to carry on board a **Shipboard Oil Pollution Emergency Plan (SOPEP)** approved by the Administration. In this manual, which needs to be approved by the Flag State or Classification Society, procedures are defined for Ship's master or Person In-Charge for alerting Local Authorities, Ship Owner or Operator, in case of an actual or threatened discharge of oil into the sea. A list of equipment and materials for controlling and clean-up of oil and requirement for recording oil spills and communication drills are also included.

(b) **Safety Management Certificate**

The International Safety Management (ISM) Code was adopted by the International Maritime Organisation (IMO) in November 1993 and made mandatory under Chapter IX of the International Convention for the Safety of Life at Sea (SOLAS). The Code sets out to **ensure safety at sea, prevent human injury or loss of life, and avoid damage to the marine environment and property.**

Phase I of the ISM Code came into force on 1st July 1998 and was applicable to passenger ships including high speed craft, tankers, bulk carriers and cargo high speed craft of 500 gross tonnes and above.

Phase II of the ISM Code, scheduled to come into force on 1st July 2002, is applicable to all other vessels above 500 gross tons which were not covered under Phase I. These include general cargo ships, survey vessels, container ships, ocean tugs, mobile offshore drilling units, reefer ships, car carriers, livestock carriers, cement carriers and woodchip carriers.

### **Establishment of Safety Management System (SMS)**

The Code requires a safety management system (SMS) to be established by "the Company", which is defined as the ship-owner or any person who has assumed responsibility for operating the ship. The SMS sets out the procedures by which the safety and pollution prevention aspects of a ship are managed, both ashore and on board. The Company should be able to follow the set procedures to check that it complies, and continues to comply, with the various rules and regulation, e.g. **the Load Line Regulations, MARPOL, STCW, other chapters of SOLAS**, etc. The Company is required to provide the necessary resources and shore-based support to implement the SMS. The Company is also expected to designate a person or persons ashore (DPA) having direct access to the highest level of management to ensure the safe operation of each ship and to provide a link between the Company and those on board.

#### **The SMS must incorporate the following:**

- *A safety and environment protection policy.*
- *Instruction and procedure to ensure safe operation of ships and protection of the environment in compliance with relevant international and flag state legislation.*
- *Flag state legislation.*
- *Defined levels of authority and lines of communication between and amongst shore and shipboard personnel.*
- *Procedures for reporting accidents and non - conformities.*
- *Procedures to prepare for and respond to emergency situation.*
- *Procedures for internal audits and management reviews .*

### **Certification**

The Administration (the State whose flag the ship is entitled to fly) or the organisation(s) recognised by the Administration is responsible for verifying compliance with the requirements of the ISM Code and for issuing the appropriate certificates.

A Document of Compliance (DOC) will be issued by the Administration or recognised organisation(s) after having verified that the Company has properly developed and implemented a SMS which complies with the ISM Code. The Company must produce objective evidence to show that the SMS has been in operation for at least three months on board at least one ship of each type operated by the Company.

A Safety Management Certificate (SMC) will be issued by the Administration or recognised organisation(s) to each ship operated by the Company after an initial verification of compliance by way of an external audit on board the particular ship.

#### **(C) Other certificates such as:**

- Cargo ship Safety Construction Certificate
- International Load Line Certificate

- Cargo Ship Safety Equipment Certificate
- Certificate of Class
- Cargo Ship Safety radio Certificate
- Certificate of Fitness (Under SOLAS) for LPG carriers

#### **7.2.4 SOLID & HAZARDOUS WASTE MANAGEMENT**

Solid wastes generated includes:

- Domestic garbage including food waste from canteen
- Office/administrative wastes (plastic, corrugated boxes, paper etc.)
- STP sludge

Wastes that can be categorized in the hazardous category include:

- Used oil from generators
- Sludge from tank cleaning operations
- Ballast from Ships

Solid waste management essentially consists of segregating, proper handling and storage and proper disposal. A brief action plan for handling various wastes are given below in **Table 23**.

#### **7.2.5 RISK ASSESSMENT AND EMERGENCY RESPONSE**

As discussed earlier, separate <sup>1</sup>HAZOP study <sup>2</sup>Risk Assessment Study and have been carried out and <sup>3</sup>Emergency Response Plans have been made for the Villa Hakatha Project. These studies are presented in separate reports. Specific recommendations for hazard minimization, occupational health and safety, emergency response action plans for fire/explosions/oil spills etc. are given in these studies.

Summary of findings and recommendations of Risk Assessment study is given in Annex IV. These recommendations should be followed in addition to ones given below."

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<sup>1</sup> HAZOP Study Report for LPG, Oil and Cement Facility of Villa Hakatha, December 2001, Serene Environmental Services.

<sup>2</sup> Risk Assessment Report for Villa Hakatha Project, December 2001, Serene Environmental Services

<sup>3</sup> Emergency Response Plan (ERP) for Villa Hakatha Project, December 2001, Serene Environmental

**Table 23 ACTION PLAN FOR SOLID AND HAZARDOUS WASTE MANAGEMENT**

<b>WASTE GENERATED</b>	<b>MITIGATION MEASURES</b>
Domestic garbage	<ul style="list-style-type: none"> <li>• Bio-degradable and non-biodegradable fraction of the waste will be segregated at source.</li> <li>• Waste will be sent for land filling to Thilafushi I, the Government designated landfill site.</li> </ul>
STP sludge	<ul style="list-style-type: none"> <li>• Dried in sludge drying beds</li> <li>• To be used as manure inside premises</li> </ul>
Used Oil from DG room	<ul style="list-style-type: none"> <li>• Stored in dedicated drums on concrete floor with a 0.5 dyke or metal trays to minimize spills.</li> <li>• Drums to be marked "Waste Oil"</li> <li>• Waste oil to be sent to Thilafushi 1 landfill site for disposal.</li> </ul>
Records	<ul style="list-style-type: none"> <li>• Waste oil generated and sent to Thilafushi 1 for disposal</li> <li>• Canteen waste disposed</li> <li>• Office and other miscellaneous waste disposed</li> </ul>

**Table 24 READY-RECKONER OF WASTE MANAGEMENT REQUIREMENTS**

ACTIVITY AREA / CONCERN	WASTE / ISSUE	HANDLING AND DISPOSAL	PROCEDURE	MONITORING / Inspections	RECORDS
<b>LPG Storage/Filling</b>	No significant wastes	--	--	--	--
	Accidental fire /explosion	--	Procedure for periodic inspections/checks as per vendor specs.  Work Instructions for Emergency Response to be made (as per Emergency Response Plan)	<ul style="list-style-type: none"> <li>• Safety audits</li> <li>• Fire drills</li> <li>• Equipment inspections as per specs.</li> </ul>	Maintenance records. Incident records.
	Occupational Safety and Health	PPEs for fire fighting such as fire jackets, SCBAs etc.	--	All equipment to be calibrated and inspected as per vendor specs.	--
<b>Oil Storage / Oil Jetty/ Oil unloading and dispensing.</b>	Oily storm water discharge from dyke areas.	Oil interceptor pit.. Oil will be removed and pumped back.	--	--	--
	Oil spills from storage tanks/pipelines on land	Clean up as per procedure.	SOP for un-loading and dispensing. SOP for spill clean-up.	Maintenance/ Inspections of Pipelines/valves etc. as per vendor specs.	Spill incident records
	Oil spills in marine areas.	As per oil spills contingency plan	SOP for un-loading And dispensing. SOPs for response as per plan. Insist on strict compliance with international codes such as MARPOL etc.	Spill response drills. Maintenance/ inspections of spill control equipment and gear as per vendor specs.	<ul style="list-style-type: none"> <li>• Spill incident records.</li> <li>• Drill records.</li> <li>• Inventory of dispersants for spill control.</li> </ul>
	Sludge from storage tanks	Will be collected in sludge tank and sent to Thilafushi1 in Govt. landfill site.	Work Instruction for sludge handling.	--	Sludge disposal records.

**TABLE 24 Cont.**

<b>ACTIVITY AREA / CONCERN</b>	<b>WASTE / ISSUE</b>	<b>HANDLING AND DISPOSAL</b>	<b>PROCEDURE</b>	<b>MONITORING / Inspections</b>	<b>RECORDS</b>
	Occupational Safety and Health	PPEs for fire fighting such as fire jackets, SCBAs etc.	--	All equipment to be calibrated and inspected as per vendor specs.	--
<b>Oil Storage / Oil Jetty/ Oil dispensing etc.</b>	Accidental fire /explosion	As per Emergency Response Plan.	Procedure for periodic inspections/checks. Work Instructions for emergency response.	<ul style="list-style-type: none"> <li>• Safety audits</li> <li>• Fire drills</li> <li>• Equipment inspections as per specs.</li> </ul>	<ul style="list-style-type: none"> <li>• Maintenance records</li> <li>• Incident records</li> </ul>
<b>DG POWER GENERATORS</b>	Used oil during oil change operations	To be stored in designated drums in the Room. Oil to be reused or sent to Thilafushi 1 disposal site.	SOP for handling used oils to avoid spills	--	Used Oil generated and disposal records
	Oily rags and other used spares from maintenance	To store in designated area in DG room and to be disposed along with other wastes to Thilafushi1.	Work Instructions for waste handling, storage and disposal.	--	--
	Air Emissions	To be let out from 18 m Stack. Use of low sulfur clean fuel.	--	Periodic Fuel quality inspection	Records of fuel quality
	Noise	Operators to use ear plugs.	--	--	--
<b>WATER TREATMENT PLANT</b>	RO rejects	To sea via marine outfall	--	--	--
<b>STORES/ Administrative block/ Residential block</b>	Packaging and office waste – Cartons, paper, plastic etc., Domestic garbage	To be stored in dedicated Waste Storage area and Sent to Thilafushi1 for disposal .	Work instruction for storage and handling.	--	Waste generation and disposal records.

**TABLE 24 Cont.**

<b>ACTIVITY AREA / CONCERN</b>	<b>WASTE GENERATION /Issue</b>	<b>HANDLING AND DISPOSAL</b>	<b>PROCEDURE</b>	<b>MONITORING / Inspections</b>	<b>RECORDS</b>
<b>Cement Storage and Packing Plant</b>	Air Emissions from Silos and packing plant	Filtered in Bag Filters.	SOP for Bag-Filter maintenance.	Bag-filter inspections as per vendor specs. Monitoring of pressure drops to assess filter performance.	Maintenance records including number of bags, solenoid valves etc. replaced.
	Occupational Safety and Health	Face masks, goggles for operators.	--	Work-place air monitoring for PM <sub>10</sub> inside packing plant every 6 months. Bag-filter differential pressure checks and maintenance as per vendor specs.	Work place monitoring records.
<b>STP</b>	Treated effluent	To be used for horticulture.  In case of STP break down, effluent after primary treatment will be discharged into sea via marine outfall.	As per O & M Manual	Monthly analysis of SS, O&G.	<ul style="list-style-type: none"> <li>• O &amp; M manual</li> <li>• Vendor Specs.</li> <li>• Monitoring records.</li> <li>• STP Operating Hours</li> </ul>
	STP sludge	Sent to Sludge drying beds and used for horticulture	As per O& M Manual	As per O& M Manual	As per O& M Manual
<b>DRAINAGE AND HOUSEKEEPING</b>	Contamination in storm water discharge	Storm water inside premises collected in separate storm water drains and discharged outside plant. Through screens to trap trash etc.	Develop Storm Water Management Plan to minimise leaks/spills etc. entering storm drains.	As per Plan	Work instructions for house-keeping.

### 7.2.5 PLANTATION AND LANDSCAPING

The plantation will have several benefits on the environment of the project area, such as:

- ◆ Control of wind blown fugitive dust and dust due to vehicular movement.
- ◆ Plantation will also help in binding the soil and in turn reduce soil erosion.

Due to space constraints, a small area near the facility boundary will be available for plantation. The following considerations will be made before selecting plant species:

- Tall growing, evergreen trees, native to the area
- Easy and quick early growth and establishment.
- Uniform spreading crown habit.
- Evergreen habit, if possible, or at any rate short deciduous period
- Ability to withstand conditions like inundation, salinity and draught
- Soil improving plants (Nitrogen fixers, rapidly decomposable leaf litter).
- Attractive appearance with good flowering and fruit bearing.
- Sustainable green cover with minimal maintenance

### 7.2.6 ENVIRONMENTAL MANAGEMENT SYSTEM

The Environmental Management System (EMS) will be developed for the Villa Hakatha Project.

The EMS will be driven by:

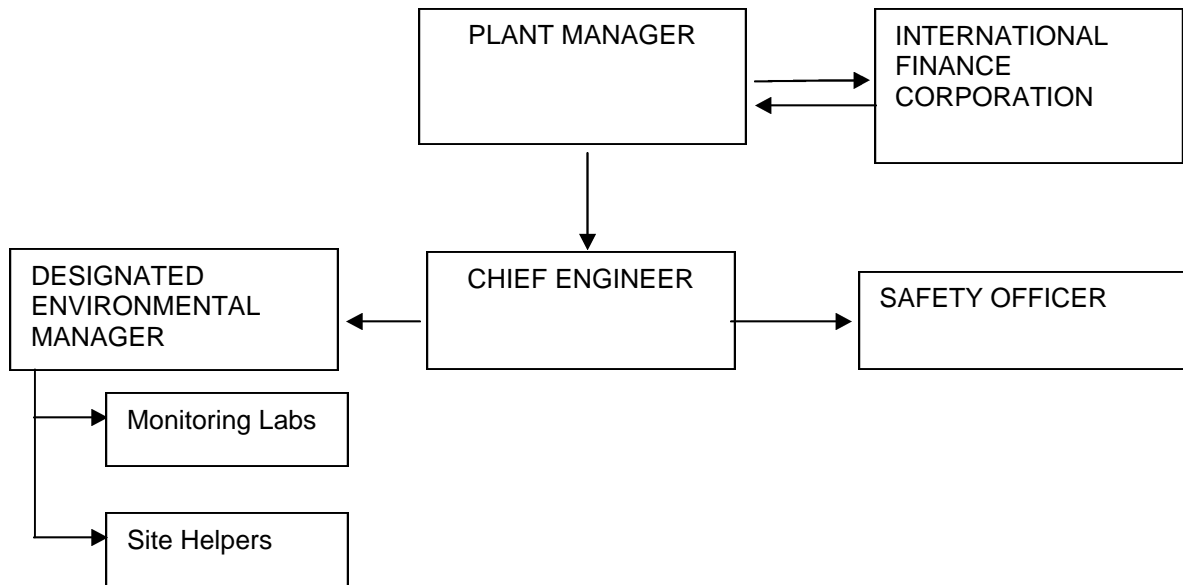
- ◆ An Environmental management cell
- ◆ EMS Documentation – SOP's, management plans, records.
- ◆ Regular Environmental Audits and Corrective Action

#### 7.2.6.1 EHS MANAGEMENT CELL

In general, all plant personnel connected with tasks which could have a significant environmental impact will be made aware/trained in environmental issues. As the facility is not yet in operation the team for EHS cannot be confirmed. The EHS responsibilities will be handled by the plant personnel. EHS cell composition will follow the framework given in **Figure 13**.

As the facility area is not extensive, a dedicated Environmental Professional is not envisaged. The environmental manager will be designated from the plant operation management. Safety officer, however, will be employed for co-ordinating all safety aspects of the facility.

**Figure 13 Environmental Management Cell Structure**



The major duties of the Environmental Manager and Safety Officer will be:

- ◆ To assure regulatory compliance with all EHS laws of GOM
- ◆ Ensure regular operation and maintenance of pollution control facilities such as STP, Bag-Filters etc.
- ◆ To minimize environmental impacts of operations
- ◆ Conduct periodic environmental, safety audits, emergency drills etc. of various facilities
- ◆ Ensure preparation and implementation of corrective actions derived from the environmental/safety audits
- ◆ Maintain documentation of good environmental practices, applicable environmental laws etc. as ready reference.
- ◆ Maintain environmental/safety/health related records.
- ◆ Coordinate with local government, external consultants, monitoring laboratories for various EHS issues.

#### **7.2.6.2 EMS DOCUMENTATION**

The EMS documentation will consist of :

- ◆ Standard Operating Procedures (SOP's) for significant environmental issues and tasks, The SOP's to be developed are described in **Table 24**.
- ◆ Environmental records and logs. Records to be maintained are given in the Action Plans in **Tables 20 to 23** and also in **Table 24**.
- ◆ Good Environmental Practice guidance documents
- ◆ External/internal EHS correspondence.
- ◆ Fire fighting, monitoring equipment and other critical equipment calibration and maintenance records.

- ◆ Records of Vessels used for bulk transport of LPG, Fuel Oil and Cement – Their Names, capacity, Owner/Operator, Copies of various certificates as mentioned in **Section 7.2.3.3** above.

### **7.2.6.3 ENVIRONMENTAL AUDITS AND CORRECTIVE ACTION PLANS**

To assess whether the implemented EMS is adequate, Villa will conduct regular Environmental Audits of its facilities. These audits will be followed by Corrective Action Plans to correct various issues identified during the audits. The audits will also include performance evaluation of pollution control facilities.

The methodology, frequency and criteria for environmental audits will be finalized before regular production.

## **7.2.7 ENVIRONMENTAL MONITORING AND REPORTING**

### **Reporting Parameters**

Environmental monitoring is an important on-going activity, which helps in tracking environmental performance. Monitoring requirements such as monitoring parameters, locations, frequency etc. are described in the **Action Plan Tables 21 to 23** for various environmental issues.

Reporting of Environmental Performance results is an important element for keeping various stake holders such as IFC, Villa Group, Govt. of Maldives and other investors. The following parameters (not a complete list, needs to be re-visited after start of operations) need to be documented at the Villa site and reported periodically to the various stake holders:

- Consolidated summary of analysis results for groundwater, marine water quality.
- Summary of treated sewage water quality and final use.
- Summary of marine surveys for reef benthos, fish habitat.
- Workplace monitoring results for PM<sub>10</sub> in Cement Plant.
- Number of incidents and causes of fire, explosions, marine oil spills and sewage treatment plant failures. Reported impacts of such incidents should be enumerated. Corrective actions suggested and implemented should also be reported.
- Summary of Vessels operated during the reporting period and compliance status with respect to various certifications such as MARPOL, ISM Code etc. (**See Section 7.2.3.3**)
- Environmental and safety audit findings and corrective action plans.
- Cost of operation and maintenance of pollution control equipment such as STP, Bag-filters etc.

### **Reporting Format**

Detailed formats for reporting of the above data will be prepared by Villa within 2 months of start of operations. Review of the actual operations will allow preparation of practical reporting formats. These will then be sent to IFC for approval.

### **Reporting Frequency**

The frequency of reporting will vary depending upon the requirements of individual stake holders:

- For the first year after commencing operations, 6 – monthly reports of the above data will be sent to IFC. Thereafter for subsequent years, annual reports shall be submitted.
- The period of reporting to GOM, will be as specified in their Environmental Permit or Permission to operate the facility.

## 8.0 PUBLIC CONSULTATION

### 8.1 PUBLIC CONSULTATION PROCESS

Public consultation for developmental projects are required both by Government of Maldives and also by International Finance Corporation (For Category A and B Projects). As per the requirement of IFC, Environmental Review Summary (ERS) will be prepared by the Environment and Social Development Department of IFC, after review of the EA report. The ERS will be circulated to the public by the Project Proponent (Villa) and conduct the public consultation process.

### 8.2 PROPOSED PUBLIC CONSULTATION

This will involve public consultation workshop aimed at a representative cross section of concerned citizens including NGOs, academicians, environmental experts etc. The approach and methodology proposed by Villa is presented in **Table 25**

**Table 25 Approach and Methodology for Public Information and Consultation Workshop**

NO.	APPROACH/ACTIVITIES
1.	The Environmental Review Summary or the Executive Summary of the EA report will be translated into the local language. The English and the local language summaries will be made available through Villas office at Male and through the Environment Ministry. A copy of the entire draft EA Report will be kept at the Environment Ministry Office or any place designated by the Environment Ministry. Availability of these documents will also be notified in the local newspapers.
2.	A notice will be published in the leading English and local language newspapers announcing the public consultation workshop at least one week prior to the workshop. The notices would indicate the date, time and venue of the event, the purpose of public consultation along with the availability of draft Executive Summary and draft Final Report at Ministry of Environment or other designated place.
3.	The Letters of Invitation to selected NGOs, academicians, researchers, implementing agencies, etc. along with Press will be sent one week prior to the event.
4.	The proceedings of the workshop will be recorded on a pre-approved checklist. The proceedings will also be recorded on an audio tape for later translation and preparation of transcripts.
5.	The findings of the proposed round of public consultations will be recorded and incorporated in the EA report.

## **9.0 REFERENCES**

Report on Soil Investigation works for Proposed LPG, Cement & Oil Storage Facilities Project at Thilafushi Island, Republic of Maldives – May 2000

Environmental/Technical Study for Dredging/Reclamation works under the Hulhumalé project, Maldives, (1999). Draft Final Report, Binnie Black and Veatch (SEA). Prepared for Ministry of Construction and Public Works, Maldives.

JAICA (1992) The development study on the seawall construction project for Male Island in the Republic of Maldives.

JAICA (1998) The study on Solid Waste Management for Male City in the Republic of Maldives

## **Annex I**

Photo 1 West -  
*construction*)

Villa Fuel tanks on the western boundary of the facility (*Still under*



Photo 2 East -

Bulk cement terminal and LPG storage and bottling plant of STO



Photo 3 North - Open Sea showing the LPG pipeline on jetty



Photo 4 North – LPG storage spheres at Villa Hakatha



Photo 5 South - STO warehouses with Garbage dump yard in the background.



Photo 6 Sediment covered live coral growing in a near vertical orientation on the reef slope.

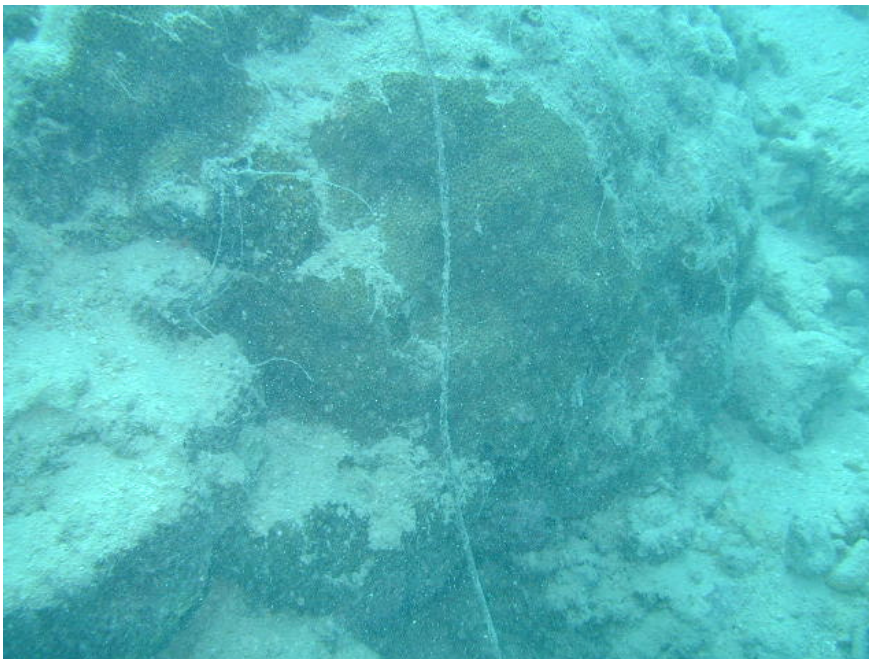


Photo 7 High level of sedimentation on the reef flat. An empty plastic can disposed off the reef slope. Similar waste, especially construction waste was present at the surveyed sites.



Photo 8 Partial mortality caused by heavy and persistent sedimentation. This is a massive coral (Diploastrea), often tolerant to severe environmental stress and grows to form very large colonies (>2meters)



a



b

Photo 9 A few years old Acropora sp. coral on the reef slope. This group of corals are not common in the reef area



Photo 10 *Acropora* species corals are vulnerable to environmental stress such as sedimentation. This coral surface is substantially covered with fine sediments, which has resulted in partial mortality of this coral.

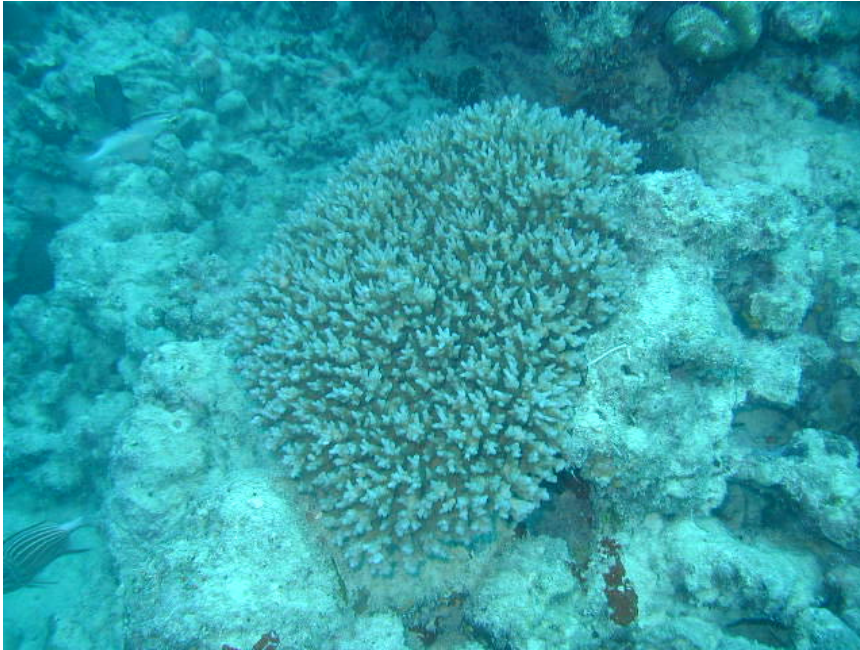


Photo 11 Newly settled acropora coral (< 2 years) growing on finely sedimented coral rock

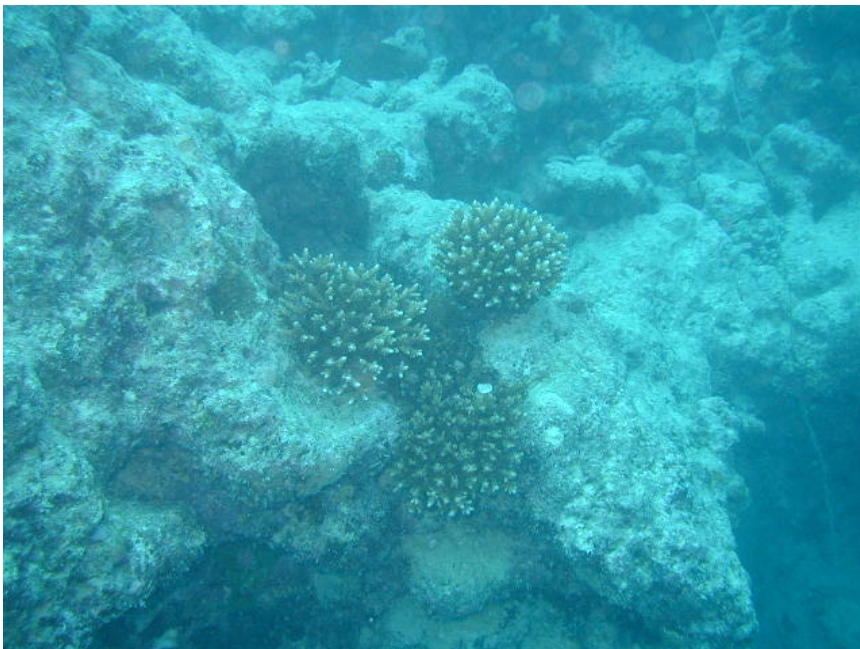


Photo 12 Newly settled Acropora coral (< 1 year old)



Photo 13 Coral settlement on the vertical face of the sheet piles



Photo 14 Photo. Napoleon wrasse, a protected marine species in the Maldives. This territorial species was frequently observed during the field surveys. Visibility was poor during the surveys.

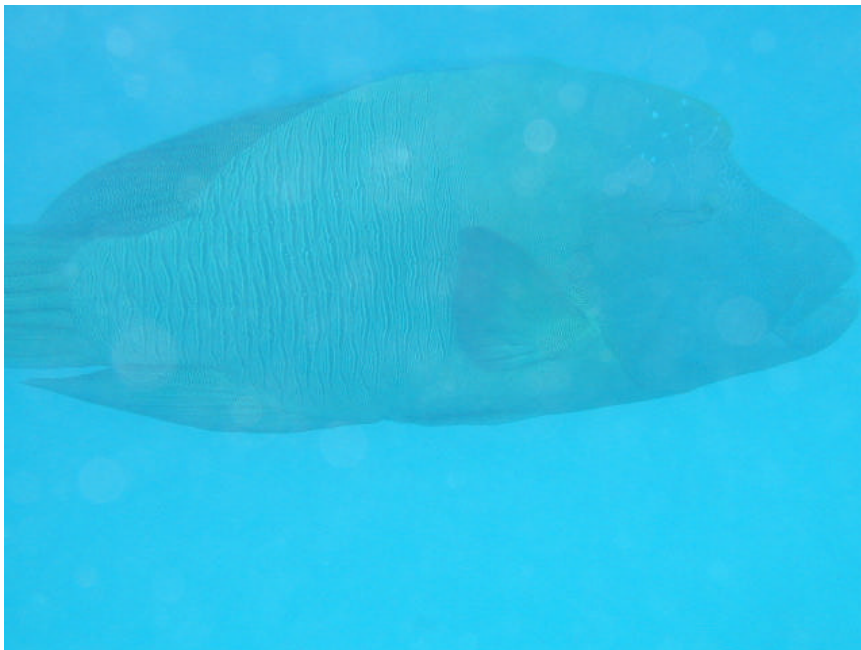


Photo 15 Few species of butterflyfishes were seen during the surveys, although coral cover was low, butterflyfishes are often used as an indicator of the health of the reef.



Photo 16 Photo. Slender grouper, sheltering under a coral colony, few grouper species were also observed during the fish surveys. Grouper are commercially important species of fish and is highly valued in the export market.

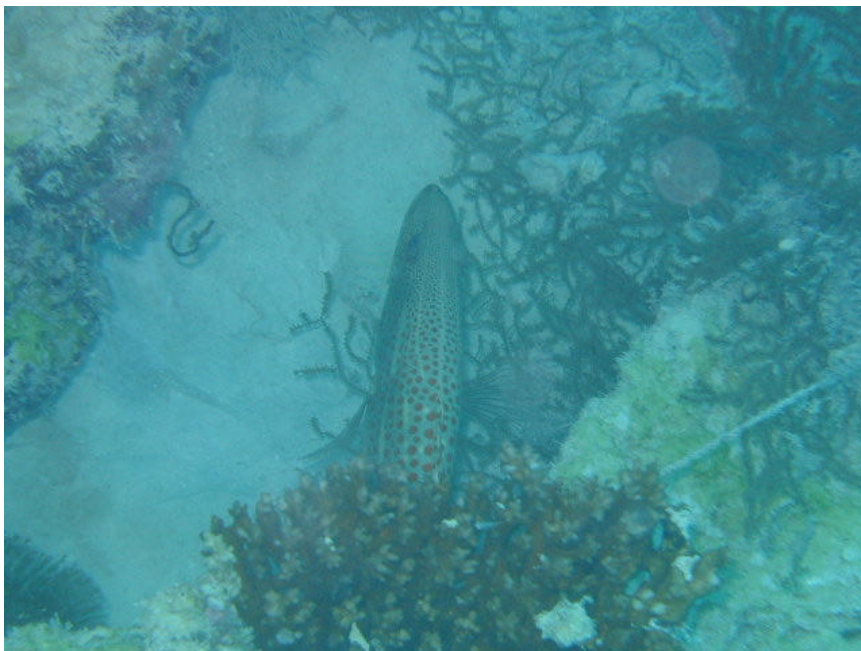
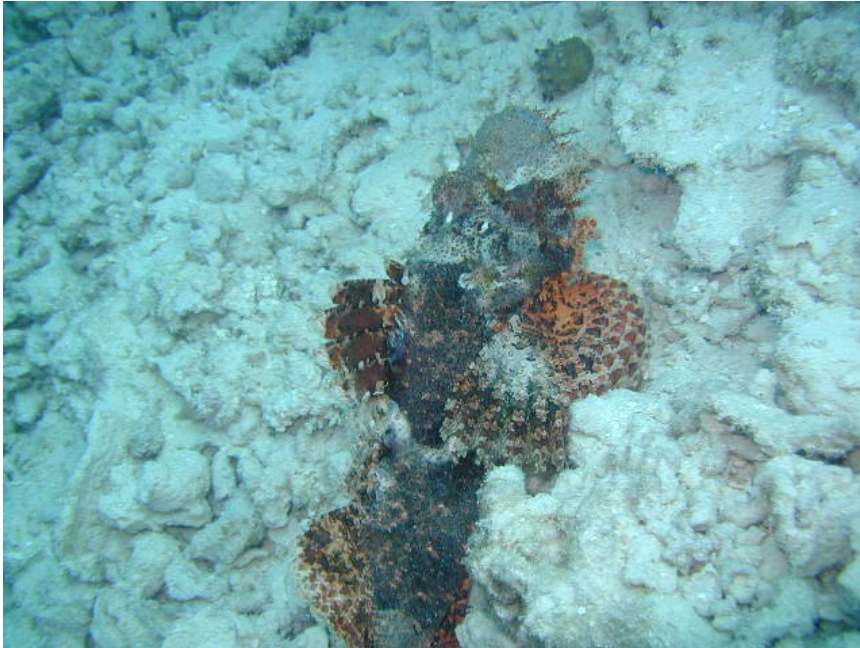


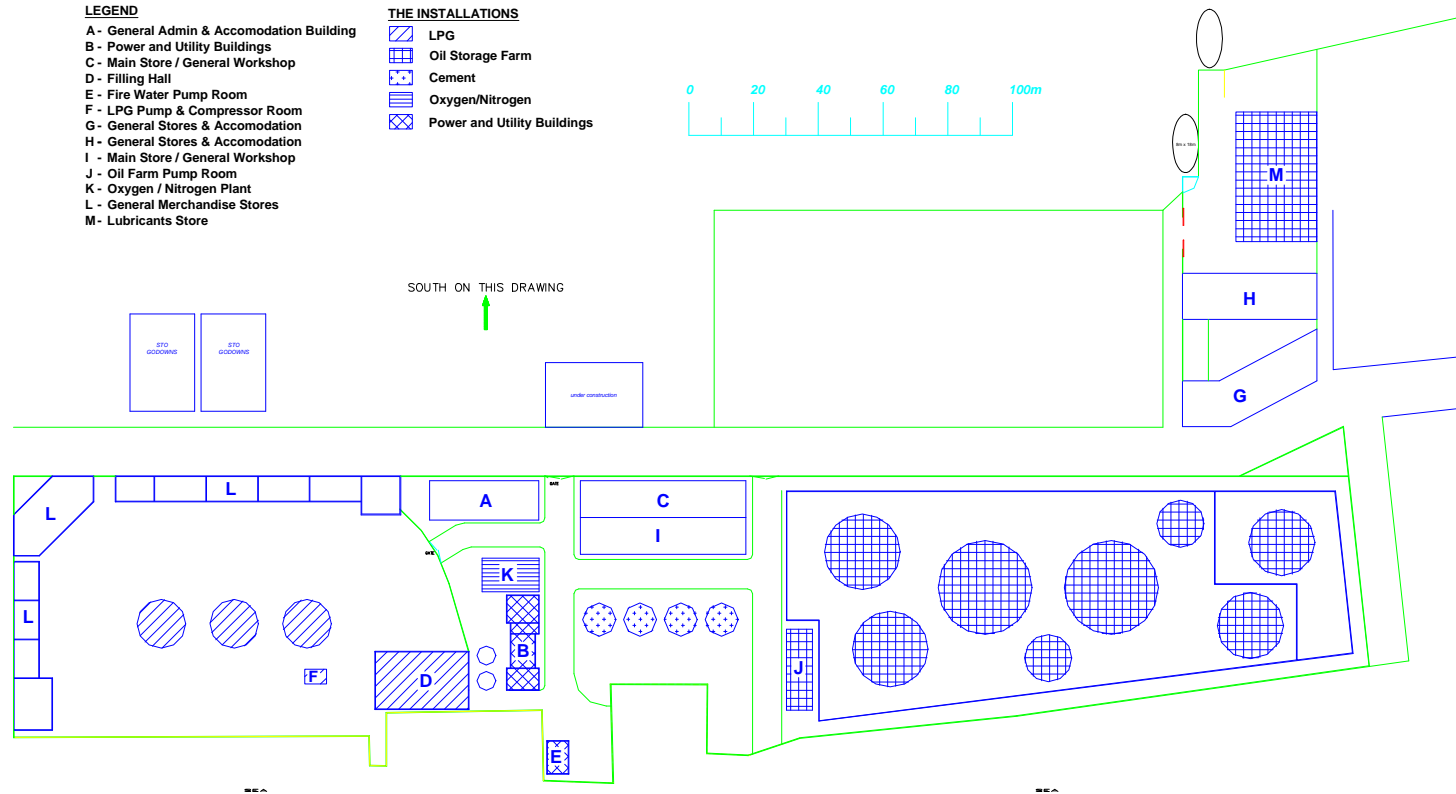
Photo 17 Baitfish species harboring near a massive coral. Species seasonality for bait fishery is well established and are common in many reef slopes, species variable depending on the season.



Photo 18 Scorpion fish observed at the fish transect during the survey. These are cryptic species and are not often conspicuous.



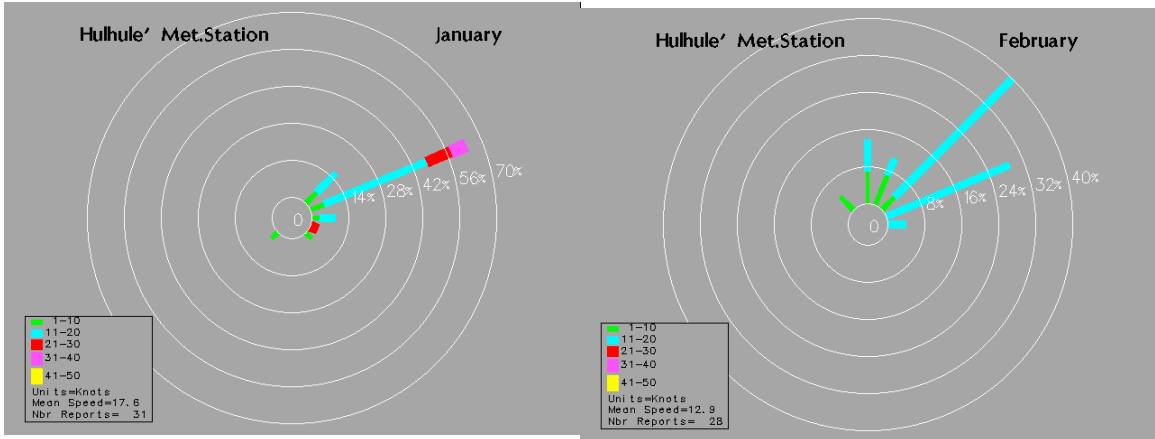
## **Annex II**



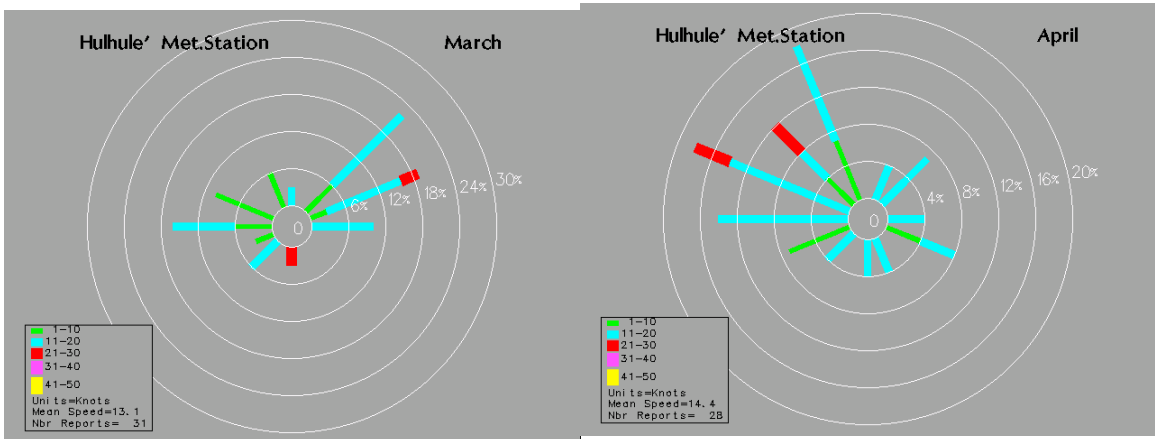
## **Annex III**

Wind rose diagrams for the 1994

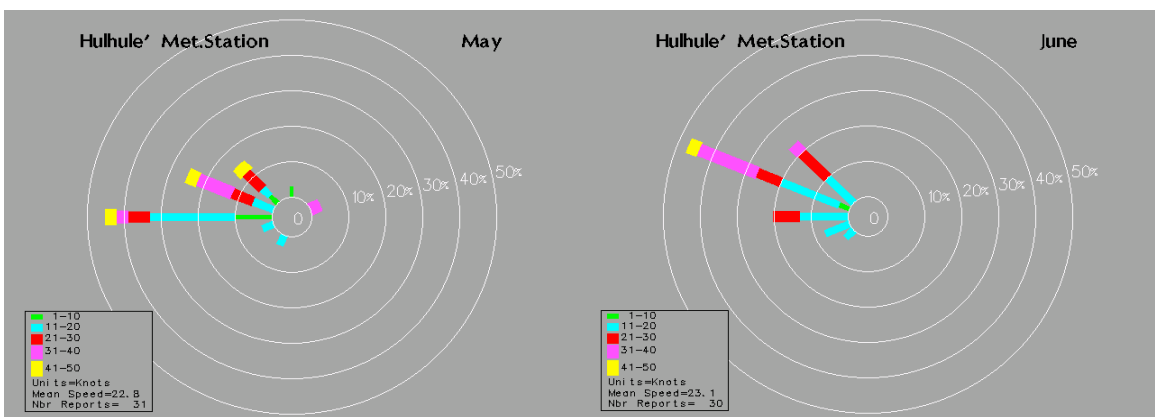
NE monsoon

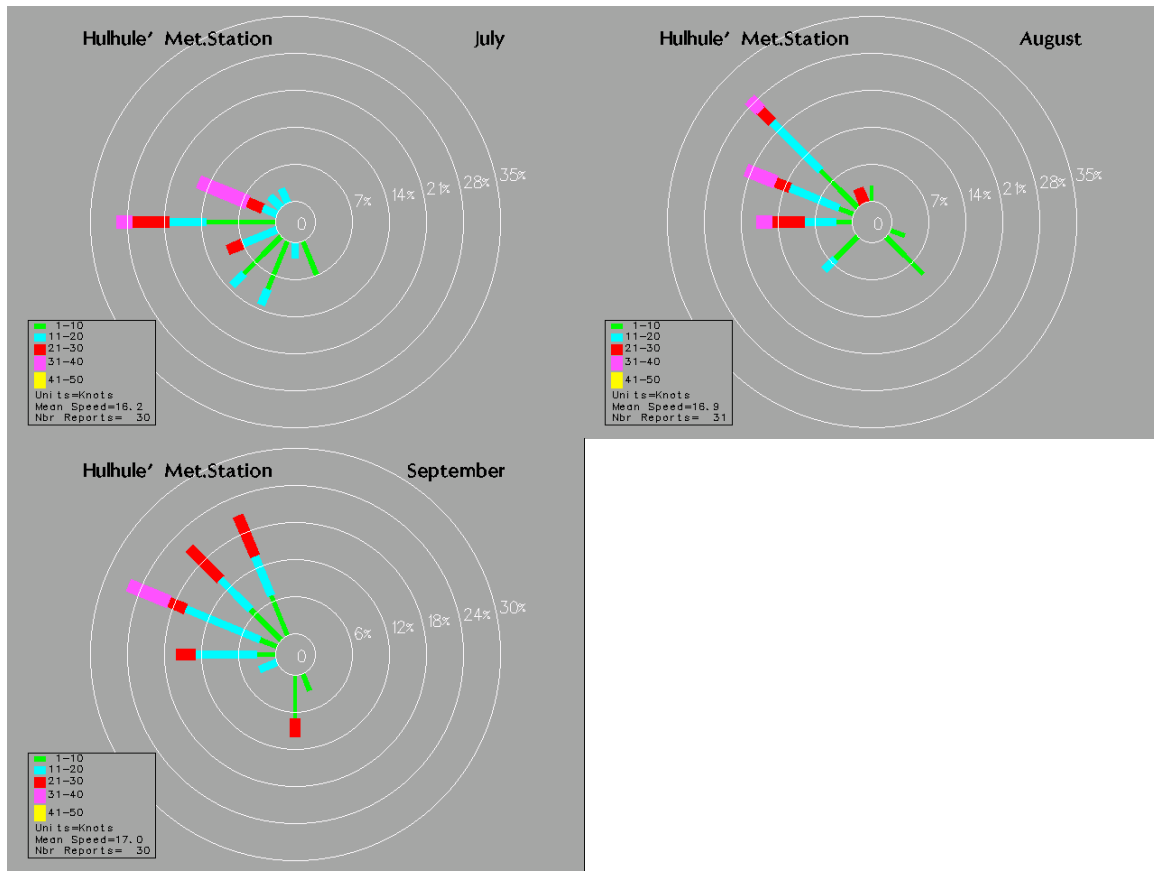


Transition between NE and SW (Hulhangu halha)

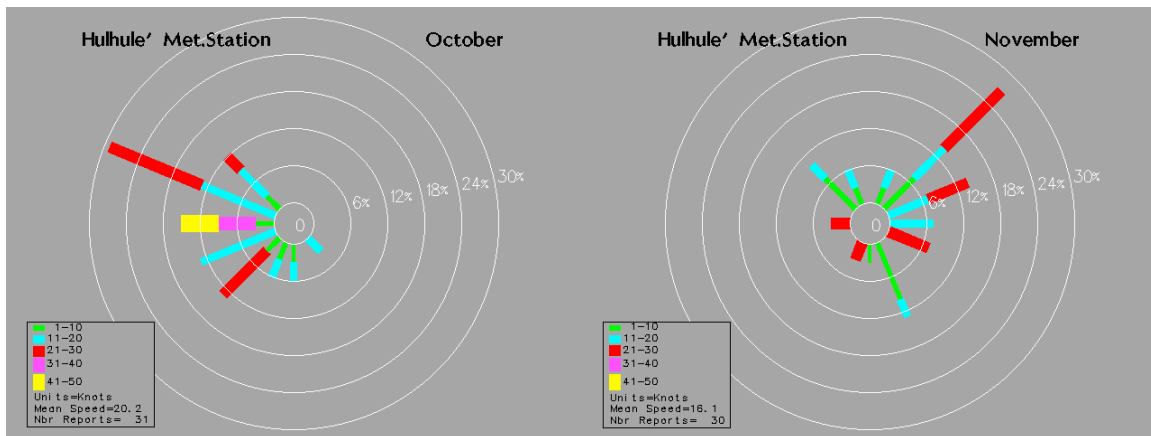


SW monsoon

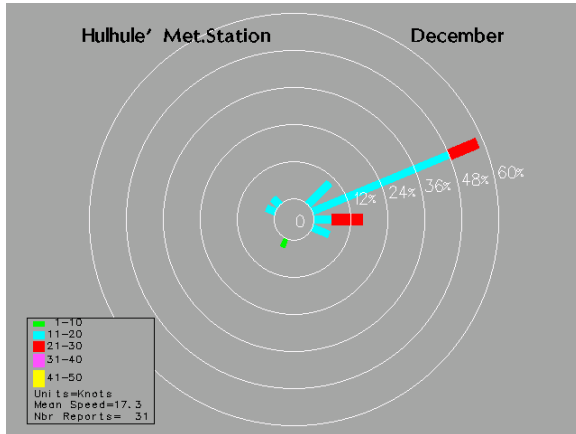




*Transition between SW and NE monsoon (Iruvaihalha)*



NE monsoon



## **Annex IV**

## Summary of Findings of Risk Analysis Study

- The worst case scenario would be a LPG ship BLEVE (2500 Tonnes) which is expected to cause about 166 fatalities – the probability of this is low  $1.64 \text{ E-}09$  – the low probabilities are due to the low berthing frequencies mainly.
- LPG unloading hose failures are expected to cause about 8 fatalities with the probability being  $2.4 \text{ E-}09$ .
- LPG Horton Sphere BLEVEs are expected to cause about 28 fatalities.
- Other incidents involving LPG such as bottling plant, compressor, LPG pump and other incidents are found to cause only minor damage in comparison. LPG cylinder rupture and BLEVE – consequent effect is low (1-2 fatalities) but the probability is higher at  $7.7 \text{ E-}04$  – this is due to the large number of LPG cylinders (600).
- Petrol and Diesel Incidents are expected to cause not more than 1 to 2 fatalities and that too with fairly low occurrence probabilities (of the order  $1 \text{ E-}07$  to  $1 \text{ E-}09$ ).
- Areas of concern for the LPG based on the risk analysis include the marine berthing and unloading and storage operations – recommendations have been made in this report as well as the HAZOP report for reducing the LPG failure probabilities.
- Risk contributions due to petrol and diesel storage are not significant overall – recommendations have been made in the Risk Analysis and HAZOP reports.
- Oxygen and Nitrogen incidents have a very minor contribution (oxygen increases the ignition probability and nitrogen causes asphyxiation) and cement operations also have no significant contribution to the risk profile.
- Over 250 recommendations have been made in the HAZOP and Risk Analysis reports aimed at risk reduction – these recommendations may be implemented systematically by the Villa group

The layout of the tankfarms, equipment standards and specifications, safety and fire protective and mitigative systems were assessed and found to be in order by and large.

Being a new facility it is also recommended that good and efficient safety system should be set in place at the earliest. These include occupational health and safety programmes, safety work permits and others. These must be put in place in right earnest immediately.

The risk analysis study has clearly identified the maximum or worst case scenarios for which emergency response and capability must be ensured. To this effect a separate emergency management plan has been prepared as a separate document.

## **RECOMMENDATIONS OF RISK ANALYSIS STUDY**

The maximum damage distances are being caused due to the LPG storage. The most contributing scenarios are the BLEVE and vapour cloud explosion of LPG.

A number of recommendations have been made for reduction of risk levels due to these release scenarios and for proper handling of pressurized LPG storage in the bottling plant.

### **Safety**

- ◆ LPG Gas detectors may be placed and maintained at suitable areas in the plant- the actual locations may be reviewed based on experience.
- ◆ Ventilation should be provided and maintained and checked for pump / compressor houses and any enclosed area where hydrocarbon vapours may accumulate. This would prevent build up of flammable concentration vapour in the enclosed space.
- ◆ Adequate number of caution boards highlighting the hazards of the various materials handled should be provided at critical locations. These must be available in the local language understandable to the majority of people. (Guidelines for safety posters and safety displays given in RA report)
- ◆ The 1978 convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) lays down extensive certification and quantification requirements for

senior officers, all officers in charge of watches on the deck, engine and radio department and ratings forming part of the watch. All such seafarers are required to hold an appropriate certification issued under the provisions of the convention. The convention also specifies basic principles to be observed when keeping deck and engine watches and the minimum training and qualifications as specifically applicable to personnel on oil, chemicals and LPG tankers. The industry recognizes importance of training. The DSHA regulations require that employees and the self employed have adequate information, instruction, training and supervision when handling dangerous substances and that records are kept of the training received by employees, and that berth operators ensure that persons present on a berth where dangerous substances are loaded or unloaded have adequate information and instruction for the health and safety of themselves and others.

- ◆ There need to be procedures for monitoring tank hydrocarbon losses, monitor drinking water condition (chemical and biological tests), forms for reporting accidents, near misses (MOST important) and auditing the effectiveness of the various safety related forms and submissions. Internal Safety Auditing must be started on priority based on predetermined (to be modified with time and experience) checklists. The audit method, checklists etc. may be evolved over time but must be regular and comprehensive.
- ◆ Detailed recommendations are given in the HAZOP.
- ◆ The company should bring out a safety policy where key objectives, roles and responsibilities for different departments and key executive positions are defined. Safety targets should be measurable and demonstrate the commitment of the management towards safety and environment.
- ◆ Safety should become an interactive process and to this effect the company should formulate and convene safety committee meetings – these should have representatives from workmen and management staff.
- ◆ Safety education and training is an extremely vital tool and proper identification of training needs and conduct of customized training programmes must be carried out. These need to be reviewed from time to time.
- ◆ A safety manual needs to be prepared for the entire complex outlining company policy, philosophy, process hazards, mechanical hazards, preventive measures etc.
- ◆ Company needs to incorporate a detailed and proper accident reporting, investigation and analysis system as it is only by learning the lessons from the past that the future can be more secure. Events to be recorded should include major, minor accident and near misses.

- ◆ The company should bring out a contractor safety manual wherein regulations governing work by contractors at site is detailed – these include minimum qualifications, level of training, protective clothing, hard hat requirements etc., procedures for hot jobs, electrical etc.
- ◆ As the villa group would be amongst the first in the LPG and Oil business, they should lead the safety stewardship effort – this includes safety education of customers, transporters and other involved parties. This has to be a concerted effort through support from the top management.
- ◆ Modifications from the blue print design have already been made but not properly documented. The company must have a plant modification authorization procedure through mini HAZOP for any change to be done in the plant. It is of interest to note that the bulk of accidents in the industry occur due to modifications.

### **Operations and Maintenance**

- ◆ In locations where flammable vapours may be present, precautions should be taken to prevent ignition by eliminating / containing source of ignition. Source of ignition may include open flames, lightening, smoking, cutting and welding operations, lighting / hot surfaces, frictional heat, sparks (static, electrical and mechanical), spontaneous and radiant heat.
- ◆ All non-routine work such as gasket replacing, welding etc. should be carried out under a permit system.
- ◆ Proper inspection of small and bigger lines and vessels periodically. It is not only the bigger lines that warrant inspection, but the smaller lines as well. The QRA clearly shows over a 100 times larger frequency for smaller releases compared to catastrophic ruptures. Small lines, vulnerable drains and vent points, small lines etc. warrant special attention. Inspection frequencies based on hazard potential may be planned and implemented.
- ◆ Ensure that combustible flammable material are not placed near the LPG spheres, lines, oil lines, oil tanks and other places where secondary fires could become a dominant issue. The cement store next to the LPG is alright, but it is avoidable storing flammable material within the danger area.
- ◆ After loading static accumulating materials into large storage tanks, delay of upto 30 minutes have been suggested before hand gauging or sampling as flammable atmosphere exist till that time period. These recommendations are based on measurements taken in large tanks after loading which have shown a slower decay of the

field strength than would be expected by normal charge relaxation. The slow decay probably resulted from further charge generation due to slow settling of small charged particles of water, dirt or other materials. For both LPG and oil homogenization is essential before bottling/ filling up.

- ◆ Small leaks could occur frequently in routine operations like pump seal failure, sample point valve or drain valve left open, flange leak as is clear from the QRA. They should be attended to immediately as they could escalate through a Work Permit system (see **Annexure 20** for Guidelines).
- ◆ All interlocks should be kept and maintained in working condition at all times. Interlocks provided for safety form the backbone of the safety at the site and their upkeep, preventive maintenance etc. must be of high order. Tests could include function tests, actual tests and simulated tests.
- ◆ Sphere bottom ROV's should be the first break flange. They should be located outside the shadow of the sphere and shall be fire safe. The orientation of ROV's in piping layout should be such that in the event of leak of its flange on the storage side with the possibility of fire, the sphere does not come in the jet flame.
- ◆ Process line ROV's should be oriented is such a way that in case of a gas leak and subsequent fire the sphere should not come in the line of the jet fire. This must be ensured in all future installations.
- ◆ All ROV's shall be operable from the control room, open/close indications on the panel. In addition, Operators **MUST** be trained on hand jack operations and on procedures requiring "forcing" valves into open condition (refer HAZOP).

### **Emergency Preparedness**

- ◆ Emergency procedures should be well rehearsed and state of readiness to be achieved. This is absolutely essential as LPG and oil are highly flammable materials to deal with and even a slightest omission could lead to a major catastrophic incident. All personnel should be trained in handling emergency situations and should be apprised of their role in handling emergency situation and to ensure adequacy of the emergency procedures simulated exercise should be carried out. A procedure for periodic response drills should be developed. Refer RA and ERP **Reports**
- ◆ By reducing the time required to stop the leak which in turn would reduce the quantity of spillage. The response time could be reduced by installing / maintaining instruments, effective communication system etc.

### **Occupational Health and Safety**

- ◆ There must be an Occupational Health and Safety system operational in the company for monitoring the Occupational health aspects in the company. These include pre medical, six monthly, yearly check ups such as lung function tests, PM 10 tests, general check ups, specific checks based on Occupation and others.