FIRST ADDENDUM

ENVIRONMENTAL IMPACT ASSESSMENT

Proposed Development of Southwest Harbour

Malé City

Maldives

PART 1: ADDITIONAL RECLAIMATION & SHORE PROTECTION

Proponent: Ministry of Housing and Infrastructure

June 2016

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Consultants Declaration

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

Ahmed Zahid

Consultant Registration No. EIA 08/07

Hussain Fizah

Consultant Registration EIA 01/14

Proponents Declaration

Re: First EIA Addendum for Male' South West Harbor

As the proponent of the proposed project we guarantee that we have read the report and to the best of our knowledge, all information relevant to this project in terms of project description, project construction works and operational aspects provided here are accurate and complete.

Signature: 

Name: Fathimath Shaana Farooq

Designation: Director General

On behalf of: Ministry of Housing and Infrastructure

Date: 07 June 2016

Executive Summary

This report is the First Addendum to the EIA report prepared for the development of the Southwest Harbour in Malé to address the environmental concerns regarding the proposed additional reclamation and modifications to the method of borrowing additional sand and location of the channel. The project is proposed by Ministry of Housing and Infrastructure.

The environmental impacts of the harbour dredging and reclamation components have already been covered in the EIA and this Addendum will cover the additional reclamation of 3.2 hectares and some of the changes to the borrow area and methodology as well as changes to the location of the channel. The additional material to be taken from Gulhee Falhu is now proposed to be taken from atoll lagoon area identified near Uthuru Thilafalhu and to be borrowed using hopper dredger. There are no issues related to dredging from these locations, as it had become the norm and material has been taken from several surveyed locations in Malé Atoll for reclamation purposes including Hulhumalé Phase 2, Thulusdhoo, Himmafushi and Gulhee Falhu reclamation. The channel has been shifted eastwards based on the recommendations of the design consultants from Japan.

Environmental impacts were assessed for both the construction and operation phase of the project. There are no changes to the environmental impacts assessed previously. The area of sedimentation slightly changes due to the change of channel location slightly eastwards, however, this change has similar degree of sedimentation and the negative impacts on the reef. The revised location has lesser wave impact and, therefore, provides safer entry. The impacts of the reclamation remain similar although the magnitude of the impacts would be slightly higher due to the increase in area and therefore volume of fill. The negative impacts of the reclamation by bringing sand from the proposed borrow area near Uthuru Thilafalhu would be some degree of sedimentation during pumping the material into the hopper and while “rainbowing” the material to site. It is believed that based on past experience in some of the projects, the hopper dredger operator will take care in pumping the material to the proposed fill area. The degree of sedimentation will be higher but short-lived compared to the rest of the dredging and shifting of shore protection structures. The area to be filled with will be confined with a sand bund with the existing tetrapods placed on the periphery as protection structures. Therefore, sedimentation on the reef from the filling using hopper material would be low.

The proposed design encloses the southwest harbour at the T-jetty area, affecting circulation. Even during the construction phase, it is observed that sediment settles in the harbour basin even with the presence of good flow between both sides. Once the area is closed-off the basin will be stagnant. Therefore, as mitigation measure, two culverts of 4m diameter each and made of concrete or HDPE have been proposed to allow flushing of the harbour basin during both monsoons.

The alternatives to the dredging and reclamation have been considered in the EIA report. The project benefits in improving living environment of residential areas, however, the extent of the benefit is not very clear at this stage. The no project option may be considered valid due to the huge cost of the project compared to the benefits. However, the project helps in improving the waste management operation in Malé as well as to create better living spaces. The alternative would be to minimize the scope of the project, especially to retain a large part or whole of the existing breakwater and reclaim inside the structure so as to reduce the cost of the project greatly while helping to achieve the objectives for pollution free living. However, since the project has been planned and partly executed, the scope could not be reduced or damages to breakwater structure could not be completely undone. Yet, a cost-effective re-design can still be considered.

Some of the mitigation measures for the impacts that have been considered above had already been incorporated into the design and the project scope. This includes the provision of culverts for improved flushing of the harbour basin. It is recommended not to fill and close the flow in the harbour until the proposed culverts have been constructed.

Regular environmental monitoring and reporting is an essential element of the EIA process. The EIA report for the South West Harbour has considered in-situ monitoring of total suspended solids and turbidity to be undertaken during the dredging process. However, regular monitoring data is not available for the ongoing dredging and reclamation works. Therefore, it is reiterated that regular monitoring of in-situ turbidity is undertaken in the area.

The project appears justified socially as well as technically with low environmental impact given the current use and damage to the marine environment of the area. However, the economic costs of the project may outweigh the benefits. Hence, effective project implementation shall be in place to ensure the objectives are achieved to the maximum.

ސާރާ ޚުލާސާ

މި ރިޕޯޓަކީ މާލޭ ހުޅަނގު ދެކުނު ބަނދަރު ތަރައްޤީ ކުރުމަށް ހުށަހަޅާފައިވާ މަޝްރޫޢު ގެ ދަށުން އިތުރަށް ހިއްސާ 3.2 ހެކްޓަރުގެ ބިމާއި ބިން ހިއްކުމަށް ބޭނުންވާ އިތުރު ވެލި ހޯދާނެ/ނަގާނެ ގޮތާއި ނެރުގަނޑަށް ދިމާއަށް ގެނުވުނު ބައެއް ބަދަލުތަކުގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރުމުގެ ގޮތުން ތައްޔާރުކުރެވިފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫޢުގެ އިދާރާއަކީ މިނިސްޓްރީ އޮފް ހައުސިންގ އެންޑް އިންފްރާސްޓްރަކްޗަރއެވެ.

މި ސަރަހައްދުގެ ބިންހިއްކުމަށް އިތުރަށް ބޭނުންވާ ވެލި ނެގުމަށް ހުށަހަޅާފައިވަނީ މާލޭގެ ހުޅަނގު ދެކުނުން ގާތްގަނޑަކަށް 20 ކިލޯމީޓަރުގައި އުތުރު ތިލަފަޅު ކައިރިން އަތޮޅުގެ އެތެރެފަރިން ކަނޑުގެ އަޑީންނެވެ. މި ގޮތަށް ވެލި ނަގައިގެން މާލެ އަތޮޅުގައި ތޮރުކަދީ، ހިންމަފުށި، ހުޅުމާލޭގެ ދެކުނު ބޮޑުއަތިރި ފިޔަވައި ބޮޑެތި ސަރަހައްދުތަކަށް ހިއްސާވާ ކަމެއް ނުވި އެންމެ އެކަށީގެންވާ ގޮތެކެވެ.

މި މަޝްރޫޢުގެ ދަށުން ކުރިން ހަދާފައިވާ ރިވެޓްމެންޓްގައި ހިއްސާ ސަރަހައްދު ހިމާޔަތްކުރުމަށް ކުރާނެ ކަންތައްތަކުގެ ތެރޭގައި ގޯސްފައި ނުހިމެ އެ ފަށްގޮ އޭގެ ތޮއްޓެތިފިހެއް ނުހިމެނޭނެއެވެ. މި މަޝްރޫޢުގެ ދަށުން ހިއްސާ ސަރަހައްދު ހިމާޔަތްކުރުމަށް އެއްގަމު ބޯޅުބިތް ފަށަން ވަކި ފޯރުކޮށްދިނުމަށް. އަދި މި ބޯޅުބިތް 2މ އިން 3.5މ ފުންމިނުގައި ރާޅު މުގުރާ ހިސާބުން ބަދަލުގައެވެ. ވީމާ، މި ސަރަހައްދުގައި ކުރިން ޖެހިފައިވާ ގެރިގާ ބޯޅު ބާރުކުރުމުގެ ގޮތުގައި އޭގެ މަތީގައި 4 ޓަނުގެ ބޮޑު ހިލައިން މި ބޯޅު ފުޅާކޮށް ފުރިހަމަކުރެވޭނެއެވެ. މިގޮތުން މި ބޯޅުގެ މަތީގައި ފުޅަދުގައި 3.2މ އުސްވާނެއެވެ.

ކަނޑުއަޑީން ވެލި ނަގައިގެން ހިއްކުމާ އެކު ސަބަބުން ހިއްކާ ސަރަހައްދު ވަށައިގެން ކިލަނބުވުމުގެ އަސަރު މަޑު ދަރަޖައަކަށް ކޯރަލްތަކަށް ކުރެއެވެ. ނަމަވެސް، މާރާގެ މި ހިސާބުގެ ފަރުވަށް މައިގަނޑު ގޮތެއްގައި އޮޅި ކަނޑުތަކުގެ ސަބަބުން މަރުވެފައި ކަމަށްވާތީ ފަރަށް ކިލަނބު/ހިލަނބުވުމުގެ ސަބަބުން ކުރާ އަސަރަކީ މާ ބޮޑު އަސަރެއް ކަމަކަށް ނުބެލެވެއެވެ. މީގެ އިތުރުން، މި ސަރަހައްދުގައި މި މަޝްރޫޢުގެ ދެމުއްދަތުގައި ހިފުން ފެށިފައިވާ ކަންތައްތަކުގެ ބޮޑު މަސައްކަތްތަކުގެ ސަބަބުން ކިލަނބުވުމުގެ އަސަރު ދަނީ ކުރަމުންނެވެ. އަދި މި މަސައްކަތްތަކުގެ ދުރާލައި ކަނޑު ޖަހާފައިވާ ގަލާއި ފަރު ކަނޑާފައިވާތީ ވީމާ، ތަރައްޤީ ކުރުމުގެ ފުރަތަމަ ފަސް އަހަރުގައި، ފަރުގެ

ފުން ހިސާބުގައި ޖަހާ ބޯޓުން ހިއްކާބިމަށް ފުރިހަމަ ހިމާޔަތެއް ނުލިބިދާނެއެވެ. އަދި މިކަމަކީ ބައެއް ފަހަރުބޯޓުތަކުން ފާރަގަނޑުކުރުމުން ދާ ކަމެއް ކަމުން މިކަމަށް ޙައްލަކީ އަރައްތިމިއްކަމެއް ދޭނެއެވެ. ނަމަވެސް، މި މަޝްރޫޢުގެ ދަށުން ފަރުމާކުރެވިފައިވާ ބޯޓު އައި އުކާލުމަށް ތައްޔާރުކޮށްފައިވާ ލިބިދާނެ ބޮޑުޖާގައެއް ބޭނުންވެއެވެ.

މި މަޝްރޫޢުގައި ހުރަހަށްފައިވާ ގޮތުން ބަނދަރުގެ ޖެޓީ-ޖެޓީ ސަރަހައްދު ވަރަށް ބޮޑުކޮށް ބޭނުންވެއެވެ. މީގެ ސަބަބުން ބަނދަރުގެ ފެންގަނޑު ތަޣައްޔަރުވުމަށް ދާނެ ކަން އީ.އައި.އޭ އިން ވަނީ ފާހަގަކޮށްފައެވެ. މީގެ، އެކަން ހައްލުކުރުމުގެ ގޮތުން މިގާރު ވަނީ ދުވަސް ފާރަގޮތުން ހިންގާ ދިގުގައި ފުން ދަށުކުރުމަށްގޮތަށް 2 "ކަލްވާޓް" ހިމަނާފައެވެ. މި ކަލްވާޓަކީ 4މ ގައިމީޓަރުގެ (ކޮންކްރީޓު ނުވަތަ އެޗް.ޑީ.ޕީ.އީ) ހުޅަނގުން ދިރި ތަކެއްޓަށް ގެއްލުމެއް ނުލިބޭނެއެވެ. އަދި 2 ދުސްވުގައިވެސް ރަގަޅަށް ފުން ދަށުކުރާނެއެވެ.

މަޝްރޫޢު އިން ޑިޒައިނަށް އިތުރުވާއި ފައިދާ ތަކެއް ކޮށްދޭ ކަމުގައި ފާހަގަކުރެވިފައެވެ. މިގޮތުން މާލޭގެ އެކި ސަރަހައްދުތަކުގައި ހުރި ގަރާޖުތަކާއި ވާރކްޝޮޕްތަކާއި ވަރކްޝޮޕްތަކާއި ސަބަބުން މާލޭގެ ރަސްފަރުނަސް ލިބޭ އުދަގޫތައް ކުޑަވާނެއެވެ. އަދި ދިރިއުޅޭ މާހައުލަށް އުނދަގޫ ބަދަލުތަކެއް އައުމަކީ އެކަށީގެންވާ ކަމެކެވެ. ނަމަވެސް، މިހާރުވެސް އެޖެގަދަވާ ޗާޕޯގެ މަސައްކަތްތަކާއި ބަހައްސަމުގެ ޗާރާޖެހުމުން ގުޅޭ ބޭސްރަ ކަރާހިރު ވަކި ގޮތަކުން ކުރަންޖެހޭ ސަރަހައްދު މިފަދަ މަޝްރޫޢުގެ އެކަށީގެންވާ ފައިދާ ނުލިބޭ ވެސް ދިމާވެދާނެކަމުން ފާހަގަކުރެވިފައިވެއެވެ. އަދި މިފަދަ މަސައްކަތްކުރާ ހުރިހާ ފަރާތްތަކަށް މިބަދަލު ބަދަލުކުރެވިފައިވާނެއެވެ. މިކަސްކަމަށް ފައިދާކުރާ އަދި މަޝްރޫޢުއަށް ބަދަލު ވެފައިވާ ބަނދަރުގެ އެހީގެ އެއްޗެކެވެ. ކުރިމަތިވާ ބަދަލުތަކަށް އެކިއެކި މަޝްރޫޢުގެ ތެރެއިން ދަތިތަކުން މުޅި ގޮތަކީ ރަށްބަދަލުކުރުމާއި ބޭނުމެއް ކަމުގައި ވާނެކަން ފާހަގަކޮށްފައިވާ ގޮތް މާލެއިން ފިހާރަތަކާއެކު ނަމަވެސް، ހިއްކުމުގެ މަސައްކަތް ކޮންމެވެސް ވަރަކަށް ހިނގާފައިވާ ގޮތުން ބޯޓު އާއްމު ބަދަލެއް ފެނުމަށް ދާނެއެވެ. އެހެންވިޔަސް، އަދިވެސް މަޝްރޫޢު ހަރަދު ކުރަމުންދާ ފަރުމާކުރެވިފައެވެ.

މަޝްރޫޢުގެ ސަބަބުން ތިމާވެށްޓަށް ކުރާނެ ނުރައްކާ އަސަރު ކުރަނީ މަޝްރޫޢުގެ ފާހަގަކުރެވޭ ކަންކަމުގެ ތެރޭގައި މަލެގައި ބޭންކުކޮށް ފަދައިން ބައެއް ކަންކަން މިގޮތުން ވަނީ ފާހަގަކުރެވި މަޝްރޫޢުގެ ފަރުމާގެ ތެރޭގައި ހިމަނާފައެވެ. އޭގެ، ކަލްވާޓްގެ ޖަރިމާ އިން ބަދަރުގައި ފުން ދަށުކުރާތީ ހުރިހާ ހިސާބު ތަކެއް ނުބޭނުން ކުރެވޭނެ ކަމުގެ ކުރެވެއެވެ.

ނަމަވެސް، މިކަންކަމަކީ ފުރިހަމަ އިންޖިނިއަރިންގެ ބުރުއިން ފުރިހަމަކޮށް ތަންފީޛުވެގެން ދާން ޗެލެންޖް ކަންކަމެވެ. އެހެން ނޫނަސް މަޝްރޫޢުގެ މަޤްބޫލު ހާސިލްކުރެވޭ ހިނގާދާނެއެވެ.

މަޝްރޫޢުގެ ސަރަޙައްދުން ވެށިބަރު އަންނަމުންދާ ބަދަލުތަކަށް ދެނެގަތުމުގެ ގޮތުން ކުރަން ޖެހޭ ބައެއް ދިރާސާތަކަށް ޓީ.އޯ.އާރު ރިޕޯޓުގައި ހިމަނާފައިވާނެއެވެ. އޭގެ ތެރޭގައި ސަރަހައްދުން ފެނުގެ ކޮލިޓީ (ކެމިކަލްގެ އަސަރު – ބޮޑުތޯ ސަސްޕެންޑެޑް ސޮލިޑްސް އާއި ބެކްޓީރިޔާ) އާއި އޮއިވަރަށް އަންނަމުންދާ ބަދަލުތައް ހިމެނެއެވެ. ނަމަވެސް، މަސައްކަތް މިހާރު ހިނގަމުން ދާއިރު މިފަދަ ޓެސްޓް ނުކުރޭ ކަން ފާހަގަކުރެވިފައެވެ. ވީމާ، ތިމާވެށީގެ އަސަރަށް ބަދަލުވުން ގެންދިއުމަށް މި ރިޕޯޓުގައިވެސް ބުނެ އަރާފައެވެ.

މި ރިޕޯޓުގައި އަދި މި މަޝްރޫޢަށް ކުރިން ހަދާފައިވާ އީ.އައި.އޭ ރިޕޯޓުގައި ހިމަނާފައިވާ ކަންކަމަށް ރިއާޔަތް ކުރުމުން މި މަޝްރޫޢަކީ އިޖްތިމާޢީ ގޮތުންނާއި ފަންނީ ގޮތުން ބަލާއިރު ކުރިއަށް ގެންދިއުން މުހިއްމު މަޝްރޫޢެކެވެ. އަދި މަޝްރޫޢުގެ ސަރަޙައްދުން ތިމާވެށްޓަށް ވެސް އެކަށީގެންވާ ރަގަޅު ފައިދާތަކެއް ކޮށްފާނެ އަދި މިހާރުވެސް ނުރައްކާ އަސަރު ކޮށްފައިވާ ތިމާވެށިން އެކުލެވޭ ސަރަޙައްދުތަކަށް ވެސް އަދި މަޝްރޫޢުގެ ސަރަޙައްދުން ކޮށްފާނެ ނުރައްކާ އަސަރުތަކެއް ނުރައްކާ އަސަރެއް ކަމަކު ކަނޑައަޅާ ދެކޮޅުވެރިން ކަންކަމަށްވާތީ، މި މަޝްރޫޢު ހުރަހަކަށްވާ ގޮތަށް ކުރިއަށް ގެންދިއުން އެންމެ ރަގަޅު ކަމަށް ފެނެއެވެ. އެހެން ނަމަވެސް މަޝްރޫޢަށް ހިނގާ ހަރަދަށް ބަލާއިރު މަޝްރޫޢުގެ އިޤްތިޞާދީ ފައިދާ ކުޑަކަމަށް ފެންނާތީ ރިޕޯޓުގައި ހުށަހެޅިފައިވާ އަލްޓަނޭޓިވް ތަކަށް ރިއާޔަތް ކުރުމަށް މަސައްކަތް ކުރުމަށް އެންމެ ރަނގަޅު ގޮތަކަށް ފާހަގަކުރަމެވެ.

1 Introduction

1.1 Introduction

This first Addendum to the Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives (Law No. 4/93) to assess the impacts of proposed changes to the proposed dredging and reclamation component of the proposed Southwest Harbour Development project. Environmental Impact Assessment Regulations provides a list of proposals requiring an EIA. As per the list, EIAs are mandatory for dredging and reclamation activities. This report will identify the potential impacts (both positive and negative) of the changes to the proposed harbour development project.

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

The findings of this report are based on qualitative and quantitative assessments undertaken for the EIA report, additional data collected during a site visit in May 2016 as well as professional judgment. The impact assessment methodology has been restricted to field data collected, professional judgement and experience of similar settings and projects across the Maldives and elsewhere. Long term data relevant to this report on specific aspects such as meteorology and climate were gathered from secondary sources and published reports on the Maldives.

Experience of the Consultant in the implementation of similar projects has also been taken into consideration in understanding impacts and making professional judgements about the environmental impacts due to the project.

1.2 Background to the EIA

This Addendum is prepared in accordance with the Terms of Reference (TOR) approved by the Environmental Protection Agency (EPA) on 4 April 2016. It is a legal requirement that projects having potential for environmental impacts gain environmental clearance or approval prior to construction and operation of such projects.

The principal environmental institution that implements EIA process in the country is Environmental Protection Agency. Additionally, the Ministry of Environment and Energy provides policy guidance before projects are implemented.

1.3 Scope of the EIA and Approach

The main scope of this EIA report as per the approved TOR is to broadly assess, identify, predict and document potential environmental impacts from the proposed development of Malé South West Harbour. This project involves dredging and reclamation of the Southwest harbour and development of the Industrial Village. This first part of the Addendum to the EIA for proposed development of Malé Southwest harbour considers the additional reclamation of 3.2hectares of land making it a total of 6.9 hectares and how the material is obtained. In addition, this report also covers shore protection of the reclaimed area and the changes to the location of the channel, which has been reconsidered most appropriate slightly east of the location indicated in the EIA report.

Importance is given to document the project components in as much detail possible, identify the main environmental impacts that are associated with the proposed changes and address the legal requirements that need to be taken into consideration while implementing this project. This document also addresses the existing environmental condition of the project area and foresees the ways in which potential environmental impacts will be managed, mitigated and reduced.

Hence the key aims of the report are to

- Describe the proposed project components in detail;
- Identify the need and justification for the proposed development;
- Describe the biophysical status of the existing environmental condition of the project site based on the findings undertaken during the site visits and previous field findings;

- Assess, identify and predict potential environmental impacts of the proposed development;
- Evaluate the significance and magnitude of impacts that will be generated; and identify and predict ways in which these environmental impacts will be prevented and removed through appropriate environmental management and mitigation measures;
- Develop a mechanism to closely monitor and understand the long-term effects and changes of the proposed development on the environment with respect to the available baseline information, mostly collected from field assessments and site visits;
- Provide legal protection with regards to the proposed development activities; and
- Review the predictions and assessments made on environmental impacts that are associated with the proposed development activities.

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

- Review of available project documentation including previous EIA report;
- Discussions with involved key personnel;
- Site visits to the project location;
- Baseline environmental assessments;
- Maldives Environmental Protection and Preservation Act No. 4/93;
- Environmental Impact Assessment (EIA) Regulation
- Other Environmental Regulations
- Maldives National Development Framework
- Sandcays' previous experience of undertaking EIAs for projects in the Maldives; and
- Other EIAs for similar projects that have been carried out in the Maldives.

1.4 Relevant Studies and Experiences

There have been several projects where the trailing suction hopper dredger has been used for reclamation, especially around Malé including Hulhumalé Phase 2 and Gulhee Falhu. Gulhee Falhu was the first project to use a TSHD and with a Protected Area just off its shores. Hulhumalé Phase 2 had similar conditions and has been one of the harshest reclamation projects in the history with several environmental concerns raised by stakeholders. Given the experience and size of these projects, the proposed project would have lesser degree of impacts to a less sensitive area. There are also several other dredging projects to learn from.

The channel location and project design has been based on studies undertaken by Pacific International Consultants (PCI) in 2002 for the proposed project for improvement of the ferry station for solid waste.

1.5 EIA Implementation and Methodologies

This study was based mainly on data collected during a field investigation missions during October 2015 for the initial environmental assessment and in May 2016 for this report by a team from Sandcays Pvt. Ltd. and published literature on similar settings and projects. The Addendum was compiled by Ahmed Zahid and Hussain Fizah. Zahid is a registered EIA consultant with over 19 years of experience and has been involved in numerous reclamation and harbour development projects in the Maldives and various other projects such as shore protection, resort development, sewerage and water projects. Fizah is a registered EIA consultant at Sandcays and has been involved in almost every EIA undertaken by Sandcays since he joined in 2012. Trained environmental surveyors at Sandcays namely Mohamed Visham and Mohamed Shifaf were involved in the baseline surveys.

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

The methods used to identify, predict and assess impacts are based on matrices that have been established by the Consultants over a long period. In the matrix, the consultants assign a likert-scale number to represent the magnitude, significance, duration and spatial extent of the potential impact for each project activity against the key environmental and socio-economic components that the specific project activity may have an impact on. The product of the magnitude, significance, duration and spatial extent for each activity and component is summed up to measure the exact nature of the impacts by each activity and the overall impact of the proposed project is the sum of all activities.

The Terms of Reference (TOR) for this EIA has been attached as Appendix 1. The Terms of Reference for the Addendum includes the development of the Malé Industrial Village, however, only the relevant components for this report have been considered.

2 Project Description

2.1 General context of the study

Malé City is faced with numerous social and environmental issues due to overcrowding and improper land use planning. Due to lack of space, a number of industrial operations and other activities regarded as hazardous to human health are currently being carried out in the residential areas of Malé. The proposed project aims at addressing these issues by providing land for improved waste management, industrial activities and fuelling operations. This EIA will be focused on the development of the EIA and changes in location of borrow area for additional fill material.

This section will provide the details of the project including detailed methodologies of undertaking the proposed project with illustrations of areas using maps at appropriate scales.

2.2 The Proponent

The project proponent is the Ministry of Housing and Infrastructure. The Ministry is the government agency responsible for the development and regulation of the housing as well as the construction sector of the country. It is also the agency which oversees the development of housing and public infrastructure of the country including harbours and land reclamation projects. While the Ministry is the regulator, the Ministry is also the implementing agency of infrastructure projects undertaken by the State.

2.3 Project Location and Study Area

Malé City is the capital of Maldives with a total land area of 195.2Ha located at 4°10'27.03"N and 73°30'33.20"E. The closest islands, Villingili, Hulhulé and reclaimed island Hulhumalé are currently administrated as part of Malé City. Villingilli is a primarily residential island while Hulhulé hosts the international airport.

The proposed project is to be carried out on the southwest harbor area of the Malé. Dredge material used for reclamation will be obtained from separate harbor maintenance projects and other offshore locations, identified as Gulhifalhu lagoon initially but changed to atoll basin close to Uthuru Thilafalhu.

Figure 2-1: location of proposed development

2.4 The Project

The proposed project involves the reclamation of land for the development of an Industrial Village on the southwest corner of Malé, one of the most congested cities and islands in the world. There is no project feasibility report, however, documented project details have been prepared by the Proponent. The proposed concept is given in Figure 2-2.

This report covers the recent changes to the reclamation area, borrow methodology and borrow areas as well as other changes brought to the dredging, reclamation and shore protection component during implementation.

The proposed changes are as follows.

1. Borrow material from the atoll lagoon close to Uthuru Thilafalhu about 20km northwest of Malé using Trailing Suction Hopper Dredger. The borrow location has been identified based on detailed geophysical surveys to find appropriate areas from where material is available. The survey results are given in the Appendix. A total volume of about 200,000m^3 of sand is proposed to be dredged from this location to reclaim a total of 6.9hectares of land under the proposed SouthWest Harbour

Development project including the 3.2 hectares of additional land covered within the scope of this Addendum.

2. Revising the location of channel in previous EIA as per the JICA report and the channel being constructed on site. The channel to be created on the south has been moved slightly east of the initially proposed location based on the findings of the wave studies during the detailed design. There are no environmental changes as a result of the proposed change.
3. Shore protection using a mix of existing tetrapods and imported granite rock of size 6 tons as the outer layer above 1 ton tetrapods from existing structures (see Figure 2-3).
4. Culverts for water circulation in the area (see Figure 2-2).

2.5 Work Methods

It has been proposed in the EIA for the Southwest Harbour that the additional fill material required for the proposed reclamation will be obtained from Gulhee Falhu. However, it is proposed now to pump sand from the atoll basin at a location near Uthuru Thilafalhu into a hopper dredger. A Trailing Suction Hopper Dredger (TSHD) will be used for the purpose. The dredger is expected to make multiple trips from the borrow area to the fill location and then pump the material to the proposed fill area. Since the fill area is close to deep water the material will be pumped easily. An external bund is being created and part of the fill area boundaries have been enclosed by sheetpile. Therefore, sediment will be controlled and allowed to move along the southern periphery instead of settling in the harbor basin. There will be one or two openings facing the southern reef through which sediment would move out and over the reef areas while getting diluted by wave action. The movement would be mainly easterly since the works will be undertaken during the southwest monsoon. Furthermore, the sand borrowed from the deep lagoon is coarse sand with lesser degree of fines (as per survey report in the Appendix), which would also help to minimize sedimentation during filling.

As for the harbor dredging and reclamation works covered in the previous EIA, excavator, loader, trucks and crane would be used in the works including sheet piling and revetment works. The temporary setup at site considered previously will be used throughout the project. The workforce is already engaged and the same workforce will proceed with the proposed. A temporary setup is created next to the Coca Cola Warehouse infront of Kalhuthukkalaa Koshi on Izzudhdheen Magu.

2.6 Project duration

The project has been started with the dredging of harbour basin and reclamation. A bund on the seaward side is being erected and the hopper dredger currently in the Maldives is expected to return to Malé area and complete the proposed reclamation of Malé Industrial Village. Outer boundary revetment is made with sheet pile retaining wall and rock boulder revetment. Sheet piling works for the scope approved by the reclamation and channel EIA is scheduled to be commenced on 1st June.

The enclosure works within the approved EIA scope except closing off the access to south west harbour has already begun. The access through the southwest harbour to south harbour would only be closed after the new channel is opened. However, only the vessel supplying oil to STELCO and waste transfer vessel will be allowed to use the channel until the channel breakwater is fully complete. However, channel breakwater core will be completed before opening of channel to provide partial protection to the channel.

The proposed components are expected to take about 2 months, as shown in the schedule below.

Table 2-1: Schedule of proposed activities

Activity	Duration
Enclosure of the Reclamation Area (works completed upto the scope of covered by the approved EIA for reclamation and channel)	Upto 20th June
Reclamation	June 22nd to June 30th
Revetment (including the construction of sheetpile retaining wall)	1st June to 20th July

2.7 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is the harbour itself and associated socio-economic benefits. These inputs and outputs are summarised in Table 2-2 and Table 2-3.

Table 2-2: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Workers	Contractor's workforce on site
Food, water and other resources	Provided on site for workforce
Machinery (excavator, barge, operational tools)	Contractor (already on site)
Energy for machinery operation (e.g. fuel)	Diesel fuel provided by contractor
Sand for reclamation	Related dredging undertaken by proponent

Table 2-3: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Wastewater from workers	No. of worker's x 95l/c/d	Through existing island sewerage system during the construction phase and through the proposed sewerage outfall during the operational phase
Possible oil leak from machinery	Trace amount	Take precautionary measures to avoid such leaks
Sediment plumes (during excavation)	Moderate	Natural dispersion over a short period

2.8 Need and Justification

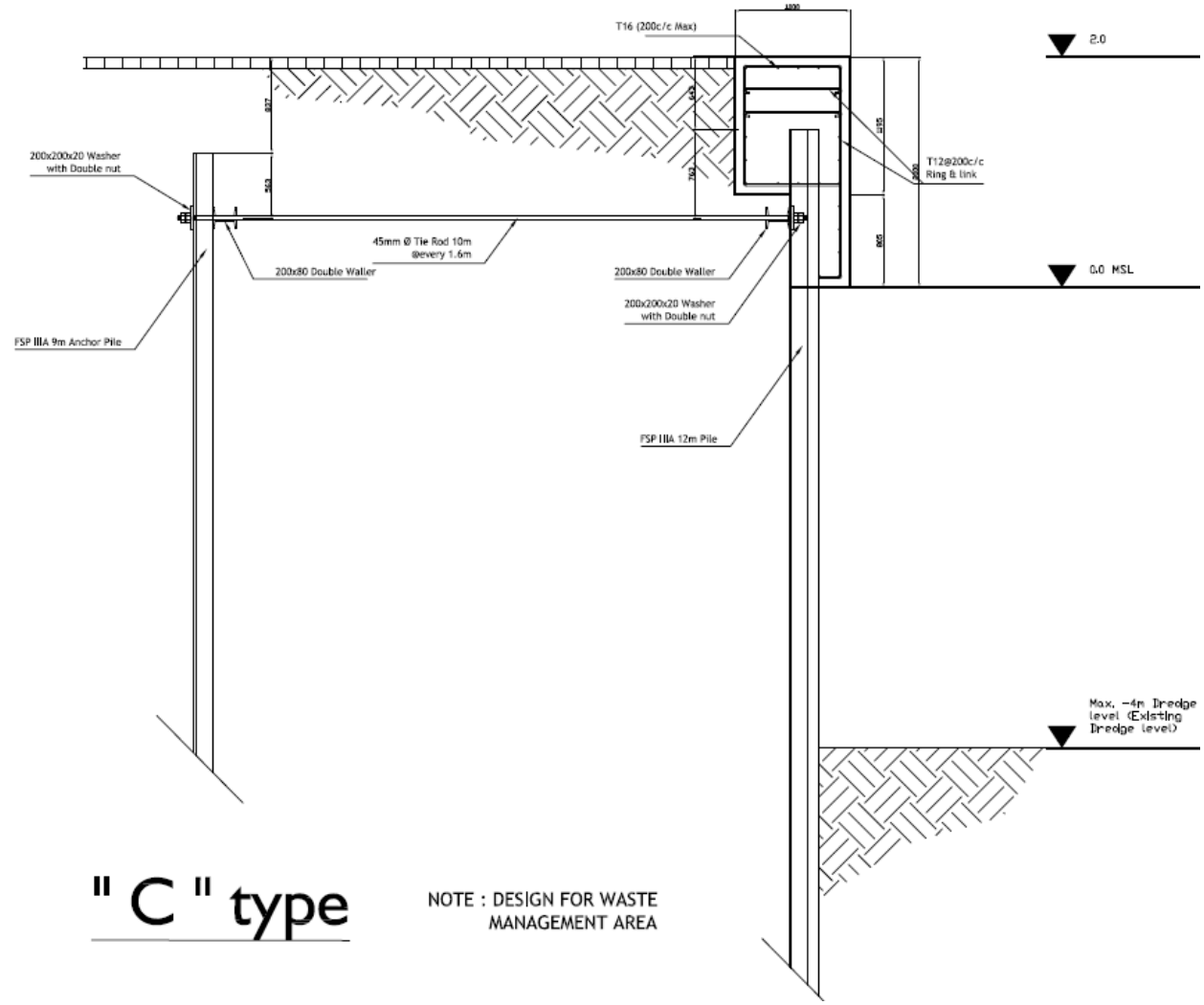
The proposed industrial village including the dredging, reclamation and shore protection components covered in this report seeks to develop a specific zone for industrial activities that currently take place within the city. The main purpose of the project is to reduce adverse health and social impacts to the community and increase the efficiency of these activities.

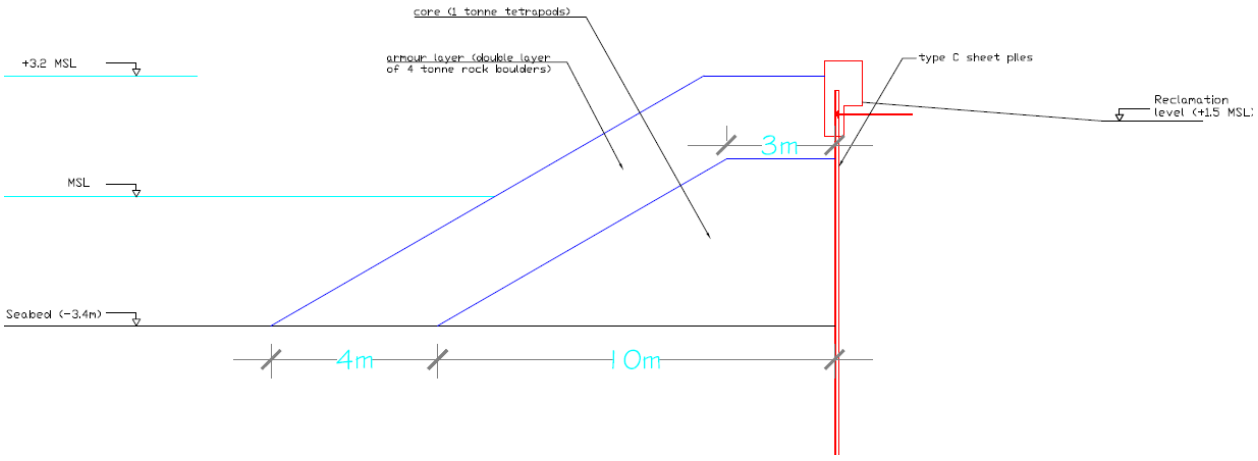
The proposed channel would provide a more direct access to the south harbor compared to the longer route presently taken through the south west entrance. The consultation carried out with STELCO confirms that the new channel will enable direct transfer for their oil supply transferring the oil through pipe connections by anchoring the main vessel near the channel. The current route only enables smaller vessels which takes more than one round to complete a single delivery.

The reclaimed land targets to tackle some of the important socio-economic problems of the congested capital city. The semi-industrial work carried out within the residential areas of Male', such as garages, carpentries, concrete mixing, fuel storage and distribution are considered serious health hazards, especially in a place such as Male' with high population density. The proposed Industrial Village will be used for waste management and relocating industrial operations from the residential areas; thereby reducing negative impacts on the community by said activities. The land use plan of the proposed reclamation covers plots for waste management, industrial activities (workshop, garage, carpentry, godown etc.), heavy load vehicle parking zone, premix concrete management zone, MNDF workshop and garage, gas filling and distribution zone and oil filling and distribution zone. Petrol and oil filling will only cater for sea vessels/ This is to reduce the number of oil bowsers on Boduthakurufaanu Magu near existing filling points. Currently it puts more pressure on the traffic flow and reduces the usable space on roads for other vehicles.

Figure 2-2: Proposed project components

Figure 2-3: Proposed shore protection design





3 Legislations and Regulations

The pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project have been identified and discussed in the EIA for the Development of Malé Southwest Harbour. The appropriate authority jurisdictions that will specifically apply to the project have also been discussed in the report.

The proposed components covered in this Addendum are expected to conform to all of the policy and regulatory aspects outlined in the original EIA report.

The proposed project has been and will be subject to the key legal tools including Environmental Protection and Preservation Act (No. 4/93), EIA Regulation and Dredging and Reclamation Regulation. Thus, it must satisfy the EIA process and get approval as well as conform to the requirements of the dredging and reclamation regulations. The application for dredging permit will be submitted with the EIA report, according to the requirements of the Dredging and Reclamation Regulation and approval procedures currently in place.

4 Existing Environment

The existing environmental conditions for the proposed project were studied in appropriate locations during the field visits undertaken for the initial EIA. Further assessments were also undertaken including existing site conditions while the project was ongoing.

This section will cover those aspects of the project which have been covered in the field investigations undertaken in May 2016. In addition, some general climatic factors have been looked at in order to understand the impacts of the project components better.

4.1 General meteorological conditions

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. Table 4-1 provides a summary of key meteorological findings recorded for Maldives.

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

Table 4-1: Key meteorological information

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February 1900mm annual average
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 ^{0}C in November 1973 31.7 ^{0}C in April

Extreme Air Temperature	34.1 ^{0}C in April 1973 17.2 ^{0}C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

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

Table 4-2: Summary of Seasons in the Maldives

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

4.1.1 Wind

Wind has been shown to be an important indirect process affecting formation, development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Winds played an important role in the recent floods in the recently completed Rasfannu Beach during the rough southwest monsoon that followed the cyclone named Roanu in May 2016. With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too.

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer 2003). Wind speed is usually higher in central region of the Maldives during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975 to 2001. Maximum wind speed recorded in the south was 17.5 m/s during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind speed was in general lower and more uniform throughout the year in the southern

region. Wind analysis indicated that the monsoon was considerably weaker in the south (Naseer 2003). During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

Figure 4-1 summarizes the wind conditions in the region throughout the year and Figure 4-1 provides the wind-rose diagram typical to the atoll (windfinder.com). This analysis represents wind data from Hulhule Airport taken between 07/2002 and 04/2016 from 0700 to 1900hrs local time.

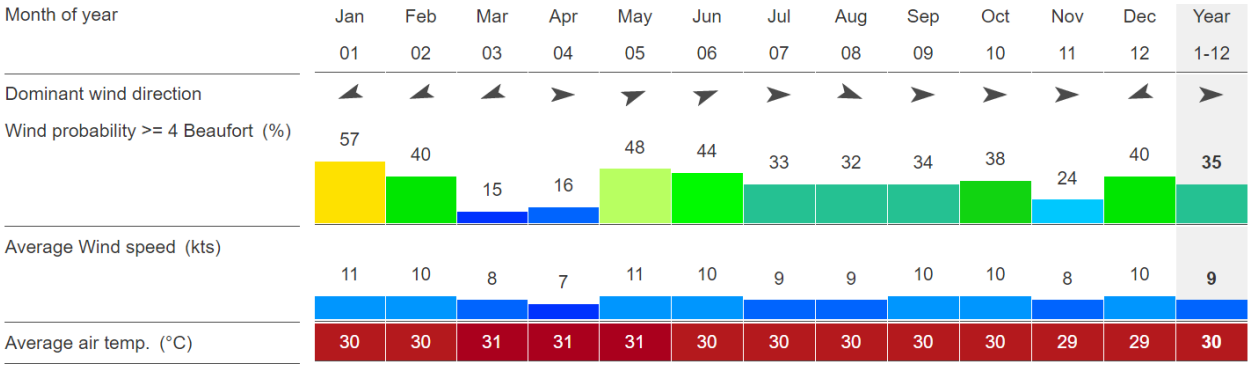


Figure 4-1: Summary of general wind conditions in Malé region

As can be seen from the figure above and the wind rose diagram below, the dominant wind directions are southwesterly during the Northeast monsoon and easterly during the Southwest monsoon. The winds are weakest during March and April, whereas in 2016, there had been strong winds even during March and April. The project is best undertaken during the northeast monsoon since the northeast monsoon is generally mild; therefore, working in the northeast monsoon is not going to pose much difficulty in this area. Also, the net flow is in the easterly direction. So, there will be stronger currents in the area during southwest monsoon compared to the northeast monsoon; so it may be easier to mobilize and operate heavy machinery at this site during northeast monsoon. However, the project falls within the southwest monsoon, especially for the dredging and reclamation component. The development of the Industrial Village will occur partly during the Northeast monsoon.

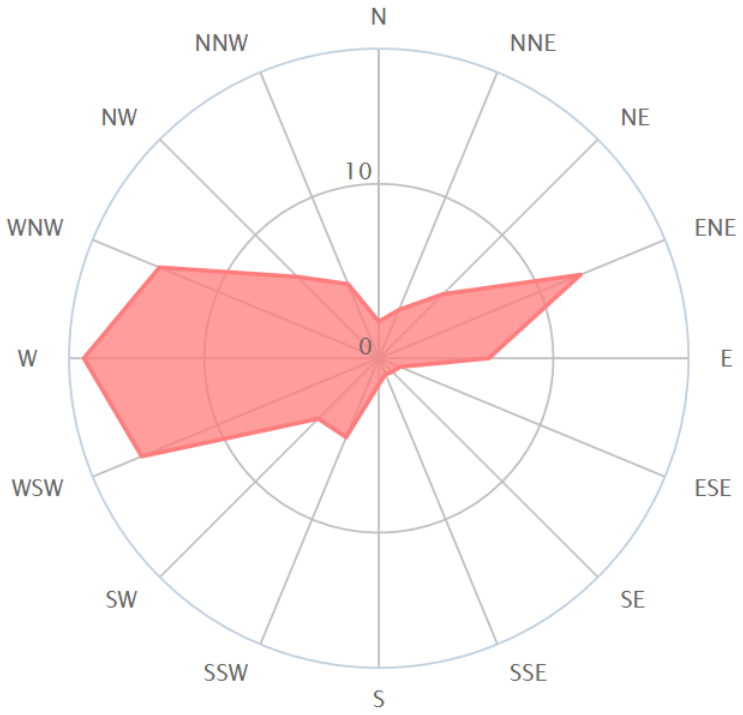


Figure 4-2: Windrose diagram based on data from Ibrahim Nasir International Airport

4.1.2 Waves

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

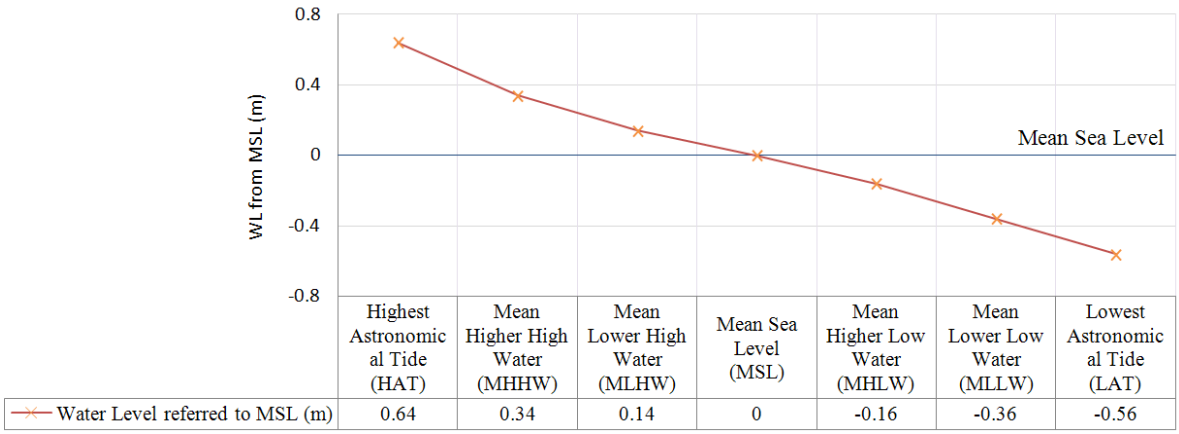
Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system of west coast of Australia, had significant wave heights in the order of 3 metres.

The proposed location has weakened swell waves acting diagonally during both monsoons. The oceanic swells from the west are dominant on this area. However, the area is quite

protected during the northeast monsoon compared to the southwest monsoon. Even during the southwest monsoon, it is in the lee of Ari Atoll on the west. Therefore, the significant wave heights at the location during the southwest monsoon would be in the range 0.5 to 1m. The structures proposed for the area would be designed on a study of waves in the area.

4.1.3 Tides

The Maldives experiences mixed semi-diurnal/diurnal type of tides which on two extreme ends of the country (North to South) found varying tidal range. The tide at Hanimaadhoo, HDh. Atoll is about 20cm lower than that recorded in Gan, Seen Atoll (MHAHE 2001). Tides affect wave conditions, wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives, where the tidal range is small (1m), tides may still have significantly important influence on the formation, development, and sediment movement process around the islands. Tides would play an important role in lagoon flushing, water circulation within the reef and water residence time within enclosed areas.



	Highest Astronomical Tide (HAT)	Mean Higher High Water (MHHW)	Mean Lower High Water (MLHW)	Mean Sea Level (MSL)	Mean Higher Low Water (MHLW)	Mean Lower Low Water (MLLW)	Lowest Astronomical Tide (LAT)
Water Level referred to MSL (m)	0.64	0.34	0.14	0	-0.16	-0.36	-0.56

Figure 4-3: Astronomical tidal variation in the Maldives

4.1.4 Currents

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

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

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

4.1.5 Bathymetry

A bathymetric map of the relevant areas is given in the Appendix. The bathymetry indicates that the existing breakwater made of tetrapods is on the reef flat with no more than 1.5m depth whereas the proposed revetment is at 2.4 to 3.5m depth on average.

4.2 Marine Water Quality

Marine water quality was initially measured from representative locations around the reef. The water quality results (in-situ) are given in Table 4-3. The tested parameters show the marine water quality was similar to pristine areas of Maldives.

Water quality tests were undertaken at 2 of the previous locations and 2 additional locations where dredging is currently underway. All locations indicated some degree of sedimentation from ongoing works with the highest levels near the new entrance channel.

Table 4-3: Water quality results

	Units	Site 1	Site 2	Site 3	Site 4
Coordinates	UTM	333601.23m E 460943.43m N	333820.45m E 460884.72m N	334187.28m E 460875.02m N	334516.11m E 460895.46m N
Temperature	^{o}C	30.21	30.33	30.18	30.28
pH		8.02	8.21	8.00	8.11
E. Conductivity	uS/cm^3	51,040	51,250	51,070	51,160
TDS	mg/l	34,150	34,150	34,680	34,300
Salinity	ppt	34.40	34.18	34.32	34.36
DO	mg/l	5.97	4.88	4.03	5.06
Turbidity	NTU	3.46	2.51	2.37	1.33
TSS	mg/l	1	0	0	0

4.3 Ecology

This section of the report describes condition of the biological environment; both the marine and coastal components of relevant areas in detail.

4.3.1 Housereef of Southwest Malé

The existing inner reef system of Male' covers an area of about 23 Ha with an average depth of -2.0m over the reef flat. About 90% of this area is covered by the southern side reef facing towards the outer sea, open to ocean swell and wind generated waves. In other parts, reef flat is in very close proximity of the coastal protection structures. In 2002, a section of the reef flat from north eastern side corner collapsed which raised questions on the stability of the reef flat around Male'. Based on studies lead by Marine Research Centre (MRC), main reason for the failure was prolonged stress due to a concrete jetty built in that area.

In various locations around Male' reef, it can be observed that there are caves and/or notches formed in the reef slope. At the western side there are a number of such caves at depths of around -7.0m in MSL. Reef slope at this area is extremely steep where the depth decreases to -20m from -3m within 3-5m increase in horizontal distance. Average maximum inward depth of such caves is 5m. (Mustafa *et al.* 2015)

However, marine surveys conducted on the southern and south-western side of Male' reef showed very few of such caves and smaller in size compared to western side.

The house reef around the proposed project area was found to consist of mostly dead coral with algae. The benthic habitat and community assessment including coral cover and marine

species were assessed through photo and video transects. Transects as shown in Figure 4-13 was conducted at 3 locations on the southern side of Malé near the proposed project location.

Figure 4-4 shows characteristics of the assessed sites obtained from photo quadrate reef survey sites and status of the reef in terms of percentage of benthic cover at these sites.

The following sub-sections provide results of the quantitative assessment of the marine environment of the project site in terms of percentage benthic cover, fish count and general status of the reef.

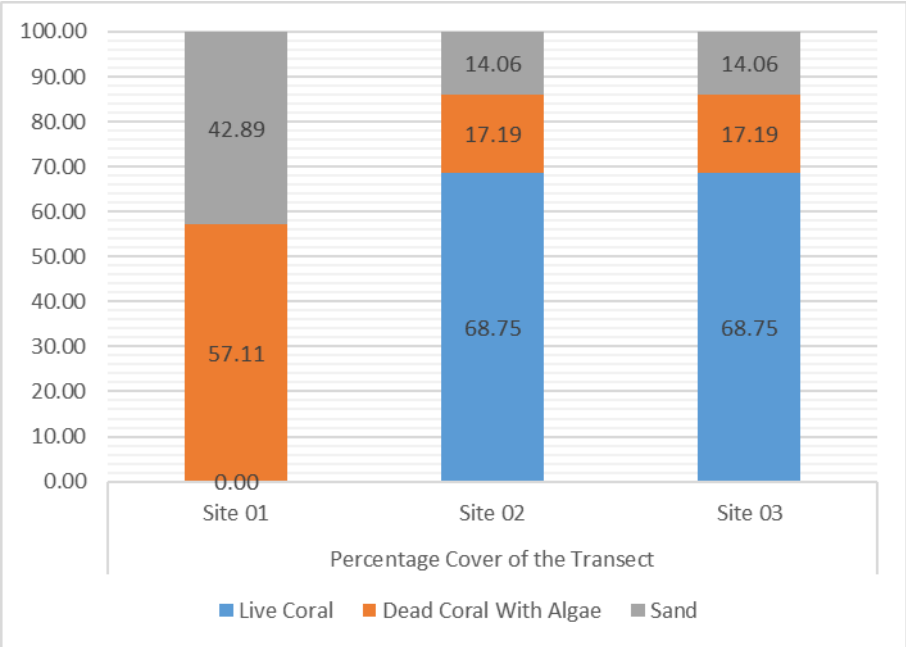


Figure 4-4: Attributes of marine environment

4.3.1.1 Site 1

Site 1 was located on the southwest corner of Malé close to the existing entrance of the southwest harbour. This area is slightly in the lee of Villingilli island during southwest monsoon. The transect is located at about 2-3.5m below MSL. The area is mainly dead due to dredging and shore protection works close to this area in the past. Since dredging was ongoing at the time of the survey, the area was sedimented and was difficult to do a fish count.

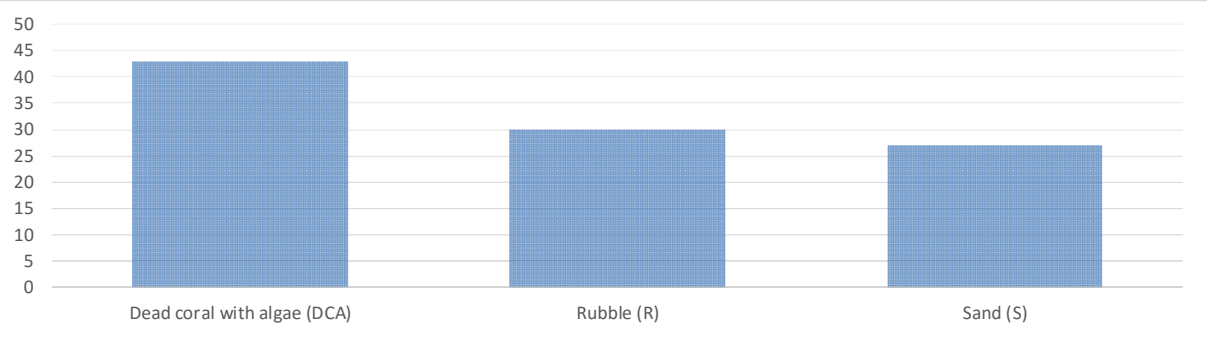


Figure 4-5: Coral cover at Site 1

Figure 4-6: Photos of Site 1

4.3.1.2 Site 2

Site 2 was located close to the southwest of the proposed reclamation area, directly on the southwest corner of Malé. This site has some juvenile recruits of coral, most of which have been bleached during the recent bleaching event, which lasted several days. About 50% of the live coral colonies at the site had been bleached. The area is slightly turbid due to the ongoing

reclamation and shore protection activities under the proposed project. The transect was done at about 3 to 4m depth. The turbidity in the area was less than that of Site 1.

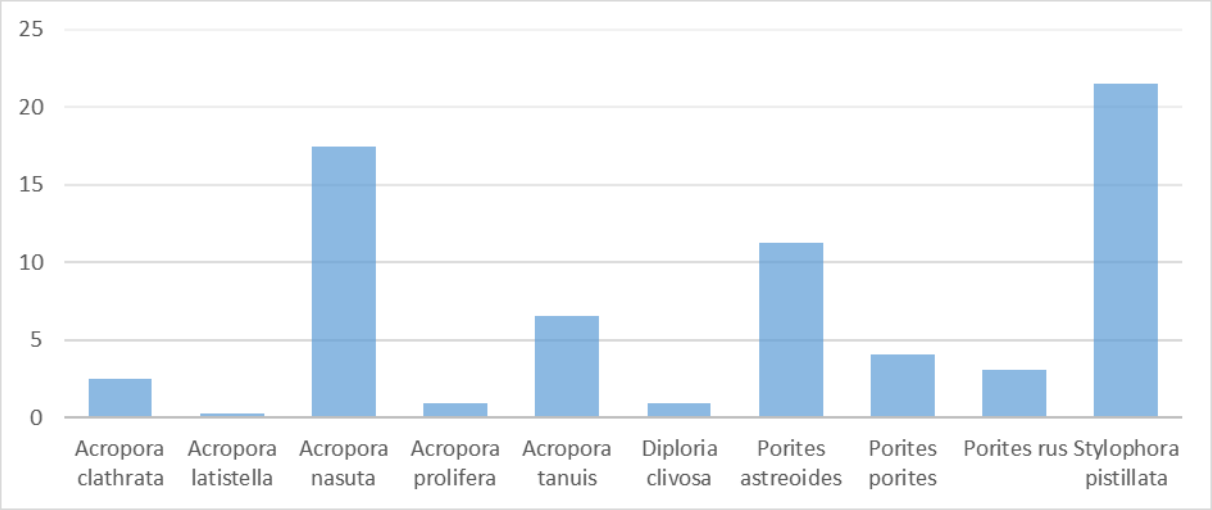


Figure 4-7: Coral cover at Site 2

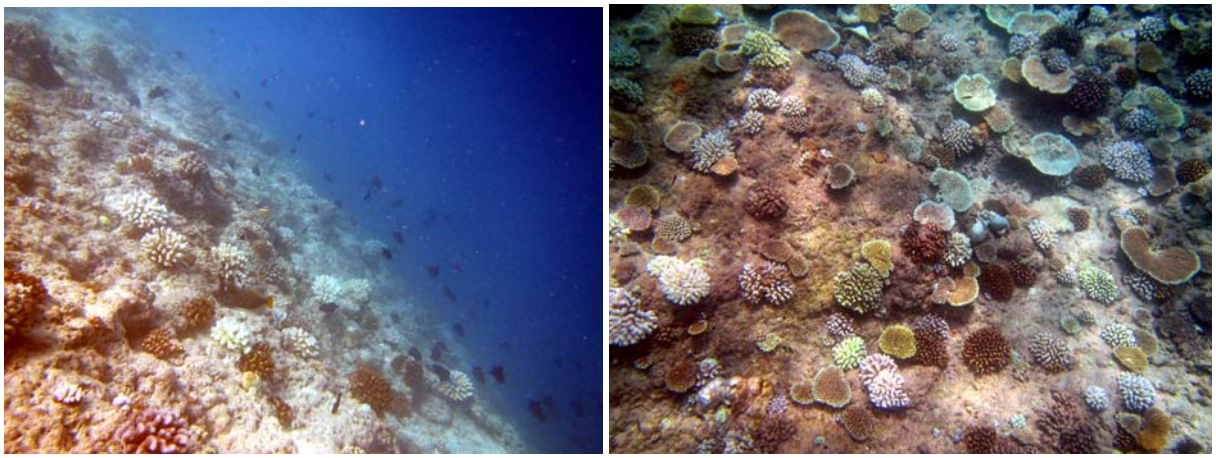


Figure 4-8: Photos of Site 2

4.3.1.3 Site 3

Site 3 is located slightly west of the proposed access channel since the sediment plume from the dredging of the channel has affected the channel area. The area is similar in benthic composition to Site 2 but had a higher percentage of live coral cover than Site 2. Nearly 60% of the corals have been bleached in the recent bleaching event. The area appears to have a slightly lesser degree of sedimentation than Site 2 on the day of the field visit. The transect at this location was also located at about 3-4m depth.

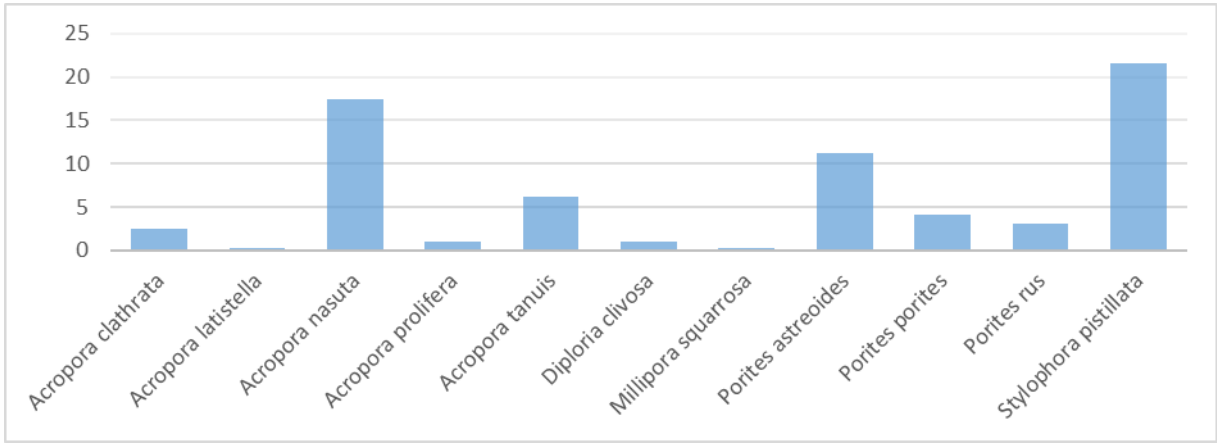


Figure 4-9: Coral cover at Site 3

Figure 4-10: Photos of Site 3

4.3.2 Coastal Environment

With multiple reclamations to original island of Male' the entire island is currently protected by a form of coastal structure. The study area (southwest corner of Male') is protected by a concrete quay wall and tetra-pod breakwater. Apart from few young coconut palms and Hirundhu (*Thespesia populnea*) vegetated for landscaping, there were no vegetation on the coastline. The harbor at the proposed project location is predominantly used by speed boats operations. Petrol is also supplied to speed boats at this location. During construction phase of the project, the vessels at this location will be relocated east of south harbor.

4.4 Social Environment

4.4.1 Demography

Malé is one of the most densely populated cities of the world. The population of Male according to Census 2014 was 150,638 as compared to 102,377 in the year 2006 (see Table 4-5). This shows an increase in population of 2.94% between 2006 and 2014. Malé is the economic hub of the country and about 30 percent of the population live in Malé. The better social services and other infrastructure have resulted in increasing inward migration to Malé. With the ongoing growth focus on Hulhumalé, there is expected to be a greater increase in population in Malé.

2006 census data indicated that the population of Malé was growing at a rate of 5.6 (between 2000 and 2006) compared to a negative growth of -0.1 for the rest of the Maldives. These figures do not show the daily inward migration for medical and trade purposes from the rest of the Maldives and the large foreign labour force residing and working in Malé. Therefore, the congested living conditions and the congested nature of Malé is unimaginable and the demand for housing and improved facilities and living conditions is ever increasing.

Table 4-4: Population census data 2006 with population from census 2000

	TOTAL (2000)	TOTAL (2006)	No. of households	Average household size	Annual population growth rate
Atolls	196,032	195,275	32,087	6.1	-0.1
Malé Total	74,069	103,693	14,107	7.4	5.6
Malé (excluding other areas)	72,230	102,377	13,831	7	5.8
Henveyru	18,100	23,597	3,177	7	4.4
Galolhu	13,878	19,414	2,640	7	5.6
Machchangolhi	13,589	19,580	2,623	7	6.1
Maafannu	22,372	29,964	3,983	8	4.9
Villingili	4,291	6,956	996	7	8.0
HulhuMalé	-	2,866	412	7	NA

With the ever-increasing congestion in Malé, Hulhumalé has been the target of managing the negative impacts of congested living in Malé. According to HDC (2012), the target population of Hulhumalé is 60,000 people by the year 2020. This target is doubled with the second phase reclaimed recently. Hulhumalé also has an industrial zone with a number of industrial activities providing several job opportunities.

Table 4-5: 2014 census results showing population of Malé (including Hulhumalé)

Locality	Population 2014									2006 Census			Maldivians 2014 ދިވެހިން		
	2014 Total			2014 Maldivians			2014 Foreigners								
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female	SEX RATIO Males per 100 Female	INTER-CENSAL AVERAGE ANNUAL GROWTH RATE 2014-2006	SHARE OF POPULATION IN LOCALITY
Male' Total	153,379	83,429	69,950	133,019	66,155	66,864	20,360	17,274	3,086	103,693	51,992	51,701	99	2.93	100.00
Male' (excluding other areas)	150,638	80,725	69,913	131,490	64,627	66,863	19,148	16,098	3,050	102,377	50,685	51,692	97	2.94	98.85
Henveiru	31,432	16,707	14,725	27,361	13,478	13,883	4,071	3,229	842	23,597	11,648	11,949	97	1.74	20.57
Galolhu	26,915	14,481	12,434	23,408	11,508	11,900	3,507	2,973	534	19,414	9,578	9,836	97	2.20	17.60
Machchangolhi	25,334	13,525	11,809	22,263	10,898	11,365	3,071	2,627	444	19,580	9,544	10,036	96	1.51	16.74
Maafannu	43,398	23,808	19,590	36,603	17,997	18,606	6,795	5,811	984	29,964	14,833	15,131	97	2.35	27.52
Villimale'	7,790	4,029	3,761	7,304	3,642	3,662	486	387	99	6,956	3,462	3,494	99	0.57	5.49
Hulhumale'	15,769	8,175	7,594	14,551	7,104	7,447	1,218	1,071	147	2,866	1,620	1,246	95	19.11	10.94
Other Areas	2741	2,704	37	1,529	1,528	1	1,212	1,176	36	1316	1,307	9	NA	NA	1.15
Harbour (including villingili and	2,417	2,392	25	1,439	1,439	0	978	953	25	1,316	1,307	9	NA	NA	1.08
Hulhule	324	312	12	90	89	1	234	223	11	0	0	0	NA	NA	0.07

4.4.2 Land Use at the Project Site

The land near the site is used for institutional and semi-industrial purposes as well as military spaces and few government buildings and recreational facilities. Figure 5-3 shows the location of these infrastructures. Below are some of the significant infrastructures:

- Kalhuthukkalaa Koshi: One of the key military establishments in the country. Used for military training, office and fire and safety operations.
- Southwest harbour: This is a mooring area for several speedboats and other vessels. There are also several MNDF vessels moored here. Also known as petrol jetty, the area is primarily used for fueling of speedboats.
- Ghiyasuddin International School: One of the main first international schools in Malé, Ghiyasuddin School is just opposite the Maafannu Stadium (sports ground) and next to Kulhivaru Ekuveni
- Kulhivaru Ekuveni: Being demolished now after several years serving the indoor sports activities for the population of Malé
- Villingilli Ferry Terminal: The connection between neighbouring Villimalé as well as the Industrial Island of Thilafushi. Thilafushi waste barges are located west of this building.

- Dhiraagu Main Building: A multi-storied building situated on the north of the harbour and Villingilli Ferry Terminal.
- Children's Park: On the northeast corner of the harbour, just off the road is a recently made park.

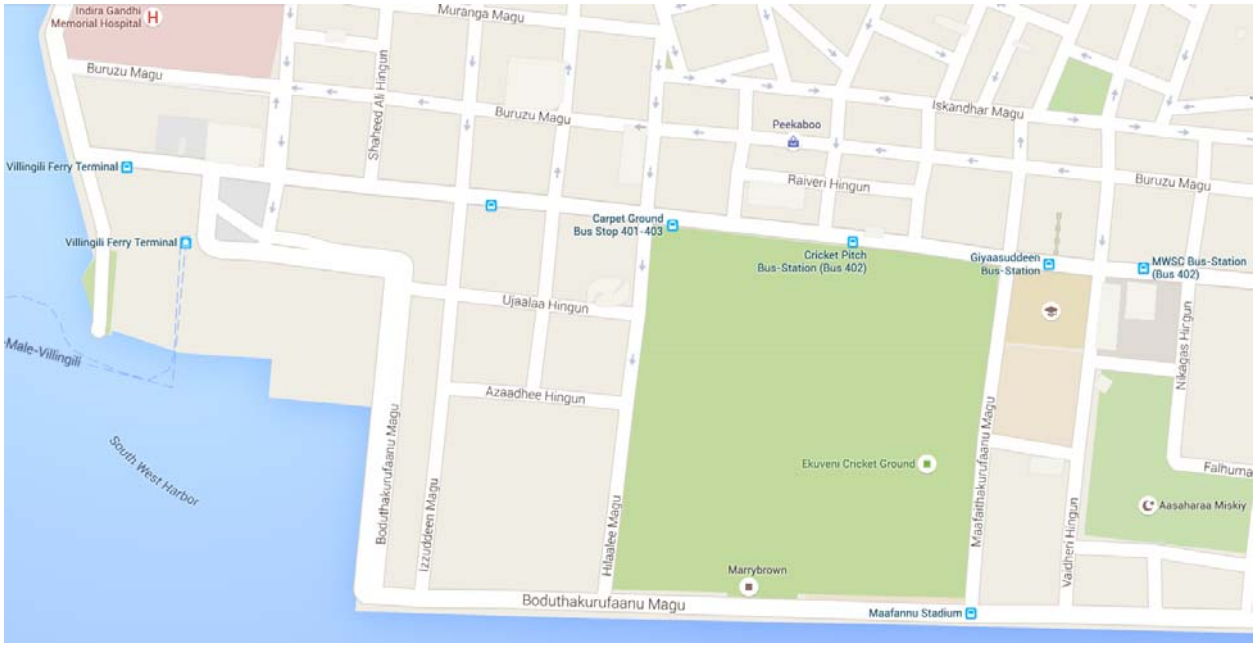


Figure 4-11: Map showing landuse in the project vicinity

4.5 Natural hazard vulnerability

As the site is on the coastline, it would be very vulnerable to natural hazards such as tidal waves or other high wave events such as tsunamis. The engineered sea wall around Malé and the site area, so far has proven to be an effective defence mechanism to such natural hazards.

The worst natural hazard that was faced by Malé was that of the tidal wave in 1987 and the tsunami. When the tidal wave hit the Maldives on 11 April 1987, Malé had poorly built breakwaters around it and about a third of Malé was affected by severe flooding resulting in severe damage to the breakwater and retaining walls around the island. A number of houses were damaged or destroyed and several people evacuated and became homeless although no loss of life was reported. Following this incident, under a grant aid from the Government of Japan, the entire perimeter of Malé was protected by revetments and breakwaters that stood the test of time when the tsunami hit the island on 26 December 2004. On that day, several islands on the eastern coast of Maldives were badly damaged by the tsunami but Malé had very little damage due to the breakwater and revetments around it. However, due to the low-

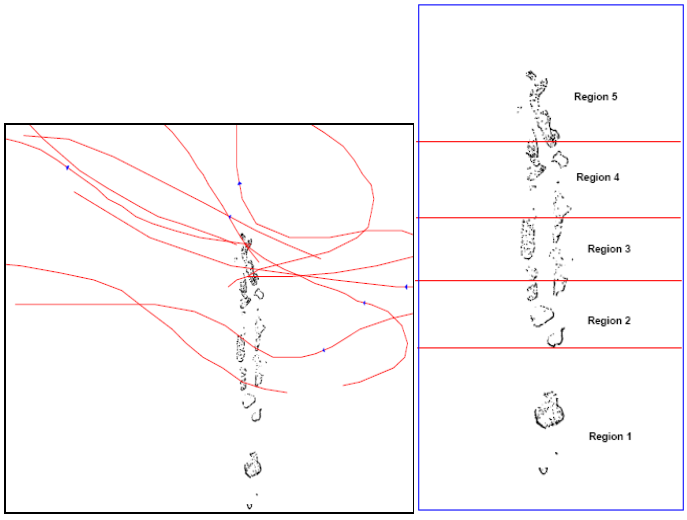
lying nature of the island, the peripheral areas including the area behind the ferry terminal has had severed days during tidal surges.

The project location is on the southwest corner of Malé where there are weakened oceanic swells from the west acting constantly. A breakwater at this location is on the shallow reef flat, however, this breakwater has not been dismantled and moved closer to the reef slope. There may be risks in doing so, however, these risks have been assumed to have been taken into consideration by the coastal engineers and appropriate shore protection designed.

Natural hazard vulnerability risks related to global warming and subsequent sea level rise remains a cause for concern. The vulnerability is further aggravated by the fact that rainfall in the region is of high intensity but short duration, which may be affected due to changes in global precipitation patterns related to climate change. However, the proposed project area has not had flooding due to rain although there are some areas in Malé where flooding following heavy rain is commonplace.

In Developing a Disaster Rick Profile for Maldives by UNDP (2006), the natural vulnerability of the islands and atolls of the country to potential hazards have been modelled to understand the risk factors of the country. In that report, the disaster risk scenario for Maldives was described as moderate in general.

Referring to Suffir-Simpson Scale, the proposed site is considered fairly safe zone when cyclonic winds and storm surges over the Maldives are concerned and also low risk when tsunamis and earthquakes are concerned (RMSI/UNDP 2005).



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

Figure 4-12: Natural hazard map of Maldives (after UNDP, 2005)

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

Figure 4-13: Survey locations

Figure 4-14: Illustrated representation of marine environment

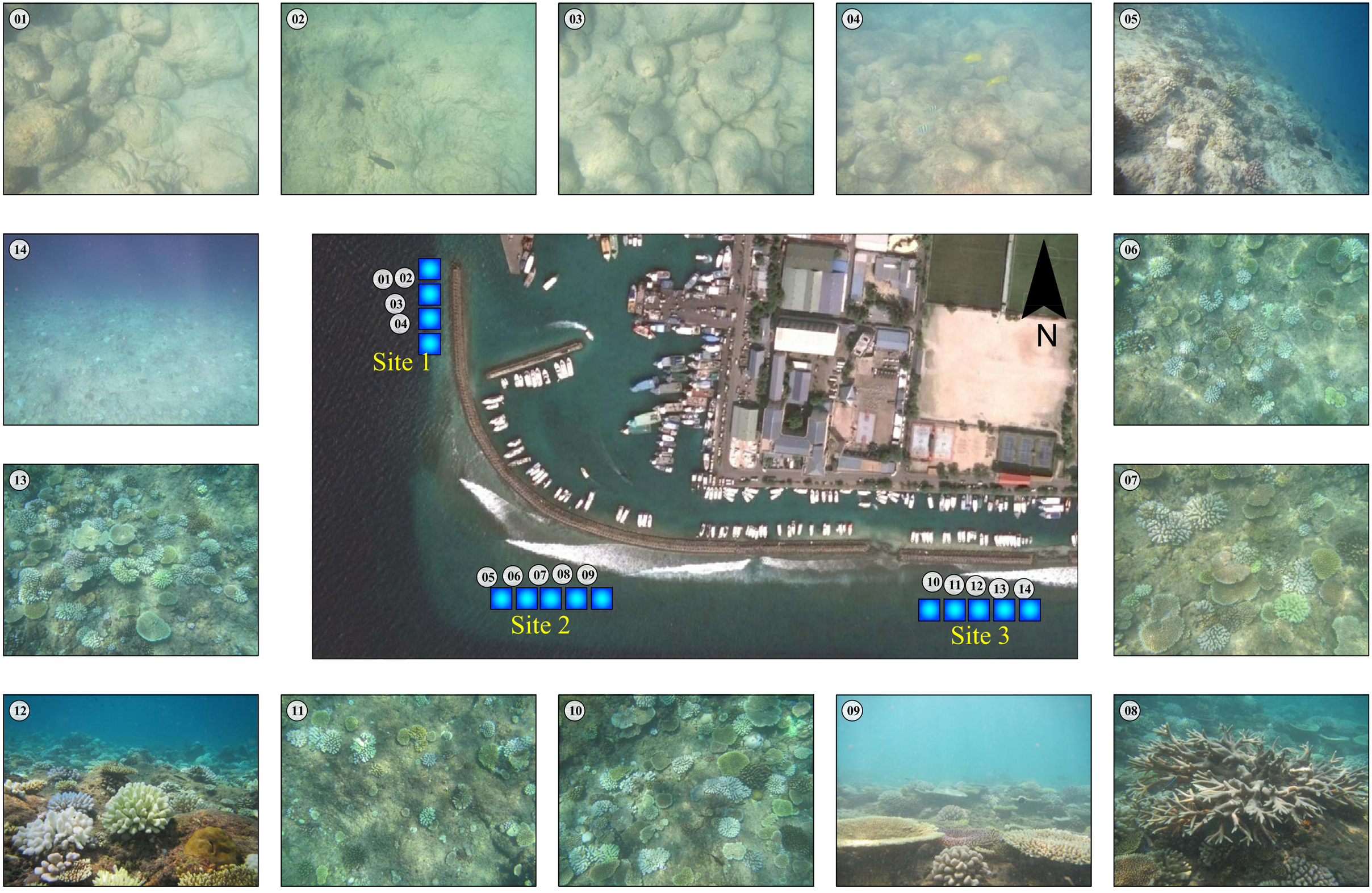
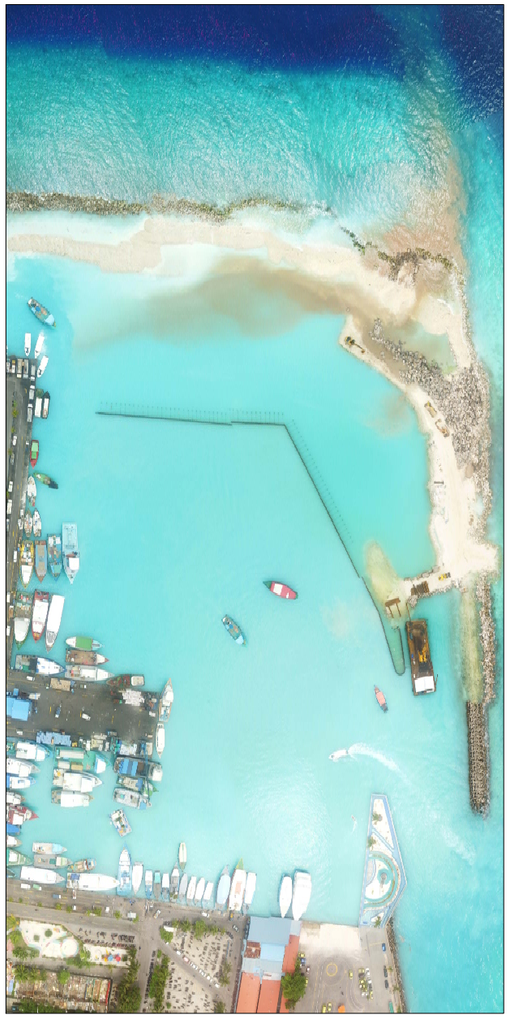


Figure 4-15: Illustrated representation of coastal environment

New channel into South Harbour being dredged. The sediment moves slightly westerly as per wind-induced currents at the time (early May 2016)

Sheet pile wall has been completed at the T Jetty area. The dredging works caused sedimentation inside the harbour area, however, the movement outside an onto the reef is slow and at lower levels.



T jetty and ferry terminal area congested with a number of vessels berthed along the quaywall.

The tetrapod breakwater was being moved seawards with a large percentage breakage of the tetrapods.

Tetrapod breakwater moved and sand bund created at the southwest end.

5 Stakeholder Consultations

Stakeholder consultations have been held with harbour users and relevant stakeholders and have been discussed in the EIA report. Further consultations are not deemed necessary.

It is worth mentioning here that stakeholders of the overall project, especially the industrial village development including MNDF, MWSC, Waste Management Corporation and entrepreneurs and staff engaged in different light industrial activities around Malé are being consulted. Consultations are being held with different parties at different avenues to discuss the project concerns. These will be covered in the second part of this Addendum in which the proposed Industrial Village component will be covered.

5.1 Consultations with MNDF

The Proponent held a meeting with MNDF on 17 May 2016 at Ministry of Housing and Infrastructure. The meeting was represented by MNDF Fire Department, Police and technical staffs from Ministry of Housing and Infrastructure.

MNDF raised concern regarding the extended reclamation facing the MNDF building and the resulting traffic from the development. The Proponent (MHI) indicated that Boduthakurufaanu Magu is going to be widened under this project. Stopping over of vehicles will not be allowed on his road. To discourage stopping over of vehicles on this area, no plots will have direct access from the main road.

Currently a significant percentage of vehicles traveling infront of Kalhuthukkalaakoshi via Boduthakurufaanu magu is lorries and pickups carrying cargo from T-jetty area to storage facilities within Male'. Industrial Village is designed with a direct access road from T-jetty area to Industrial Village area. Therefore, part of the traffic that is currently moving in front of Kalhuthukkalaakoshi will be diverted to industrial village before it even joins traffic stream on Boduthakurufaanu Magu.

Moreover, major storage facilities on Izzudhdheen Magu near T-jetty area would be relocated to the Industrial Village area. Widening of Izzudhdheen Magu starting from Boduthakurufaanu Magu end to Ameenee Magu is also part of the project. Therefore, there would be no negative impact on traffic in the area due to the project.

6 Environmental Impacts

6.1 Introduction

Development projects involving construction of coastal structures and dredging in island environments are believed to generate a series of environmental impacts, of which some can be felt immediately on the surrounding environment while others can be felt continually and can be far reaching. By far and large the most significant environmental impacts are those that are felt on the immediate environment. Marine environment is directly affected from high rates of sedimentation caused by dredging activities. Coral reefs environments are very sensitive and highly susceptible to immediate changes in physical environment such as changes in water quality. Therefore, all the development activities must take into consideration the understanding of the environment and changes as well as implications that it will bring about to the environment and surrounding.

The following account describes potential environmental impacts that will be associated with the proposed southwest harbour development at Male' during construction and operation phases of the project.

6.2 Methods and Limitations

The methods used to predict and evaluate the environmental impacts that may be associated with the proposed harbour rehabilitation may not be the most comprehensive methods as they are quite simple prescriptive methods. The main shortcoming of these methods is that only assumptions have been made to predict the impacts which may or may not be accurate. Also, the degrees at which these impacts are either accurate or inaccurate as well as uncertainties and natural variability are the key factors that affect the accuracy of these methods. Nonetheless, the methods used are concise and provide a general overview as well as the range of impacts that can affect the environment. Also, the EIA report has taken into consideration similar studies undertaken in the Maldives as well as expert judgment in identifying the main environmental impacts that may be associated with the proposed project.

6.3 Impact Identification

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

- A consultative process within the EIA team and the Proponent
- Purpose-built matrices
- Existing literature and reports on similar developments in the Maldives
- Baseline environmental conditions described in Chapter 4.
- Consultant's experience of projects of similar nature and similar settings

A purpose built matrix has been used to evaluate the overall impacts of the proposed project. The impacts of the project have been evaluated according to the following criteria:

1. Magnitude (or severity): the amount or scale of change that will result from the impact
2. Significance: importance of the impact. Reversibility is considered part of its significance
3. Duration: the time over which the impact would be felt
4. Extent/spatial distribution: the spatial extent over which the impact would be felt

The scales associated with the above criteria are given in the table below.

Table 6-1: Impact evaluation scale

Criteria	Scale	Attribute
Magnitude *Change caused by impact*	-3	Major adverse
	-2	Moderate adverse
	-1	Minor adverse
	0	Negligible
	1	Minor positive
	2	Moderate positive
	3	Major positive
Significance/Reversibility *Impact implications / Reversibility of impact's effects*	0	Insignificant
	1	Limited implications / easily reversible
	2	Broad implications / reversible with costly intervention
	3	Nationwide or global implications / irreversible
Duration *Duration / Frequency of Impact*	0	Immediate
	1	Short term/construction period only
	2	Medium term (five years of operation)
	3	Longterm/continuous
Extent/Spatial Distribution *Distribution of impact*	0	None/within 1m from point of discharge/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

Based on the above scale, an impact matrix was developed for the proposed development to determine the overall impact of the proposed project. This matrix is given in Table 6-2.

An impact potential index was then developed from Table 6-2. The impact potential index table represents a product of the magnitude (M), significance (S), duration (D) and extent/spatial distribution (E) given in the above table. The sum of all key component specific indexes for one activity (i.e. sum by rows) provides the Activity Potential Impact Index (API) and the sum of all activity specific indexes for one key component (i.e. sum by column) provides the Component Potential Vulnerability Index (CPVI) which gives an indication of the vulnerability of each key component to activity related impacts. Table 6-3 represent the impact potential indices for the proposed project.

6.4 Overall Impacts of the Proposed Project

The overall impact of the proposed project is slightly positive due to the strong socio-economic potential of the proposed project. However, there are some minor negative impacts on some of the environmental components. The direct and project specific negative impacts of the proposed project are due to sedimentation and sediment re-suspension in the water column as a result of dredging and reclamation (minor), and direct impact on lagoon and marine biodiversity (moderate).

The creation of employment opportunities (indirect) as a number of industrial activities are proposed to be carried out on the reclaimed land and related economic opportunities (indirect), the value of property associated with the development are considered as positive socio-economic impacts of the project. One of the main direct socio-economic impacts of the project would be relocation of waste transfer site and little industrial work currently carried out in residential areas of Malé.

Table 6-2: Impact matrix for the proposed project

	KEY COMPONENTS																			
	Environment								Socio-Economic											
PROJECT ACTIVITIES	Reefs incl. live bait		Lagoon/seawater		Hydrodynamics		Air/Noise/land or seascape		Services and Infrastructure		Health and Safety		Employment		Property Value		Costs to consumer/tax payer	
Construction																		
Culverts	-1	0	-1	0	1	1	0		1	1	1	1	1	1	-1	1	-1	1
	1	1	1	1	3	1			1	1	3	1	2	1	1	2	1	2
New access channel construction	-1	1	-2	0	-1	0	-1	1	1	1	-1	1	1		-1	1	-1	1
	1	1	1	1	1	2	1	1	1	1	1	1			1	2	1	2
Reclamation of additional land	-3	1	-3	1	-1	0	-1	2	-1	1	-1	0	1	2	-1	1	-1	1
	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2
Construciton of quay wall and revetments	-1	1	-1	0	-1	1	-1	1	1	1	-1	1	1	2	-1	1	-2	2
	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2
Operation																		
Use of new access channel	0		-1	0	0		-1	0	2	1	1	1	1	1	2	1	1	1
			3	1			3	1	3	2	3	2	3	2	3	2	3	1
Use of reclaimed land	0		-1	0	0		2	3	2	1	1	2	1	2	2	1	1	1
			3	1			3	2	3	2	3	2	3	2	3	1	3	1
KEY:	M	S	Magnitude				Significance											
	D	E	Duration				Extent (spatial)											

Table 6-3: Impact potential indices for the proposed project

	KEY COMPONENTS									
	Environment				Socio-economic					
PROJECT ACTIVITIES	Reefs incl. live bait	Lagoon/seawater	Hydrodynamics	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer	TOTAL API
Construction										
Culverts	0	0	0.04	0	0.01	0.04	0.02	-0.02	-0.02	0.07
New access channel construction	-0.01	0	0	-0.01	0.01	-0.01	0	-0.02	-0.02	-0.06
Reclamation of additional land	-0.04	-0.04	0	-0.02	-0.01	0	0.02	-0.02	-0.02	-0.13
Construciton of quay wall and revetments	-0.01	0	-0.02	-0.01	0.01	-0.01	0.02	-0.02	-0.1	-0.14
Operation										
Use of new access channel	0	0	0	0	0.15	0.07	0.07	0.15	0.04	0.48
Use of reclaimed land	0	0	0	0.44	0.15	0.15	0.15	0.07	0.04	1
TOTAL CPVI	-0.06	-0.04	0.02	0.4	0.32	0.24	0.28	0.14	-0.08	1.22

API = Activity Potential Impact Index
CPVI = Component Potential Vulnerability Index

The table above indicates that the project has minor negative environmental impacts during construction which are short-lived and moderate to moderately positive social impacts during the operational phase. As such, the social and economic benefits of the project outweigh the negative environmental impact, as a result of which the total potential impact index for the project is slightly positive. Depending on the outcomes of the project, the project may have major social impacts with greatly positive impact index.

6.5 Project Specific Impacts – Construction Phase

6.5.1 Temporary facilities, machinery and workforce

These remain the same as that covered in the EIA report.

6.5.2 Dredging of channel

The shift of the channel slightly to the east improves the usability of the channel since there will be less wave activity and low level currents in the new location. However, the rest of the

impacts including impacts of sedimentation on the reef would be the same as or similar to the previous location.

Figure 6-1: Aerial view of site conditions in May 2016

6.5.3 Construction of quaywall and revetments

These have also been considered in the EIA report. However, it is important to mention that the proposed revetment details were not available at the time the EIA was done. Therefore, this addendum will consider the new conceptual design and the impacts. The proposed design is suitable for the existing waves in the area. However, there are concerns due to the structure being on the reef slope, which needs to be taken into consideration in the final design.

6.5.4 Construction of culverts

The proposed culverts have been considered as a mitigation measure to address the possible concerns of stagnation of the southwest harbour. The culverts will aid flow and improve circulation within the harbour. This was necessary since the proposed reclamation almost completely cuts natural flow existing within the harbour.

The impacts of construction cumulatively adds to the sedimentation impacts of the dredging and reclamation component and is considered insignificant in terms of the overall project.

6.6 Project Specific Impacts – Operational Phase

The operational impacts of the project do not change as a result of the proposed changes except for the proposed culverts which improve the concerns related to stagnation expressed in the EIA report.

6.6.1 Changes in hydrodynamics

Significant changes to hydrodynamics around the area are not expected to occur due to the proposed project components. However, it should be noted, as is currently observed, floating debris is common place within the harbor. The proposed reclamation will close off the flow from southwest harbor into the south harbor and vice-versa. It is for this reason, as described earlier, that the proposed culverts have been incorporated in the design. The culverts will improve flow in the harbour and address the stagnation concerns.

6.7 Uncertainties in Impact Prediction

Environmental impact assessment involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or socio-economic conditions in a particular place. There are some uncertainties with reference to achieving the objectives of the Industrial Village development. These include the appropriate usage of the area and relevant traffic issues in the area, which will depend on effective implementation of the project.

As mentioned in the EIA report, it is important to consider that there are elements that are different from other projects and that there will be uncertainties and to undertake voluntary monitoring as described in the monitoring programme given in this EIA report.

7 Project Alternatives

The alternative borrow area is the same as those considered in the EIA report. However, the proposed location has been seen to have adequate supply of sand and has been recommended by the dredging contractor. This location was arrived at after studying several locations in North Malé Atoll, the details of which are provided in the Appendix. The following figure shows the five different locations that have been studied.

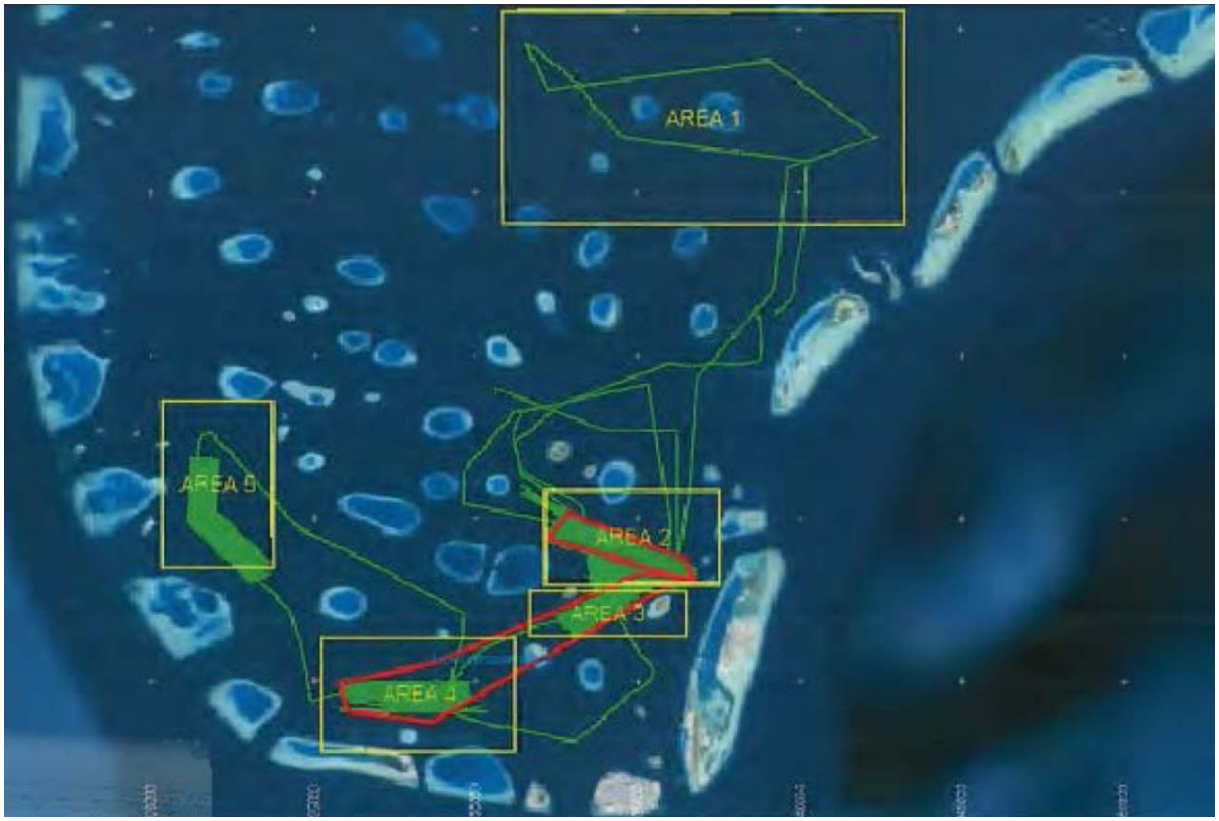


Figure 7-1: Sailed lines and borrow sites identified in North Malé Atoll

Site 1 surveys show the presence of a thick sedimentary layer on top of what appears to be bedrock. The sediments from the sedimentary layer are fine grained and consisted of Silt. Area 2 data showed that most of the area is depleted and only small sand dunes remained after previous dredging activities with a small lump of sand remaining in the central part and some sand available at the eastern-most edge. However, those areas with sand are unreachable for larger hopper dredgers due to rock outcrops in the vicinity of the sand patch at Area 2.

Area 3 is a fairly small area located in the northern end of the large dredge area of the Leiv Eriksson directly east of the presidential island. The bathymetry from the multi beam and PES data showed a small stretch of sand on an elevated area of this site. However, the area is

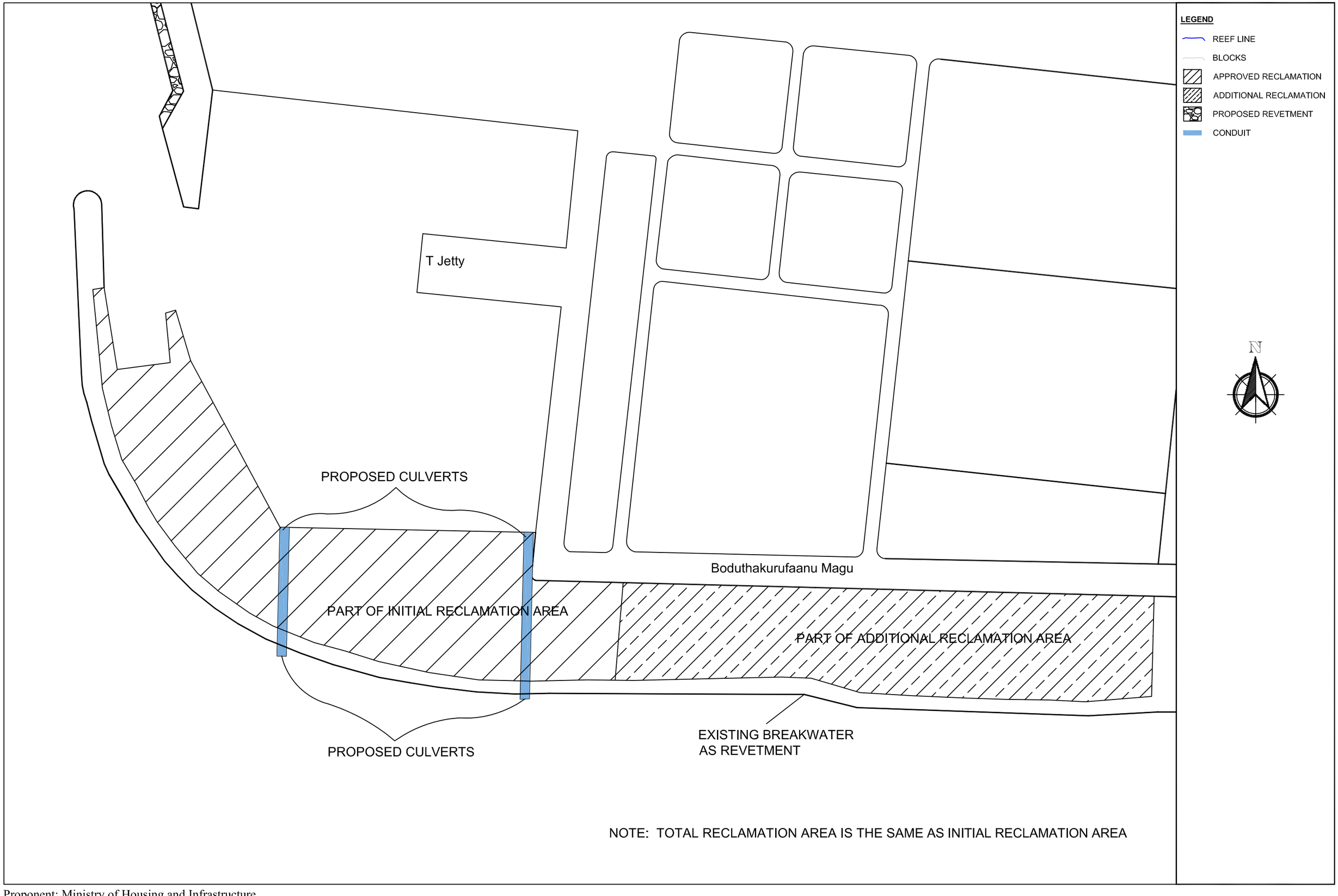
crossing a busy fairway with heavy traffic and close proximity to Presidential Island was considered to complicate dredging operations. Area 4 has a large part of the area depleted as a result of previous dreding operations. The central part, however, still shows a sediment layer between 1 to 3 meter I thickness. However, it was not considered suitable for reclamation due to the high fine content which will result in large sediment plumes.

Area 5, located in the south west corner of the Male' Atoll about 15km west of the airport, was considered to be the most suitable dredge location. There were no dredge tracks and at several locations a 0.5 to 2.5-meter-thick sediment deposit, consisting of fine to medium and occasionally coarse sand, was found on top of what appears to be bedrock. 2 small potential borrow areas were identified: the northern area has a surface area of 0.31km^2 and the southern area has a surface area of 0.39km^2. This location is considered to yield more than sufficient quantities of sand for the proposed additional fill.

The project benefits in improving living environment of residential areas, although the extent of the benefit is not very clear at this stage. Works allocated for the sites include works such as pre-mixing of concrete which needs to be zoned off from the residential blocks. Due to the geographic, economic and infrastructure constraints it is not feasible to place this facility in Thilafushi or any other island and transfer it to Malé. The current locations of the warehouses and semi-industrial works poses a burden to the traffic flow in the city during the transfer and supply of materials. Hence, the proposed project is expected to take some pressure from the traffic problem of Malé.

The no project option may be considered valid due to the huge cost of the project compared to the benefits. However, the project helps in improving the waste management operation in Malé as well as to create better living spaces. The alternative would be to minimize the scope of the project, especially to retain a large part or whole of the existing breakwater and reclaim inside the structure so as to reduce the cost of the project greatly while helping to achieve the objectives for pollution free living. However, since the project has been planned and partly executed, the scope could not be reduced or damages to breakwater structure could not be completely undone. Yet, there are financial justifications since all plots are commercial lands and will generate revenue for the government. Therefore, the initial investment is expected to be recovered.

Figure 7-2: Alternative development concept



8 Mitigation and Monitoring

There are no additional mitigation measures than that given in the EIA report, except the proposed culverts to mitigate the impacts related to stagnation and lack of circulation in the southwest harbour area, which would be enclosed as a result of the reclamation. Furthermore, the reclamation area has been bunded as proposed in the EIA report, therefore, further mitigation measures would not be required for the reclamation component.

For the shore protection component, as discussed earlier, it would be necessary to ensure that a functional design takes precedence over aesthetics. The revetment should have a maximum number of voids/cavities while ensuring a stable structure. The size of boulders proposed is appropriate to provide required size of voids within the structure and help absorb wave energy to the greatest possible extent.

Environmental monitoring is an important element of environmental assessment, which is often ignored by Contractors and Proponents. It is therefore, recommended to carryout regular environmental monitoring as proposed in the EIA report.

Additionally, it is recommended to include water quality monitoring at the inlet and outlet of the culverts as well as marine biota at the same locations as part of the monitoring programme. The monitoring programme given in the EIA report is, therefore, revised an included in this report, as Table 8-1 and Table 8-2.

Monitoring reports shall be submitted to the EPA at the end of construction and yearly for at least 2 years thereafter. The reporting format is given in the EIA Regulations as discussed in the initial EIA report.

Table 8-1: Monitoring programme for construction phase

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (Locations given in this Addendum plus 1 location slightly east of the channel)	Water quality: temperature, conductivity/salinity, DO, pH, Turbidity, TSS	Every six months	5	5	5	5	5	5	5			5			40	50.00	**2,000.00**
2	Marine life/biodiversity (3 baseline locations + 2 additional locations given in this Addendum)	Live coral cover and fish survey - Photo quadrates/LIT and fish survey	Annual	4						4						8	30.00	**240.00**
3	Currents/hydrodynamics	Drogue tracks	Every three months for one year	4			4			4			4			16	30.00	**480.00**
4	End of construction stage monitoring report		Construction phase only												1	1	200.00	**200.00**
TOTAL																		**2,920.00**

Note:

M indicates Month

After the initial end of construction monitoring report, the proponent will submit a monitoring report annually for 2 years

Table 8-2: Monitoring programme for operational phase

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (Locations given in this Addendum plus 1 location slightly east of the channel)	Water quality: temperature, conductivity/salinity, DO, pH, Turbidity, TSS	Every six months	5						5						10	50.00	**500.00**
2	Marine life/biodiversity (3 baseline locations + 2 additional locations given in this Addendum)	Live coral cover and fish survey - Photo quadrates/LIT and fish survey	Annual	4												4	30.00	**120.00**
3	Currents/hydrodynamics	Drogue tracks	Every three months for one year	4			4			4			4			16	30.00	**480.00**
4	Annual Monitoring Report														1	1	500.00	**500.00**
TOTAL																		**1,600.00**

Note:

M indicates Month

After the initial end of construction monitoring report, the proponent will submit a monitoring report annually for 2 years

9 Conclusions

In conclusion, it appears justified from a technical and environmental point of view, to carry out the proposed additional reclamation using hopper dredger, as proposed and also to incorporate the changes proposed to the southwest harbour development project. The alternative reclamation and shore protection option may be considered, given the uncertainties in achieving project objectives. These alternatives may usefully guide the designer/engineer in the final design.

The negative impacts of the proposed project remain the same or similar except for the proposed culverts which help to improve flow and circulation within the harbour, which is necessary in the long term. The culverts are the main mitigation measure for the concerns of stagnation considered in the EIA report. No further mitigation measures are considered within the scope of this part of the EIA Addendum.

Some of the sediment control measures that have been considered in the EIA report may not be necessary since the area has already been closed off with sand bunds and sheet pile structures and due to the nature of the project area as well as given that the waves and currents will quickly disperse the sediments which may be considered better than keeping sediments contained.

It is recommended to continue to monitor how the sediments move and settle and monitor changes to the marine ecology in affected areas and areas where the sediment appears to settle.

10 Acknowledgements

The author wishes to acknowledge the work of several people who have contributed to this report. The following people have been mentioned due to their specific contributions. Thanks are also due to Aishath Bariyya and Nafha Aujaz, who represented the Proponent, for providing relevant project information, for taking part in the scoping meeting and helping the survey team gather necessary data in the field. Nafha also deserves special acknowledgement for reviewing the report thoroughly for clarity and accurateness of project details provided in the document.

The Technical Team of Sandcays who gathered field data, analysed the data and presented some of the data in the report are worthy of credit for the important work they did. Thanks to Mohamed Shifaf and Mohamed Visham for going to the field and analysing field data.

11 Bibliography

AECOM & WS (2010), Social and Environmental Impact Assessment of Expansion and Modernization of Malé International Airport

B. Lapointe, M. Littler, & D. Littler, 1993, Modification of benthic community structure by natural eutrophication: The Belize Barrier Reef, *Proceedings of the 7th International Symposium on Coral Reefs*, p. 317-328, Guam

Binnie Black and Veatch (2000), Environmental/Technical Study for Dredging/Reclamation Works under the Hulhumalé Project, Maldives

Brown, B. E. and J. C. Ogden (2003). Coral bleaching. Scientific American 268:64-70.

Brown, et al (1990), Effects on the degradation of local fisheries in the Maldives. Final Report to Overseas Development Administration.

CDE (2013), *EIA for land reclamation and resort development in K. Dhiffushi Reef*

Choi, B. H., Pelinovsky, E., Kim, K. O., and Lee, J. S. (2003), Simulation of the trans-oceanic tsunami propagation due to the 1883 Krakatau volcanic eruption. In *Natural Hazards and Earth System Sciences* **3**:321-332

Clark, S., Akester, S. and Naeem, H. (1999). Conservation and Sustainable Use of Coral Reefs: Status of Coral Reef Communities in North Male' Atoll, Maldives; Recovery Following a Severe Bleaching Event in 1998, MacAlister Elliot and Partners Ltd.

Dawson, B. and Spannagle, M. (2009), *The Complete Guide to Climate Change*, Routledge

DHI (1999), Physical modelling on wave disturbance and breakwater stability. Fuvahmulah Port Project, Port Consult, Denmark

Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., George, R (2003), *Wind energy resources Atlas of Srilanka and Maldives*, National Renewable Energy Laboratory, USA

English, S., Wilkinson, C. and Baker, V. (1997). *Survey Manual for Tropical Marine Resources* (2nd edition), Australian Institute of Marine Science

Environmental Protection Agency (EPA) (2009), *List of Environmentally Sensitive Areas-Version 1*, EPA, Maldives

Goda, Y (1988), Report on environmental conditions and related problems at Malé Port, Malé Port Development Project, Maldives, ADB

Goda, Y. (1988), *Causes of high waves at Male' in April 1987*, Dept. of Public Works and Labour, Male, Maldives,

MEE (2012), *Environmental Impact Assessment Regulations 2012*, Maldives

Ministry of Housing, Transport and Environment (2009), *Maldives National Sustainable Development Strategy*, Maldives

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

Morner et al (2004), New Perspectives for the future of the Maldives. In *Global and Planetary Change* **40:**177–182

Naseer, A. (2003), *The integrated growth response of coral reefs to environmental forcing: morphometric analysis of coral reefs of the Maldives*, Halifax, Nova Scotia, Dalhousie University

P. Bell, 1992, Eutrophication and coral reefs: some examples in the Great Barrier Reef lagoon, *Water Research* **26**: 553-568

PCI (2002), Basic design study report on the project for improvement of the ferry station for solid waste, Ministry of Construction and Public Works, Maldives

Roe D, Dalal-Clayton & Hughes, R (1995), *A Directory of Impact Assessment Guidelines*, IIED, Russell Press, Nottingham, UK

Saeed (2011), *Environmental Impact Assessment for the land reclamation (Phase II) of Gulhifalhu Island*

Sandcays (2015a) *EIA for proposed resort development on L. Boduhuraa, Faress and Kudafaress*

Sandcays (2015b), *EIA for the proposed resort development on K. Kuda Villingili*

Sandcays (2016a), *EIA for the proposed reclamation at Maadhunifaru*, Malé Atoll

Sandcays (2016b), *EIA for the proposed Malé Southwest Harbour Development*

The United Kingdom Hydrographic Office (2005), *Admiralty Tide Tables – Indian Ocean and South China Sea*, Vol3 (NP203)

UNDP (2006), *Developing a Disaster Risk Profile for Maldives*, UNDP Maldives

UNEP (2005), *Maldives: Post-Tsunami Environmental Assessment*, United Nations Environment Programme

Water Solutions (2013), *EIA for proposed reclamation at Thulusdhoo*

Zahid *et al* (2008), *EIA for proposed resort upgrading by reclamation on K. Bolifushi*

Zahid (2011), *EIA for reclamation of 67 hectares of land in Thilafalhu*, Sandcays, Maldives

Zahir et al. (2013), *Environmental Impact Assessment Report for the Development of MNDF Coast Guard Base and Berthing Facility Phase- I*

12 Appendices

Appendix 1: Terms of Reference

Appendix 2: Commitment letter

Appendix 3: Design details

Appendix 4: Dredging survey report

Appendix 5: Recommended channel location map and wave analysis from PCI (2002)

Appendix 6: Receipt of Communication of final draft to City Council/MHI

203-EIARES/138/2016/80

Terms of Reference for Addendum to Environmental Impact Assessment for Proposed Male' City South West Harbour Development Project

The following is the Terms of Reference (ToR) following the scoping meeting held on **23th March 2016** for undertaking the EIA of the Proposed Reclamation for Harbour Development at *Male' South West Harbour.* The proponent of this project is Ministry of Housing and Infrastructure.

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

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

2. **Study area –** Submit a minimum A3 size scaled plan with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites

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

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

The main activities of the reclamation and coastal works are:

- Dredging material from burrow area and use of it for reclamation;
- Environmental monitoring during construction activities;
- Measures to protect environmental values during construction and once the new land has been reclaimed
- Project management (include scheduling and duration of the project and life span of facilities; communication of construction details, progress and target dates)

Construction requirements and temporary facilities

- Construction methods, scheduling and operation of temporary facilities including power generation, oil storage, water supply, waste water treatment, accommodation facilities, waste management and decommissioning.

Dredging:

- Location and size of sand burrow areas (s) on a map;
- Quantity and characteristics of fill material;
- Indication of guarantees for sufficient availability of fill material;
- Method and equipment used for dredging
- Duration of dredging activity;
- Emergency plan in case of spills (diesel, grease, oil)

Coastal Protection

- Details and justification of location, number, size and materials of coastal protection structures e.g. groins, seawall or breakwaters;

Landscaping

- Location for obtaining required plants
- Quantity and types of plants to be used

Fuel Management

- Fuel storage tank details (size, location,);
- Measures of fuel containment
  Method of fuel transport from and to storage

Road construction works

- Paving methodology
- Project implementation plan

Waste management plan

- Composting methodology if practiced;
- Incineration construction and operational plan.

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

The baseline data will be collected before construction. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects and manta tows sites for posterior data comparison. Submit all raw data collected for the purpose of the project along with the soft copy.

All data must be collected as per the requirements of the EPA Data Collection Guidelines (published on www.epa.gov.mv). The report should outline detailed methodology of data collection utilized.

Information should be divided into the categories shown below:

Hydrography/hydrodynamics (use maps)

- Sea water quality measuring these parameters: temperature, pH, salinity, total suspended solids, dissolved oxygen and turbidity.

Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector.
- Benthic and fish community monitoring within the study area (see appendix for monitoring guidelines);

Air Quality with noise levels

The report should outline the detailed methodology of data collection utilized to describe the existing environment.

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

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- Loss of marine bottom habitat, both in the borrow area as well as due to reclamation area, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity and density of crabs, shellfish etc.;
- Sediment dispersal in water column (turbidity at the dredging site (overflow), the reclamation areas and related to shore protection activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.;
- Impacts of noise, vibration and disturbance;
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment

- Impacts of the works on harbour users;
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Monitoring of socioeconomic and demographic development.

Construction related hazards and risks

- Pollution of the natural environment (e.g. oil spills, discharge of untreated waste water and solid waste, including construction waste);
- Risk of accidents and pollution on workers and local population, and

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

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternative location and design of facility that includes environmental, social and economic factors. The report should highlight how the location was determined. All alternatives must be compared according to commonly accepted standards and norms and international standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project. Comparison of alternatives should be provided in terms of short-term, medium-term and long term costs and environmental impacts and benefits in order to decide the best alternative.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures with particular attention paid to sedimentation control and future changes in coastal processes. Mitigation measures to avoid or compensate habitat destruction caused by dredging will have to be considered, e.g. temporal sediment control structures, coastal protection structures to reduce erosion, coral reconstruction and MPA replacement areas. Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

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

The following maybe considered during the development of the monitoring program;

- Water quality, especially turbidity;
- Condition of the sensitive ecosystems and marine resources;
- Re-colonization of the benthic organisms in the borrow areas;
- Environmentally sound site clearance;
- Environmentally sound removal of dredging and other equipment including construction materials, and

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities such as;

- Ministry of Environment and Energy,
- Male' City Council
- Harbour Users
- Male Water and Sewerage Company
- Waste Management Corporation
- Transport Authority of Maldives
- Ministry of Defence and National Security

The EIA report should include a list of people/groups consulted and summary of the major outcomes.

Presentation- The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations f or any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012

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

…………………………………….

04 April 2016

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
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Fax: [+960] 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

بسم الله الرحمن الرحيم

Ministry of Housing and Infrastructure
Male', Republic of Maldives.

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Date: 07 June 2016

No: 138-PIS1/203/2016/157

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency,
Ministry of Environment and Energy,
Green Building, Male',
Maldives.

Dear Sir,

This is in reference to the First EIA Addendum report for the proposed Male' Industrial village. As the Proponent of the project, we assure you our commitment to undertake the proposed mitigation measures and monitoring programme as given in the report.

Thanking you

Sincerely,

Fathimath Shaana Farooq,
Director General

Ameenee Magu, Maafannu, Male', 20392, Republic of Maldives.
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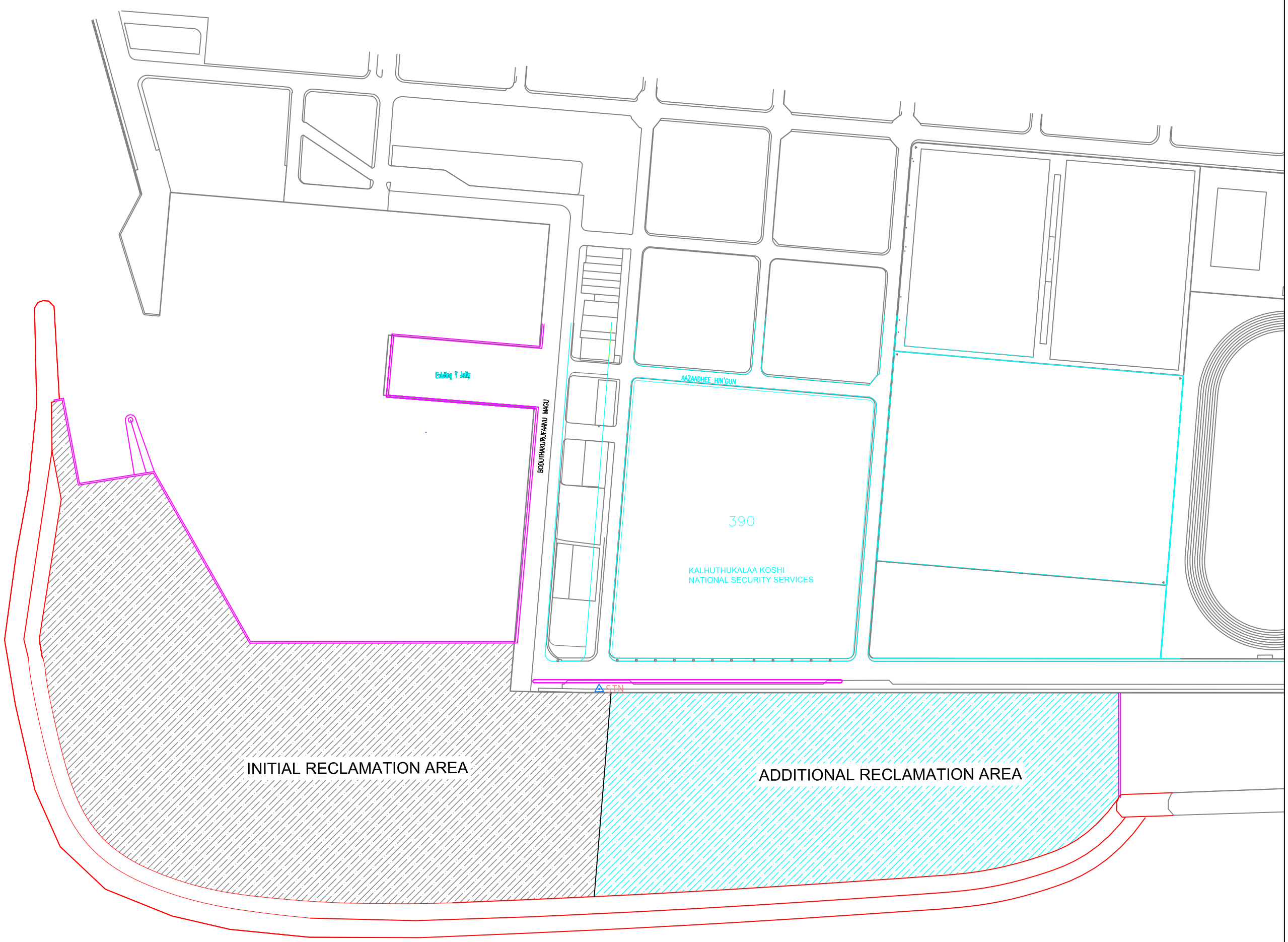


REVISED DATE :

8 JUNE 2016

LAST PRINTED:

PROJECT :

MALE' INDUSTRIAL VILLAGE

TITLE :

CLIENT :

SCALE :

DATE :

PROJECT NO :

ARCHITECT :

ENGINEER :

DRAWN BY :

CHECKED BY :

APPROVED BY :

DWG NO :

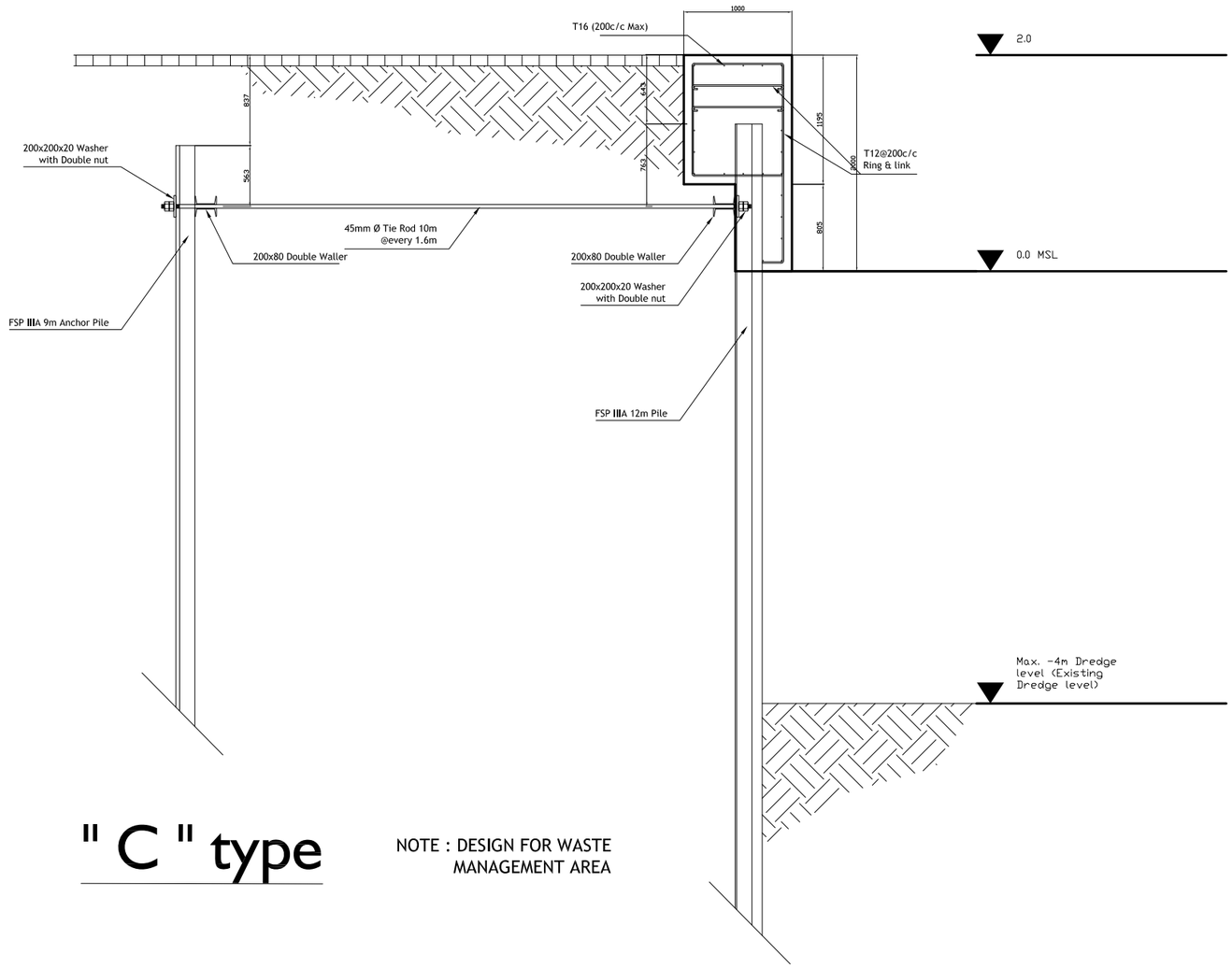
INFRASTRUCTURE DEPARTMENT
MINISTRY OF HOUSING AND INFRASTRUCTURE
AMEENEE MAGU MALE'
REPUBLIC OF MALDIVES
TEL: 3004300, FAX:3004301, WEB: www.housing.gov.mv


STN

SHEETPILING

Region	Sheet Pile Detail		Tie Rods		c/c Spacing of Tie Rods / Anchor Piles	Wale Double C-Channel size
	Main wall	Anchor	Diameter	Lenght		
" A " type	9m	6m	min.32mm	6m	max 2.4m	200x80
" B " type	9m	6m	min.32mm	6m	max 1.6m	200x80
" C " type	12m	9m	min.45mm	10m	max 1.6m	200x80
" D " type	9m		min.32mm	6.5m	max 2.4m	200x80

Note: All Sheetpiles will be FSPIIIA



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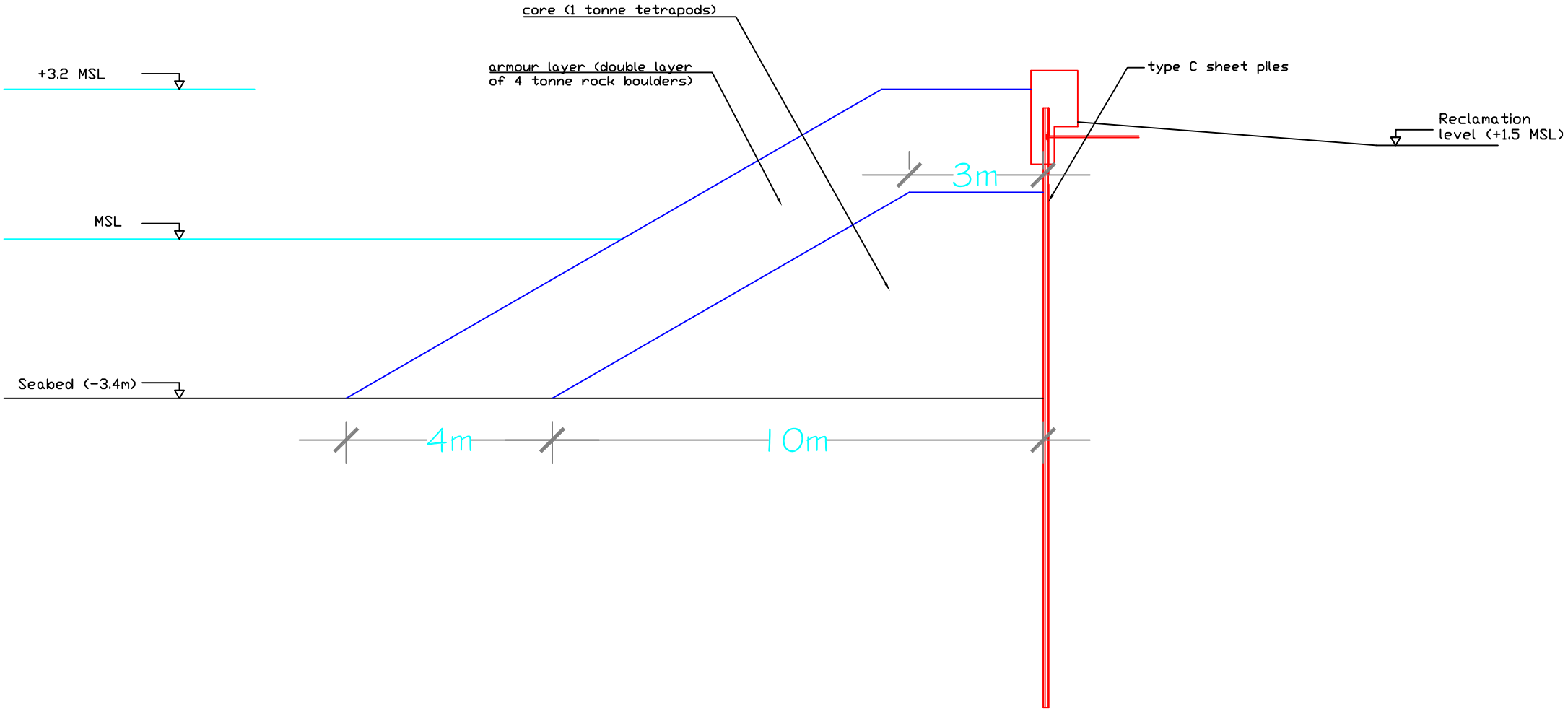
NOTE : DESIGN FOR WASTE MANAGEMENT AREA



South-West Harbour Development _ revetment cross-section

INFRASTRUCTURE DEPARTMENT
MINISTRY OF HOUSING AND INFRASTRUCTURE
IZZUDHDHEEN MAGU MALE' 20-01
REPUBLIC OF MALDIVES
TEL:323234, 323474, FAX:328300

Male' Industrial Village Reclamation

Project Details

Project Scope:
- Reclamation of 6.9 Ha.
- to a height of 1.4m above MSL (uncompacted height); Reclamation level is maintained at this level to avoid flooding of Boduthakurufaanu magu which is at 1.12m from MSL.
Revetment and sheet pile retaining wall on outer boundary. Revetment cross-section attached

Estimated Sand Requirement: Approximately 204,400m^3 of sand

Machinery and Equipment: Trailing Suction Hopper Dredger (TSHD); Bulldozers will be used to spread the sand.

Project Schedule:

Tentative Work Schedule for Reclamation and Shore Protection (2 months)	
Sand extraction through maintenance dredging of southwest/ south harbour	May 2016 (completed)
Sand extraction from deep sea borrow locations of Male' atoll	25 of June and 11 of July 2016
Enclosure of the Reclamation Area (works completed upto the scope of covered by the approved EIA for reclamation and channel)	Upto 20th June 2016
Reclamation	22nd June to 30th June 2016
Revetment (including the construction of sheet pile retaining wall	1st June to 20th July 2016

Duration: 2months (for reclamation, shore protection and culverts installation)

Ameenee Magu, Maafannu, Male', 20392, Republic of Maldives. ދާދިވަރުމަގު، ފ.ގ، 20392، ދިވެހިރާއްޖެ.
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Borrow Area Details

Introduction

Option 1: Approximately 4,400 cbm was extracted through maintenance dredging of the southwest/ south harbour. The dredging permit has been already approved for this maintenance dredging on 29th September 2015.

Option 2: A sand search campaign was conducted between 15-03-2016 and 28-03-2016 by Van Oord to source the remaining 200,000 cbm. An extensive search was conducted to verify if any suitable material still remain close to the project location.

Method Used in Sand Search

The vessel used for the sand search was the Blackbird, a Push buster type vessel belonging to Van Oord. Initially, the inside of Male' Atoll was surveyed using the SES 2000 Standard, a parametic echo sounder produced by Innomar. Based on this data a borrow area was selected. For obtaining samples in the borrow area, the crane of the Blackbird was used to deploy a high power electric vibrocorer constructed and operated by Marine Sampling Holland. The retrieved material was logged and selected samples were sent to the Fugro lab in Dubai for lab analysis.

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Results of Sand Search

In figure 1 the lines that were surveyed in order to find a suitable borrow areas inside the Male' Atoll are marked in green. The exploration lines sailed through the atoll yielded 5 areas of interest which were further investigated. The 5 areas are shown in figure 5 and will be discussed individually below.

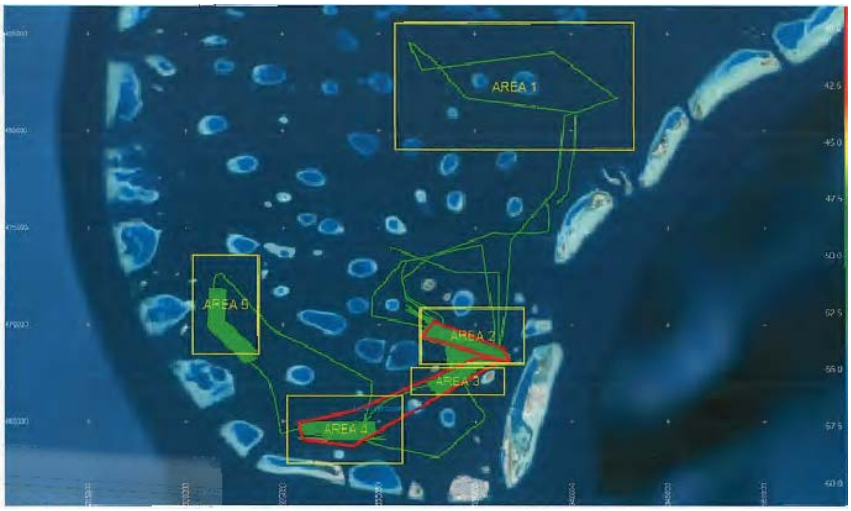

Figure 1 Overview of sailed lines in Male' Atoll

Option 2A: Area 1

Several exploration lines were sailed in area 1.

The PES profiles clearly show the presence of a thick sedimentary layer on top of what appears to be bedrock. In order to test the nature of the sediment layers, two vibrocores were deployed. Both returned unfavorable results as the sediment are fine grained and consists of SILT.

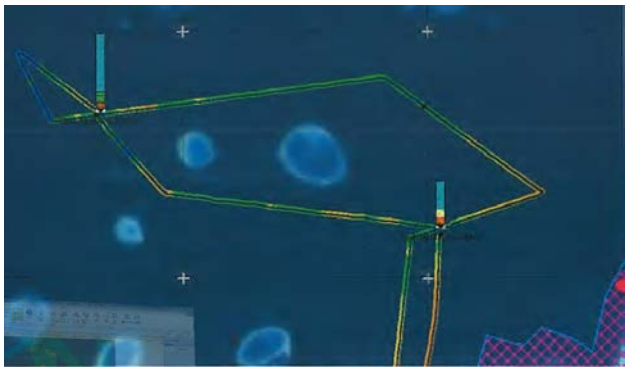

Figure 2 Sailed lines in area 1 and vibrocore locations both cores recovered a thick layer of medium dense SILT

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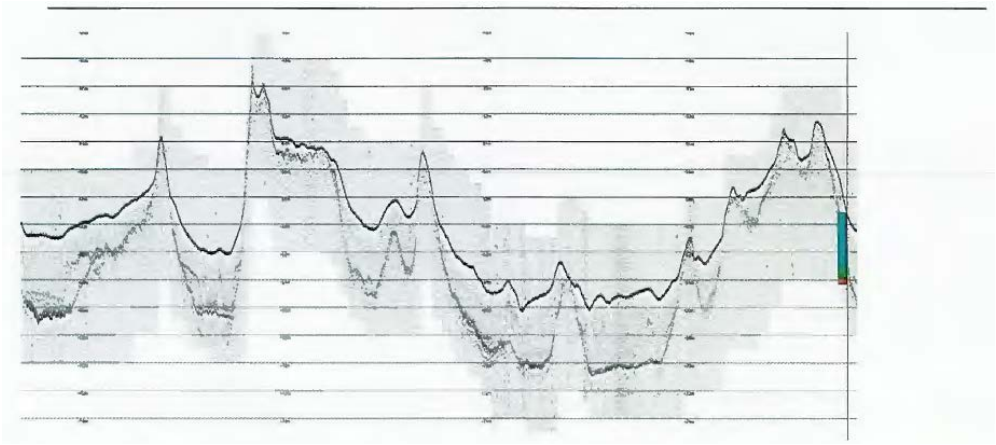

Figure 3 Typical PES profile area 1. Clearly visibe is the bedrock which is covered by a thick "blanket" of silt

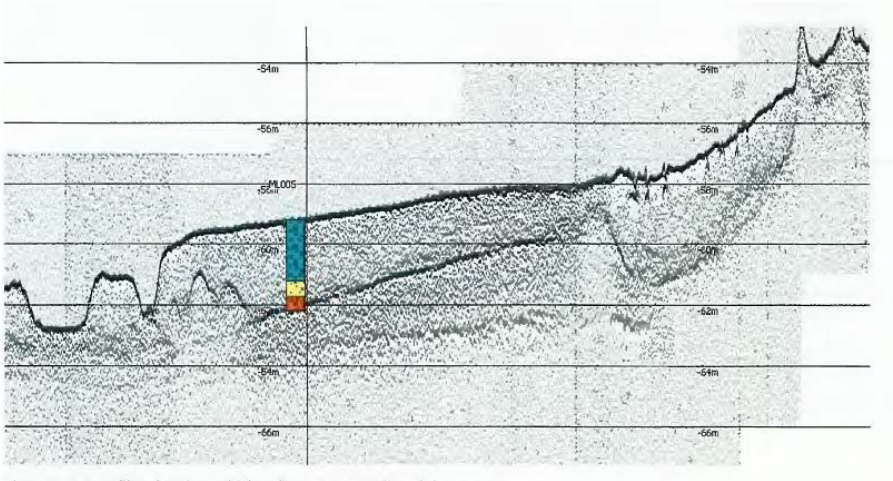

Figure 4 PES profiles showing a thick sedimentary SILT deposit in area 1

Option 2B: Area 2

Area two located in the northern former dredge area of the Leiv Eriksson. Figure 2 clearly shows the dredging tracks. The PES data shows that most of the area is depleted and only small sand dunes remained after dredging. In the central part a small lump of sand remains as well as most eastern edge where some sand is still available. Unfortunately these areas are unreachable for larger hopper dredgers due to rock outcrops in the vicinity of the sand patch.

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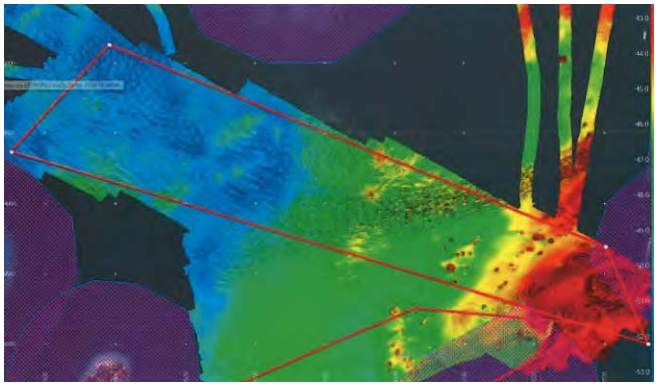

Figure 5 Former dredge area of the Leiv Erikson. The dredge tracks are clearly visible.

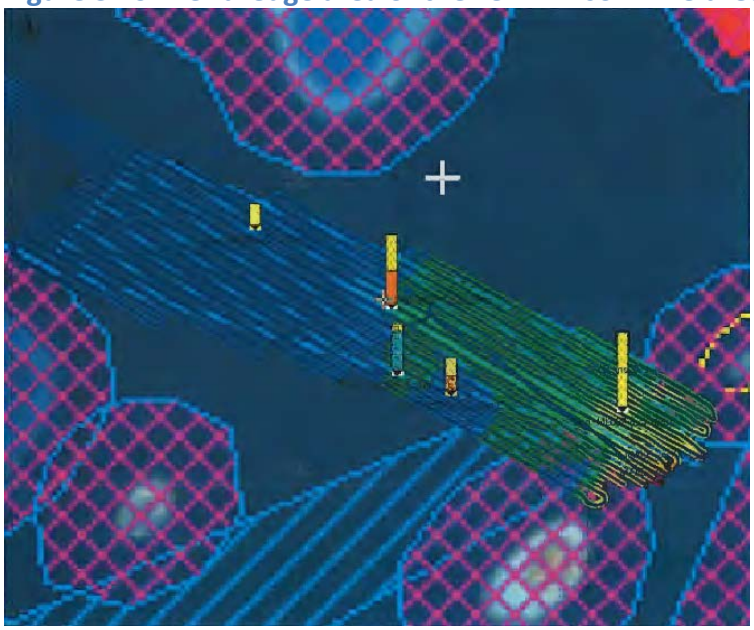

Figure 6 Sailed lines in Area 1. Vibrocores showed small sandbar in the east and central part.

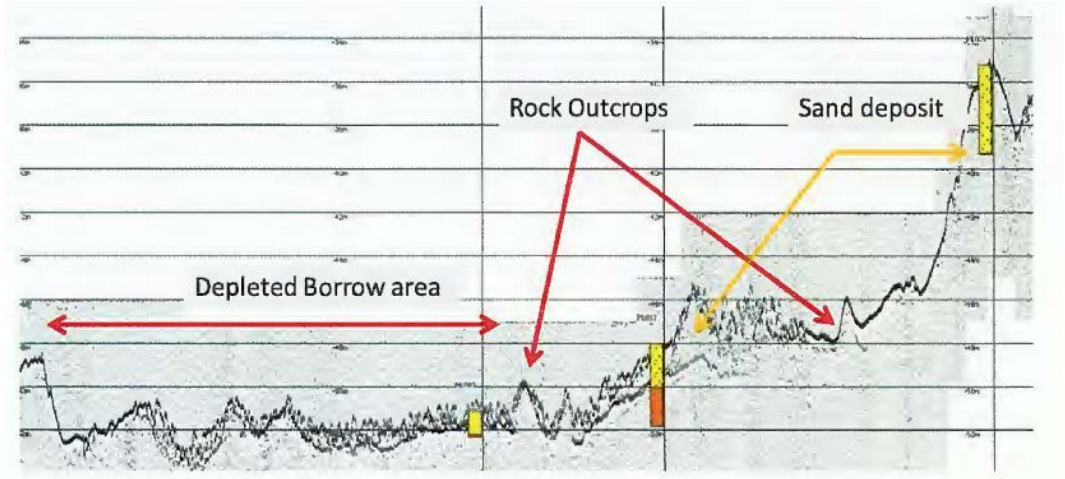

Figure 7 PES profile across area 2 clearly shows the depeleted area in the west, some small pockets of sand remain in the east

Area 3

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A fairly small area located in the northern end of the large dredge area of the Leiv Eriksson directly east of the presidential island was identified. No dredging took place in this area. The bathymetry from the multi beam and PES data shows a small stretch of SAND on an elevated area. This was confirmed by 4 vibrocores. The maneuvering in the area. It should also be taken into consideration the area is crossing a busy fairway with heavy traffic which might complicate dredging operations. During the site investigation, the teams were requested by the coast guard and navy to abandon the operations in the area due to the close proximity of the presidential island.

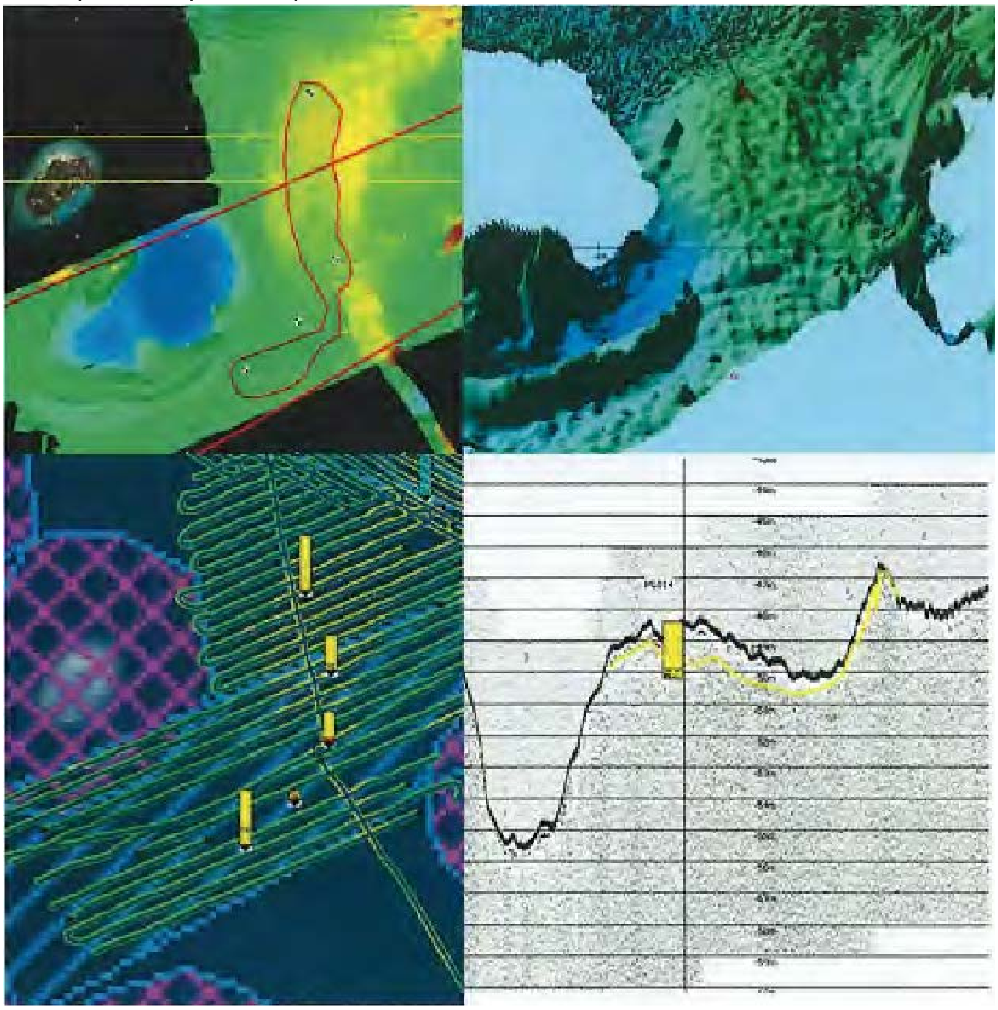

Figure 8 upper left: top view of vibrocores locations and potential borrow area, Top right: 3d view of ridge, Bottom left: Sailed PES lines, Bottom right: PES profile of sand deposit.

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Option 2C: Area 4

Area 4 is located in the southern extend of large dredge area of the Leiv Eriksson just south of the major anchorage areas. Due to anchored ships located outside the designated anchorage area, some part could not be surveyed (area just south of anchorage). Extensive dredging took place in the surveyed areas as can be seen in figure 9. Large part of area are depleted. The central part however still shows a sediment layer between 1 to 3 meter I thickness. Six vibrocores have been deployed in the area which all return very silty very fine sand. The quality of the material is not considered suitable for reclamation due to the high fine content which will result in large sediment plumes. This is likely the reason the material has not been dredged in this part of the borrow area.

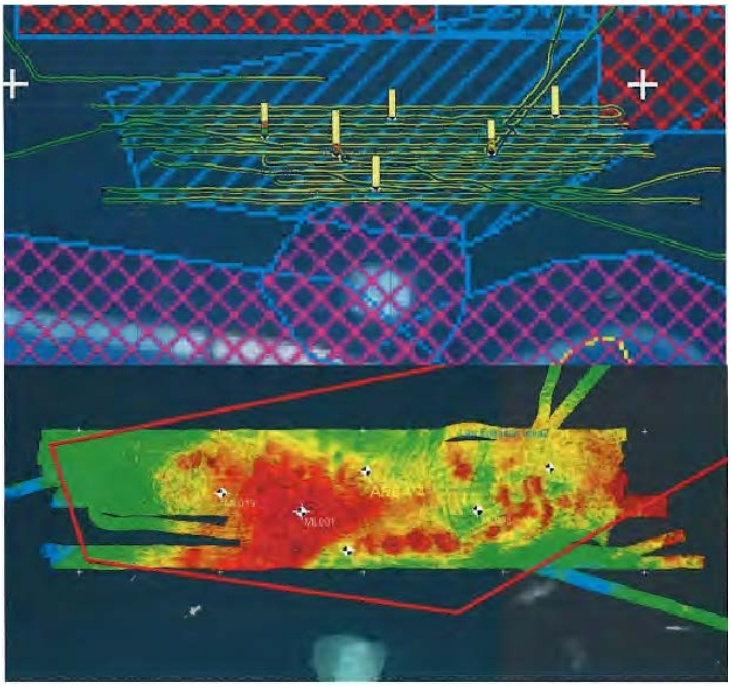

Figure 9 Overview of Vibrocores, sailed lines and bathymetry

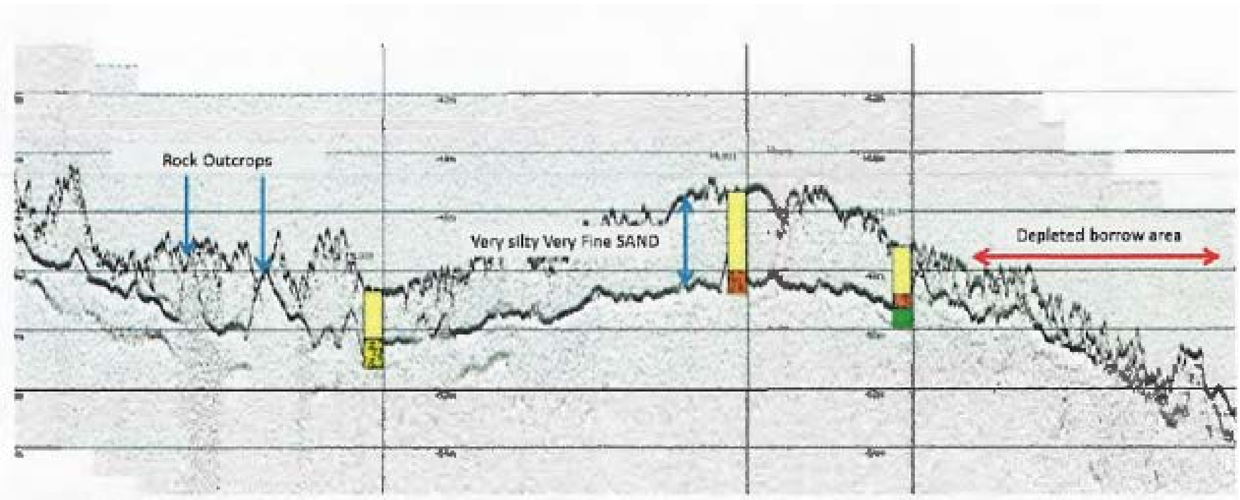

Figure 10 PES vibrocores show very fine very silty sediments in the central part of the former Leiv Eriksson Borrow Area

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Option 2D: Area 5

Area 5 is located in the south west corner of the Male' Atoll about 15km west of the airport. No dredge tracks were encountered in the area. At several locations a 0.5 to 2.5 meter thick sediment deposit was found on top of what appears to be bedrock. Vibrocores confirmed that the investigated areas contained sediments consisting of fine to medium and occasionally coarse sand. The deeper areas which are clearly visible on the multibeam survey contain silt and organic clays and were hence omitted as potential borrow area. The multibeam did also reveal several area with rock outcrops. Based on the multibeam, PES and vibrocore data, 2 small potential borrow areas can be appointed and are indicated in pink hatched polygons. The northern area has a surface area of 0.31km^2, the southern area has a surface area of 0.39km^2.

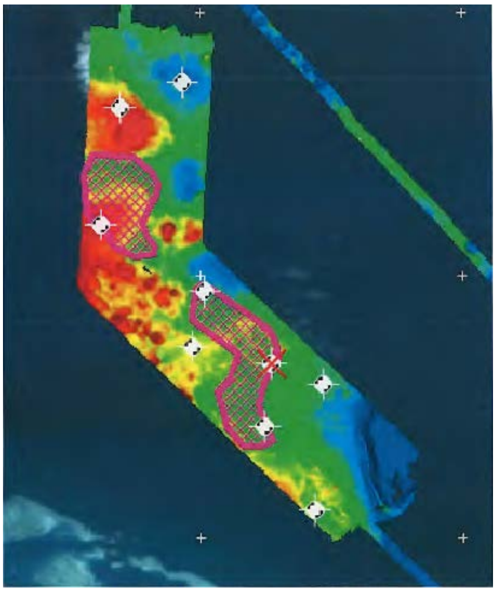

Figure 11 Bathymetric survey and multibeam locations

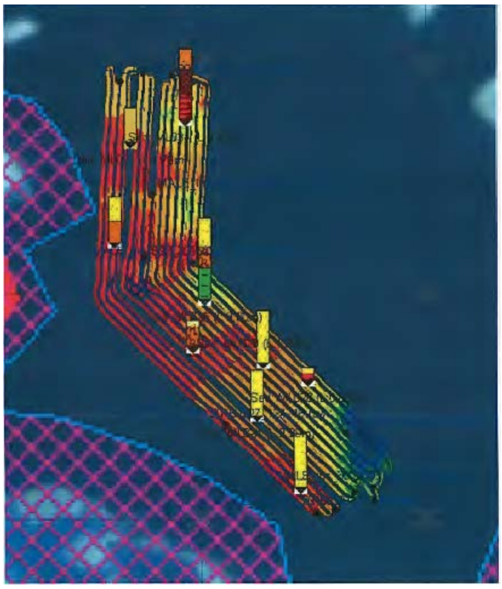

Figure 12 Area 5 sailed PES lines

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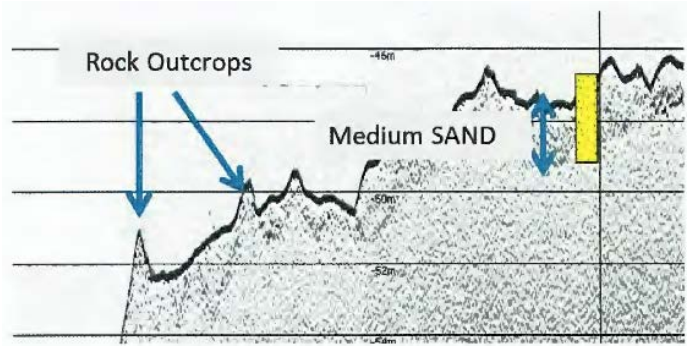

Figure 13PES profiles show a sediment layer of between 0 and 2.6 meters in thickness

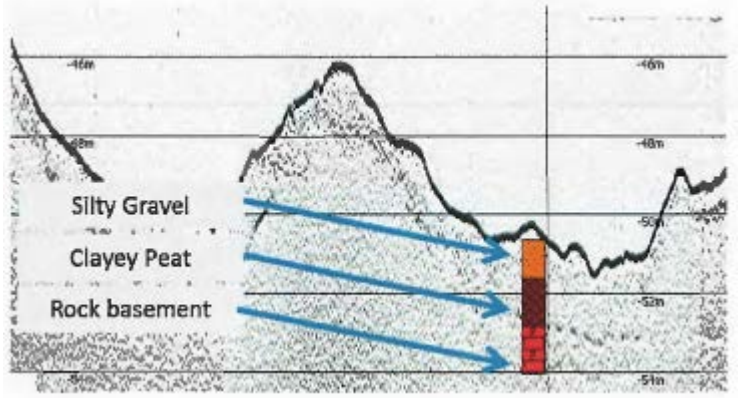

Figure 14 The deeper areas within the survey area revealed a thin layer of silty gravel on top of clayey peat deposits

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Conclusion

Approximately 4,400 cbm has been already extracted by maintenance dredging and the remaining 200,00 cbm is scheduled to be extracted from deep sea between 25th June and 11th July.

The most suitable area with respect to availability of the required amount and quality of sand is area 5. Two locations have been identified within Area 5 as marked in Figure 15.

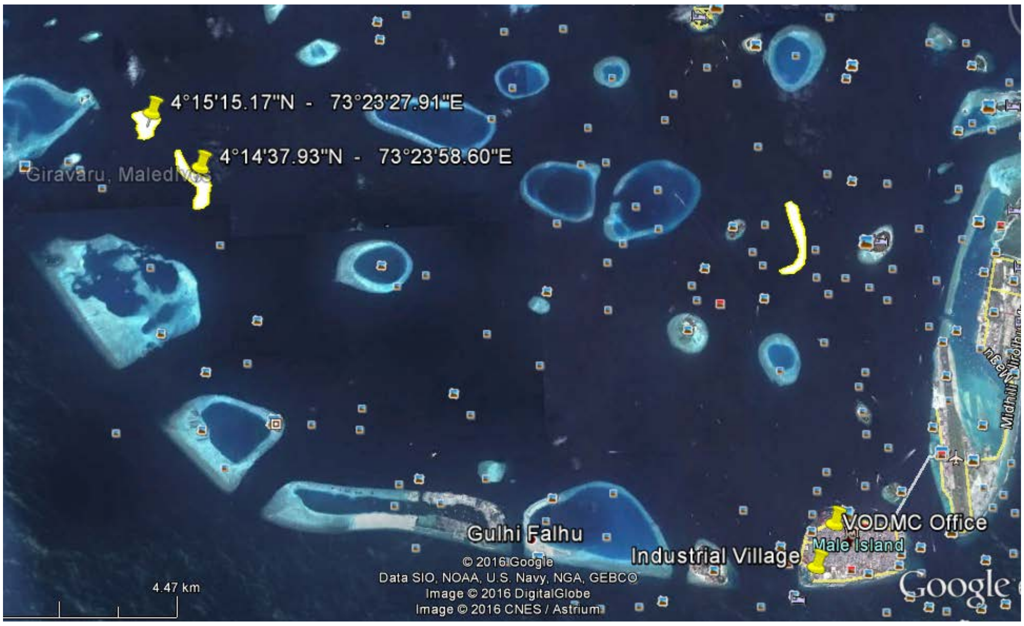

Figure 15 Suitable 2 borrow locations marked from Option 2D: Area 5

Location borrow area, GPS coordinates (center)	Option 2D: Area 5: Location 1	4° 15' 15.17'' N - 73° 23' 27.91'' E
	Option 2D: Area 5: Location 2	4° 14' 37.93'' N - 73° 23' 58.60'' E
Available volume estimate from borrow area	276,000 M³	
Estimated volume to be borrowed from each location	Between 100,000 to 125,000 cbm	
Surface	210,000 M²	
Length	570 m'	
Width	400 m'	
Minimum bottom depth	- 40 CD	
Maximum bottom depth	- 50 CD	
Sand size	0.650 mm (650 mu)	
Average sailing distance	14.40 km (inside sailing if permitted)	
Distance to connection point outside Atoll	23.60 km (sailing outside Atoll – preferred by Authorities).	

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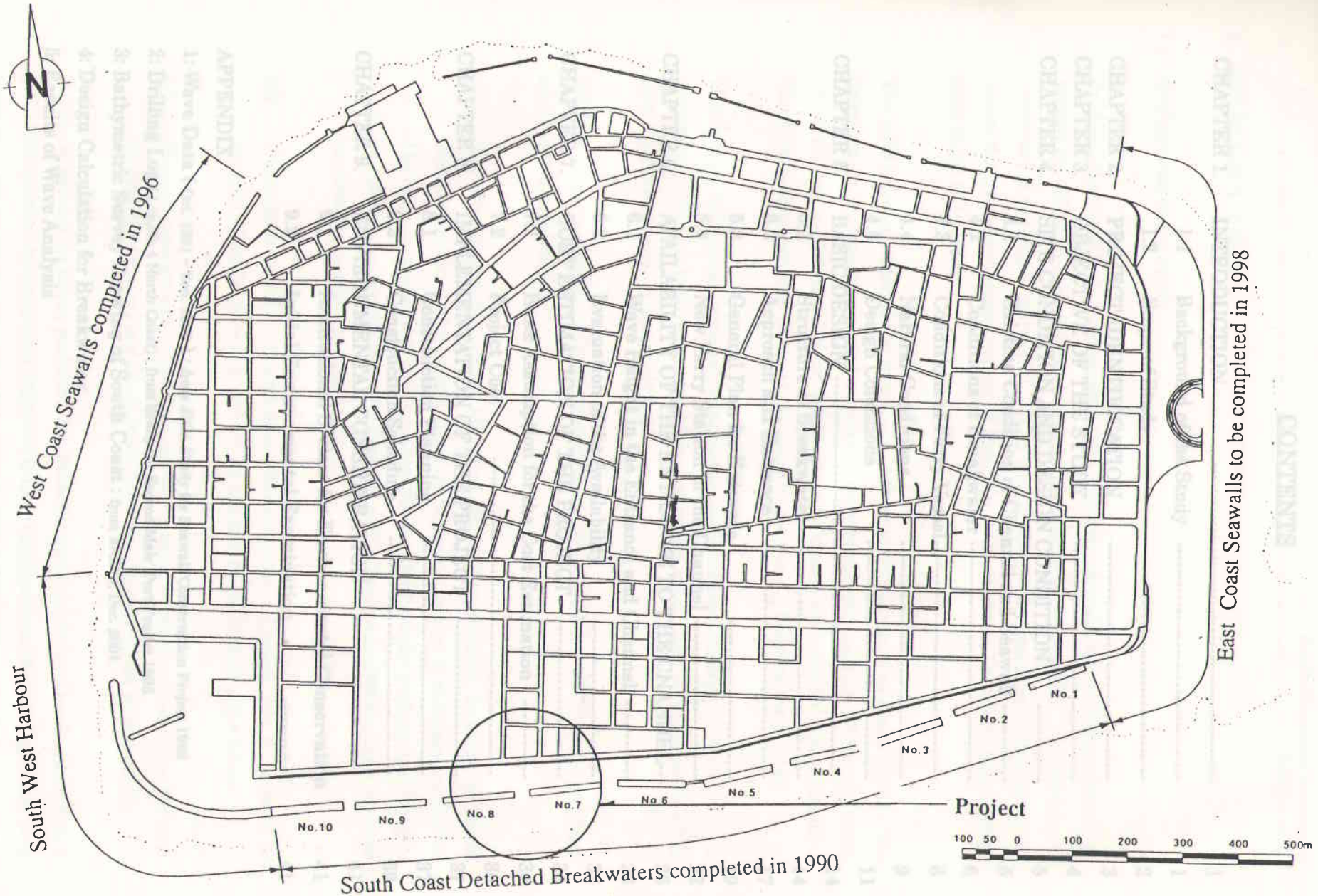
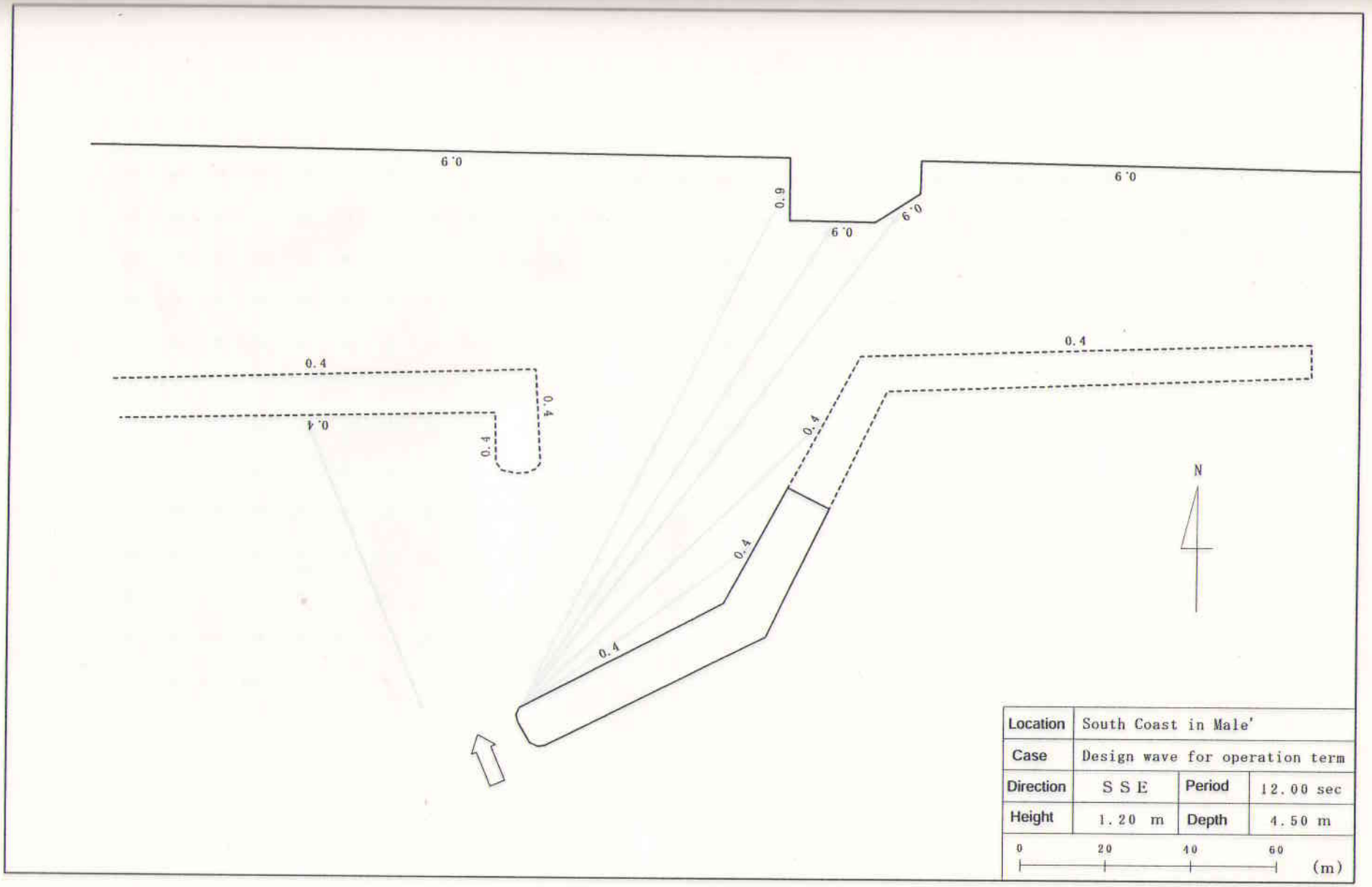
APPENDIX 5

Wave Analysis

(Data)



Location Map



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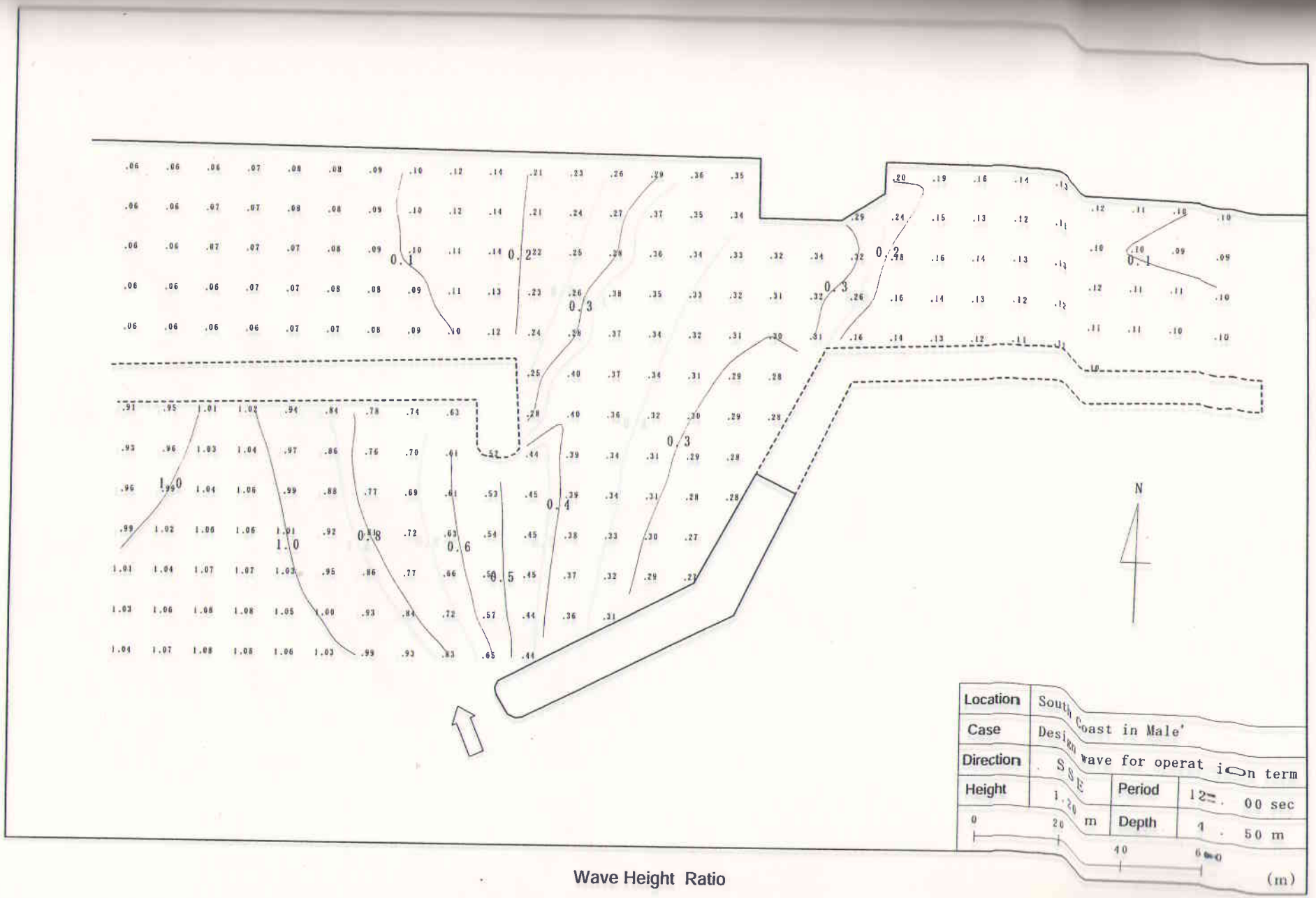

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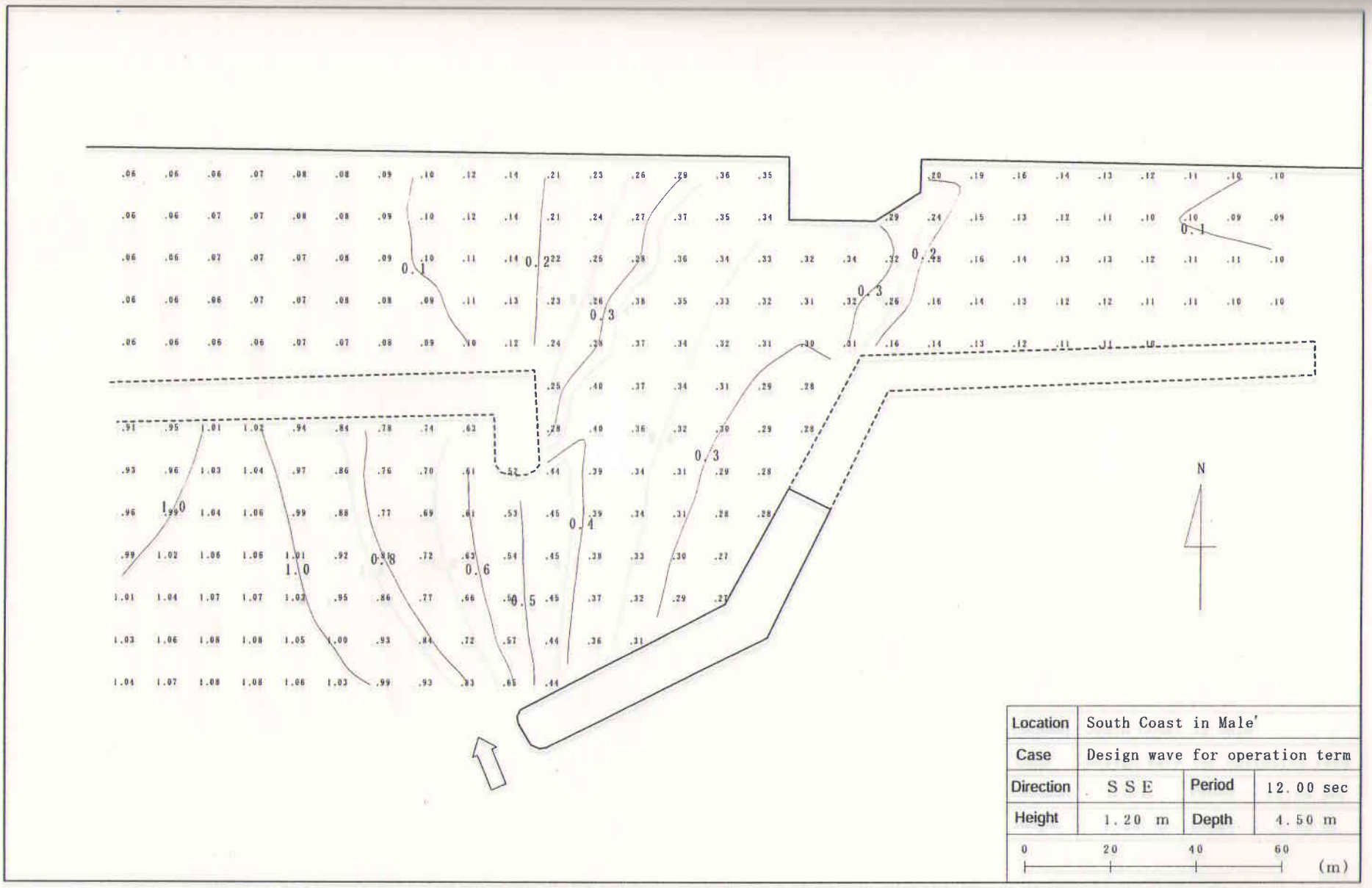

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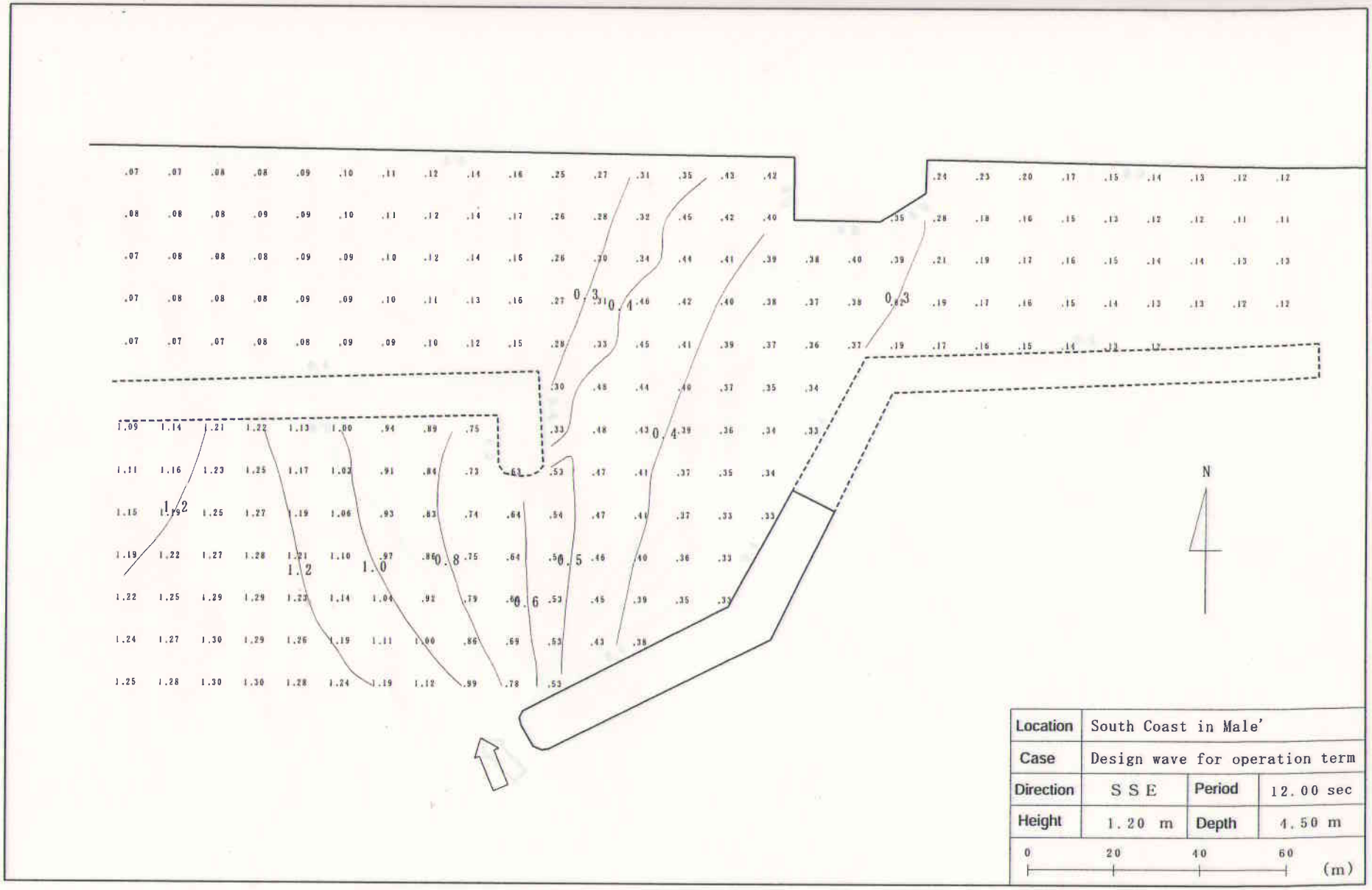
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Case Design wave for operation term
Direction S S E
Period 12.00 sec
Height 1.20 m
Depth 4.50 m
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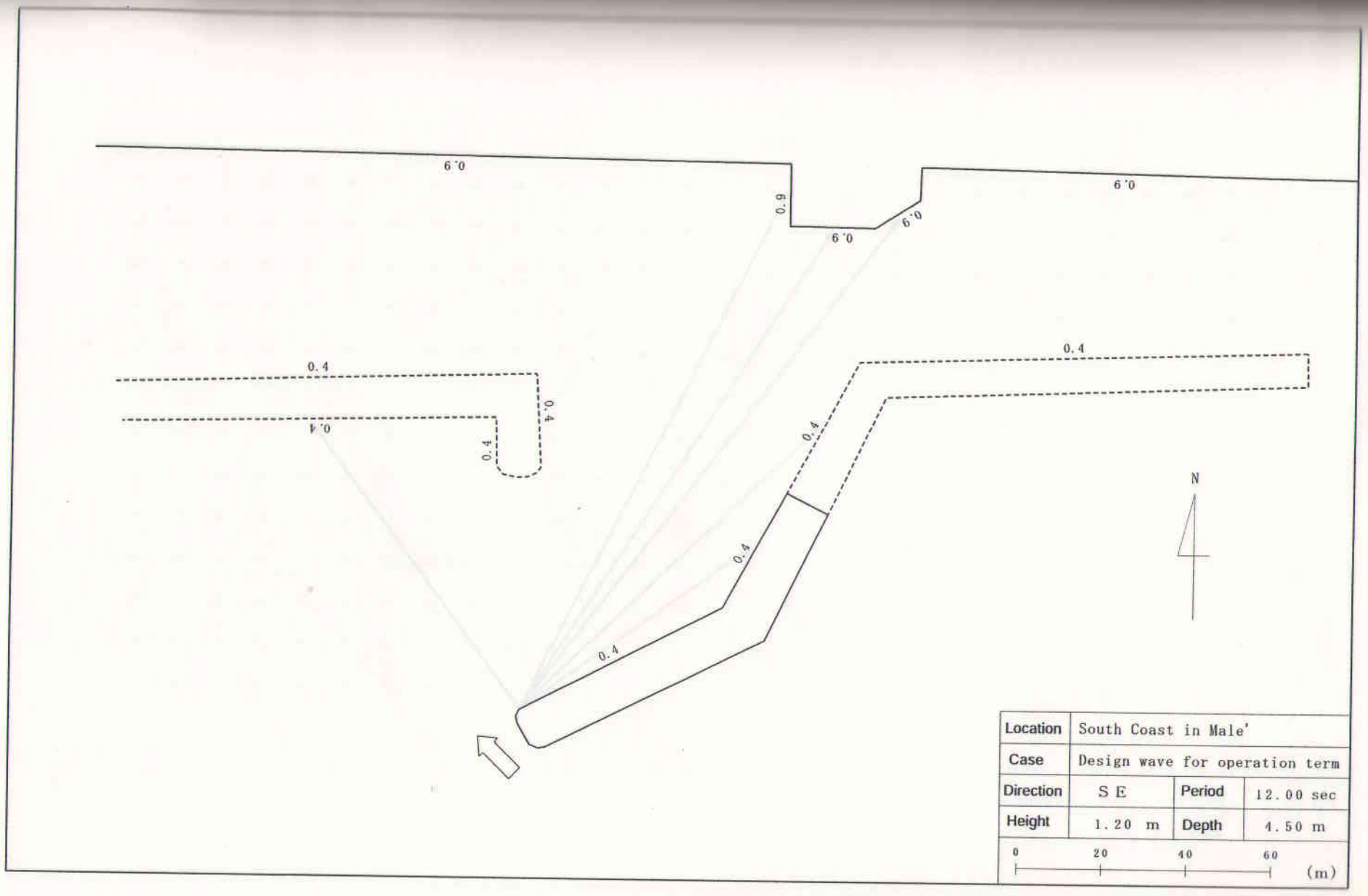
Wave Height



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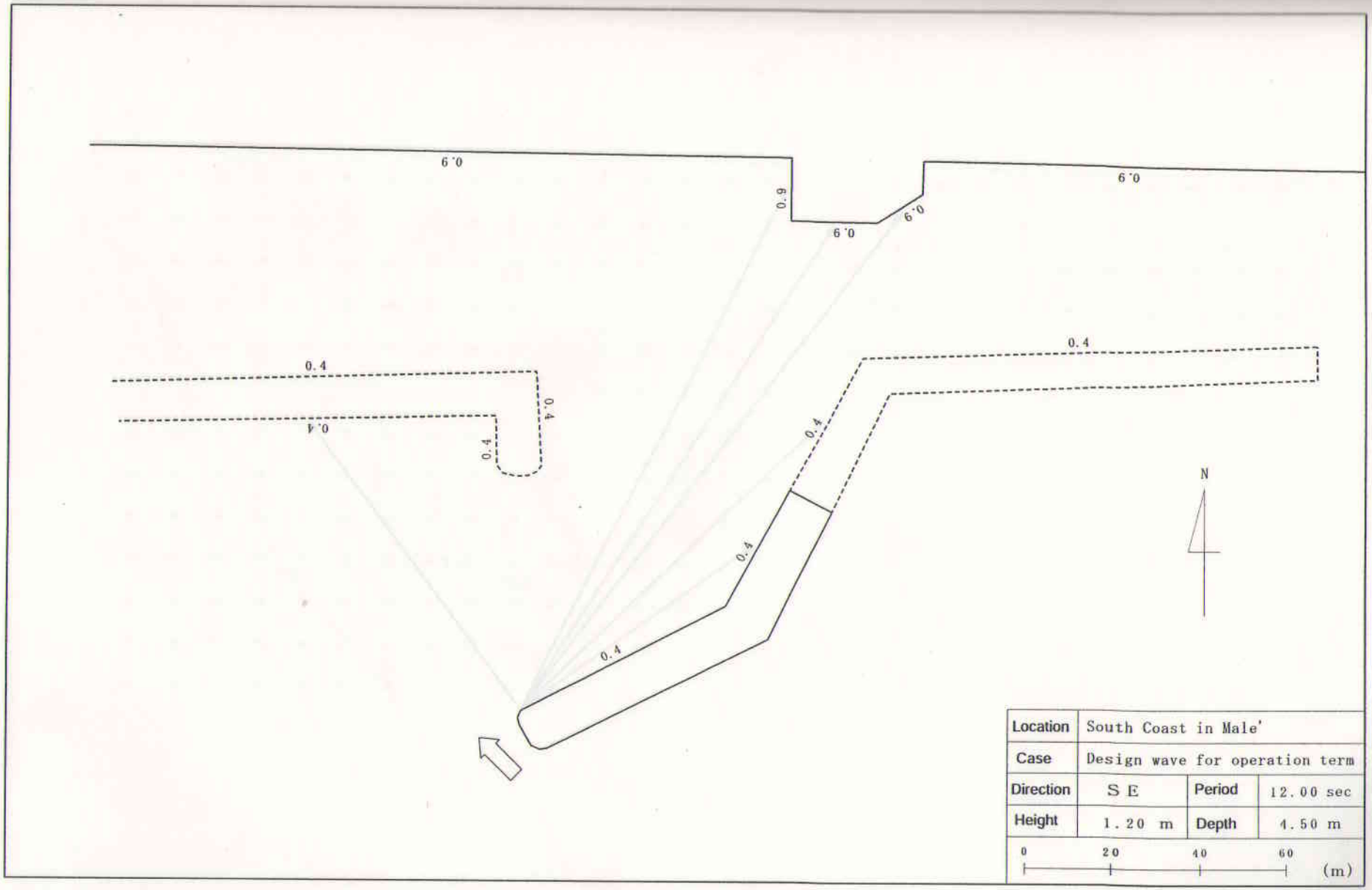

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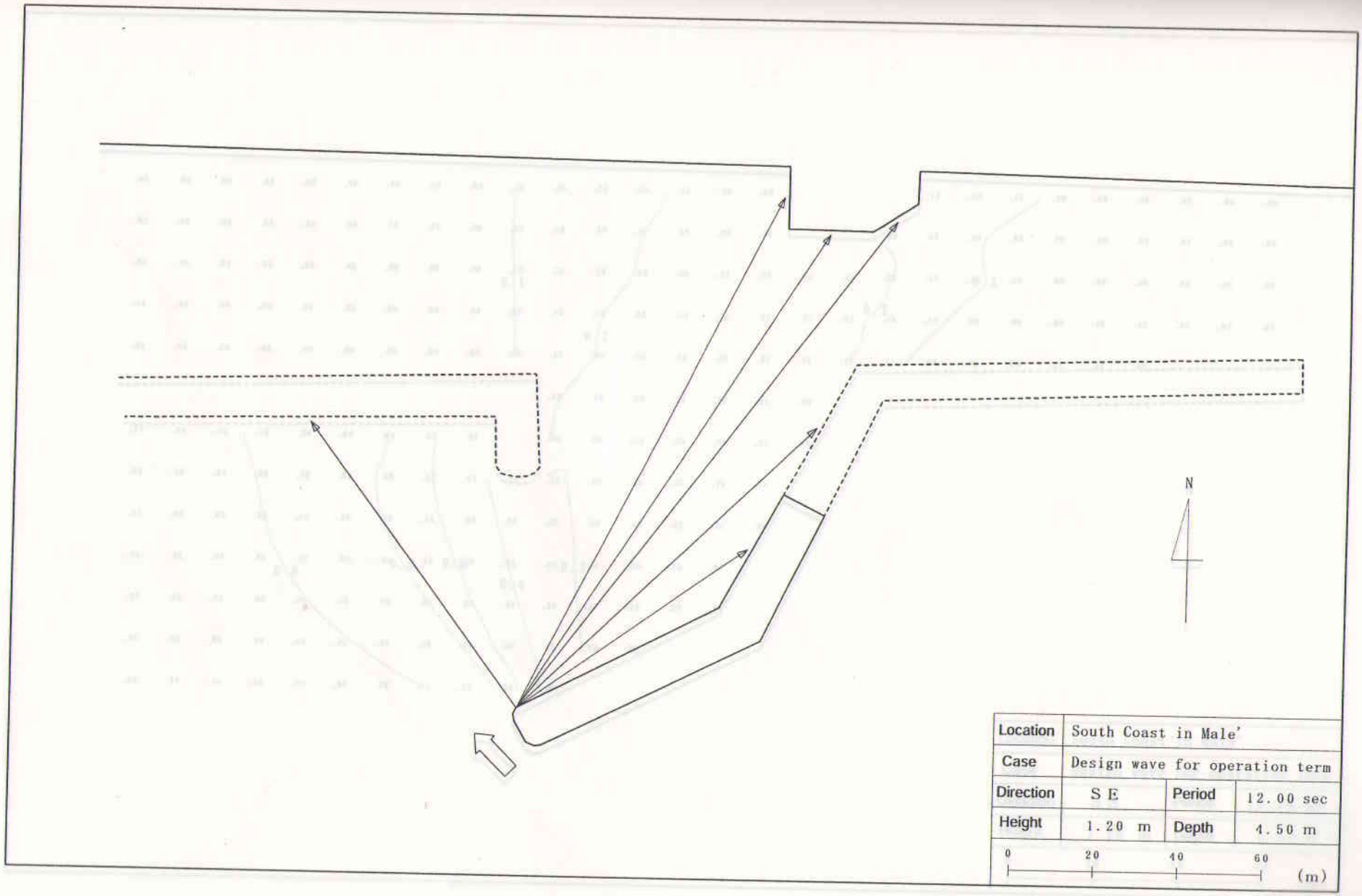
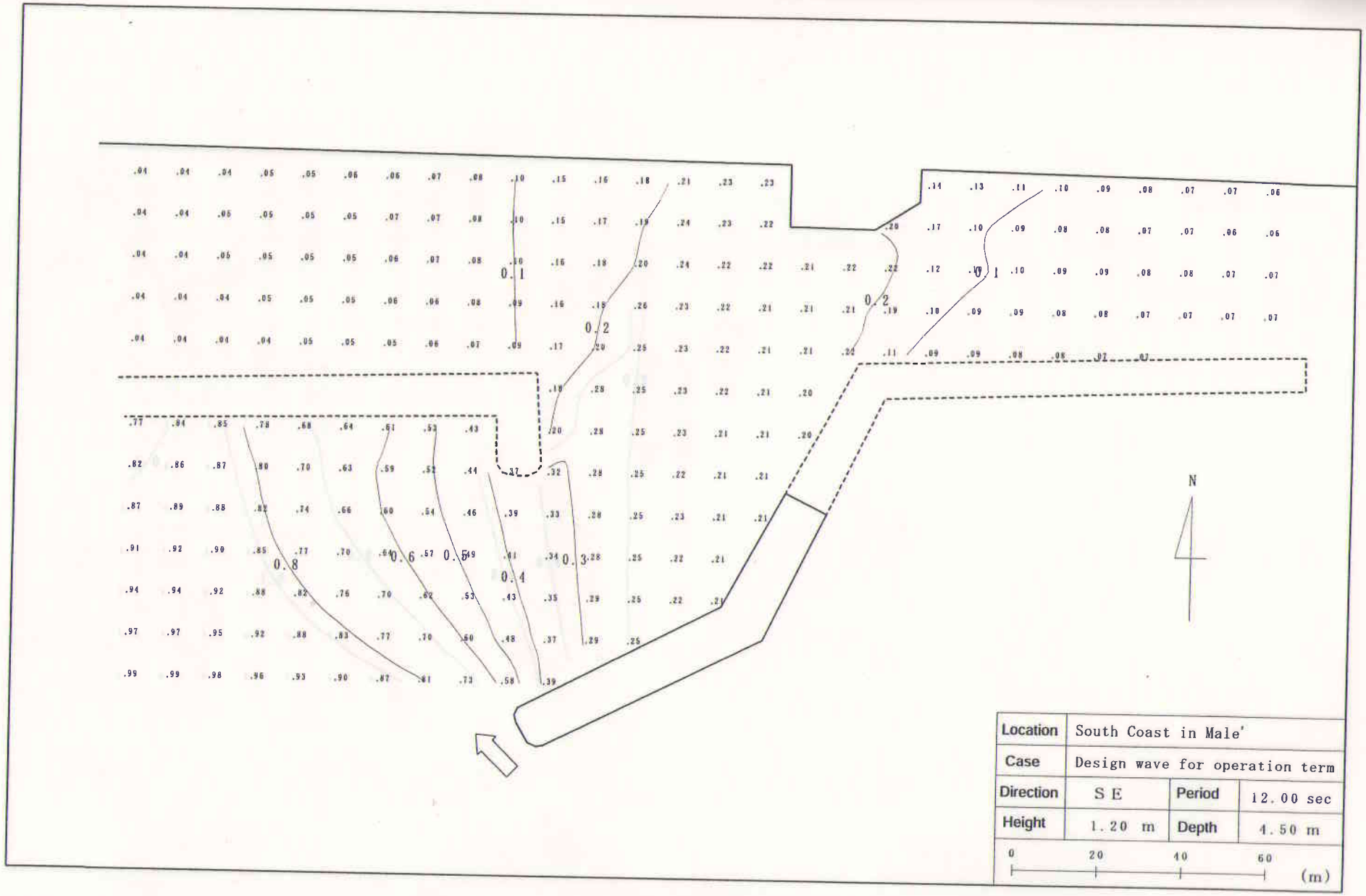


Positions of Reflection



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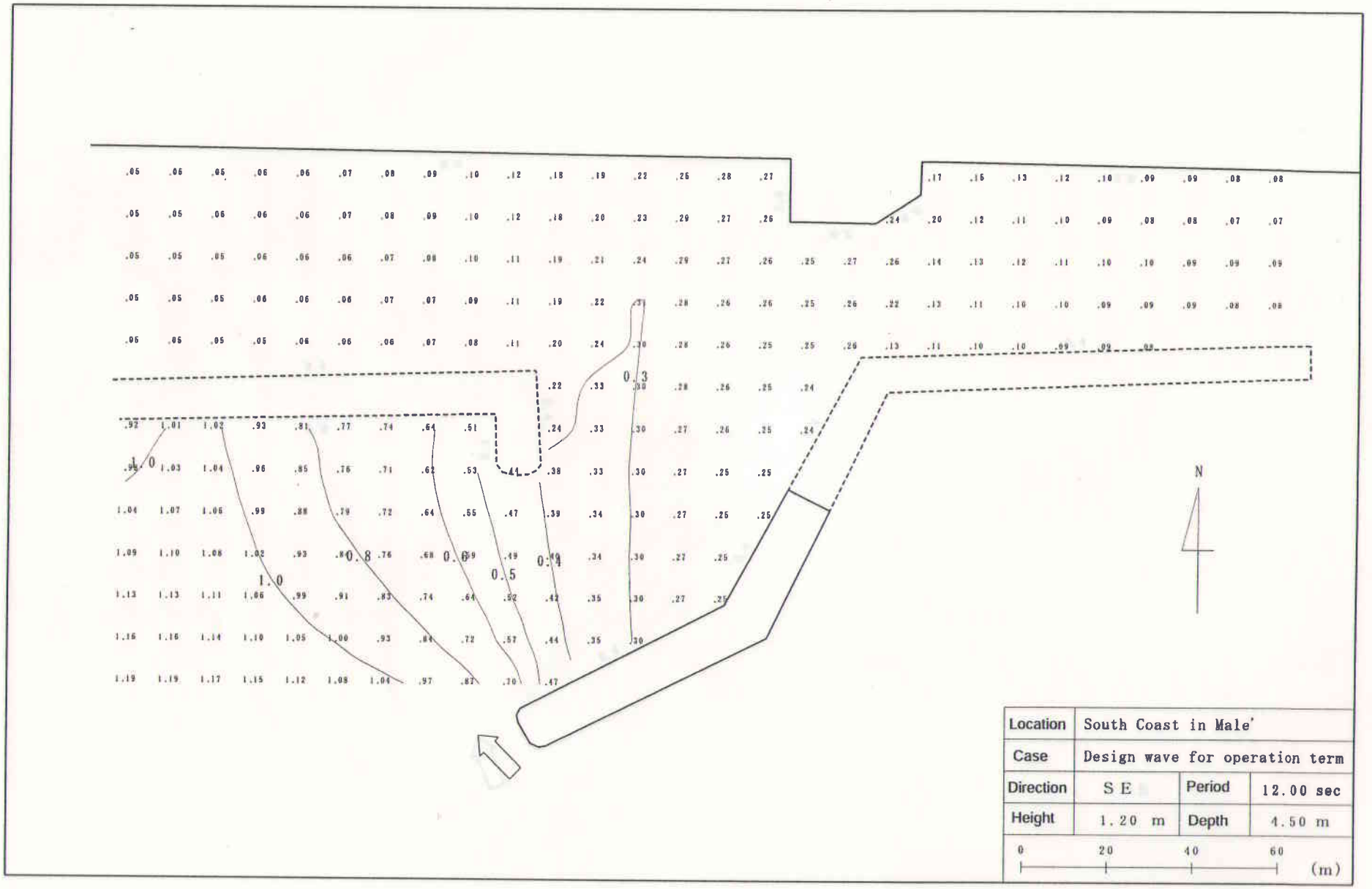
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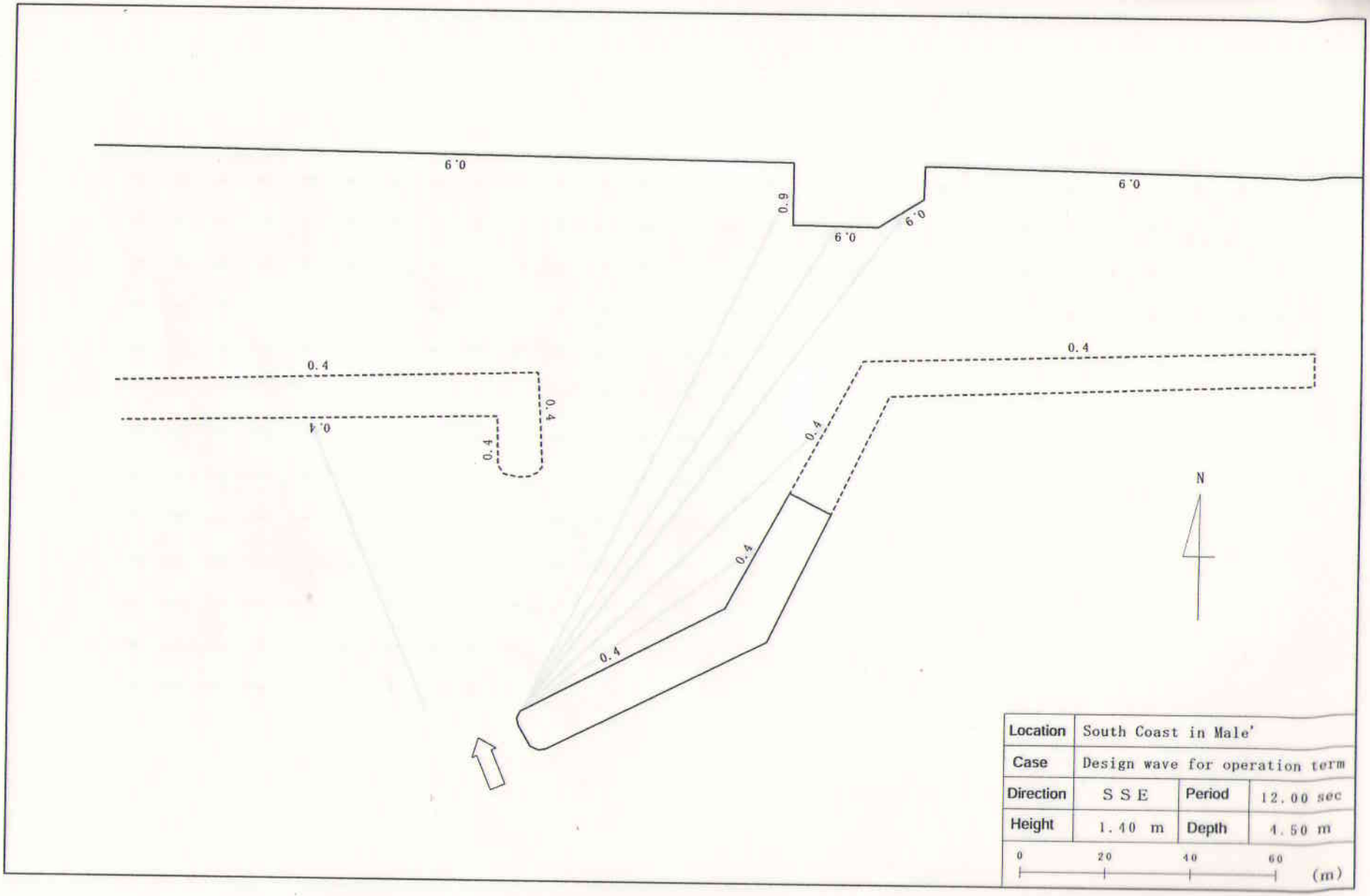
Wave Height



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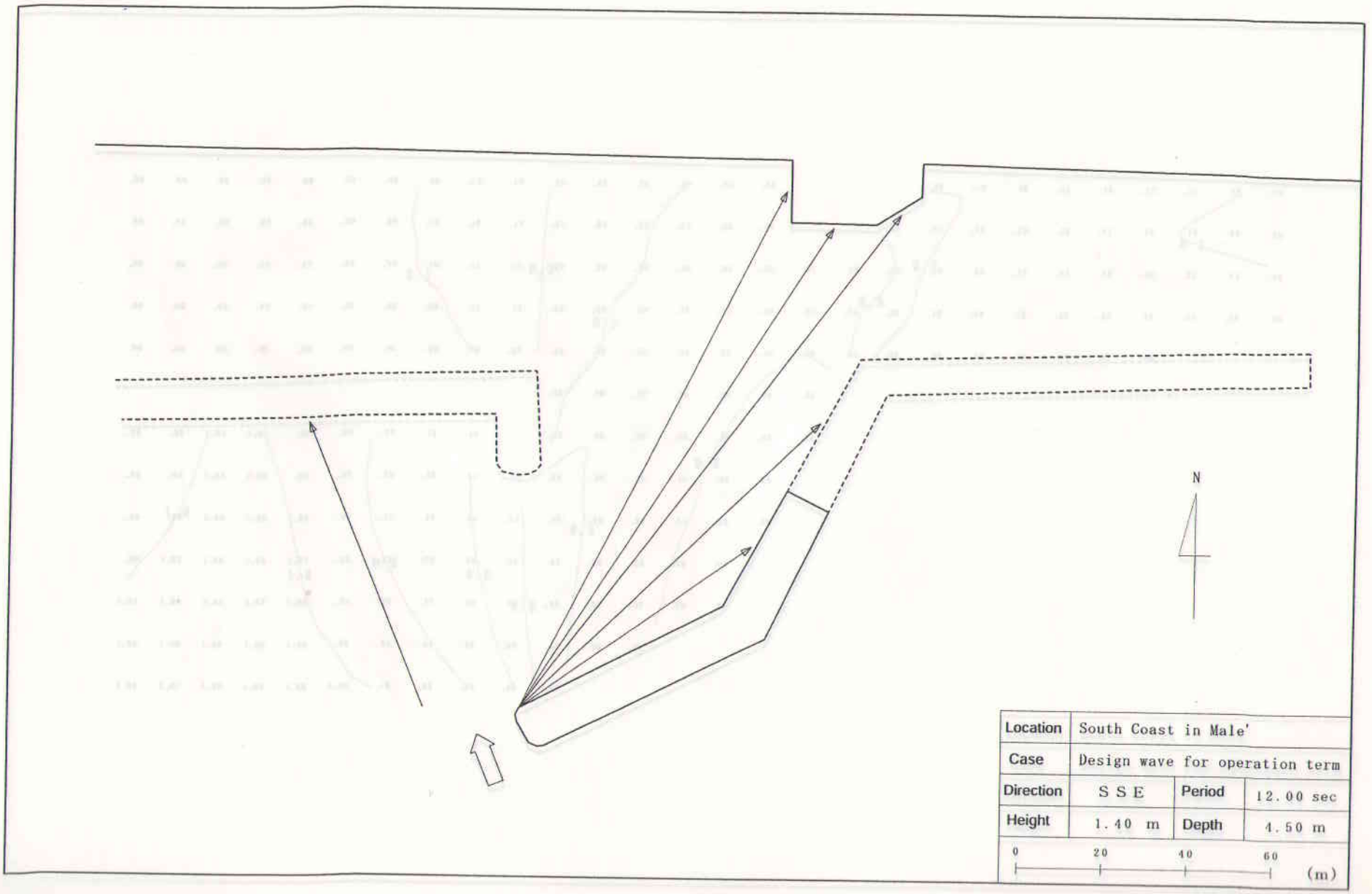

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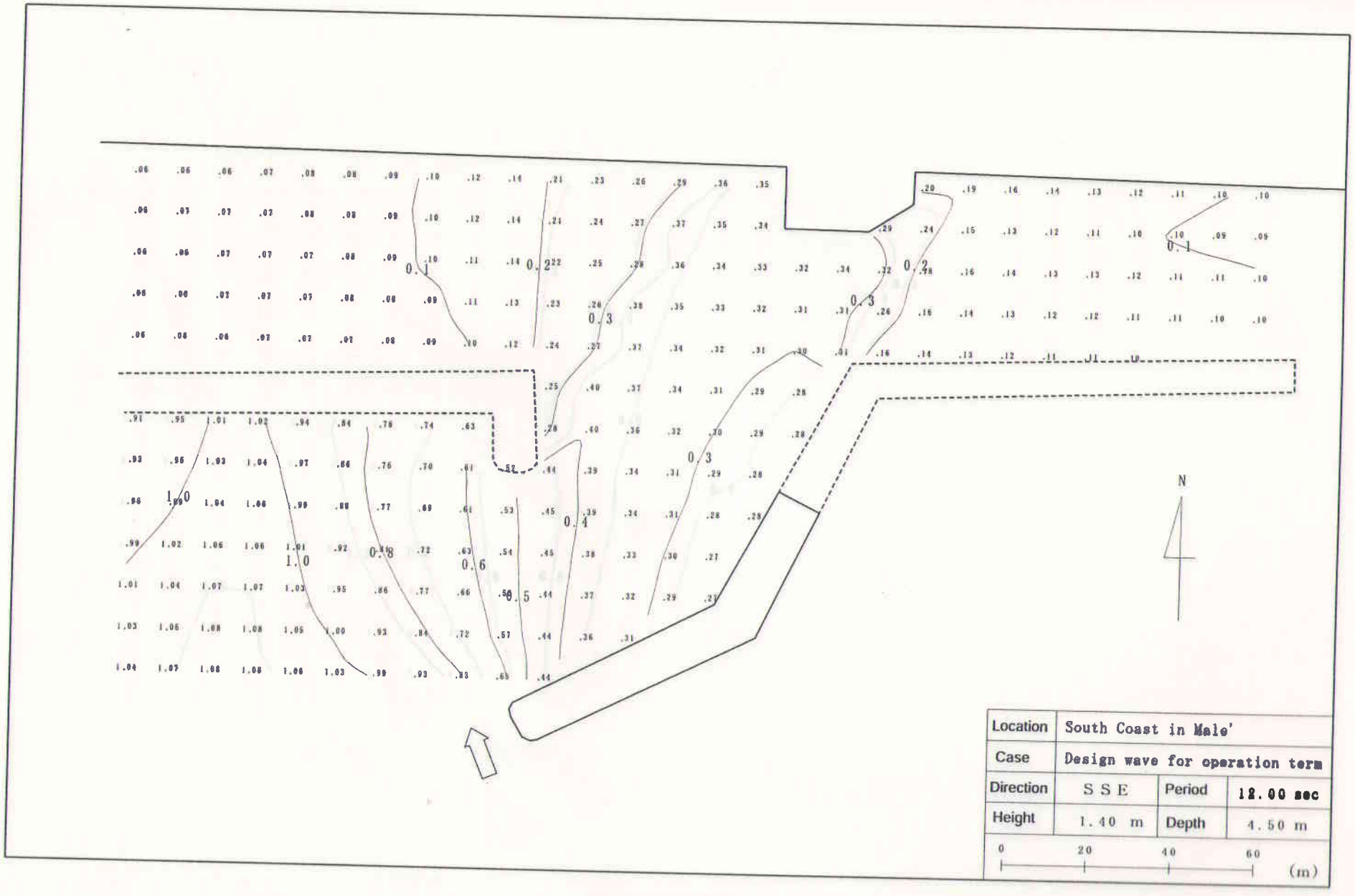

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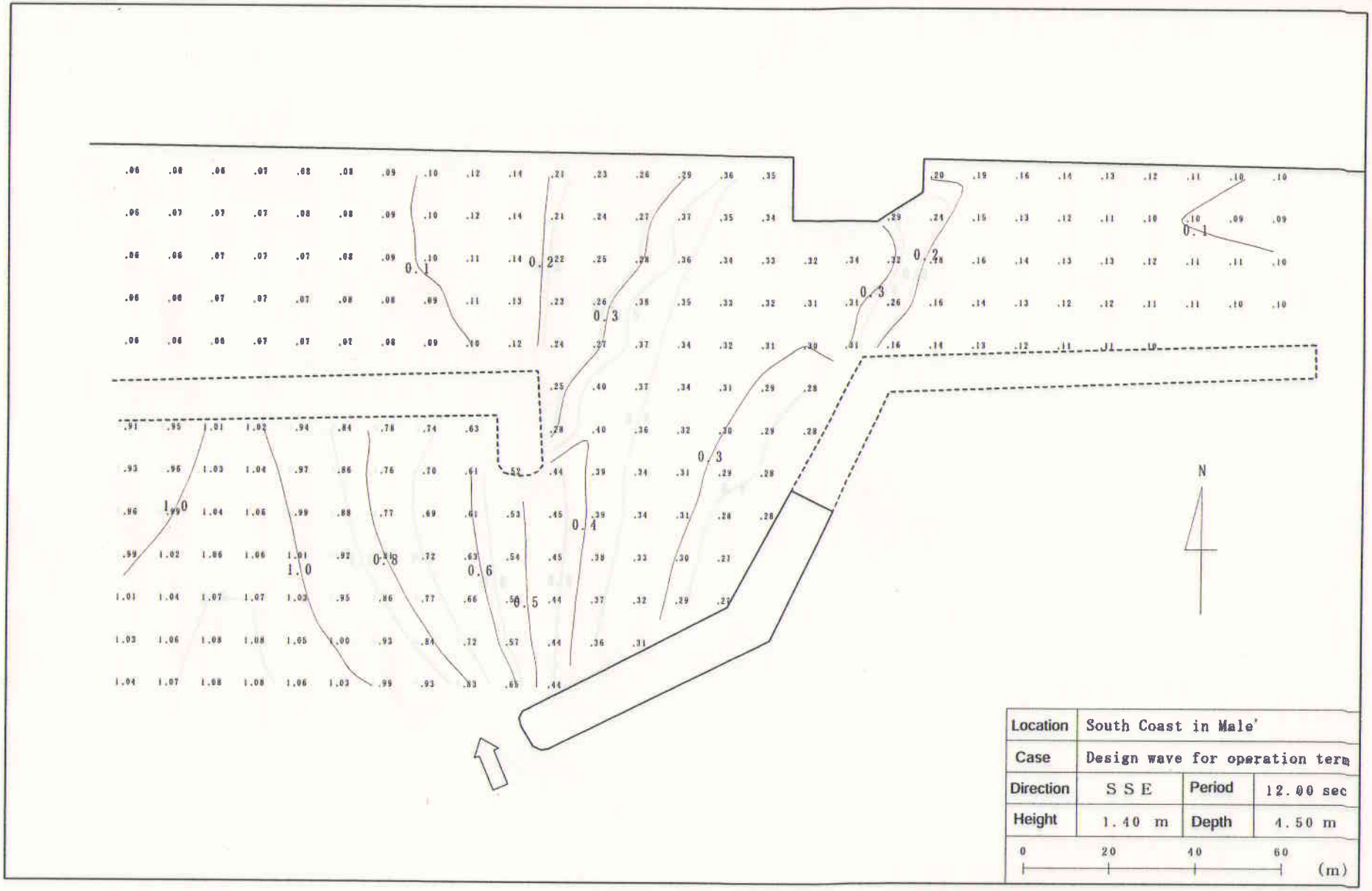

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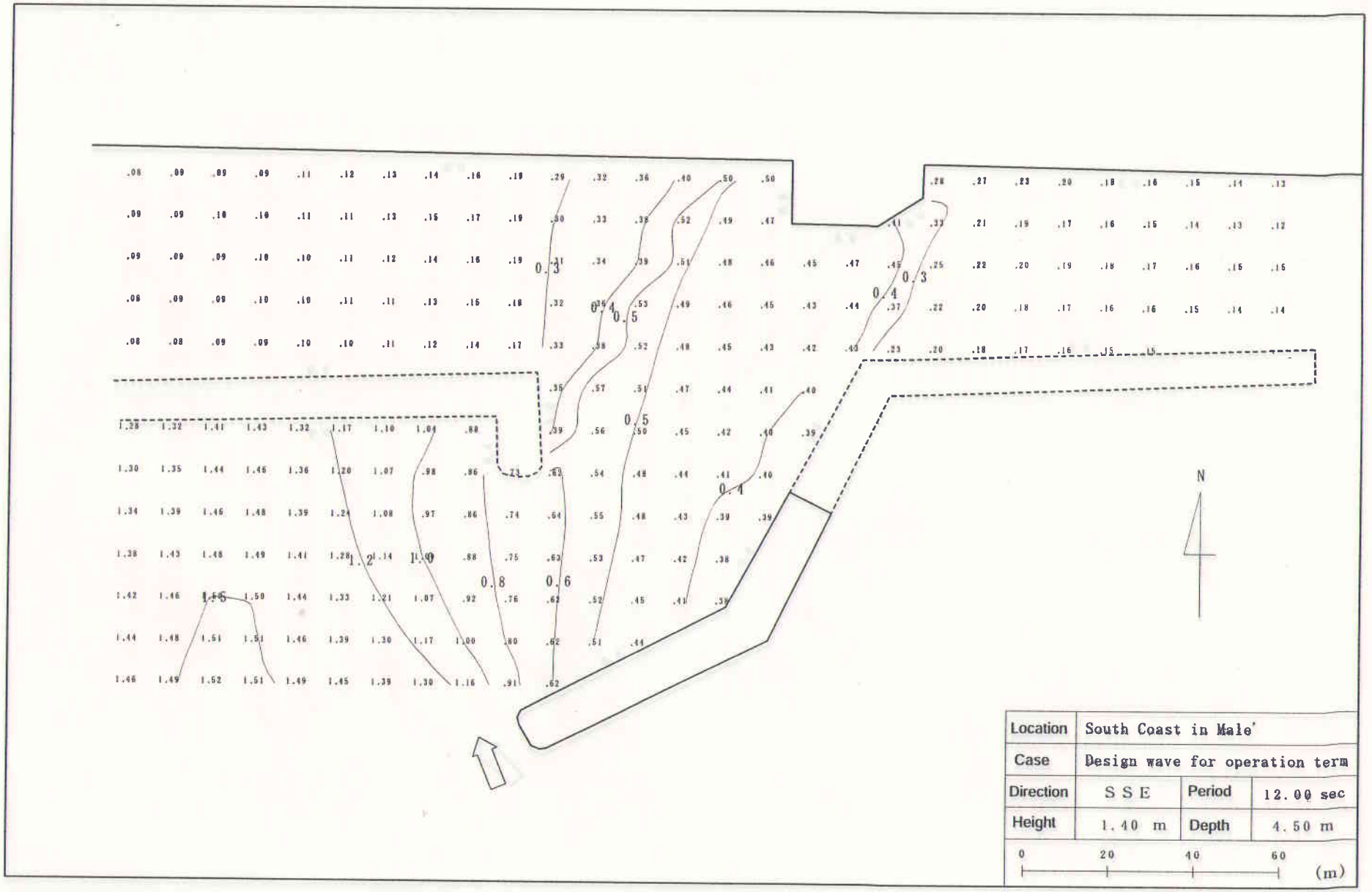
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Case Design wave for operation term
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Depth 4.50 m
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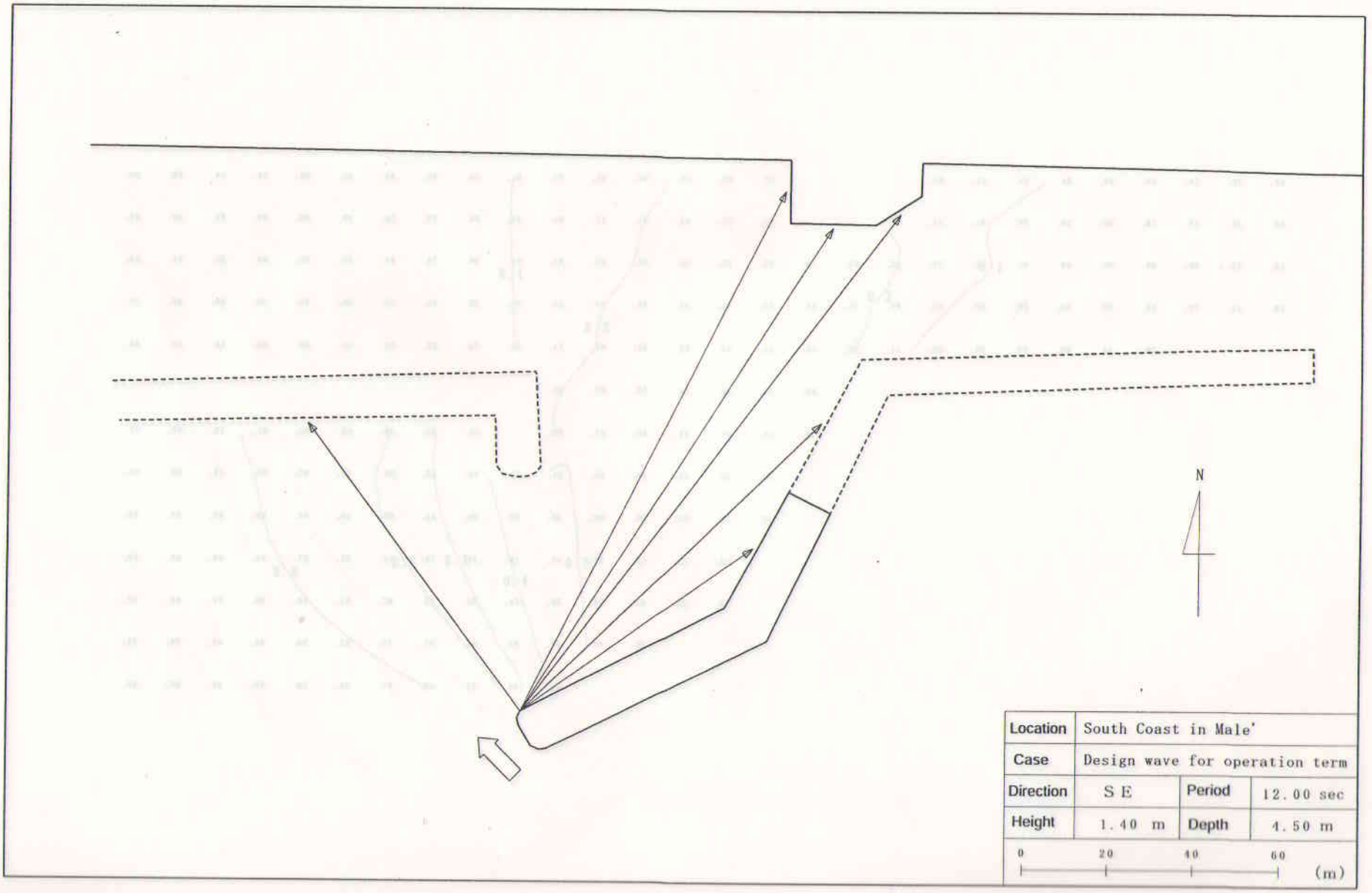
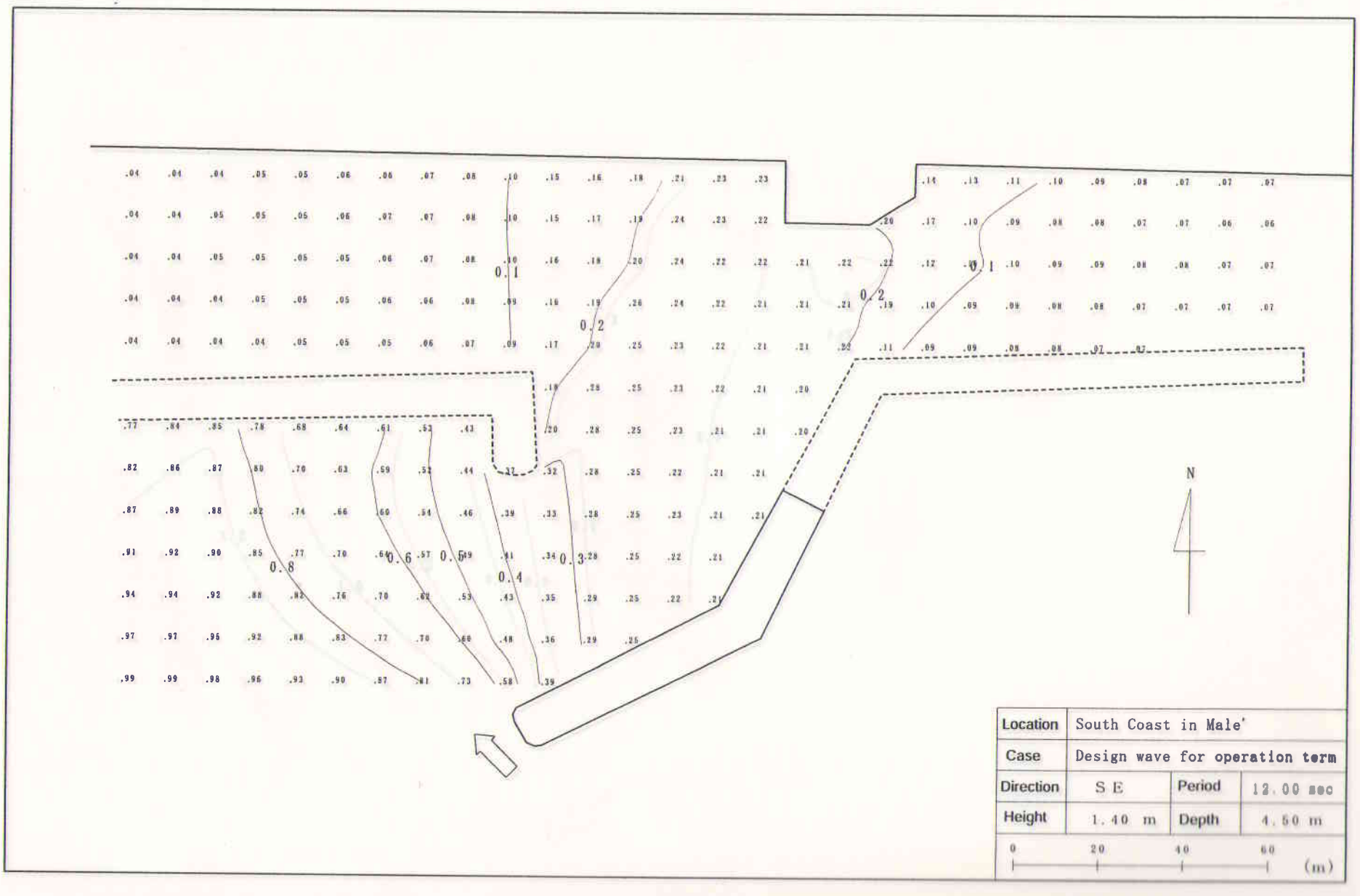
Wave Height



Positions of Reflection



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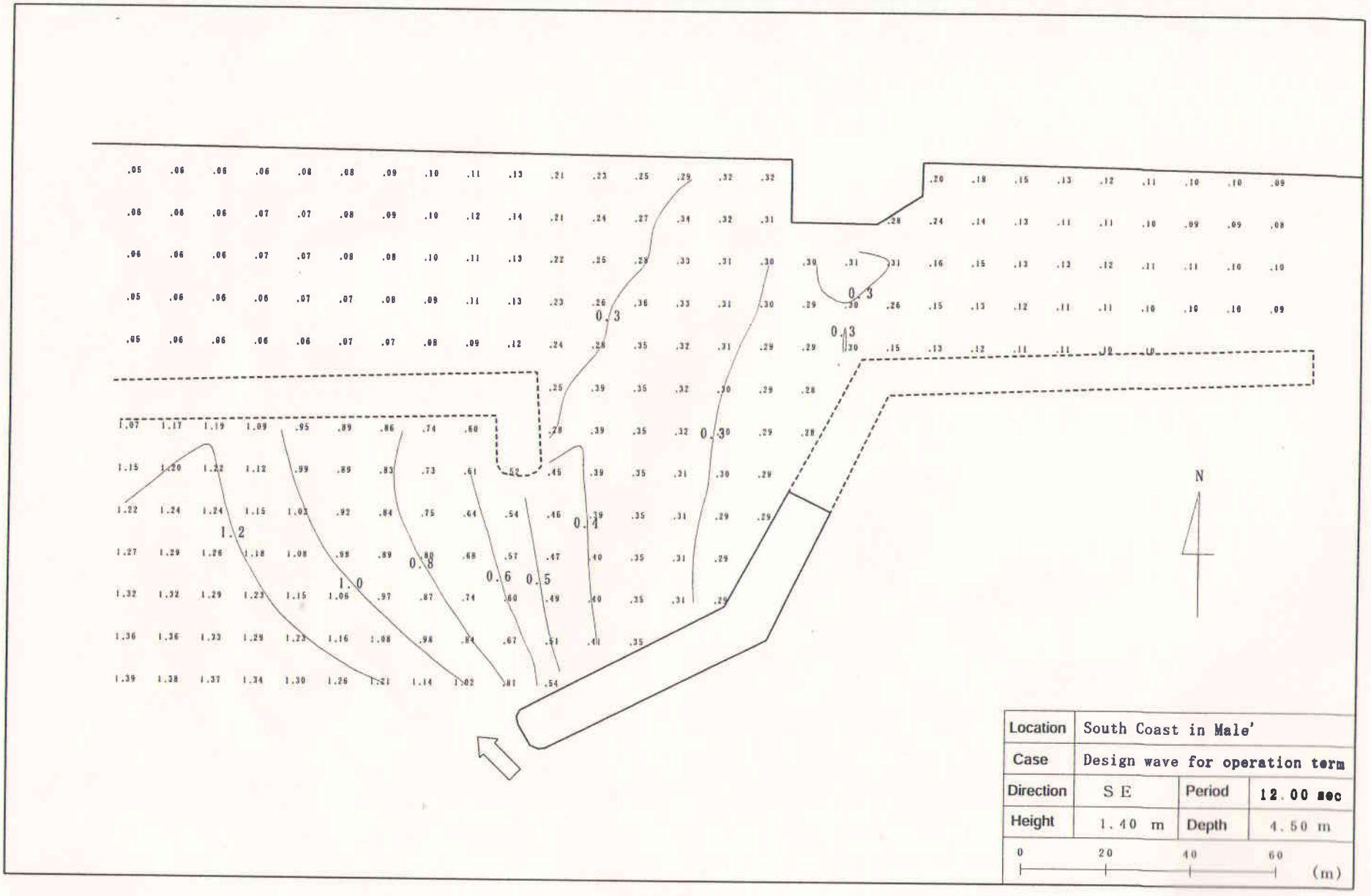
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Location South Coast in Male'
Case Design wave for operation term
Direction S E
Period 12.00 sec
Height 1.40 m
Depth 4.50 m
0 20 40 60 (m)

Wave Height

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First Addendum EIA report for Male South Harbour

(24.0 M)

shifaf@sandcays.com [shifaf@sandcays.com]

Sent: 2:05 am

To: secretariat@housing.gov.mv

Cc: Zahid Ahmed, azmeel@sandcays.com

Attachments: First Addendum_EIA for SW Harbour Dev Project.rar

Dear Sir,

Attached please find first addendum EIA report for Male South Harbour.

Regards,

Mohamed Shifaf
Senior Surveyor

Mobile phone: 960 9995095

Email: shifaf@sandcays.com

Sandcays

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