SEDIMENTATION RATE MONITORING REPORT - 01

PROJECT: GULHIFALHU PORT DEVELOPMENT
PROJECT PHASE 1: DREDGING, RECLAMATION AND SHORE PROTECTION

Monitoring Period

30th May 2020 – 15th June 2020

Report Number

SedRate_1/7/2020 (Rev 2.2)

Client

Boskalis Westminster Contracting Limited

Contact person(s):

- Andrew Abley, Environmental Engineer
  (email: Andrew.Abley@boskalis.com)

Environmental Consultant

CDE Consulting, Maldives

4F, Orchidmaage, Ameer Ahmed Magu
Malé, 20095, Republic of Maldives
Tel: +960-3312514

Table of Contents

List of Tables

List of Figures

Abbreviations and Symbols

π	Pi
cm	Centimeter
cm^2	Square centimeter
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
g	Gram
GPS	Global Positioning System
mg	Milligram
mg/L	Milligram per Liter

1 Introduction

1.1 Purpose of the report

This document provides the sedimentation rate measurements undertaken from 30th May 2020 to 15th June 2020 at reef monitoring sites prescribed in the Environmental Monitoring Plan approved by the Environmental Protection Agency (EPA) for the Phase I of Gulhifalhu Port development Project (Dredging, Reclamation and Revetment works).

This report has been prepared by CDE Consulting under a service contract with Boskalis Westminster Contracting Limited for the purpose of meeting EPA requirement for monitoring sedimentation rate at select reefs within the project impact area.

1.2 Major project activities during monitoring period

The following were the major project activities ongoing during this monitoring period, which could contribute to changes to natural sedimentation rate on reefs.

1. Reclamation of temporary work site on the south eastern reef flat of Gulhifalhu using in-situ material dredged using a back-hoe dredger.
2. Deployment of big sand bags on the eastern reef flat of Gulhifalhu, outside the planned sand bund boundary using an excavator mounted on a barge.
3. Construction of sand bund on the eastern reef flat using in-situ material dredged using a back-hoe dredger.

2 Methodology

Materials

- Sediment traps
    - Constructed from 5 cm internal diameter PVC pipe, 11.5 cm long and sealed at one end, with baffles placed in the top to prevent entry of fishes (English, Wilkinson, & Baker , 1997, p. 55)
- Iron rods

Procedure

- Iron rod was hammered into the substratum, so that it is vertical and firmly secured.
- Three sediment traps were then attached to the rod using cable ties. The base of the trap was kept 20 cm from the substratum, and the traps were be tied to the rod in a way that rod does not protrude above the opening of the pipes (Figure 2-1). At each monitoring site 4 sets of traps (each with three sediment traps) were installed

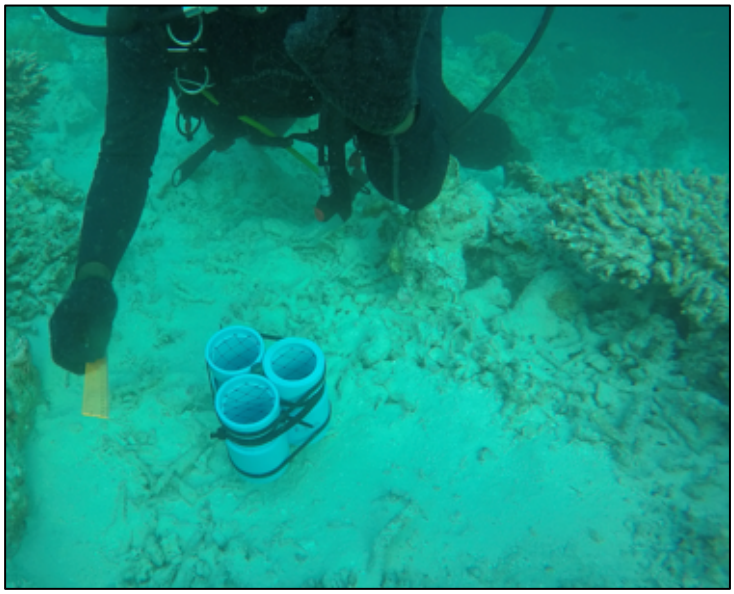

Figure 2-1: Sedimentation trap installed for sedimentation rate monitoring

- The traps were to be left for over a fourteen-day period and retrieved. On occasions when the weather did not permit this, traps were retrieved the earliest when the weather permitted.
- The traps were sealed prior to removal from the rod, to prevent loss of any material.
- The sample were dried in an oven (at 60 °C), and weighed to the nearest milligram.
- Sedimentation rate is calculated as mg of sediment per cm^2 per day, using the following formula, where Sediment Weight is average dry weight of the sediment samples, and "r" is radius of the trap opening.

$$Sedimentation\ Rate = \frac{Sediment\ Weight}{Number\ of\ day\ \times\ \pi r^2}$$

3 Monitoring Sites

Sedimentation rate monitoring is required at a total 14 sites in the approved Environmental Monitoring Plan for the project. This include 8 sites at or near the reclamation site (T-2, T-4, T-6, T-7, T-8, T-9, T-10 and T-11) and 6 sites near the sand borrow area (T-19, T-20, T21, T-22, T-23 and T-24).

As mentioned earlier during this monitoring period the main project activities were reclamation of the temporary work site on the south eastern corner of Gulhifalhu and construction of sand bund on the eastern reef flat. As required in the approved monitoring plan for the reclamation site, sediment traps were installed at T-2, T4, T-6, T-7 and T-11.

As no dredging was undertaken within the sand borrow area during this period, there was no requirement for sedimentation rate monitoring at the sites near the sand borrow area. However, as the baseline sedimentation rate was not established at T-21, T-23 and

T-24 during the Environmental Impact Assessment (EIA) for this project, sediment traps were installed at these sites to establish the baseline.

GPS coordinates and depth of the sedimentation rate monitoring sites are provided in Table 3-1 and location map is provided in Figure 3-1.

Table 3-1: GPS coordinates and depth of sedimentation rate monitoring sites

Trap ID	Description	Latitude	Longitude	Depth (m)
T-2	Gulhifalhu (N)	4.18785°	73.4684°	2.5 m
T-4	Gulhifalhu (NE)	4.182291°	73.475565°	3 m
T-6	Gulhifalhu (SE)	4.172121°	73.478178°	5 m
T-7	Gulhifalhu (SE)	4.172238°	73.474390°	5 m
T-8	Gulhifalhu (S)	4.17332°	73.467003°	5 m
T-9	Gulhifalhu (S)	4.174529°	73.461196°	3.3 m
T-10	Gulhifalhu (SW)	4.176124°	73.454658°	5 m
T-11	Villingili (NW)	4.176084°	73.483121°	10 m
T-19	Feydhoo Finolhu (SW)	4.211618°	73.481556°	3 m
T-20	Olhuhaa (S)	4.217497°	73.458640°	2.5 m
T-21	Bangau (S)	4.222450°	73.429949°	2.7 m
T-22	Kurumba (W)	4.226931°	73.517007°	2.5 m
T-23	Dhiyaneru (SW)	4.231697°	73.471358°	2.5 m
T-24	Kandinmafalhu (SW)	4.238414°	73.457170°	2.5 m

Figure 3-1: Sedimentation Rate Monitoring Sites

4 Results

The guideline trigger value set by EPA for the maximum daily sedimentation rate is 15 mg/cm^2/day (Environmental Protection Agency, N.D.).

During this monitoring period two out of the five monitoring sites at/or near reclamation site and two out of three monitoring sites near the sand borrow area exceeded the set maximum daily sedimentation rate.

4.1 Reclamation Site

Figure 4-1 shows the average sedimentation rates recorded at monitoring sites at/near reclamation site during this period.

The highest sedimentation rate was recorded at T-4 which was the nearest monitoring site to the sand bund that was under construction. Average sedimentation rate at this site was 263±4.12 mg/cm^2/day (mean ± SE), which far exceeds the trigger value set by EPA. The next highest sedimentation rate was recorded at T-2 located on the northern side of Gulhifalhu recorded average sedimentation rate of 18.63±4.30 mg/cm^2/day which is slightly above the trigger value.

Both sediment traps T-6 and T-7 located on the south-eastern side Gulhifalhu and trap placed on the north western side of Villingili (T-11) were below the trigger value.

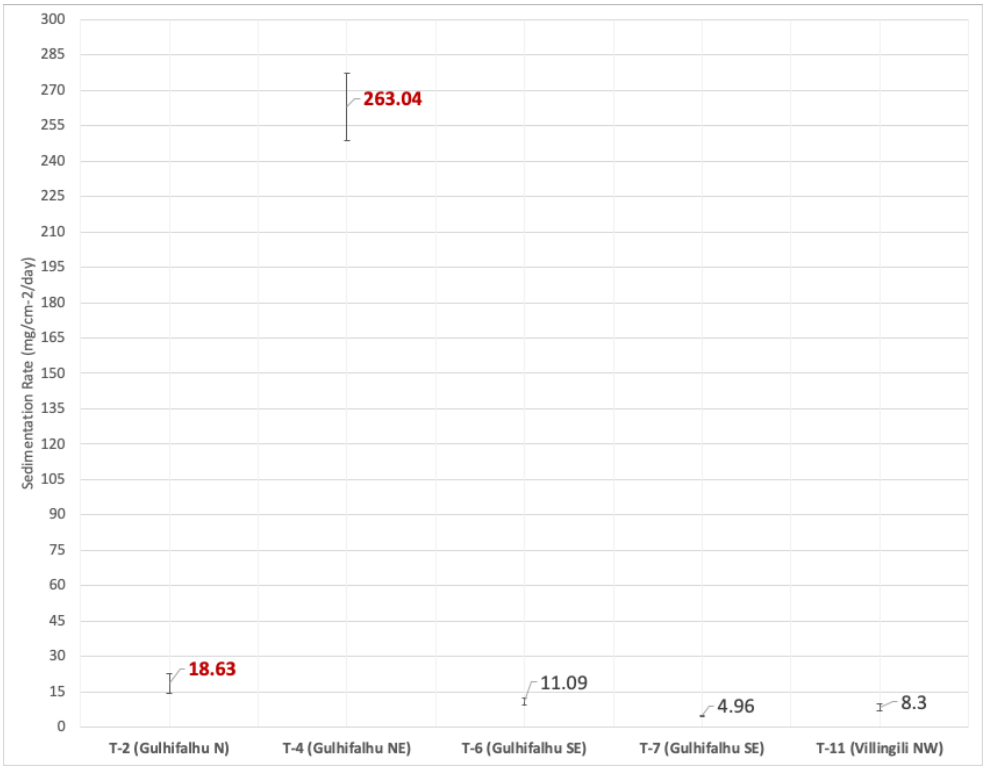

Figure 4-1: Average sedimentation rates recorded at/or reclamation area

Table 4-1: Sedimentation rate measurement at/or near reclamation site

Trap ID	Installation Date	Retrieval Date	Average Sedimentation Rate (mg/cm^2/day)	±Standard Error
T-2	31-May-20	14-June-20	18.63	4.30
T-4	31-May-20	15-June-20	263.04	14.12
T-6	30-May-20	14-June-20	11.09	1.45
T-7	30-May-20	14-June-20	4.96	0.20
T-11	30-May-20	15-June-20	8.30	1.49

4.2 Dredging Site

Figure 4-2 shows the average sedimentation rates recorded at the monitoring sites near the proposed sand borrow area during this period. The highest sedimentation rate was recorded at monitoring site located on the south side of Bangau (T-21) followed by the T-23 (located on the southwest side of Dhiyaneru). The lowest sedimentation rate recorded during this period was recorded on the southwest of Kandinmafalhu.

As stated earlier no dredging was undertaken at the sand borrow area during this period. And no major anthropogenic activities that may influence sedimentation rates at these monitoring sites were recorded during this period. Hence it can only be assumed that the sedimentation rate recorded at these sites are localized and is part of natural sediment flow at the site. Sediment movement and deposition on a reef is influenced by various natural factors such as tidal changes, wave condition (Storlazzi, Ogston, Bothner, Field, & Presto, 2004), speed and direction of current flow and weather condition (Otaño-Cruz, Montañez-Acuña, Torres-López, Hernández-Figueroa, & Edwin A. Hernández-Delgado, 2017).

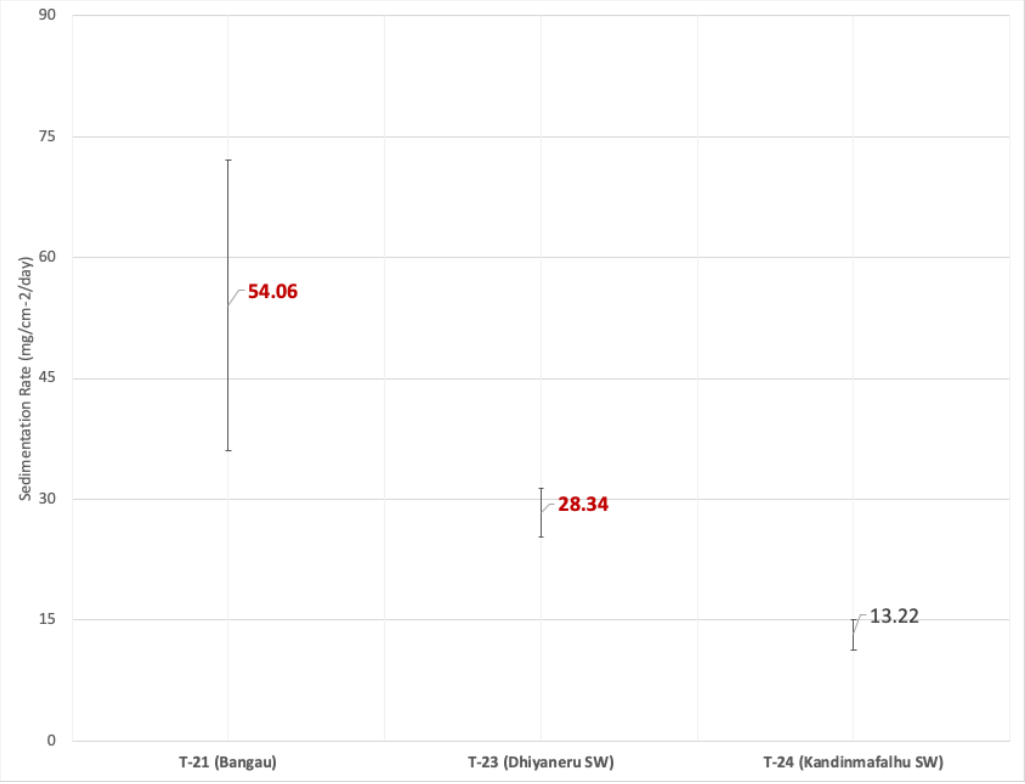

Figure 4-2: Average sedimentation rate measured at monitoring sites near dredging area

Table 4-2: Sedimentation rate measurement near sand borrow area

Trap ID	Installation Date	Retrieval Date	Average Sedimentation Rate (mg/cm^2/day)	±Standard Error
T-21	1-June-20	14-June-20	54.06	18.06
T-23	1-June-20	15-June-20	28.34	3.07
T-24	1-June-20	15-June-20	13.22	1.87

References

English, S., Wilkinson, C., & Baker , V. (1997). *Survey manual for tropical marine resources* (2nd Edition ed.). Townsville, Australia: Australian Institute of Marine Science .

Environmental Protection Agency. (N.D.). *EIA data collection guidelines* .

Otaño-Cruz, A., Montañez-Acuña, A. A., Torres-López, V., Hernández-Figueroa, E. M., & Edwin A. Hernández-Delgado, E. A. (2017). Effects of Changing Weather, Oceanographic Conditions, and Land Uses on Spatio-Temporal Variation of Sedimentation Dynamics along Near-Shore Coral Reefs. *Front. Mar. Sci.* doi:doi: 10.3389/fmars.2017.00249

Storlazzi, C. D., Ogston, A. S., Bothner, M. H., Field, M. E., & Presto, M. K. (2004). Wave- and tidally-driven flowand sediment flux across a fringing coral reef: Southern Molokai, Hawaii. *Continental Shelf Research*, 1397–1419.