SEDIMENTATION RATE MONITORING REPORT - 07

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

Monitoring Period

22nd August 2020 – 8th September 2020

Report Number

SedRate_21/9/2020 (Rev 1.0)

Client

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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
MMS	Maldives Meteorological Services
TSHD	Trailing Suction Hopper Dredger

1 Introduction

1.1 Purpose of the report

This document provides the sedimentation rate measurements undertaken from 22nd August 2020 to 8th September 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

Dredging operations were completed on 20th August 2020, hence no project related activities were ongoing at the sand borrow area during this 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. Preparations for installation of permanent revetment on the reclaimed area.
2. Placement of temporary revetment at northeast section of reclamation.

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.

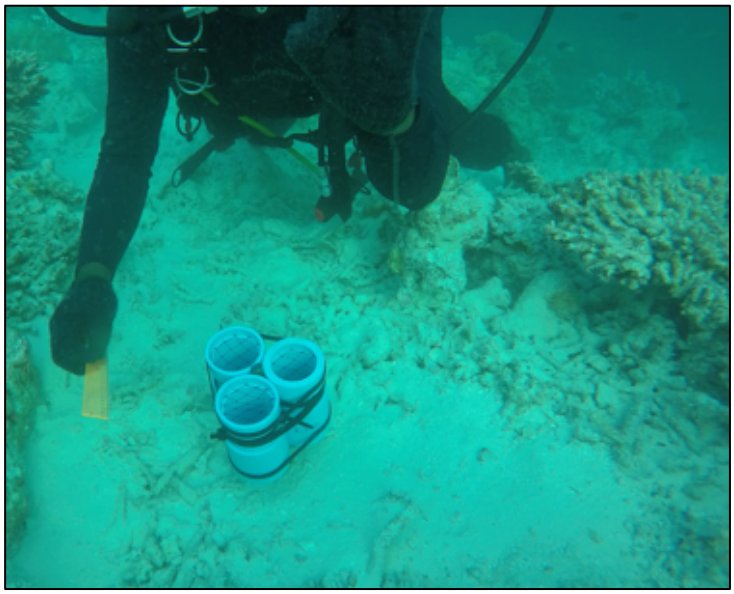


Figure 2-1: Sedimentation trap installed for sedimentation rate monitoring

- 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).

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

Trap ID	Description	Latitude	Longitude	Depth (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 trigger value set by EPA for the maximum daily sedimentation rate is 15 mg/cm^2/day (Environmental Protection Agency, N.D.).

Three out of the five monitoring sites at Gulhifalhu recorded average sedimentation rates above the trigger value. Sedimentation rate recorded at Villingili monitoring site was well below the trigger value. All sites around the sand borrow site recorded sedimentation rates above the trigger value.

There are several natural factors that can influence sedimentation rate, this includes 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). During this monitoring period swell wave surges, heavy rain rough seas were recorded by the Maldives Meteorological Services (MMS), all of which could have contributed to the high sedimentation rates recorded at the sites around the sand borrow area.

4.1 Reclamation Site

Table 4-1 provides the average sedimentation rates recorded at monitoring sites in Gulhifalhu reclamation site and neighboring Villingili reef during this period. Figure 4-1 provides a comparison of average sedimentation rates recorded at these sites during baseline and subsequent monitoring rounds.

The highest sedimentation rate recorded at Gulhifalhu reef was at T-2 located on the north side (177.75 mg/cm^2/day), followed by T-4 located on the north eastern side and T-6 on the south eastern side of the reef. All these monitoring sites recorded sedimentation rates exceeding the set trigger value. Erosion of the sand bund around the reclaimed area, and ongoing preparation works of the shoreline for installation of revetment works in combination with rough seas and severe weather conditions during this monitoring period may have contributed to the high sedimentation rates at these sites.

The traps placed at T-7 and T-9 recorded sedimentation rate of 14.85 mg/cm^2/day and 4.24 mg/cm^2/day respectively, both readings below the trigger value.

Sedimentation rate recorded at Villingili monitoring site was 5.19 mg/cm^2/day, well below the trigger value.

Table 4-1: Average sedimentation rate recorded at Gulhifalhu and Villingili

Trap ID	Installation Date	Retrieval Date	Average Sedimentation Rate (mg/cm^2/day)	±Standard Error
T-2	23-Aug-2020	5-Sept-2020	177.75	62.84
T-4	23-Aug-2020	5-Sept-2020	41.32	3.22
T-6	23-Aug-2020	7-Sept-2020	67.04	5.98
T-7	23-Aug-2020	5-Sept-2020	14.85	3.28

Trap ID	Installation Date	Retrieval Date	Average Sedimentation Rate (mg/cm^2/day)	±Standard Error
T-9	22-Aug-2020	5-Sept-2020	4.24	0.79
T-11	22-Aug-2020	7-Sept-2020	5.19	1.56

4.2 Dredging Site

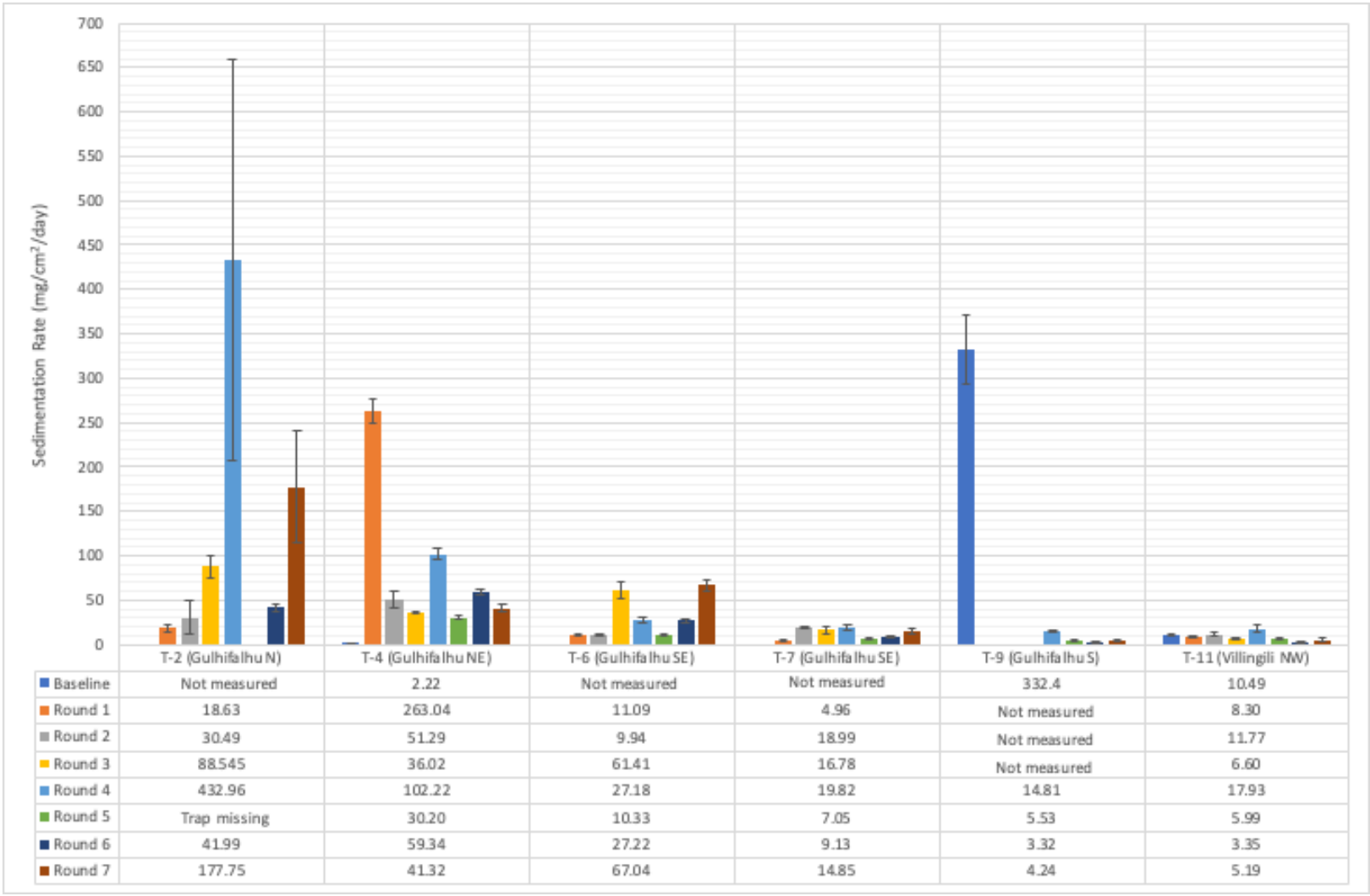
Table 4-2 provides the average sedimentation rates recorded at monitoring sites near the sand borrow area during this monitoring period. Figure 4-2 shows a comparison of sedimentation rates recorded at these sites during baseline and subsequent monitoring rounds.

Dredging operations were completed on 20th August 2020, hence no project related activities were ongoing at the sand borrow area during this monitoring period.

Sedimentation rates recorded at all monitoring sites around the sand borrow area was significantly above the set trigger value at all sites. As mentioned earlier severe weather condition and rough seas during this monitoring period is the likely cause of the high sedimentation rates.

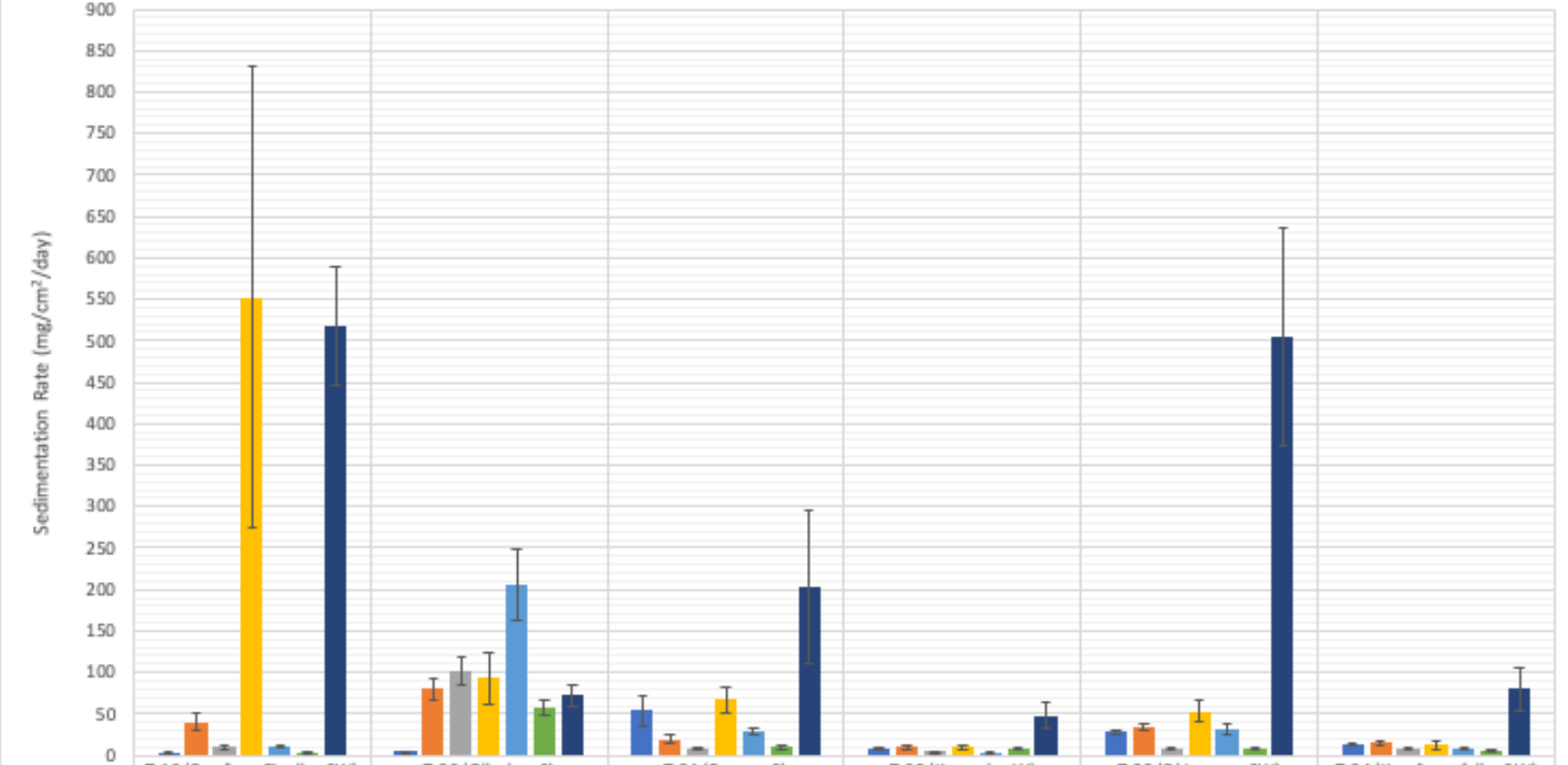
Table 4-2: Sedimentation rate measurement near sand borrow area

Trap ID	Installation Date	Retrieval Date	Average Sedimentation Rate (mg/cm^2/day)	±Standard Error
T-19	22-Aug-2020	8-Sept-2020	516.91	71.21
T-20	23-Aug-2020	8-Sept-2020	72.06	13.32
T-21	23-Aug-2020	7-Sept-2020	203.94	91.91
T-22	24-Aug-2020	8-Sept-2020	47.74	15.52
T-23	23-Aug-2020	7-Sept-2020	504.39	132.03
T-24	23-Aug-2020	7-Sept-2020	80.06	26.23



	T-2 (Gulhifalhu N)	T-4 (Gulhifalhu NE)	T-6 (Gulhifalhu SE)	T-7 (Gulhifalhu SE)	T-9 (Gulhifalhu S)	T-11 (Villingili NW)
Baseline	Not measured	2.22	Not measured	Not measured	332.4	10.49
Round 1	18.63	263.04	11.09	4.96	Not measured	8.30
Round 2	30.49	51.29	9.94	18.99	Not measured	11.77
Round 3	88.545	36.02	61.41	16.78	Not measured	6.60
Round 4	432.96	102.22	27.18	19.82	14.81	17.93
Round 5	Trap missing	30.20	10.33	7.05	5.53	5.99
Round 6	41.99	59.34	27.22	9.13	3.32	3.35
Round 7	177.75	41.32	67.04	14.85	4.24	5.19

Figure 4-1: Comparison of average sedimentation rates recorded at monitoring sites in Gulhifalhu and Villingili



	T-19 (Feydhoo Findhu SW)	T-20 (Olhuhaa S)	T-21 (Bangau S)	T-22 (Kurumba W)	T-23 (Dhiyaneru SW)	T-24 (Kandinmafalhu SW)
Baseline	3.46	5.11	54.06	7.54	28.34	13.23
Round 1	40.27	80.37	19.75	9.76	34.69	14.86
Round 2	9.48	101.54	8.83	4.67	8.39	7.94
Round 3	552.57	92.64	66.95	10.10	53.52	13.07
Round 4	10.64	206.04	28.37	3.94	32.19	7.64
Round 5	4.06	57.34	9.96	8.21	8.32	5.48
Round 6	516.91	72.06	203.94	47.74	504.39	80.06

Figure 4-2: Comparison of average sedimentation rate at monitoring sites near dredging site

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