# APPENDIX F

## Hydrodynamic & Sediment Modelling

DRAFT

Deltares

# Feasibility Studies for enhancement of Mandai Mangroves and Mudflat

Modelling report on hydrodynamics, sediment dynamics and morphodynamics

**Feasibility Studies for enhancement of Mandai Mangroves and Mudflat**
Modelling report on hydrodynamics, sediment dynamics and morphodynamics

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**Feasibility Studies for enhancement of Mandai Mangroves and Mudflat**
Modelling report on hydrodynamics, sediment dynamics and morphodynamics

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# Summary

National Parks Board (NParks) in Singapore are planning to extend and further develop the nature park at Mandai Mangrove and Mudflat, aiming to safeguard and enhance the habitats and biodiversity within the park and make it accessible for public education and outreach, conservation and research activities.

In support of the development of the extended nature park, NParks requested TEMBUSU Asia Consulting Pte Ltd (Tembusu) and LOOK Architects to design the extended nature park, and to carry out an environmental impact study (EIS) for this design. The extension of this park involves, among other things, the construction of park features and landscaping. The park will have one additional wet infrastructure site, namely the Sungei Pangsua Pavilion with an Experiential Walk. The existing mudflat at the planned location of the Experiential Walk will be excavated to allow water to partially inundate the area.

Tembusu requested Deltares to provide input to their EIS by assessing the following impacts by means of numerical modelling:

1. changes to the hydrodynamics (water levels, currents and waves) as a result of the construction of the Experiential Walk (i.e. the piles of the boardwalk and excavation) in the intertidal zone (‘wet infrastructure');
2. changes to the sediment dynamics (suspended sediment concentration and bed sediments) and morphology as a result of the interventions mentioned under #1; and
3. changes to the hydrodynamics (water levels, currents and waves), sediment dynamics and morphology as a result of future predicted sea level rise.

This report presents the approach, results and conclusions of these numerical modelling tasks. The main conclusions are:

- As a result of the very limited new ‘wet infrastructure’, the construction of the Sungei Pangsua Pavilion will have no significant impact on the water levels, currents or waves in Mandai area. The hydrodynamic impacts will be limited to the area within a few meters from the Experiential Walk and associated excavations.
- Following from the low hydrodynamic energy, sediment dynamics in Mandai area is also very limited. The construction of the Sungei Pangsua Pavilion – the only very limited new ‘wet infrastructure’ – will have no significant impact on the sediment dynamics and morphology in Mandai area. As for the hydrodynamics, the impacts on sediments will also be limited to the area within a few meters from the Experiential Walk and associated excavations.
- Sea level rise will have a negligible effect on the currents and waves in Mandai area. Only the local waterdepth at the excavation and thus the tidal inundation period of the area will be affected. Moreover, sea level rise will cause a decrease in the time-averaged suspended sediment concentrations in the shallow areas with respect to the present situation, whereas erosion and sedimentation patterns are not significantly affected.

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# 1 Introduction

## 1.1 Project overview

National Parks Board (NParks) in Singapore are planning to extend and further develop the nature park at Mandai Mangrove and Mudflat, aiming to safeguard and enhance the habitats and biodiversity within the park and make it accessible for public education and outreach, conservation, and research activities. The extension of this park involves, among other things, the construction of park features and landscaping. The existing Mandai Mangrove and Mudflat is indicated in Figure 1-1.

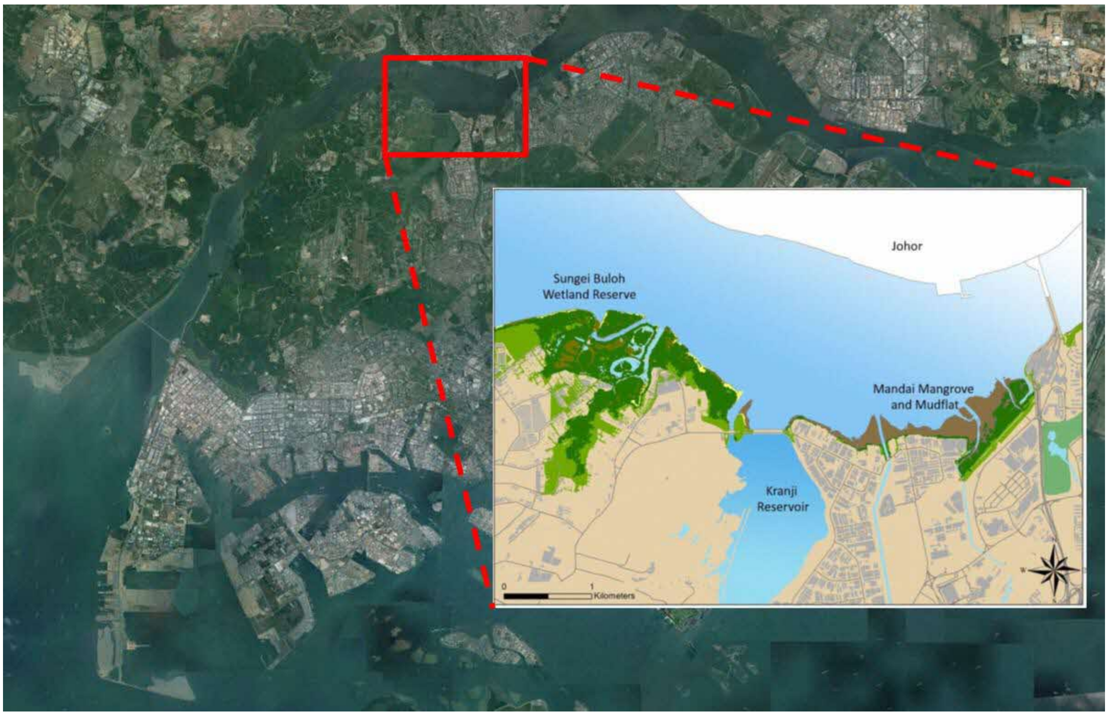


*Figure 1-1: Location of Mandai Mangrove and Mudflat in Singapore (figure source: Google Earth, inset: NParks ITT)*

In support of the development of the extended nature park, NParks requested TEMBUSU Asia Consulting Pte Ltd (Tembusu) and LOOK Architects to carry out the design and engineering. Tembusu requested Deltares to conduct specific parts of the work regarding hydrodynamic, sediment transport and morphodynamic modelling. The project area for the extended Mandai Mangrove and Mudflat is indicated in Figure 1-2.


*Figure 1-2: Site plan of Mandai Mangrove & Mudflat, including the extent of the project area (red dashed line) (figure source: Annex A to project brief Tender Ref.: NPARKS/N/41/2021).*

The scope of Deltares included the modelling of the baseline conditions in the project area (water levels, currents, waves, sediment transport and morphology) and to assess the impacts of the new park features on the surrounding environment by means of hydrodynamic (currents and waves), sediment and morphology modelling. The latter modelling activities will feed into the Environmental Impact Study (EIS) carried out by Tembusu. The modelling approach uses the numerical models (flow & waves) that were setup and validated by Deltares in the 2019 Mandai study (Tembusu et al., 2019) and was presented in Deltares (2022) as input to the inception report. The objectives, approach and results of the numerical modelling as input to the EIS are presented in this report.

## 1.2 Modelling objectives

As input to the EIS, the following aspects were assessed by means of numerical modelling:

1. changes to the hydrodynamics (water levels, currents and waves) as a result of the construction of the Experiential Walk (i.e., placement of the boardwalk and excavation) in the intertidal zone (‘wet infrastructure');
2. changes to sediment dynamics and morphodynamics as a result of the interventions mentioned under #1; and
3. changes to the hydrodynamics (water levels, currents and waves), sediment dynamics and morphology as a result of future predicted sea level rise.

## 1.3 Report outline

The new wet infrastructure that is part of the extended Mandai nature park’s spatial layout is presented in Chapter 2. Chapter 3 presents our hydrodynamic modelling approach and the impacts of the new park’s wet infrastructure on the hydrodynamics. The model setup and results for sediment dynamics and morphodynamics are described in Chapter 4. The results and conclusions are summarised in Chapter 5.

# 2 Spatial layout plan and wet infrastructure

According to the latest enhancement plans for the Mandai Mangrove and Mudflat (Figure 2-1 to Figure 2-6, from: LOOK Architects and Tinderbox Landscape Studio, 2022), a Sungei Pangsua Pavilion with an Experiential Walk will be built and improvements will be made to the Kranji Reservoir Park (KRP).

The improvements to the KRP include a new pedestrian bridge and channels that will be created on the island. The bridge is not expected to affect the hydrodynamics and sediments of the area because it does not touch the water (Figure 2-2), based on the plans. The planned channels are indicated in Figure 2-3 and will have an average depth of less than a metre. Based on the small dimensions of these channels, the impact on the local currents and waves are expected to be negligible and not affecting the larger system dynamics. The KRP improvements are not included in this modelling study and thus, the only additional wet infrastructure site included is the Experiential Walk of the Sungei Pangsua Pavilion.

The Sungei Pangsua Pavilion will consist of a viewing tower which will be built on an existing plot of land, protected by a seawall (Figure 2-4). East of the tower, there will be an Experiential Walk. The mudflat in this area will be excavated to allow water to partially inundate the area (Figure 2-5). Cross-sectional images provided by Tembusu (LOOK Architects and Tinderbox Landscape Studio, 2022) were used to schematise the excavation in the model's bathymetry. Specifically, Figure 2-5 is a cross-section at the Experiential Walk showing a bed level which is partially inundated versus Figure 2-6 shows a cross-section to the east of the Experiential Walk, where offices and ground-level structures are planned. The difference between the bedlevels indicated in these figures is approximately one meter.

Recently, NParks decided to apply a uniform coastal slope of 1:5 along the coastline of the park (LOOK Architects and Tinderbox Landscape Studio, 2023). Details of these changes and an assessment of their impact on hydrodynamics are presented in Appendix A.

The schematisation of the Experiential Walk in the hydrodynamic model is discussed in Section 3.1 and 3.2.


*Figure 2-1: Location of new wet infrastructure, Sungei Pangsua Pavilion (from: LOOK Architects and Tinderbox Landscape Studio, 2022)*

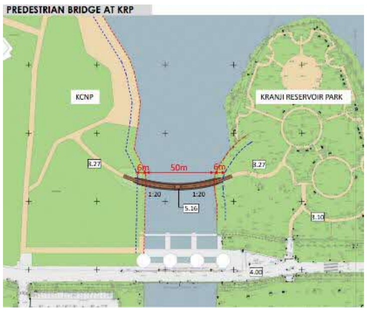


*Figure 2-2: Planned pedestrian bridge at Kranji Reservoir Park (KRP) (from: Client Consultant Meeting 11 with NParks, 20 September 2022)*


*Figure 2-3: Plans for Kranji Reservoir park, indicating the channels to be created to the east (indicated in the figure as "Coastal Incision")*


*Figure 2-4: Experiential Walk at Sungei Pang Sua Pavilion*


*Figure 2-5: Experiential Walk cross-sectional profile. Cross-sectional pane is shown on the upper left in yellow. The dashed yellow line indicates the bed level, to be compared with the dashed yellow line in Figure 2-6.*

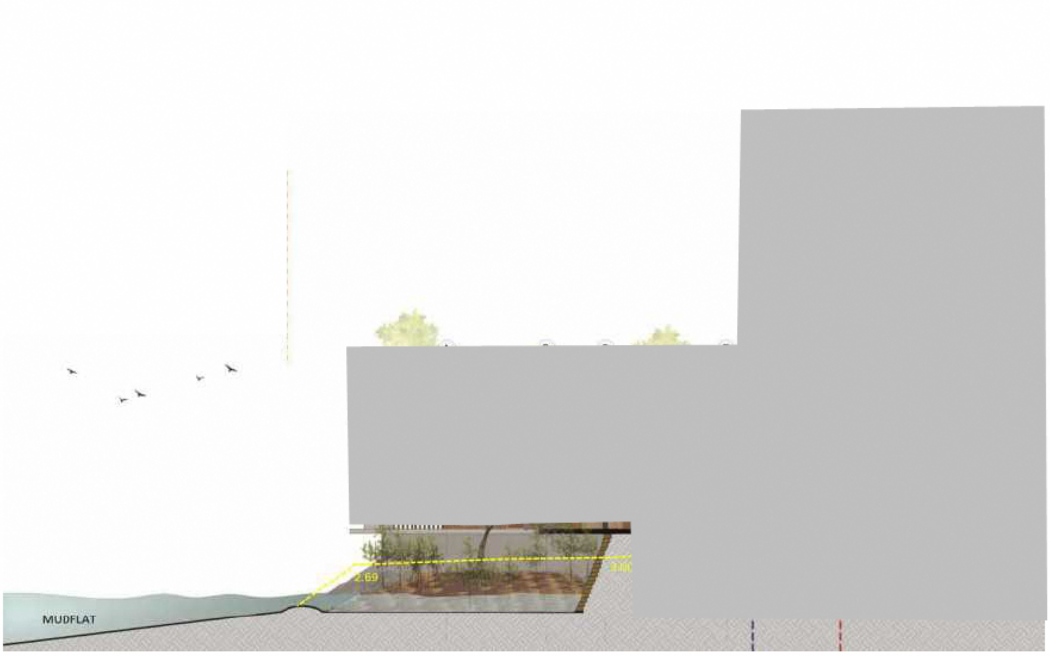


*Figure 2-6: Cross-sectional profile east of the Experiential Walk, showing what is assumed to be a similar ground level before excavation. Cross-sectional pane is shown on the upper left in yellow. The dashed yellow line indicates the bed level, which is markedly higher than in Figure 2-5.*

# 3 Impacts on water levels, currents and waves

## 3.1 Introduction

The impacts of the extension of the Mandai park on the hydrodynamics were assessed by means of hydrodynamic modelling. In terms of ‘wet infrastructure’, the main future development is the Sungei Pangsua Pavilion. The developments for this pavilion include an Experiential Walk in the water, for which wet infrastructure is to be built (presented in Section 2).

For the numerical modelling, the Delft3D-FLOW and Delft3D-WAVE models from the 2019 Mandai study were used (Tembusu et al, 2019). Figure 3-1 shows the computational grid for the entire model domain. The bathymetry is updated with data provided to Deltares by Tembusu. In addition, the Experiential Walk support piles and excavation were incorporated into the models. As the resolution of the model’s computational grid (approximately 10 m × 10 m) is larger than the Experiential Walk structures (order of a few decimetres), the piles that are in the wet model domain are included as sub-grid features which cause partial blocking of flow and waves. The bathymetry of the model at the location of the Experiential Walk was deepened with one meter (refer to Section 2).

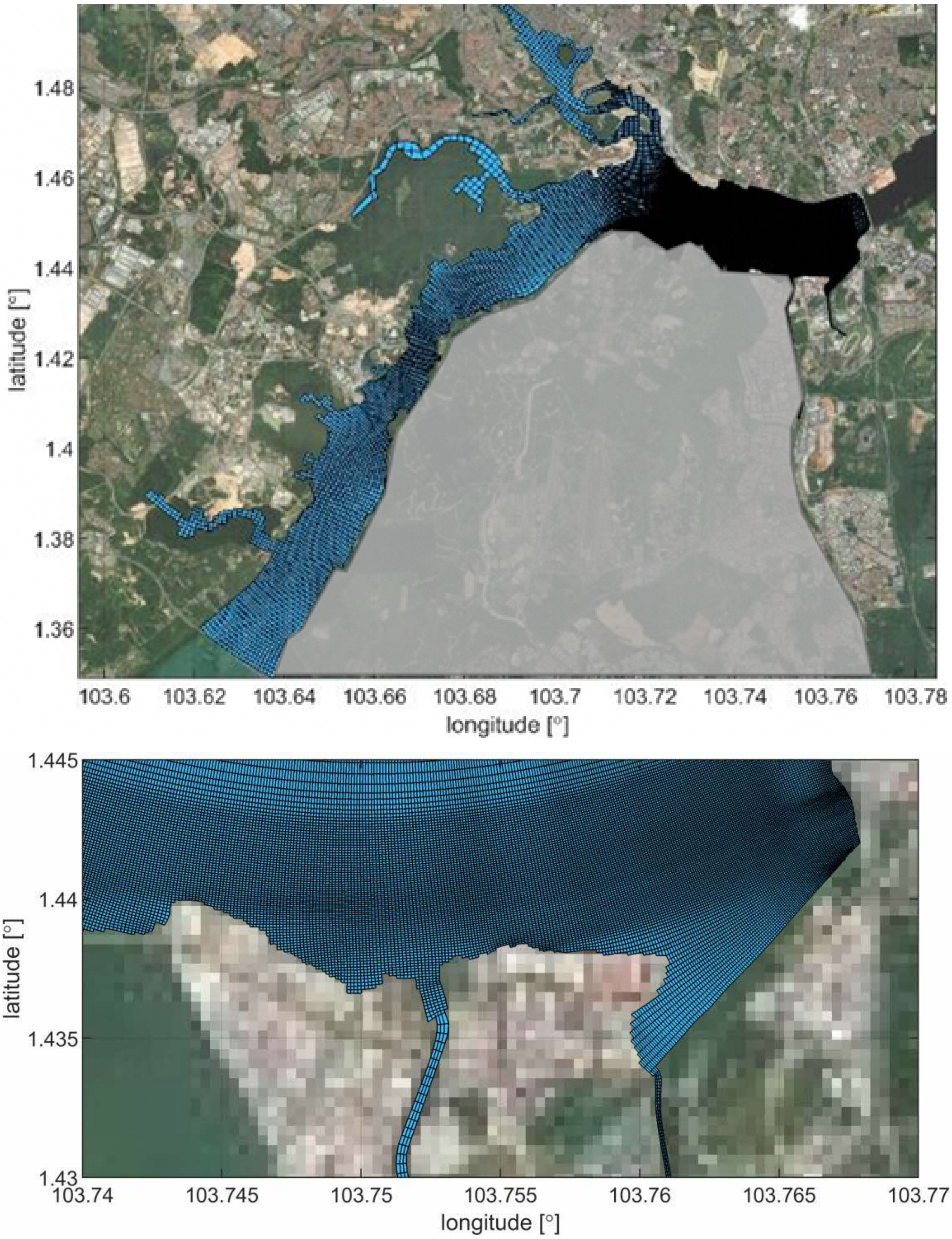


*Figure 3-1: Extent of the computational grid for the entire model domain (upper panel) and zoomed (bottom panel) into the project area of Mandai Park.*

After implementing these changes, the models are run for scenarios representing normal monsoon conditions, extreme high tide (King Tide), squall, and scenarios accounting for El Niño Southern Oscillation (ENSO). To assess the impact of sea level rise on the area, simulations are performed with predicted water levels for 2030, 2050, and 2100.

The results of the hydrodynamic modelling are presented in Section 3.3 as difference plots between the baseline modelling result and the scenario with the park wet infrastructure included. Differences are presented spatially in map figures and as timeseries at representative locations in the model domain. First, in Section 3.2, the update of the models and considered modelling scenarios are described.

## 3.2 Model configuration and scenarios

The model configuration of the first Mandai study was updated to include an improved grid, the new bathymetric data and discharge from the Kranji Dam. These are discussed in Section 3.2.1. Although the simulated conditions are largely the same as those in the 2019 study, some adjustments have been made to account for ENSO conditions and to include additional sea level rise scenarios. The updated scenarios are discussed in Section 3.2.2.

### 3.2.1 Model configuration

*Updated grid and bathymetry*

In comparison with the 2019 study, the grid was improved to match the exact locations of the channels and additional cells on the coastline. A hydrographic survey and Lidar measurements were carried out in 2022 and were provided to Deltares by Tembusu. This new data was implemented in the model bathymetry. In the remainder of the model domain outside of this new dataset, bathymetric information from the 2019 study (Figure 3-2) is used. In comparison with the 2019 bathymetry, the most significant changes are in front of the Kranji Dam. In the area extending away from the dam there is a deepening of approximately 4 meters, while some areas along the coast are now shallower by 4 metres. During the set-up of the model, this area was outside of the area of interest and no high resolution bathymetric data was available for this channel. Around the mudflat and in Sungei Pangsua, many areas are deeper in the new bathymetry, with differences of up to 2 metres. Waterlevels and currents with the updated bathymetry were compared with 2019 data collected at the ADCP 2 point (Figure 3-2) and showed no significant effect.

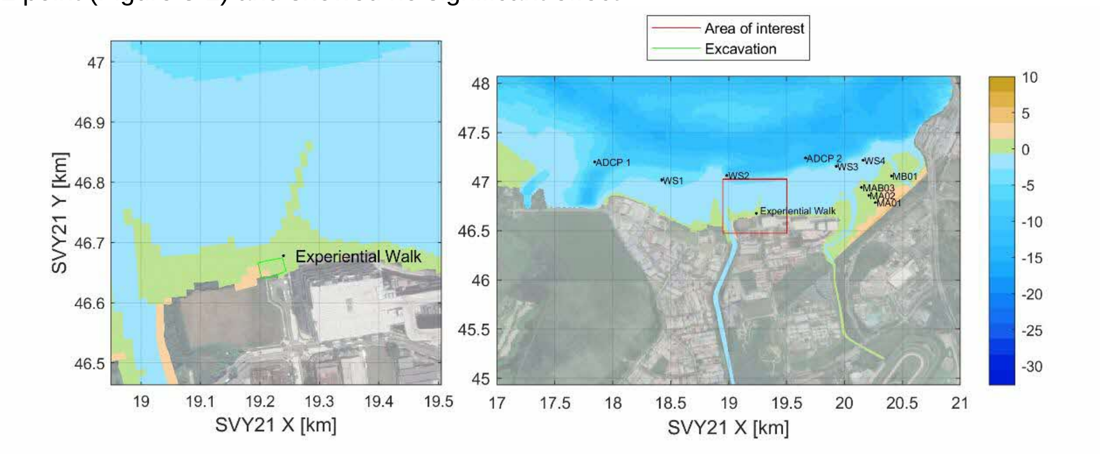


*Figure 3-2: Model bathymetry and control points.*

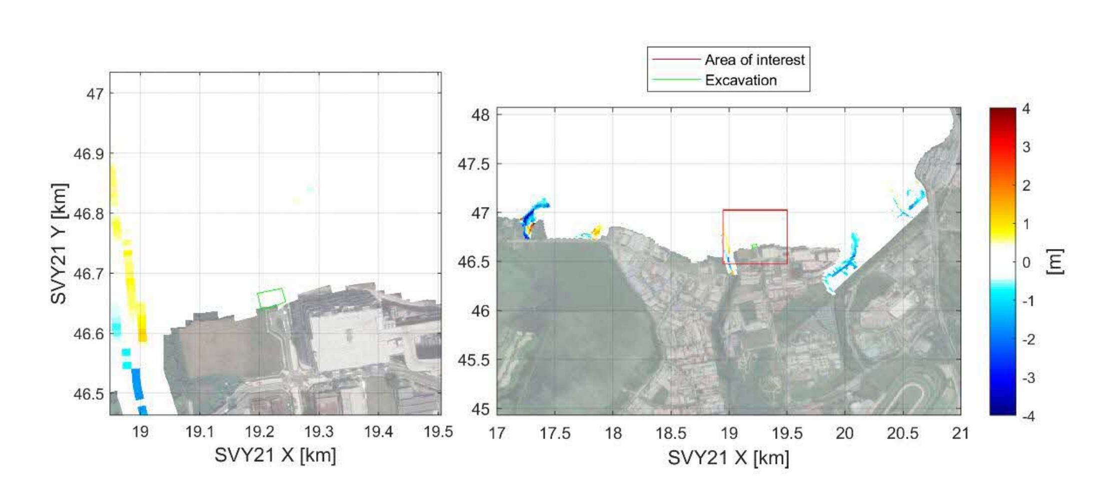


*Figure 3-3: The change in bathymetry from Mandai the 2019 study to this study, incorporating new measurements taken in 2022. Negative values indicate a deepening, compared to the 2019 study.*

*Discharge from Kranji Dam*

A discharge from the Kranji Dam (see location in Figure 3-2) is included in the hydrodynamic model based on the study of Xing et al. (2012), who state that within their 59-day observation period from April to June 2007, release events were observed ranging from 1 - 6 hours and averaging 3 hours and 15 minutes. The total discharge recorded was $1.6 \times 10^7$ $m^3$ within this time period. From this information, one discharge event was included every two days approximately (specifically every 4 tidal cycles), such that the discharge coincides with the ebb tide. The motivation behind this tidal timing is that operators would likely discharge during ebb tide, when the currents are directed towards the open sea. The rate of the discharge is 40 $m^3$/s, which is computed from the total discharge mentioned. Each discharge event lasts for 3 hours and 15 minutes, except during the large squall simulations when heavy rainfall is assumed and then the duration would be the longest possible (6 hours) with the same discharge rate.

*Vegetation*

Around the Johor Strait there are many mangrove areas. In our model, they are implemented as shown in Figure 3-4, where the amount of vegetation per polygon would exert shear stresses on the flow computed by the model software depending on the prevailing water level condition, vegetation type, stem diameter, and amount of vegetation. Extensive mangrove areas are also located at Sungei Buloh Wetland Reserve and at the existing Mandai Mangrove area in the East. Along the extended Mandai park (project area) a narrow strip of mangroves is schematised in the model. The mangroves areas implemented in the model have not been altered since the 2019 study.

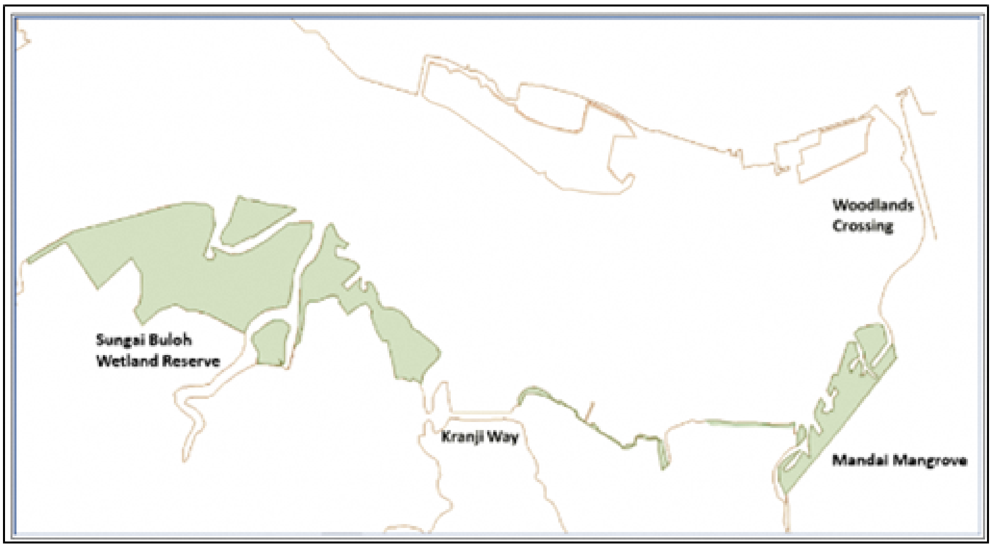


*Figure 3-4: Overview of mangrove areas (green color polygons) in the model.*

### 3.2.2 Model validation

During the model development of the feasibility studies for Mandai Mangroves and Mudflat (Tembusu et al., 2019), the validation performed was limited to the data available at the time: two sets of two-day current measurements from 2015 and two sets of one-week water level and current measurements from 2019, which were data collected for this project. Despite the data constraints, the model demonstrates satisfactory performance in reproducing the tides in the Johor Strait. Because of the limited data availability during the model development, a more extensive model calibration was not possible at that time.

During this project data from Lim Chu Kang's table was provided to the Deltares team, covering the entire month of January 2023. This data was used to validate the hydrodynamic model. A simulation was performed for the covered time period. For the wind forcing in the model, global reanalysis wind data from the ERA-5 database (Hersbach et al., 2023) was used for its ready availability.

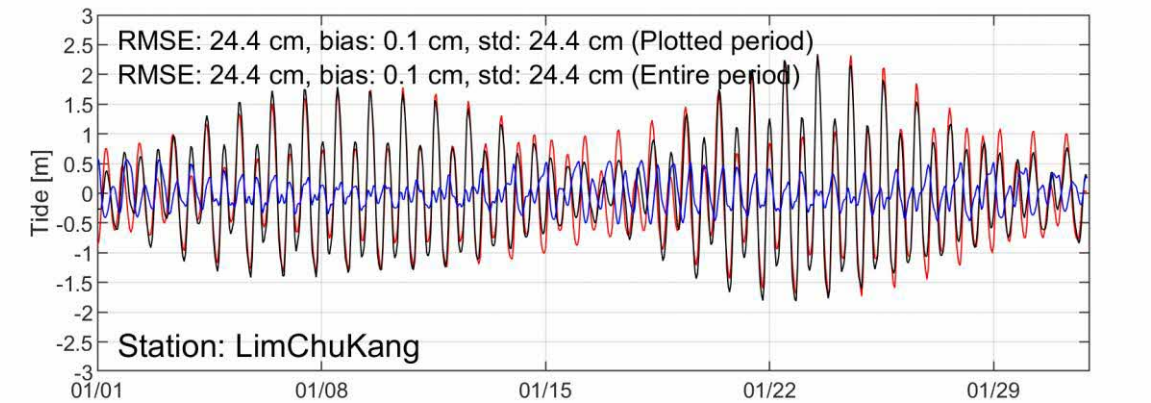


*Figure 3-5: Tidal waterlevels at the Lim Chu Kang station (1°26.8' N, 103°42.4' E) from measurements (red), from model results (black) and the difference between the two (blue). Text shows root mean square error (RMSE), bias, and standard deviation (std).*

A comparison between the tides measured and those simulated by the model is presented in Figure 3-5, where the tidal signals are extracted from waterlevels via harmonic analysis. In general, the tides are captured by the model. The phase of the tide shows excellent agreement between the model and measurements. The waterlevels are generally in the correct magnitude and show distinct spring-neap packets which correspond with measurements. However, there are overestimations in the magnitudes approaching spring tide and then underestimations during neap tide, with a root mean square error of 24.4 cm. An analysis performed on the tidal constituents shows that the most significant error is in the $S_2$ component, which is among the main components of the spring-neap cycle. Thus, the error in the modelled constituents explains the mismatch between these cycles in model and observations.

It should be noted that a one-month period is relatively short for such a validation and calibrating the tidal constituents at the model boundary is not expected to affect the model results significantly, nor the conclusion of this study. For a model that has not been calibrated based on a large dataset of observations, the representation of the tides at Lim Chu Kang is satisfactory.

### 3.2.3 Updated scenarios

Descriptions of the most relevant model inputs are provided below. For more information on the model set-up, refer to Tembusu et al. (2019). A summary of the various runs is presented in Table 3-1.

*Tides*

Tidal action in the model is included by means of astronomic boundary conditions at the southwestern entrance of the Johor Strait, obtained from the Singapore Regional Model (Kurniawan et al., 2009; Kurniawan et al., 2011). Since the planned wet infrastructure is located in the more elevated locations in the model, the selected simulation period includes an extreme high tide event with a water level of 2.08 m above Singapore Height Datum (SHD, approximately equal to mean sea level) on June 6, 2019. The Highest Astronomical Tide (HAT) at Mandai Mangroves Mudflat is of a similar height of 2.14 m above SHD. The total model simulation period covers a complete spring-neap tide cycle in June 2019, covering this so-called King Tide event.

*Meteorological forcing*

During this spring-neap cycle, the hydrodynamic modelling was performed for both NE and SW monsoon conditions. The applied wind for these conditions was based on the 10-minute measured time series at station Admiralty (Tembusu et al., 2019), identical to the implementation in the 2019 study. In addition to these seasonal conditions, a separate simulation was performed for an extreme squall event coinciding with extreme high water on June 6, 2019. The squall event is also taken to be representative of La Niña conditions during which such weather events can be amplified. Such a situation was observed during the June months of 2010 where rains and squall events were intensified by the rapidly developing La Niña conditions developing in the region during June-July of that year (Meteorological Service Singapore, 2010). The parameterized squall event has wind speeds of 15 m/s, originates from the West or 270°, and occurs from June 5 at 23:00 – June 6 at 03:00. This is identical to the squall implemented in the 2019 study, except with higher wind speeds (previously 12 m/s) which were observed in the 2010 La Niña conditions. Due to the effect on rainfall, the duration of the Kranji dam discharge is also increased to the maximum observed in the study of Xing et al. (2012), i.e. six hours. On the other hand, taking one of the worst recent El Niño occurrences, 2015 as an example, Singapore experienced record low rainfall and high temperatures in the months of June and July, respectively (Meteorological Service Singapore, 2015a). Although warm and dry conditions are typical of El Niño, they cannot be represented in the model because precipitation, temperature, and salinity are not included. The winds from June-July 2015 are consistent with SW monsoon conditions and thus, this scenario is representative of El Niño conditions.

*Sea level rise*

To assess the impact of sea level rise on the experiential walk, simulations were performed to compare the present-day and future hydrodynamic conditions around the structure. The worst case scenario sea level rise projections are used for the years 2030, 2050, and 2100. In consultation with Tembusu, the upper values for RCP8.5[1] were used, based on local predictions by the Meteorological Service Singapore (2015b) for the years 2050 and 2100. The value for 2030 was a linear interpolation from present-day to 2050. Thus, the final values implemented were 0.10 m for 2030, 0.32 m for 2050 and 1.02 m for 2100. It is notable that the upper value presented for RCP4.5, a more moderate scenario, in 2050 is quite similar (0.30 m) to the RCP 8.5 upper value (0.32 m), so the model results for 2030 and 2050 can be interpreted as representative for both RCP scenarios.

*Table 3-1: Scenarios with and without Sungei Pangsua pavilion and Experiential Walk. Four sea level rise (SLR) conditions are considered. All runs include a King Tide.*

| **No SLR**<br>**0.00 m** | **SLR in 2030**<br>**0.10 m** | **SLR in 2050**<br>**0.32 m** | **SLR in 2100**<br>**1.02 m** |
|---|---|---|---|
| SW monsoon<br>with King Tide<br>(also representative<br>of El Niño) | SW monsoon<br>with King Tide<br>(also representative<br>of El Niño) | SW monsoon<br>with King Tide<br>(also representative<br>of El Niño) | SW monsoon<br>with King Tide<br>(also representative<br>of El Niño) |
| NE monsoon<br>with King Tide | - | - | - |
| Extreme squall<br>with 15 m/s winds<br>(also representative<br>of La Niña)<br>with King Tide | - | - | - |

## 3.3 Hydrodynamic modelling results

Model results are analysed at points near the wet infrastructure. An overview of the locations is provided in Figure 3-2.

### 3.3.1 Monsoon conditions

*Water levels*

At the site of the Experiential Walk, water levels reach a maximum of approximately 2.3 m above Singapore Height Datum (SHD, approximately equal to mean sea level). This is due to the extreme high water event or “King Tide”, and is consistent in both NE and SW monsoon conditions. Figure 3-6 up to Figure 3-9 show spatial pictures of the water level differences between scenarios with and without the Experiential Walk. These figures show the timestep during high water, at 00:00 a.m. on June 6. Simulated waterlevel differences are minor, and at the few locations where differences occur these are less than 1 centimetre large. Only locally, at the location of the excavation, bedlevel differences are up to a metre when the area is dry due to the excavation itself, as these grid cells were not wet in the present situation.

Figure 3-10 is a two-day timeseries immediately in front of the Experiential Walk. The figures on the right show the difference in water levels due to the planned wet infrastructure. Differences are not provided when the computational cells are dry. These figures reveal that the magnitude of these differences is milimetres, and therefore the effect of the planned

[1] Representative Concentration Pathways 8.5, which is the scenario where human society fails to reduce the rate of anthropogenic carbon emissions.

infrastructure on the waterlevels is negligible. Thus, the impact of the Experiential Walk is small and local with the largest effect at the excavation site itself. A minimal increase in waterlevels in the order of milimetres is visible to the east in the direct vicinity.

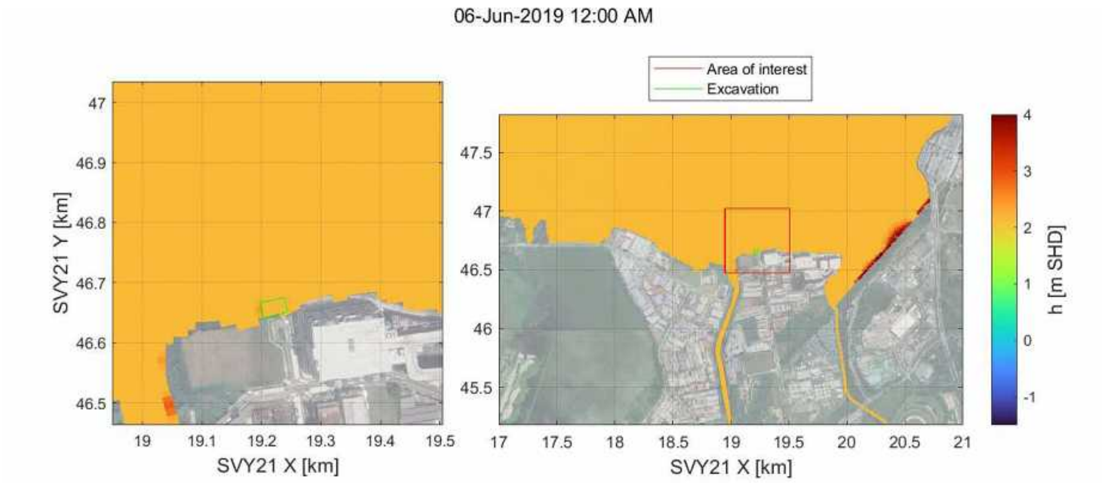


*Figure 3-6: Modelled waterlevels (h) after the implementation of the experiential walk at high water 12:00 a.m. of June 6, 2019 for SW monsoon conditions.*

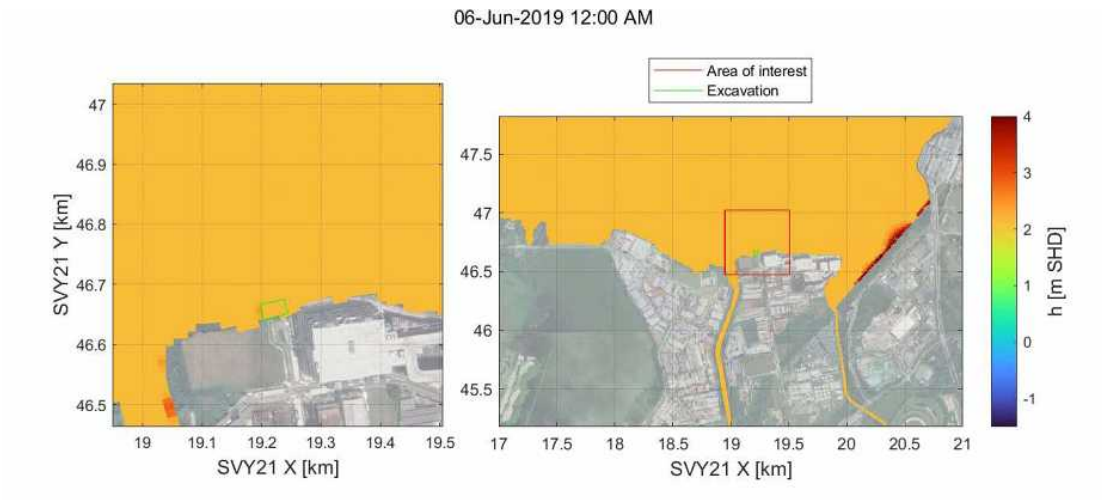


*Figure 3-7: Modelled waterlevels (h) after the implementation of the experiential walk at high water 12:00 a.m. of June 6, 2019 for NE monsoon conditions.*

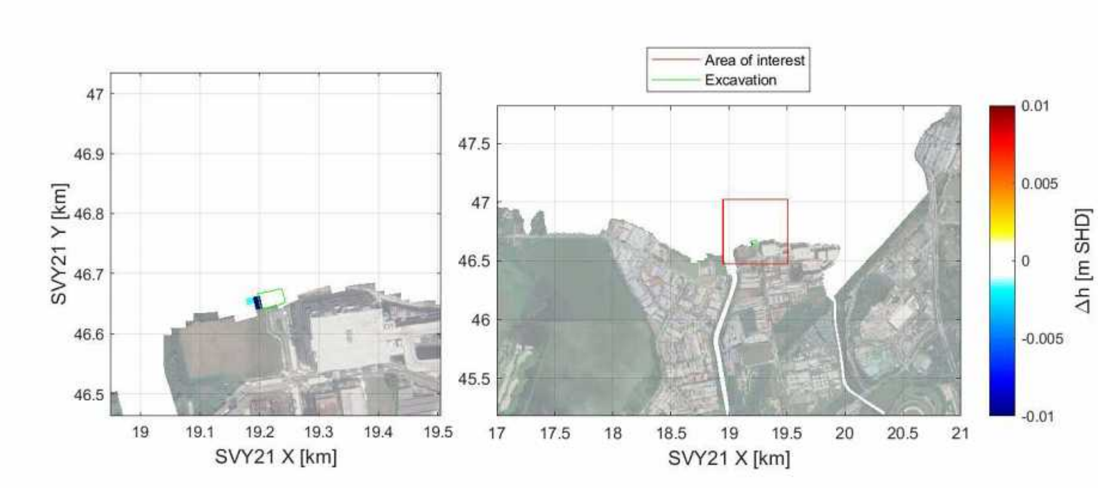


*Figure 3-8: Modelled waterlevel differences (Δh) after the implementation of the experiential walk at high water 12:00 a.m. of June 6, 2019 for SW monsoon conditions.*

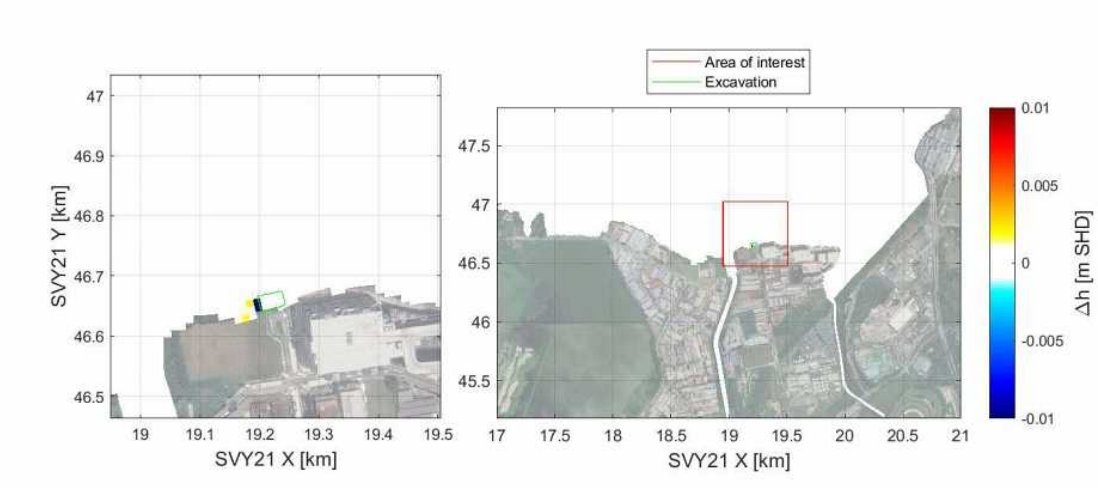


*Figure 3-9: Modelled waterlevel differences (Δh) after the implementation of the experiential walk at high water 12:00 a.m. of June 6, 2019 for NE monsoon conditions.*

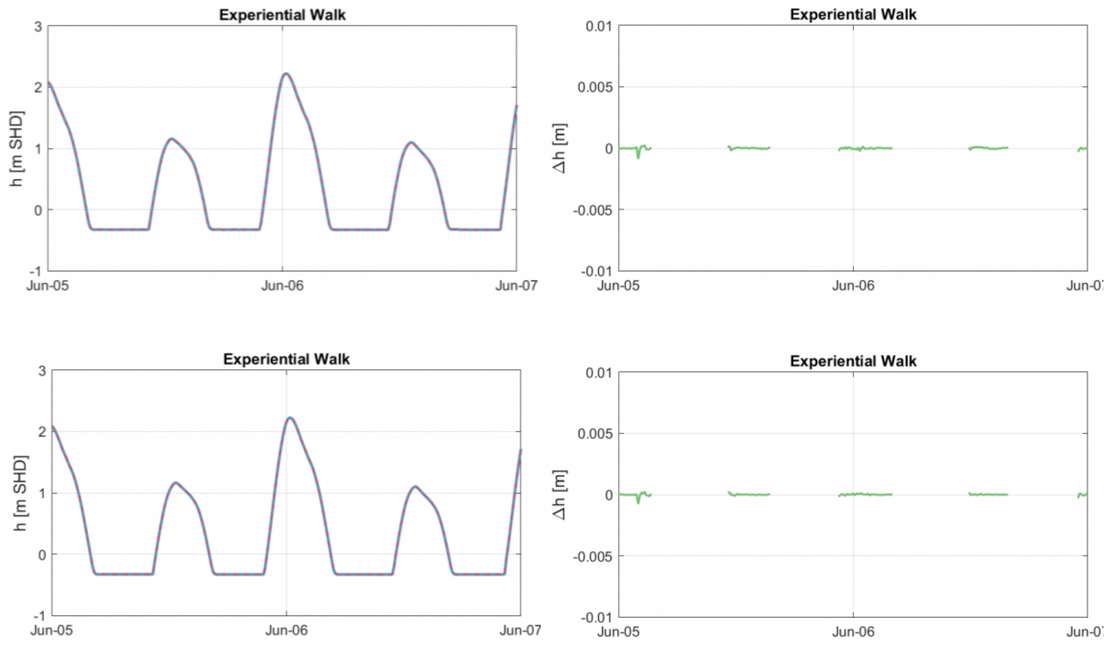


*Figure 3-10: Water levels (h) at the Experiential Walk without (blue) and with (red) the wet infrastructure and water level differences (green) for a NE monsoon (top) and SW monsoon (bottom).*

*Currents*

Current magnitudes at the coastline where the Sungei Pangsua Pavilion and Experiential Walk will be located are very small, generally less than 0.02 m/s (Tembusu et al., 2019). This holds true in the model simulations with and without the Experiential Walk. In Figure 3-11 and Figure 3-12, the modelled currents show low velocity magnitudes around the coast respectively for SW monsoon and NW monsoon conditions. Differences in the simulations with the Experiential Walk are revealed in Figure 3-13 and Figure 3-14. In Figure 3-19, the time series shows velocity magnitudes around 0.02 m/s throughout the two-day period with very small (<0.01 m/s) differences caused by the Experiential Walk.

*Waves*

Significant wave heights at the Experiential Walk are small during both monsoon conditions (Figure 3-15 and Figure 3-16) with a height of up to 0.2 m approximately. During the NE monsoon, Figure 3-18 shows no differences in significant wave height while during the SW monsoon, differences up to 0.05 m can be seen (Figure 3-17). These differences are located away from the coast (approximately 200 m away) and are relatively small. In the timeseries plots (Figure 3-20) at the Experiential Walk, the differences in significant wave height are seen to be less than 0.005 m. Thus, the effect of the planned wet infrastructure on the waterlevels is not significant.

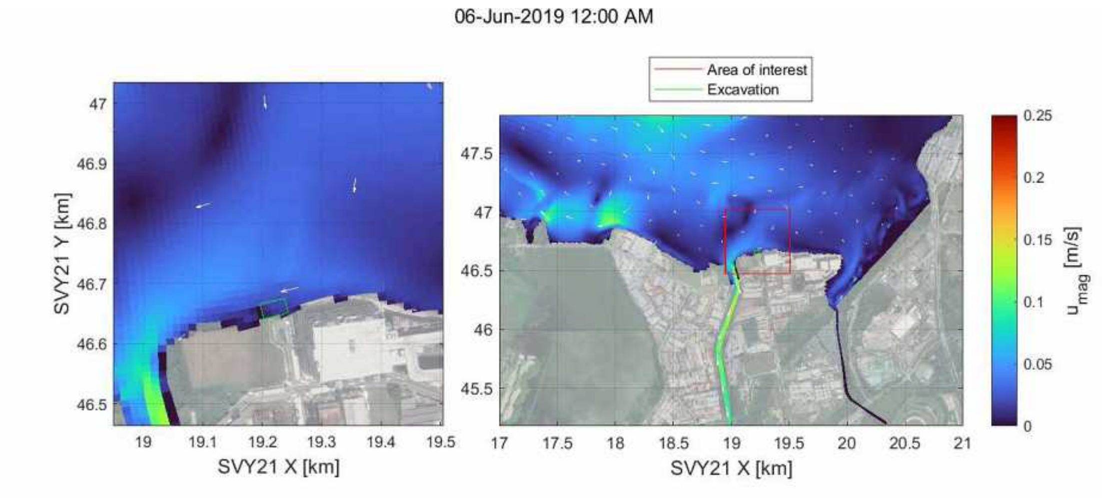


*Figure 3-11: Modelled currents ($u_{mag}$) with the experiential walk at high tide, 00:00 a.m. of June 6 for SW monsoon conditions.*

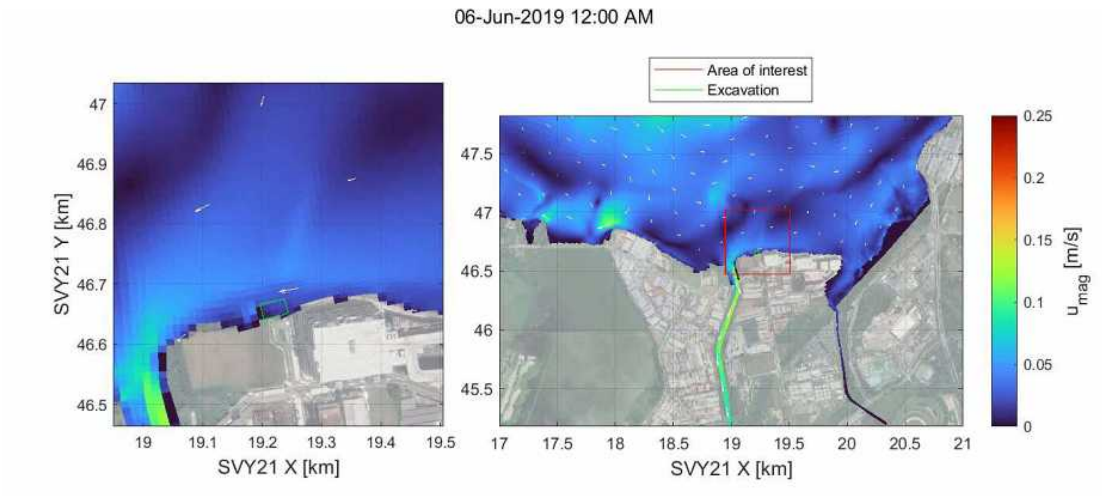


*Figure 3-12: Modelled currents ($u_{mag}$) with the experiential walk at high tide, 00:00 a.m. of June 6 for NE monsoon conditions.*

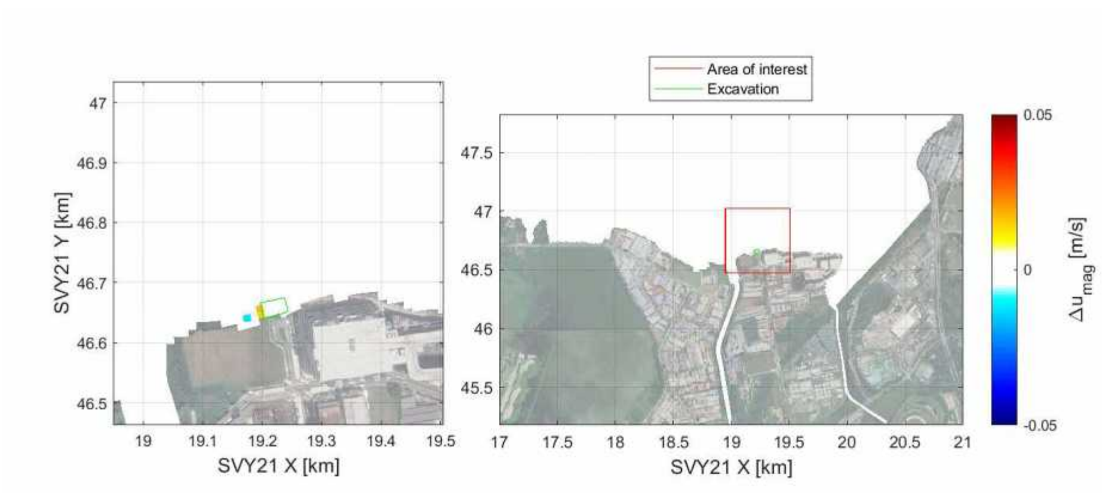


*Figure 3-13: Modelled current differences (Δumag) with the experiential walk at high tide, 00:00 a.m. of June 6 for SW monsoon conditions.*

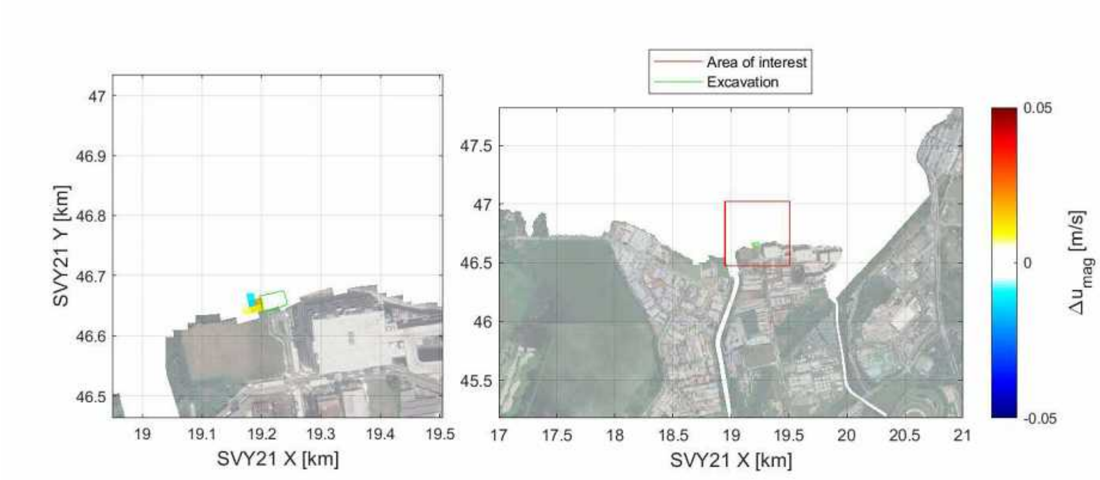


*Figure 3-14: Modelled current differences ($\Delta u_{mag}$) with the experiential walk at high tide, 00:00 a.m. of June 6 for NE monsoon conditions.*

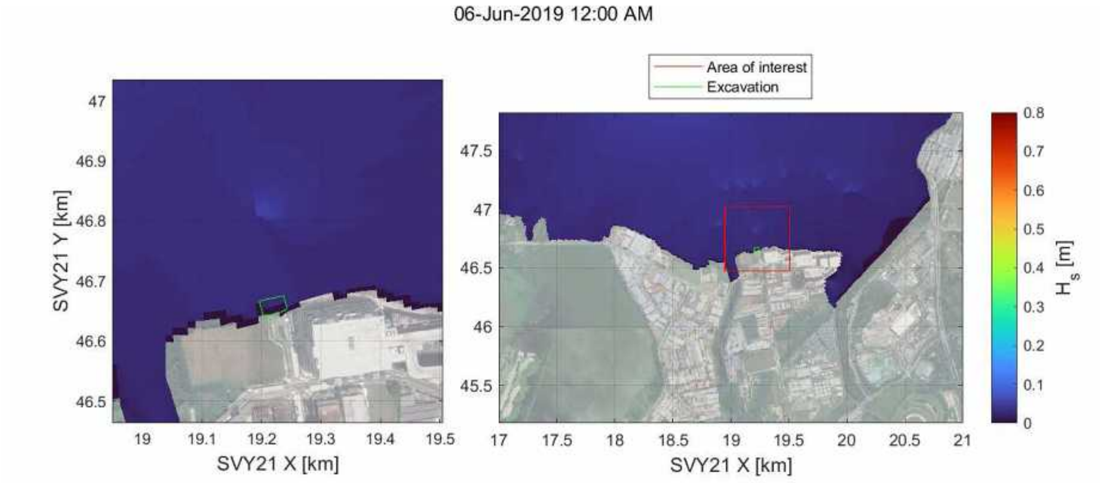


*Figure 3-15: Modelled significant wave heights ($H_s$) with the experiential walk at high tide, 00:00 a.m. of June 6 for SW monsoon conditions.*

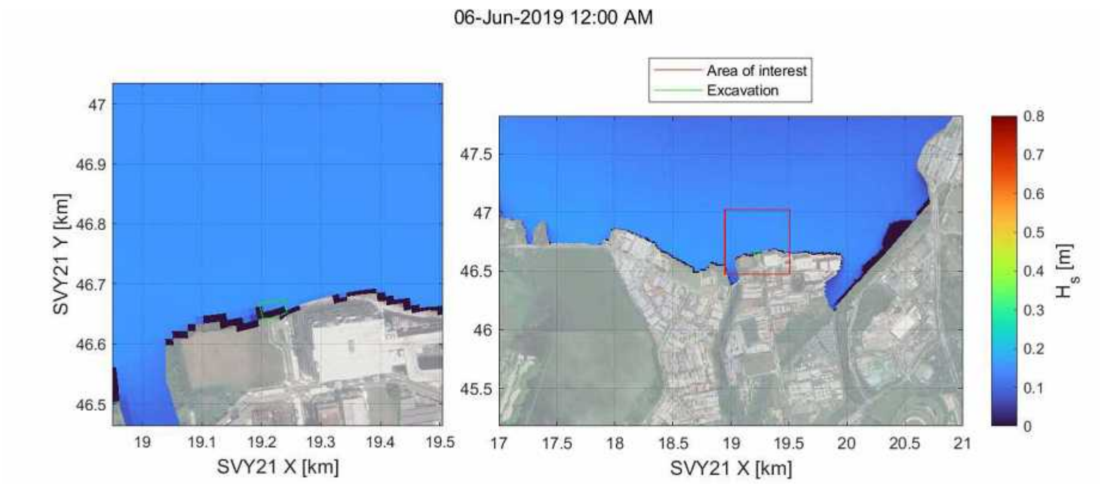


*Figure 3-16: Modelled significant wave heights ($H_s$) with the experiential walk at high tide, 00:00 a.m. of June 6 for NE monsoon conditions.*

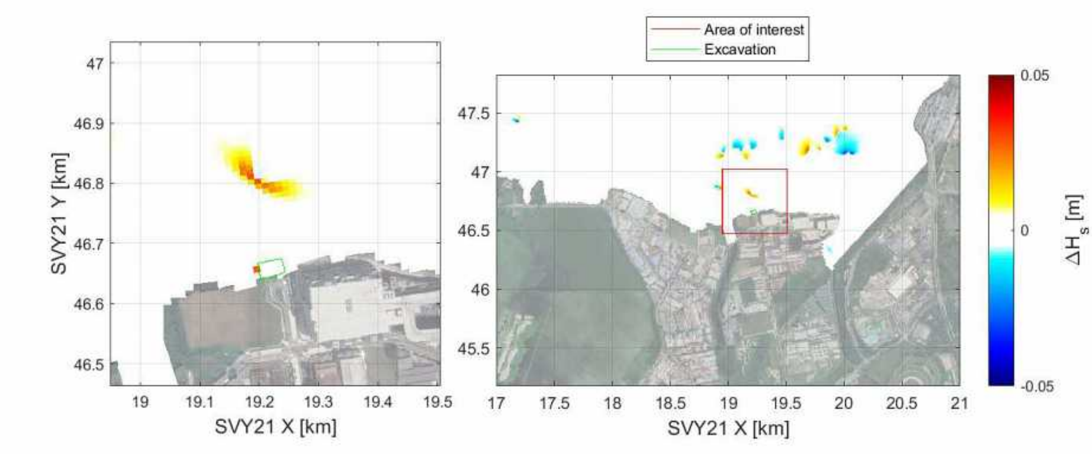


*Figure 3-17: Modelled significant wave height differences ($\Delta H_s$) with and without the experiential walk at high tide, 00:00 a.m. of June 6 for SW monsoon conditions.*

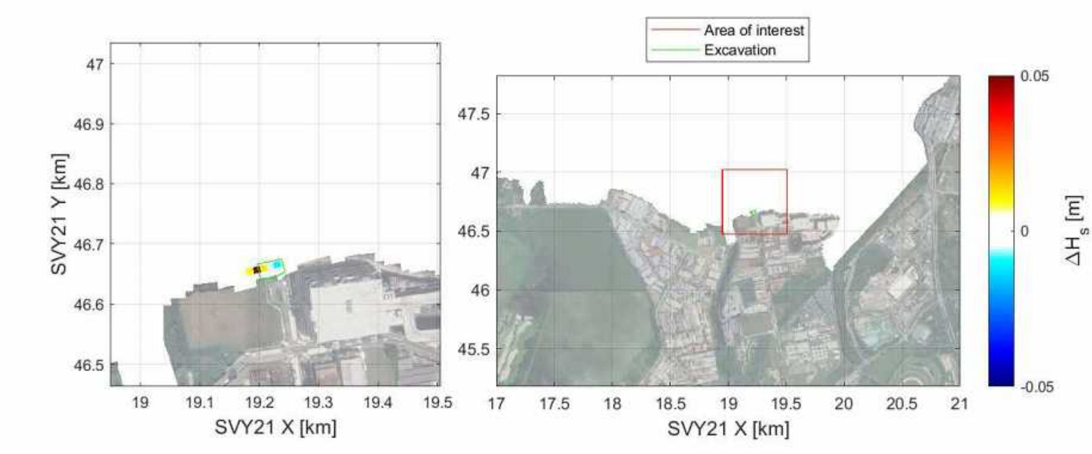


*Figure 3-18: Modelled significant wave height differences ($\Delta H_s$) with and without the experiential walk at high tide, 00:00 a.m. of June 6 for NE monsoon conditions.*

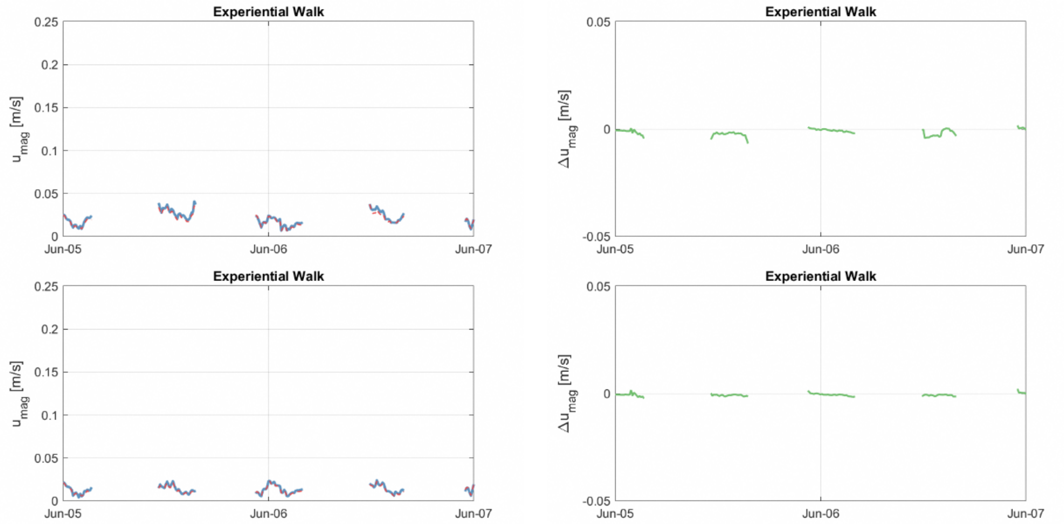


*Figure 3-19: Velocity magnitudes ($u_{mag}$) at the Experiential Walk without (blue) and with (red) the wet infrastructure and velocity magnitude differences (green) for NE monsoon (top) and SW monsoon (bottom).*

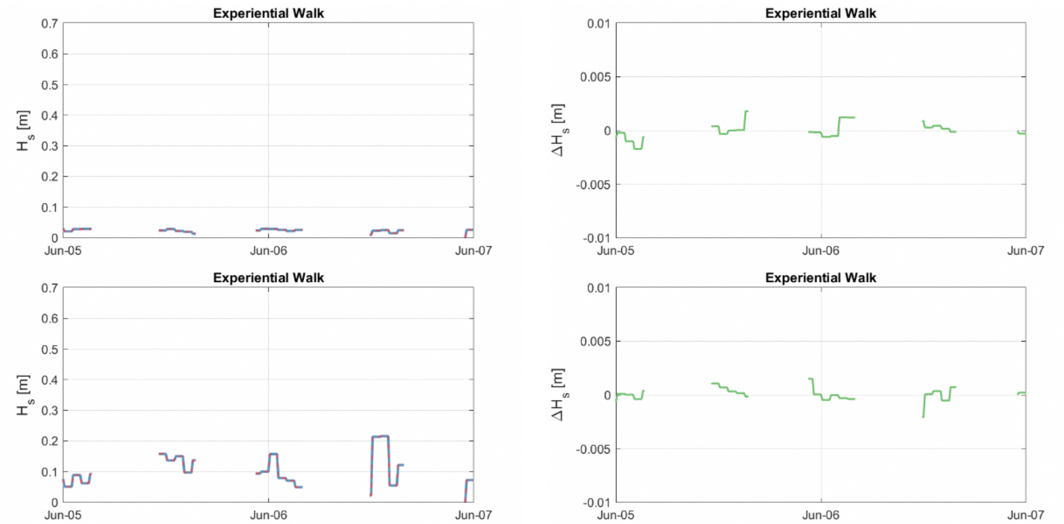


*Figure 3-20: Significant wave heights ($H_s$) at the Experiential Walk without (blue) and with (red) the wet infrastructure  and significant wave height differences (green) for NE monsson (top) and SW monsoon (bottom).*

### 3.3.2 Extreme squall event

The parameterized squall event occurs from June 5 at 11:00 p.m. – June 6 at 03:00 a.m. with winds of 15 m/s, originating from the West or 270°. Figure 3-21 shows the water levels before the event, on June 5 at 06:00 p.m. then water levels during the squall at high water or June 6 at 12:00 a.m. The differences are shown in Figure 3-22 and during the squall event, little difference is shown except at the excavation itself. The timeseries shows that water levels at high tide reach 2.26 m above SHD at the Experiential Walk between midnight and 01:00 a.m. on June 6, 2019 (Figure 3-23). Water level set-up in comparison with both the NE and SW monsoon is limited to 0.04 m and is therefore negligible. With a squall event, the water level differences are shown as a timeseries are still less than 0.002 m (Figure 3-23).

Although the squall event may not have much effect on the water levels, the magnitude of the currents in Figure 3-24 and Figure 3-25 appear higher than in the normal monsoon conditions (e.g. up to 0.25 m/s). However at the location of the Experiential Walk, the timeseries (Figure 3-26) shows current magnitudes up to 0.15 m/s during the duration of the squall. The difference plots show a change of less than 0.02 m/s by adding the wet infrastructure. Thus, during a squall event the current magnitudes are higher but the addition of the Experiential Walk does not significantly change them.

The squall event also causes higher wave heights in comparison with the monsoon conditions, with significant wave heights up to 0.8 m (Figure 3-27, Figure 3-28). This is slightly larger than the significant wave height of 0.6 m that was computed during the 2019 study (Tembusu, 2019), and is caused by the increased wind speed of the squall condition (from 12 m/s to 15 m/s). At the Experiential Walk itself, the wave heights reach approximately 0.6 m. However, just like the current magnitudes, there is not much difference between the model scenarios with the wet infrastructure and without (differences up to 0.015 m). Thus, the building of the Experiential Walk will have a negligible impact on significant wave heights.

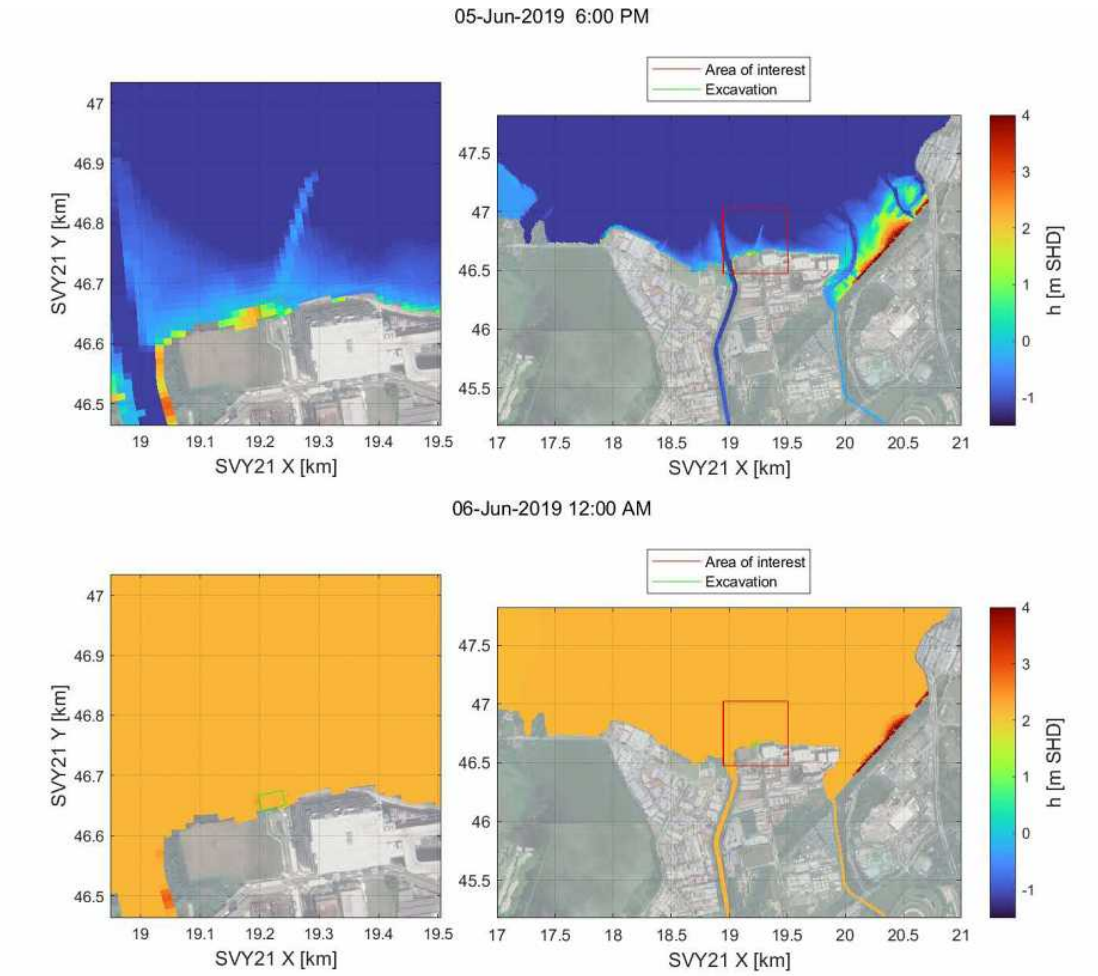


*Figure 3-21 Modelled water level (h) relative to SHD around low water at 06:00 p.m. on June 5, 2019 (top) and at around high water at 00:00 a.m. on June 6, 2019 (bottom) for an extreme squall event.*

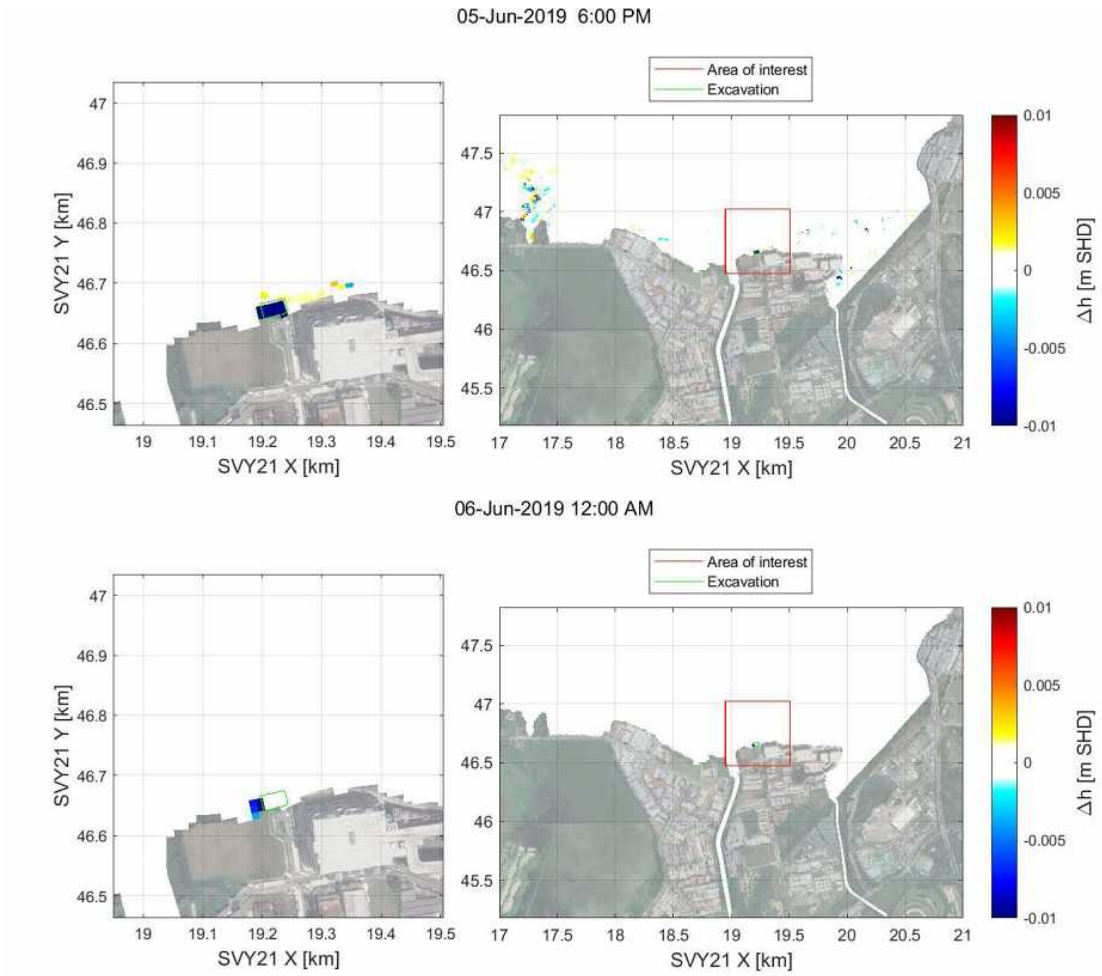


*Figure 3-22: Modelled water level differences (Δh) around low water at 06:00 p.m. on June 5, 2019 (top) and at around high water at 00:00 a.m. on June 6, 2019 (bottom) for an extreme squall event.*

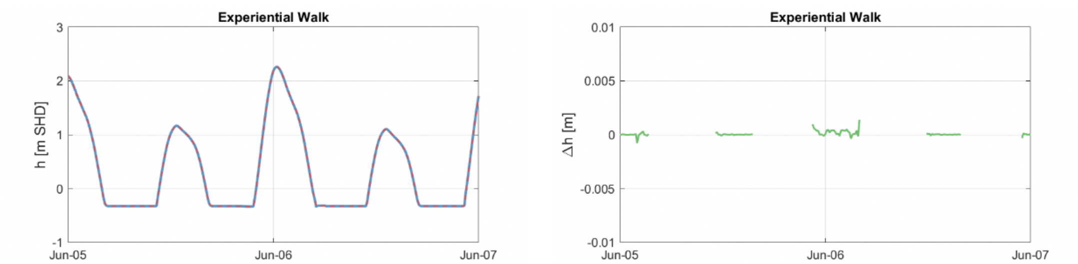


*Figure 3-23: Water levels (h) at the experiential walk without (blue) and with wet infrastructure (red) and water level differences (green) for an extreme squall event.*

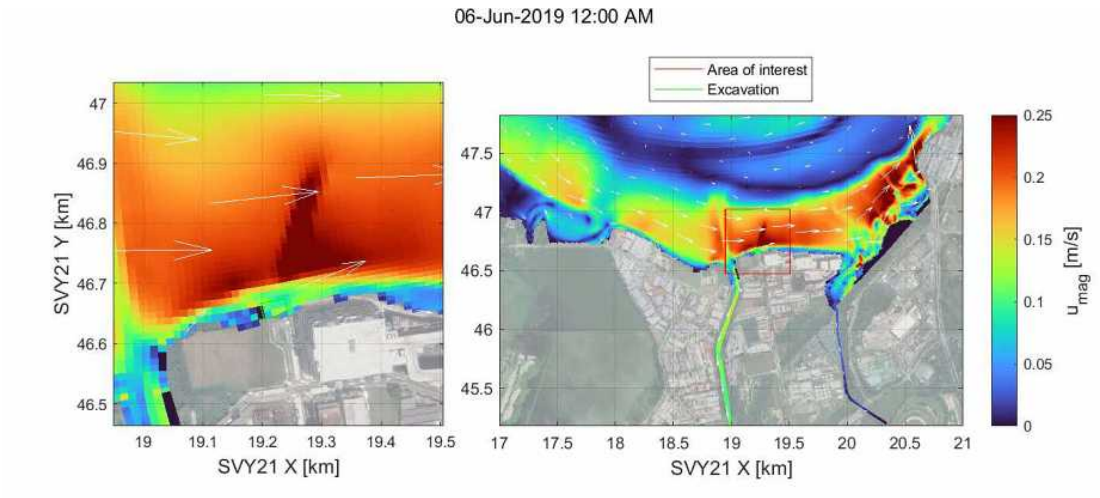


*Figure 3-24: Modelled currents ($u_{mag}$) with the experiential walk at high tide, 00:00 a.m. of June 6 for an extreme squall event.*

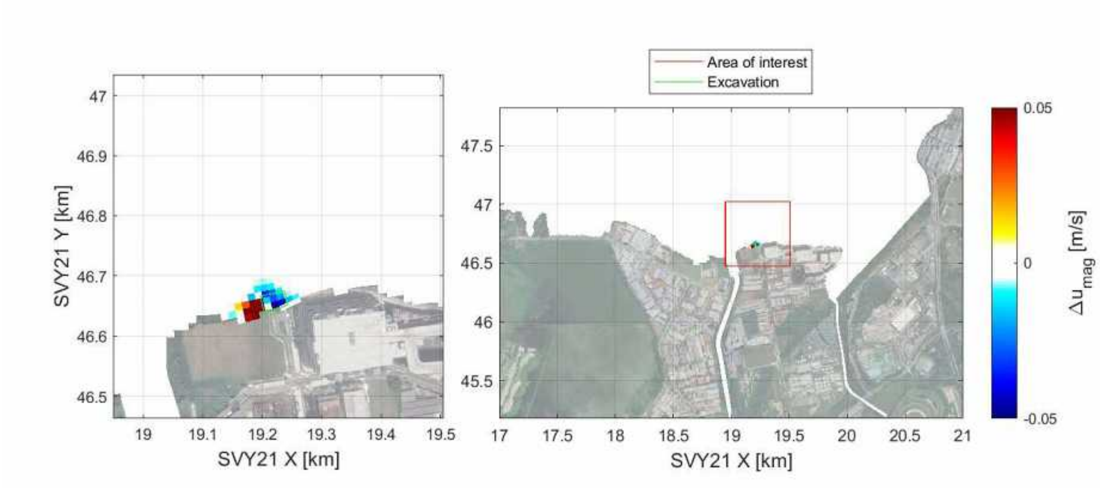


*Figure 3-25: Modelled velocity magnitude differences ($\Delta u_{mag}$) at 00:00 a.m. of June 6 for an extreme squall event.*

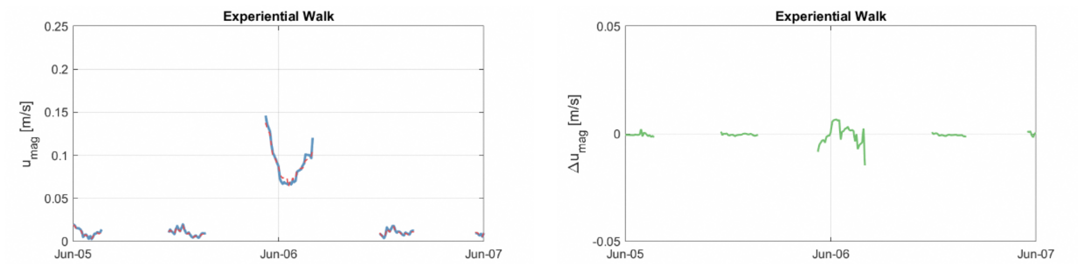


*Figure 3-26: Velocity magnitudes ($u_{mag}$) at the Experiential Walk without (blue) and with wet infrastructure (red) and velocity magnitude differences (green) for an extreme squall event.*

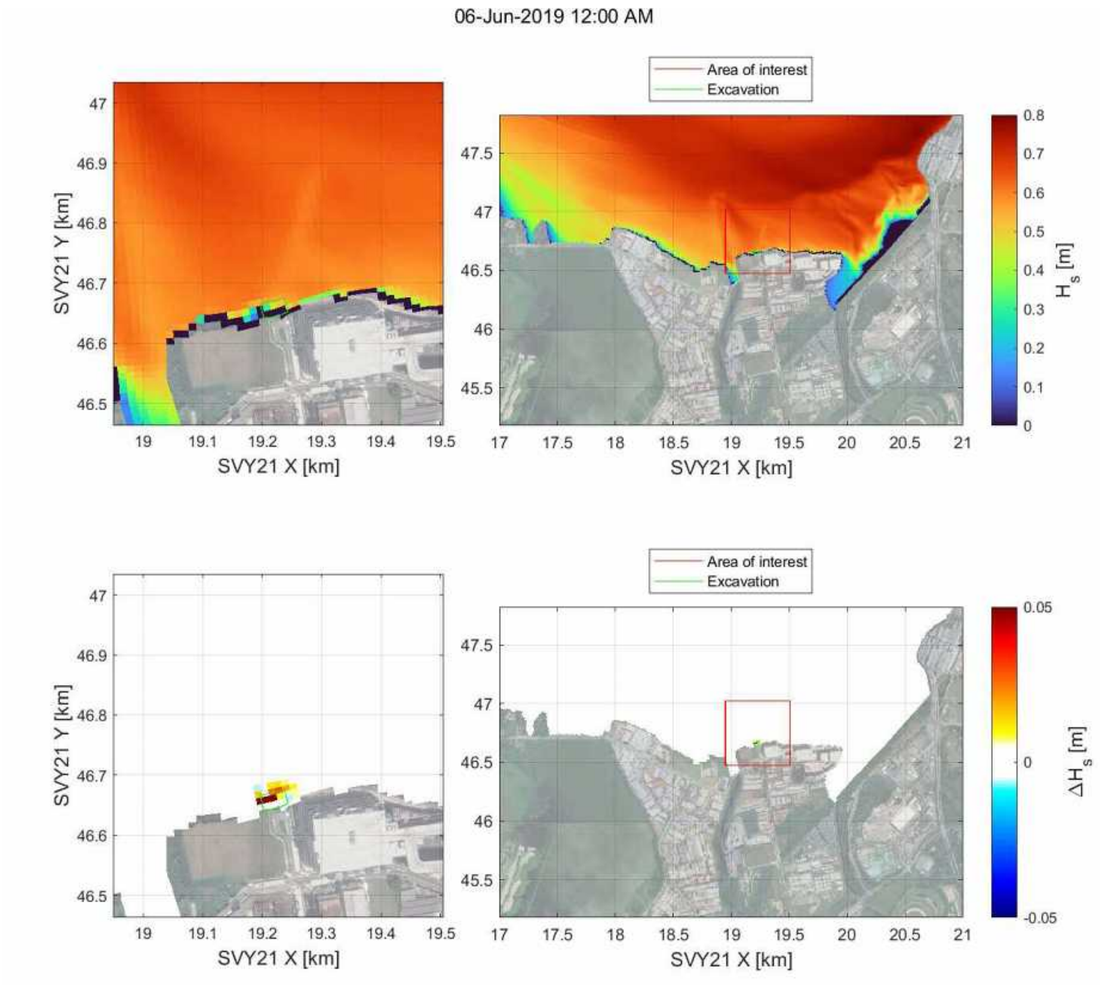


*Figure 3-27: Modelled significant ($H_s$) wave heights at 00:00 a.m. of June 6 (top) and differences (bottom) for an extreme squall event.*

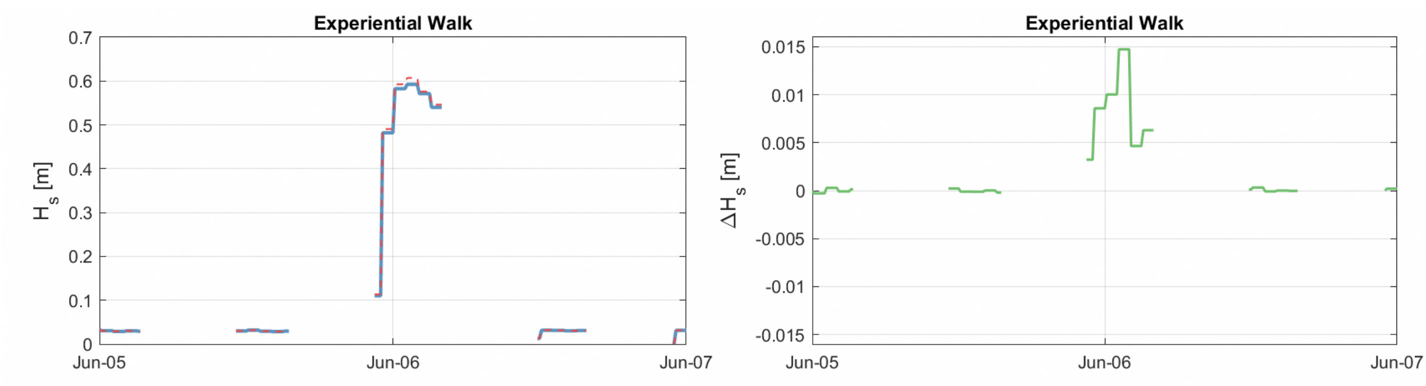


*Figure 3-28: Modelled significant ($H_s$) wave heights at 00:00 a.m. of June 6 (left) and differences (right) for an extreme squall event.*

### 3.3.3 Effects of future Sea Level Rise on the hydrodynamics at Mandai Park

Three different sea level rise scenarios are considered forced with SW monsoon wind conditions. The timeseries for the 2100 scenario with 102 cm sea level rise is shown in Figure 3-29. Timeseries for 2030 with 10 cm sea level rise, and 2050 with 32 cm sea level rise, are presented in Appendix B (2030 in Figure B-1 and Figure B-2; 2050 in Figure B-3 and Figure B-4).

Sea level rise influences the duration throughout which the Experiential Walk area is dry during low water. In all the scenarios, the area will be inundated for longer, increasing with the height of the sea level rise. The modelled velocities and their differences are approximately the same magnitude, namely, below 0.02 m/s (Figure 3-29). The wave heights show an increase of up to 0.03 m from the scenario with no sea level rise to the 2100 scenario (Figure 3-29). Such differences largely result from the instances when the area is dry in the no-sea level rise scenario and when it is still inundated in the sea level rise scenario. Nonetheless, the differences are small. The differences in velocity magnitude and significant wave height in the area are shown in Figure 3-30 for the 102 cm sea level rise scenario; Figure B-2 for 10 cm; and Figure B-4 for 32 cm. The impact of the wet infrastructure is similar for a situation with and without sea level rise, and sea level rise is not expected to have a significant effect on the feasibility or technical lifetime of the Experiential Walk.

Recently, NParks decided to apply a uniform coastal slope of 1:5 along the coastline of the park (LOOK Architects and Tinderbox Landscape Studio, 2023). These changes are above the High Water Mark and thus, these areas along the coastline were not previously considered as they would not be inundated in the simulations. However, the hydrodynamics of the area could be affected in situations with sea level rise. To determine the impact of the slope change, a comparison is presented in Appendix A with and without the slope changes in each sea level rise scenario.

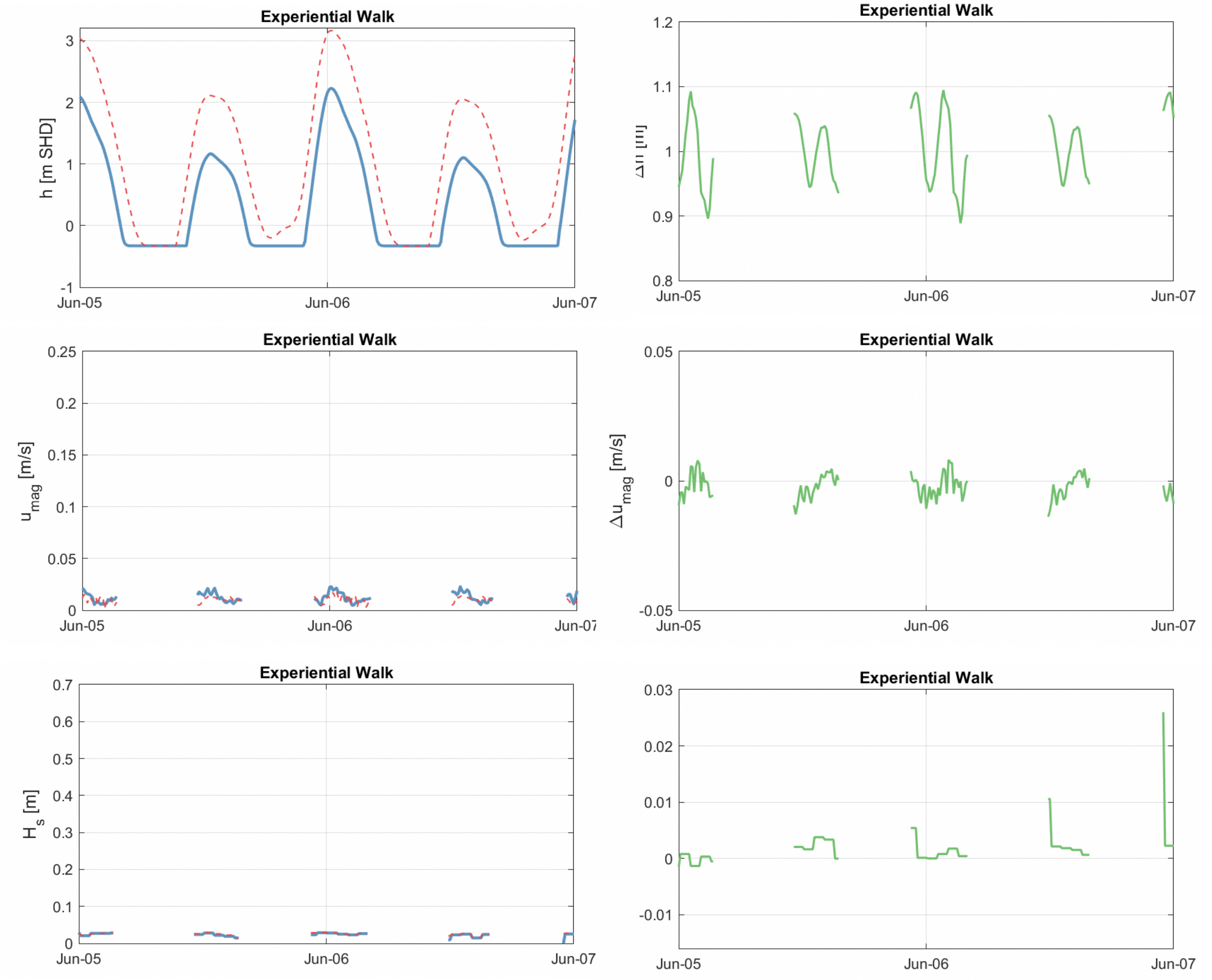


*Figure 3-29: Model results without (blue) and with sea level rise (red) at the Experiential Walk, and the differences (green) for water levels (h, top), velocity magnitudes ($u_{mag}$, middle) and significant wave heights ($H_s$, bottom) for SW monsoon conditions.*

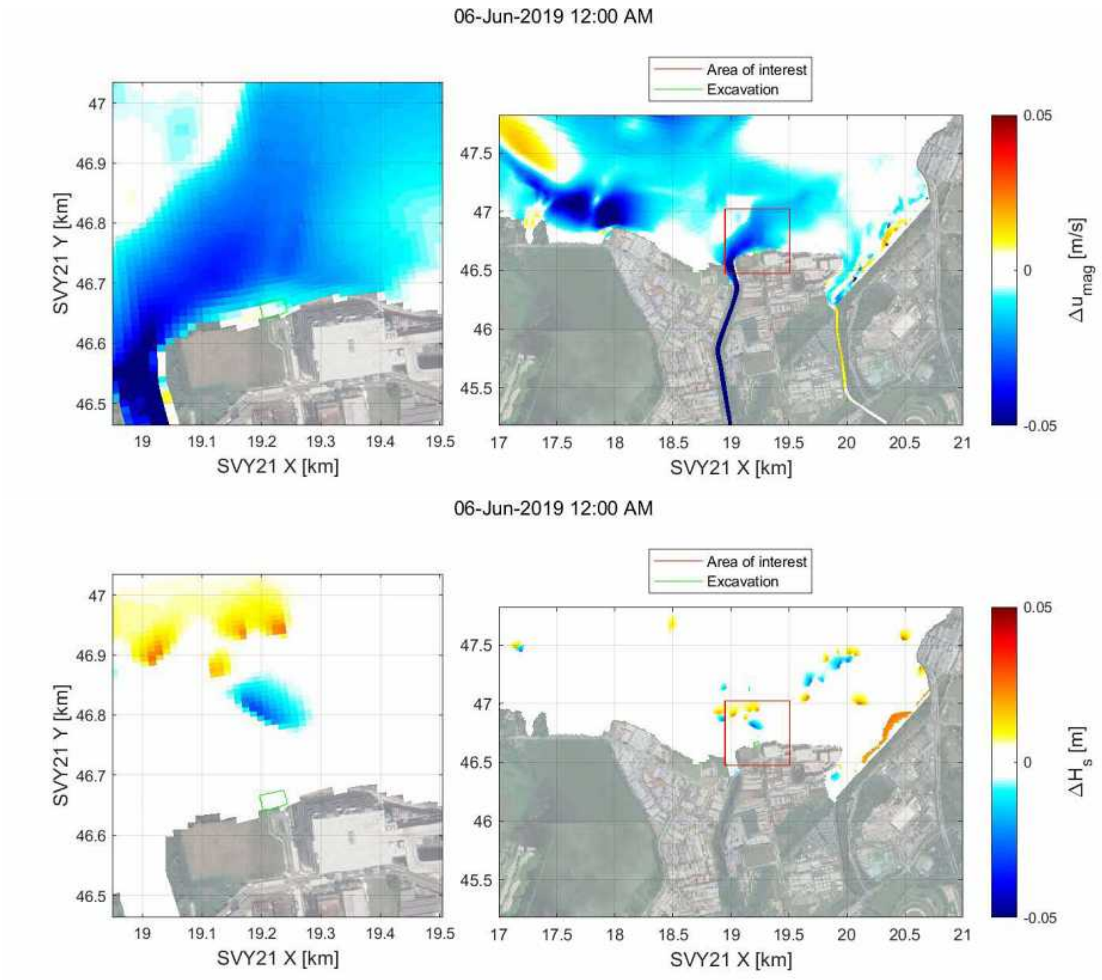


*Figure 3-30: Differences in velocity magnitude ($\Delta u_{mag}$, top) and significant wave height ($\Delta H_s$, bottom) at 00:00 a.m. on June 6, nearly high water, between a situation with and without sea level rise for SW monsoon conditions.*

## 3.4 Conclusions

An analysis of the impact of the placement of the proposed wet infrastructure on the hydrodynamics in the area of the Mandai Mangrove and Mudflat Park shows no or very limited effects. According to our model results, this holds true for normal monsoon conditions and squall events, both during King Tide conditions. For the monsoon conditions and an extreme squall event, the impact of the Experiential Walk on water levels is small and local with the largest effect at the excavation site itself. A minimal increase in waterlevels in the order of milimetres is visible to the east in the direct vicinity. Differences in current magnitude and wave heights are only expected within a few meters of the Experiential Walk and excavation.

Furthermore, future sea level rise will hardly affect the current magnitudes and wave heights, but only the local waterdepth at the excavation and thus the duration of the inundation of the area.

# 4 Impacts on sediment dynamics & morphology

## 4.1 Introduction

The sediment dynamics and morphology at and around Mandai Mangrove and Mudflat are simulated to study the baseline conditions and to assess the impacts of the new park features on sediment dynamics and morphology. This includes suspended sediment concentrations (SSC) and erosion and deposition patterns at the scale of the full model domain (Johor Strait). In contrast to previous feasibility study for Mandai in 2019, where only sediment plume modelling as a consequence of the construction works were included, here the (background) system dynamics are considered. Sediment plume modelling due to for instance backfilling or piling activities was not part of the present scope.

To assess the environmental impact of the design layout on sediment dynamics and morphology, model scenarios before and after implementation of the new wet infrastructure (as presented in Chapter 2) are compared. This new wet infrastructure is located in the higher parts of the intertidal areas that are only wet during highwater or more extreme high tide and squall events. As can be seen from Chapter 3, the current magnitudes and wave heights, which drive the sediment dynamics in the area, are very limited at Mandai park. Moreover, the changes in currents and waves due to the planned wet infrastructure will be very limited and only in the direct vicinity of the infrastructure, as indicated in Chapter 3. Therefore, the impact of the wet infrastructure implementation on sediment dynamics and morphology are expected to be minor.

The setup and results of the sediment dynamics and morphology modelling for a number of environmental scenarios are presented in this chapter. The aim is to show the impact of the planned wet infrastructure on sediment dynamics and morphology (objective 2) and the impact of future predicted sea level rise on sediment dynamics and morphology (objective 3).

## 4.2 Model input and scenarios

The approach of simulating the (background) sediment dynamics and morphology in the project area is different from the previous feasibility study for Mandai in 2019, where sediment plumes were modelled. For sediment and morphology modelling the Delft3D modelling software (Deltares, 2023) was applied. The same computational grid, (initial) depth schematisation, meteorological forcing, wave forcing, and schematisation of the new wet infrastructure were applied as for the Delft3D hydrodynamic model presented in Section 3.2. So the (initial) resulting water level, current and wave fields are the same (but may differ after bed level changes). The sediment and morphology modelling was done in 2D depth-averaged mode, as the Johor Strait is relatively well-mixed and 3D effects are expected to be negligible.

This section first describes the concepts of the applied sedimentation and erosion modelling (Section 4.2.1), the parameterisation of sediment characteristics and morphology (Section 4.2.2), and the scenarios representing different morphological responses to sea level rise (Section 4.2.3).

### 4.2.1 Conceptual model description

The sedimentation and erosion processes in the Delft3D model originate from the Partheniades-Krone formulations (Partheniades, 1965), with modifications made by Van Kessel et al., (2011) that allow for buffering of fine sediment in the seabed. For the sediment model, two cohesive sediment fractions are included with one cohesive fraction representative for poorly flocculated mud particles and the other fraction for flocculated cohesive particles. Sediment parameter settings are determined based on assessment of properties of the sediment samples and expert judgement (elaborated in Section 4.2.2).

The bed is schematized using a two-layer model (Van Kessel et al., 2011): an easily erodible, mobile upper layer that contains fresh deposits of unconsolidated mud (layer S1) and a less mobile underlayer with consolidated mud (layer S2). The upper layer represents a thin layer of fine sediment resting temporarily on the bed (prior to consolidating), while the underlayer represents the subsoil, comprising of a mix of sand and less-erodible (consolidated) mud. Erosion rates of the upper layer depend on the amount of sediment available in this layer. Erosion rates increase along with the available amount of sediment until a critical mass is reached, after which erosion rates are independent of the amount of sediment present in the mobile upper layer. A schematization of this two-layer bed model is provided in Figure 4-1.

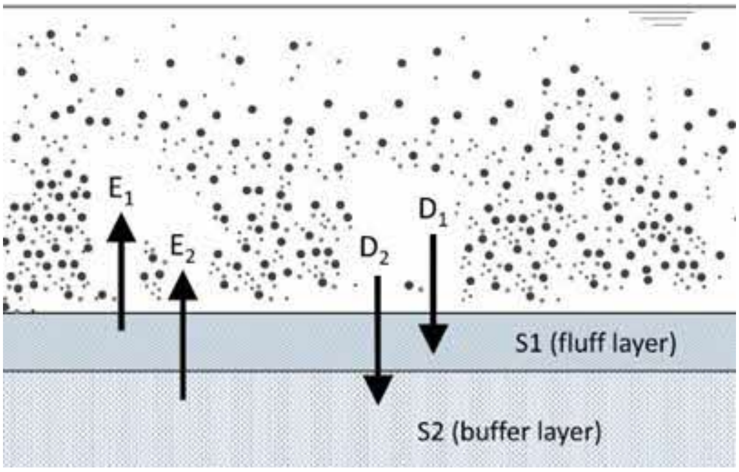


*Figure 4-1: Representation of the two-layer bed schematization in Delft3D with suspended sediment particles in the water column on top of bed layers S1 (thin fluff layer) and layer S2 (buffer layer). $D_{1,2}$ = deposition flux towards layer S1,S2; $E_{1,2}$=erosion flux from layer S1,S2.*

### 4.2.2 Sediment characteristics & Morphology parameters

Field measurements of median grainsize in the project area were delivered by Tembusu (see Figure 4-2 and Table 4-1). These measurements were performed by Marchwood Laboratory Services.

Settling velocities for sediment particles are based on the Stokes equation, see Equation 1. Here, $w_s$ denotes the settling velocity, $\rho_s$ the density of dry sediment (2600 kg/m$^3$), $\rho_f$ the density of the fluid (1000 kg/m$^3$), $g$ the accelation constant (m/s$^2$), $D50$ the median grainsize (m) and $\eta$ the viscosity of water (1000 Pa/s). We we assumed spherical particles.

*Equation 1: Stokes for settling velovity, adopted from on Ferguson and Church (2004).*

$$w_s = \frac{2}{9}\frac{\left(\rho_s - \rho_f g (D50/2)^2\right)}{\eta}$$

Based on this assessment (see Figure 4-3) two fractions were modelled 1) fraction 1 with larger flocs with a settling velocity of $10^{-4}$ m/s, and 2) fraction 2 with smaller flocs with a settling velocity of $10^{-5}$ m/s. These values are in agreement with the model set-up of Willemsen et al. (2016).


*Figure 4-2: Sediment sample locations, median grain size is indicated in Table 4-1.*

*Table 4-1: Sediment sample locations, bulk density and median grainsize.*

| Location | Bulk density (kg/m$^3$) | D50 (µm) |
|---|---|---|
| SD1 | 1590 | 10 |
| SD2 | 1420 | 9 |
| SD3 | 1290 | 2 |
| SD4 | 1480 | 2 |
| SD5 | 1220 | 2 |
| SD6 | 1230 | 2.5 |
| SD7 | 1380 | 2.5 |
| SD8 | 1430 | 3 |

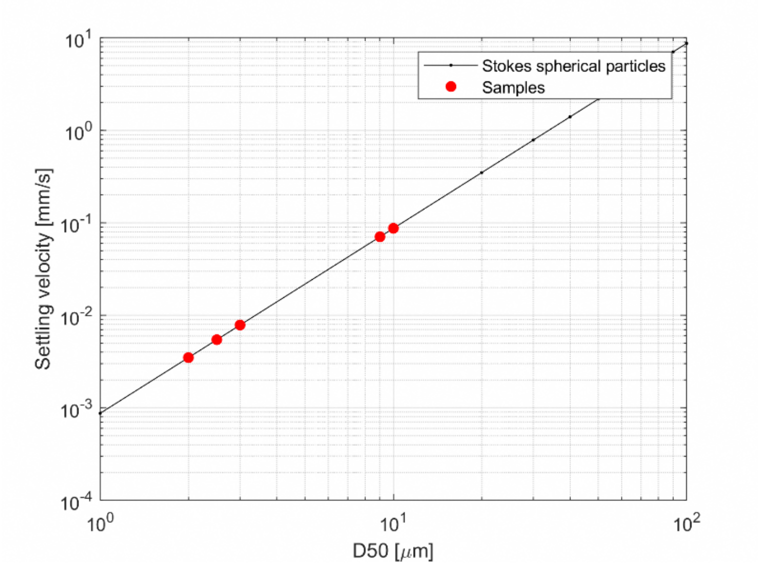


*Figure 4-3: Settling velocity as a function of median grainsize using the Stokes formulation (Ferguson and Church, 2004).*

**Initial conditions and boundary conditions**
Initial conditions for sediment thickness in the bed are 0.9 m fine sediment fraction 1 and 0.1 m fine sediment fraction 2; all applied uniformly over the model domain. Initial conditions for suspended sediment concentrations are zero for all sediment fractions. As no data is available on the sediment concentration conditions at the upstream boundaries, the sediment concentrations are based on data presented in Van Maren et al. (2014): an average of 150 mg/L east of the Strait of Johor. The sediment concentration boundary conditions result in nearly equal sediment influx and outflux (in order to prevent net sediment export out of the model domain by the flood currents). For all boundaries the distribution in SSC of the incoming flow between the fine sediment fractions is 50% fraction 1 and 50% fraction 2.

Sediment charactertics of the model domain are portrayed in Table 4-2. The same locations were also modelled by Willemsen et al., (2016). Therefore, sediment characteristics of the model approach of that study are also indicated in Table 4-2. It can be seen that the model approach of this study is largely in line with Willemsen et al. (2016).

In absence of detailed observations, the sediment characteristics are assumed to apply over the entire model domain, see Table 4-2. Suitable representative values for the critical shear stress for erosion could range between 0.5 and 3.0 Pa, based on the the range of bulk densities reported in Table 4 1. A sensitivity run was made with 3.0 Pa which showed less perturbations in suspended sediment concentrations and morphological change than when using 0.5 Pa. Therefore 0.5 Pa was applied in the scenario simulations as conservative approach.

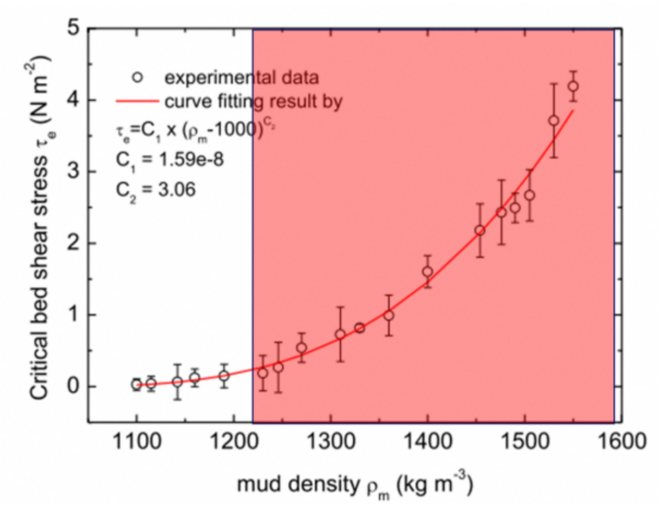


*Figure 4-4: Critical bed shear stress as function of bulk density of mud. The red square indicates the range of bulk densities reported in Table 4-1 and the critical bed shear stresses we can expect. Based on Xu et al. (2015).*

*Table 4-2: Uniform values for sediment characteristics over the model domain.*

| Variable | Value in current model | Value in Willemsen et al. (2016) |
|---|---|---|
| Critical bed shear stress for erosion (Pa) | 0.5 | 0.5<br>1.0 for sensitivity analysis |
| Critical bed shear stress for erosion of fluff layer (Pa) | 0.1 | - |
| Erosion parameter (kg $m^{-2} s^{-1}$) | $1.10^{-4}$ | $1.10^{-4}$ |
| Settling velocity large flocs of fraction 1 (m/s) | $1.10^{-4}$ | $1.10^{-4}$ |
| Settling velocity small flocs of fraction 2 (m/s) | $1.10^{-5}$ | - |
| Layer thickness fraction 1 (m) | 0.9 | Not specified |
| Layer thickness fraction 2 (m) | 0.1 | Not specified |

Three varying wind conditions and their effect on suspended sediment concentration (SSC) (g/L), available mass of sediment (kg/$m^2$) and morphological change (m) were modelled:

1. Extreme squall event
2. NE monsoon conditions
3. SW monsoon conditions

To evaluate the systems respons under SLR after implementation of the Experiential Walk, three sea levels rise scenarios with SW monsoon wind conditions were modelled:

1. SW monsoon with 10 cm SLR
2. SW monsoon with 32 cm SLR
3. SW monsoon with 102 cm SLR

For all models the simulation period lasted from the 27th of May until the 10th of June to keep the same tidal conditions over the different scenarios. However, wind data that generate the local waves will vary between the runs (i.e. representing different wind conditions), as described in Section 3.2.2.

### 4.2.3 Response to sea level rise

To assess the impact of sea level rise on the sediment transport and morphology in the project area, simulations with water level projections for 2030, 2050, and 2100 were applied, as described in Section 3.2.2. In these simulations, the water level is increased homogenenously throughout the domain (i.e. no changes in tidal boundary conditions, meteorological forcing or sediment availability) and no morphological response of the Mandai Mudflat to sea level rise was assumed, although the seabed of tidal basins and estuaries typically rises (partially) with sea level rise due to increased accommodation space. To study the impact of sea level rise projections with morphological response, situations where the bed was assumed to grow fully or only partly with sea level rise based on the SLR model scenarios listed in Section 4.2.2 were assessed. In this indicative assessment it is assumed that the morphological response would be uniform within the (wet) domain, implying that full growth with sea level rise would create an identical situation to a scenario without sea level rise (see sections 3.3.1-3.3.2). No additional model scenarios were executed for this.

For the scenario where the bed grows only partly with sea level rise, it was assumed that the bed grows with 50% of the sea level rise. This creates a (spatially-uniform) relative sea level rise of 5 cm (in 2030), 16 cm (in 2050) and 51 cm (in 2100). Additional model scenarios were not included. The impact was indicatively assessed based on the existing SLR scenarios for 10 cm, 32 cm and 1.02 m in Section 4.3.3. For example, the scenario with 51 cm SLR (representative for RCP8.5 projection in 2100 and partial growth with SLR), the results will be in between the scenario of 32 cm and 1.02 m.

## 4.3 Morphodynamic modelling results

In this section the results of the mean suspended sediment concentration (SSC) (g/L) and morphological change (m) under the three varying wind conditions (extreme squall event, NE monsoon conditions and SW monsoon conditions) are presented. The available mass of sediment (kg/m$^2$) for these scenarios can be found in Appendix C.1.

The variables were analysed in the situation after implementation of the Experiential Walk under these conditions together with difference maps. The difference maps are computed as intervention results minus without intervention results. So, positive values indicate an increase in the reported variable after construction of the Experiential Walk and excavation.

The results for the extreme scenario of 102 cm SLR scenario is presented in this section. The results for the scenarios with seabed rise of 10 cm and 32 cm are included in Appendices C.1 and C.3. These scenarios include implementation of the boardwalk and are compared with the current SW monsoon scenario, which includes implementation of the Experiential Walk and excavation, by means of difference maps. These difference maps are computed as follows:

*output of SW monsoon with SLR scenario including experiential walk*
*- output of SW monsoon under current conditions including experiential walk*

Therefore, positive values indicate a decrease of the reported variable with respect to the present. In this section, all reported scenarios are modelled with high mobility of the bed with a critical bed shear stress of 0.5Pa to analyse maximum variation in the sediment variable values.

### 4.3.1 Monsoon conditions

Figure 4-5 and Figure 4-7 show that time-averaged SSC during NE conditions are higher than during SW monsoon conditions, surpassing 0.5 g/L close to the intertidal mudflats. However, the construction of the Experiential Walk and excavation induce only a local change in SSC. As a consequence of the excavation and Experiential Walk construction, both during NE and SW monsoon conditions SSC is increased within the excavation with a maximum of 0.05 g/L and decreased with a maximum of 0.05 g/L in the direct vicinity of the excavation, see Figure 4-6 and Figure 4-8. During NE monsoon conditions the affected area is slightly larger compared to SW monsoon conditions as a consequence of the construction.

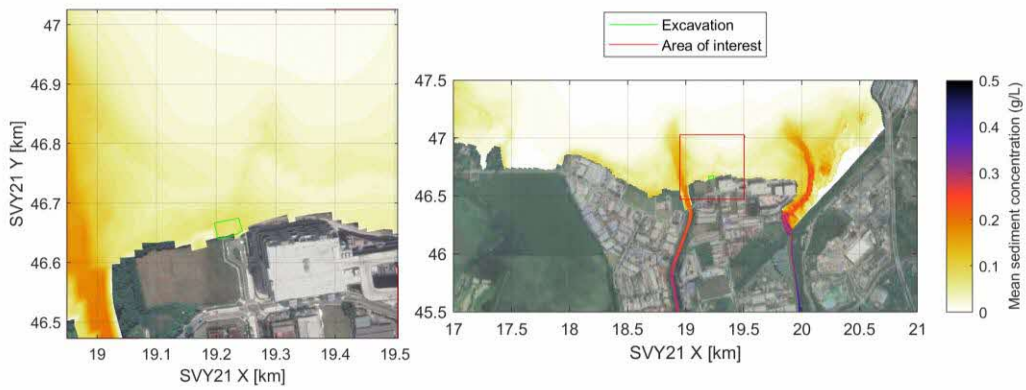


*Figure 4-5: Time-averaged suspended sediment concentration (g/L) of the SW monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

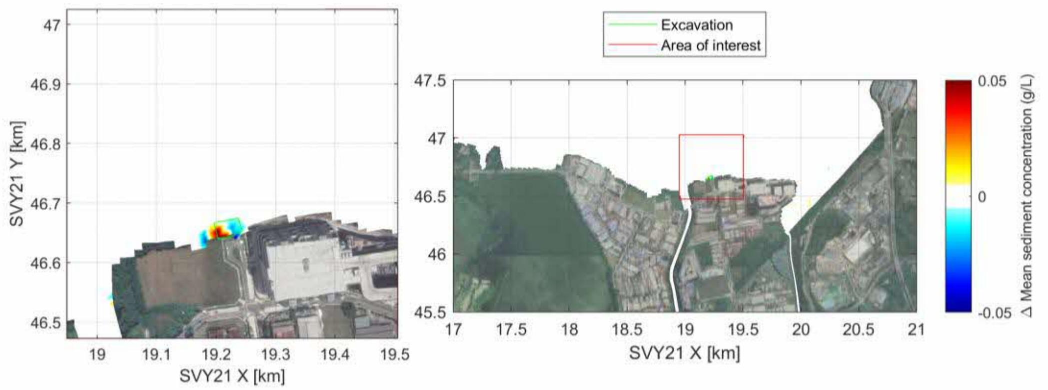


*Figure 4-6: Change of the time-averaged suspended sediment concentration (g/L) of the SW monsoon scenario including Experiential Walk. Positive values indicate an increase of the time-averaged suspended sediment concentration after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

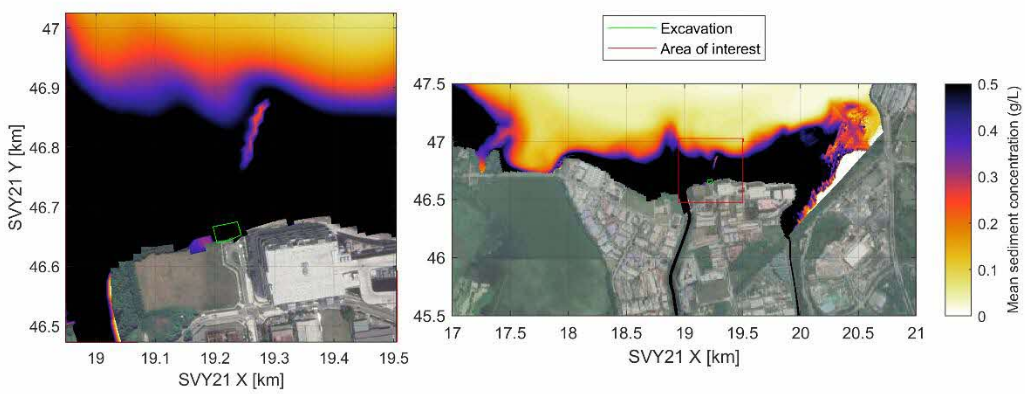


*Figure 4-7: Time-averaged suspended sediment concentration (g/L) of the NE monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

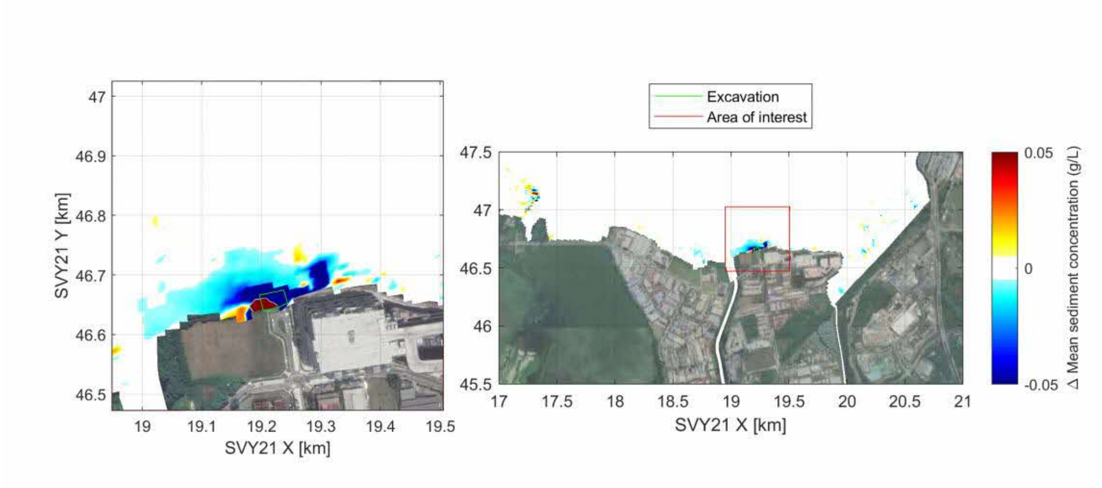


*Figure 4-8: Change of the time-averaged suspended sediment concentration (g/L) of the NE monsoon scenario including Experiential Walk. Positive values indicate an increase of the time-averaged suspended sediment concentration after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

More pronounced morphological change is visible in the NE monsoon scenario compared with the SW monsoon, see Figure 4-9 and Figure 4-10. Yet, the erosion in the NE scenario is minor with cummulative erosion up to 5 cm in the shallow areas close to the coast. There is no morphological change observed in the SW scenario.

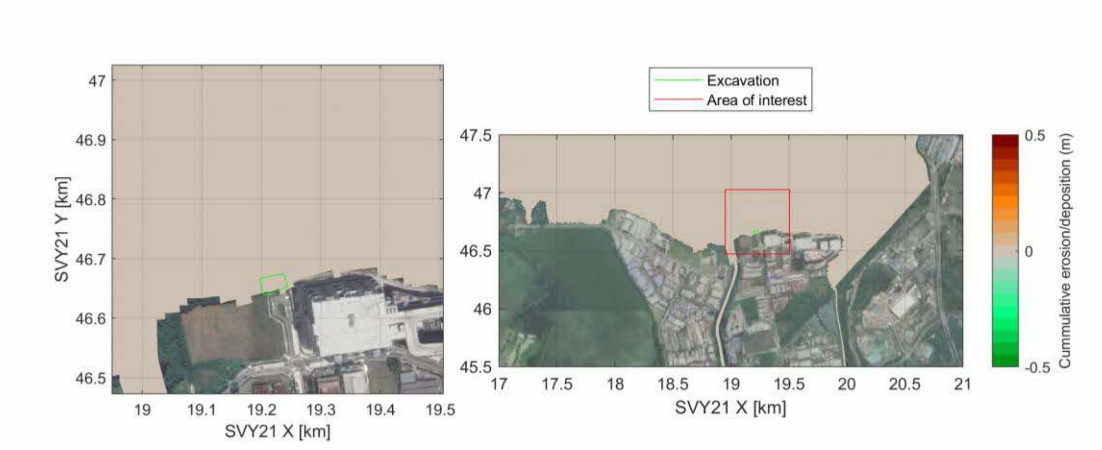


*Figure 4-9: Cummulative erosion/deposition (m) at the last time step of the SW monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

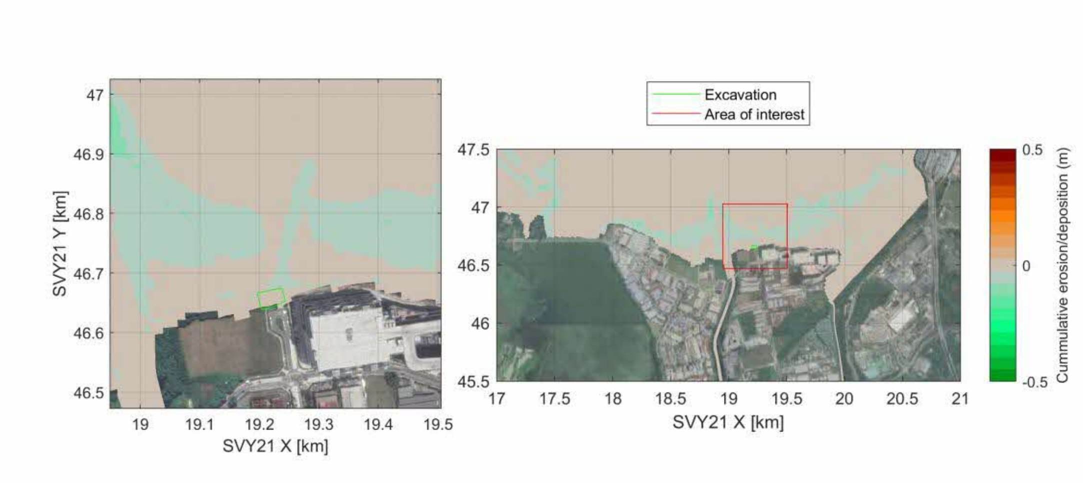


*Figure 4-10: Cummulative erosion/deposition (m) at the last time step of the NE monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

The construction of the Experiential Walk only leads to limited deposition (1-5 cm) within the excavated area in the NE scenarios, while there is no effect of the Experiential Walk on morphological change in the SW scenario, see Figure 4-11 and Figure 4-12. However, this is a very local effect, since a control point directly next to the Experiential Walk and excavation indicates no change between model result with and without experiental walk, see Figure 4-13.

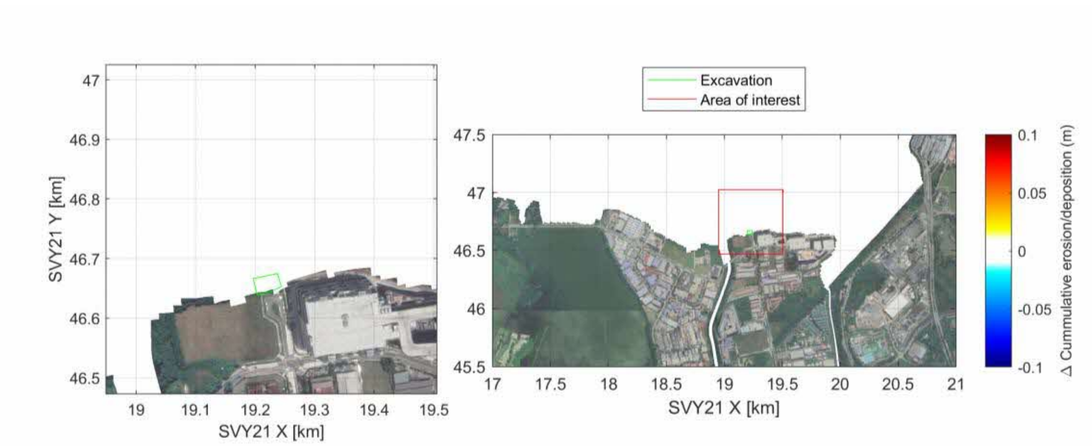


*Figure 4-11: Change of the cummulative erosion/deposition (m) of the SW monsoon scenario including Experiential Walk. Positive values indicate more deposition or less erosion after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

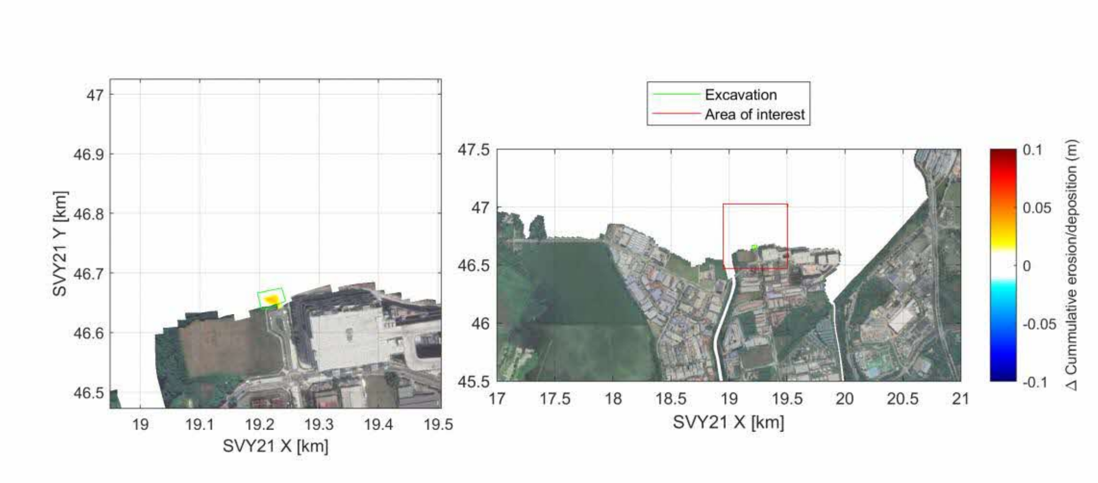


*Figure 4-12: Change of the cummulative erosion/deposition (m) of the NE monsoon scenario including Experiential Walk. Positive values indicate more deposition or less erosion after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

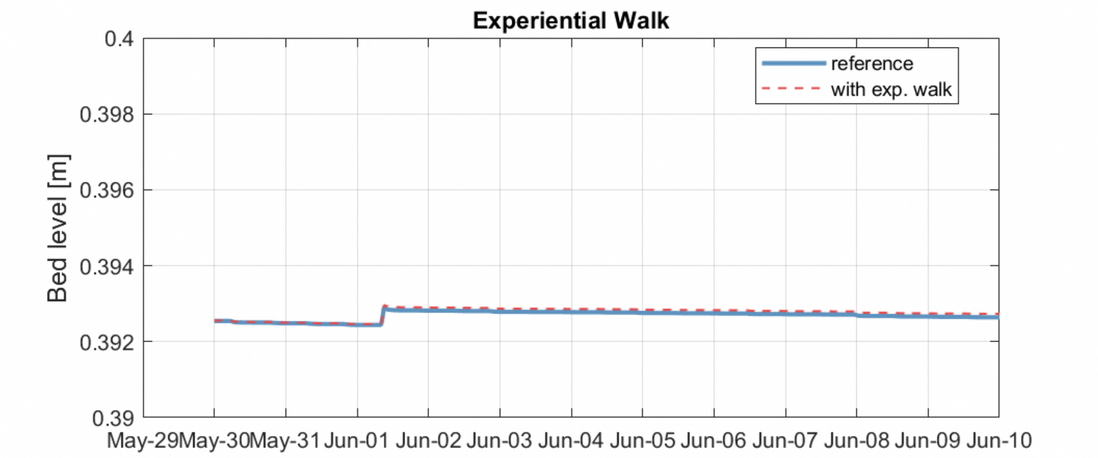


*Figure 4-13: Time verus sediment bed level during NE monsoon conditions at an control point directly next to the experiental walk.*

### 4.3.2 Extreme squall event

Results of the extreme squall event scenario (Figure 4-14 up to Figure 4-19) are comparable with the NE monsoon scenario. However, during an extreme squall event most of the change in SSC and morphology enfolds during a relatively short time interval with energetic conditions (the 6th of June), while observed change for the NE monsoon condition is the consequence of intermediately energetic conditions over a longer timespan (27th of May until the 10th of June). During the extreme squall event a peak in NW wind conditions at the 6th of June, generate significant wave heights up to 0.8 m at the Experiential Walk (Figure 3-27). This erodes the shallow areas facing the northwest with 0.5-1 cm, see Figure 4-17. Therefore, more sediment is brought into suspension reaching SSC values up to 5 g/L, see Figure 4-14 and Figure 4-16. The impact of the Experiential Walk on the water column is primarily very local (Figure 4-15). The impact on the sediment bed level is negligible (Figure 4-18 and Figure 4-19): the excavation and Experiential Walk will experience 1-2 cm more deposition with respect to the reference (Figure 4-17).

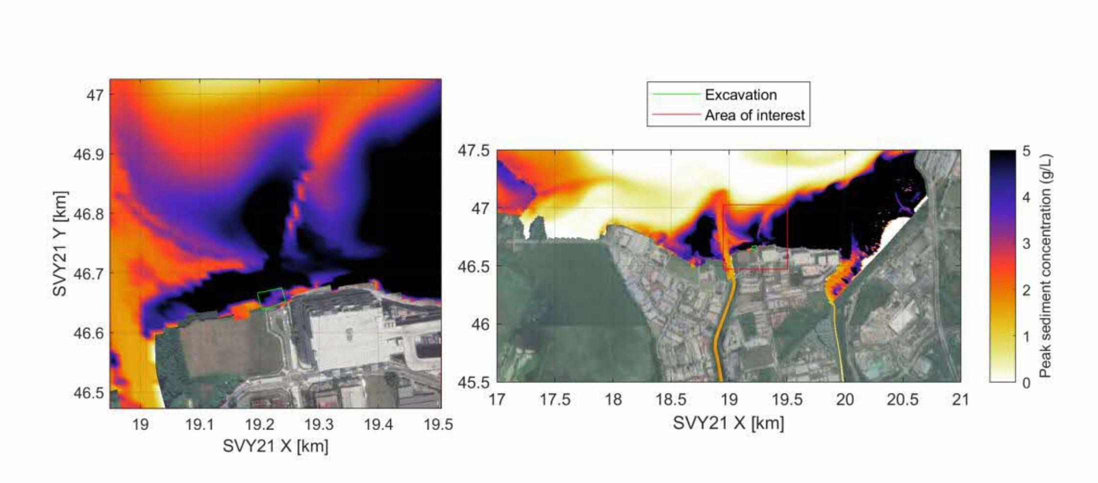


*Figure 4-14: Suspended sediment concentration (g/L) during the peak of the squall scenario (at 06:00 p.m. on June 6, 2019) including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

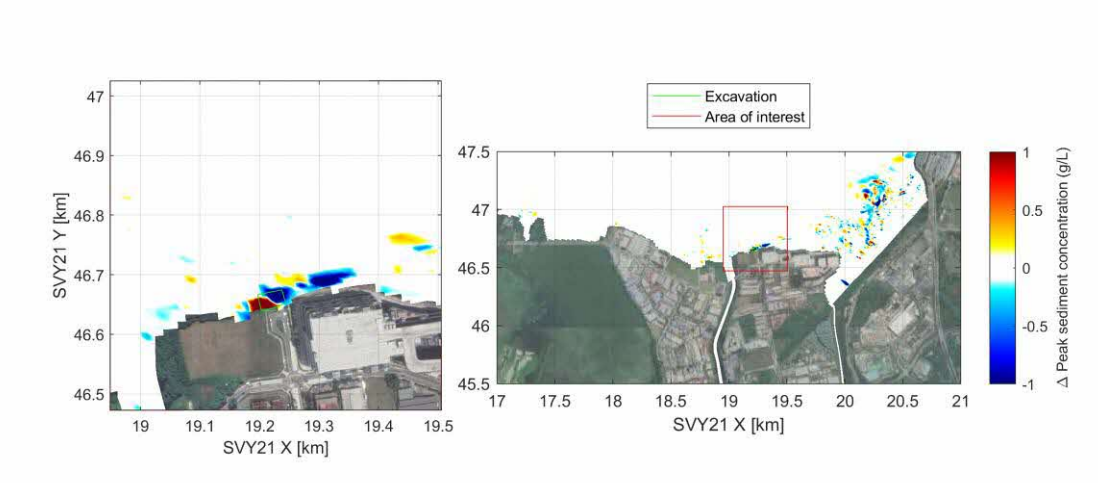


*Figure 4-15: Change of the suspended sediment concentration (g/L) during the peak of the squall scenario (at 06:00 p.m. on June 6, 2019) due to the Experiential Walk. Positive values indicate an increase of the time-averaged suspended sediment concentration after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

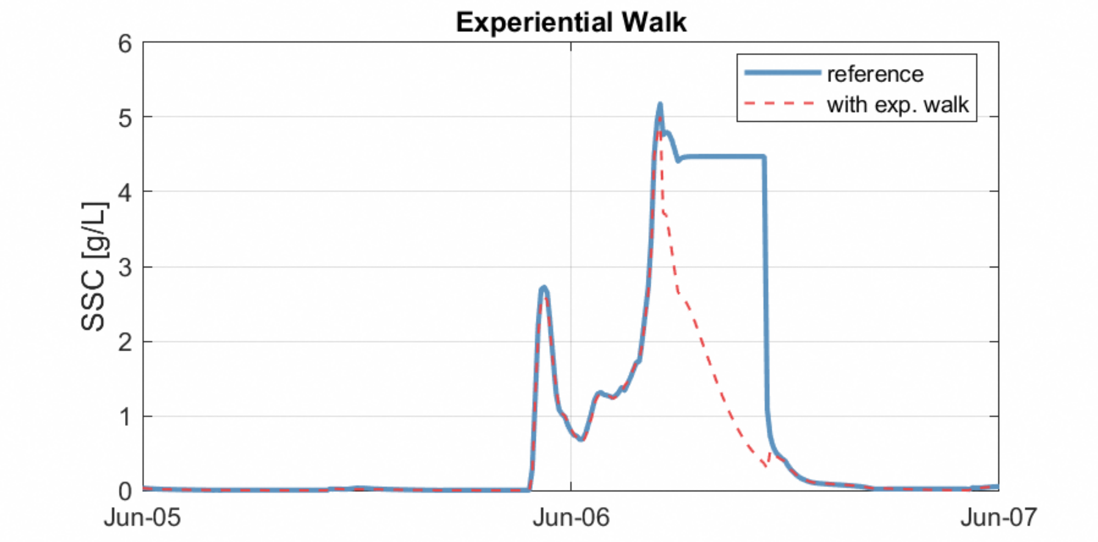


*Figure 4-16: SSC over time during the extreme squall event at an control point directly next to the Experiential Walk. SSC values for the reference after the peak remain constant for some hours on June 6 as this control point was not inundated.*

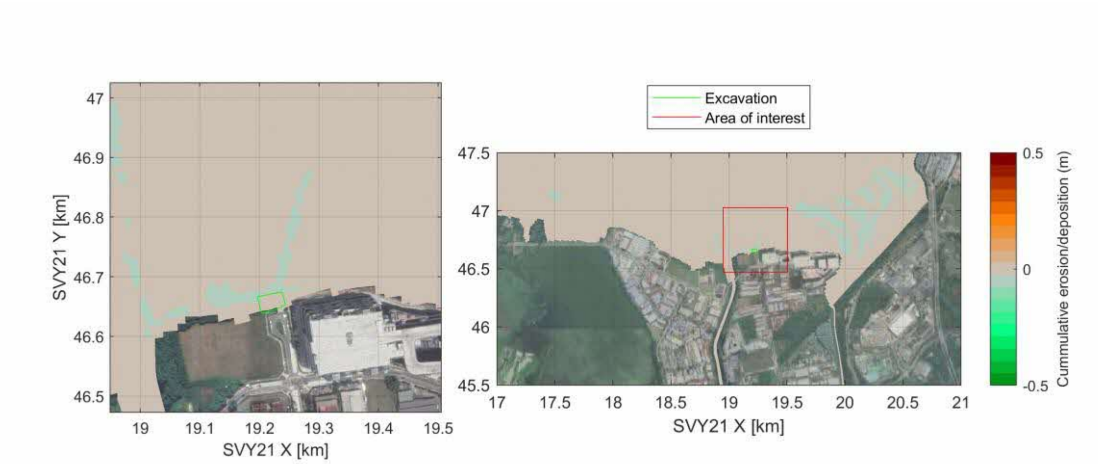


*Figure 4-17: Cummulative erosion/deposition (m) at the last time step of the squall scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

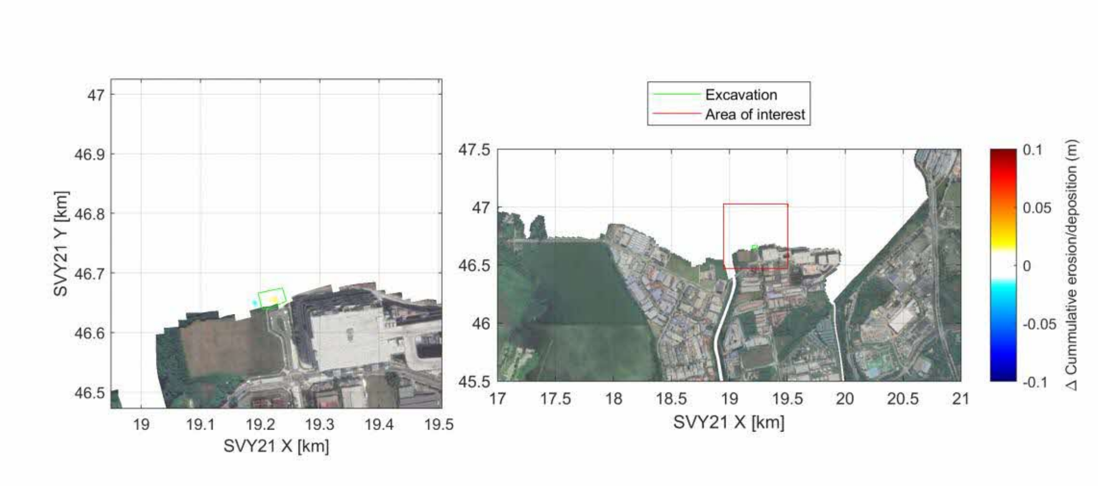


*Figure 4-18: Change of the cummulative erosion/deposition (m) of the squall scenario including Experiential Walk. Positive values indicate an increase of the cummulative erosion/deposition after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

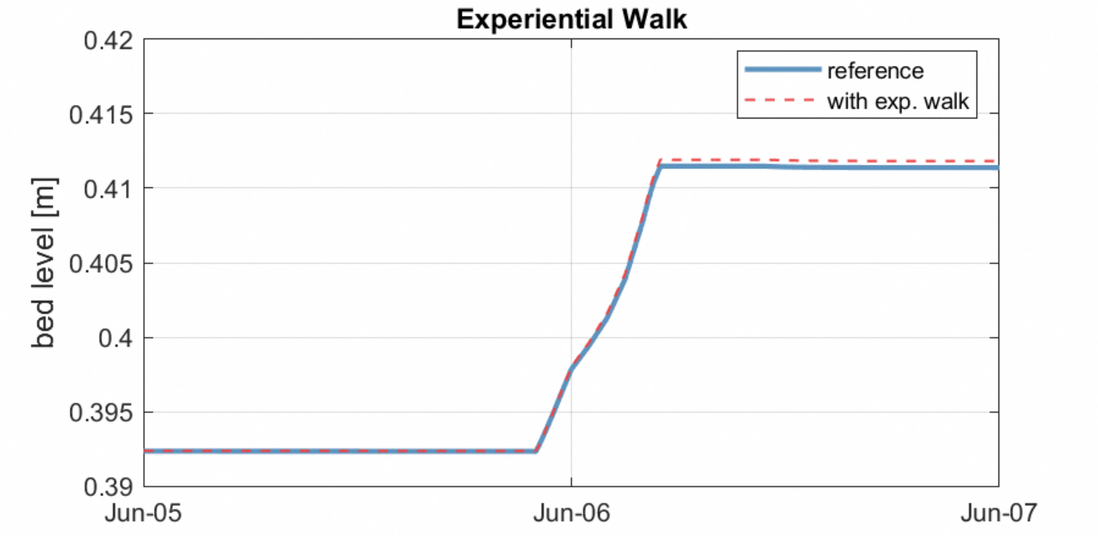


*Figure 4-19: Sediment bed level over time during the extreme squall event.*

### 4.3.3 Effects of future Sea level Level Rise on the sediment dynamics and morphology at Mandai Park

In this section the model results of sea level rise (SLR) representative for the RCP8.5 projection in 2100 are presented, without increase in bed elevation (most conservative scenario). This scenario consists of 102 cm SLR. The scenarios with 10 cm (RCP8.5 in 2030) and 32 cm (RCP8.5 in 2050) SLR can be found in Appendices C.1 and C.3. All SLR model results indicate a decrease in the time-averaged SSC of more than 0.05 g/L in the shallow areas with respect to the present, see Figure 4-20 and Figure 4-21. However, this is not consequence of enhanced deposition with respect to the present, since morphological change is similar to present SW monsoon conditions, see Figure 4-22 and Figure 4-23.

To study the impact of sea level rise projections with morphological response, we assess situations where the bed would grow fully or only partly with sea level rise based on the SLR model scenarios described above. Assuming full seabed growth with sea level rise ('keeping pace') would create an identical situation to a scenario without sea level rise (see Sections

4.3.1 and 4.3.2). So, no changes in hydrodynamics or sediment dynamics due to the present situation are anticipated if the seabed keeps pace with SLR.

The impact of a SLR scenario where the seabed grows with 50% of the sea level rise ("partially keeping pace"), the impact is indicatively assessed based on the existing SLR scenarios for 10 cm, 32 cm and 1.02 m in Section 3.3.3. In 2100 a SLR of 102 cm and a seabed rise of 51 cm would result in a relative SLR of 51 cm. The changes in hydrodynamics and sediment dynamics will be in between the scenario of 32 cm and 1.02 m, i.e. the time-averaged SSC would decrease in the shallow areas compared to the current situation. No significant morphological changes are expected within the timeframe of a spring-neap cycle.

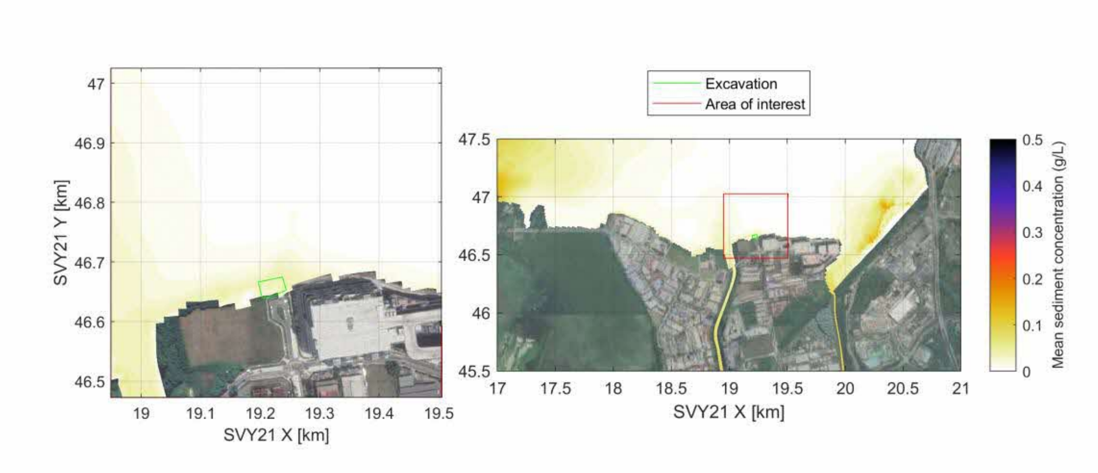


*Figure 4-20: Time-averaged suspended sediment concentration (g/L) of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

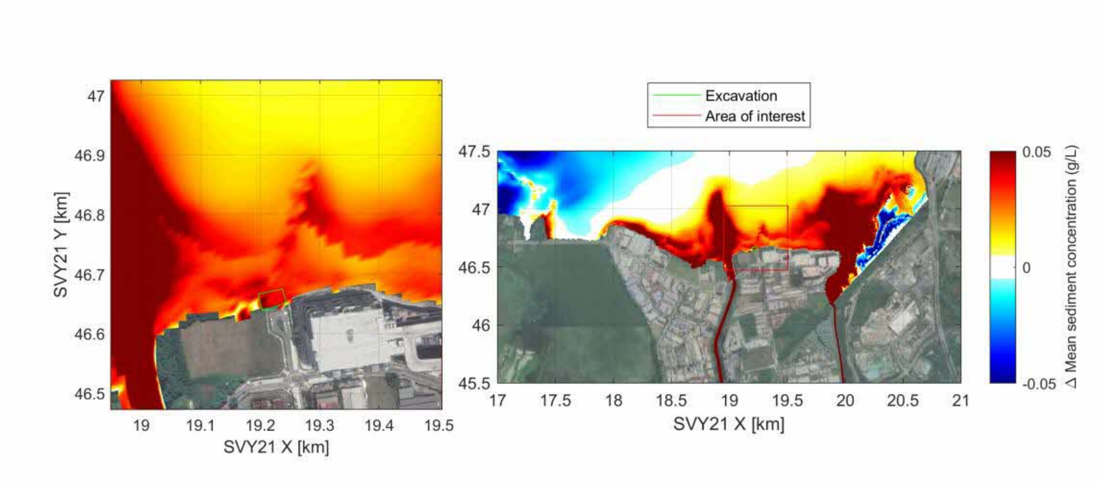


*Figure 4-21: Change of the time-averaged suspended sediment concentration (g/L) of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the time-averaged suspended sediment concentration with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

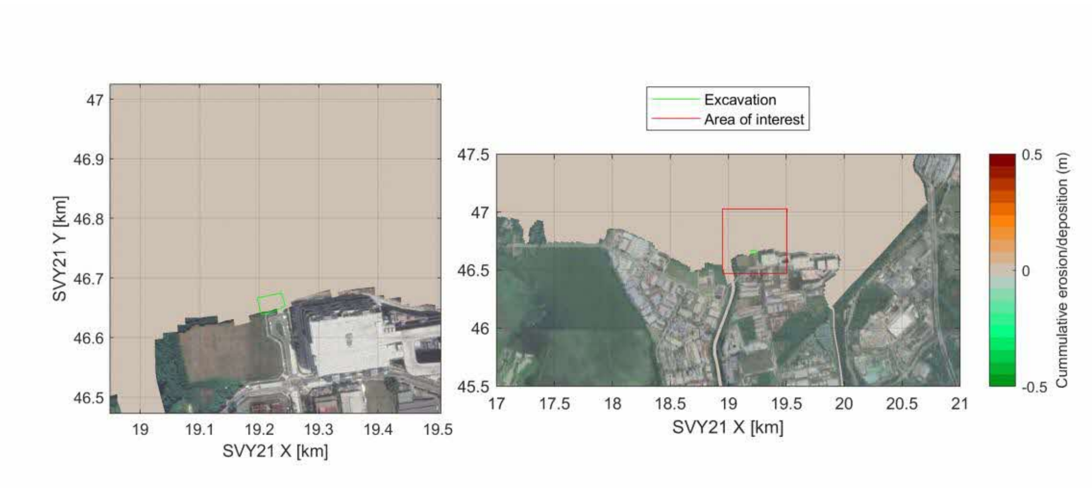


*Figure 4-22: Cummulative erosion/deposition (m) at the last time step of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated*

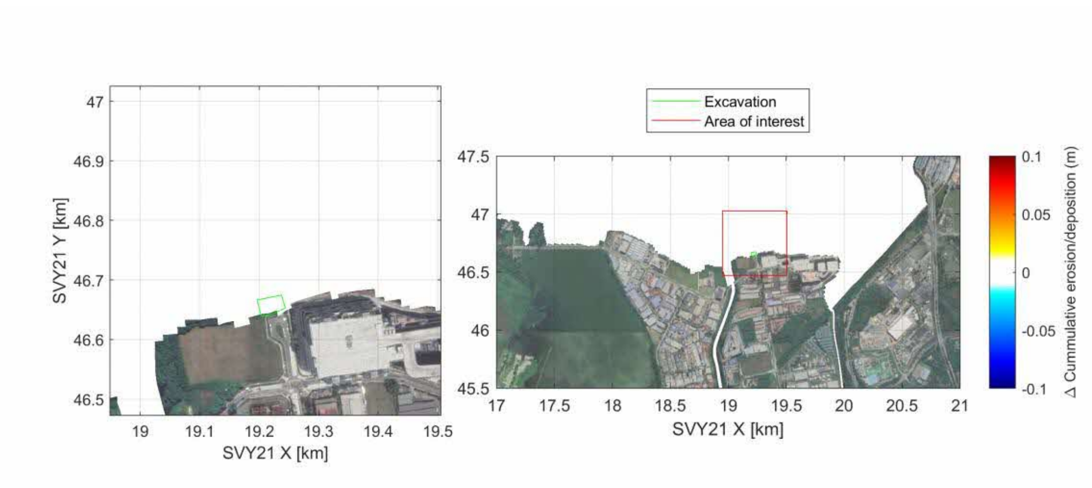


*Figure 4-23: Change of the cummulative erosion/deposition (m) of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the cummulative erosion/deposition with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

## 4.4 Conclusions

Numerical modelling of the impacts of the proposed wet infrastructure on the sediment dynamics and morphology in the area of the Mandai Mangrove and Mudflat Park show very limited effects. According to the modelling, this is the case for both normal monsoon conditions and for squall events. For the monsoon conditions and an extreme squall event, the impact of the Experiential Walk on sediment concentrations is small and local with the largest effect at the excavation site itself. During NE monsoon conditions the system is more dynamic compared with SW monsoon conditions. Therefore, the construction of the Experiential Walk will have more effect on SSC during NE monsoon conditions compared with SW monsoon conditions. Yet, the construction of the Experiential Walk and excavation will result in only 1-3 cm deposition within the excavation during NE monsoon conditions, while no change is detected during SW monsoon conditions. So, the piles of the Experiential Walk and the excavation for the Sungei Pangsua Pavilion will therefore cause negligible disturbances to the sediment dynamics and morphology of the system.

Finally, sea level rise will cause a decrease in the time-averaged SSC in the shallow areas with respect to the present, whereas erosion and sedimentation patterns are not significantly affected.

# 5 Summary and conclusions

As input to an environmental impact study (EIS) of the extended nature park by Tembusu, Deltares was requested to assess changes, if any, on the hydrodynamics, sediment transport and morphology by means of numerical modelling. The extension of this park involves one additional wet infrastructure site, namely the Sungei Pangsua Pavilion with an Experiential Walk. The mudflat in this area will be excavated to allow water to partially inundate the area. This excavation and the Experiential Walk piles are included in the model schematisation.

As input to the EIS the following aspects were assessed by means of numerical modelling:

1. changes to the hydrodynamics (water levels, currents and waves) as a result of the construction of the Experiential Walk (i.e. the piles of the boardwalk and excavation) in the intertidal zone ('wet infrastructure');
2. changes to the sediment dynamics (suspended sediment concentration and bed sediments) and morphology as a result of the interventions mentioned under #1; and
3. changes to the hydrodynamics (water levels, currents and waves), sediment dynamics and morphology as a result of future predicted sea level rise.

The main conclusions of the numerical modelling for the above aspects are:

- As a result of the very limited new 'wet infrastructure', the construction of the Sungei Pangsua Pavilion will have no significant impact on the water levels, currents or waves in Mandai area. The hydrodynamic impacts will be limited to the area within a few meters from the Experiential Walk and associated excavations.
- Following from the low hydrodynamic energy, sediments dynamics in the area are limited anyway. The construction of the Sungei Pangsua Pavilion – the only very limited new 'wet infrastructure' – will have no significant impact on the sediment dynamics and morphology in Mandai area. As for the hydrodynamics, the impacts on sediments will also be limited to the area within a few meters from the Experiential Walk and associated excavations.
- Sea level rise will have a negligible effect on the currents and waves in Mandai area. Only the local waterdepth at the excavation and thus the tidal inundation period of the area will be affected. Moreover, sea level rise will cause a decrease in the time-averaged suspended sediment concentrations in the shallow areas with respect to the present situation, whereas erosion and sedimentation patterns are not significantly affected.

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# A Impact of adjusted slope profiles

## A.1 Introduction

Recently, NParks decided to apply a uniform coastal slope of 1:5 along the entire coastline of the park above the High Water Mark (SHD +1.36 m) for a distance of 8 to 10 m inland. The area with the uniform coastal slope is presented in Figure A-1 (Profiles A to D).

This appendix presents the effects on the water levels, currents, and waves of the planned slope change for three Sea Level Rise scenarios by comparing additional model simulations (including the uniform slope) with the model simulations from the main study.

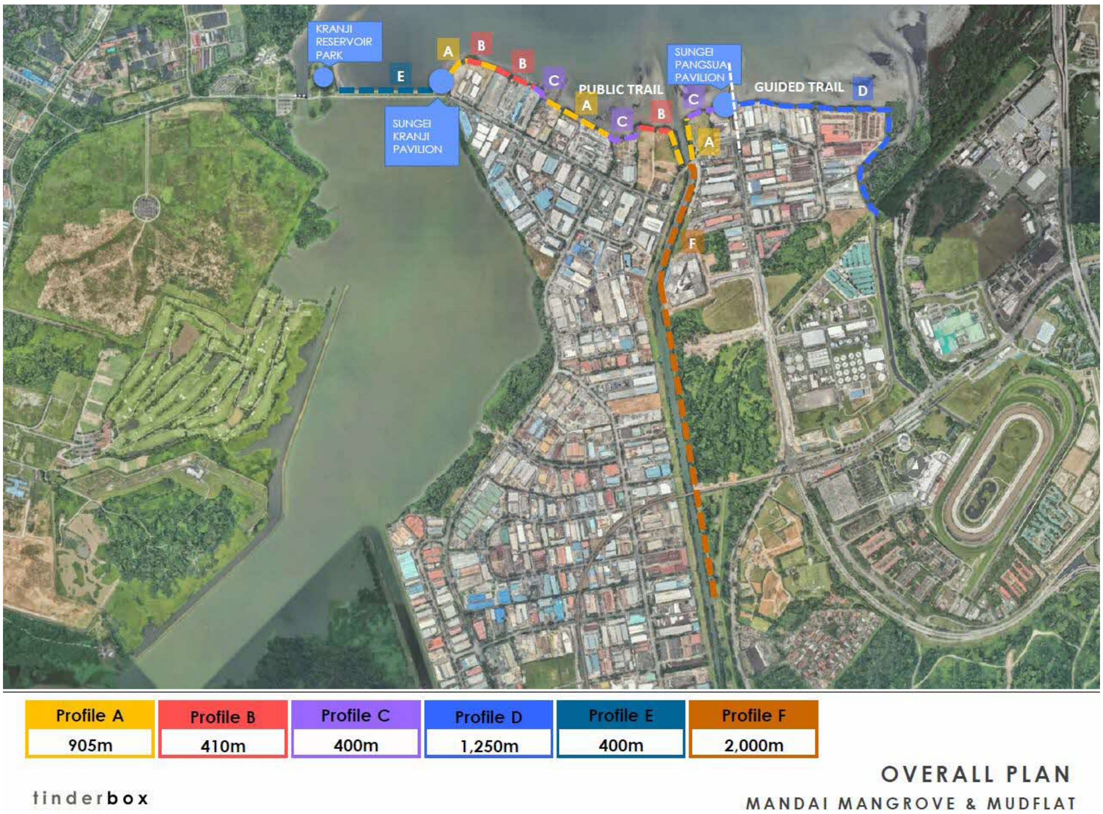



*Figure A-1: Locations (Profiles A to D) where the uniform coastal profile is planned along the coast for the Mandai Mangrove and Mudflat Park (from: LOOK Architects and Tinderbox Landscape Studio, 2023).*

## A.2 Methodology

The computational grids of the hydrodynamic and wave models developed in the main study were updated to include cells landward along the coast (Profiles A to D in Figure A-1). This area was not previously part of the model domain as the original topography was above the High Water Mark and would not be inundated in the simulations. Grid cells have been added in the new simulations to cover the upper beach slopes along the coast (Profiles A to D in Figure A-1) up to a distance of 20 to 30 m from the High Water Mark (SHD +1.36m) to ensure sufficient model space is available to capture the 1:5 slope. Depth values were defined to each added grid cell, assuming a profile slope of about 1:5. Note however, that with a 10 m grid resolution, the slope will not be continuous but seen as a stair-case shape in the models. Figure A-2 and Figure A-3 present the added grid cells and depth schematization. The excavation and sub-grid schematization of the supporting piles of the Experiential Walk are also included in the updated models.

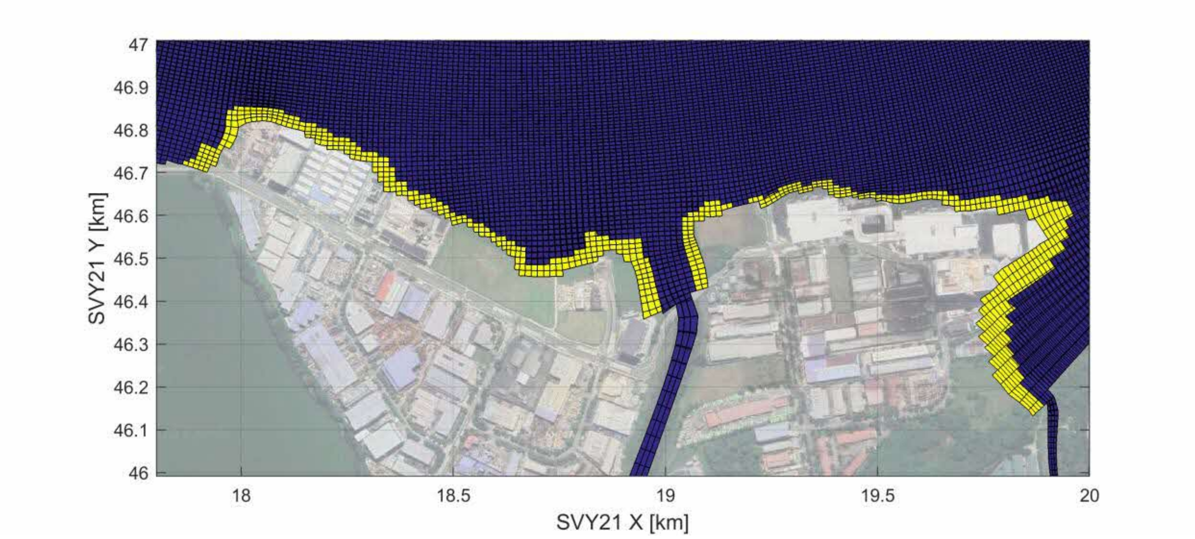



*Figure A-2: Computational grid used in the main study by Deltares (2023) (dark blue) and added cells for this memo (yellow).*

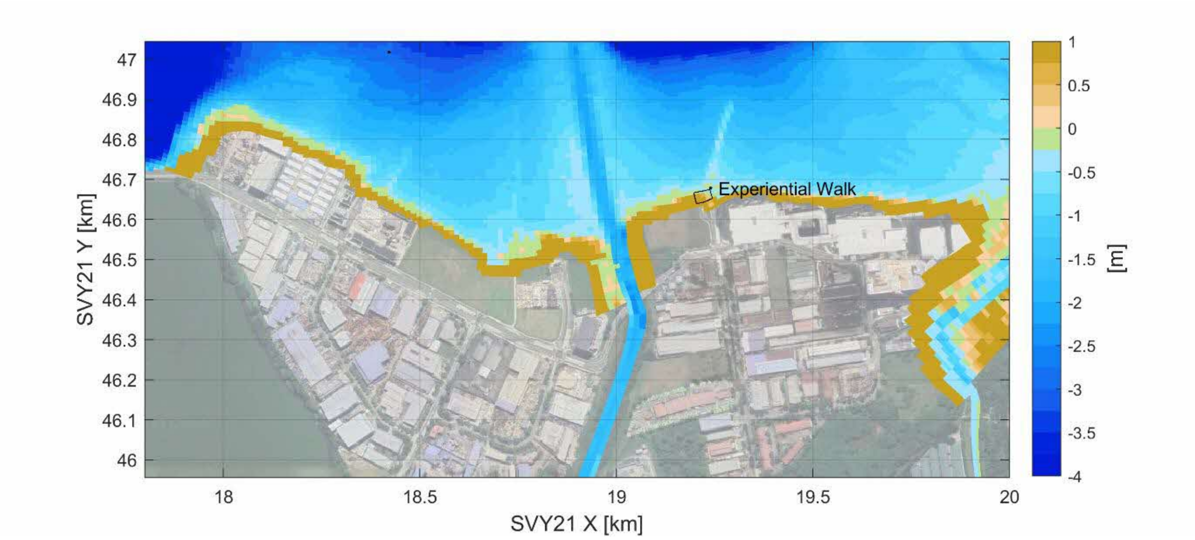



*Figure A-3: Bathymetry taken from the hydrographic survey and Lidar measurements carried out in 2022 and provided by Tembusu to Deltares. The Experiential Walk excavation is labelled and marked with a black rectangle.*

## A.3 Effect of the coastal slope change on the hydrodynamic conditions

In the following analysis, the hydrodynamic conditions are compared for the sea level rise scenarios included in Table A-1, with and without the coastal slope change.

*Table A-1: Sea level rise (SLR) scenario name, corresponding horizon (year), and SLR relative to present (cm).*

| SLR scenario | Horizon (year) | Sea level rise relative to present (cm) |
|---|---|---|
| SLR 2030 | 2030 | 10 |
| SLR 2050 | 2050 | 32 |
| SLR 2100 | 2100 | 102 |

### A.3.1 Water levels

Comparison between simulations with and without the changes showed no noticeable changes in the modelled water levels, for all the scenarios (Figure A-4 for SLR 2030; Figure A-5 for SLR 2050; Figure A-6 for SLR 2100) around high water at 00:00 on June 6, 2019.

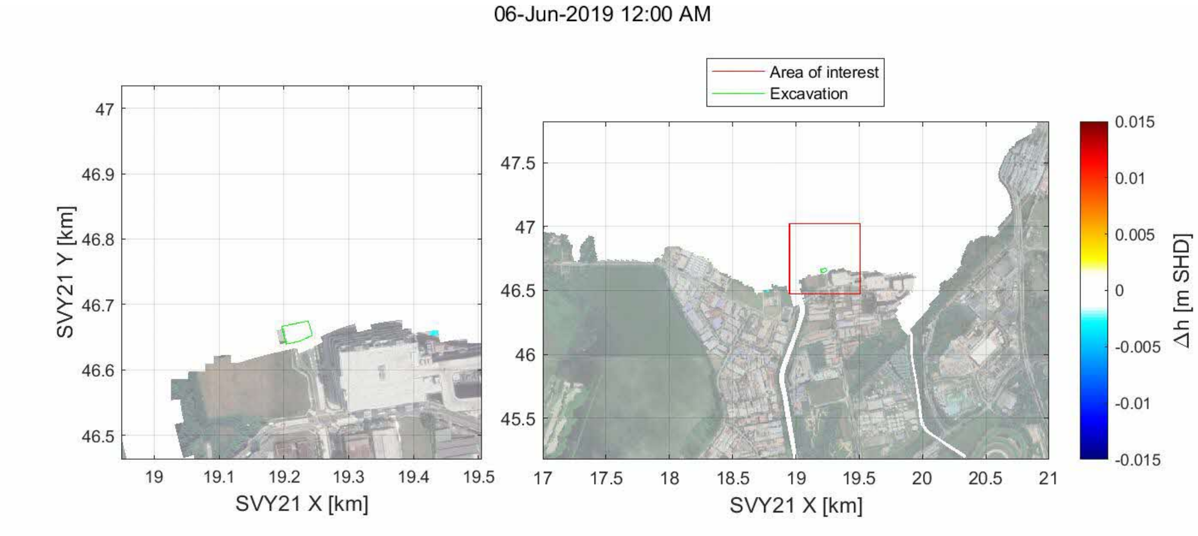



*Figure A-4: Differences in water level (Δh) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2030.*

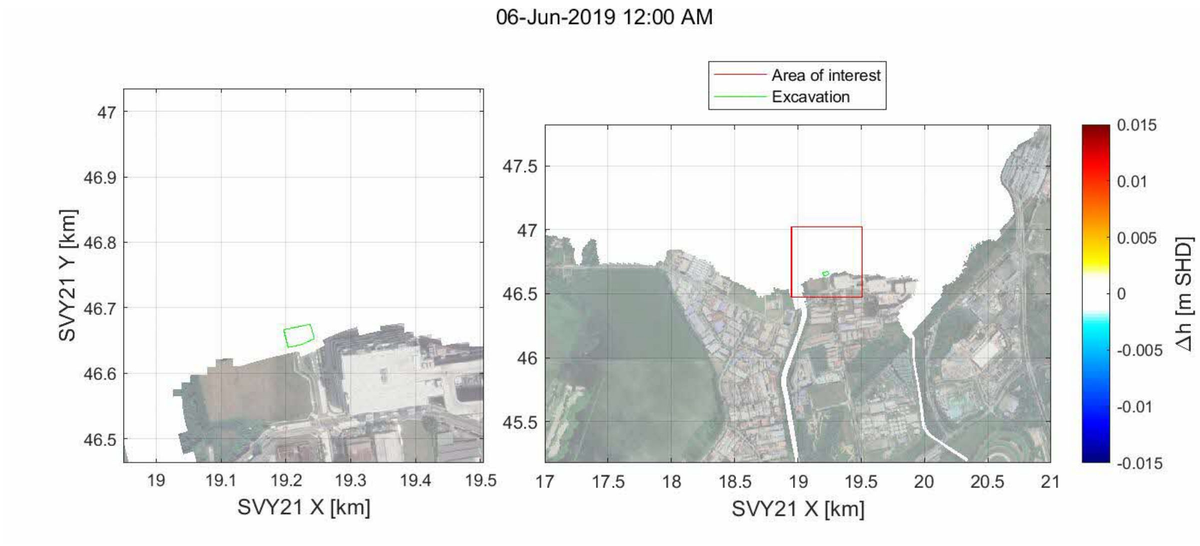



*Figure A-5: Differences in water level (Δh) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2050.*

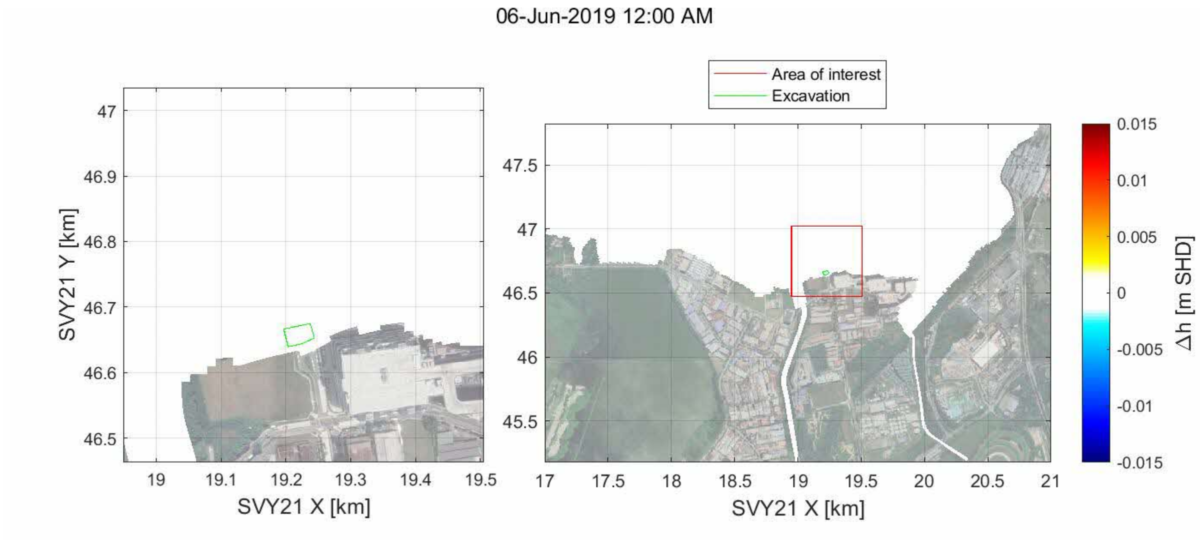



*Figure A-6: Differences in water level (Δh) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2100.*

### Velocity magnitudes

The impact of the slope can be seen near the coast, in and adjacent to the added grid cells with the new slope. There are differences in velocity magnitudes (Figure A-7 for SLR 2030; Figure A-8 for SLR 2050; Figure A-9 for SLR 2100) in the order of 0.02 m/s. These changes in velocity are very small and considered negligible.

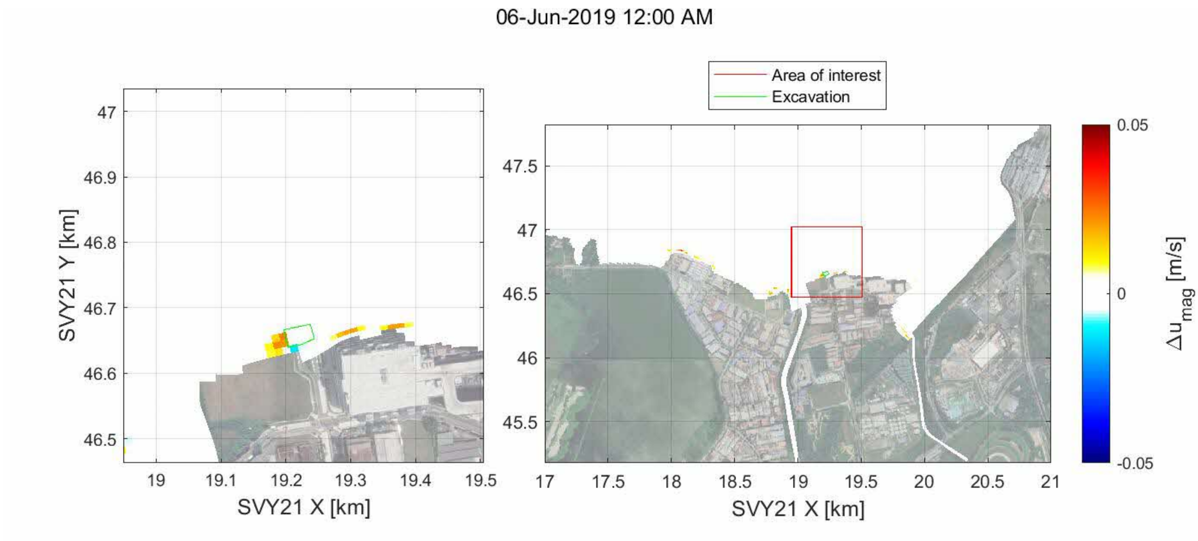



*Figure A-7: Differences in velocity magnitude (Δumag) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2030.*

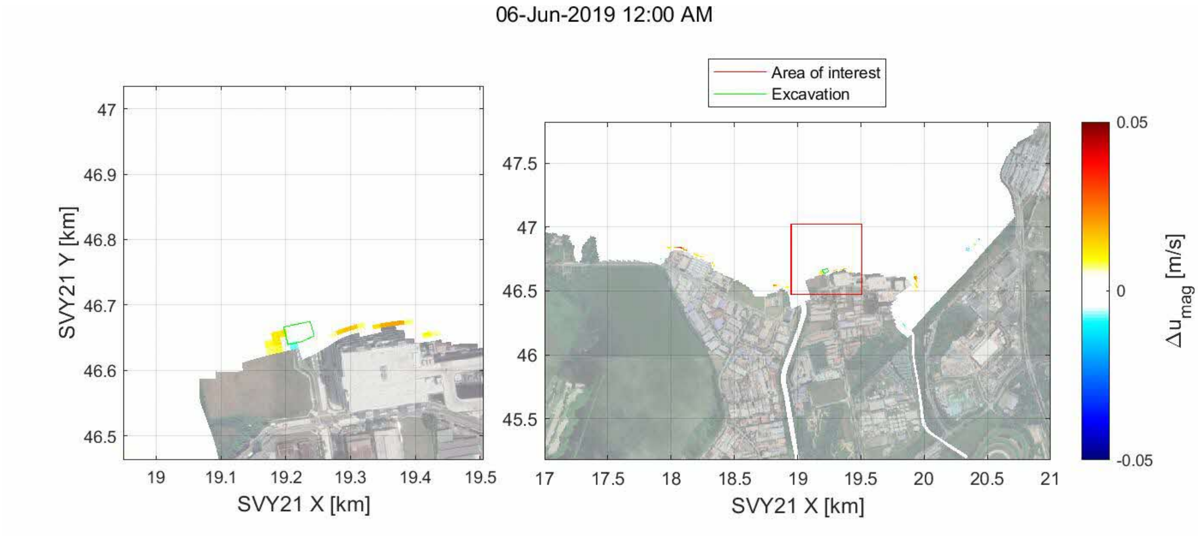



*Figure A-8: Differences in velocity magnitude (Δumag) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2050.*

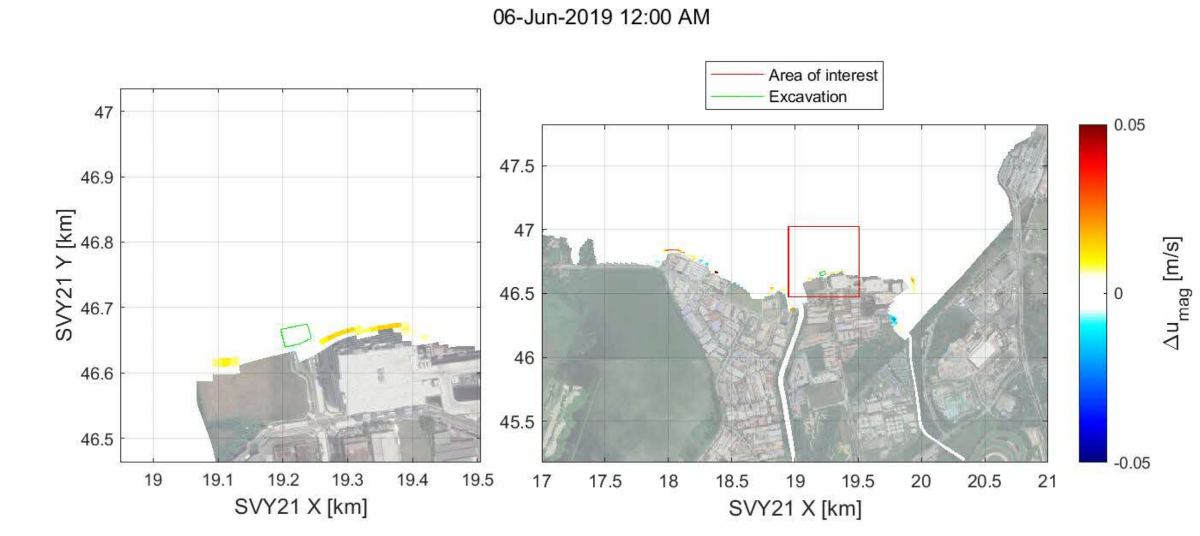



*Figure A-9: Differences in velocity magnitude (Δumag) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2100.*

### A.3.2 Significant wave height

There are differences in significant wave height (Figure A-10 for SLR 2030; Figure A-11 for SLR 2050; Figure A-12 for SLR 2100) in the order of 0.03 m near the coast, in and adjacent to the added grid cells. In general, the slope change and Experiential Walk had little to no effect in each scenario.

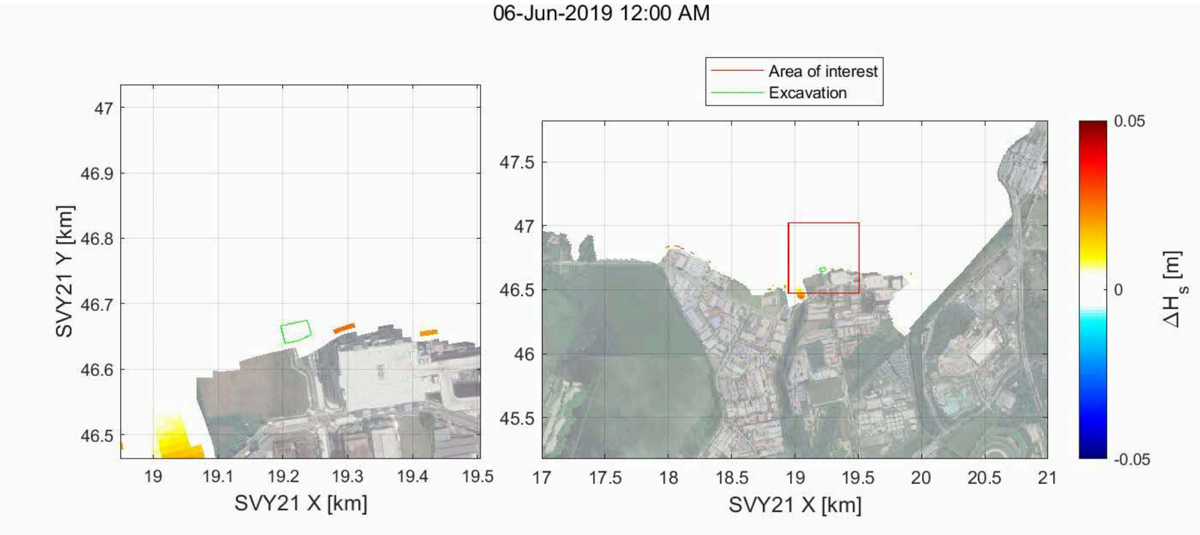



*Figure A-10: Differences in significant wave height (ΔHs) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2030.*

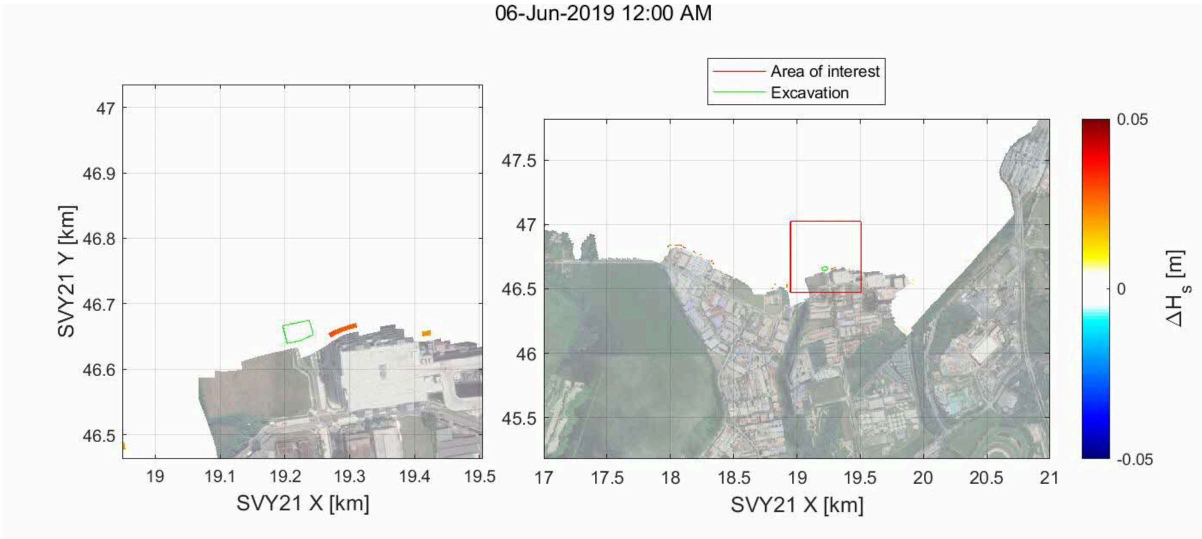



*Figure A-11: Differences in significant wave height (ΔHs) between the simulations with and without slope change and Experiential Walk wave height differences around high water of a King Tide event for SLR scenario 2050.*

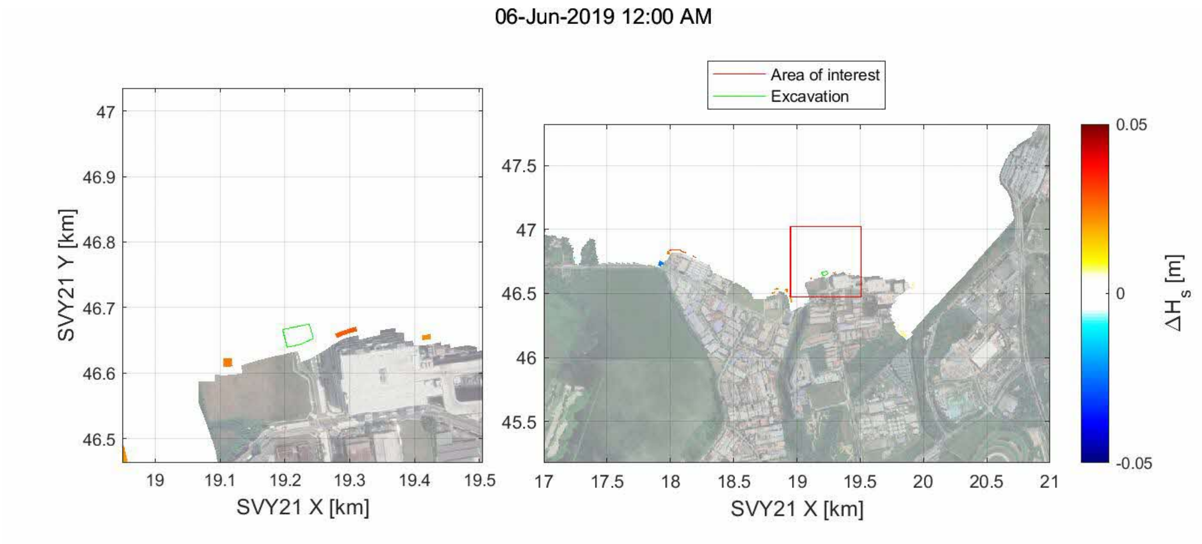



*Figure A-12: Differences in significant wave height (ΔHs) between the simulations with and without slope change and Experiential Walk around high water of a King Tide event for SLR scenario 2100.*

## A.4 Conclusions

Hydrodynamic model simulations for three sea level rise scenarios showed that the effects of a planned slope change at the Mandai Mangrove and Mudflat coastline on the hydrodynamics of the area will be very limited and only noticeable in the area of the changed slope.

Since the influence of the slope change on the hydrodynamics were shown to be very limited, the influence of the slope changes on sediment transport and morphology are expected to be negligible. Hence, no morphodynamic simulations were executed with the slope changes.

# B Water levels, currents, waves

## B.1 Sea level rise under SW Monsoon, 10 cm

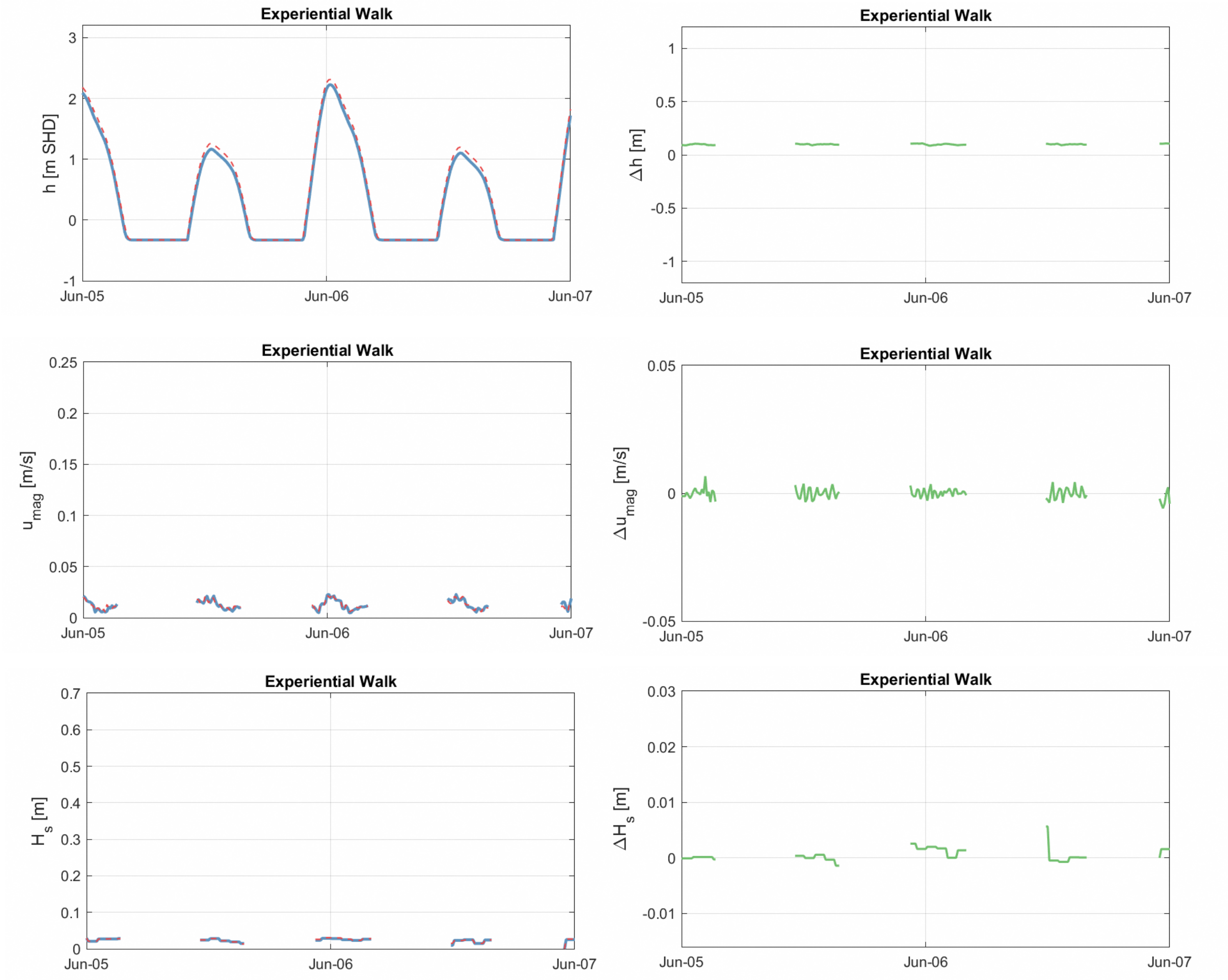
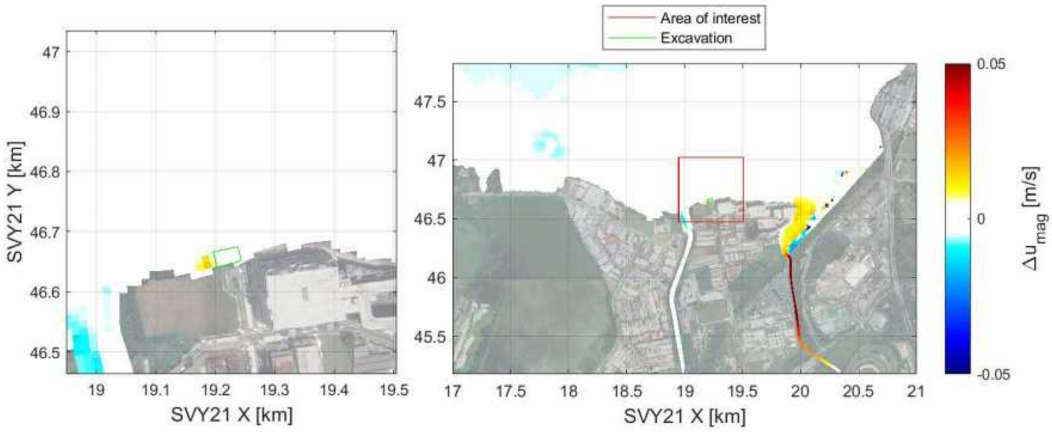



*Figure B-1: Model results without (blue) and with (red) sea level rise and the differences for water levels (h, top), velocities ($u_{mag}$, middle) and significant wave height ($H_s$, bottom) for a sea level rise scenario of 10 cm or representative of 2030, for southwest monsoon conditions.*



Deltares



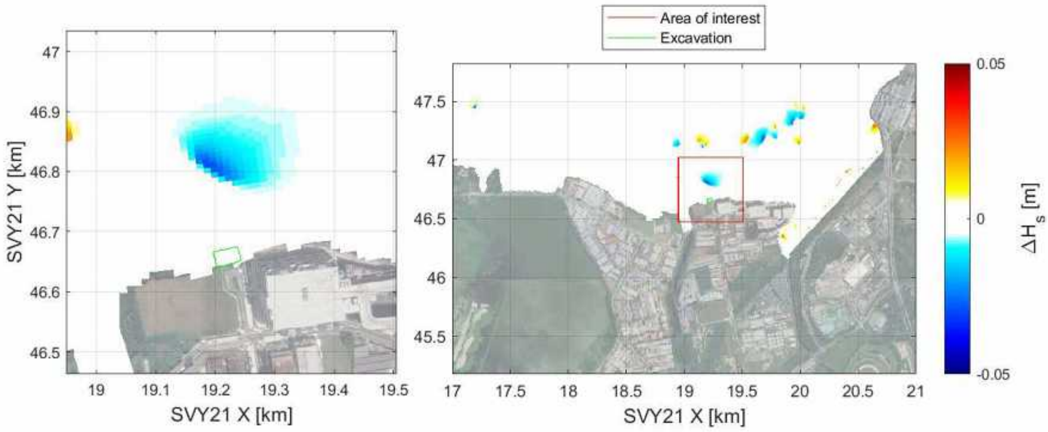




*Figure B-2: Differences in velocity magnitude ($u_{mag}$, top) and significant wave height ($H_s$, bottom) at 00:00 a.m. on June 6, nearly high water, between a situation with and without sea level rise of 10 cm for SW monsoon conditions.*

## B.2 Sea level rise under SW Monsoon, 32 cm

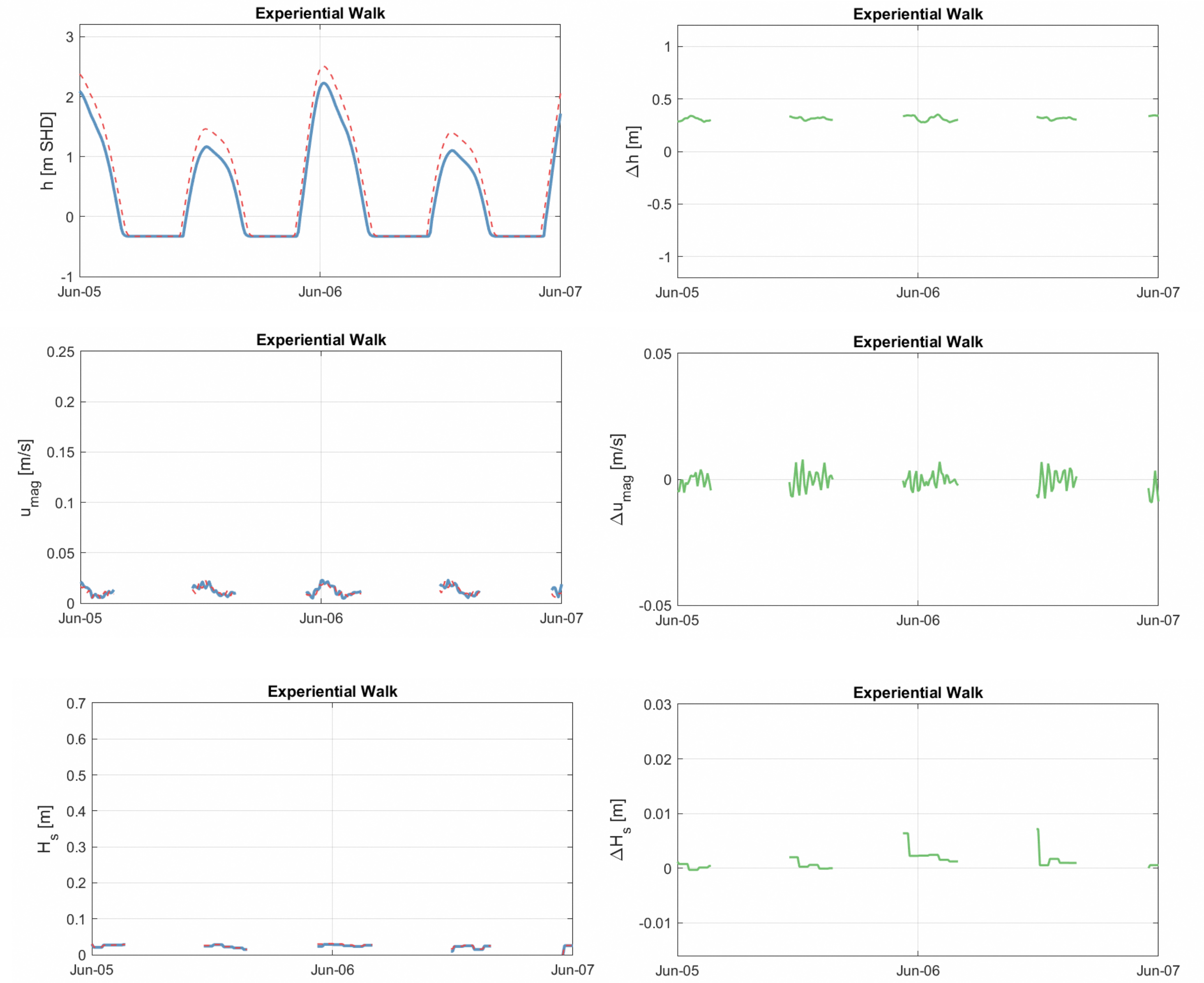
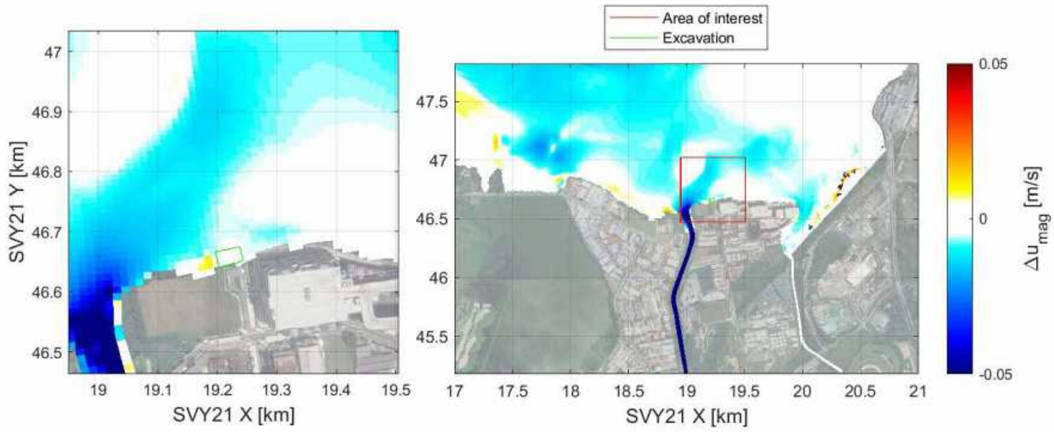



*Figure B-3: Model results without (blue) and with (red) sea level rise and the differences for water levels (h, top), velocities ($u_{mag}$, middle) and significant wave height ($H_s$, bottom) for a sea level rise scenario of 32 cm or representative of 2050, for SW monsoon conditions.*



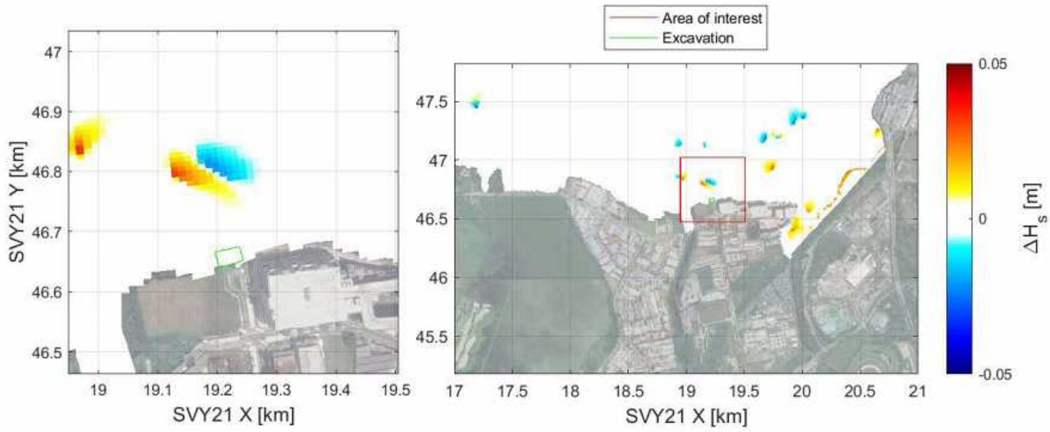




*Figure B-4: Differences in velocity magnitude ($u_{mag}$, top) and significant wave height ($H_s$, bottom) at 00:00 a.m. on June 6, nearly high water, between a situation with and without sea level rise of 32 cm for SW monsoon conditions*

# C Appendix: Sediment dynamics & morphology

## C.1 Available mass of sediment of Monsoon conditions, extreme squall event and sea level rise under SW Monsoon, 102cm

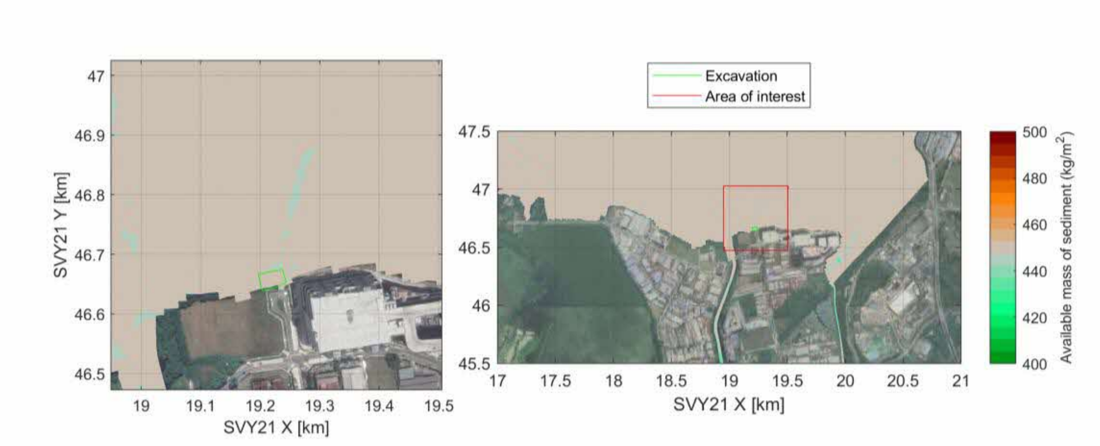



*Figure C-1: Available sediment mass at the last time step of the SW monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

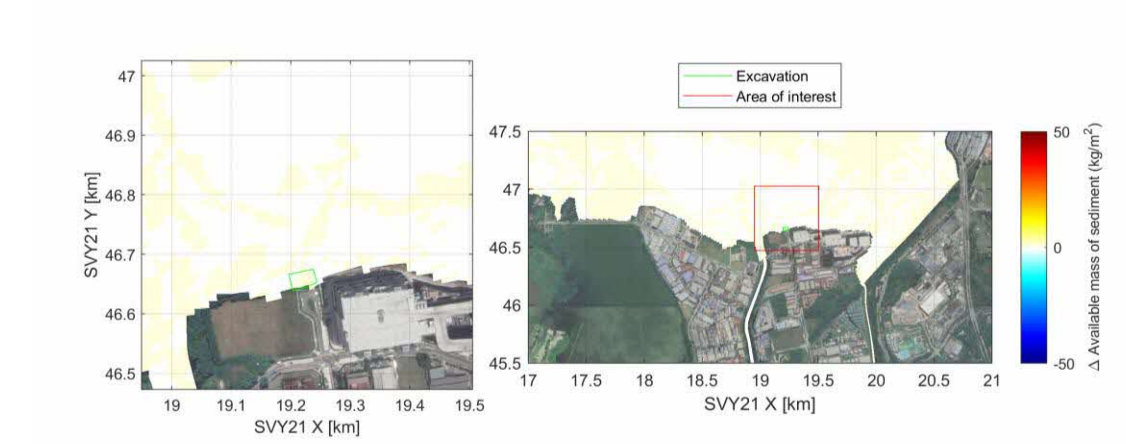



*Figure C-2: Change of the available mass of sediment (kg/m²) of the SW monsoon scenario including Experiential Walk. Positive values indicate an increase of the available mass of sediment after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

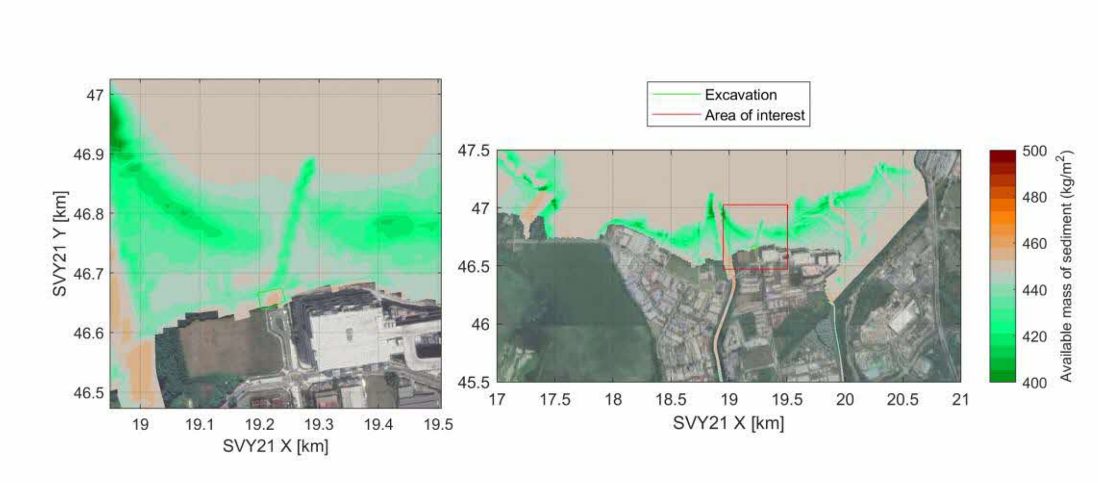



*Figure C-3: Available sediment mass at the last time step of the NE monsoon scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

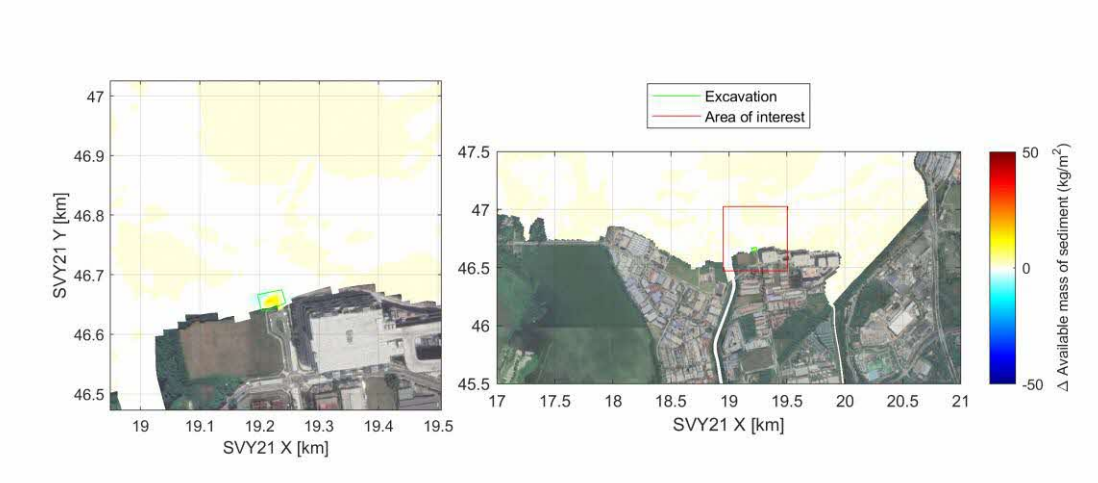



*Figure C-4: Change of the available mass of sediment (kg/m²) of the NE monsoon scenario including Experiential Walk. Positive values indicate an increase of the available mass of sediment after the construction of the Experiential Walk and excavation.  Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

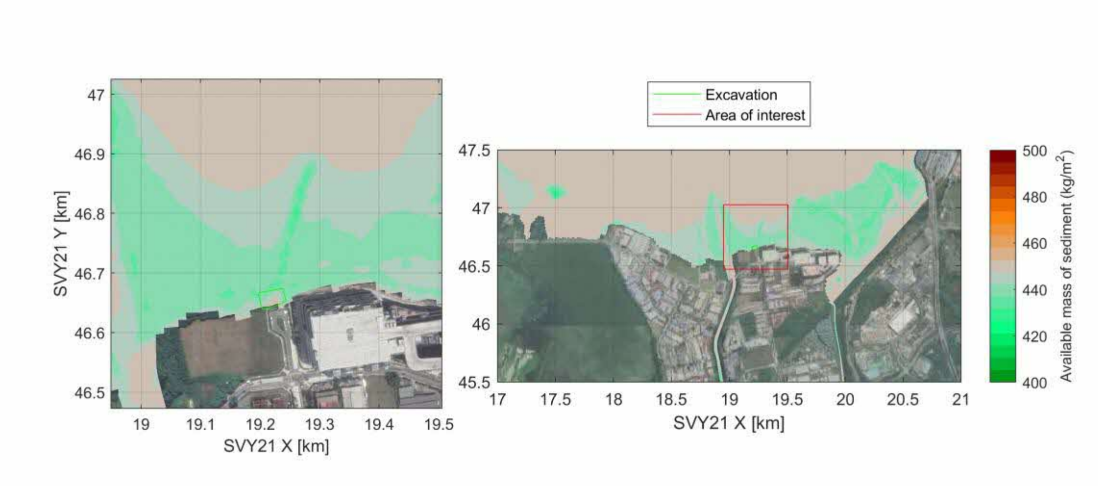



*Figure C-5: Available sediment mass at the last time step of the squall scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

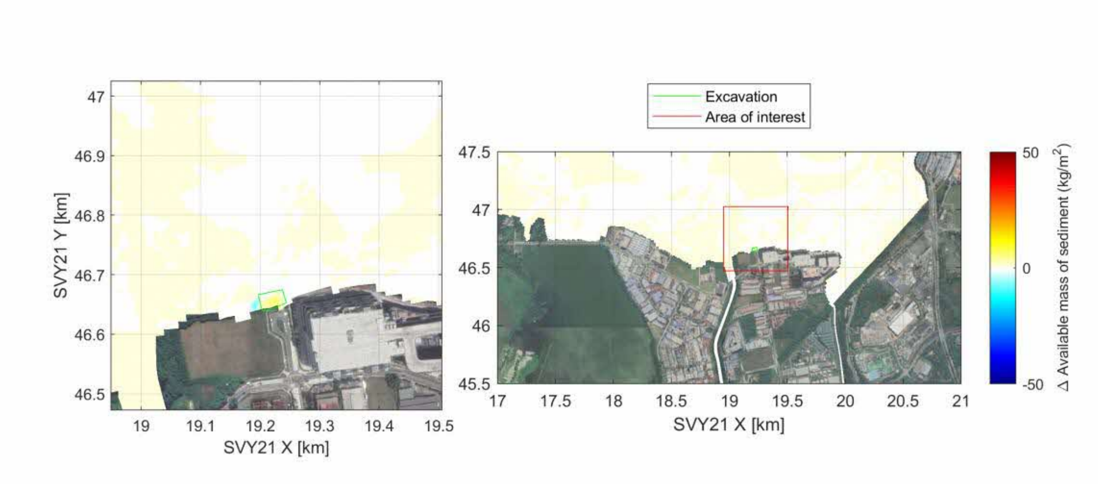



*Figure C-6: Change of the available mass of sediment (kg/m$^2$) of the squall scenario including Experiential Walk. Positive values indicate an increase of the available mass of sediment after the construction of the Experiential Walk and excavation. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

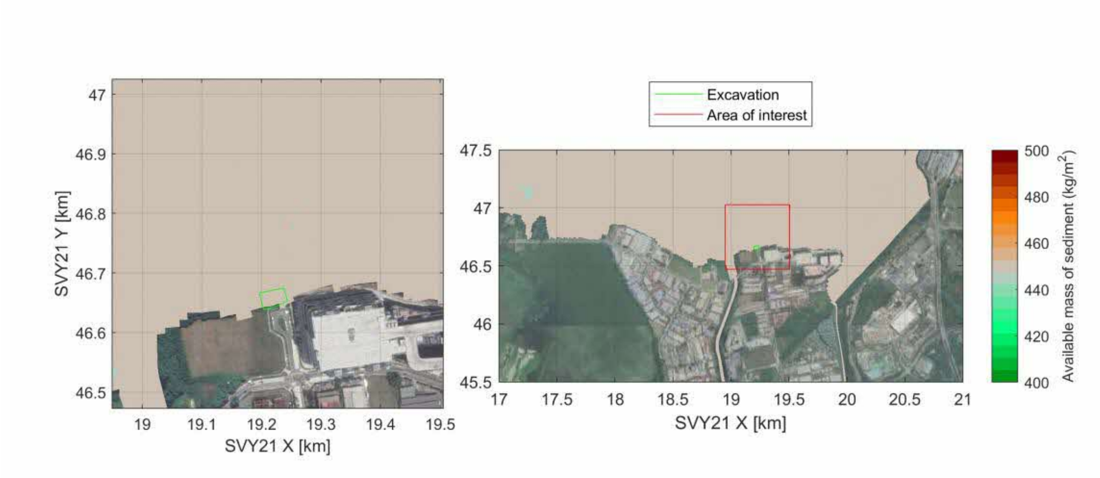



*Figure C-7: Available sediment mass at the last time step of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

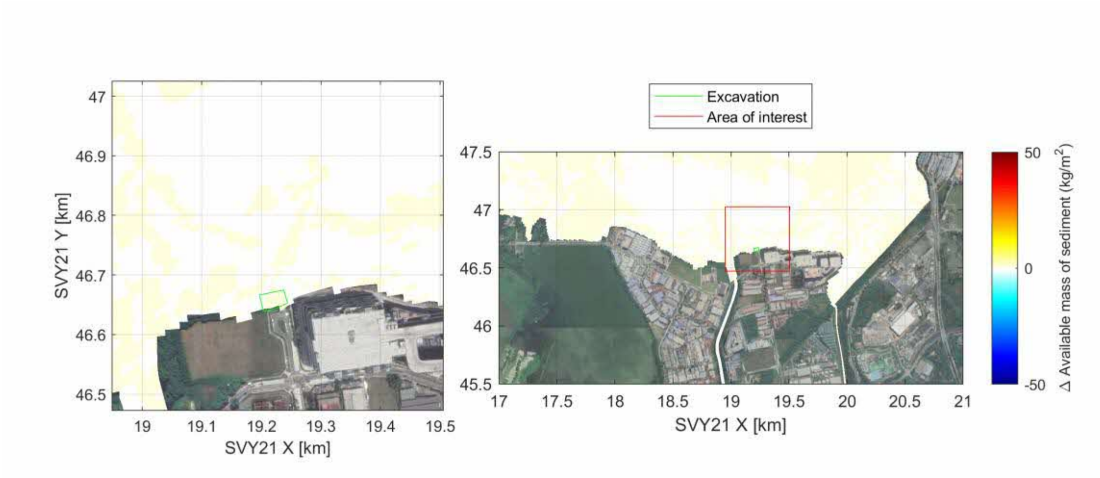



*Figure C-8: Change of the available mass of sediment (kg/m²) of the 'SLR under SW Monsoon, 102 cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the available mass of sediment with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

## C.2 Sea level rise under SW Monsoon, 10cm

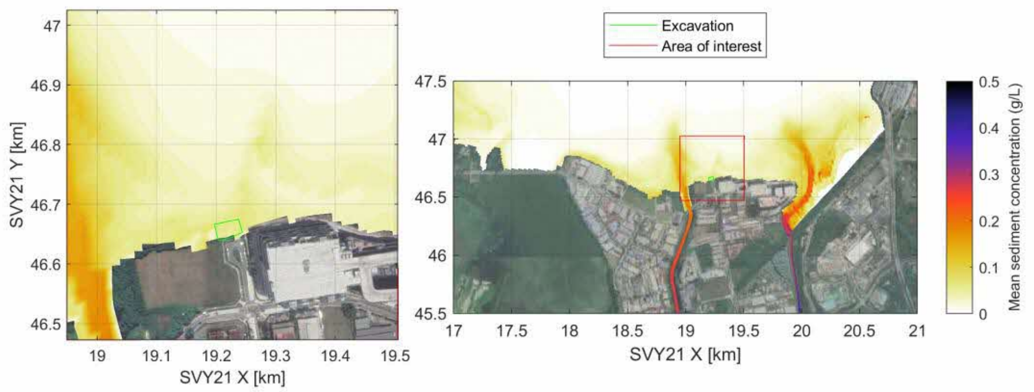



*Figure C-9: Time-averaged suspended sediment concentration (g/L) of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

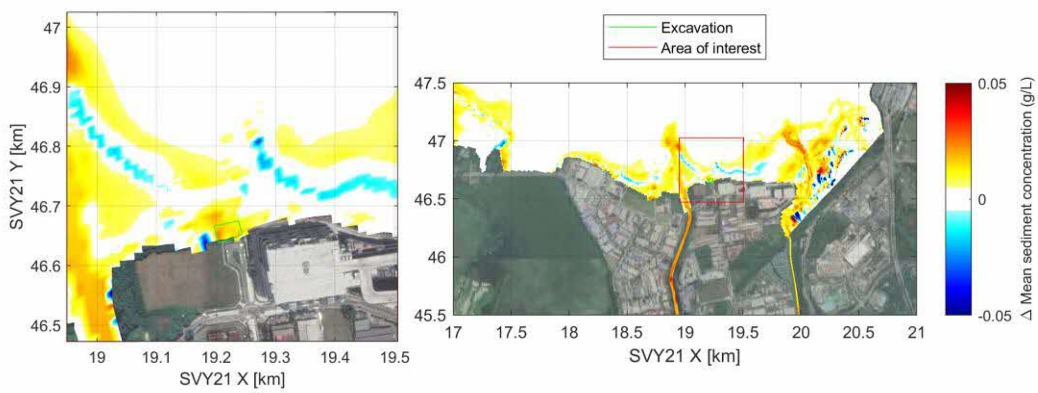



*Figure C-10: Change of the time-averaged suspended sediment concentration (g/L) of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the time-averaged suspended sediment concentration with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

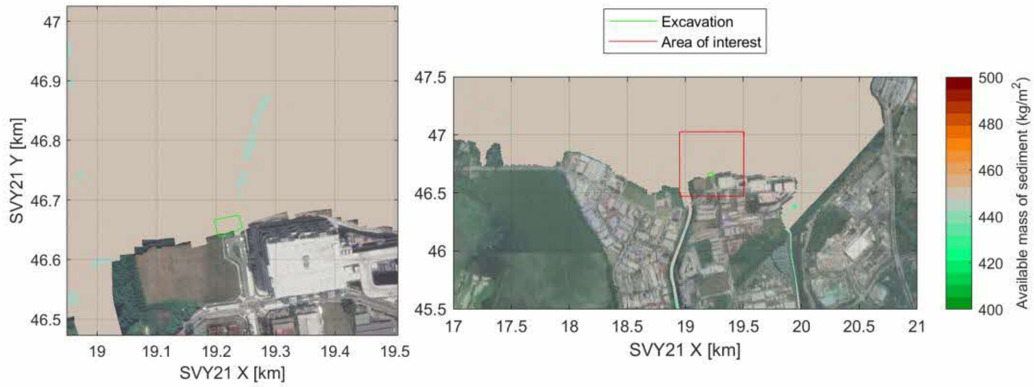



*Figure C-11: Available sediment mass at the last time step of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

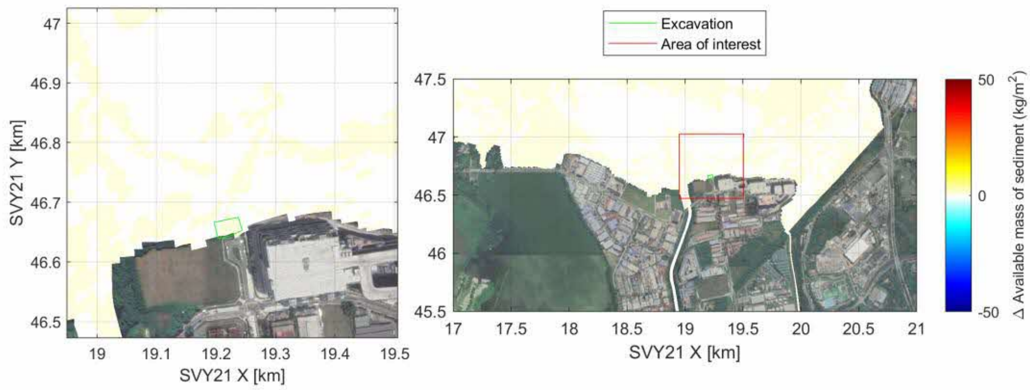



*Figure C-12: Change of the available mass of sediment (kg/m²) of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the available mass of sediment with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

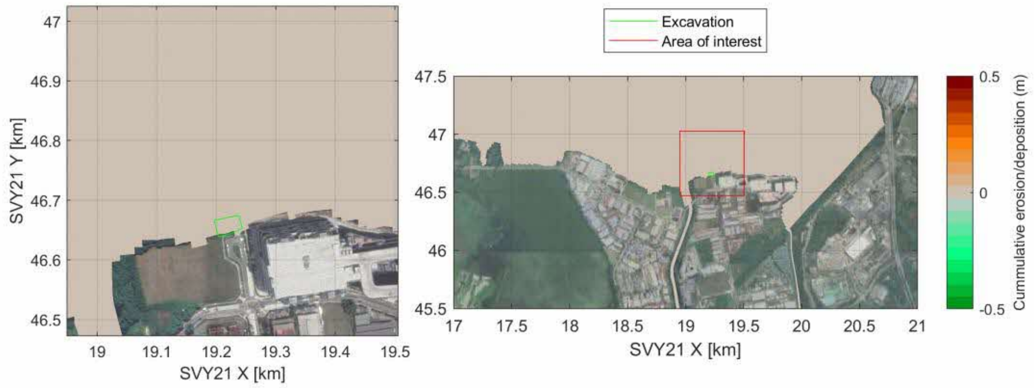



*Figure C-13: Cummulative erosion/deposition (m) at the last time step of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated*

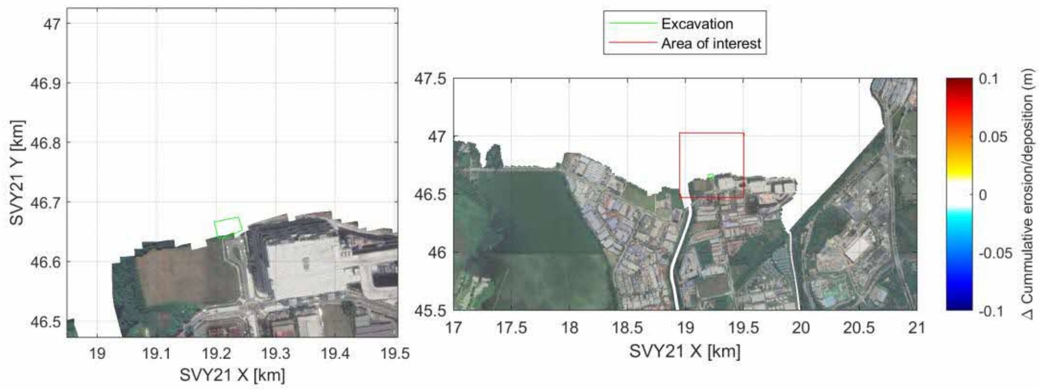



*Figure C-14: Change of the cummulative erosion/deposition (m) of the 'sea level rise under SW Monsoon, 10cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the cummulative erosion/deposition with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

## C.3 Sea level rise under SW Monsoon, 32cm

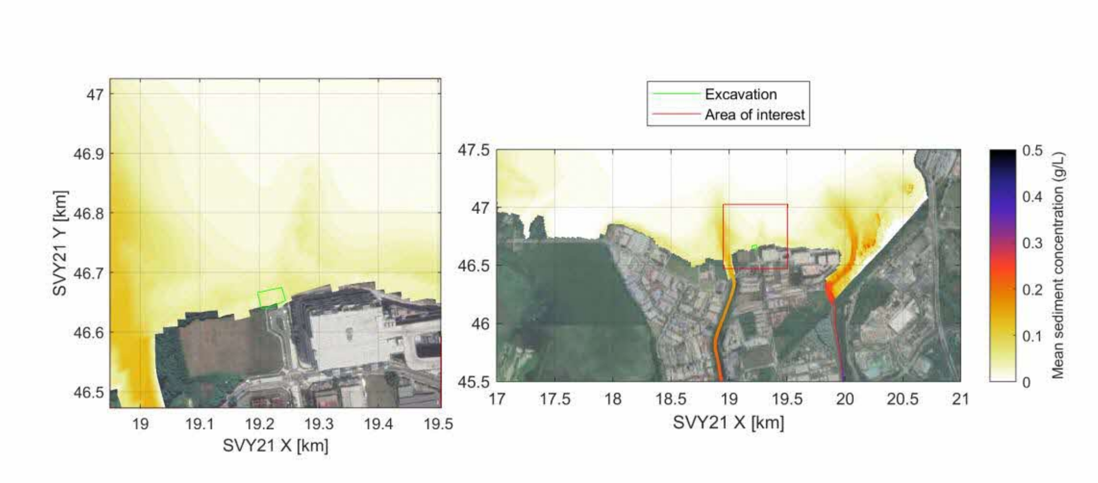



*Figure C-15: Time-averaged suspended sediment concentration (g/L) of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated*

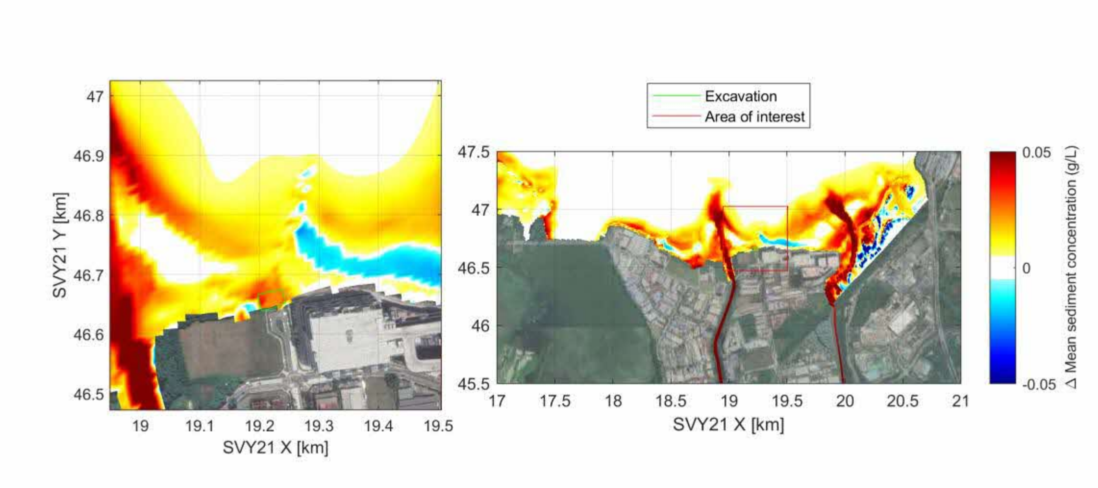



*Figure C-16: Change of the time-averaged suspended sediment concentration (g/L) of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the time-averaged suspended sediment concentration with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

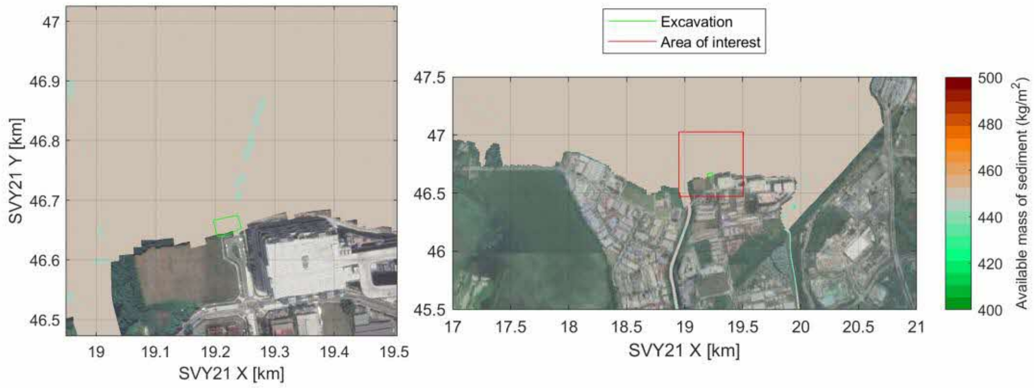



*Figure C-17: Available sediment mass at the last time step of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

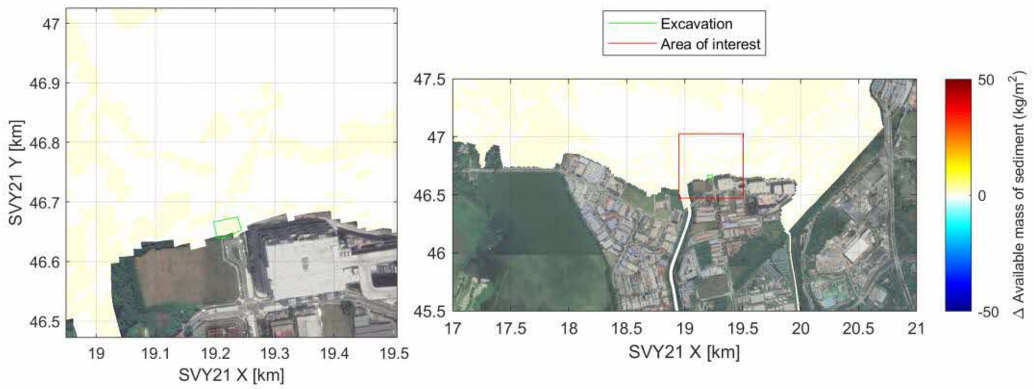



*Figure C-18: Change of the available mass of sediment (kg/m²) of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the available mass of sediment with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

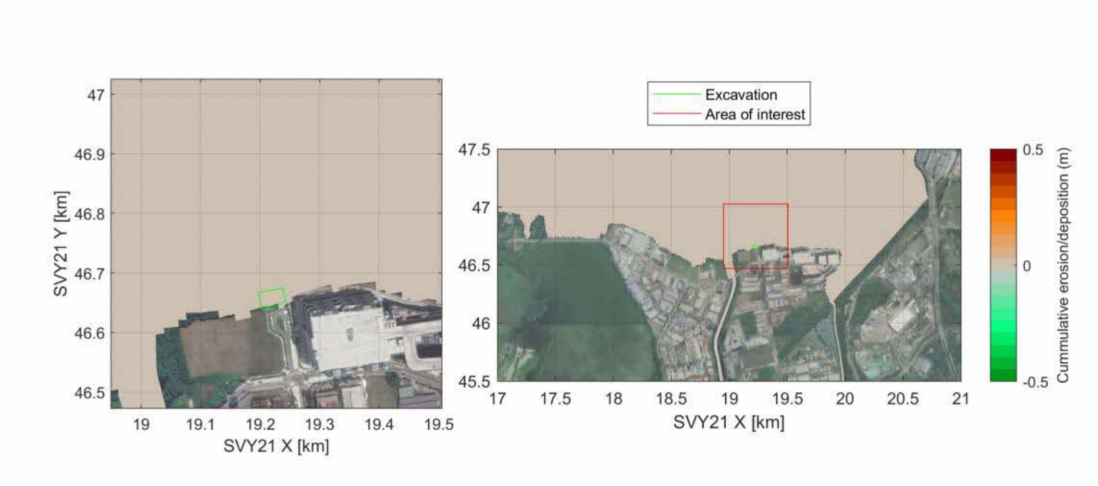



*Figure C-19: Cummulative erosion/deposition (m) at the last time step of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated*

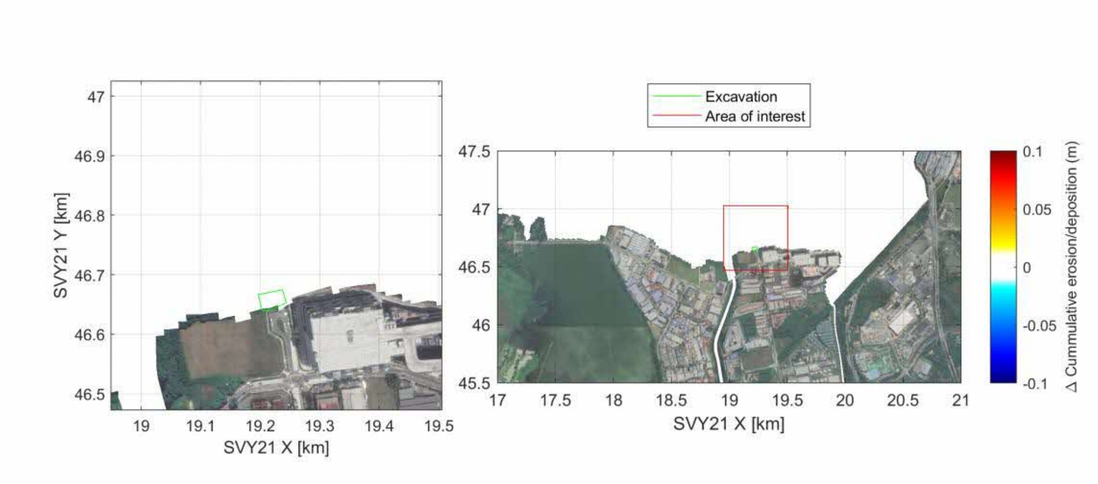



*Figure C-20: Change of the cummulative erosion/deposition (m) of the 'sea level rise under SW Monsoon, 32cm'-scenario including Experiential Walk. Here, the output of the model of current SW monsoon conditions is substracted from the output of the model under this sealevel rise scenario. Positive values indicate a decrease of the the cummulative erosion/deposition with repect to the present. Left: region of interest. Right: Surrounding area of region of interest in which the extent of the region of interest is indicated.*

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**Analysis wind conditions**

The climate of Singapore is characterized by two monsoon seasons separated by inter-monsoonal periods. Chenoli et al. (2018) focuses on the southwest (SW) monsoon in Malaysia and determines its onset based on multiple parameters such as wind, outgoing long-wave radiation (OLR), rainfall, and relative humidity. The period for the southwest monsoon in Malaysia is found to be mid-May until September. Bases on rainfall intensity Simón-Moral et al. (2021) defined the northeast monsoon to be between December and March. As seen in Figure 1, the NE monsoon generally has higher windspeeds compared to the SW monsoon. Additionally, the post NE inter-monsoon period has higher windspeeds compared to the SW monsoon, and is mainly distinctive by it's change in direction from North to South. The post SW inter-monsoon period is characterized by change in wind direction from South to North with comparable windspeeds to the SW monsoon. North winds signify the majority of the inter-monsoon periods.

In conclusion, the wind regime in the inter-monsoon periods seems to differ from the regime in the monsoon periods in terms of the directional change and variable wind direction, but is mainly characterized by north winds. The wind intensity is slightly lower, which makes these periods comparable to NE monsoons with lower intensity. This is in agreement with Simón-Moral et al. (2021), who stated the inter-monsoon periods consists of 'light and variable winds'. Using wind data for the inter-monsoon periods as input for the hydrodynamic model would, therefore, be comparable to model results of the NE monsoon with lower energetic conditions. This will likely lead to less morphological change but with comparable spatial patterns of erosion and deposition.

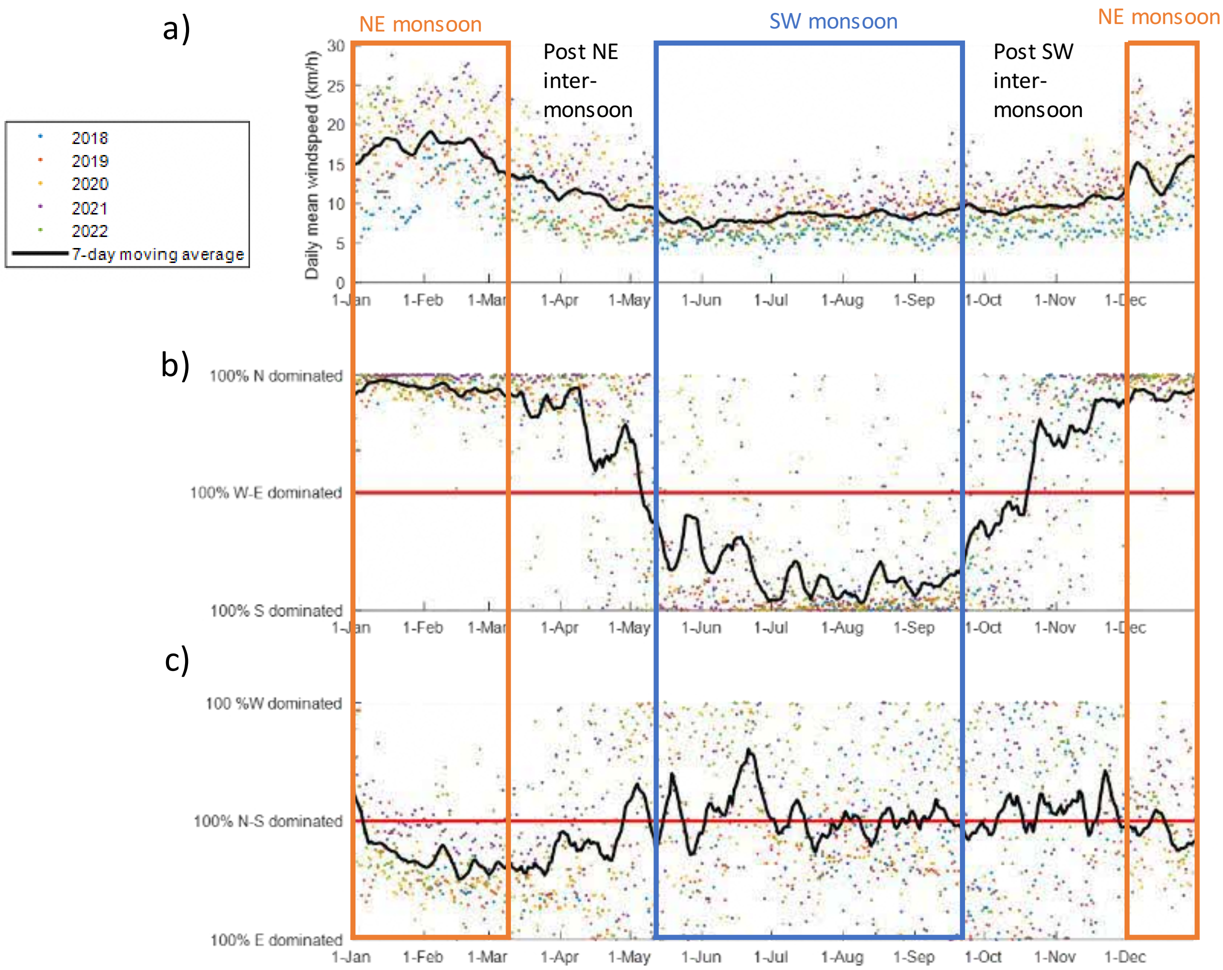


*Figure 1: Dailly windspeed between 2018-2022 from the Admiralty station in Singapore (panel a); North (N) and South (S) component of wind direction (panel b); North (W) and South (E) component of wind direction (panel c). The monsoon periods are indicated by the orange (northeast) and blue (southwest) dotted squared. The monsoon periods are sequenced by inter-monsoon periods. Colored markers express the different years. A red line indicates whether the wind direction is orthogonal to N-S direction (panel b) or orthogonal to the W-E direction (panel c). In all panels a black line indicates a 7-day moving window of the 5-year average on that date.*

**References**

Chenoli, S. N., Jayakrishnan, P. R., Samah, A. A., Hai, O. S., Ahmad Mazuki, M. Y., & Lim, C. H. (2018). Southwest monsoon onset dates over Malaysia and associated climatological characteristics. *Journal of Atmospheric and Solar-Terrestrial Physics*, *179*(June), 81–93. https://doi.org/10.1016/j.jastp.2018.06.017

Horstman, E. M., Dohmen-Janssen, C. M., Bouma, T. J., & Hulscher, S. J. M. H. (2015). Tidal-scale flow routing and sedimentation in mangrove forests: Combining field data and numerical modelling. *Geomorphology*, *228*, 244–262. https://doi.org/10.1016/j.geomorph.2014.08.011

Hu, K., Ding, P., Wang, Z., & Yang, S. (2009). A 2D/3D hydrodynamic and sediment transport model for the Yangtze Estuary, China. *Journal of Marine Systems*, *77*(1–2), 114–136. https://doi.org/10.1016/j.jmarsys.2008.11.014

Simón-Moral, A., Dipankar, A., Doan, Q. Van, Sanchez, C., Roth, M., Becker, E., & Huang, X. Y. (2021). Urban intensification of convective rainfall over the Singapore – Johor Bahru region. *Quarterly Journal of the Royal Meteorological Society*, *147*(740), 3665–3680. https://doi.org/10.1002/qj.4147

Willemsen, P. W. J. M., Horstman, E. M., Borsje, B. W., Friess, D. A., & Dohmen-Janssen, C. M. (2016). Sensitivity of the sediment trapping capacity of an estuarine mangrove forest. *Geomorphology*, *273*, 189–201. https://doi.org/10.1016/j.geomorph.2016.07.038

# APPENDIX G

## Baseline Sediment Quality Laboratory Test

# TEST REPORT

| | | | | | |
|---|---|---|---|---|---|
| Our Reference No. | : | **R227125** | Date Received | : | 28/10/2022 |
| Project Code / Ref. | : | - | Date Commenced | : | 28/10/2022 |
| | | | Date Reported | : | 16/11/2022 |

Customer Ref. No. : -
Customer Name : TEMBUSU Asia Consulting Pte Ltd
Customer Address : 1 Commonwealth Lane
#06-06, One Commonwealth
Singapore 149544

Attention To : Mr Eric Chng

Sample Description : 8 Sediment samples as per received.

**RESULTS:** Refer to Page 2 to Page 18

**Tan Thuan Piang**
**Technical Manager**

**Terms & Conditions:**

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

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Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

R227125

**RESULTS**

| Test Parameter | Unit | Test Method | Sample 1 SD1 28/10/2022 | Sample 2 SD2 28/10/2022 | Sample 3 SD3 28/10/2022 | Sample 4 SD4 28/10/2022 | Sample 5 SD5 28/10/2022 | Sample 6 SD6 28/10/2022 | Sample 7 SD7 28/10/2022 | Sample 8 SD8 28/10/2022 | LOR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulk Density | $Mg/m^3$ | BS EN ISO 17892-2 : 2014 Section 5.1 | 1.59 | 1.42 | 1.29 | 1.48 | 1.22 | 1.23 | 1.38 | 1.43 | 0.01 |
| Organic Matter as LOI | % | BS 1377: Part 3:2018 | 6.25 | 1.00 | 5.92 | 5.39 | 11.3 | 9.00 | 6.61 | 1.68 | 0.1 |
| Cadmium as Cd | mg/kg | APHA 3120B | 0.48 | 0.45 | 0.49 | 0.39 | 0.95 | 0.75 | 0.53 | 0.040 | 0.0075 |
| Chromium as Cr | mg/kg | APHA 3120B | 14.1 | 23.8 | 35.9 | 22.8 | 46.5 | 37.5 | 25.9 | 3.99 | 0.005 |
| Mercury as Hg | mg/kg | USEPA 245.1 (FIMS) (1994) | 0.11 | 0.18 | 0.20 | 0.13 | 0.26 | 0.19 | 0.12 | 0.021 | 0.01 |
| Nickel as Ni | mg/kg | APHA 3120B | 7.48 | 12.0 | 15.6 | 10.3 | 15.9 | 14.8 | 12.3 | 2.09 | 0.025 |
| Zinc as Zn | mg/kg | APHA 3120B | 197 | 210 | 335 | 178 | 494 | 368 | 222 | 28.8 | 0.01 |
| Copper as Cu | mg/kg | APHA 3120B | 26.1 | 44.9 | 69.7 | 39.2 | 83.2 | 72.6 | 46.3 | 4.09 | 0.02 |
| Lead as Pb | mg/kg | APHA 3120B | 18.0 | 25.8 | 31.3 | 21.0 | 56.0 | 57.1 | 33.4 | 5.78 | 0.1 |
| Arsenic as As | mg/kg | APHA 3120B | 15.7 | 24.5 | 28.8 | 16.1 | 40.2 | 26.5 | 18.1 | 2.54 | 0.125 |
| Total Petroleum Hydrocarbons (by FTIR) | mg/kg | USEPA 8440 (1996) | 383 | 399 | 444 | 515 | 1,124 | 795 | 651 | ND | 44 |

***Note:***

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. LOR = Limit of Reporting.
3. "ND" = Not detected. The data reported is less than the LOR.

R227125

## RESULTS FOR PARTICLE DENSITY

| | | |
|---|---|---|
| **Project Code / Ref.** | : | - |
| **SN** | : | **Sample 1** |
| **Sample ID** | : | **SD1** |

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.241 | 30.551 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.418 | 79.551 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.629 | 2.641 |

| Description/ Job No. | Sample ID | Average Particle Density, ps (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S01 | 2.64 |

***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE DENSITY

| | | |
|---|---|---|
| **Project Code / Ref.** | : | - |
| **SN** | : | **Sample 2** |
| **Sample ID** | : | **SD2** |

**PARTICLE DENSITY, $\rho_s$**

Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.189 | 30.746 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.386 | 79.674 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\quad \rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.630 | 2.644 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S02 | 2.64 |

***Note:***

1. The above test was sub-contracted to external lab.

R227125

**RESULTS FOR PARTICLE DENSITY**

**Project Code / Ref.** : -
**SN** : **Sample 3**
**Sample ID** : **SD3**

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | **1** | **2** |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.387 | 30.235 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.504 | 79.347 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.625 | 2.626 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S03 | 2.63 |

***Note:***

1. The above test was sub-contracted to external lab.

## RESULTS FOR PARTICLE DENSITY

| | | |
|---|---|---|
| **Project Code / Ref.** | : | - |
| **SN** | : | **Sample 4** |
| **Sample ID** | : | **SD4** |

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.188 | 30.866 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.409 | 79.751 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.656 | 2.648 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S04 | 2.65 |

***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE DENSITY

**Project Code / Ref.** : -
**SN** : **Sample 5**
**Sample ID** : **SD5**

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.188 | 30.866 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.409 | 79.751 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.656 | 2.648 |

| Description/ Job No. | Sample ID | Average Particle Density, ps (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S05 | 2.65 |

***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE DENSITY

**Project Code / Ref.** : -
**SN** : **Sample 6**
**Sample ID** : **SD6**

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.881 | 31.057 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.850 | 79.871 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.665 | 2.650 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S06 | 2.66 |

***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE DENSITY

| | | |
|---|---|---|
| **Project Code / Ref.** | : | - |
| **SN** | : | **Sample 7** |
| **Sample ID** | : | **SD7** |

PARTICLE DENSITY, $\rho_s$
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.318 | 30.322 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.475 | 79.421 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.640 | 2.684 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S07 | 2.65 |

***Note:***

1. The above test was sub-contracted to external lab.

## RESULTS FOR PARTICLE DENSITY

| | | |
|---|---|---|
| **Project Code / Ref.** | : | - |
| **SN** | : | **Sample 8** |
| **Sample ID** | : | **SD8** |

**PARTICLE DENSITY, $\rho_s$**
Test Method - BS 1377 : 1990-PART 2: 8.3
SMALL PYKNOMETER METHOD
(SPECIFIC GRAVITY)

| Test No: | 1 | 2 |
|---|---|---|
| Pyknometer $\rho_s$ Bottle No: | 1 | 2 |
| Mass of $\rho_s$ bottle with stopper, M1 (g) | 33.954 | 26.645 |
| Mass of $\rho_s$ bottle with stopper & Soil, M2 (g) | 40.118 | 30.257 |
| Mass of $\rho_s$ bottle with stopper, Soil & Distilled Water, M3 (g) | 88.371 | 79.391 |
| Mass of $\rho_s$ bottle with stopper & Distilled Water, M4 (g) | 84.522 | 77.124 |
| Particle density, $\rho_s$ $\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ | 2.663 | 2.686 |

| Description/ Job No. | Sample ID | Average Particle Density, ρs (Mg/m$^3$): |
|---|---|---|
| CE-2211033/1 | R227125-S08 | 2.67 |

***Note:***

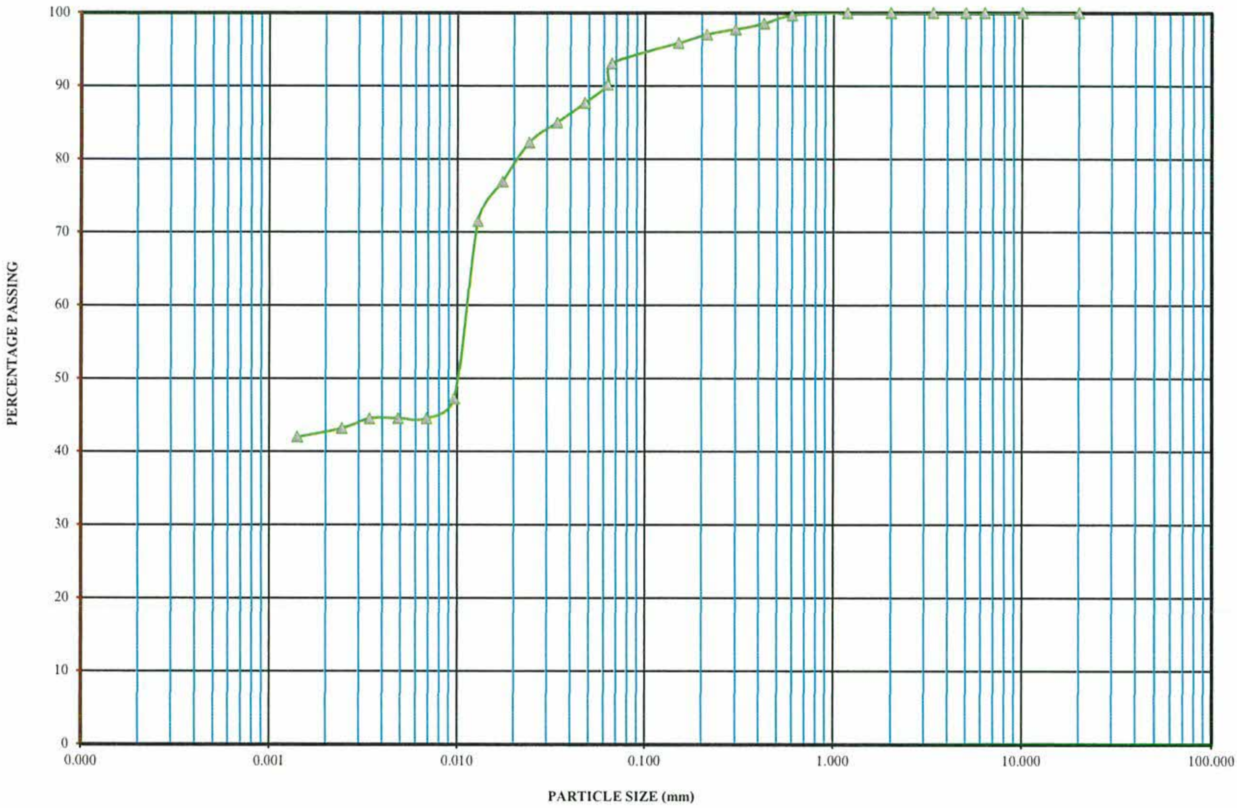
1. The above test was sub-contracted to external lab.

MLS

R227125

**RESULTS FOR PARTICLE SIZE DISTRIBUTION**

| | | |
|---|---|---|
| **Project Code / Ref.** | **:** | **-** |
| **SN** | **:** | **Sample 1** |
| **Sample ID** | **:** | **SD1** |




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 43 | 47 | 10 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 97 | 96 | 90 | 43 |

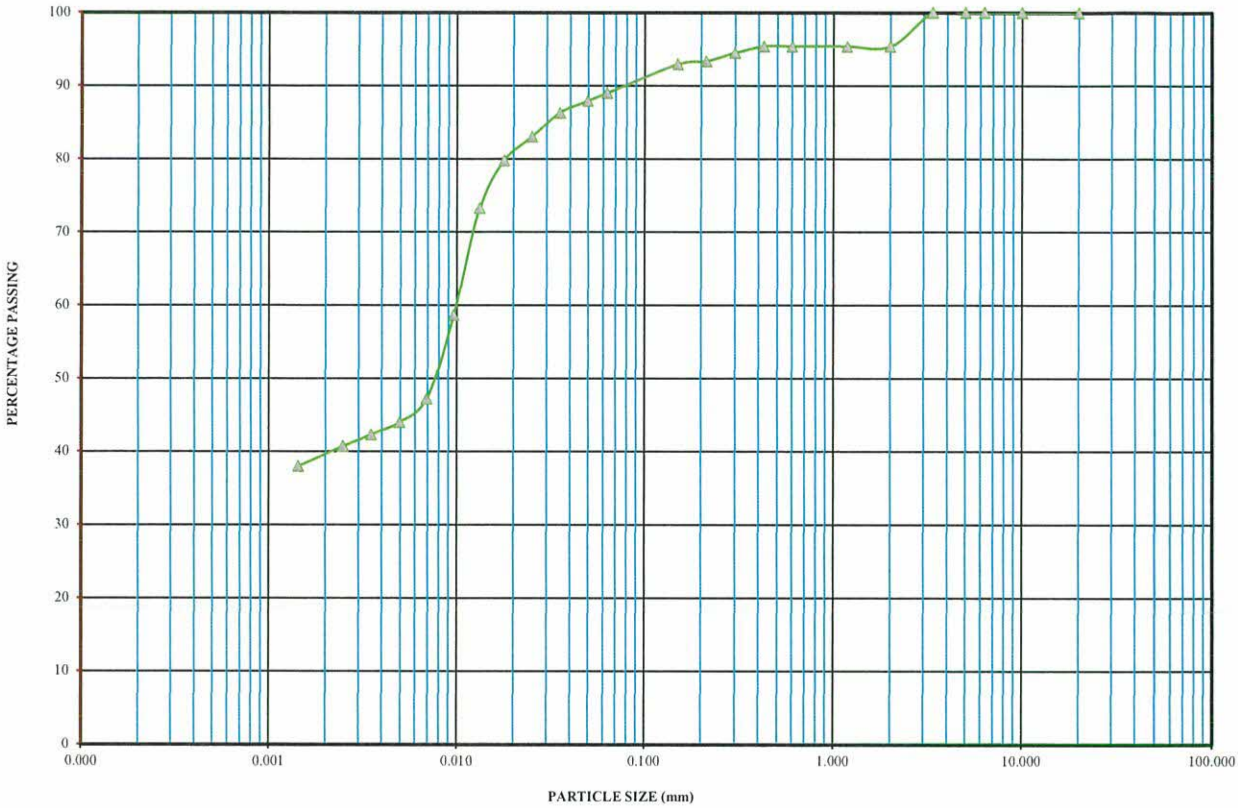
***Note:***

1. The above test was sub-contracted to external lab.

R227125

**RESULTS FOR PARTICLE SIZE DISTRIBUTION**

**Project Code / Ref. :** -
**SN :** Sample 2
**Sample ID :** SD2




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 41 | 48 | 6 | 5 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 95 | 95 | 95 | 95 | 94 | 93 | 93 | 89 | 41 |

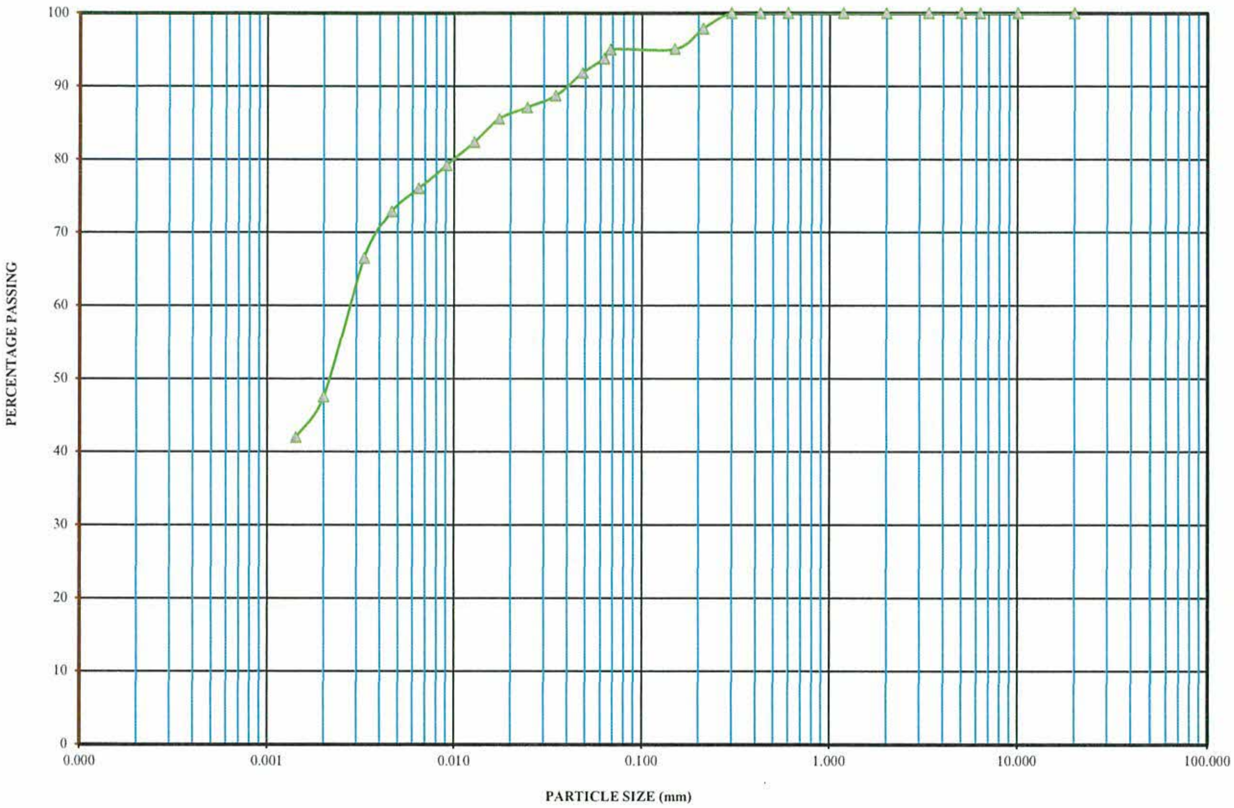
***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE SIZE DISTRIBUTION

**Project Code / Ref.** : -
**SN** : Sample 3
**Sample ID** : SD3




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 48 | 46 | 6 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98 | 95 | 94 | 48 |

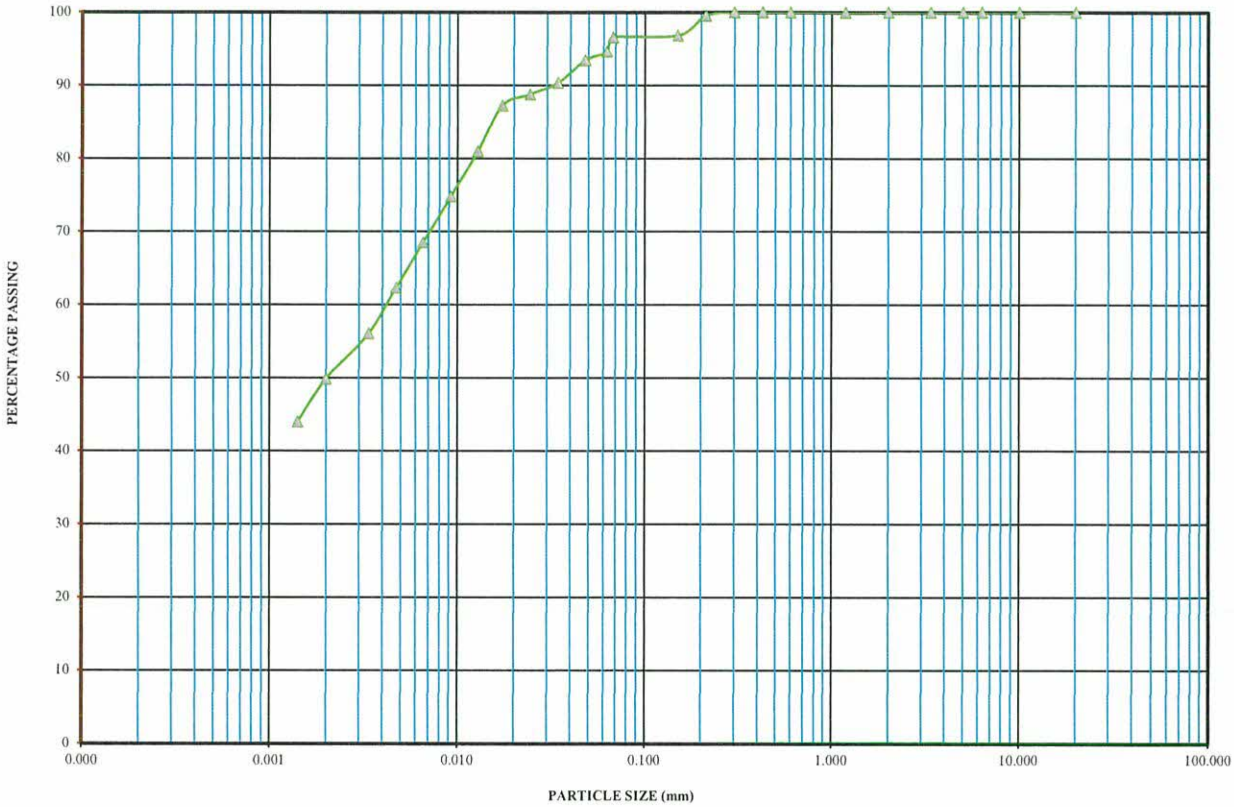
***Note:***

1. The above test was sub-contracted to external lab.

R227125

**RESULTS FOR PARTICLE SIZE DISTRIBUTION**

Project Code / Ref. : -
SN : Sample 4
Sample ID : SD4




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 50 | 45 | 5 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 95 | 50 |

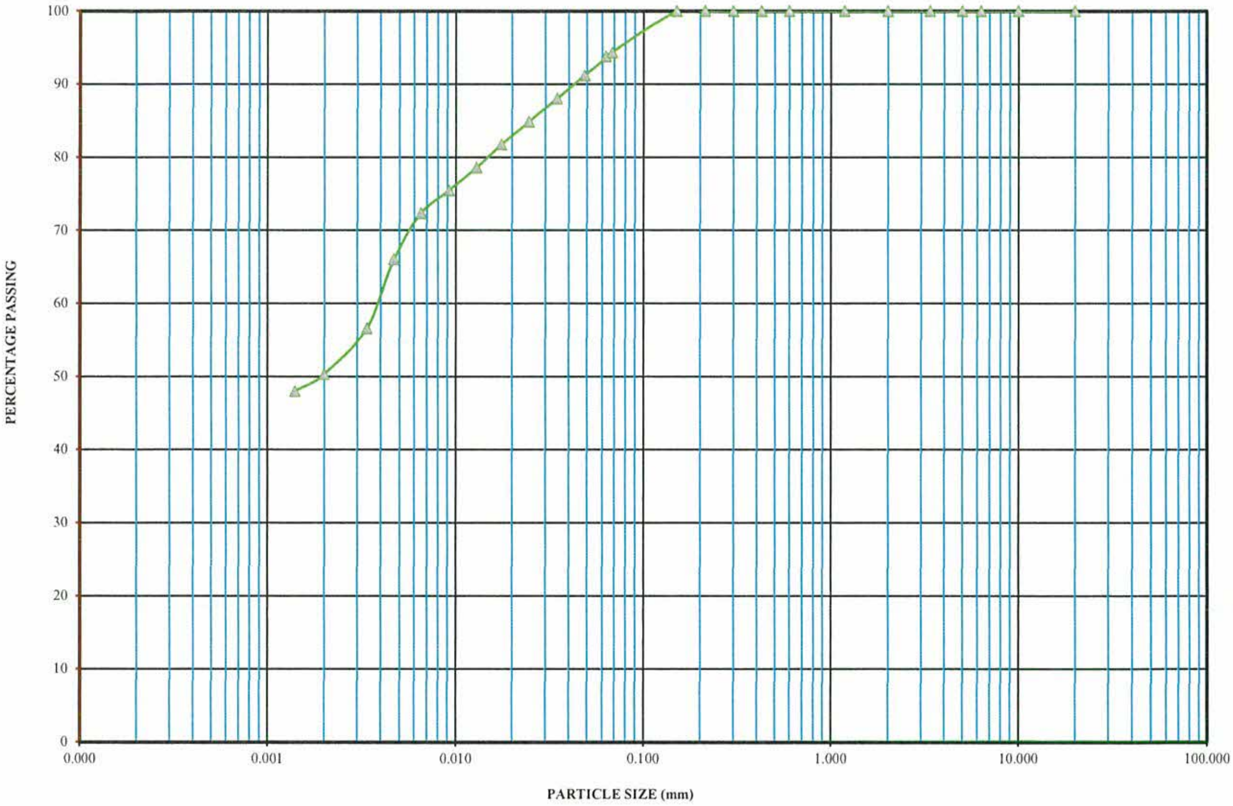
***Note:***

1. The above test was sub-contracted to external lab.

R227125

**RESULTS FOR PARTICLE SIZE DISTRIBUTION**

**Project Code / Ref. :** -
**SN :** Sample 5
**Sample ID :** SD5




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 50 | 44 | 6 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 94 | 50 |

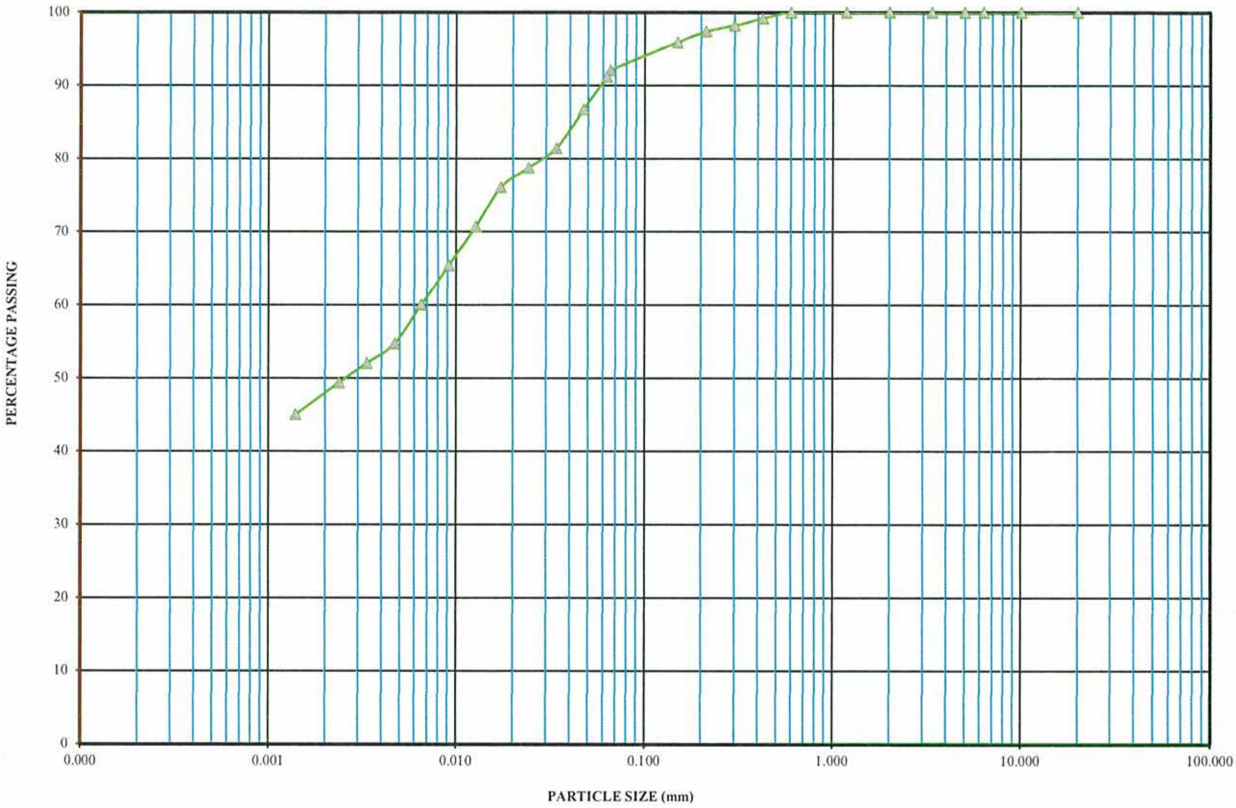
***Note:***

1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE SIZE DISTRIBUTION

**Project Code / Ref.** : -
**SN** : Sample 6
**Sample ID** : SD6




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 49 | 42 | 9 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 97 | 96 | 91 | 49 |

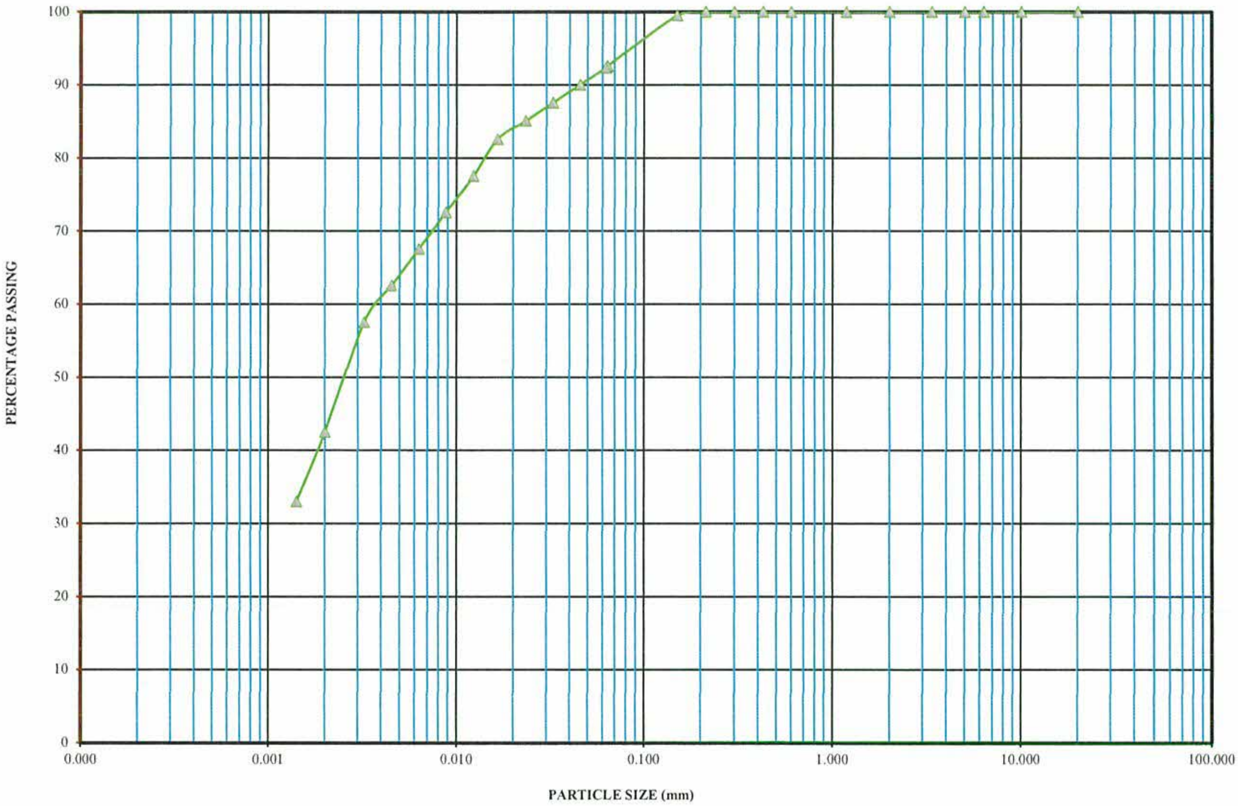
***Note:***

1. The above test was sub-contracted to external lab.

R227125

**RESULTS FOR PARTICLE SIZE DISTRIBUTION**

**Project Code / Ref. :** -
**SN :** Sample 7
**Sample ID :** SD7




| CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|

| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 43 | 49 | 8 | 0 |

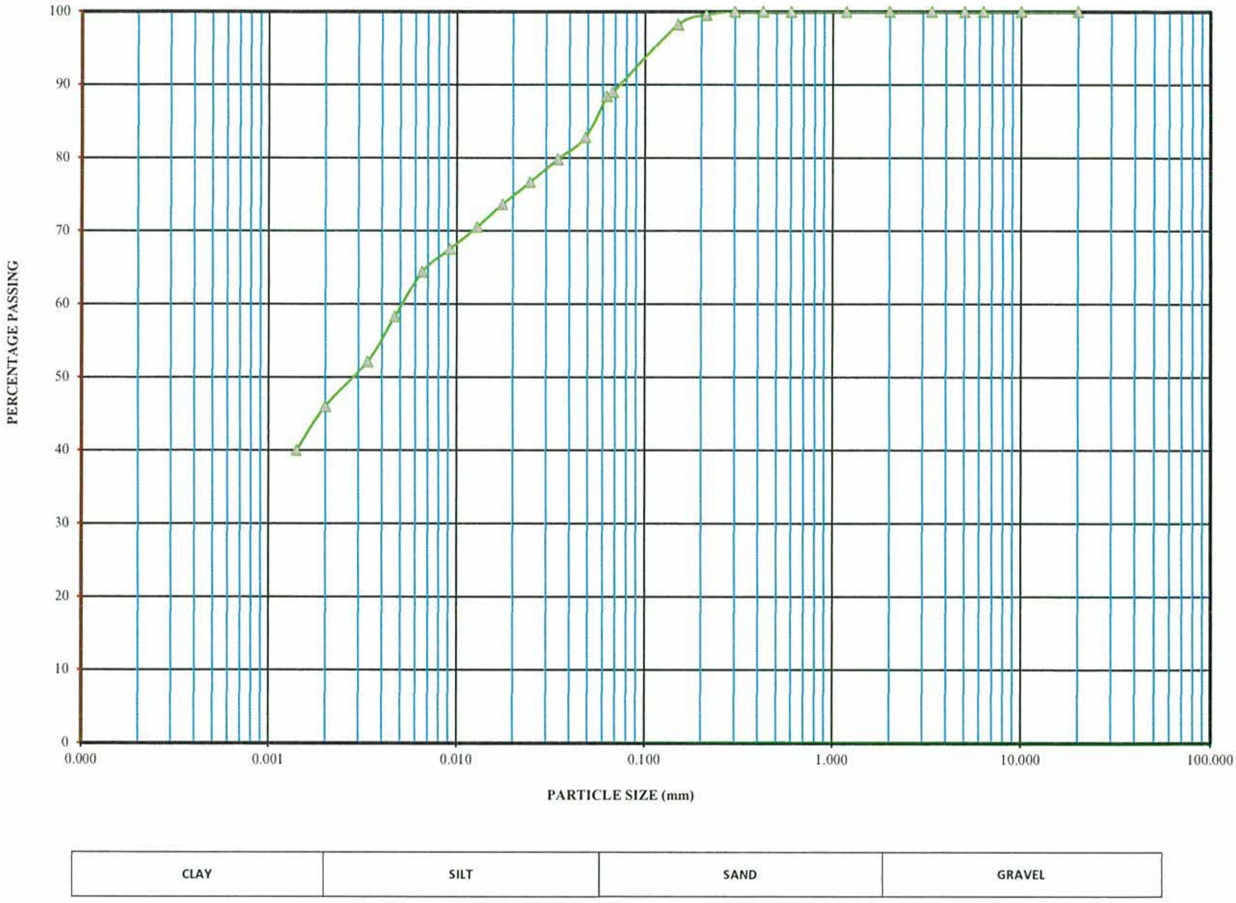
| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 92 | 43 |

***Note:***
1. The above test was sub-contracted to external lab.

R227125

## RESULTS FOR PARTICLE SIZE DISTRIBUTION

Project Code / Ref. : -
SN : Sample 8
Sample ID : SD8




| Percentage | CLAY | SILT | SAND | GRAVEL |
|---|---|---|---|---|
| | 46 | 42 | 12 | 0 |

| Diameter (mm) | 20.00 | 10.00 | 6.30 | 5.00 | 3.35 | 2.00 | 1.18 | 0.600 | 0.425 | 0.300 | 0.212 | 0.150 | 0.063 | 0.002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98 | 88 | 46 |

*Note:*

1. The above test was sub-contracted to external lab.

# APPENDIX H

## Baseline Ambient Noise Quality Monitoring Data

# TEST REPORT

| | | | | | |
|---|---|---|---|---|---|
| Our Reference No. | : | **R226304** | Date of Monitoring | : | 31/08/22 to 15/09/22 |
| Project Code / Ref. | : | - | Date Reported | : | |

Customer Ref. No. : TAC / 20097 /SC 04
Customer Name : TEMBUSU Asia Consulting Pte Ltd
Customer Address : 1 Commonwealth Lane
#06-06, One Commonwealth
Singapore 149544

Attention To : Mr Eric Chng / Ms Tan Xiang Yun

**Subject** : **Baseline Noise Monitoring for Mandai Mudflats**

Description : Baseline Noise Monitoring for 1 week at 3 locations each

## SCOPE OF WORK

Baseline Noise Monitoring was carried out at 3 locations over a period of 1 week each within the vicinity of Admiralty Park. Each location is monitored over a period of 7 days and shifted to the next location at the end of each monitoring. Locations N1 and N3 are monitored concurrently in the same week. The description of location and scope of work are as described in Table 1A and 1B.

Table 1A: Scope of work carried out

<table>
<tr><th>Location ID</th><th>Monitoring Period</th><th>Parameters</th><th>Data</th></tr>
<tr><td>N1</td><td rowspan="2">31/08/22<br>to<br>06/09/22</td><td rowspan="3">LAeq</td><td rowspan="3">LAeq 5min<br>LAeq 1hr<br>LAeq 12hr</td></tr>
<tr><td>N2</td></tr>
<tr><td>N3</td><td>08/09/22<br>to<br>15/09/22</td></tr>
</table>

Table 1B: Scope of work carried out

| Locations | GPS Coordinates | Description |
|---|---|---|
| N1 | N 01°26'17.7"<br>E 103°45'16.4" | End of Kranji Road, Behind fence line (access by Police Coast Guard) |
| N2 | N 01°26'20.6"<br>E 103°44'34.7" | Open field on the right next to service road in Kranji Park Carpark A |
| N3 | N 01°26'22.4"<br>E 103°44'16.5" | Eastern open field within Kranji Reservoir Park B |

## MONITORING LOCATIONS

The monitoring locations are shown in the Google Earth image below. Site photos are in Appendix B.


## SAMPLING METHODOLOGY AND EQUIPMENT

Noise levels were monitored using a Type 1 Sound Level Meter (Svantek Model SVAN 971, Serial No. 60603 and Serial No. 87162), at all locations listed below. The equipment was battery operated with solar panel and was housed in an environmental enclosure for field deployment.

Sound Level Meter

1) Svantek Model SVAN971 (Serial No. 60603)
   (N2 - Pre Calibration: 113.9 dBA; Post Calibration: 114.2 dBA)
   (N3 - Pre Calibration: 114.0 dBA; Post Calibration: 114.1 dBA)

2) Svantek Model SVAN971 (Serial No. 87162)
   (N1 - Pre Calibration: 114.0 dBA; Post Calibration: 114.1 dBA)

Data was logged every 1 second at fast response at A weighting over the frequency of 10Hz to 20khz. The 1 second data is then used to calculate 5min, 1-hour and 12-hour equivalent readings. The Sound Level Meter is calibrated before and after the deployment at each location using the Acoustic Calibrator (Svantek Model SVAN SV33A, Serial No. 58609) producing 114dBA at 1000Hz. Calibration certificates are attached in Appendix A of this report.

## MONITORING RESULTS

The data from continuous baseline monitoring for all 3 locations were calculated and presented in daily basis throughout the time periods as stipulated in Environmental Protection and Management (Control of Noise At Construction Sites) Regulations whereby Day is 7am to 7pm (highlighted in yellow), Evening is 7pm – 10pm (highlighted in green) and Night is 10pm to 7am (highlighted in blue). Raw data for the LAeq 5 min was sent to client electronically.

**Monitoring Date :** 31-Aug-22 to 01-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 50.7 | 56.0 | 53.0 | 60.6 |
| 0800 - 0900 | 51.5 | 57.4 | 54.6 | |
| 0900 - 1000 | 52.6 | 73.6 | 66.8 | |
| 1000 - 1100 | 53.8 | 67.7 | 59.3 | |
| 1100 - 1200 | 52.3 | 57.7 | 55.3 | |
| 1200 - 1300 | 51.2 | 54.6 | 52.9 | |
| 1300 - 1400 | 52.5 | 65.7 | 57.5 | |
| 1400 - 1500 | 53.5 | 75.7 | 66.0 | |
| 1500 - 1600 | 53.3 | 67.7 | 61.7 | |
| 1600 - 1700 | 54.8 | 57.4 | 56.3 | |
| 1700 - 1800 | 53.1 | 57.6 | 55.2 | |
| 1800 - 1900 | 51.1 | 57.1 | 53.7 | |
| 1900 - 2000 | 50.8 | 56.1 | 52.6 | 51.1 |
| 2000 - 2100 | 51.1 | 53.2 | 52.4 | |
| 2100 - 2200 | 49.5 | 66.6 | 57.0 | |
| 2200 - 2300 | 48.8 | 51.6 | 50.0 | |
| 2300 - 0000 | 48.3 | 52.3 | 49.5 | |
| 0000 - 0100 | 46.8 | 49.4 | 48.0 | |
| 0100 - 0200 | 46.5 | 50.9 | 49.0 | |
| 0200 - 0300 | 46.8 | 49.4 | 48.4 | |
| 0300 - 0400 | 44.9 | 49.2 | 46.9 | |
| 0400 - 0500 | 46.4 | 49.1 | 47.7 | |
| 0500 - 0600 | 48.2 | 49.8 | 49.0 | |
| 0600 - 0700 | 48.6 | 52.9 | 50.7 | |

**Monitoring Date :** 01-Sep-22 to 02-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 51.2 | 60.9 | 55.0 | 62.9 |
| 0800 - 0900 | 51.6 | 56.1 | 53.1 | |
| 0900 - 1000 | 52.0 | 54.3 | 53.5 | |
| 1000 - 1100 | 52.0 | 55.2 | 53.4 | |
| 1100 - 1200 | 52.0 | 55.2 | 53.2 | |
| 1200 - 1300 | 51.3 | 53.5 | 52.5 | |
| 1300 - 1400 | 52.0 | 62.1 | 56.2 | |
| 1400 - 1500 | 52.9 | 82.5 | 72.3 | |
| 1500 - 1600 | 55.0 | 68.0 | 61.5 | |
| 1600 - 1700 | 55.0 | 57.1 | 55.8 | |
| 1700 - 1800 | 54.9 | 70.5 | 64.3 | |
| 1800 - 1900 | 54.4 | 57.3 | 55.3 | |
| 1900 - 2000 | 53.3 | 57.3 | 54.5 | 52.4 |
| 2000 - 2100 | 53.5 | 57.6 | 55.5 | |
| 2100 - 2200 | 53.2 | 57.8 | 55.1 | |
| 2200 - 2300 | 51.6 | 53.8 | 52.6 | |
| 2300 - 0000 | 50.7 | 53.1 | 51.4 | |
| 0000 - 0100 | 49.4 | 51.2 | 50.4 | |
| 0100 - 0200 | 49.2 | 50.8 | 50.1 | |
| 0200 - 0300 | 49.0 | 50.9 | 49.8 | |
| 0300 - 0400 | 48.9 | 50.8 | 50.0 | |
| 0400 - 0500 | 49.1 | 50.7 | 49.7 | |
| 0500 - 0600 | 50.1 | 54.0 | 51.2 | |
| 0600 - 0700 | 51.0 | 53.4 | 52.6 | |

**Monitoring Date :** 02-Sep-22 to 03-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 55.0 | 57.8 | 57.0 | 56.8 |
| 0800 - 0900 | 55.6 | 58.2 | 57.2 | |
| 0900 - 1000 | 55.9 | 58.4 | 57.3 | |
| 1000 - 1100 | 55.3 | 57.5 | 56.6 | |
| 1100 - 1200 | 56.4 | 58.5 | 57.6 | |
| 1200 - 1300 | 55.6 | 59.5 | 57.2 | |
| 1300 - 1400 | 55.2 | 58.0 | 57.0 | |
| 1400 - 1500 | 54.7 | 59.1 | 57.5 | |
| 1500 - 1600 | 54.7 | 59.5 | 57.2 | |
| 1600 - 1700 | 55.6 | 58.7 | 57.3 | |
| 1700 - 1800 | 54.5 | 58.8 | 56.9 | |
| 1800 - 1900 | 53.9 | 56.7 | 55.5 | |
| 1900 - 2000 | 51.6 | 56.1 | 54.2 | 52.3 |
| 2000 - 2100 | 50.9 | 53.5 | 52.2 | |
| 2100 - 2200 | 50.4 | 56.4 | 52.9 | |
| 2200 - 2300 | 50.9 | 57.6 | 52.9 | |
| 2300 - 0000 | 48.3 | 55.8 | 51.7 | |
| 0000 - 0100 | 48.6 | 58.8 | 52.0 | |
| 0100 - 0200 | 47.7 | 54.5 | 50.0 | |
| 0200 - 0300 | 48.1 | 50.7 | 48.7 | |
| 0300 - 0400 | 47.5 | 61.4 | 53.9 | |
| 0400 - 0500 | 47.6 | 50.3 | 48.3 | |
| 0500 - 0600 | 49.2 | 52.1 | 49.8 | |
| 0600 - 0700 | 49.9 | 57.9 | 54.3 | |

**Monitoring Date :** 03-Sep-22 to 04-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.8 | 56.4 | 55.7 | 56.3 |
| 0800 - 0900 | 54.4 | 57.8 | 56.5 | |
| 0900 - 1000 | 54.4 | 58.3 | 56.5 | |
| 1000 - 1100 | 55.1 | 57.3 | 56.6 | |
| 1100 - 1200 | 55.6 | 58.4 | 57.3 | |
| 1200 - 1300 | 55.2 | 57.5 | 56.5 | |
| 1300 - 1400 | 55.8 | 57.9 | 57.2 | |
| 1400 - 1500 | 56.1 | 58.1 | 57.5 | |
| 1500 - 1600 | 55.0 | 59.5 | 57.4 | |
| 1600 - 1700 | 54.1 | 57.2 | 56.1 | |
| 1700 - 1800 | 53.3 | 55.8 | 54.6 | |
| 1800 - 1900 | 54.0 | 57.8 | 55.4 | |
| 1900 - 2000 | 51.5 | 58.6 | 54.4 | 52.0 |
| 2000 - 2100 | 49.8 | 54.0 | 52.0 | |
| 2100 - 2200 | 50.4 | 55.9 | 54.1 | |
| 2200 - 2300 | 49.3 | 52.3 | 50.3 | |
| 2300 - 0000 | 49.0 | 53.1 | 50.6 | |
| 0000 - 0100 | 48.7 | 53.1 | 51.3 | |
| 0100 - 0200 | 49.8 | 51.4 | 50.4 | |
| 0200 - 0300 | 49.4 | 52.6 | 50.4 | |
| 0300 - 0400 | 49.2 | 50.7 | 49.3 | |
| 0400 - 0500 | 49.6 | 51.6 | 50.0 | |
| 0500 - 0600 | 49.9 | 51.6 | 50.1 | |
| 0600 - 0700 | 50.5 | 57.8 | 54.2 | |

**Monitoring Date :** 04-Sep-22 to 05-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.2 | 58.1 | 55.0 | 54.1 |
| 0800 - 0900 | 51.6 | 54.8 | 53.3 | |
| 0900 - 1000 | 50.6 | 55.3 | 52.9 | |
| 1000 - 1100 | 53.6 | 58.2 | 55.7 | |
| 1100 - 1200 | 52.1 | 57.5 | 54.7 | |
| 1200 - 1300 | 51.6 | 55.6 | 53.9 | |
| 1300 - 1400 | 53.2 | 57.6 | 55.7 | |
| 1400 - 1500 | 51.6 | 56.8 | 54.3 | |
| 1500 - 1600 | 51.8 | 58.3 | 55.0 | |
| 1600 - 1700 | 49.8 | 56.9 | 53.0 | |
| 1700 - 1800 | 49.3 | 56.6 | 51.7 | |
| 1800 - 1900 | 49.4 | 54.7 | 51.8 | |
| 1900 - 2000 | 48.7 | 53.2 | 50.6 | 52.1 |
| 2000 - 2100 | 48.3 | 58.3 | 54.8 | |
| 2100 - 2200 | 51.7 | 54.8 | 52.7 | |
| 2200 - 2300 | 49.9 | 52.6 | 50.9 | |
| 2300 - 0000 | 49.1 | 53.5 | 50.8 | |
| 0000 - 0100 | 47.6 | 52.3 | 49.1 | |
| 0100 - 0200 | 46.8 | 49.7 | 47.2 | |
| 0200 - 0300 | 47.5 | 49.2 | 48.2 | |
| 0300 - 0400 | 49.0 | 51.7 | 50.2 | |
| 0400 - 0500 | 47.1 | 50.2 | 48.2 | |
| 0500 - 0600 | 47.7 | 51.4 | 48.8 | |
| 0600 - 0700 | 49.7 | 60.3 | 57.9 | |

**Monitoring Date :** 05-Sep-22 to 06-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 54.3 | 60.9 | 56.9 | 65.5 |
| 0800 - 0900 | 55.4 | 73.6 | 69.7 | |
| 0900 - 1000 | 54.6 | 73.7 | 65.7 | |
| 1000 - 1100 | 53.5 | 57.6 | 55.5 | |
| 1100 - 1200 | 55.4 | 81.9 | 74.6 | |
| 1200 - 1300 | 55.6 | 68.9 | 64.6 | |
| 1300 - 1400 | 55.6 | 73.2 | 68.7 | |
| 1400 - 1500 | 54.6 | 57.6 | 56.6 | |
| 1500 - 1600 | 55.9 | 74.6 | 66.6 | |
| 1600 - 1700 | 54.9 | 57.7 | 56.8 | |
| 1700 - 1800 | 55.4 | 77.6 | 70.5 | |
| 1800 - 1900 | 54.8 | 61.2 | 58.3 | |
| 1900 - 2000 | 52.8 | 69.8 | 64.4 | 55.7 |
| 2000 - 2100 | 51.6 | 54.6 | 53.7 | |
| 2100 - 2200 | 52.8 | 55.3 | 54.0 | |
| 2200 - 2300 | 48.8 | 54.0 | 50.9 | |
| 2300 - 0000 | 48.9 | 53.7 | 50.3 | |
| 0000 - 0100 | 49.3 | 54.0 | 51.1 | |
| 0100 - 0200 | 48.2 | 53.0 | 50.6 | |
| 0200 - 0300 | 48.7 | 51.2 | 49.5 | |
| 0300 - 0400 | 48.7 | 51.2 | 48.9 | |
| 0400 - 0500 | 48.8 | 51.1 | 49.7 | |
| 0500 - 0600 | 50.0 | 54.8 | 51.5 | |
| 0600 - 0700 | 54.7 | 61.8 | 61.0 | |

**Monitoring Date :** 06-Sep-22 to 07-Sep-22
**Location:** N1
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 54.6 | 58.1 | 56.5 | 58.4 |
| 0800 - 0900 | 56.2 | 63.7 | 60.1 | |
| 0900 - 1000 | 55.2 | 60.7 | 58.6 | |
| 1000 - 1100 | 55.8 | 60.1 | 58.3 | |
| 1100 - 1200 | 56.2 | 59.7 | 58.0 | |
| 1200 - 1300 | 55.4 | 61.5 | 59.3 | |
| 1300 - 1400 | 55.4 | 61.1 | 58.0 | |
| 1400 - 1500 | 55.1 | 59.8 | 57.8 | |
| 1500 - 1600 | 55.7 | 61.2 | 57.8 | |
| 1600 - 1700 | 55.4 | 67.9 | 63.0 | |
| 1700 - 1800 | 55.5 | 63.7 | 59.3 | |
| 1800 - 1900 | 52.6 | 62.9 | 56.6 | |
| 1900 - 2000 | 50.6 | 68.4 | 60.2 | 53.6 |
| 2000 - 2100 | 52.5 | 60.3 | 54.7 | |
| 2100 - 2200 | 50.8 | 53.9 | 52.6 | |
| 2200 - 2300 | 49.1 | 51.4 | 50.2 | |
| 2300 - 0000 | 50.9 | 52.5 | 51.5 | |
| 0000 - 0100 | 49.5 | 52.6 | 50.3 | |
| 0100 - 0200 | 49.9 | 51.6 | 50.3 | |
| 0200 - 0300 | 49.8 | 50.6 | 49.6 | |
| 0300 - 0400 | 49.7 | 55.9 | 51.5 | |
| 0400 - 0500 | 50.3 | 55.9 | 52.5 | |
| 0500 - 0600 | 50.9 | 52.1 | 51.1 | |
| 0600 - 0700 | 51.3 | 59.6 | 56.5 | |

**Monitoring Date :** 31-Aug-22 to 01-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.6 | 61.2 | 56.8 | 63.8 |
| 0800 - 0900 | 54.1 | 56.4 | 55.7 | |
| 0900 - 1000 | 54.9 | 78.6 | 71.2 | |
| 1000 - 1100 | 53.9 | 57.0 | 55.8 | |
| 1100 - 1200 | 54.6 | 57.9 | 56.4 | |
| 1200 - 1300 | 53.2 | 56.3 | 55.3 | |
| 1300 - 1400 | 55.0 | 66.8 | 59.7 | |
| 1400 - 1500 | 55.7 | 77.6 | 70.2 | |
| 1500 - 1600 | 55.6 | 64.2 | 59.2 | |
| 1600 - 1700 | 55.7 | 58.5 | 57.0 | |
| 1700 - 1800 | 55.2 | 59.2 | 56.9 | |
| 1800 - 1900 | 53.4 | 60.3 | 55.9 | |
| 1900 - 2000 | 49.5 | 58.0 | 54.8 | 51.1 |
| 2000 - 2100 | 49.4 | 53.2 | 51.0 | |
| 2100 - 2200 | 47.7 | 61.0 | 52.7 | |
| 2200 - 2300 | 47.0 | 51.3 | 48.9 | |
| 2300 - 0000 | 47.6 | 49.4 | 48.3 | |
| 0000 - 0100 | 47.4 | 57.0 | 50.6 | |
| 0100 - 0200 | 45.7 | 50.7 | 47.5 | |
| 0200 - 0300 | 45.1 | 47.9 | 46.4 | |
| 0300 - 0400 | 44.8 | 47.3 | 46.0 | |
| 0400 - 0500 | 46.7 | 48.1 | 47.2 | |
| 0500 - 0600 | 47.2 | 49.1 | 48.1 | |
| 0600 - 0700 | 48.5 | 59.3 | 56.3 | |

**Monitoring Date :** 01-Sep-22 to 02-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.1 | 60.2 | 56.6 | 63.7 |
| 0800 - 0900 | 53.9 | 59.9 | 56.7 | |
| 0900 - 1000 | 52.1 | 56.8 | 55.2 | |
| 1000 - 1100 | 52.4 | 55.7 | 54.2 | |
| 1100 - 1200 | 52.1 | 56.6 | 55.1 | |
| 1200 - 1300 | 52.9 | 57.7 | 55.3 | |
| 1300 - 1400 | 54.7 | 58.2 | 56.1 | |
| 1400 - 1500 | 54.1 | 83.9 | 73.7 | |
| 1500 - 1600 | 55.6 | 62.9 | 59.9 | |
| 1600 - 1700 | 54.4 | 58.8 | 56.8 | |
| 1700 - 1800 | 54.1 | 57.8 | 55.9 | |
| 1800 - 1900 | 53.2 | 55.7 | 54.4 | |
| 1900 - 2000 | 50.8 | 55.0 | 52.7 | 53.4 |
| 2000 - 2100 | 50.6 | 57.8 | 56.9 | |
| 2100 - 2200 | 53.3 | 57.6 | 56.1 | |
| 2200 - 2300 | 48.5 | 58.1 | 55.5 | |
| 2300 - 0000 | 47.2 | 49.8 | 48.6 | |
| 0000 - 0100 | 48.1 | 49.9 | 49.1 | |
| 0100 - 0200 | 48.6 | 51.3 | 49.7 | |
| 0200 - 0300 | 48.0 | 50.2 | 48.8 | |
| 0300 - 0400 | 47.9 | 48.9 | 48.4 | |
| 0400 - 0500 | 48.4 | 51.0 | 49.4 | |
| 0500 - 0600 | 49.3 | 51.0 | 50.1 | |
| 0600 - 0700 | 48.9 | 61.0 | 57.8 | |

**Monitoring Date :** 02-Sep-22 to 03-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 54.6 | 57.7 | 56.6 | 56.7 |
| 0800 - 0900 | 55.3 | 58.3 | 56.8 | |
| 0900 - 1000 | 55.6 | 58.5 | 56.9 | |
| 1000 - 1100 | 55.0 | 57.4 | 56.2 | |
| 1100 - 1200 | 56.2 | 58.5 | 57.2 | |
| 1200 - 1300 | 55.3 | 59.7 | 56.8 | |
| 1300 - 1400 | 54.9 | 58.0 | 56.6 | |
| 1400 - 1500 | 54.3 | 59.2 | 57.1 | |
| 1500 - 1600 | 54.3 | 59.6 | 56.8 | |
| 1600 - 1700 | 55.3 | 58.8 | 56.9 | |
| 1700 - 1800 | 54.1 | 58.9 | 56.5 | |
| 1800 - 1900 | 53.4 | 56.6 | 55.1 | |
| 1900 - 2000 | 50.8 | 55.9 | 53.9 | 51.8 |
| 2000 - 2100 | 50.1 | 53.0 | 51.8 | |
| 2100 - 2200 | 49.5 | 56.2 | 52.5 | |
| 2200 - 2300 | 50.1 | 57.5 | 52.5 | |
| 2300 - 0000 | 47.2 | 55.5 | 51.3 | |
| 0000 - 0100 | 47.6 | 58.9 | 51.6 | |
| 0100 - 0200 | 46.5 | 54.1 | 49.6 | |
| 0200 - 0300 | 47.0 | 49.9 | 48.3 | |
| 0300 - 0400 | 46.3 | 61.8 | 53.5 | |
| 0400 - 0500 | 46.4 | 49.4 | 47.9 | |
| 0500 - 0600 | 48.2 | 51.4 | 49.4 | |
| 0600 - 0700 | 49.0 | 57.8 | 54.0 | |

**Monitoring Date :** 03-Sep-22 to 04-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.3 | 56.2 | 55.3 | 56.1 |
| 0800 - 0900 | 54.0 | 57.8 | 56.1 | |
| 0900 - 1000 | 54.0 | 58.3 | 56.1 | |
| 1000 - 1100 | 54.7 | 57.3 | 56.2 | |
| 1100 - 1200 | 55.3 | 58.4 | 56.9 | |
| 1200 - 1300 | 54.9 | 57.4 | 56.1 | |
| 1300 - 1400 | 55.5 | 57.8 | 56.8 | |
| 1400 - 1500 | 55.8 | 58.1 | 57.1 | |
| 1500 - 1600 | 54.6 | 59.6 | 57.0 | |
| 1600 - 1700 | 53.7 | 57.1 | 55.7 | |
| 1700 - 1800 | 52.7 | 55.6 | 54.2 | |
| 1800 - 1900 | 53.5 | 57.7 | 55.0 | |
| 1900 - 2000 | 50.7 | 58.6 | 54.0 | 51.4 |
| 2000 - 2100 | 48.9 | 53.5 | 51.7 | |
| 2100 - 2200 | 49.6 | 55.6 | 53.7 | |
| 2200 - 2300 | 48.3 | 51.6 | 49.9 | |
| 2300 - 0000 | 48.0 | 52.6 | 50.2 | |
| 0000 - 0100 | 47.6 | 52.6 | 50.9 | |
| 0100 - 0200 | 48.9 | 50.7 | 50.0 | |
| 0200 - 0300 | 48.4 | 51.9 | 50.0 | |
| 0300 - 0400 | 48.2 | 49.9 | 48.9 | |
| 0400 - 0500 | 48.7 | 50.9 | 49.6 | |
| 0500 - 0600 | 49.0 | 50.9 | 49.7 | |
| 0600 - 0700 | 49.7 | 57.8 | 53.8 | |

**Monitoring Date :** 04-Sep-22 to 05-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 52.7 | 58.1 | 54.6 | 53.7 |
| 0800 - 0900 | 50.9 | 54.4 | 52.9 | |
| 0900 - 1000 | 49.8 | 55.0 | 52.5 | |
| 1000 - 1100 | 53.1 | 58.2 | 55.3 | |
| 1100 - 1200 | 51.4 | 57.4 | 54.3 | |
| 1200 - 1300 | 50.9 | 55.3 | 53.5 | |
| 1300 - 1400 | 52.7 | 57.6 | 55.3 | |
| 1400 - 1500 | 50.8 | 56.7 | 53.9 | |
| 1500 - 1600 | 51.1 | 58.3 | 54.6 | |
| 1600 - 1700 | 48.8 | 56.8 | 52.6 | |
| 1700 - 1800 | 48.3 | 56.5 | 51.3 | |
| 1800 - 1900 | 48.5 | 54.3 | 51.4 | |
| 1900 - 2000 | 47.7 | 52.7 | 50.2 | 51.6 |
| 2000 - 2100 | 47.3 | 58.3 | 54.4 | |
| 2100 - 2200 | 51.0 | 54.4 | 52.3 | |
| 2200 - 2300 | 49.0 | 52.0 | 50.5 | |
| 2300 - 0000 | 48.1 | 53.0 | 50.4 | |
| 0000 - 0100 | 46.5 | 51.7 | 48.8 | |
| 0100 - 0200 | 45.6 | 48.7 | 46.8 | |
| 0200 - 0300 | 46.3 | 48.3 | 47.8 | |
| 0300 - 0400 | 48.0 | 51.0 | 49.8 | |
| 0400 - 0500 | 45.9 | 49.3 | 47.8 | |
| 0500 - 0600 | 46.5 | 50.7 | 48.4 | |
| 0600 - 0700 | 48.8 | 60.5 | 57.5 | |

**Monitoring Date :** 05-Sep-22 to 06-Sep-22
**Location:** N2
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 53.8 | 61.2 | 56.5 | 67.2 |
| 0800 - 0900 | 55.1 | 75.3 | 69.2 | |
| 0900 - 1000 | 54.2 | 75.4 | 65.3 | |
| 1000 - 1100 | 53.0 | 57.6 | 55.1 | |
| 1100 - 1200 | 55.1 | 84.5 | 74.1 | |
| 1200 - 1300 | 55.3 | 70.0 | 64.2 | |
| 1300 - 1400 | 55.3 | 74.9 | 68.3 | |
| 1400 - 1500 | 54.3 | 57.5 | 56.2 | |
| 1500 - 1600 | 55.7 | 76.3 | 66.2 | |
| 1600 - 1700 | 54.5 | 57.7 | 56.4 | |
| 1700 - 1800 | 55.1 | 79.7 | 70.1 | |
| 1800 - 1900 | 54.4 | 61.5 | 57.9 | |
| 1900 - 2000 | 52.2 | 71.1 | 64.0 | 56.1 |
| 2000 - 2100 | 50.9 | 54.2 | 53.3 | |
| 2100 - 2200 | 52.2 | 55.0 | 53.6 | |
| 2200 - 2300 | 47.7 | 53.5 | 50.5 | |
| 2300 - 0000 | 47.9 | 53.2 | 49.9 | |
| 0000 - 0100 | 48.3 | 53.5 | 50.7 | |
| 0100 - 0200 | 47.1 | 52.4 | 50.2 | |
| 0200 - 0300 | 47.7 | 50.4 | 49.1 | |
| 0300 - 0400 | 47.7 | 50.4 | 48.5 | |
| 0400 - 0500 | 47.7 | 50.3 | 49.3 | |
| 0500 - 0600 | 49.1 | 54.4 | 51.1 | |
| 0600 - 0700 | 54.3 | 62.2 | 60.6 | |

**Monitoring Date :** 06-Sep-22 to 07-Sep-22

**Location:** N2

**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 54.2 | 58.1 | 56.1 | 58.6 |
| 0800 - 0900 | 56.0 | 64.2 | 59.7 | |
| 0900 - 1000 | 54.9 | 60.9 | 58.2 | |
| 1000 - 1100 | 55.6 | 60.3 | 57.9 | |
| 1100 - 1200 | 56.0 | 59.9 | 57.6 | |
| 1200 - 1300 | 55.1 | 61.9 | 58.9 | |
| 1300 - 1400 | 55.1 | 61.4 | 57.6 | |
| 1400 - 1500 | 54.8 | 60.0 | 57.4 | |
| 1500 - 1600 | 55.4 | 61.5 | 57.4 | |
| 1600 - 1700 | 55.0 | 68.9 | 62.6 | |
| 1700 - 1800 | 55.2 | 64.3 | 58.9 | |
| 1800 - 1900 | 52.0 | 63.4 | 56.2 | |
| 1900 - 2000 | 49.8 | 69.5 | 59.8 | 53.5 |
| 2000 - 2100 | 51.9 | 60.5 | 54.3 | |
| 2100 - 2200 | 50.0 | 53.4 | 52.2 | |
| 2200 - 2300 | 48.1 | 50.6 | 49.8 | |
| 2300 - 0000 | 50.1 | 51.9 | 51.2 | |
| 0000 - 0100 | 48.5 | 52.0 | 49.9 | |
| 0100 - 0200 | 49.0 | 50.8 | 49.9 | |
| 0200 - 0300 | 48.9 | 49.8 | 49.2 | |
| 0300 - 0400 | 48.8 | 55.7 | 51.1 | |
| 0400 - 0500 | 49.4 | 55.6 | 52.2 | |
| 0500 - 0600 | 50.1 | 51.4 | 50.7 | |
| 0600 - 0700 | 50.5 | 59.8 | 56.1 | |

**Monitoring Date :** 08-Sep-22 to 09-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 51.7 | 57.6 | 53.4 | 51.4 |
| 0800 - 0900 | 50.9 | 52.9 | 52.4 | |
| 0900 - 1000 | 50.8 | 51.8 | 51.4 | |
| 1000 - 1100 | 50.1 | 54.2 | 52.2 | |
| 1100 - 1200 | 49.8 | 52.5 | 50.9 | |
| 1200 - 1300 | 48.1 | 50.5 | 49.7 | |
| 1300 - 1400 | 47.7 | 51.6 | 49.6 | |
| 1400 - 1500 | 47.0 | 50.8 | 49.4 | |
| 1500 - 1600 | 47.9 | 51.3 | 49.9 | |
| 1600 - 1700 | 49.6 | 52.7 | 51.4 | |
| 1700 - 1800 | 50.0 | 58.5 | 52.8 | |
| 1800 - 1900 | 49.5 | 52.0 | 50.9 | |
| 1900 - 2000 | 48.0 | 57.8 | 53.7 | 53.7 |
| 2000 - 2100 | 49.3 | 58.7 | 56.2 | |
| 2100 - 2200 | 50.2 | 54.5 | 51.7 | |
| 2200 - 2300 | 50.6 | 53.1 | 52.0 | |
| 2300 - 0000 | 50.4 | 54.5 | 52.0 | |
| 0000 - 0100 | 50.9 | 52.1 | 51.6 | |
| 0100 - 0200 | 50.9 | 53.0 | 51.9 | |
| 0200 - 0300 | 50.3 | 51.7 | 51.0 | |
| 0300 - 0400 | 50.5 | 53.2 | 51.3 | |
| 0400 - 0500 | 50.9 | 56.0 | 53.3 | |
| 0500 - 0600 | 52.7 | 57.2 | 56.2 | |
| 0600 - 0700 | 54.4 | 61.4 | 57.0 | |

**Monitoring Date :** 09-Sep-22 to 10-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 51.9 | 53.3 | 52.7 | 62.8 |
| 0800 - 0900 | 49.7 | 78.4 | 67.9 | |
| 0900 - 1000 | 50.0 | 73.7 | 64.5 | |
| 1000 - 1100 | 52.3 | 63.9 | 59.9 | |
| 1100 - 1200 | 50.5 | 54.4 | 52.6 | |
| 1200 - 1300 | 50.4 | 77.2 | 67.9 | |
| 1300 - 1400 | 50.0 | 76.1 | 67.6 | |
| 1400 - 1500 | 49.7 | 53.8 | 51.1 | |
| 1500 - 1600 | 50.4 | 52.7 | 51.7 | |
| 1600 - 1700 | 49.4 | 51.6 | 50.5 | |
| 1700 - 1800 | 50.2 | 51.9 | 51.3 | |
| 1800 - 1900 | 48.1 | 52.9 | 51.2 | |
| 1900 - 2000 | 47.8 | 57.5 | 51.7 | 52.7 |
| 2000 - 2100 | 52.0 | 54.1 | 52.8 | |
| 2100 - 2200 | 51.6 | 53.7 | 52.4 | |
| 2200 - 2300 | 52.3 | 54.6 | 53.4 | |
| 2300 - 0000 | 51.1 | 52.6 | 51.9 | |
| 0000 - 0100 | 51.9 | 53.8 | 52.7 | |
| 0100 - 0200 | 51.6 | 52.9 | 52.1 | |
| 0200 - 0300 | 50.5 | 52.9 | 51.4 | |
| 0300 - 0400 | 50.3 | 52.8 | 51.3 | |
| 0400 - 0500 | 51.5 | 53.2 | 52.6 | |
| 0500 - 0600 | 52.2 | 53.9 | 53.0 | |
| 0600 - 0700 | 53.1 | 59.4 | 55.3 | |

**Monitoring Date :** 10-Sep-22 to 11-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 52.3 | 53.9 | 53.3 | 50.6 |
| 0800 - 0900 | 49.8 | 53.1 | 51.9 | |
| 0900 - 1000 | 50.7 | 53.0 | 51.6 | |
| 1000 - 1100 | 50.6 | 52.6 | 51.8 | |
| 1100 - 1200 | 47.7 | 51.1 | 49.9 | |
| 1200 - 1300 | 47.1 | 50.6 | 49.1 | |
| 1300 - 1400 | 47.6 | 51.2 | 49.5 | |
| 1400 - 1500 | 49.1 | 52.0 | 50.3 | |
| 1500 - 1600 | 47.3 | 51.2 | 50.2 | |
| 1600 - 1700 | 46.6 | 50.6 | 49.2 | |
| 1700 - 1800 | 46.7 | 51.0 | 49.1 | |
| 1800 - 1900 | 47.7 | 49.6 | 48.7 | |
| 1900 - 2000 | 46.9 | 52.4 | 49.0 | 51.9 |
| 2000 - 2100 | 52.2 | 53.5 | 52.8 | |
| 2100 - 2200 | 51.2 | 53.1 | 52.2 | |
| 2200 - 2300 | 50.3 | 52.8 | 51.9 | |
| 2300 - 0000 | 50.3 | 52.6 | 51.6 | |
| 0000 - 0100 | 51.1 | 52.2 | 51.6 | |
| 0100 - 0200 | 50.6 | 52.3 | 51.3 | |
| 0200 - 0300 | 51.3 | 52.2 | 51.7 | |
| 0300 - 0400 | 50.2 | 51.1 | 50.8 | |
| 0400 - 0500 | 50.7 | 51.9 | 51.3 | |
| 0500 - 0600 | 50.3 | 52.7 | 51.5 | |
| 0600 - 0700 | 51.9 | 59.8 | 54.5 | |

**Monitoring Date :** 11-Sep-22 to 12-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 51.5 | 53.0 | 52.2 | 58.2 |
| 0800 - 0900 | 48.6 | 50.9 | 49.9 | |
| 0900 - 1000 | 47.2 | 49.9 | 48.8 | |
| 1000 - 1100 | 48.0 | 68.4 | 63.6 | |
| 1100 - 1200 | 47.9 | 56.9 | 51.8 | |
| 1200 - 1300 | 47.5 | 65.5 | 57.5 | |
| 1300 - 1400 | 48.4 | 76.5 | 66.2 | |
| 1400 - 1500 | 46.1 | 52.1 | 50.4 | |
| 1500 - 1600 | 45.7 | 52.5 | 49.0 | |
| 1600 - 1700 | 45.8 | 49.3 | 47.0 | |
| 1700 - 1800 | 46.0 | 50.8 | 47.8 | |
| 1800 - 1900 | 47.7 | 50.7 | 49.6 | |
| 1900 - 2000 | 47.0 | 51.9 | 50.2 | 53.6 |
| 2000 - 2100 | 52.3 | 55.3 | 54.2 | |
| 2100 - 2200 | 53.2 | 55.5 | 54.9 | |
| 2200 - 2300 | 52.6 | 54.6 | 53.8 | |
| 2300 - 0000 | 51.4 | 54.8 | 53.1 | |
| 0000 - 0100 | 52.8 | 54.9 | 53.9 | |
| 0100 - 0200 | 52.8 | 53.7 | 53.3 | |
| 0200 - 0300 | 52.0 | 53.9 | 52.9 | |
| 0300 - 0400 | 52.0 | 53.0 | 52.3 | |
| 0400 - 0500 | 52.0 | 52.9 | 52.4 | |
| 0500 - 0600 | 51.8 | 54.6 | 53.3 | |
| 0600 - 0700 | 52.2 | 60.8 | 56.3 | |

**Monitoring Date :** 12-Sep-22 to 13-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 54.0 | 56.1 | 55.6 | 63.1 |
| 0800 - 0900 | 52.4 | 57.7 | 54.7 | |
| 0900 - 1000 | 50.9 | 54.3 | 52.7 | |
| 1000 - 1100 | 50.0 | 80.5 | 69.8 | |
| 1100 - 1200 | 47.8 | 79.0 | 71.2 | |
| 1200 - 1300 | 48.3 | 54.5 | 51.6 | |
| 1300 - 1400 | 48.5 | 66.2 | 56.3 | |
| 1400 - 1500 | 48.6 | 51.8 | 50.1 | |
| 1500 - 1600 | 48.6 | 51.0 | 49.9 | |
| 1600 - 1700 | 47.3 | 53.5 | 49.6 | |
| 1700 - 1800 | 46.6 | 50.6 | 49.3 | |
| 1800 - 1900 | 47.8 | 61.0 | 53.2 | |
| 1900 - 2000 | 45.5 | 78.4 | 67.8 | 58.6 |
| 2000 - 2100 | 49.5 | 70.9 | 60.8 | |
| 2100 - 2200 | 50.3 | 51.6 | 50.9 | |
| 2200 - 2300 | 50.3 | 51.2 | 50.8 | |
| 2300 - 0000 | 49.7 | 51.0 | 50.4 | |
| 0000 - 0100 | 50.3 | 53.1 | 52.1 | |
| 0100 - 0200 | 50.8 | 52.5 | 52.0 | |
| 0200 - 0300 | 50.8 | 51.8 | 51.1 | |
| 0300 - 0400 | 50.2 | 51.5 | 51.0 | |
| 0400 - 0500 | 50.4 | 51.4 | 50.9 | |
| 0500 - 0600 | 50.9 | 52.9 | 51.8 | |
| 0600 - 0700 | 50.7 | 58.1 | 53.6 | |

**Monitoring Date :** 13-Sep-22 to 14-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 52.0 | 58.6 | 53.8 | 60.7 |
| 0800 - 0900 | 52.5 | 54.5 | 53.4 | |
| 0900 - 1000 | 51.0 | 54.3 | 52.7 | |
| 1000 - 1100 | 50.0 | 54.8 | 52.0 | |
| 1100 - 1200 | 48.0 | 63.3 | 56.7 | |
| 1200 - 1300 | 49.7 | 60.1 | 53.2 | |
| 1300 - 1400 | 49.7 | 54.1 | 51.5 | |
| 1400 - 1500 | 49.7 | 53.5 | 51.5 | |
| 1500 - 1600 | 49.7 | 52.4 | 51.1 | |
| 1600 - 1700 | 49.6 | 52.6 | 51.2 | |
| 1700 - 1800 | 48.9 | 52.6 | 51.2 | |
| 1800 - 1900 | 50.1 | 81.5 | 70.8 | |
| 1900 - 2000 | 47.8 | 78.9 | 68.2 | 58.2 |
| 2000 - 2100 | 47.8 | 56.1 | 50.2 | |
| 2100 - 2200 | 48.9 | 49.9 | 49.3 | |
| 2200 - 2300 | 49.0 | 50.7 | 49.9 | |
| 2300 - 0000 | 49.2 | 52.1 | 50.3 | |
| 0000 - 0100 | 47.6 | 51.4 | 49.5 | |
| 0100 - 0200 | 46.7 | 50.3 | 49.2 | |
| 0200 - 0300 | 49.2 | 50.7 | 50.3 | |
| 0300 - 0400 | 49.4 | 50.1 | 49.8 | |
| 0400 - 0500 | 48.8 | 50.0 | 49.4 | |
| 0500 - 0600 | 48.5 | 50.6 | 49.7 | |
| 0600 - 0700 | 49.4 | 59.4 | 54.1 | |

**Monitoring Date :** 14-Sep-22 to 15-Sep-22
**Location:** N3
**Job Number:** R226304

| Period | 5 min LAeq, dBA | | 1 hour LAeq, dBA | 12 hour LAeq, dBA |
|---|---|---|---|---|
| | Min | Max | Results | Results |
| 0700 - 0800 | 52.0 | 57.3 | 54.1 | 58.7 |
| 0800 - 0900 | 51.3 | 53.9 | 52.7 | |
| 0900 - 1000 | 50.9 | 52.6 | 51.5 | |
| 1000 - 1100 | 50.2 | 52.4 | 51.7 | |
| 1100 - 1200 | 51.3 | 72.0 | 61.9 | |
| 1200 - 1300 | 51.1 | 59.8 | 54.8 | |
| 1300 - 1400 | 53.9 | 57.0 | 55.6 | |
| 1400 - 1500 | 52.8 | 77.1 | 66.6 | |
| 1500 - 1600 | 50.7 | 58.4 | 54.0 | |
| 1600 - 1700 | 50.2 | 66.4 | 59.3 | |
| 1700 - 1800 | 50.4 | 59.9 | 53.9 | |
| 1800 - 1900 | 50.1 | 55.3 | 51.7 | |
| 1900 - 2000 | 47.2 | 79.5 | 71.8 | 61.4 |
| 2000 - 2100 | 47.9 | 61.6 | 54.9 | |
| 2100 - 2200 | 47.8 | 59.9 | 53.3 | |
| 2200 - 2300 | 48.4 | 51.0 | 49.5 | |
| 2300 - 0000 | 48.6 | 50.8 | 49.1 | |
| 0000 - 0100 | 48.8 | 49.9 | 49.4 | |
| 0100 - 0200 | 48.4 | 49.8 | 49.2 | |
| 0200 - 0300 | 49.0 | 50.6 | 49.8 | |
| 0300 - 0400 | 48.5 | 50.8 | 49.6 | |
| 0400 - 0500 | 48.4 | 50.1 | 49.0 | |
| 0500 - 0600 | 48.9 | 54.4 | 50.4 | |
| 0600 - 0700 | 50.4 | 57.0 | 53.4 | |

# APPENDIX I

## Baseline Ambient Air Quality Monitoring Data

# TEST REPORT

| | | | | | |
|---|---|---|---|---|---|
| Our Reference No. | : | **R226303** | Date of Monitoring | : | 31/08/22 to 07/09/22 |
| Project Code / Ref. | : | - | Date Reported | : | |

| | | |
|---|---|---|
| Customer Ref. No. | : | TAC / 20097 /SC 04 |
| Customer Name | : | TEMBUSU Asia Consulting Pte Ltd |
| Customer Address | : | 1 Commonwealth Lane<br>#06-06, One Commonwealth<br>Singapore 149544 |
| Attention To | : | Mr Eric Chng / Ms Tan Xiang Yun |

**Subject** : **Baseline Air Quality Monitoring for Mandai Mudflats**

Description : Baseline Air Quality Monitoring for 1 week at 3 locations each

## SCOPE OF WORK

Baseline Ambient Air Monitoring was carried out at total 3 locations over a period of 7 days.

Table 1: Scope of work carried out

| Location ID | Monitoring Period | Parameters | Limit of Reporting / Detection Limit | Data Logging Interval | GPS Coordinates |
|---|---|---|---|---|---|
| A1 | 31/08/2022 To 07/09/2022 | $PM_{10}$ | 1 $\mu g/m^3$ | 10-min Ave | N 01°26'17.7" E 103°45'16.4" |
| | | $PM_{2.5}$ | | | |
| | | $SO_2$ | 0 to 10000 ppb | 15-min Ave | |
| | | CO | 0 to 6000 ppb | | |
| | | $NO_2$ | 0 to 4000 ppb | | |
| | | $O_3$ | 0 to 1800 ppb | | |
| | | VOC | 0 to 5000 ppm | Hourly | |
| A2 | | $PM_{10}$ | 1 $\mu g/m^3$ | 10-min Ave | N 01°26'20.6" E 103°44'34.7" |
| | | $PM_{2.5}$ | | | |
| | | $SO_2$ | 0 to 10000 ppb | 15-min Ave | |
| | | CO | 0 to 6000 ppb | | |
| | | $NO_2$ | 0 to 4000 ppb | | |
| | | $O_3$ | 0 to 1800 ppb | | |
| | | VOC | 0 to 15000 ppm | Hourly | |
| A3 | | $PM_{10}$ | 1 $\mu g/m^3$ | 10-min Ave | N 01°26'22.4" E 103°44'16.5" |
| | | $PM_{2.5}$ | | | |
| | | $SO_2$ | 0 to 10000 ppb | 15-min Ave | |
| | | CO | 0 to 6000 ppb | | |
| | | $NO_2$ | 0 to 4000 ppb | | |
| | | $O_3$ | 0 to 1800 ppb | | |
| | | VOC | 0 to 15000 ppm | Hourly | |

## MONITORING LOCATIONS

The monitoring locations are shown in the Google Earth image below.


**Disclaimer by MLS:**
Official Test Report in hard copy or PDF which carries signature will be the final version. MLS shall not be responsible or made liable for any application or misinterpretation of the raw data or Word/Excel results which are subjected to prior review, countersigning by approved signatory and issuance of an official Test Report.

## SAMPLING METHODOLOGY AND EQUIPMENT

PM10 and PM2.5

PM10 and PM2.5 were monitored using TSI DustTrak Aerosol Monitor Model 8543-M (Serial No: 8543210602, 8543220801 & 8543203202). The analysers use light scattering laser photometer, providing real time aerosol mass reading and data logging for both PM10 and PM2.5. The instrument was designed for harsh outdoor environments, with a heated inlet sample conditioner to reduce humidity effects. This instrument model is UKAS M-CERTS certified (certificate number: Sira MC 160381/00).

The analyser was operating continuously on solar power throughout the monitoring. Data logging was set at 10-minute intervals and the 24-hour daily averages were computed based on the averaging data obtained and the results were compared against the Singapore Ambient Air Quality Targets. Equipment calibration certificate is attached in Appendix A of this report.

$SO_2$, CO, $O_3$ and $NO_2$

$SO_2$, CO, $O_3$ and $NO_2$ were monitored using AQMesh Air Quality Monitoring System (Serial No: 2450718, 2450781 & 2140150). The monitoring system was battery operated and uses electrochemical sensors for all 4 pollutants, providing real time concentration reading and data logging accessible online. The instrument is designed to be weatherproof.

Data logging was set at 15-minute intervals while the hourly and 24-hour daily averages were computed based on the averaging data obtained and the results were compared against the Singapore Ambient Air Quality Targets. Equipment calibration certificate is attached in Appendix A of this report.

VOC

VOC were monitored using RAE systems MiniRAE 3000 and MultiRAE Lite pump (Serial No: 592-925856, 592-925854 and M01C019238). The gas monitors are battery operated and uses photoionization detector (PID) with 10.6eV gas-discharge lamp. The gas monitors are also able to conduct continuous datalogging at pre-set intervals over extended periods of time by tapping power from undisrupted sources such as solar power.  The VOC concentrations are based on Iso-butylene as the calibration gas.

## SINGAPORE AMBIENT AIR QUALITY TARGETS

Table 2: The following table summarises the Singapore Ambient Air Quality Guidelines

| Pollutant | Singapore Targets by 2020 | Singapore Long Term Targets |
|---|---|---|
| Particulate Matter ($PM_{2.5}$) | **24-hour mean: 37.5 μg/m³** | **24-hour mean: 25 μg/m³** |
| Particulate Matter ($PM_{10}$) | **24-hour mean: 50 μg/m³** | **24-hour mean: 50 μg/m³** |
| Sulphur Dioxide ($SO_2$) | **24-hour mean: 50 μg/m³** | **24-hour mean: 20 μg/m³** |
| Carbon Monoxide (CO) | **8-hour mean: 10 mg/m³** | **8-hour mean: 10 mg/m³** |
| | **1-hour mean: 30 mg/m³** | **1-hour mean: 30 mg/m³** |
| Nitrogen Dioxide ($NO_2$) | **1-hour mean: 200 μg/m³** | **1-hour mean: 200 μg/m³** |
| Ozone ($O_3$) | **8-hour mean: 100 μg/m³** | **8-hour mean: 100 μg/m³** |

## MONITORING RESULTS

The results for the various parameters monitored were summarised in the following tables. Raw Data are submitted electronically.

Table 3: Summary of 24-hour mean for $PM_{10}$, $PM_{2.5}$ and $SO_2$ for A1

| Pollutants | | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ |
|---|---|---|---|---|
| **Averaging Period** | | **24 hours** | | |
| **Unit** | | **μg/m³** | | |
| **24-hr mean Pollutant concentrations for each day** | **31-Aug-22** | 26.2 | 21.3 | <5 |
| | **01-Sep-22** | 44.3 | 37.5 | <5 |
| | **02-Sep -22** | 47.8 | 38.5 | <5 |
| | **03-Sep 22** | 22.9 | 17.2 | <5 |
| | **04-Sep-22** | 28.2 | 23.8 | <5 |
| | **05-Sep-22** | 44.9 | 38.1 | <5 |
| | **06-Sep-22** | 47.9 | 40.6 | <5 |
| **Singapore's Ambient Air Quality Targets by 2020** | | **50** | **37.5** | **50** |
| **Singapore's Ambient Air Quality Long Term Targets** | | **50** | **25** | **20** |

Table 4: Summary of Maximum Pollutant Concentrations (CO, $NO_2$ and $O_3$) for A1

| Pollutants | | CO | CO | $NO_2$ | $O_3$ |
|---|---|---|---|---|---|
| **Averaging Period** | | **1 hour** | **8 hours** | **1 hour** | **8 hours** |
| **Unit** | | **mg/m³** | | **µg/m³** | |
| **Maximum Pollutant concentrations for each day** | **31-Aug-22** | 0.78 | 0.39 | 92.71 | 32.51 |
| | **01-Sep-22** | 0.75 | 0.45 | 205.54 | 21.47 |
| | **02-Sep -22** | 0.74 | 0.62 | 105.16 | 13.06 |
| | **03-Sep 22** | 0.58 | 0.23 | 83.83 | 28.01 |
| | **04-Sep-22** | 0.49 | 0.32 | 89.31 | 10.80 |
| | **05-Sep-22** | 0.60 | 0.48 | 156.14 | 10.12 |
| | **06-Sep-22** | 0.93 | 0.64 | 179.92 | 27.02 |
| **Singapore's Ambient Air Quality Targets by 2020** | | **30** | **10** | **200** | **100** |
| **Singapore's Ambient Air Quality Long Term Targets** | | **30** | **10** | **200** | **100** |

Table 5: Summary of 24-hour mean for $PM_{10}$, $PM_{2.5}$ and $SO_2$ for A2

| Pollutants | | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ |
|---|---|---|---|---|
| **Averaging Period** | | **24 hours** | | |
| **Unit** | | **µg/m³** | | |
| **24-hr mean Pollutant concentrations for each day** | **31-Aug-22** | 22.5 | 18.6 | <5 |
| | **01-Sep-22** | 35.0 | 29.5 | <5 |
| | **02-Sep -22** | 37.7 | 32.2 | <5 |
| | **03-Sep 22** | 14.9 | 11.4 | <5 |
| | **04-Sep-22** | 26.7 | 21.8 | <5 |
| | **05-Sep-22** | 37.8 | 31.5 | <5 |
| | **06-Sep-22** | 42.1 | 35.2 | 10.26 |
| **Singapore's Ambient Air Quality Targets by 2020** | | **50** | **37.5** | **50** |
| **Singapore's Ambient Air Quality Long Term Targets** | | **50** | **25** | **20** |

Table 6: Summary of Maximum Pollutant Concentrations (CO, $NO_2$ and $O_3$) for A2

| Pollutants | | CO | CO | $NO_2$ | $O_3$ |
|---|---|---|---|---|---|
| Averaging Period | | 1 hour | 8 hours | 1 hour | 8 hours |
| Unit | | mg/m³ | | µg/m³ | |
| Maximum Pollutant concentrations for each day | 31-Aug-22 | 0.81 | 0.39 | 101.76 | 29.52 |
| | 01-Sep-22 | 0.71 | 0.42 | 128.00 | 20.89 |
| | 02-Sep -22 | 0.81 | 0.60 | 74.56 | 15.00 |
| | 03-Sep 22 | 0.28 | 0.22 | 73.82 | 25.49 |
| | 04-Sep-22 | 0.60 | 0.40 | 72.95 | 18.20 |
| | 05-Sep-22 | 0.63 | 0.46 | 82.69 | 12.63 |
| | 06-Sep-22 | 1.01 | 0.67 | 119.85 | 32.57 |
| Singapore's Ambient Air Quality Targets by 2020 | | **30** | **10** | **200** | **100** |
| Singapore's Ambient Air Quality Long Term Targets | | **30** | **10** | **200** | **100** |

Table 7: Summary of 24-hour mean for $PM_{10}$, $PM_{2.5}$ and $SO_2$ for A3

| Pollutants | | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ |
|---|---|---|---|---|
| Averaging Period | | 24 hours | | |
| Unit | | µg/m³ | | |
| 24-hr mean Pollutant concentrations for each day | 31-Aug-22 | 17.0 | 16.6 | <5 |
| | 01-Sep-22 | 26.0 | 25.8 | <5 |
| | 02-Sep -22 | 24.6 | 24.4 | <5 |
| | 03-Sep 22 | 11.1 | 10.6 | <5 |
| | 04-Sep-22 | 19.8 | 19.5 | <5 |
| | 05-Sep-22 | 24.3 | 24 | <5 |
| | 06-Sep-22 | 29.2 | 28.8 | <5 |
| Singapore's Ambient Air Quality Targets by 2020 | | **50** | **37.5** | **50** |
| Singapore's Ambient Air Quality Long Term Targets | | **50** | **25** | **20** |

Table 8: Summary of Maximum Pollutant Concentrations (CO, $NO_2$ and $O_3$) for A3

| Pollutants | | CO | CO | $NO_2$ | $O_3$ |
|---|---|---|---|---|---|
| Averaging Period | | 1 hour | 8 hours | 1 hour | 8 hours |
| Unit | | $mg/m^3$ | | $\mu g/m^3$ | |
| Maximum Pollutant concentrations for each day | 31-Aug-22 | 1.08 | 0.52 | 101.34 | 59.15 |
| | 01-Sep-22 | 0.89 | 0.60 | 139.80 | 45.28 |
| | 02-Sep -22 | 1.09 | 0.93 | 83.65 | 28.48 |
| | 03-Sep 22 | 0.44 | 0.35 | 70.69 | 43.72 |
| | 04-Sep-22 | 0.87 | 0.62 | 87.13 | 37.26 |
| | 05-Sep-22 | 0.81 | 0.63 | 112.91 | 23.67 |
| | 06-Sep-22 | 1.55 | 0.94 | 125.26 | 65.85 |
| Singapore's Ambient Air Quality Targets by 2020 | | **30** | **10** | **200** | **100** |
| Singapore's Ambient Air Quality Long Term Targets | | **30** | **10** | **200** | **100** |

Table 9: Summary of Maximum Pollutant Concentrations (VOC)

| Pollutants | VOC | | | | | | |
|---|---|---|---|---|---|---|---|
| Averaging Period | 24 Hours | | | | | | |
| Unit | ppm | | | | | | |
| Point ID | Maximum Pollutant concentrations for each day | | | | | | |
| | 31-Aug-22 | 01-Sep-22 | 02-Sep -22 | 03-Sep 22 | 04-Sep-22 | 05-Sep-22 | 06-Sep-22 |
| A1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| A2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| A3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

Note:

1) All the monitoring dates represent data collected from 0000hrs to 2359hrs.

TSI Dustrak Calibration Certificates

# CERTIFICATE OF CALIBRATION AND TESTING

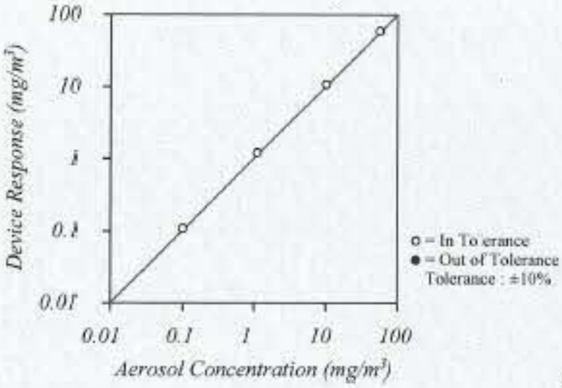
TSI Singapore Pte Ltd 150, Kampong Ampat
#05-05, KA Centre Singapore 368324
Phone: +65 6595 6391

| Environment Conditions | | |
|---|---|---|
| Temperature | 23.4 | °C |
| Relative Humidity | 56 | %RH |
| Barometric Pressure | 1004.7 | hPa |

| | |
|---|---|
| Model | 8543-M |
| Serial Number | 8543203202 |

☒ As Left ☐ As Found ☒ In Tolerance ☐ Out of Tolerance

**Concentration Linearity Plot**




System ID: DTII04-01

| FLOW AND PRESSURE VERIFICATION | | | | | | | SYSTEM DTII04-01 |
|---|---|---|---|---|---|---|---|
| Parameter | Standard | Measured | Allowable Range | Parameter | Standard | Measured | Allowable Range |
| Flow lpm | 3.00 | 3.12 | 2.88 ~ 3.12 | Pressure kPa | 100.6 | 100.6 | 95.57 ~ 105.63 |
| Full Flow lpm | N/A | 6.20 | >3.80 | | | | |

*TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adusted to respirable mass of standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1.*

| Measurement Variable | System ID | Last Cal. | Cal. Due | Measurement Variable | System ID | Last Cal. | Cal. Due |
|---|---|---|---|---|---|---|---|
| DC Voltage | E020187 | 12-05-21 | 31-05-22 | Pressure | E020123 | 20-01-22 | 31-01-23 |
| Microbalance | E020125 | 25-01-22 | 31-01-23 | Photometer | E020114 | 13-08-21 | 28-02-22 |
| Flowmeter | E020119 | 29-04-21 | 30-04-22 | 3 um PSL | 206030 | n/a | n/a |
| 1um PSL | 698880 | n/a | n/a | 10 um PSL | 212455 | n/a | n/a |

Mukhlis Zakariah
Calibrated

13 February, 2022
Date

TSI P/N 2300157

# CERTIFICATE OF CALIBRATION AND TESTING

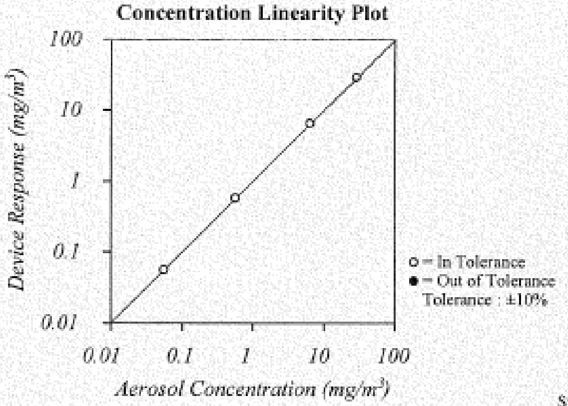
TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

| Environment Conditions | | |
|---|---|---|
| Temperature | 74.60 (23.7) | °F (°C) |
| Relative Humidity | 21.8 | %RH |
| Barometric Pressure | 28.86 (977.3) | inHg (hPa) |

| | |
|---|---|
| Model | 8543 |
| Serial Number | 8543220801 |

☒ As Left ☒ In Tolerance
☐ As Found ☐ Out of Tolerance

**Concentration Linearity Plot**




System ID: DTII01-01

**FLOW AND PRESSURE VERIFICATION** — **SYSTEM DTII01-01**

| Parameter | Standard | Measured | Allowable Range | Parameter | Standard | Measured | Allowable Range |
|---|---|---|---|---|---|---|---|
| Flow lpm | 3.00 | 3.06 | 2.88 ~ 3.12 | Pressure kPa | 97.6 | 97.6 | 92.72 ~ 102.48 |
| Full Flow lpm | N/A | 6.58 | >3.80 | | | | |

*TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass per standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1*

| Measurement Variable | System ID | Last Cal. | Cal. Due | Measurement Variable | System ID | Last Cal. | Cal. Due |
|---|---|---|---|---|---|---|---|
| Photometer | E003433 | 09-22-21 | 03-31-22 | Flowmeter | E003434 | 08-26-21 | 08-31-22 |
| DC Voltage(Keithley) | E002859 | 06-09-21 | 06-30-22 | Microbalance | M001324 | 01-29-21 | 01-31-23 |
| Pressure | E005651 | 07-30-21 | 07-31-22 | 1 um PSL | 698880 | n/a | n/a |
| 3 um PSL | 655484 | n/a | n/a | 10 um PSL | 247067 | n/a | n/a |

[signature] February 16, 2022

Calibrated Date

TSI P/N 2300157

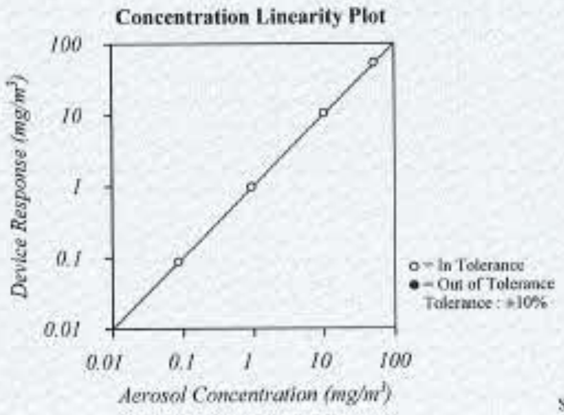
# CERTIFICATE OF CALIBRATION AND TESTING

TSI Singapore Pte Ltd 150, Kampong Ampat
#05-05, KA Centre Singapore 368324
Phone: +65 6595 6391

| Environment Conditions | | |
|---|---|---|
| Temperature | 23.5 | °C |
| Relative Humidity | 50 | %RH |
| Barometric Pressure | 1004.1 | hPa |

| | |
|---|---|
| Model | 8543-M |
| Serial Number | 8543210602 |

☒ As Left ☒ In Tolerance
☐ As Found ☐ Out of Tolerance




System ID: DTH04-01

**FLOW AND PRESSURE VERIFICATION** — **SYSTEM DTH04-01**

| Parameter | Standard | Measured | Allowable Range | Parameter | Standard | Measured | Allowable Range |
|---|---|---|---|---|---|---|---|
| Flow lpm | 3.00 | 3.11 | 2.88 ~ 3.12 | Pressure kPa | 100.6 | 100.6 | 95.58 ~ 105.64 |
| Full Flow lpm | N/A | 6.52 | >3.80 | | | | |

*TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass of standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1.*

| Measurement Variable | System ID | Last Cal. | Cal. Due | Measurement Variable | System ID | Last Cal. | Cal. Due |
|---|---|---|---|---|---|---|---|
| DC Voltage | E020187 | 12-05-21 | 31-05-22 | Pressure | E020123 | 20-01-22 | 31-01-23 |
| Microbalance | E020125 | 25-01-22 | 31-01-23 | Photometer | E020114 | 13-08-21 | 28-02-22 |
| Flowmeter | E020119 | 29-04-21 | 30-04-22 | 3 um PSL | 206030 | n/a | n/a |
| 1um PSL | 698880 | n/a | n/a | 10 um PSL | 212455 | n/a | n/a |

ESLEUPR

Calibrated

16 February, 2022

Date

TSI P/N 2220157

AQmesh Calibration certificates

ENVIRONMENTAL Instruments

Tel. +44 (0)1789 207459
Email. info@aqmesh.com
www.aqmesh.com

AQMesh Certificate of calibration

This is to certify that the AQMesh pod of the following serial number

2450781

has been calibrated against certified reference equipment for the following measurements:

| | |
|---|---|
| NO2 | Thermo Scientific 42i |
| O3 | Monitor Labs ML9810B |
| CO | Thermo Environmental Instruments 48C |
| SO2 | Thermo Scientific 43i |

Date of manufacture: 15th September 2021

Richard Handy

Operations Manager

ENVIRONMENTAL Instruments

Tel. +44 (0)1789 207459
Email. info@aqmesh.com
www.aqmesh.com

AQMesh

# Certificate of calibration

This is to certify that the sensors

NO2: 202350601

O3: 204023723

CO: 162740256

SO2: 164741333

In AQMesh pod of the following serial number 2140150 have been calibrated against certified reference equipment for the following measurements:

| | |
|---|---|
| NO2 | Thermo Scientific 42i |
| O3 | Monitor Labs ML9810B |
| CO | Thermo Environmental Instruments 48C |
| SO2 | Thermo Scientific 43i |

Date of calibration: 31st May 2022

Richard Handy

Operations Manager

ENVIRONMENTAL Instruments

Tel. +44 (0)1789 207459
Email. info@aqmesh.com
www.aqmesh.com

AQMesh

# Certificate of calibration

This is to certify that the AQMesh pod(s) of the following serial number

2450718

Have been calibrated against certified reference equipment for the following measurements:

| | |
|---|---|
| NO2 | Thermo Scientific 42i |
| O3 | Monitor Labs ML9810B |
| CO | Thermo Environmental Instruments 48C |
| SO2 | Thermo Scientific 43i |

Date of manufacture: 1ST June 2021

Richard Handy

Operations Manager

MiniRAE lite / MiniRAE Calibration certificates

CitiSafe Pte Ltd

Blk 20 Woodlands Link
#06-12 Singapore 738733
T: (+65) 6482 4582 F: (+65) 6482 4381
Email: sales@citisafe.com.sg
Website: www.citisafe.com.sg
Co & GST Reg No. 200712184N

## TEST / CALIBRATION CERTIFICATE

| | | |
|---|---|---|
| Instrument Model | : | MultiRAE Lite Pump |
| Part No. | : | PGM 6208 |
| Instrument Serial No. | : | M01C019238 |
| Manufacturer | : | RAE Systems |
| Test/Calibration Date | : | 25-May-2022 |
| Reference No. | : | M01C019238_220525 |
| Flow Rate | : | 0.7 Lpm |
| Calibration Gas Cyl. | : | Batch W0348660-1 Valid to May 2024, Concentration: 50 %LEL Methane, 18 %VOL O2, 50 ppm CO, 10 ppm H2S<br>Batch: WO313771-2 Valid to Aug 2024, Concentration: 100 ppm Iso-Butylene |

**Test Result**

| Sensor | Zero Cal Result | Cal Gas | Span Cal Result | Lo Alarm | Hi Alarm |
|---|---|---|---|---|---|
| CO (ppm) | 0 ppm | 50 ppm | 50 ppm | 35 ppm | 200 ppm |
| H2S (ppm) | 0 ppm | 10 ppm | 10 ppm | 10 ppm | 20 ppm |
| LEL (%LEL) | 0 %LEL | 50 %LEL | 52 %LEL | 10 %LEL | 20 %LEL |
| O2 (%Vol) | 20.9 %Vol | 18 %Vol | 18.0 %Vol | 19.5 %Vol | 23.5 %Vol |
| VOC (ppm) | 0 ppm | 100 ppm | 101 ppm | 50 ppm | 100 ppm |

This instrument has been calibrated using calibration gases which are traceable to N.I.S.T. equivalent standards and manufacturer's procedures.

Calibrated by:

CITISAFE PTE LTD

Larry Tan

Service Technician

CitiSafe Pte Ltd

Blk 20 Woodlands Link
#06-12 Singapore 738733
T: (+65) 6482 4582 F: (+65) 6482 4381
Email: sales@citisafe.com.sg
Website: www.citisafe.com.sg
Co & GST Reg No. 200712184N

# TEST / CALIBRATION CERTIFICATE

| | | |
|---|---|---|
| Instrument Model | : | MiniRAE 3000 |
| Part No. | : | PGM - 7320 |
| Instrument Serial No. | : | 592-925856 |
| Manufacturer | : | RAE Systems |
| Test/Calibration Date | : | 30/Aug/2022 |
| Reference No. | : | 592-925856_220830 |
| Flow Rate | : | 0.6 Lpm |
| Calibration Gas Cyl. | : | Batch WO348657-1 Valid to May 2025,<br>Concentration: 100 ppm Iso-Butylene |

## TEST RESULT

| Sensor | Zero Cal Result | Cal Gas | Span Cal Result | Lo Alarm | Hi Alarm |
|---|---|---|---|---|---|
| PID (VOC) ppm | 0 ppm | 100 ppm ISO-Butylene | 100.0 ppm | 50 ppm | 100 ppm |

This instrument has been calibrated using calibration gases which are traceable to N.I.S.T. equivalent standards and manufacturer's procedures.

Calibrated by:

CITISAFE PTE LTD

Ben Lau

Service Engineer

CitiSafe Pte Ltd

Blk 20 Woodlands Link
#06-12 Singapore 738733
T: (+65) 6482 4582 F: (+65) 6482 4381
Email: sales@citisafe.com.sg
Website: www.citisafe.com.sg
Co & GST Reg No. 200712184N

# TEST / CALIBRATION CERTIFICATE

| | | |
|---|---|---|
| Instrument Model | : | MiniRAE 3000 |
| Part No. | : | PGM - 7320 |
| Instrument Serial No. | : | 592-925854 |
| Manufacturer | : | RAE Systems |
| Test/Calibration Date | : | 30/Aug/2022 |
| Reference No. | : | 592-925854_220830 |
| Flow Rate | : | 0.6 Lpm |
| Calibration Gas Cyl. | : | Batch WO348657-1 Valid to May 2025,<br>Concentration: 100 ppm Iso-Butylene |

## TEST RESULT

| Sensor | Zero Cal Result | Cal Gas | Span Cal Result | Lo Alarm | Hi Alarm |
|---|---|---|---|---|---|
| PID (VOC) ppm | 0 ppm | 100 ppm ISO-Butylene | 100.0 ppm | 50 ppm | 100 ppm |

This instrument has been calibrated using calibration gases which are traceable to N.I.S.T. equivalent standards and manufacturer's procedures.

Calibrated by:

Ben Lau

Service Engineer

# APPENDIX J

## Baseline Vibration Level Monitoring Report

# 1ST MONITORING REPORT

# (30 AUGUST 2022 TO 7 SEPTEMBER 2022)

**FOR**

**VIBRATION MONITORING**

**AT**

**MANDAI MUDFLATS**

**SUBMITTED TO**

**M/S MARCHWOOD LABORATORY SERVICES PTE. LTD.**

**12 SEPTEMBER 2022**

**SOIL INSTRUMENTATION PTE LTD**
BLK 3007 UBI ROAD 1
#03 – 424
SINGAPORE 408701
TEL: 67433766 FAX: 67451169
EMAIL: soil_instrument@yahoo.com

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**APPENDIX**

# 1. INTRODUCTION

This Report presents the Vibration Monitoring Results at Mandai Mudflats for M/S Marchwood Laboratory Services Pte. Ltd.

# 2. GEOTECHNICAL INSTRUMENTATION

Appendix A shows the locations of the Geotechnical Instruments installed and monitored for this Site.

The Instruments installed during this period covered in this Report are listed below:

i. Vibration Monitoring 3 Location

# 3. MONITORING PERIOD

This Report covers the Results of the above Instruments from 30-August-2022 to 7-September-2022.

# 4. MONITORING RESULTS

The summaries of the Monitoring Results in this Monitoring Period together with the Review Levels are presented in Tables 1. The detailed Readings of each Instrument installed i.e. Vibration Monitoring are shown in Appendix B.

## 4.1. Trend of Monitoring Results

The following sections brief our observations during this monitoring period:

### 4.1.1. Vibration Monitoring

- Vibration monitoring was carried out using three units of the Micromate manufactured by Instantel Inc..
- The Vibration Monitoring equipment (named as V1) was installed at end of Kranji Road. The Coordinates is Northing: 01°26'17.7", Easting: 103°45'16.4".
- For V1, the vibration recorded during this monitoring period was:

- On 30 August 2022, the Maximum Vibration recorded was 3.052mm/s at 10:11:53hrs.
- On 31 August 2022, the Maximum Vibration recorded was 0.803mm/s at 9:45:50hrs.
- On 1 September 2022, the Maximum Vibration recorded was 3.734mm/s at 14:45:39hrs.
- On 3 September 2022, the Maximum Vibration recorded was 0.704mm/s at 15:50:16hrs.
- On 5 September 2022, the Maximum Vibration recorded was 1.341mm/s at 11:47:19hrs.
- On 6 September 2022, the Maximum Vibration recorded was 1.116mm/s at 17:01:02hrs.
- On 7 September 2022, the Maximum Vibration recorded was 10.60mm/s at 13:57:33hrs.
- The Vibration Recorded during the rest of the time was less than the Threshold Level.

- The Vibration Monitoring equipment (named as V2) was installed at Open Patch adjacent to pavilion beside trail. The Coordinates is Northing: 1˚26' 55", Easting: 103˚ 46' 47".
- For V2, the vibration recorded during this monitoring period was:
  - On 30 August 2022, the Maximum Vibration recorded was 12.18mm/s at 11:03:09hrs.
  - On 31 August 2022, the Maximum Vibration recorded was 0.796mm/s at 14:51:45hrs.
  - On 1 September 2022, the Maximum Vibration recorded was 4.20mm/s at 14:53:22hrs.
  - On 5 September 2022, the Maximum Vibration recorded was 1.681mm/s at 11:54:09hrs.
  - On 7 September 2022, the Maximum Vibration recorded was 75.95mm/s at 14:14:58hrs.
  - The Vibration Recorded during the rest of the time was less than the Threshold Level.

- The Vibration Monitoring equipment (named as V3) was installed at Open field on top of slope beside SUTD (Republic Poly). The Coordinates is Northing: 1˚26' 39.5", Easting: 103˚ 46' 58".
- For V3, the vibration recorded during this monitoring period was:
  - On 30 August 2022, the Maximum Vibration recorded was 20.52mm/s at 11:51:45hrs.
  - On 1 September 2022, the Maximum Vibration recorded was 1.006mm/s at 14:46:34hrs.
  - On 5 September 2022, the Maximum Vibration recorded was 1.228mm/s at 11:47:21hrs.
  - On 6 September 2022, the Maximum Vibration recorded was 1.129mm/s at 16:42:59hrs.
  - On 7 September 2022, the Maximum Vibration recorded was 10.74mm/s at 14:20:23hrs.
  - The Vibration Recorded during the rest of the time was less than the Threshold Level.

## Table 1 Weekly Summary from 30-August-2022 to 7-September-2022 for Vibration Monitoring

| Instrument No. | Date | Recorded Vibration Level | | Threshold Level (mm/s) | Location | Construction Activity | Remarks |
|---|---|---|---|---|---|---|---|
| | | Time | Peak Vector Sum (mm/s) | | | | |
| V1 | 30-Aug-22 | 10:09:56 | 0.607 | 0.500 | End of Kranji Road | Baseline | |
| | 30-Aug-22 | 10:10:20 | 0.517 | | N: 01°26'17.7", E: 103°45'16.4" | Study | |
| | 30-Aug-22 | 10:10:29 | 1.482 | | | | |
| | 30-Aug-22 | 10:10:56 | 0.899 | | | | |
| | 30-Aug-22 | 10:11:17 | 1.974 | | | | |
| | 30-Aug-22 | 10:11:25 | 1.533 | | | | |
| | 30-Aug-22 | 10:11:40 | 0.873 | | | | |
| | 30-Aug-22 | 10:11:53 | 3.052 | | | | |
| | 30-Aug-22 | 13:42:38 | 0.551 | | | | |
| | 30-Aug-22 | 13:43:49 | 0.640 | | | | |
| | 30-Aug-22 | 13:44:15 | 0.679 | | | | |
| | 30-Aug-22 | 13:44:40 | 0.622 | | | | |
| | 30-Aug-22 | 15:42:16 | 0.574 | | | | |
| | 31-Aug-22 | 9:42:00 | 0.731 | | | | |
| | 31-Aug-22 | 9:42:19 | 0.657 | | | | |
| | 31-Aug-22 | 9:42:34 | 0.696 | | | | |
| | 31-Aug-22 | 9:45:50 | 0.803 | | | | |
| | 31-Aug-22 | 9:46:01 | 0.594 | | | | |
| | 31-Aug-22 | 9:50:04 | 0.702 | | | | |
| | 31-Aug-22 | 9:50:25 | 0.699 | | | | |
| | 31-Aug-22 | 9:50:35 | 0.590 | | | | |
| | 31-Aug-22 | 14:43:38 | 0.537 | | | | |
| | 31-Aug-22 | 14:44:56 | 0.587 | | | | |
| | 31-Aug-22 | 14:45:08 | 0.540 | | | | |
| | 31-Aug-22 | 14:47:31 | 0.649 | | | | |
| | 31-Aug-22 | 14:47:44 | 0.621 | | | | |
| | 31-Aug-22 | 14:53:56 | 0.593 | | | | |
| | 31-Aug-22 | 15:12:48 | 0.517 | | | | |
| | 31-Aug-22 | 21:02:46 | 0.502 | | | | |
| | 01-Sep-22 | 14:44:16 | 2.878 | | | | |
| | 01-Sep-22 | 14:45:39 | 3.734 | | | | |
| | 01-Sep-22 | 14:45:48 | 0.577 | | | | |
| | 01-Sep-22 | 14:46:33 | 1.982 | | | | |
| | 01-Sep-22 | 14:47:17 | 0.612 | | | | |
| | 01-Sep-22 | 14:48:24 | 1.185 | | | | |
| | 01-Sep-22 | 14:48:34 | 0.515 | | | | |
| | 01-Sep-22 | 14:48:43 | 0.599 | | | | |
| | 01-Sep-22 | 14:48:53 | 0.580 | | | | |
| | 01-Sep-22 | 14:49:09 | 0.602 | | | | |
| | 01-Sep-22 | 14:57:35 | 0.550 | | | | |
| | 03-Sep-22 | 15:50:16 | 0.704 | | | | |
| | 05-Sep-22 | 8:43:45 | 0.718 | | | | |
| | 05-Sep-22 | 8:43:55 | 0.577 | | | | |
| | 05-Sep-22 | 8:48:29 | 0.648 | | | | |
| | 05-Sep-22 | 8:48:38 | 0.514 | | | | |
| | 05-Sep-22 | 8:48:46 | 0.574 | | | | |
| | 05-Sep-22 | 8:59:58 | 0.544 | | | | |
| | 05-Sep-22 | 9:44:34 | 0.840 | | | | |
| | 05-Sep-22 | 9:45:06 | 0.639 | | | | |
| | 05-Sep-22 | 9:45:24 | 0.545 | | | | |
| | 05-Sep-22 | 9:45:56 | 0.545 | | | | |
| | 05-Sep-22 | 9:46:06 | 0.520 | | | | |
| | 05-Sep-22 | 9:47:13 | 0.645 | | | | |
| | 05-Sep-22 | 9:58:20 | 0.538 | | | | |
| | 05-Sep-22 | 9:58:30 | 0.547 | | | | |
| | 05-Sep-22 | 11:27:26 | 0.541 | | | | |
| | 05-Sep-22 | 11:29:09 | 0.507 | | | | |
| | 05-Sep-22 | 11:30:02 | 0.697 | | | | |
| | 05-Sep-22 | 11:30:42 | 0.763 | | | | |
| | 05-Sep-22 | 11:31:26 | 0.645 | | | | |
| | 05-Sep-22 | 11:32:18 | 0.656 | | | | |
| | 05-Sep-22 | 11:32:42 | 0.786 | | | | |
| | 05-Sep-22 | 11:33:51 | 1.070 | | | | |
| | 05-Sep-22 | 11:36:26 | 0.524 | | | | |
| | 05-Sep-22 | 11:41:08 | 0.498 | | | | |
| | 05-Sep-22 | 11:41:19 | 0.570 | | | | |
| | 05-Sep-22 | 11:43:26 | 0.509 | | | | |
| | 05-Sep-22 | 11:43:59 | 0.734 | | | | |
| | 05-Sep-22 | 11:47:19 | 1.341 | | | | |
| | 05-Sep-22 | 12:08:57 | 0.717 | | | | |
| | 05-Sep-22 | 12:20:06 | 0.560 | | | | |
| | 05-Sep-22 | 13:45:53 | 0.526 | | | | |
| | 05-Sep-22 | 13:46:35 | 0.689 | | | | |
| | 05-Sep-22 | 13:54:51 | 0.545 | | | | |
| | 05-Sep-22 | 13:55:36 | 0.599 | | | | |

## Table 1 Weekly Summary from 30-August-2022 to 7-September-2022 for Vibration Monitoring

| Instrument No. | Date | Recorded Vibration Level | | Threshold Level (mm/s) | Location | Construction Activity | Remarks |
|---|---|---|---|---|---|---|---|
| | | Time | Peak Vector Sum (mm/s) | | | | |
| V1 | 05-Sep-22 | 15:38:47 | 0.659 | 0.500 | End of Kranji Road | Baseline | |
| | 05-Sep-22 | 15:39:15 | 0.879 | | N: 01°26'17.7", E: 103°45'16.4" | Study | |
| | 05-Sep-22 | 17:12:34 | 0.647 | | | | |
| | 05-Sep-22 | 17:12:56 | 0.510 | | | | |
| | 05-Sep-22 | 17:13:55 | 0.507 | | | | |
| | 05-Sep-22 | 17:14:18 | 0.572 | | | | |
| | 05-Sep-22 | 17:15:05 | 0.699 | | | | |
| | 05-Sep-22 | 17:29:38 | 0.507 | | | | |
| | 05-Sep-22 | 19:39:32 | 0.720 | | | | |
| | 06-Sep-22 | 16:17:31 | 0.551 | | | | |
| | 06-Sep-22 | 17:01:02 | 1.116 | | | | |
| | 06-Sep-22 | 17:36:48 | 0.649 | | | | |
| | 06-Sep-22 | 17:41:27 | 0.635 | | | | |
| | 06-Sep-22 | 18:18:16 | 0.535 | | | | |
| | 06-Sep-22 | 18:20:52 | 0.632 | | | | |
| | 07-Sep-22 | 9:04:49 | 0.593 | | | | |
| | 07-Sep-22 | 9:05:06 | 0.700 | | | | |
| | 07-Sep-22 | 9:06:37 | 0.640 | | | | |
| | 07-Sep-22 | 9:08:12 | 0.769 | | | | |
| | 07-Sep-22 | 9:09:38 | 0.735 | | | | |
| | 07-Sep-22 | 9:09:59 | 0.521 | | | | |
| | 07-Sep-22 | 9:26:30 | 0.505 | | | | |
| | 07-Sep-22 | 12:42:21 | 0.546 | | | | |
| | 07-Sep-22 | 12:42:30 | 0.556 | | | | |
| | 07-Sep-22 | 12:42:44 | 0.641 | | | | |
| | 07-Sep-22 | 12:44:24 | 0.576 | | | | |
| | 07-Sep-22 | 12:58:40 | 0.544 | | | | |
| | 07-Sep-22 | 13:33:24 | 0.570 | | | | |
| | 07-Sep-22 | 13:57:12 | 0.878 | | | | |
| | 07-Sep-22 | 13:57:23 | 0.526 | | | | |
| | 07-Sep-22 | 13:57:33 | 10.600 | | | | |
| | 07-Sep-22 | 13:57:42 | 1.399 | | | | |
| V2 | 30-Aug-22 | 11:01:34 | 0.614 | | Kranji Park Car Park A | | |
| | 30-Aug-22 | 11:02:24 | 2.226 | | N: 01°26'20.6", E: 103°44'34.7" | | |
| | 30-Aug-22 | 11:02:36 | 2.349 | | | | |
| | 30-Aug-22 | 11:02:46 | 2.765 | | | | |
| | 30-Aug-22 | 11:02:56 | 1.238 | | | | |
| | 30-Aug-22 | 11:03:09 | 12.180 | | | | |
| | 30-Aug-22 | 11:03:33 | 4.067 | | | | |
| | 30-Aug-22 | 12:13:25 | 1.334 | | | | |
| | 30-Aug-22 | 13:49:17 | 0.645 | | | | |
| | 30-Aug-22 | 13:50:40 | 0.647 | | | | |
| | 30-Aug-22 | 13:51:02 | 0.646 | | | | |
| | 30-Aug-22 | 13:51:27 | 0.747 | | | | |
| | 31-Aug-22 | 10:01:22 | 0.624 | | | | |
| | 31-Aug-22 | 14:51:45 | 0.796 | | | | |
| | 31-Aug-22 | 14:51:56 | 0.695 | | | | |
| | 31-Aug-22 | 14:54:19 | 0.574 | | | | |
| | 31-Aug-22 | 14:54:34 | 0.617 | | | | |
| | 31-Aug-22 | 15:00:43 | 0.655 | | | | |
| | 01-Sep-22 | 14:51:07 | 2.373 | | | | |
| | 01-Sep-22 | 14:52:33 | 1.925 | | | | |
| | 01-Sep-22 | 14:53:22 | 4.200 | | | | |
| | 01-Sep-22 | 14:54:08 | 0.591 | | | | |
| | 01-Sep-22 | 14:55:17 | 0.625 | | | | |
| | 05-Sep-22 | 11:40:40 | 0.816 | | | | |
| | 05-Sep-22 | 11:43:28 | 0.702 | | | | |
| | 05-Sep-22 | 11:45:08 | 0.529 | | | | |
| | 05-Sep-22 | 11:53:39 | 0.526 | | | | |
| | 05-Sep-22 | 11:54:09 | 1.681 | | | | |
| | 05-Sep-22 | 11:54:53 | 0.840 | | | | |
| | 05-Sep-22 | 11:55:10 | 0.761 | | | | |
| | 05-Sep-22 | 11:56:49 | 0.667 | | | | |
| | 05-Sep-22 | 12:02:48 | 0.747 | | | | |
| | 05-Sep-22 | 12:03:43 | 1.213 | | | | |
| | 05-Sep-22 | 12:05:12 | 0.565 | | | | |
| | 05-Sep-22 | 12:05:56 | 0.687 | | | | |
| | 05-Sep-22 | 12:15:45 | 0.502 | | | | |
| | 05-Sep-22 | 12:15:56 | 0.517 | | | | |
| | 05-Sep-22 | 13:07:17 | 0.950 | | | | |
| | 05-Sep-22 | 19:21:43 | 0.593 | | | | |
| | 05-Sep-22 | 19:24:57 | 0.585 | | | | |
| | 07-Sep-22 | 12:49:18 | 0.881 | | | | |
| | 07-Sep-22 | 14:14:35 | 1.046 | | | | |
| | 07-Sep-22 | 14:14:49 | 0.655 | | | | |

**Table 1 Weekly Summary from 30-August-2022 to 7-September-2022 for Vibration Monitoring**

| Instrument No. | Date | Recorded Vibration Level: Time | Peak Vector Sum (mm/s) | Threshold Level (mm/s) | Location | Construction Activity | Remarks |
|---|---|---|---|---|---|---|---|
| V2 | 07-Sep-22 | 14:14:58 | 75.950 | 0.500 | Kranji Park Car Park A N: 01°26'20.6", E: 103°44'34.7" | Baseline Study | |
| | 07-Sep-22 | 14:15:11 | 3.283 | | | | |
| | 07-Sep-22 | 14:15:24 | 2.007 | | | | |
| V3 | 30-Aug-22 | 11:51:45 | 20.520 | | Middle of Kranji Reservoir Park B N: 01°26'22.4", E: 103°44'16.5" | | |
| | 30-Aug-22 | 11:52:02 | 1.146 | | | | |
| | 30-Aug-22 | 11:52:16 | 9.599 | | | | |
| | 30-Aug-22 | 11:52:31 | 1.264 | | | | |
| | 30-Aug-22 | 11:52:47 | 5.168 | | | | |
| | 30-Aug-22 | 11:53:15 | 1.195 | | | | |
| | 30-Aug-22 | 11:53:42 | 4.744 | | | | |
| | 30-Aug-22 | 11:54:04 | 0.741 | | | | |
| | 30-Aug-22 | 11:57:37 | 2.601 | | | | |
| | 01-Sep-22 | 14:46:34 | 1.006 | | | | |
| | 05-Sep-22 | 11:32:44 | 0.672 | | | | |
| | 05-Sep-22 | 11:47:21 | 1.228 | | | | |
| | 05-Sep-22 | 12:09:07 | 0.559 | | | | |
| | 06-Sep-22 | 16:42:59 | 1.129 | | | | |
| | 06-Sep-22 | 16:43:30 | 0.990 | | | | |
| | 06-Sep-22 | 16:43:51 | 0.943 | | | | |
| | 07-Sep-22 | 14:19:41 | 1.743 | | | | |
| | 07-Sep-22 | 14:19:56 | 0.609 | | | | |
| | 07-Sep-22 | 14:20:09 | 1.058 | | | | |
| | 07-Sep-22 | 14:20:23 | 10.740 | | | | |

# APPENDIX A

# SITE PLAN


V3
V2
V1

# APPENDIX B

# MONITORING RESULTS

# VIBRATION MONITORING
# V1

VM1 fr 070922

Printed: September 12, 2022 (V 10.72 - 10.72) Event Report: Event List - f:\blastware 10\event\kranji rd vm1\2022-09-07.14

| Type | Serial No. | Date/Time | No. Chan | Trigger | Tran Peak (mm/s) | Tran Freq. Hz. | Tran Accel (g) | Long Peak (mm/s) | Long Freq. Hz. | Long Accel (g) | Vert Peak (mm/s) | Vert Freq. Hz. | Vert Accel (g) | PVS1 (mm/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOG | UM15192 | Aug 30 /22 10:09:49 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Start Monitoring |
| W | UM15192 | Aug 30 /22 10:09:56 | 3 | Vert | 0.323 | 34.13 | 0.016 | 0.260 | 42.67 | 0.018 | 0.536 | 42.67 | 0.026 | 0.607 | |
| W | UM15192 | Aug 30 /22 10:10:20 | 3 | Tran | 0.497 | >100 | 0.033 | 0.213 | >100 | 0.018 | 0.378 | 51.20 | 0.027 | 0.517 | |
| W | UM15192 | Aug 30 /22 10:10:29 | 3 | Vert | 1.064 | 64.00 | 0.072 | 0.694 | >100 | 0.046 | 1.340 | 56.89 | 0.090 | 1.482 | |
| W | UM15192 | Aug 30 /22 10:10:56 | 3 | Long | 0.205 | 32.00 | 0.010 | 0.654 | 39.38 | 0.019 | 0.591 | 39.38 | 0.018 | 0.899 | |
| W | UM15192 | Aug 30 /22 10:11:17 | 3 | Vert | 1.442 | 36.57 | 0.129 | 1.001 | 39.38 | 0.088 | 1.789 | >100 | 0.207 | 1.974 | |
| W | UM15192 | Aug 30 /22 10:11:25 | 3 | Vert | 0.457 | >100 | 0.065 | 1.182 | >100 | 0.143 | 1.332 | >100 | 0.202 | 1.533 | |
| W | UM15192 | Aug 30 /22 10:11:40 | 3 | Vert | 0.410 | 36.57 | 0.026 | 0.497 | 36.57 | 0.053 | 0.678 | 34.13 | 0.053 | 0.873 | |
| W | UM15192 | Aug 30 /22 10:11:53 | 3 | Vert | 1.064 | 7.529 | 0.072 | 2.719 | 5.172 | 0.082 | 1.679 | >100 | 0.177 | 3.052 | |
| W | UM15192 | Aug 30 /22 13:42:38 | 3 | Vert | 0.221 | >100 | 0.020 | 0.134 | >100 | 0.018 | 0.544 | >100 | 0.048 | 0.551 | |
| W | UM15192 | Aug 30 /22 13:43:49 | 3 | Vert | 0.284 | >100 | 0.026 | 0.158 | >100 | 0.020 | 0.615 | >100 | 0.063 | 0.640 | |
| W | UM15192 | Aug 30 /22 13:44:15 | 3 | Vert | 0.292 | >100 | 0.030 | 0.173 | >100 | 0.026 | 0.670 | >100 | 0.111 | 0.679 | |
| W | UM15192 | Aug 30 /22 13:44:40 | 3 | Vert | 0.244 | >100 | 0.028 | 0.142 | >100 | 0.017 | 0.615 | >100 | 0.068 | 0.622 | |
| W | UM15192 | Aug 30 /22 15:42:16 | 3 | Vert | 0.189 | >100 | 0.016 | 0.118 | >100 | 0.014 | 0.567 | >100 | 0.044 | 0.574 | |
| W | UM15192 | Aug 31 /22 09:42:00 | 3 | Vert | 0.252 | >100 | 0.024 | 0.118 | >100 | 0.016 | 0.717 | >100 | 0.083 | 0.731 | |
| W | UM15192 | Aug 31 /22 09:42:19 | 3 | Vert | 0.181 | >100 | 0.018 | 0.126 | >100 | 0.018 | 0.646 | >100 | 0.076 | 0.657 | |
| W | UM15192 | Aug 31 /22 09:42:34 | 3 | Vert | 0.260 | >100 | 0.028 | 0.260 | >100 | 0.026 | 0.686 | >100 | 0.082 | 0.696 | |
| W | UM15192 | Aug 31 /22 09:45:50 | 3 | Vert | 0.300 | >100 | 0.029 | 0.252 | >100 | 0.028 | 0.796 | >100 | 0.066 | 0.803 | |
| W | UM15192 | Aug 31 /22 09:46:01 | 3 | Vert | 0.244 | >100 | 0.026 | 0.173 | >100 | 0.021 | 0.567 | >100 | 0.064 | 0.594 | |
| W | UM15192 | Aug 31 /22 09:50:04 | 3 | Vert | 0.221 | >100 | 0.027 | 0.213 | >100 | 0.030 | 0.686 | >100 | 0.066 | 0.702 | |
| W | UM15192 | Aug 31 /22 09:50:25 | 3 | Vert | 0.339 | >100 | 0.035 | 0.197 | >100 | 0.019 | 0.686 | >100 | 0.088 | 0.699 | |
| W | UM15192 | Aug 31 /22 09:50:35 | 3 | Vert | 0.236 | >100 | 0.026 | 0.095 | >100 | 0.014 | 0.583 | >100 | 0.065 | 0.590 | |
| W | UM15192 | Aug 31 /22 14:43:38 | 3 | Vert | 0.244 | >100 | 0.022 | 0.166 | >100 | 0.021 | 0.536 | >100 | 0.047 | 0.537 | |
| W | UM15192 | Aug 31 /22 14:44:56 | 3 | Vert | 0.244 | >100 | 0.036 | 0.252 | >100 | 0.029 | 0.544 | >100 | 0.064 | 0.587 | |
| W | UM15192 | Aug 31 /22 14:45:08 | 3 | Vert | 0.221 | >100 | 0.019 | 0.142 | >100 | 0.016 | 0.528 | >100 | 0.049 | 0.540 | |
| W | UM15192 | Aug 31 /22 14:47:31 | 3 | Vert | 0.229 | >100 | 0.025 | 0.205 | >100 | 0.021 | 0.646 | >100 | 0.083 | 0.649 | |
| W | UM15192 | Aug 31 /22 14:47:44 | 3 | Vert | 0.221 | >100 | 0.021 | 0.142 | >100 | 0.014 | 0.599 | >100 | 0.051 | 0.621 | |
| W | UM15192 | Aug 31 /22 14:53:56 | 3 | Vert | 0.213 | >100 | 0.028 | 0.150 | >100 | 0.025 | 0.591 | >100 | 0.060 | 0.593 | |
| W | UM15192 | Aug 31 /22 15:12:48 | 3 | Vert | 0.229 | >100 | 0.023 | 0.118 | 85.33 | 0.016 | 0.512 | >100 | 0.052 | 0.517 | |
| W | UM15192 | Aug 31 /22 21:02:46 | 3 | Vert | 0.181 | >100 | 0.012 | 0.095 | >100 | 0.011 | 0.497 | >100 | 0.045 | 0.502 | |
| W | UM15192 | Sep 1 /22 14:44:16 | 3 | Vert | 1.064 | >100 | 0.116 | 0.788 | >100 | 0.072 | 2.735 | >100 | 0.439 | 2.878 | |
| W | UM15192 | Sep 1 /22 14:45:39 | 3 | Vert | 1.135 | >100 | 0.131 | 0.938 | >100 | 0.120 | 3.602 | >100 | 0.331 | 3.734 | |
| W | UM15192 | Sep 1 /22 14:45:48 | 3 | Vert | 0.142 | 85.33 | 0.013 | 0.158 | >100 | 0.012 | 0.560 | >100 | 0.049 | 0.577 | |
| W | UM15192 | Sep 1 /22 14:46:33 | 3 | Vert | 0.804 | >100 | 0.089 | 0.670 | >100 | 0.059 | 1.860 | >100 | 0.217 | 1.982 | |
| W | UM15192 | Sep 1 /22 14:47:17 | 3 | Vert | 0.197 | >100 | 0.019 | 0.110 | >100 | 0.014 | 0.599 | >100 | 0.048 | 0.612 | |
| W | UM15192 | Sep 1 /22 14:48:24 | 3 | Vert | 0.292 | >100 | 0.028 | 0.307 | >100 | 0.039 | 1.143 | >100 | 0.104 | 1.185 | |
| W | UM15192 | Sep 1 /22 14:48:34 | 3 | Vert | 0.189 | >100 | 0.022 | 0.118 | >100 | 0.015 | 0.504 | >100 | 0.064 | 0.515 | |
| W | UM15192 | Sep 1 /22 14:48:43 | 3 | Vert | 0.276 | >100 | 0.023 | 0.142 | >100 | 0.014 | 0.536 | >100 | 0.049 | 0.599 | |
| W | UM15192 | Sep 1 /22 14:48:53 | 3 | Vert | 0.260 | >100 | 0.022 | 0.158 | 85.33 | 0.013 | 0.567 | >100 | 0.071 | 0.580 | |
| W | UM15192 | Sep 1 /22 14:49:09 | 3 | Vert | 0.189 | >100 | 0.017 | 0.079 | >100 | 0.008 | 0.591 | >100 | 0.044 | 0.602 | |
| W | UM15192 | Sep 1 /22 14:57:35 | 3 | Vert | 0.213 | >100 | 0.024 | 0.126 | 64.00 | 0.014 | 0.544 | >100 | 0.040 | 0.550 | |
| W | UM15192 | Sep 3 /22 15:50:16 | 3 | Vert | 0.166 | 17.07 | 0.012 | 0.166 | 16.00 | 0.016 | 0.694 | 18.96 | 0.033 | 0.704 | |
| W | UM15192 | Sep 5 /22 08:43:45 | 3 | Vert | 0.229 | >100 | 0.026 | 0.197 | >100 | 0.023 | 0.686 | >100 | 0.108 | 0.718 | |
| W | UM15192 | Sep 5 /22 08:43:55 | 3 | Vert | 0.229 | >100 | 0.022 | 0.173 | >100 | 0.017 | 0.536 | >100 | 0.055 | 0.577 | |
| W | UM15192 | Sep 5 /22 08:48:29 | 3 | Vert | 0.213 | >100 | 0.021 | 0.158 | >100 | 0.017 | 0.631 | >100 | 0.055 | 0.648 | |
| W | UM15192 | Sep 5 /22 08:48:38 | 3 | Vert | 0.197 | >100 | 0.021 | 0.158 | >100 | 0.024 | 0.512 | >100 | 0.059 | 0.514 | |
| W | UM15192 | Sep 5 /22 08:48:46 | 3 | Vert | 0.260 | >100 | 0.021 | 0.166 | 36.57 | 0.015 | 0.536 | >100 | 0.062 | 0.574 | |
| W | UM15192 | Sep 5 /22 08:59:58 | 3 | Vert | 0.260 | >100 | 0.042 | 0.142 | >100 | 0.016 | 0.536 | >100 | 0.045 | 0.544 | |
| W | UM15192 | Sep 5 /22 09:44:34 | 3 | Vert | 0.150 | 5.069 | 0.007 | 0.292 | 5.626 | 0.006 | 0.796 | 7.642 | 0.011 | 0.840 | |
| W | UM15192 | Sep 5 /22 09:45:06 | 3 | Vert | 0.142 | 5.505 | 0.007 | 0.189 | 7.111 | 0.007 | 0.638 | 9.309 | 0.016 | 0.639 | |
| W | UM15192 | Sep 5 /22 09:45:24 | 3 | Vert | 0.181 | 11.91 | 0.007 | 0.142 | 5.120 | 0.006 | 0.544 | 7.111 | 0.020 | 0.545 | |
| W | UM15192 | Sep 5 /22 09:45:56 | 3 | Vert | 0.126 | 3.657 | 0.007 | 0.150 | 28.44 | 0.007 | 0.544 | 13.84 | 0.015 | 0.545 | |
| W | UM15192 | Sep 5 /22 09:46:06 | 3 | Vert | 0.126 | 5.333 | 0.007 | 0.158 | 4.531 | 0.005 | 0.512 | 6.737 | 0.011 | 0.520 | |
| W | UM15192 | Sep 5 /22 09:47:13 | 3 | Vert | 0.331 | 5.333 | 0.007 | 0.244 | 4.063 | 0.007 | 0.638 | 8.127 | 0.015 | 0.645 | |
| W | UM15192 | Sep 5 /22 09:58:20 | 3 | Vert | 0.173 | 11.64 | 0.007 | 0.166 | 15.06 | 0.007 | 0.536 | 7.314 | 0.012 | 0.538 | |
| W | UM15192 | Sep 5 /22 09:58:30 | 3 | Vert | 0.229 | 5.885 | 0.007 | 0.158 | 30.12 | 0.006 | 0.544 | 14.63 | 0.017 | 0.547 | |
| W | UM15192 | Sep 5 /22 11:27:26 | 3 | Vert | 0.189 | >100 | 0.021 | 0.126 | >100 | 0.012 | 0.520 | >100 | 0.049 | 0.541 | |
| W | UM15192 | Sep 5 /22 11:29:09 | 3 | Vert | 0.150 | >100 | 0.016 | 0.118 | >100 | 0.012 | 0.497 | >100 | 0.035 | 0.507 | |
| W | UM15192 | Sep 5 /22 11:30:02 | 3 | Vert | 0.252 | >100 | 0.019 | 0.134 | >100 | 0.012 | 0.678 | >100 | 0.059 | 0.697 | |
| W | UM15192 | Sep 5 /22 11:30:42 | 3 | Vert | 0.244 | >100 | 0.028 | 0.213 | >100 | 0.024 | 0.749 | >100 | 0.061 | 0.763 | |
| W | UM15192 | Sep 5 /22 11:31:26 | 3 | Vert | 0.189 | >100 | 0.025 | 0.166 | >100 | 0.019 | 0.631 | >100 | 0.074 | 0.645 | |
| W | UM15192 | Sep 5 /22 11:32:18 | 3 | Vert | 0.181 | >100 | 0.015 | 0.134 | >100 | 0.015 | 0.638 | >100 | 0.054 | 0.656 | |
| W | UM15192 | Sep 5 /22 11:32:42 | 3 | Vert | 0.252 | >100 | 0.026 | 0.150 | >100 | 0.016 | 0.757 | >100 | 0.073 | 0.786 | |
| W | UM15192 | Sep 5 /22 11:33:51 | 3 | Vert | 0.426 | >100 | 0.031 | 0.252 | >100 | 0.024 | 1.048 | >100 | 0.086 | 1.070 | |
| W | UM15192 | Sep 5 /22 11:36:26 | 3 | Vert | 0.158 | >100 | 0.013 | 0.118 | 39.38 | 0.009 | 0.512 | >100 | 0.045 | 0.524 | |
| W | UM15192 | Sep 5 /22 11:41:08 | 3 | Vert | 0.150 | 85.33 | 0.010 | 0.181 | 39.38 | 0.009 | 0.497 | 7.877 | 0.017 | 0.498 | |
| W | UM15192 | Sep 5 /22 11:41:19 | 3 | Vert | 0.142 | 85.33 | 0.012 | 0.181 | 39.38 | 0.010 | 0.567 | 11.64 | 0.020 | 0.570 | |
| W | UM15192 | Sep 5 /22 11:43:26 | 3 | Vert | 0.142 | 85.33 | 0.010 | 0.166 | 46.55 | 0.011 | 0.504 | 9.143 | 0.021 | 0.509 | |
| W | UM15192 | Sep 5 /22 11:43:59 | 3 | Vert | 0.205 | 85.33 | 0.012 | 0.181 | 36.57 | 0.012 | 0.733 | 8.258 | 0.027 | 0.734 | |
| W | UM15192 | Sep 5 /22 11:47:19 | 3 | Tran | 1.230 | >100 | 0.114 | 0.662 | >100 | 0.070 | 1.072 | >100 | 0.133 | 1.341 | |
| W | UM15192 | Sep 5 /22 12:08:57 | 3 | Vert | 0.300 | >100 | 0.021 | 0.197 | >100 | 0.020 | 0.694 | >100 | 0.048 | 0.717 | |
| W | UM15192 | Sep 5 /22 12:20:06 | 3 | Vert | 0.205 | 73.14 | 0.016 | 0.118 | 46.55 | 0.010 | 0.544 | >100 | 0.041 | 0.560 | |
| W | UM15192 | Sep 5 /22 13:45:53 | 3 | Vert | 0.189 | >100 | 0.025 | 0.166 | >100 | 0.018 | 0.512 | >100 | 0.066 | 0.526 | |
| W | UM15192 | Sep 5 /22 13:46:35 | 3 | Vert | 0.229 | >100 | 0.023 | 0.173 | >100 | 0.021 | 0.662 | >100 | 0.086 | 0.689 | |
| W | UM15192 | Sep 5 /22 13:54:51 | 3 | Vert | 0.205 | >100 | 0.016 | 0.118 | >100 | 0.013 | 0.544 | >100 | 0.050 | 0.545 | |
| W | UM15192 | Sep 5 /22 13:55:36 | 3 | Vert | 0.213 | >100 | 0.022 | 0.142 | >100 | 0.016 | 0.567 | >100 | 0.054 | 0.599 | |
| W | UM15192 | Sep 5 /22 15:38:47 | 3 | Vert | 0.236 | >100 | 0.024 | 0.166 | >100 | 0.021 | 0.631 | >100 | 0.087 | 0.659 | |
| W | UM15192 | Sep 5 /22 15:39:15 | 3 | Vert | 0.284 | >100 | 0.032 | 0.213 | >100 | 0.036 | 0.859 | >100 | 0.129 | 0.879 | |
| W | UM15192 | Sep 5 /22 17:12:34 | 3 | Vert | 0.213 | >100 | 0.022 | 0.166 | >100 | 0.020 | 0.631 | >100 | 0.062 | 0.647 | |
| W | UM15192 | Sep 5 /22 17:12:56 | 3 | Vert | 0.142 | >100 | 0.017 | 0.118 | >100 | 0.012 | 0.497 | >100 | 0.051 | 0.510 | |
| W | UM15192 | Sep 5 /22 17:13:55 | 3 | Vert | 0.181 | >100 | 0.016 | 0.110 | >100 | 0.013 | 0.497 | >100 | 0.049 | 0.507 | |
| W | UM15192 | Sep 5 /22 17:14:18 | 3 | Vert | 0.205 | >100 | 0.030 | 0.110 | >100 | 0.014 | 0.544 | >100 | 0.072 | 0.572 | |
| W | UM15192 | Sep 5 /22 17:15:05 | 3 | Vert | 0.236 | >100 | 0.022 | 0.181 | >100 | 0.021 | 0.694 | >100 | 0.072 | 0.699 | |
| W | UM15192 | Sep 5 /22 17:29:38 | 3 | Vert | 0.189 | >100 | 0.018 | 0.126 | >100 | 0.013 | 0.497 | >100 | 0.064 | 0.507 | |
| W | UM15192 | Sep 5 /22 19:39:32 | 3 | Vert | 0.118 | 73.14 | 0.007 | 0.150 | 7.420 | 0.006 | 0.717 | 7.420 | 0.016 | 0.720 | |
| W | UM15192 | Sep 6 /22 16:17:31 | 3 | Vert | 0.150 | 7.642 | 0.006 | 0.095 | 8.393 | 0.006 | 0.544 | 6.919 | 0.010 | 0.551 | |
| W | UM15192 | Sep 6 /22 17:01:02 | 3 | Vert | 0.292 | >100 | 0.025 | 0.205 | >100 | 0.019 | 1.103 | >100 | 0.095 | 1.116 | |
| W | UM15192 | Sep 6 /22 17:36:48 | 3 | Vert | 0.173 | 6.649 | 0.004 | 0.142 | 4.096 | 0.006 | 0.646 | 7.014 | 0.007 | 0.649 | |
| W | UM15192 | Sep 6 /22 17:41:27 | 3 | Vert | 0.229 | 46.55 | 0.023 | 0.142 | >100 | 0.016 | 0.631 | >100 | 0.040 | 0.635 | |
| W | UM15192 | Sep 6 /22 18:18:16 | 3 | Vert | 0.197 | 7.877 | 0.007 | 0.166 | 8.678 | 0.005 | 0.528 | 7.014 | 0.010 | 0.535 | |
| W | UM15192 | Sep 6 /22 18:20:52 | 3 | Vert | 0.292 | 13.84 | 0.014 | 0.229 | 25.60 | 0.016 | 0.631 | 16.52 | 0.022 | 0.632 | |
| W | UM15192 | Sep 7 /22 09:04:49 | 3 | Vert | 0.205 | >100 | 0.026 | 0.158 | >100 | 0.021 | 0.575 | >100 | 0.069 | 0.593 | |
| W | UM15192 | Sep 7 /22 09:05:06 | 3 | Vert | 0.236 | >100 | 0.022 | 0.142 | >100 | 0.014 | 0.686 | >100 | 0.092 | 0.700 | |
| W | UM15192 | Sep 7 /22 09:06:37 | 3 | Vert | 0.268 | >100 | 0.036 | 0.189 | >100 | 0.023 | 0.607 | >100 | 0.063 | 0.640 | |
| W | UM15192 | Sep 7 /22 09:08:12 | 3 | Vert | 0.244 | >100 | 0.026 | 0.213 | >100 | 0.031 | 0.757 | >100 | 0.100 | 0.769 | |
| W | UM15192 | Sep 7 /22 09:09:38 | 3 | Vert | 0.244 | >100 | 0.024 | 0.181 | >100 | 0.020 | 0.694 | >100 | 0.081 | 0.735 | |
| W | UM15192 | Sep 7 /22 09:09:59 | 3 | Vert | 0.197 | >100 | 0.014 | 0.110 | >100 | 0.012 | 0.504 | >100 | 0.039 | 0.521 | |
| W | UM15192 | Sep 7 /22 09:26:30 | 3 | Vert | 0.181 | 5.389 | 0.005 | 0.134 | 5.689 | 0.005 | 0.504 | 6.564 | 0.005 | 0.505 | |
| W | UM15192 | Sep 7 /22 12:42:21 | 3 | Vert | 0.213 | >100 | 0.021 | 0.118 | >100 | 0.012 | 0.536 | >100 | 0.049 | 0.546 | |
| W | UM15192 | Sep 7 /22 12:42:30 | 3 | Vert | 0.244 | >100 | 0.030 | 0.173 | >100 | 0.020 | 0.520 | >100 | 0.053 | 0.556 | |
| W | UM15192 | Sep 7 /22 12:42:44 | 3 | Vert | 0.331 | >100 | 0.036 | 0.205 | >100 | 0.023 | 0.631 | >100 | 0.083 | 0.641 | |
| W | UM15192 | Sep 7 /22 12:44:24 | 3 | Vert | 0.276 | >100 | 0.035 | 0.158 | >100 | 0.026 | 0.560 | >100 | 0.067 | 0.576 | |
| W | UM15192 | Sep 7 /22 12:58:40 | 3 | Vert | 0.189 | >100 | 0.017 | 0.102 | >100 | 0.014 | 0.536 | >100 | 0.049 | 0.544 | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | UM15192 | Sep 7 /22 | 13:33:24 | 3 | Vert | 0.229 | >100 | 0.024 | 0.197 | >100 | 0.023 | 0.567 | >100 | 0.059 | 0.570 | |
| W | UM15192 | Sep 7 /22 | 13:57:12 | 3 | Vert | 0.284 | 56.89 | 0.026 | 0.434 | 39.38 | 0.035 | 0.867 | 51.20 | 0.048 | 0.878 | |
| W | UM15192 | Sep 7 /22 | 13:57:23 | 3 | Vert | 0.197 | 64.00 | 0.014 | 0.300 | 34.13 | 0.017 | 0.512 | 34.13 | 0.032 | 0.526 | |
| W | UM15192 | Sep 7 /22 | 13:57:33 | 3 | Long | 2.759 | 14.22 | 0.056 | 10.26 | 12.49 | 0.155 | 2.404 | 16.00 | 0.094 | 10.60 | |
| W | UM15192 | Sep 7 /22 | 13:57:42 | 3 | Tran | 1.316 | >100 | 0.132 | 0.859 | 85.33 | 0.050 | 0.875 | >100 | 0.095 | 1.399 | |
| LOG | UM15192 | Sep 7 /22 | 13:57:55 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Stop Monitoring |

# VIBRATION MONITORING
# V2

VM2 fr 070922

Printed: September 12, 2022 (V 10.72 - 10.72)  Event Report: Event List - f:\blastware 10\event\kranji rd vm2\2022-09-07.14

| Type | Serial No. | Date/Time | No. Chan | Trigger | Tran Peak (mm/s) | Tran Freq. Hz. | Tran Accel (g) | Long Peak (mm/s) | Long Freq. Hz. | Long Accel (g) | Vert Peak (mm/s) | Vert Freq. Hz. | Vert Accel (g) | PVS1 (mm/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOG | UM13763 | Aug 30 /22 11:01:33 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Start Monitoring |
| W | UM13763 | Aug 30 /22 11:01:34 | 3 | Tran | 0.607 | 51.20 | 0.025 | 0.307 | 10.45 | 0.011 | 0.197 | 32.00 | 0.009 | 0.614 | |
| W | UM13763 | Aug 30 /22 11:02:24 | 3 | Vert | 1.529 | 42.67 | 0.039 | 1.135 | 32.00 | 0.022 | 1.734 | 25.60 | 0.044 | 2.226 | |
| W | UM13763 | Aug 30 /22 11:02:36 | 3 | Tran | 1.829 | 30.12 | 0.108 | 1.253 | 25.60 | 0.055 | 1.450 | 22.26 | 0.105 | 2.349 | |
| W | UM13763 | Aug 30 /22 11:02:46 | 3 | Tran | 1.135 | 14.63 | 0.045 | 2.294 | 2.893 | 0.026 | 1.632 | 16.52 | 0.041 | 2.765 | |
| W | UM13763 | Aug 30 /22 11:02:56 | 3 | Long | 0.662 | 51.20 | 0.031 | 0.969 | 85.33 | 0.081 | 0.765 | 21.33 | 0.054 | 1.238 | |
| W | UM13763 | Aug 30 /22 11:03:09 | 3 | Vert | 11.70 | 30.12 | 0.413 | 5.289 | 15.52 | 0.265 | 2.987 | >100 | 0.397 | 12.18 | |
| W | UM13763 | Aug 30 /22 11:03:33 | 3 | Long | 2.207 | 51.20 | 0.128 | 2.711 | 19.69 | 0.086 | 3.184 | 24.38 | 0.205 | 4.067 | |
| W | UM13763 | Aug 30 /22 12:13:25 | 3 | Long | 0.749 | 56.89 | 0.058 | 1.119 | 64.00 | 0.054 | 0.694 | >100 | 0.080 | 1.334 | |
| W | UM13763 | Aug 30 /22 13:49:17 | 3 | Vert | 0.276 | 85.33 | 0.021 | 0.418 | >100 | 0.034 | 0.528 | >100 | 0.046 | 0.645 | |
| W | UM13763 | Aug 30 /22 13:50:40 | 3 | Long | 0.244 | >100 | 0.017 | 0.497 | >100 | 0.039 | 0.426 | >100 | 0.033 | 0.647 | |
| W | UM13763 | Aug 30 /22 13:51:02 | 3 | Long | 0.276 | 85.33 | 0.020 | 0.512 | >100 | 0.039 | 0.441 | >100 | 0.056 | 0.646 | |
| W | UM13763 | Aug 30 /22 13:51:27 | 3 | Vert | 0.292 | >100 | 0.021 | 0.489 | >100 | 0.040 | 0.607 | >100 | 0.057 | 0.747 | |
| W | UM13763 | Aug 31 /22 10:01:22 | 3 | Tran | 0.497 | 73.14 | 0.037 | 0.363 | >100 | 0.026 | 0.434 | >100 | 0.037 | 0.624 | |
| W | UM13763 | Aug 31 /22 14:51:45 | 3 | Long | 0.355 | >100 | 0.021 | 0.631 | >100 | 0.049 | 0.567 | >100 | 0.052 | 0.796 | |
| W | UM13763 | Aug 31 /22 14:51:56 | 3 | Vert | 0.284 | >100 | 0.024 | 0.536 | >100 | 0.051 | 0.591 | >100 | 0.077 | 0.695 | |
| W | UM13763 | Aug 31 /22 14:54:19 | 3 | Vert | 0.355 | 85.33 | 0.030 | 0.465 | >100 | 0.044 | 0.528 | >100 | 0.053 | 0.574 | |
| W | UM13763 | Aug 31 /22 14:54:34 | 3 | Vert | 0.339 | >100 | 0.026 | 0.441 | >100 | 0.033 | 0.504 | >100 | 0.039 | 0.617 | |
| W | UM13763 | Aug 31 /22 15:00:43 | 3 | Vert | 0.410 | >100 | 0.026 | 0.504 | >100 | 0.045 | 0.528 | >100 | 0.039 | 0.655 | |
| W | UM13763 | Sep 1 /22 14:51:07 | 3 | Vert | 0.465 | >100 | 0.044 | 1.182 | >100 | 0.109 | 2.207 | >100 | 0.255 | 2.373 | |
| W | UM13763 | Sep 1 /22 14:52:33 | 3 | Vert | 0.504 | >100 | 0.044 | 0.796 | 85.33 | 0.058 | 1.852 | >100 | 0.170 | 1.925 | |
| W | UM13763 | Sep 1 /22 14:53:22 | 3 | Vert | 1.135 | 73.14 | 0.128 | 1.458 | >100 | 0.131 | 3.941 | >100 | 0.528 | 4.200 | |
| W | UM13763 | Sep 1 /22 14:54:08 | 3 | Vert | 0.181 | 85.33 | 0.018 | 0.260 | >100 | 0.022 | 0.575 | >100 | 0.052 | 0.591 | |
| W | UM13763 | Sep 1 /22 14:55:17 | 3 | Vert | 0.189 | 85.33 | 0.026 | 0.292 | 85.33 | 0.021 | 0.599 | >100 | 0.070 | 0.625 | |
| W | UM13763 | Sep 5 /22 11:40:40 | 3 | Vert | 0.520 | >100 | 0.039 | 0.449 | >100 | 0.037 | 0.796 | >100 | 0.067 | 0.816 | |
| W | UM13763 | Sep 5 /22 11:43:28 | 3 | Vert | 0.654 | 64.00 | 0.030 | 0.252 | 85.33 | 0.017 | 0.528 | 85.33 | 0.034 | 0.702 | |
| W | UM13763 | Sep 5 /22 11:45:08 | 3 | Vert | 0.229 | 64.00 | 0.024 | 0.229 | 73.14 | 0.017 | 0.528 | 46.55 | 0.041 | 0.529 | |
| W | UM13763 | Sep 5 /22 11:53:39 | 3 | Vert | 0.292 | 46.55 | 0.015 | 0.244 | 73.14 | 0.016 | 0.504 | 64.00 | 0.035 | 0.526 | |
| W | UM13763 | Sep 5 /22 11:54:09 | 3 | Vert | 1.135 | 85.33 | 0.119 | 0.717 | >100 | 0.077 | 1.411 | >100 | 0.164 | 1.681 | |
| W | UM13763 | Sep 5 /22 11:54:53 | 3 | Long | 0.276 | 64.00 | 0.021 | 0.575 | >100 | 0.044 | 0.599 | 42.67 | 0.036 | 0.840 | |
| W | UM13763 | Sep 5 /22 11:55:10 | 3 | Long | 0.315 | 56.89 | 0.026 | 0.520 | >100 | 0.045 | 0.560 | 30.12 | 0.033 | 0.761 | |
| W | UM13763 | Sep 5 /22 11:56:49 | 3 | Vert | 0.197 | 56.89 | 0.023 | 0.244 | >100 | 0.020 | 0.646 | 56.89 | 0.047 | 0.667 | |
| W | UM13763 | Sep 5 /22 12:02:48 | 3 | Vert | 0.197 | 36.57 | 0.015 | 0.402 | 73.14 | 0.032 | 0.670 | 85.33 | 0.040 | 0.747 | |
| W | UM13763 | Sep 5 /22 12:03:43 | 3 | Vert | 0.323 | 56.89 | 0.030 | 0.583 | 64.00 | 0.047 | 1.080 | 85.33 | 0.065 | 1.213 | |
| W | UM13763 | Sep 5 /22 12:05:12 | 3 | Vert | 0.197 | 42.67 | 0.013 | 0.268 | 25.60 | 0.018 | 0.497 | 30.12 | 0.026 | 0.565 | |
| W | UM13763 | Sep 5 /22 12:05:56 | 3 | Vert | 0.292 | 39.38 | 0.021 | 0.347 | 46.55 | 0.026 | 0.583 | 56.89 | 0.039 | 0.687 | |
| W | UM13763 | Sep 5 /22 12:15:45 | 3 | Tran | 0.497 | >100 | 0.036 | 0.197 | 85.33 | 0.014 | 0.142 | >100 | 0.016 | 0.502 | |
| W | UM13763 | Sep 5 /22 12:15:56 | 3 | Tran | 0.512 | >100 | 0.038 | 0.252 | 85.33 | 0.018 | 0.142 | >100 | 0.020 | 0.517 | |
| W | UM13763 | Sep 5 /22 13:07:17 | 3 | Tran | 0.875 | 85.33 | 0.054 | 0.370 | >100 | 0.028 | 0.213 | >100 | 0.016 | 0.950 | |
| W | UM13763 | Sep 5 /22 19:21:43 | 3 | Tran | 0.497 | >100 | 0.034 | 0.331 | >100 | 0.024 | 0.142 | >100 | 0.013 | 0.593 | |
| W | UM13763 | Sep 5 /22 19:24:57 | 3 | Tran | 0.544 | 85.33 | 0.033 | 0.252 | 85.33 | 0.020 | 0.158 | >100 | 0.012 | 0.585 | |
| W | UM13763 | Sep 7 /22 12:49:18 | 3 | Tran | 0.701 | >100 | 0.056 | 0.504 | >100 | 0.039 | 0.481 | >100 | 0.044 | 0.881 | |
| W | UM13763 | Sep 7 /22 14:14:35 | 3 | Tran | 0.701 | 73.14 | 0.058 | 0.441 | >100 | 0.042 | 0.828 | >100 | 0.089 | 1.046 | |
| W | UM13763 | Sep 7 /22 14:14:49 | 3 | Tran | 0.638 | 51.20 | 0.029 | 0.418 | 51.20 | 0.025 | 0.315 | 73.14 | 0.030 | 0.655 | |
| W | UM13763 | Sep 7 /22 14:14:58 | 3 | Tran | 52.89 | 2.813 | 0.355 | 59.35 | 2.844 | 0.263 | 20.19 | 6.649 | 0.724 | 75.95 | |
| W | UM13763 | Sep 7 /22 14:15:11 | 3 | Tran | 2.711 | 2.681 | 0.059 | 1.868 | 11.38 | 0.032 | 0.575 | 85.33 | 0.042 | 3.283 | |
| W | UM13763 | Sep 7 /22 14:15:24 | 3 | Vert | 1.505 | 13.84 | 0.033 | 1.088 | 39.38 | 0.031 | 1.655 | 42.67 | 0.045 | 2.007 | |
| LOG | UM13763 | Sep 7 /22 14:15:33 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Stop Monitoring |

# VIBRATION MONITORING
# V3

VM3 fr 070922

Printed: September 12, 2022 (V 10.72 - 10.72)  Event Report: Event List - f:\blastware 10\event\kranji rd vm3\2022-09-07.14

| Type | Serial No. | Date/Time | No. Chan | Trigger | Tran Peak (mm/s) | Tran Freq. Hz. | Tran Accel (g) | Long Peak (mm/s) | Long Freq. Hz. | Long Accel (g) | Vert Peak (mm/s) | Vert Freq. Hz. | Vert Accel (g) | PVS1 (mm/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOG | UM15195 | Aug 30 /22 11:50:57 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Start Monitoring |
| W | UM15195 | Aug 30 /22 11:51:45 | 4 | Long | 16.41 | 32.00 | 0.355 | 12.64 | 8.982 | 0.265 | 16.89 | 46.55 | 0.452 | 20.52 | |
| W | UM15195 | Aug 30 /22 11:52:02 | 4 | Vert | 0.276 | 64.00 | 0.019 | 0.465 | 64.00 | 0.022 | 1.143 | 56.89 | 0.046 | 1.146 | |
| W | UM15195 | Aug 30 /22 11:52:16 | 4 | Vert | 8.575 | 18.96 | 0.219 | 4.201 | 17.07 | 0.149 | 5.557 | 26.95 | 0.226 | 9.599 | |
| W | UM15195 | Aug 30 /22 11:52:31 | 4 | Tran | 0.962 | 20.48 | 0.034 | 0.883 | 19.69 | 0.039 | 0.867 | 42.67 | 0.033 | 1.264 | |
| W | UM15195 | Aug 30 /22 11:52:47 | 4 | Tran | 1.907 | 26.95 | 0.090 | 1.364 | >100 | 0.098 | 4.824 | 12.49 | 0.091 | 5.168 | |
| W | UM15195 | Aug 30 /22 11:53:15 | 4 | Vert | 0.891 | 28.44 | 0.057 | 0.457 | >100 | 0.049 | 1.174 | 42.67 | 0.047 | 1.195 | |
| W | UM15195 | Aug 30 /22 11:53:42 | 4 | Long | 2.806 | 32.00 | 0.123 | 3.389 | 11.38 | 0.067 | 4.296 | 34.13 | 0.087 | 4.744 | |
| W | UM15195 | Aug 30 /22 11:54:04 | 4 | Tran | 0.678 | 36.57 | 0.029 | 0.434 | 24.38 | 0.015 | 0.457 | 42.67 | 0.030 | 0.741 | |
| W | UM15195 | Aug 30 /22 11:57:37 | 4 | Tran | 2.278 | 16.52 | 0.032 | 1.442 | 18.96 | 0.021 | 1.080 | 36.57 | 0.026 | 2.601 | |
| W | UM15195 | Sep 1 /22 14:46:34 | 4 | Vert | 0.410 | >100 | 0.049 | 0.631 | >100 | 0.072 | 0.969 | 64.00 | 0.067 | 1.006 | |
| W | UM15195 | Sep 5 /22 11:32:44 | 4 | Vert | 0.173 | 85.33 | 0.010 | 0.173 | 64.00 | 0.012 | 0.662 | 64.00 | 0.025 | 0.672 | |
| W | UM15195 | Sep 5 /22 11:47:21 | 4 | Vert | 0.449 | 85.33 | 0.031 | 0.520 | >100 | 0.038 | 1.174 | 85.33 | 0.094 | 1.228 | |
| W | UM15195 | Sep 5 /22 12:09:07 | 4 | Vert | 0.166 | 85.33 | 0.012 | 0.221 | 85.33 | 0.012 | 0.504 | 73.14 | 0.027 | 0.559 | |
| W | UM15195 | Sep 6 /22 16:42:59 | 4 | Tran | 0.938 | 51.20 | 0.034 | 0.426 | 46.55 | 0.016 | 0.843 | 56.89 | 0.039 | 1.129 | |
| W | UM15195 | Sep 6 /22 16:43:30 | 4 | Vert | 0.875 | 42.67 | 0.029 | 0.701 | 46.55 | 0.037 | 0.851 | 46.55 | 0.032 | 0.990 | |
| W | UM15195 | Sep 6 /22 16:43:51 | 4 | Long | 0.623 | 46.55 | 0.020 | 0.670 | 17.66 | 0.026 | 0.922 | 64.00 | 0.035 | 0.943 | |
| W | UM15195 | Sep 7 /22 14:19:41 | 4 | Vert | 0.788 | 28.44 | 0.045 | 0.788 | 34.13 | 0.071 | 1.726 | 36.57 | 0.106 | 1.743 | |
| W | UM15195 | Sep 7 /22 14:19:56 | 4 | Vert | 0.292 | 85.33 | 0.018 | 0.323 | 39.38 | 0.023 | 0.552 | 46.55 | 0.024 | 0.609 | |
| W | UM15195 | Sep 7 /22 14:20:09 | 4 | Tran | 0.607 | 32.00 | 0.025 | 0.654 | 8.127 | 0.038 | 0.843 | 19.69 | 0.032 | 1.058 | |
| W | UM15195 | Sep 7 /22 14:20:23 | 4 | Tran | 4.469 | 42.67 | 0.308 | 4.934 | 73.14 | 0.351 | 10.60 | 56.89 | 0.531 | 10.74 | |
| LOG | UM15195 | Sep 7 /22 14:20:36 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | Stop Monitoring |

# APPENDIX K

## Wildlife Incident Report Form

# WILDLIFE INCIDENT FORM

## Part A – Wildlife Incident Details

*The CEMMP In-charge is to complete the Form and submit to PM* ***within 24 hours*** *of reporting incident.*

| | | | |
|---|---|---|---|
| **Reference No.**<br>(by CEMMP In-charge) | | | |
| **Personnel** | **Reporting Person** | **Witness** | |
| **Name:** | | | |
| **Contact Number:** | | | |
| **Title / Company:** | | | |
| **Time / Date of Wildlife Encounter** | **Date** | **Time** | |
| | | | |
| **Affected Area** | | | |
| **Weather:** | ☐ Clear | ☐ Overcast | ☐ Thunderstorm |
| | ☐ Sunny | ☐ Others (To Describe): | |
| **Actual Location:** | | | |
| **Description of Area:** | ☐ Vegetated area | ☐ Non-vegetated area | |
| | ☐ Excavated area | ☐ Others (to describe): | |
| **Activities Carried Out Nearby at Time of Incident:** | If there are no active works near wildlife encountered, please state so. | | |

| | | | |
|---|---|---|---|
| **Details of Animal** | | | |
| **Animal:** | Where identifiable, please provide [Common Name (Scientific Name)]<br><br>If animal cannot be identified, carcass to be described to the best of ability. | | |
| **Animal Condition:** | ☐ Active | ☐ Outwardly injured (e.g. bleeding, limping) | ☐ Flattened |
| | ☐ Stationary | ☐ Decomposed | ☐ Trapped |
| | ☐ Others (to describe): | | |
| **Photographs**: | 1) Close-up of Animal<br>☐ No Close-up available<br>Please provide reason here if close-up photographs could not be obtained, e.g. unsafe to approach | | |
| | 2) Animal with surroundings or showing full width of road (if roadkill), indicating where the animal is. | | |
| | ☐ No photographs available. Reason: e.g. animal moved away too quickly | | |

TEMBUSU Asia

| Incident Details | |
|---|---|
| **Incident Summary:** To be filled by reporting party | Briefly describe when, what, who, where and how the incident happened.<br><br>*Sample incident summary:*<br>*[Personnel] was conducting [activity] on [date/time] when he observed an [animal] at [location]. The animal was observed to be [condition]. [Personnel] reported the incident to [contractor representative] who contacted the WMO. While awaiting wildlife response, [contractor] barricaded the area and continued monitoring for movement of animal.*<br><br>If EMMP Specialist (Fauna) visited site: Recommended actions |
| **Follow-up Actions:** To be filled by CEMMP In-charge | ☐ Animal rescued to NParks Shelter<br>☐ Immediate relocation<br>☐ Carcass transported to disposal location<br>☐ Others:________________________________________ |
| | ☐ No Action Taken by CEMMP In-charge |

## Part B – Closure of Incident

| **Possible Causes** What is/are the possible cause/s of the incident? (Man / Machine / Management / Medium / Mission) | | |
|---|---|---|
| | | |
| **Preventive/Corrective Actions** To be filled by CEMMP In-charge | **Close-up** To be filled by reporting party | |
| 1) | Close-up Action. | Close-up Date |
| 2) | | Close-up Date |
| **Closure of Incident Report** | | |
| **Date of Closure of Incident Report:** | | |
| **Acknowledged by PM (Name/Title):** | | |