



TRANSNET NATIONAL PORTS AUTHORITY

SCOPING AND ENVIRONMENTAL IMPACT REPORTING PROCESS FOR THE DEVELOPMENT OF NEW BERTH 605 AND ASSOCIATED INFRASTRUCTURE TO SUPPORT THE CONTAINER HANDLING FACILITY, PORT OF RICHARDS BAY, KWAZULU-NATAL

**DREDGING AND DREDGE MATERIAL DISPOSAL MODELLING
STUDY**

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EXECUTIVE SUMMARY

This report comprises the Dredging and Dredge Material Disposal modelling study that is one of a suite of specialist studies informing the Environmental Impact Assessment being undertaken for the Berth 605 development project being undertaken by Transnet.

The primary goal of this report is to inform the Estuarine and Marine Ecology Impact specialist study for the Environmental Impact Assessment (EIA).



INTRODUCTION

Transnet National Ports Authority (TNPA) has identified the need to develop a new berth (Berth 605) in the Port of Richards Bay by extending the 600 series Berth Basin. The intention of the proposed new Berth 605 is to serve a proposed new container handling facility (CHF) that is ultimately intended to increase container volumes handled at the port to stimulate economic development in the region.



Port of Richards Bay and the location of the proposed New Berth 605 and Container Handling Facility

The project requires dredging of the 600 series basin and berth areas to ensure a proclaimed depth of -14.5m Port Chart Datum (PCD). Initial estimates indicated that the dredging and dredge material disposal activities would require the dredging of approximately 2.8 million m³ of *in-situ* dredge material to be disposed of at the existing disposal site presently authorised for maintenance dredging soil disposal. However, based on updated geotechnical survey data and progressed engineering designs, this has been reduced to just less than 2.6 million m³ of *in-situ* dredge material to be disposed of at the existing disposal site.

The excavation of road material and a quay wall excavation will occur in the dry prior to the commencement of the main basin dredging activities. The material from these excavations will be placed in and/or over the existing pond where caissons were cast for the Port of Richards Bay Berth 306 development undertaken in the mid-2000's. This material will then be dredged from the caisson pond area at the time that the dredging for the extension of the existing 600 series basin occurs.



Basin area to be excavated plus outline of the existing pond where caissons were formerly cast

SCOPE OF WORK

This study is intended to inform the impacts of Dredging and Dredge Spoil Disposal activities, particularly potential impacts of elevations in water column turbidity / total suspended solids concentrations in the water column and changes in benthic habitats, specifically potential smothering effects. The purpose of this study is to inform the *Estuarine and Marine Ecology Impact* specialist study to be undertaken for the Environmental Impact Assessment studies. It also is intended to inform the Dumping at Sea application. This study does not address the changes in wave climate and potential shoreline changes associated with the disposal of dredge material on the existing offshore disposal site as this is addressed in a companion *Wave Climate and Shoreline Change* specialist study

APPROACH AND METHOD

This study includes the synthesis of an environmental baseline based on existing data and reports, with a focus on Total Suspended Solid (TSS) concentrations in the water column. A coupled wave and hydrodynamic model has been set-up and calibrated using existing data.

Based on a sufficiently encompassing dredge description (detailing dredge quantities and quality, dredging technology to be used, dredging durations, etc.), model scenarios have been developed for assessment in the calibrated hydrodynamic-sediment transport model set-up for the study.

The results of the model have been assessed in terms of exceedances of elevations in TSS concentrations against agreed upon thresholds of concern / guidelines. Also reported are the days of exceedance per season of these thresholds of concern / guidelines. The smothering impacts are presented as the maximum sediment thickness deposition over the duration of the model simulations. These are the metrics made available to the specialist undertaking the Estuarine and Marine Impacts Assessment study.

Included in the reporting are potential mitigation measures where needed and proposed monitoring activities to manage the dredging activities.

SUMMARY OF RESULTS AND CONCLUSIONS OF THE STUDY

The results and conclusions of the study are summarised below. Conclusions around the assessment of estuarine and marine impacts are provided in the specialist study undertaken by others, based on the results of this study.

VISUAL IMPACTS

The visual impacts of dredging plumes in the surface waters within the port are predicted to be negligible, with visual plumes only very rarely observable beyond the 600 series basin. However, the increased turbidity at depth is likely to increase the surface plumes from shipping and berthing activities within the 600 series basin and its immediate surrounds.

Elevations in turbidity exceed the threshold assumed for aesthetic (visual) impacts for large distances southwest (SW) and more so northeast (NE) of the disposal site resulting from the re-suspension of sediments and from the disposal site and the mixing of such sediment throughout the water column. These elevations in turbidity and TSS concentrations in the surface layers are associated with storm conditions when there is a general elevation of turbidity and TSS

concentrations in the water column that are likely largely to mask the presence of such dredging-related plumes.

ECOLOGICAL IMPACTS ASSOCIATED WITH ELEVATED TURBIDITY & TSS CONCENTRATIONS

From the modelling results for TSS concentrations in the water column we can conclude that:

- The exceedance of the relevant guidelines for elevation in TSS concentrations in the water column within the port remain relatively constrained to the 600 series berth area and its immediate surroundings, no matter which threshold for elevations in TSS concentration is used as a guideline to assess marine ecological impacts. No sensitive sites on the tidal flats are indicated to be impacted upon.
- In the offshore region the predicted maximum elevations in TSS exceed a lower precautionary 20 mg/l threshold over fairly extensive distances from the disposal site in both the surface (~ 8km) and bottom waters (8 to 10 km). However, more persistent elevations in TSS concentrations only occur in the bottom waters for more limited distances from the disposal site (4 km to the NE and 1.5 km to the SW).
- In the offshore region the predicted maximum elevations in TSS exceed an upper high risk 80 mg/l threshold only in the bottom waters and then only for a more modest 1 to 2 km from the disposal site while persistent exceedances of this threshold typically remain within 1 km of the disposal site. Elevations in TSS concentrations are not predicted to be of concern in the inshore area, particularly at the mouth of the Mhlathuze Estuary. Time series plots for locations within approximately a kilometre of the disposal site show that the persistence of such exceedances comprise many occasions of short duration exceedances of the thresholds during weather events.

Note that, based on the updated geotechnical surveys and progressed engineering design, the presently estimated fines loading associated with dredging activities within the port remain the same however the fines loading at the dredge spoil disposal site is approximately only 60% of that assumed in the modelling study. Thus, the presently modelled turbidity impacts are deemed to be representative within the port but moderately to possibly highly conservative at the offshore disposal site, *i.e.*, the turbidity impacts indicated by the modelling study are greater than will occur in reality.

IMPACTS ASSOCIATED WITH ACCUMULATION OF SEDIMENTS ON THE SEABED

From the modelling results for sediment accumulation on the seabed, we can conclude that:

- Within the port, major sediment accumulation largely comprises relatively unconsolidated fines and is restricted largely to the 600 series basin. Their presence is expected to lead to chronic and relatively high elevations in TSS concentrations in the water column until such time as this material is removed to the offshore disposal site.
- The maximum sediment thickness of accumulated sediments predicted is approximately 3 to 4 m over the southeastern half of the dredge spoil disposal site where most of the dredged material is intended to be placed. The typical sediment thickness within 500m to 1 km of the site is predicted in the model to be between 10 and 20 cm. In the short-term, however historical records indicate a more extensive distribution of sediment from the disposal site, albeit on time scales that would mitigate some of the likely impacts of smothering and changes in benthic habitats.

Note that, based on the updated geotechnical surveys and progressed engineering design, the presently estimated loading (mass) of non-cohesive material (sand and generated gravels from the dredging of siltstone by the CSD) associated with dredging and dredge spoil disposal is approximately 10% to 15% greater of that assumed in the modelling study. However, the overall percentage of fines in the content of the material (that add disproportionately to the effective bulking of the material on the disposal site), is substantially reduced (-40%). This, together with the general reduction in dry mass of material disposed of on the disposal site (approximately -7.4%) suggest that the modelled maximum sediment thicknesses remain representative of those that would be predicted for these changed sediment loadings associated with the interpretation of the updated geotechnical survey data and progressed engineering designs.

There is a slight increase in the bulking factor from the 1.55 assumed in the modelling study to a maximum of 1.64 due to the changes in the material types. However, this is not a substantive change as the combination of a reduced mass (-7.4%) of material discharged onto the disposal site and the slightly increased bulking factor results in a negligible net change in the volume of material released onto the disposal site. In reality, the (bulked) volume of material released onto the disposal site decreases slightly (-1.9%) from the approximately 4.3 million m³ used in the modelling studies for this report and the Change in Wave Climate and Shoreline Report (WSP, 2025).

The above estimated 15% increase in the dry mass of less mobile non-cohesive sediments compared to a 40% decrease in more mobile fine sediments being released onto the disposal site, suggest a slower dispersion of dredge material off the existing dredge spoil disposal site than that modelled. This greater longevity of dredge material on the disposal site (constituting a longer duration of effective reduction in the capacity of the dredge spoil disposal site), increases the risk of there being limitations on the rate of maintenance dredge spoil disposal onto the disposal site in the short- to medium-term.

POTENTIAL TOXICITY EFFECTS OF CONTAMINANTS RELEASED FROM THE SEDIMENTS

The simulation and assessment of toxicity effects from potential contaminants released into the water column was not assessed in the modelling study as this was deemed superfluous based on analyses undertaken in CSIR (2024) that state that such impacts are of limited concern as the required dilution of contaminants released into the water column will be achieved within the port and more so in the offshore region.

LONG-TERM CHANGES IN HYDRODYNAMIC FLOWS

The long-term changes in flow and reduced flushing within the Port of Richards Bay will be modest and any such impacts will be confined to the 600 series basin and immediate surrounds. The changing depth at the disposal site will result in local modifications of flows and possible wave conditions. However, of potentially greater concern are change in wave climate over a wider area and potential shoreline change. These are addressed in a companion *Wave Climate and Shoreline Change Specialist Study* (WSP, 2025). The impacts in the offshore region will reduce as dredged material is dispersed from the disposal site over time.

CLIMATE CHANGE EFFECTS

Climate change may affect some of the environmental baseline conditions and also the coastal processes of relevance to this study. However, the anticipated changes in key processes such as sea level and storminess will be extremely limited and not easily discernible from natural variability over the short to medium term when potential dredging impacts associated with the Berth 605 dredging activities are likely to be observed. The issues around long-term climate change effects on wave climate and possible shoreline change are addressed in a companion *Wave Climate and Shoreline Change Specialist Study* (WSP, 2025).

RECOMMENDATIONS AND MITIGATION MEASURES

The Port of Richards Bay is a working port. Therefore, any mitigation measures proposed require careful consideration and should be practically achievable within this context.

Within the port the only mitigations that could be considered are to limit hopper overflows or that silt curtains or a similar measure be deployed (if necessary) to limit the spread of fine sediments through the port. The requirement for such measures, their practicality and efficacy need to be carefully assessed before committing to such measures.

There are no obvious mitigation measures for the offshore dredge spoil disposal site, since elevated turbidity and the redistribution of sediments beyond the confines of the dredge spoil disposal site are largely determined by previous disposal of dredge material and prevailing environmental conditions, neither of which can be managed/controlled. It is unlikely that any specific mitigation measures are warranted.

The material being deposited on the disposal site will include coarse material with a $d_{50} = 6$ mm from the dredging of rock by the Cutter Suction Dredger (CSD). This coarser material will not easily be dispersed from the disposal site, if at all. Given the nature of the siltstone being dredged, it is likely that the material will degrade over time when exposed to wave and currents at the offshore disposal site. It is recommended that the implication of this for the long-term capacity of the disposal site to accommodate dredge material disposal from maintenance dredging needs to be carefully assessed. This issue was also raised in the studies for the 2015 Richards Bay Port Expansion Project.

The only other substantive requirement/recommendation is that the compliance monitoring procedures and management options (see Section 7) be followed diligently and to adhere to the normal due diligence measures associated with dredging. These are expected to include standard ballast water management practices, supplemented by dredger-specific operational procedures (e.g., procedures at the port of origin such as the washing of the hoppers, flushing the discharge pipes, and inspection of the hopper, pipes and dredge head to ensure no material is retained that may transport organisms to location of the proposed dredging dredge spoil disposal activities), particularly should local dredging vessels not be utilised for the proposed dredging. Where compliance monitoring and management procedures are suggested to be options (e.g., in the Dumping at Sea permit application and/or any relevant tender documentation), the requirement for such measures, their practicality and efficacy need to be carefully assessed before committing to such measures.

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APPENDICES

APPENDIX A

HISTORICAL MAINTENANCE DREDGING VOLUMES

GLOSSARY

The glossary presented in the table below offers a reference for defines terms used throughout this document.

Abbreviation	Description
ADCP	Acoustic Doppler Current Profiler
BF	Bulking Factor
CD	Chart Datum
CSD	Cutter Suction Dredger
CHF	Container Handling Facility
CSD	Cutter Suction Dredger
CSIR	Council for Scientific and Industrial Research
Cu	Copper (chemical element)
Cr	Chromium (chemical element)
DFFE	Department of Forestry, Fisheries and the Environment
D50	Median Grain Size
DS	Disposal Site (e.g., DS05, DS09)
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
H_{m0}	Significant Wave Height
IPOSS	Integrated Port Operations Safety System
LNG	Liquefied Natural Gas
LMOB	Lean Mixture Overboard
ME	Erosion Parameter (kg/m ² /s)
NCEP	National Center for Environmental Prediction

NE	North-East
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
Pa	Pascal (unit of pressure)
PoRB	Port of Richards Bay
PCD	Port Chart Datum
PRDW	Prestedge Retief Dresner Wijnberg (Engineering Consultants)
SW	South-West
SWAN	Simulating WAVes Nearshore (wave model)
TNPA	Transnet National Ports Authority
TSS	Total Suspended Solids
WSP	WSP Group (Engineering and Environmental Consultants)
Z_{eu}	Euphotic Depth (depth of light penetration)
Zn	Zinc (chemical element)

1 INTRODUCTION

1.1 BACKGROUND

Transnet National Ports Authority (TNPA) has identified the need to develop a new berth (Berth 605) in the Port of Richards Bay by extending the 600 Berth Basin. The new Berth 605 is intended to be developed adjacent the existing Berth 600 series, located in the Bayvue Precinct in the western region of the Port of Richards Bay (Figure 1-1). The intention of the proposed new Berth 605 is to serve a proposed new container handling facility (CHF) that is ultimately intended to increase container volumes handled at the port to stimulate economic development in the region (TNPA, 2022). TNPA identified an area 270 m x 250 m in which the terminal operator is envisaged to operate. This area is located behind the new proposed Berth 605. The container handling facility will be built and operated by the container handling facility operator Grindrod. The key aspects of the Berth 065 developments are presented in the *Engineering Basis of Design and Draft Terminal Operating Philosophy Report* (WSP, 2024a).



Figure 1-1 - Port of Richards Bay and the location of the proposed New Berth 605 and Container Handling Facility (CHF).

1.2 CONTEXT OF THIS STUDY

The assessment of the potential environmental impacts associated with the proposed capital dredging for the Berth 605 development requires:

- The assessment of the quality of the material to be dredged against accepted sediment quality guidelines to determine their suitability for possible beneficial use and/or (offshore) disposal.
- The prediction and assessment of potential impacts of dredging and dredge spoil disposal activities, the primary concerns being:
 - the potential impacts associated with elevations in total suspended solids (TSS) concentration / turbidity in the water column
 - possible releases of contaminants from the dredged sediments into the water column
 - potential smothering effects on benthic biota.
- The prediction and assessment of potential impacts of accumulation of dredged material on the on the offshore disposal site (i.e., changes in water depth) on waves and possible associated changes in adjacent shorelines.
- Other potential effects such as aesthetic and noise impacts also will be assessed.

The present study is of one of several studies that inform the impact assessment of the proposed capital dredging activities for the Berth 605 development. These include:

- An analysis of the sediment and soil quality (and contamination status) of the material to be dredged within the proposed development area, is provided in CSIR (2024). These data are used to inform the potential contaminant releases from the sediments being dredged, i.e., to estimate the contaminant loadings in the dredging and dredge material disposal model simulations should such detailed modelling be required.
- The development of a biophysical environmental baseline description (CSIR, 2025) that includes the sediment and water quality (specifically the water column turbidity) information required to inform the assessment of impacts associated with the capital dredging activities for the Berth 605 Project. This baseline biophysical environmental description is a synthesis of ongoing monitoring of sediment and water quality undertaken by the CSIR in Richards Bay, available literature (e.g., Mehlhorn, 2021) and previous dredging baseline reports undertaken for the Port of Richards Bay Capacity Expansion studies (CSIR, 2009, 2013a,b,c) and a prior assessment of a potential floating power plant development in the Port of Richards Bay (van Ballegooyen and Jacobs, 2020, Cyrus and Vivier, 2021a,b).
- An assessment of changes in wave climate inshore of the dredge spoil disposal site and possible associated changes in adjacent shorelines due to accumulation of dredge material on the offshore disposal site and resultant changes in water depths (WSP, 2025).
- A specialist marine ecology impact assessment for the Berth 605 Development EIA, that is focussed primarily on the impacts of capital dredging activities for the Berth 605 Project (CSIR, 2025).

1.3 SCOPE OF WORK

The Scope of Work for this *Dredging and Dredge Material Disposal Modelling Study*, together with that of the *Wave Climate and Shoreline Change Study* (WSP, 2025), needs to ensure that these studies adequately inform the specialist marine ecology impact assessment undertaken for the Berth 605 Development EIA (CSIR, 2025).

The focus of this study is to undertake a detailed assessment of potential physico-chemical impacts of dredging and dredge material disposal activities associated with the proposed Berth 605 development within Richards Bay, namely elevations in TSS concentration / turbidity in the water column, possible releases of contaminants from the dredged sediments into the water column and potential smothering effects on benthic biota. Accordingly, the Scope of Work for the present study is to:

- Develop a sufficiently detailed Dredge Description to inform the model scenarios
- Set-up and adequately calibrate a coupled wave and hydrodynamic-sediment transport model to undertake the dredging and dredge spoil disposal scenario simulations
- In consultation with the marine ecology specialists, select appropriate thresholds of concern/impacts for the analysis presentation of the model results that need to include the quantification of
 - elevations in TSS concentration / turbidity in the water column,
 - potential smothering effects on benthic biota, and
 - possible releases of contaminants from the dredged sediments into the water column should these be deemed to be potential concern.
- Suggest potential mitigation measures where required / possible.
- Provide recommendations on the monitoring required to manage dredging activities.

1.4 METHOD AND APPROACH

Key to the success of this assessment is the development of a sufficiently detailed Dredge Description to be used in the modelling study. Of relevance in this regard are all excavations for construction activities requiring dredging and the disposal of the resultant dredge material. This includes excess material from road and rail construction and the construction of the quay wall, as well as the dredging of the adjacent berth pocket and the larger basin area required to accommodate the planned vessel operations for Berth 605. Presently it is proposed that all such material except for a layer of topsoil, ultimately, will be disposed of at an offshore dredge material disposal site (see Section 2.4.4). The key elements of the proposed capital dredging and dredge spoil disposal are provided in the *Sediment and Dredging Concept Report* (WSP, 2024b) undertaken to inform the *Concept Design Report* (WSP, 2024c) for the proposed project.

The prediction of potential water quality and smothering impacts is achieved by the set-up and calibration of a three-dimensional model that is then used to predict the extent, severity and duration of changes in turbidity, water quality and smothering associated with dredging and dredge spoil disposal activities. Specifically, this requires the prediction of the short to medium-term dispersal of dredge spoil from the proposed offshore dredge spoil disposal site. The model results are

summarised in terms of exceedances of dredging (water quality) guidelines as well as other relevant guidelines determined in consultation with the marine and estuarine ecology specialists for the EIA.

Where relevant, mitigation measures are proposed and inputs are made to the Environmental Management Programme (EMPr) for the proposed dredging activities, specifically inputs into the sampling design of compliance monitoring and other relevant monitoring activities associated with the proposed dredging activities.

1.5 ASSUMPTIONS AND LIMITATIONS OF THE STUDY

The following assumptions and limitations apply to this specialist study:

- The modelling assessment of the dredging and dredge spoil disposal is based on the project description as it existed at the commencement of this study at the end of March 2025. Where sufficiently detailed information was lacking at the commencement of this study, particularly in terms of the specifics of the dredging description, the specialists compiling this study have provided the necessary specifications based on the available information and experience of similar dredging projects. This has been done under the assumption that this will be acceptable to all relevant parties having an interest in the Berth 605 project. Specifically:
 - the characteristics of the sediments to be dredged (grain size) used in the modelling have been based on available geotechnical and sediment quality (CSIR, 2024) information as existed at the end of March 2025 as the project-specific geotechnical field survey data were not yet available at the time of the commencement of the study. However, subsequent to the completion of the modelling undertaken to inform this study, an updated dredge description has been developed based on the receipt of additional project-specific geotechnical survey information and progressed engineering designs. A re-assessment of the resultant changes in sediment loadings used in the modelling suggest that the model-based predictions of dredging impacts based on the initial dredge description remains representative of those likely to occur for this updated and presently valid description of dredging activities. It should, however, be noted that the model predicted elevations in TSS concentrations in the water column reported in Sections 6.2 and 6.3 are likely to be overly conservative compared to those expected for the updated and presently valid dredge description.
 - It is assumed that the disposal of dredge material will occur at the existing offshore disposal site presently permitted for the disposal of dredged material arising from maintenance dredging activities as no other viable offshore disposal sites were identified at the time of the commencement of the study.
- It is conservatively assumed that material from the capital dredging activities associated with the Berth 605 capital dredging will not be used to nourish the beaches and shoreline to the north of the Port of Richards Bay entrance, *i.e.*, that all material from the capital dredging undertaken will be disposed of the existing offshore dredge spoil disposal. This approach is supported by a preliminary assessment of potential beneficial uses in WSP (2024b, 2025).
- The cumulative impacts of other major capital dredging within the Port of Richards Bay have not been quantitatively assessed in this study. Initially it was assumed that the time elapsed between major capital dredging activities (~18 month to 2 years) will be sufficient to avoid significant cumulative impacts due to elevations in water column turbidity. This also was assumed to be true for cumulative impacts associated with the accumulation of material and smothering of benthos

on the dredge spoil disposal site and its immediate surrounds, albeit an inherently less robust assumption due to the increased longevity of these smothering impacts compared to associated with elevations in turbidity of the water column.

- The updated dredge description based on additional geotechnical information and progressed engineering designs received after the completion of the modelling undertaken to inform this study and the Wave Climate and Shoreline Change study (WSP, 2025), indicate an approximate 15% increase in the volume of non-cohesive (gravels and sand) material and an approximate 40% decrease in cohesive (fines) material placed on the dredge spoil disposal site. This suggests an increased longevity of the dredge spoil on the disposal site and that the initially assumed time elapsed between major capital dredging activities (of approximately 6 to 18 months of one another) possibly will need similarly to be increased (18 months to 2 years) to ensure that there will be no significant cumulative impacts due to persistent changes in wave climate and possible associated change in adjacent shoreline (WSP, 2025).
- The modelling study is intended to inform the marine and estuarine ecological specialist study (and other EIA specialist studies) that have the role of providing a detailed assessment of the potential impacts of the proposed dredging activities.
- Specifically excluded from this study is the detailed assessment of potential dredge spoil disposal impacts on the adjacent shoreline in terms of the influence that the dredge spoil disposal mound may have on the wave climate and consequently on possible shoreline erosion and/or accretion. These potential impacts are addressed in a companion study *Wave Climate and Shoreline Change Study* (WSP, 2025).

1.6 REPORT STRUCTURE

The structure of the report is as follows. Section 1 introduces the project together with the scope of work proposed for the assessment of the potential environmental impacts associated with the capital dredging required for the Berth 605 project. Section 2 contains a more comprehensive project description and associated dredging activities, including a detailed dredging description for use in the modelling studies. The key issues of concern and environmental quality objective of relevance to this study are summarised in Section 3. Included in Section 3 is a brief review of previous capital dredging and ongoing maintenance activities for the Port of Richards Bay.

Section 4 provides a summary of the environmental conditions of relevance to this study. The set-up and calibration of the wave, three-dimensional hydrodynamic and sediment transport models and model simulations of changes in water column turbidity and sediment deposition and re-distribution, are reported in Section 5. The results of the modelling study are summarised in Section 6, while the recommendation on the required monitoring of the dredging activities is provided in Section 7. The conclusions and recommendations of the study are summarised in Section 8.

2 PROJECT DESCRIPTION

In this section a brief description is given of the aspects of the project relevant to the assessments of dredging impacts.

2.1 EXSITING AND PROPOSED NEW INFRASTRUCTURE

The existing infrastructure in the region of interest is outlined in Figure 1-1. The Berth 605 development project is intended to support a container handling facility to be built and operated by the container handling facility operator. The full scope of works for the proposed Berth 605 development is provided in the overall concept design report (WSP, 2024c).

Of relevance to this study is the basin design and associated capital dredging activities (Figure 2-1) as outlined in the initial Sedimentation and Dredging Concept report (WSP, 2024a), the overall concept design report (WSP 2024c), the updated Wave Climate and Shoreline Change study as well as the overall concept design report (WSP 2025).



Figure 2-1 - Basin area to be excavated plus outline of the existing pond where caissons were formerly cast (Source WSP, 2024b).

2.2 DREDGING AND DREDGE MATERIAL DISPOSAL DESCRIPTION

The dredging description below outlines the dredging methodology, the quantity and quality of material to be dredged, the dredging technology to be used and an outline of the planned dredging activities including beneficial use options and dredge spoil disposal activities.

2.2.1 DREDGING METHOD

A proclaimed depth of -14.5m PCD needs to be maintained to accommodate the design vessel (WSP, 2024a). Added to this depth is an allowance for sedimentation (between maintenance dredging campaigns) and for bathymetry sounding accuracy, resulting in a required depth of -15.1 m PCD (WSP, 2024b). To achieve this depth, the basin area will be excavated by means of dredging, except for the topsoil (an assumed 300 mm of surface material and associated vegetation) that is to be removed and carted away separately (WSP, 2024c).

In addition to the basin dredging material, material will be excavated for road (and rail) construction, and for the quay wall construction (WSP, 2024a, 2025). The excavation of road material and a quay wall excavation will occur “in-the-dry” prior to the commencement of the main basin dredging activities. The material from these excavations will be placed in and/or over the existing pond where caissons were cast for a prior Berth 306 development project for the Port of Richards Bay (Goussard, 2009), henceforth referred to as the “former construction caisson pond”. Ultimately, this “former construction caisson pond” area will become part of the future basin opposite Berth 605 (Figure 2-1).

The dredging activity for the project thus will comprise the excavation of the basin as well as this additional material from the road (and rail) construction and quay wall excavation that has been placed in and/or over the former construction caisson pond. The dredging will take place primarily using a Cutter Suction Dredger (CSD) with material loaded into barges and transported to an offshore disposal site, here assumed to be the existing dredge spoil disposal that is presently is used for the disposal of spoil from ongoing maintenance dredging activities (WSP, 2024b). While a backhoe dredger or long-reach excavator may be used to dredge the upper slopes where necessary, for the purposes of this modelling study all material is assumed to be dredged by a CSD.

2.2.2 QUANTITY OF MATERIAL TO BE DREDGED

An initial assessment of the dredge material volumes and types was made to inform the modelling study reported here, as the project-specific detailed geotechnical surveys had not yet been completed at the time of the commencement of this study. Similarly, these quantities also were based on the engineering design detail contained in the initial concept design report (WSP, 2024c). Subsequent to the completion of the modelling undertaken to inform this study, the project-specific geotechnical surveys and associated analyses progressed substantively, as has the engineering design for the project (specifically aspects of the construction activities and associated dredging design).

The estimated dredge volumes from the initial assessment used to inform the modelling undertaken for this study, are reported in Section 2.2.2.1. An updated assessment based on the newly available geotechnical survey data and associated analyses, as well as the progressed engineering design, is reported in Section 2.2.2.2. These data indicate that the modelling undertaken for this study remains conservative in terms of volumes to be dredged as the newly estimated dredge volumes in Section 2.2.2.2 are less than those used in the modelling undertaken to inform this study.

2.2.2.1 Initial Assessment of dredge volumes

The dredge material quantities from the initial assessment used to inform the modelling for this study are provided in Table 2-1. The quantity of material excavated “in-the-dry” will comprise approximately 386 540 m³ of *in-situ* excavation material (comprising 350 000 m³ of *in-situ* material excavated for the quay wall construction and 36 500 m³ of *in situ* material from road excavations). Assuming a bulking factor of 1.3, once excavated and placed in and/or over the former caisson construction pond, these volumes will increase to approximately 502 500 m³.

The material to be dredged from Berth 605 berths and basin only, will comprise approximately 2 295 000 m³ of *in-situ* material (comprising sediments and rock). If an allowance is made for a potential dredging accuracy of 0.4 m for a CSD, the volumes of material to be dredged from the Berth 605 berth and basin area only, increases to 2 393 000 m³ of *in-situ* material. For the purposes of this study, we have conservatively assumed the larger dredge volume (2 393 000 m³ of *in-situ* material) that includes an allowance for potential over-dredging associated with a vertical dredging accuracy of 0.4 m (WSP, 2024b, c).

Table 2-1 – Initial assessment of Dredging Volumes

<u>Source of Material</u>	<u><i>In-situ</i> volumes (m³)</u>	<u>Volumes to be dredged by the CSD (m³)</u>	<u>Volume of material placed on the offshore site*⁴ (m³)</u>
<u>Road Excavation</u>	36 540	47 500* ¹	56 640
Quay wall excavations	350 000	455 000* ¹	542 500
Total volume of material excavated “in-the dry”	386 540	502 500* ¹	599 140
Berth and Basin Only	2 295 000	2 295 000* ²	3 557 250
Berth and Basin Only (including over-dredging)	2 393 000	2 393 000* ²	3 709 150
Total volumes being dredged by the CSD	2 779 540	2 895 500* ³	4 308 290

*¹ These are the bulked volumes (assumed initial bulking factor of 1.3) to be re-dredged from the former caisson construction pond area after having been placed there from excavations undertaken “in-the-dry”.

*² These are the *in-situ* volumes to be dredged from berths and adjacent basin.

*³ This is the volume of material that will be dredged both from the caisson pond area (material from the “in-the-dry” excavations) and directly from the 600 basin and berths.

*⁴ These are the (bulk) material volumes upon placement on the dredge spoil disposal site. A bulking factor of 1.55 has been assumed for the material placed on the dredge spoil disposal site based on the expected transformation of the rock material by the CSD and an assumed approximate one-month period of consolidation. Note that in the Concept Design Report (WSP, 2024c) a bulking factor of 1.3 was assumed, subject to confirmation by the project-specific geotechnical studies. The estimated bulking factor of 1.55 used here could have an upper limit of 1.75 depending on assumptions made and changes in material type and therefore remained to be verified. See Section 2.2.2.2 for further comment on applicable bulking factors, based on updated geotechnical survey information and the progressed engineering designs.

The CSD dredging operations thus will need to dredge 2 393 000 m³ of *in-situ* material from the proposed new basin area and a further 502 500 m³ of bulked material from the former caisson construction pond area. The total volume to be dredge by the CSD thus will be 2 895 000 m³, comprising 2 295 000 m³ of *in-situ* material to be dredged from the berth area and basin (~83% of the material to be dredged) and the remaining 502 000 m³ of material comprising the bulked material that has been placed in and/or over the former caisson construction pond (~17% of the material to be dredged).

Given that the sediment loading rates in the dredge and dredge spoil disposal modelling study are based on the dry density of:

- the *in-situ* sediments being dredged by the CSD (lower for the sediments in the former caisson construction pond area).
- the sediments in the hopper.
- the sediments once placed on the offshore dredge spoil disposal site (after a period of consolidation).

the volume of material placed on the dredge spoil disposal site has been calculated used a bulking factor of 1.55 on the total *in-situ* volume of material to be dredged (WSP, 2025). Given the nature of the material being dredged, a bulking factor of 1.55 is deemed representative of material placed and retained on the dredge spoil disposal site in the short to medium term (see Section 2.4.2). Using a bulking factor of 1.55, the bulked volume needing to be accommodated on the disposal site is just over 4.3 million m³.

2.2.2.2 Updated estimates of dredge volumes

The updated dredge material quantities, as presently understood after reviewing the more detailed geotechnical survey data and the progressed engineering design information presently available, are as detailed in Table 2-2. The quantity of material excavated "in-the-dry" will comprise approximately 1 102 060 m³ of *in-situ* excavation material (comprising 1 037 160 m³ of *in-situ* material excavated for the quay wall construction/temporary access road excavations and 64 900 m³ of *in situ* material from road and rail excavations that excludes 17 500 m³ of topsoil that will not be placed in the caisson pond to be subsequently dredged by the CSD). The 1 037 160 m³ of *in-situ* material excavated for the quay wall construction comprises a net volume of 522 815 m³ of *in-situ* material excavated on the seaward side of the proposed quay wall face and a volume of 514 340 m³ of *in-situ* material excavated on the landward side of the proposed quay wall face.

The material to be dredged from Berth 605 berths and basin only, will total approximately 1 413 240 m³ of *in-situ* material (comprising sediments and rock). If an allowance is made for a potential dredging accuracy of 0.4 m for a CSD, the volumes of material to be dredged from the Berth 605 berth and basin area then increases to 1 475 130 m³ of *in-situ* material. For the purposes of this study, we have conservatively assumed the larger of these two dredge volumes (1 475 130 m³ of *in-situ* material) that includes an allowance for potential over-dredging associated with a vertical dredging accuracy of 0.4 m (WSP, 2024b, c).

In summary, based on the above updated excavation and dredge material volumes, the CSD dredging operations thus will need to dredge 1 475 130 m³ of *in-situ* material from the proposed new basin area and a further 1 432 680 m³ of bulked material from the former caisson construction pond area. The total volume to be dredged by the CSD thus will be 2 907 810 m³.

Table 2-2 – Updated assessment of Dredging Volumes

Source of Material	<i>In-situ</i> volumes (m ³)	Volumes to be dredged by the CSD (m ³)	Volume of placed material on the offshore site for an assumed bulking factors as indicated (m ³)	
			Assumed bulking factor = 1.50 ^{*4}	Assumed bulking factor = 1.64 ^{*5}
Road Excavation	64 900	84 370 ^{*1}	97 350	106 440
Quay wall excavations	1 037 155	1 348 310 ^{*1}	1 555 740	1 700 940
Total volume of material excavated in the dry	1 102 060	1 432 680 ^{*1}	1 653 090	1 807 380
Berth and Basin Only	1 413 240	1 413 240^{*2}	2 119 860	2 317 710
Berth and Basin Only (including over-dredging)	1 475 130	1 475 130 ^{*2}	2 212 700	2 419 210
Total volumes being dredged by the CSD	2 577 190	2 907 810^{*3}	3 865 790	4 226 590

- ^{*1} These are the bulked volumes (assumed initial bulking factor of 1.3) to be re-dredged from the former caisson construction pond area after having been placed there from excavations undertaken in the dry.
- ^{*2} These are the *in-situ* volumes to be dredged from berths and adjacent basin.
- ^{*3} This is the volumes of material that will be dredged both from the caisson pond area (material from the “in-the-dry” excavations) and directly from the 600 basin and berths.
- ^{*4} An estimated bulking factor of 1.51 to 1.64 is indicated based on the updated material types and dry density of siltstone that was overestimated in the modelling study. These are the (bulked) material volumes assuming a representative least conservative bulking factor of 1.50 for the material placed on the dredge spoil disposal site based on the expected transformation of the rock material by the CSD and an assumed approximate one-month period of consolidation.
- ^{*5} Based on the updated material types and a (reduced estimate of) dry density for the siltstone (that was overestimated in the modelling study), the presently estimated bulking factor ranges between 1.51 to 1.64. The volume reported is based on a bulking factor of 1.64 that leads to the most conservative modelling outcomes in terms of potential impacts. This change means that the bulking factor (of 1.55) used in the initial modelling study was slightly underestimated. When considering the volumes of (bulked) material being deposited onto the disposal site and the associated consequences for volume of material accumulation on the disposal site, this minor underestimation of bulking factor is largely offset by the predicted reduction in *in-situ* dredge volumes compared to those used in the modelling study. The net result is that the modelled sediment thicknesses on the disposal site remain largely representative of those that will occur based on the updated geotechnical survey information and progressed engineering design, *i.e.*, the presently estimated (bulked) dredge volumes of 4.23 million m³ to be disposed of onto the disposal site are marginally less (-1.9%) than the ~4.3 million m³ (bulked) dredge spoil disposal volumes assumed in the modelling study

Given that the sediment loading rates in the dredge and dredge spoil disposal modelling study are based on the dry density of:

- the *in-situ* sediments being dredged by the CSD (lower for the sediments in the former caisson construction pond area);
- the sediments in the hopper;
- the sediments once placed on the offshore dredge spoil disposal site (after a period of consolidation);

the volume of material placed on the dredge spoil disposal site initially was calculated using a bulking factor of between 1.40 to 1.50 on the total *in-situ* volume of material to be dredged (WSP, 2025). Applying a conservative bulking factor of 1.50 suggests that the bulked volume needing to be accommodated on the disposal site is approximately 3.87 million m³ that represents a decrease of just over 10% of that modelled both in this study and the companion *Wave Climate and Shoreline Change* modelling study (WSP, 2025). However, the above bulking factor does not consider the lower dry density of the siltstone compared to other typical rock material. Taking the lower dry density of the siltstone into account, the predicted bulking factor increases to between 1.51 to 1.64 compared to the BF of between 1.4 and 1.50 expected for other typical rock material. This suggests that the bulked volume of material needing to be accommodated on the disposal site of approximately 4.23 million m³. This represents an approximate 1.9% decrease in the bulked volume of material needing to be accommodated on the disposal site compared to the volumes used in the modelling undertaken to inform both this study and the *Wave Climate and Shoreline Change* modelling study (WSP, 2025).

2.2.3 COMPOSITION OF MATERIAL TO BE DREDGED

Below we provided both an initial assessment of the composition of material to be dredged as used in the modelling undertaken to inform this study, as well as an updated material description based on updated geotechnical information from the project-specific geotechnical surveys as well as changes in dredging quantities associated with the progressed engineering design (particularly that related to constructability and dredging activities).

2.2.3.1 Initial Assessment of the Composition of Material to be Dredged

Available geotechnical information for the initial assessment comprised boreholes along the quay line and a further three (3) boreholes west and south of the dredging area. Further project-specific geotechnical data were not available at the time that the dredging and dredge spoil disposal modelling informing this study was undertaken. From this limited information and drawing on prior experience of silt stone decomposition upon dredging, the composition of *in-situ* material to be dredged assumed for this study is reported in Table 2-3 below.

Table 2-3 – Initial valuation of the composition of *in-situ* dredge material.

Material type	Basin Excavation (<i>in-situ</i> volume) (m ³)	Quay wall and road excavation (<i>in-situ</i> volume) (m ³)	Grain size (D ₅₀) of main material type	Percentage of fines in the material type	Total volumes (m ³)
Sand	541 982	75450* ¹	350 µm	4%	653 980
Silty Clay	1 024 259	57 800	< 63 µm	100%	1 082 060
Silt ^{ly} /clayey sand	506 759	100 760	280 µm	20%	570 980
Siltstone	320 000	152 520	6 mm* ²	20%* ²	472 520
Total	2 393 000	386 540	-	-	2 779 540

*¹ This includes the road excavation material, that based on limited data, here is assumed to comprise silty/clayey sands.

***2** The siltstone when dredged by the CSD is assumed to be transformed into 80% granular material (6mm) and 20% fines (<63µm) – see WSP (2024b; 2025).

2.2.3.2 Updated Assessment of the Composition of Material to be Dredged

Using the updated project-specific geotechnical survey information and updated volumes from the progressed engineering design, a re-assessment of the composition of the material to be dredged is provided in Table 2-4. The changes are a result of both the changes in overall dredge volumes as well as the proportion of material types in the material to be dredged. These changes in material type are reported Table 2-4 in terms of the mass of the various sediment types (as the sediments loadings used in the model are based on mass of material rather than volume of material).

Table 2-4 – Re-evaluation of the composition of *in-situ* dredge material.

Material type	Basin Excavation (including “in-the-dry” access road and quay wall excavations seawards of the quay wall) (<i>in-situ</i> volume) (m³)	Basin Excavation (excluding “in-the-dry” access road and quay wall excavations seawards of the quay wall) (<i>in-situ</i> volume) (m³)	Quay wall and access Road excavations seawards of the quay wall (<i>in-situ</i> volume) (m³)	Quay wall and access Road excavations landwards of the quay wall (<i>in-situ</i> volume) (m³)	Grain size (D ₅₀) of main material type	% of fines in the material type	Total volumes (m³)
Sand	464 653	304 910	159 740	207 920 ^{*1}	350 µm	4%	672 570
Silty Clay	290 408	190 570	99 840	89 390	< 63 µm	100%	379 800
Silt ^{ly} /clayey sand	587 858	385 760	202 100	180 940	280 µm	25% ^{*2}	768 7800
Siltstone	655 023	593 890	61 130	101 000	6 mm ^{*3}	20% ^{*3}	756 020
Total	1 997 942	1 475 130	512 810	579 250	-	-	2 577 180

***1** This includes the road excavation material, that based on limited data, here is assumed to comprise sand only and not silty/clayey sands as initially assumed (see Table 2-3) but excludes the topsoil (17 500 m³) that will not be disposed of at the offshore dredge spoil disposal site..

***2** The initial assessment used in the modelling study suggested that only 20% of the silty/clayey sand comprised fines, however the updated geotechnical survey information suggest a higher fines content. Consequently, it has been conservatively assumed a the silty/clayey sands have a 25% fines content.

***3** The siltstone when dredged by the CSD is assumed to be transformed into 80% granular material (6mm) and 20% fines (<63µm) – see WSP (2024b; 2025).

Compared to the initial assessment of material types, the presently estimated mass of *in-situ* material to be excavated and/or dredged indicate a 17.3 % increase in siltstone, a 13.6% increase in non-cohesive sediments and an approximate 47.4 % decrease in fine sediments, but an overall decrease of 7.4% in the mass of sediments dredged. After dredging by the CSD (which transforms the siltstone into 80% gravels and 20% fines), the presently estimated mass of dredged material indicates a 14.9% increase in non-cohesive material (gravels and sands) and an approximate

39.3 % decrease in fine sediments. As noted above, there will be an overall 7.4% decrease in the mass of sediment dredged and disposed of at the offshore disposal site.

2.2.4 QUALITY OF SEDIMENTS TO BE DREDGED

The quality of the sediments to be dredged is based on surficial soil and sediment sampling on the seabed (CSIR, 2024). The location of the soil and sediment sampling reported upon is provided in Figure 2-2.

These samples were analysed for grain size, organic content and metals concentrations in the sediments (iron, arsenic, cadmium, cobalt, chromium, copper, cobalt, manganese, mercury, lead, vanadium and zinc). The metal concentrations in the soil/marine sediment samples were assessed against baseline metal concentration models (developed on historical data metal concentration data for the sediments in Richards Bay), for possible enrichment. Further, these metal concentrations were further assessed against Action List (sediments quality guidelines) that the Department of Forestry, Fisheries and the Environment Action List uses to decide if sediment that is identified for dredging in South African ports, is suitable for open water disposal based on three action levels, namely.

- Warning Level provides a warning of incipient metal contamination of sediment but is not used for decision-making.
- Level I: metal contamination below this warning level is not considered to pose a hazard to biological resources and is suitable for open water disposal. Metal contamination above Warning Level I but not exceeding Warning Level II are cause for potential concern to biological resources, the degree of concern increasing as metal concentrations approach the Level II.
- Level II: metal concentrations exceeding this level are deemed to pose a high hazard to biological resources and are considered unsuitable for open water disposal unless evidence to the contrary is provided.

Given potential concerns around the concentration of metals in the soil and marine sediments samples, additional toxicity testing was undertaken to confirm the possible toxicity of the sediments when dredged, with a focus on the bioavailability of any toxicants present in the sediment samples (e.g. high metals concentrations in the soil and sediment samples). Greater detail of the nature and purpose of such toxicity testing is provided in CSIR (2024). The testing included:

- sediment/soil-water interface toxicity testing to estimate the likelihood that chemicals will be remobilised into the water column from soils and sediments that deposit on the seabed at a concentration that poses a toxic hazard to biological resources.
- elutriate testing to estimate the likelihood of chemicals being remobilised from sediment into the water during:
 - dredging in the 600 Berth Basin (at dredge head, in the hopper overflows) and
 - the descent of sediment and soil at the open water dredged spoil disposal site;
 to a degree that the chemicals exert a toxic effect on sea urchin embryo-larvae.



Figure 2-2 - Aerial views of the Port of Richards Bay, showing the positions where sediment and soil was sampled in and near the 600 Berth Basin in November 2024 and where soil was sampled in 2009 (CSIR, unpublished data). The red shaded area denotes the proposed Berth 605 dredging and excavation footprint (Source: CSIR, 2024)

The key findings of the CSIR (2024) study are:

- The sediment sampled at all but one station in the 600 Berth Basin and soil at all but one station near the basin was dominated by mud sized material.
- The total organic content in soil at two stations was slightly above the baseline.
- The Chromium concentrations in the sediments was found to be above Level II of the Action List (that the Department of Forestry, Fisheries and the Environment use to decide if sediment identified for dredging in South African ports is suitable for open water disposal) at several sample locations and copper concentration at one station.
- The finding of the toxicity testing was that metals and other possibly noxious chemicals in the sediment and soil, despite some being above the Action Level II, are thus unlikely to be remobilised into the water column to a degree this will pose a toxic hazard to biological resources:
 - when sediment is dredged in the 600 Berth Basin and
 - when dredged sediment and soil that is excavated across most of the Berth 605 development footprint deposits on the seabed at the dredged spoil disposal site off Richards Bay.

The one sample location of concern (site 15) where toxicity was indicated to be of concern will require only minimal dilution (~ 2 dilutions) to prevent the toxicity of metals released into the

water column. Such a dilution will be achieved at the dredging location and easily achieved at the offshore disposal site.

Based on the above evidence, the simulation and assessment of the release of metals into the water column and potential toxicity effects were considered superfluous in the modelling undertaken for this study.

Geotechnical core samples were not available at the time that the soil/surficial; marine sediments sampling and analyses were undertaken so the information above refers only to surficial soil/marine sediments. Typically, there is no reason to believe that any sediments other than the surficial sediments could be significantly contaminated by metals or other contaminants of potential concern. Consequently, no further sediment quality analyses of core samples (or toxicity testing of the associated elutriates) from the project-specific geotechnical surveys is planned.

2.3 BENEFICIAL USE OF DREDGED MATERIAL

The possibilities for the disposal and/or beneficial use of the dredged material for a previous assessment for dredging at the 600 series berths and basin (Port of Richards Bay Expansion project) has been discussed in some detail in BKS (2013), based largely on a number of previous feasibility studies by the CSIR (e.g. CSIR, 1994a, 2000a,b, 2002, 2004a,b,c,d. 2005a.b). Given that the material to be dredged for Berth 605 is largely similar to the capital dredging under consideration at that time (van Ballegooyen *et al.*, 2015), the findings remain largely unchanged despite a re-assessment of beneficial uses for material to be dredged for the capital dredging of Berth 605.

The dredge spoil disposal and or beneficial use options considered by van Ballegooyen *et al.* (2015) for the Port of Richards Bay Expansion project undertaken for the capital dredging at the 600 series berths and basin in 2015 are summarised below.

Beneficial Uses considered as non-viable were:

- **Land creation (sand, silt):** No need was identified for land creation in Richards Bay (for plans up until the year 2060).
- **Land improvement (sand, silt):** This includes the improvement of the quality of soil and/or making the land functional by elevating it above flood levels. At that stage (2015) no need for land improvement was identified within this study in Richards Bay.
- **Capping of waste sites (sand, clay):** Sand material can be used for capping of contaminated material disposal sites on the seabed for which sand, clay or mixed materials can be used. However, there is at present no requirement for this in Richards Bay.
- **Capping at landfill sites:** This requires clay, and while a viable usage from the dredge material, it may require separation of clays from other size fractions. Furthermore, depending on the origin of the material and how it was excavated or dredged, the available material may not be suitable for this purpose.
- **Other on-land uses:** Other on-land uses such as construction material (present dredged material mostly not suitable) and habitat generation (for which fines are quite suitable). No viable options were identified at that time (2015).

Beneficial uses considered as potentially viable at that time but ultimately screened out as options were.

- **Offshore berms (sand):** This involves the construction of offshore sand berms for the protection/nourishment of adjacent beaches. These have been previously evaluated (e.g. CSIR, 1994a) as a nourishment method (*i.e.*, as feeder berms) for the northern beaches in Richards Bay, however an environmental concern is the suspension of fine material in the water column during the placement of the sediments. It may be necessary to separate sand from clay to make this option viable.
- **Beach nourishment (sand):** There is a clear need for sand for beach nourishment on the northern beaches of Richards Bay, in addition to sand routinely supplied from maintenance dredging operations (e.g., CSIR, 2005a, b). It was stated that the efficacy of this would need to be carefully evaluated, particularly given that the dredge material the Port of Richards Bay Expansion project under assessment constituted mainly clays (48%) and rock (48%). This option was not assessed as a viable option by van Ballegooyen *et al.* (2015) but was subsequently assessed in a modelling study undertaken by van Ballegooyen and Jacobs (2020) as part of the dredging component of a proposed power development project in the Port of Richards Bay where the dredged material comprised 90% sands and 10% muds.
- **Replacement fill (sand):** Fill is a beneficial use that can be considered when dredged material has superior physical qualities compared to soils near the dredging site. The material proposed to be dredged for the Port of Richards Bay Expansion project in 2015 comprised mainly clays (48%) that are unsuitable for this purpose; however there also was a large percentage of rock (48%) that potentially may be useful for this purpose. Replacement fill was not assessed as being a viable option by van Ballegooyen *et al.* (2015) due to the nature of the material being dredged.

A re-assessment of beneficial uses specifically for the Berth 605 project considered the following potentially viable options as an alternative to offshore disposal:

- **Use as infill or construction material:** The use of siltstone rock was considered for beneficial use. However, when dredged using a CSD, the material transforms to a condition which is not useful, *i.e.*, a potentially degradable gravel (~6 mm grain size) with 20% fine material (WSP, 2025). This material is therefore not of use, for example, as for revetment rock in the port. Furthermore, should it be possible to effectively isolate such gravels or other sands from the fines in the material dredged, the opportunity for use as construction fill is modest compared to the volume of material to be dredged for the Berth 605 project. The initial assessment indicated that once dredged by a CSD, the overall material dredged on average would have a fines content of 41%. The re-assessment of material types from the updated geotechnical survey information indicated a reduced average fines content of 29%, but nevertheless a fines content that would prove challenging for use the material being dredged as infill material.
- **Beach nourishment:** The sand component of the material to be dredged can be considered for sediment nourishment discharges onto the beach. As noted for the initial assessment of material types (Table 2-3), about 653 980 m³ of sand (< 23% of the material to be dredged) exists with a low percentage of fines and a grain size that would be suitable for beach nourishment. The re-assessment of material types based on the updated geotechnical survey information (Table 2-4), suggest a similar volume of 672 570 m³ of sand (~ 26.% of the material to be dredged) with a low percentage of fines and a grain size that would be suitable for beach nourishment. The

silty/clayey sand underlying these upper layers has a fines content of between 20% (initial assessment) and 25% (re-assessment) that is unsuitable for beach nourishment. However, most of this potentially suitable sandy material in the upper layers is situated above existing water-level in the port and the proposed method of dredging is such that this suitable sand gets mixed with unsuitable material. Specifically, the cutter suction dredger will be working below water-level (where layers of material largely are not suitable) and will undercut the slope (sometimes with the aid of water jets) causing the suitable sand to collapse/avalanche into the basin where it will mix with the unsuitable material. The resulting material discharged into the hopper barges will then be sub-optimal for beach placement as it will contain a relatively high percentage of fines. This would result in significant plumes of fine sediment at the beach discharge, which is visually and ecologically undesirable. Similarly, coarse material (6 mm) generated from dredging of siltstone by the CSD, if it could be isolated, also is not ideal for placement on the beaches to the north of the port. This material is both coarser than existing beach sands and also potentially degradable (and therefore likely to be an ongoing source of fines once placed on the northern beaches).

A further consideration is the means of transport of material to the beach. The hopper barges discharge material by means of a split hull and are not geared for hooking up to the beach reclamation pipe and pumping material to the northern beaches.

If this sand were to be used for beach nourishment, carting by truck and/or significant adaptations to equipment could be considered. However, noting that the quantity available is close to the annual sand requirement to the northern beach, it would be more economical to source the material from the existing sand trap and / or the nearshore region of the southern beaches.

Although the material to be dredged contains more sands (38% based on the initial assessment or 47% based on the re-assessment of available geotechnical information) than the Port of Richards Bay Expansion project (4%), it also contains a high quantity of fines as well as coarse material both of which are problematic for placement on the northern beaches.

Consequently, offshore disposal of the dredge material from the capital dredging for the Berth 605 project is considered the most viable dredge material disposal option for the capital dredging undertaken for the Berth 605 development project and therefore, the option assessed in this modelling study.

2.4 DETAILED DESCRIPTION OF DREDGING ACTIVITIES

An overview of the proposed dredging activities is contained in an initial *Sedimentation and Dredging Concept* report (WSP, 2024b) and the subsequent overall *Concept Design report* (WSP 2024c). The dredging description used in the modelling studies is based on these two reports. However, subsequently the dredging description has been modified based on updated geotechnical survey information and progressed engineering designs. The changes are related to primarily the updated dredge material volumes and types (see 2.2.2 and 2.2.3 above). These changes have been incorporated and commented upon in the updated dredging description provided below.

2.4.1 DREDGING OF THE BERTHS AND BASIN

As noted in Section 2.2.1, the initial excavation of road (and rail) material and a quay wall excavation will occur in the dry prior to the commencement of the main basin dredging activities. The material from these excavations will be placed in and/or over the existing pond where caissons were cast for

a prior Berth 306 development project for the Port of Richards Bay (Figure 2-1). This material will be re-dredged from this basin at the same time as material is dredged from the berth and basin area. Based on the initial assessment of geotechnical information used in the modelling undertaken to inform this study, the total volume of *in-situ* material to be dredged is 2 779 540 m³, while the total volume material to be dredged by the CSD is slightly larger (2 895 900 m³) due to the bulking of the sediments excavation the dry and placed in and/or over the former construction caisson pond for later dredging by the CSD (Table 2-1). The re-assessment of dredge volumes based on the updated geotechnical survey information and progressed engineering designs indicate the total volume of *in-situ* material to be dredged to be 2 577 190 m³, while the total volume material to be dredged by the CSD again is slightly larger (2 907 810 m³) due to the bulking of the sediments excavated the dry and placed in and/or over the former construction caisson pond for later dredging by the CSD.

2.4.2 SEDIMENT COMPOSITION AFTER BEING DREDGED BY A CSD

Based on the composition of the sediments to be dredged and the effective porosity of sand/mud mixtures reported by Winterwerp (1996), initially a dry density of ~ 1 760 kg/m³ and a wet bulk density of ~2100 kg/m³ was assumed for the *in-situ* material to be dredged. These are relatively high values due to the large quantity of rock in the material to be dredged.

In the process of dredging of the material by CSD, there will be some “transformation” of the material being dredged, specifically the siltstone that will result in 80% comprising coarse material with an approximate D₅₀ of 6 mm and the remaining 20% comprising fine material with a diameter < 63 µm. Thus, the mass fraction of material released onto the offshore disposal site is expected to comprise 20.5% coarse material/gravels (D₅₀ = 6mm), 20.1% coarse sand (D₅₀ = 350 µm), 18.4% medium sand (D₅₀ = 275 µm) and 41% silts and clays (grain size < 63 µm). This comprises a mixture of 59% non-cohesive material and 41% cohesive material. In the initial assessment (used in the modelling study) the overall dry density of the material deposited on the dredge spoil disposal site after a primary consolidation period, was determined to be approximately 1130 kg/m³. It is a relatively high value (*i.e.*, on the upper end of the scale reported by van Rijn and Barth, 2019 for sand mud mixtures but broadly consistent with that reported by van Rijn, 1989), for one month to one year of material consolidation). This is primarily due to the fact that the largest percentage of the fine material is preferentially removed from the material released onto the site, both during the initial deposition process and by re-suspension processes. It is from these values that an estimated bulking factor of 1.55 has been determined for primary consolidated material on the disposal site.

However, the updated geotechnical survey data and progressed engineering designs suggest slightly different values based on the changed dredged volumes and material types, particularly that of the siltstones. While the *in-situ* volume of siltstone is estimated to increase by 60% compared to the initial assessment, the *in-situ* mass of siltstone to be dredged is estimated to increase by only 17.3 % compared to the initial assessment used in the modelling study. This is due to the dry density of the siltstone being over-estimated in the initial assessment (where an *in-situ* dry density of 2 650 kg/m³ was assumed for the siltstone rather than the presently estimated 1 942 kg /m³). Based on the re-assessment of the updated geotechnical survey information and progressed engineering designs, the mass of material to be disposed of at the offshore disposal site decreases by ~ 7.4% and also now contains increased non-cohesive material (73.1%) and a significantly reduced fines

content (26.9%). Considering the updated dredge volumes, changes in material types and the changes in the assumed dry density of the siltstone:

- the estimated dry density of the in-situ material to be dredged ($\sim 1\,758\text{ kg/m}^3$) remains largely similar to the initial assessment used in the modelling study.
- the mass fraction of material released onto the offshore disposal site is expected to comprise 25.9% coarse material/gravels ($D_{50} = 6\text{mm}$), 23.6% coarse sand ($D_{50} = 350\text{ }\mu\text{m}$), 23.6% medium sand ($D_{50} = 275\text{ }\mu\text{m}$) and 26.9% silts and clays (grain size $< 63\text{ }\mu\text{m}$), thus comprising a mixture of 73.1% non-cohesive material and 26.9% cohesive material.
- the overall dry density of the material deposited on the dredge spoil disposal site after a primary consolidation period, is determined to be between approximately $1\,073\text{ kg/m}^3$ to $1\,163\text{ kg/m}^3$ depending on the assumptions around the siltstone once dredged by a CSD. This results in an estimated bulking factor of between 1.51 and 1.64 for the dredge material placed on the offshore disposal site.

2.4.3 ASSUMED SEDIMENT LOADINGS

The loadings in the model are based on the dry mass loading at the dredge head, the lean mixture overboard (LMOB) and actual disposal of material from the hopper barges at the offshore dredge spoil disposal site.

It is assumed that a medium cutter suction hopper dredger will be utilised having an effective dredge rate of $170\,000\text{ m}^3$ of *in-situ* material per week. This implies approximately 139 days of consecutive dredging. A hopper barge volume of $3\,700\text{ m}^3$ is assumed. with the use of lean mixture overboard resulting in the hopper barge volume comprising 30% of sediments by mass prior to discharge onto the dredge spoil disposal site. It is assumed that 12 releases of sediments from hopper barges will occur each day onto the disposal site during active dredging and disposal activities. The releases of material from the hopper barges at the offshore disposal site assumes that between 3 to 5% of the material mass being released will be distributed throughout the full water column and will comprise fines. The remaining 95% of the material is released at the seabed. It is assumed that the duration of each release will be approximately 3 minutes.

Based on data reported in van Ballegooyen *et al.*, (2015) and van Ballegooyen and Jacobs (2020), the sediment releases rates at the CSD dredge head are assumed to be of 6 kg/m^3 of *in-situ* material dredged, with sediment loading rates for lean mixture overboard of an additional 10 kg/m^3 of *in-situ* material dredged. Both releases are assumed to be continuous for periods of active dredging, a conservative assumption as sediment loading from lean mixture overboard only occurs once the initial filling of the hopper barge has occurred. Based on information in Vasblom (2003, 2016), it is estimated that this assumption could lead to a possible 15 to 25% overestimation of the loading at the dredging site, although evidence from the Berth 306 suggests that these losses at the dredging site be larger than generally anticipated leading van Ballegooyen and Jacobs (2020) to caution that there are likely to be potentially significant differences between the percentage fines in the *in-situ* material being dredged and that being disposed of at the dredge spoil disposal sites due to the losses of fines that occur both at the dredging location and from hopper overflows.

Nevertheless, this assumption provides a conservative estimate of potential turbidity impacts within the port. The sediment loading from the dredge head is assumed to occur near the seabed while that from lean mixture overboard is considered to occur at a depth of 3 to 4 m below the sea surface.

2.4.4 DREDGE SPOIL DISPOSAL SITE

The history of the disposal of dredged material from capital dredging and maintenance dredging is summarised in detail in CSIR (2004c, d) and more recently in van Ballegooyen and Jacobs (2020).

2.4.4.1 Disposal of dredge material from capital dredging

Historical dredge spoil disposal from capital dredging that has taken place both during the initial development of the Port of Richards Bay and subsequent port developments, is summarised in Table 2-5 below. Most of the dredge spoil from capital dredging has been discharged onto the surrounding beaches, however material has also been released onto several offshore disposal sites (Connel *et al.*, 1985). It is only the dredge spoil from the most recent capital dredging project (Berth 306) that has been disposed of at the offshore dredge spoil disposal site (Weerts, 2008). The potential environmental impacts of such dredge spoil disposal onto the beaches surrounding Richards Bay has been addressed in numerous reports (e.g. Swart, 1981; Coppoolse *et al.*, 1994; CSIR, 1993, 1994a, 1998a,b,d, 2000a,b; Luger *et al.*, 2002; CSIR, 2004c,d).

Table 2-5 - Volumes of material dredged during harbour construction and subsequent expansion of port facilities (capital dredging) that have been placed on Richards Bay beaches or disposed of at offshore dredge spoil disposal sites (Source: Predominantly from Smith 2004c,d).

Area Dredged	Year	Disposal Location	Volume	% Sand in Spoil	Source / Reference
Harbour construction	1973 - 1976	Central Beach (P8)	75 000 000 m ³	15% ^{*1}	S. Brown
Harbour construction	1977	North Beach (P9)	1 100 000 m ³	100%	Swart (1981)
Berths 303 - 304	1983	North Beach (P9)	9 915 000 m ³	15% ^{*2}	R. Newton
Berths 705 - 708	1985 - 1987	North Beach (P9)	5 500 000 m ³	15% ^{*2}	Calculated
Berth 304	1986	South Beach (P4)	2 017 000 m ³	15% ^{*3}	D. Silk
Berths 606/607	1996 - 1997	Central Beach (P8)	5 345 000 m ³	98% ^{*4}	L. de Waal
Berth 305 (304 Ext.)	1998	Central Beach (P8)	500 000 m ³	15% ^{*3}	J. Hills
Berth 207	1998	Central Beach (P8)	182 874 m ³	15% ^{*3}	J. Hills
Berth 306	2006	Offshore (Site D)	3 840 361 m ³	44% (20%) ^{*5}	Weerts (2008)

^{*1} CSIR (1993) indicates a range of percentage sands in the dredge spoil of between 10% and 20%.

^{*2} the 15% sands assumed, is based on the estimated percentage sand observed for material dredged during harbour construction (*in lieu* of data). This sand estimate agrees with CSIR (1994a).

^{*3} the 15% sands assumed, is based on the estimated percentage sand observed for material dredged during harbour construction (*in lieu* of better data).

^{*4} the 98% sands is based on samples measured at the beach outlet of dredge spoil. It is likely that the percentage of fines in the material dredged would be underestimated in these samples, due to losses of fines at the dredging location and from hopper overflows.

^{*5} Analysis of the sediment cores collected during the feasibility studies suggest a fines (mud) content of 80%, however analysis of 99 random samples taken from the *Lelystad* hopper during the dredging exercise, suggest that the dredge spoil contained a 56% mud (44% sand) content (Weerts, 2008). This discrepancy most probably arises from losses of fines at the dredging location and from hopper overflows.

2.4.4.2 Disposal of material from maintenance dredging

Maintenance dredging for the Port of Richards Bay is conducted by Transnet National Port Authority's Dredging Services. Historically, this has been primarily conducted by the vessel *Ingwenya* (Figure 2-3). Occasionally, when the *Ingwenya* has been deployed elsewhere and, if this resulted in Dredging Services falling behind (in maintaining channels, dredging the sand trap situated south of the south breakwater and supplying sand to the northern beach), then the vessel *Piper* has been deployed. Dredging of the sand trap is generally conducted by means of the suction bow pipe, however the *Ingwenya* also makes use of a side trailing suction technique to dredge the sand-trap. Dredging of the channel is also generally conducted by this latter method.



Figure 2-3 - The *Ingwenya*, the hopper dredger operated at Richards Bay by Transnet NPA Dredging Services.

Maintenance dredging is focussed on the sand trap and the entrance channel to the port with a much lesser quantity of material being dredged from the shipping basins (see Table A-1 in Appendix A). Suitable sandy material dredged from the sand trap and partly from the outer channel, is discharged to the beach at Alkantstrand. This is achieved by means of pumping through a pipeline employing pumps on the dredger. Occasionally, conditions for discharge of material dredged from the sand trap to the beach, are not favourable (*i.e.*, a pump out of operation; tide too low to allow access to dredge berth from which pumping occurs on the north shore). Under these conditions, sand is discharged at the offshore disposal site by opening the bottom doors of the hopper. Residual sand in the hopper after pumping sand to the beach is also dumped offshore. However, the sand quantities sourced from the sand trap and discharged offshore for these reasons amounts to only about 4% of the total sediment disposed of at the offshore dredge spoil disposal site, or about 33 600 m³/year on average (based on reported sand volumes disposed of at the offshore dredge spoil disposal site for the period 1989 to 2003– see Table 2-6). Unlike the material

from the sand trap, only a small percentage of the sediment dredged in the channel is sand (the remainder being silt and clay). This sand component from the material dredged in the channel makes up only about 8% of the material disposed of at the offshore disposal site, or about 65 900 m³/year on average.

Table 2-6 - Volumes of sand only, disposed of at the offshore dredge spoil disposal site (Source: CSIR, 2005a)

YEAR	DREDGE SPOIL DISPOSED OF AT THE OFFSHORE DREDGE SPOIL DISPOSAL SITE	
	From mid-channel (m ³)	From sand trap (m ³)
1989	0	0
1990	0	0
1991	87 402	31 231
1992	183 527	29 224
1993	116 690	85 358
1994	91 505	14 661
1995	31 568	52 193
1996	157 875	72 448
1997	144 774	112 120
1998	46 804	9 500
1999	2005	6 588
2000	310	15 890
2001	54 038	37 785
2002	35 956	25 095
2003	35 945	12 730
Total	988 399	504 823

The median grain size (D_{50}) of the material dredged from the sand trap is approximately 175 μm to 230 μm (CSIR, 2004a, Rautenbach *et al.*, 2015), while that on the Richards Bay beaches is roughly 300 μm (Laubscher *et al.*, 1991) with more recent measurements suggesting typical median grain sizes (D_{50}) of 240 μm to the north and south of the port entrance, increasing to as much as 450 μm at the far Northern beaches (Rautenbach *et al.*, 2015).

2.4.4.3 Historical offshore disposal sites for dredge material

Historically, the shoreline discharge of dredge spoil has occurred at three locations as indicated in (Figure 2-4), namely beaches to the south of the Mhlathuze Estuary mouth (P4), on the Central Beach (P8) between the Mhlathuze Estuary mouth and the entrance to the port of Richards Bay and onto the beaches to the north of the port entrance (P9). The offshore disposal of dredge material from both capital and maintenance dredging, has occurred at several offshore dredge spoil disposal sites.

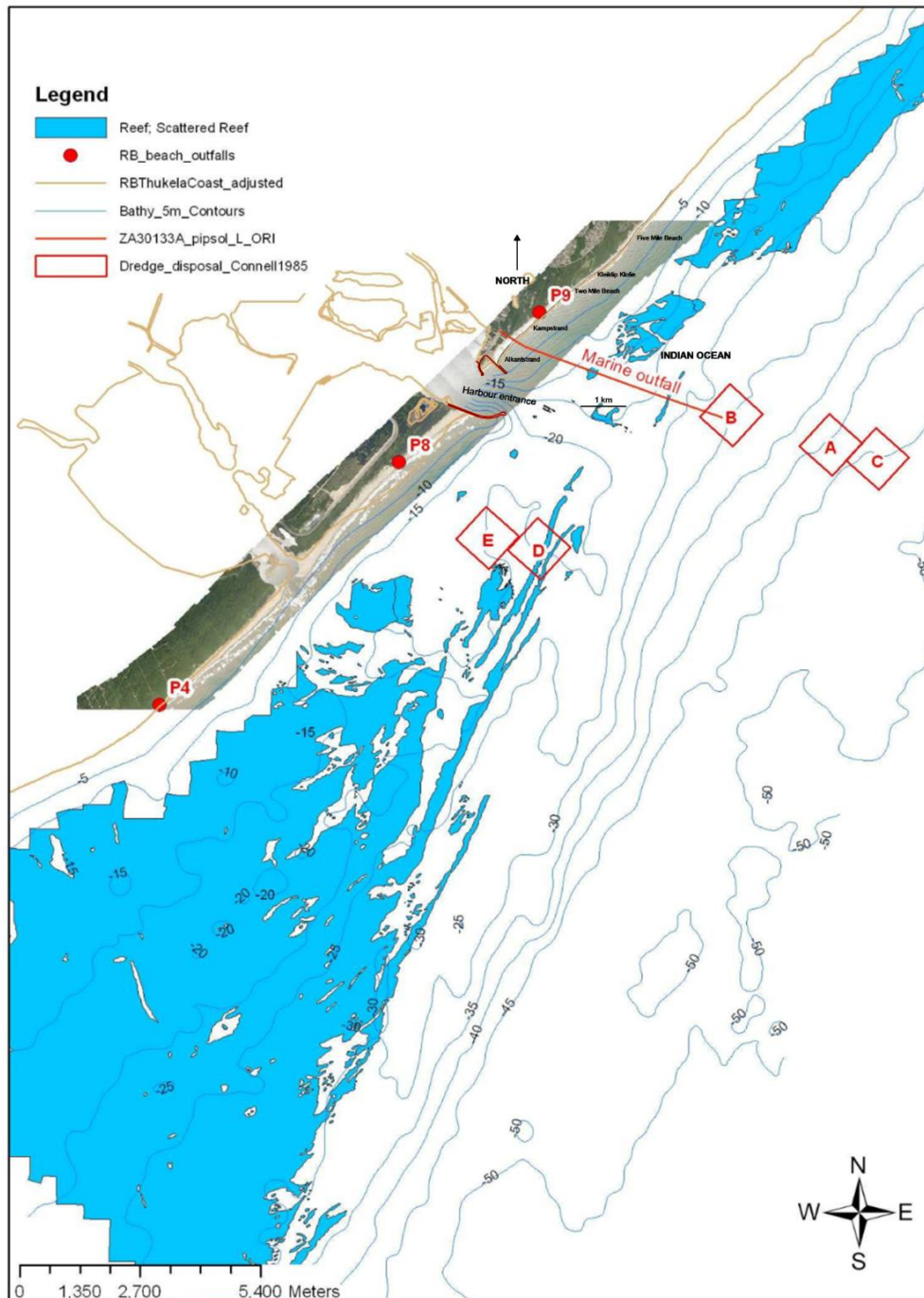


Figure 2-4 - Historical dredge spoil disposal sites/locations (after Celliers, 2008)

During the initial harbour construction between 1972 and 1976, the bulk (more than 50 million m³) of the dredge spoil was dumped on the beaches south of the harbour entrance (Connell *et al.* 1985). A quantity of material was also disposed of at sea in an area at least 6 km offshore Site A, (Figure 2-4) and at a water depth greater than 34 m. From 1978 to 1985, between one and two million cubic metres of sand and some silt, taken mainly from just south of the harbour entrance, has been dumped annually offshore (see Table A-1 in Appendix A). Dumping of this dredge spoil took place at the present marine pipeline outfall site, located approximately 4 km offshore (site B). Early in 1983 (Connell *et al.*, 1985) this dredge spoil disposal site was moved to a position approximately 6.5 km offshore in water deeper than 40 m (site C).

A new disposal area was specifically selected in May 1984 for silt disposal (site D) and reportedly has been used for dredge spoil disposal since 1987 (CSIR, 2005a). An estimated 13.5 million m³ of dredge spoil was disposed of at this site between 1987 and 2003 (CSIR, 2005a). During the coal berth extension that took place between 1981 and 1982, approximately one million cubic metres of dredge spoil was disposed at a site just over 2 km offshore (Site E) (Connell *et al.*, 1985). It is not clear why these latter dredge and dredge spoil disposal volumes were not listed in the literature used to compile Table 2-5.

The official dredge disposal volumes as described above, are summarised in Table 2-5 (capital dredging) and Table A-1 in Appendix A (maintenance dredging). Presently the official dredge spoil disposal site is located at Site D (Figure 2-4) but the presently permitted disposal site is orientated somewhat differently (Figure 2-5). This is the location at which the dredge spoil from the Berth 306 development project were disposed and the location subsequently assessed for capital dredging material disposal for subsequent proposed developments within the Port of Richards Bay (e.g., van Ballegooyen *et al.*, 2015; van Ballegooyen and Jacobs, 2020). Presently this offshore disposal site is only permitted for maintenance dredging, *i.e.*, 2 600 000 m³ over a two-year period April 2025 to March 2027 (DFFE 2025).

2.4.4.4 Offshore Disposal Site for the Capital Dredging of Berth 605

Given no presently identified alternatives to the existing disposal site used for the disposal of material from maintenance dredging activities in the Port of Richards Bay, this study assumed that all material from the capital dredging for Berth 605 will be disposed of at this existing disposal site (Figure 2-5).

The change in bathymetry on the present disposal site has been significant for the period 2007 to 2022 and a distinct mound had developed on the northwestern corner of the site. The 2025 bathymetry data show that this remained at more or less the same dimensions (Figure 2-6), thus limiting further disposal on this area of the existing disposal site as it already poses a potential navigational hazard. For this reason the dredge material disposal onto the site specified in the modelling study is focussed on the southeast corner of the disposal site (Figure 2-7), resulting in a bathymetry (Figure 2-8) used for the wave climate and shoreline change modelling study (WSP, 2025), *i.e.*, a water depth of -13.5 m CD over most of the site decreasing to approximately -13 m CD on the existing mound. This change in water depth in the model is based on an effective bulked dredge material volume of 4 308 290 m³ being deposited on the site (*i.e.*, an *in-situ* dredge material volume of 2 779 540 m³ with a bulking factor of 1.55). The re-assessment of the geotechnical survey data and the progressed engineering design, suggests that a slightly reduced bulked dredge material volume of 4 226 590 m³ will be placed on the dredge spoil disposal site.

As noted in Section 2.5.1 below, the actual depth changes on the disposal site at the cessation of dredging and dredge material disposal activities is expected to be approximately only 40% to 60% of that indicated in Figure 2-8.

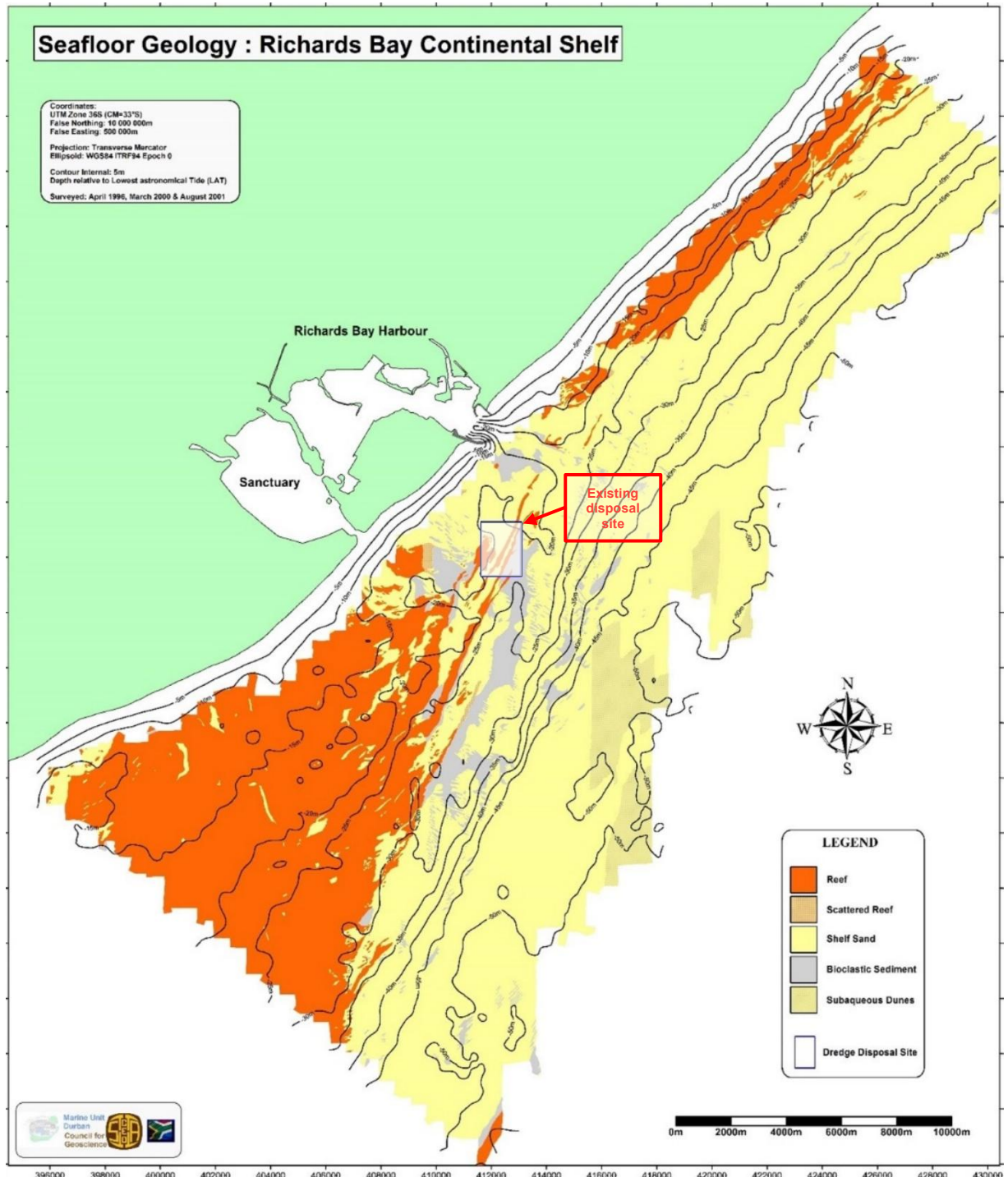


Figure 2-5 - Location of the Disposal Site (Source: Council for Geosciences as reported in CSIR, 2015).

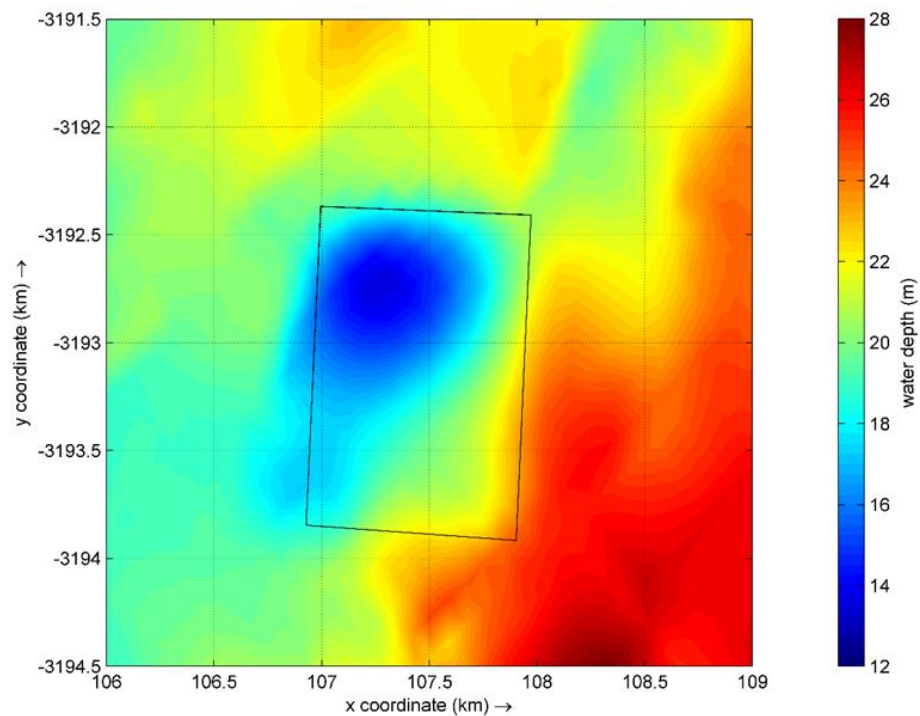


Figure 2-6 - Existing bathymetry (CD) at dumpsite before dredge material disposal activities (2025 Bathymetry survey – TNPA)

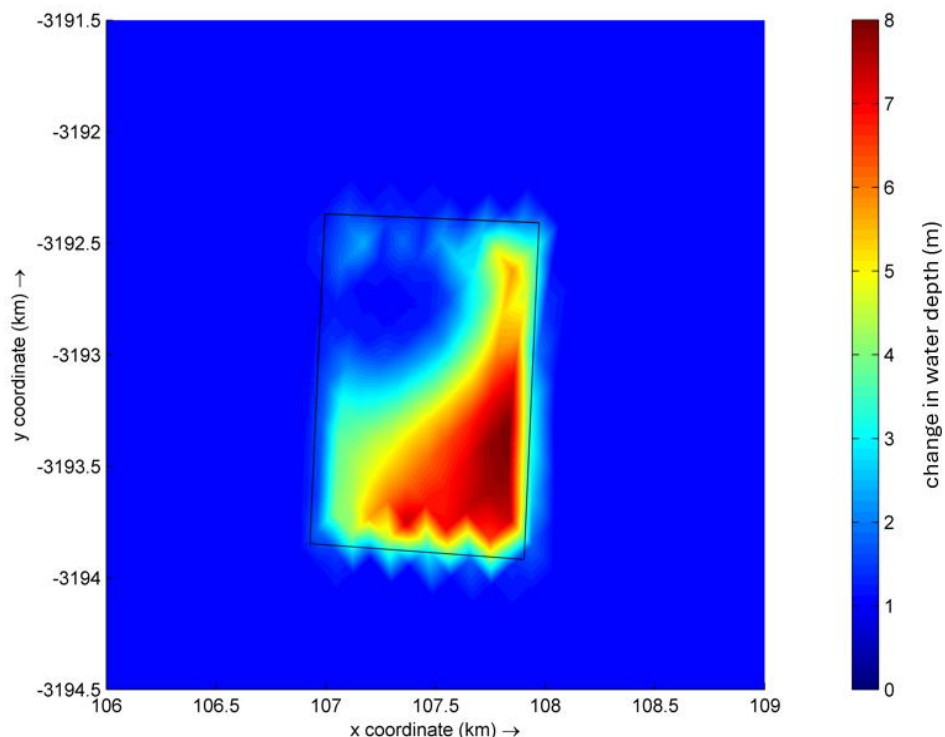


Figure 2-7 – Sediment thickness of material placed on the disposal site in the modelling study

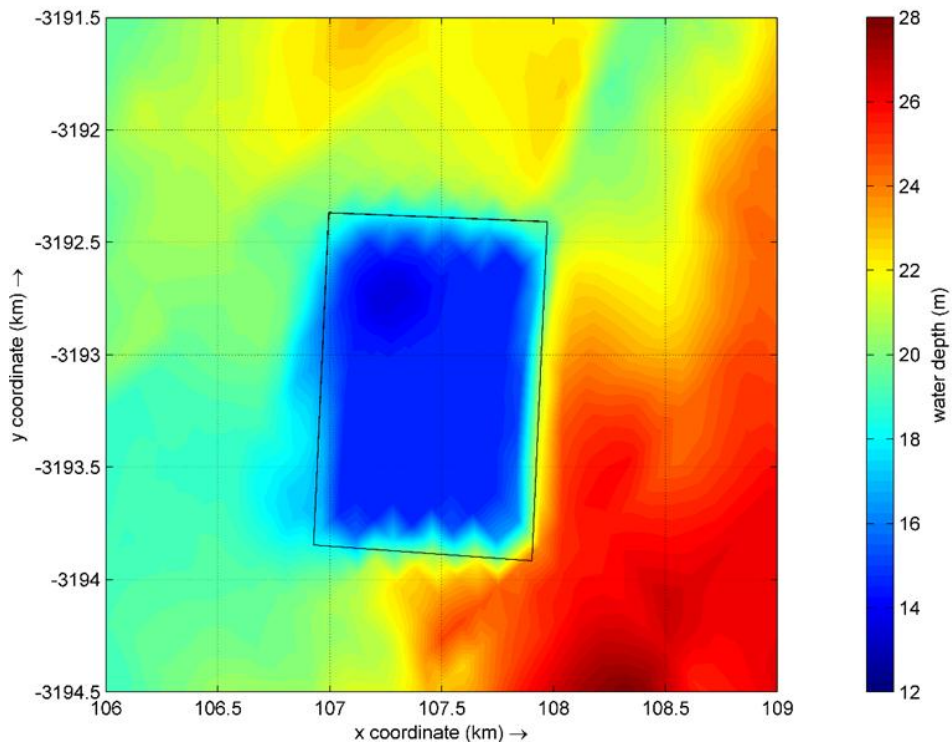


Figure 2-8 - Bathymetry (CD) at dumpsite after dredge material disposal activities

2.5 CUMULATIVE IMPACTS

Of potential concern are the cumulative impacts of dredging impacts from capital dredging activities associated with various planned projects for the Port of Richards Bay. It is difficult to unequivocally identify the sequence and detail dredge descriptions for projects likely to be implemented within a similar time frame to the Berth 605 project and that are likely to lead to cumulative impacts.

The two main considerations in terms of potential cumulative impacts are:

- Obtaining sufficiently accurate estimates of the likely quantity of material and longevity of changes in bathymetry on the disposal site for both the Berth 605 capital dredging and any project occurring within a time frame that will lead to cumulative changes in water depth on and around the dredge spoil disposal site.
- Determining the potential cumulative turbidity loading due to dredging and dredge spoil disposal activities.

An accurate estimate of representative changes in water depth on the disposal site when one or more projects occur within close succession of one another (*i.e.*, within a time frame that could lead to cumulative depth changes on the dredge spoil disposal site and its surrounds), is primarily of importance to the *Wave Climate and Shoreline Changes* specialist assessment (WSP, 2025). The issue is addressed in greater detail in that report.

However, of relevance to this study is the potential cumulative impacts of elevations in TSS concentrations associated with dredge material loadings at the site of active dredging (sediment

releases at the dredgehead and from lean mixture overboard operations) and cumulative impacts of turbidity loadings on and surrounding the offshore disposal site due to the resuspension of material already disposed of onto the dredge spoil disposal site.

2.5.1 ACCUMULATION OF MATERIAL AND DEPTH CHANGES ON THE DISPOSAL SITE

The accumulation and rate of removal and ultimate fate of material disposal from the existing disposal site not only informs the effective changes in bathymetry to include in the *Wave Climate and Shoreline Change* assessments (WSP, 2025), it also helps to validate the sediment behaviours in the hydrodynamic and sediment transport model used in this study. The predicted settling and erosion of sediments in the hydrodynamic-sediment transport model is highly sensitive to model parameterisations. Thus, it is helpful to have measured data in changes occurring on the disposal site over time to help validate these parameters.

A sequence of bathymetric surveys covering the site, together with dredging records, have been used to characterise the mounding of dredge material released onto the existing disposal site and the subsequent rate of erosion of such material from the disposal site. Multibeam bathymetry surveys were conducted at the existing offshore physical monitoring site / dredge disposal site of Richards Bay:

- during July 2005 just prior to the commencement of the Berth 605 dredging activities (Ramsay and MacHutcheon, 2005),
- during January immediately post-dredging activities (Ramsay and MacHutcheon, 2006), and
- in June 2007 some 18-month post-dredging (van den Bossche, 2007).

In June 2022 and January 2025, single beam surveys were conducted by TNPA, however these were confined to only the existing dumpsite area rather than a larger area surrounding disposal site as was undertaken in the 2005, 2006 and 2007 bathymetric surveys. Using the above data, bathymetries were developed for the dredging spoil disposal site and its immediate surrounds for June 2005, January 2006, July 2007, June 2022 and January 2025. These bathymetric survey data were then subtracted from one another to provide estimates of the net accumulation (or loss) of sediments from only the existing dredge spoil disposal site between these surveys. This was achieved using DELFT3D QUICKIN that calculates both the accumulation and loss of sediments from the designated disposal area. The net accumulation and loss of sediments over the full disposal site for the specified periods comprise the sum of these two values (*i.e.*, accumulation and erosion volumes for the disposal site).

A summary of the available dredging disposal volumes, together with the calculated accretion and erosion volumes, is presented in Table 2-7. The positive volumes indicate accretion of material on the site and the negative volumes erosion from the site. The initial assessment of available geotechnical survey information suggested a bulking factor of 1.55, but could have been as large as 1.75 depending on assumptions around the material to be dredged. The re-assessment of the dredge material quantities using the updated Geotech survey information suggest a possibly of bulking factor of between 1.50 and 1.64 for the dredged material from the Berth 605 project to be placed on the dredge disposal site, the upper limit being greater than the 1.55 bulking factor assumed in the modelling undertaken for this study. Where the dredging of substantive quantities of rock by a CSD is not involved, the effective bulking factor could be less, thus the reporting of results

for lower bulking factors of 1.2 and 1.35. This is particularly true for more sandy dredged material being dredged. Historical dredge spoil disposal from capital dredging projects is unlikely to contain as high quantities of siltstone (rock) as the Berth 605 project. Furthermore, the material from maintenance dredging is unlikely to contain any rock at all. Consequently, the historical on-site disposal volumes (m³) reported in Table 2-7 are calculated using the bulking factors (BF) ranging from 1.25 to only 1.55 on the reported *in-situ* dredge volumes, *i.e.*, an upper BF value less than the maximum BF of 1.64 expected for the Berth 605 dredge disposal volumes that include higher volumes of rock (siltstone) dredged by the CSD. See Section 2.2.2.2 for a more detailed description on how the BF were determined. The volume of material being dredged and disposed of for the Berth 605 capital dredging in the modelling study is assumed to have a bulking factor of 1.55.

For the Berth 306 project, only 31 % to 41 % of the dredged material remained on site shortly after the dredge spoil disposal operations ceased (see period 2005-2006 in Table 2-7). However, it should be noted that it was determined that a large quantity of the fine material present in the *in-situ* dredge material may not have remained in the dredger hopper by the time that disposal occurred offshore (see footnote *5 in Table 2-5), a possible explanation for the reported observations of a large initial loss of material observed on the site immediately after the cessation of dredging activities. After a further 18 months, material was re-distributed, both on the disposal site and around the disposal site. This left only 26 % to 33 % of the disposed dredge material from the Berth 306 capital dredging on the site (see period 2005 – 2007 in Table 2-7). The detailed erosion and movement of dredge material on the disposal site and in its surrounds during this period, is described in greater detail in van den Bossche *et al.* (2007), Smith *et al.*, 2010 and van Ballegooyen and Jacobs (2020).

Shorter term disposal of material from maintenance dredging seems largely to be removed from the site, provided the annual maintenance dredging volumes are not too large (see periods 2006 – 2007 and 2002-2025 in Table 2-7). However long-term records between 2007 and 2022 suggest that as much as 15 % to 20 % of the long-term maintenance dredging spoil remained on the disposal site. The fact that the dredge spoil was disposed of mainly in a location to the north of the site and formed a substantial mound (less than -13 m CD) may be the reason for such a large quantity of maintenance dredging spoil remaining on the site during this period. Other factors such as the nature of the dredging and high volume of cohesive fines and organics may also have played a role in changing the effective critical shear stress of erosion.

The rate at which dispersion of material occurs off the disposal site depends not only on the nature of the disposal (concentrated in mounds) but also on prevailing (particularly extreme) metocean conditions as well as the nature of the material being disposed on the site. As noted by van Ballegooyen and Jacobs (2015), a particular concern is the amount of rock and coarse material disposed of at the disposal site as this material would be very slow to disperse, if at all. Should a significant proportion of the material from capital dredging include rock, then the volume remaining on the disposal site immediately after the cessation of capital dredging and disposal activities could be higher than the 31 % to 41 % estimated for the Berth 306 capital dredging and disposal (perhaps being as much as 60%, depending on the actual volumes of rock or rock-derived coarser material in the dredge material placed on the site). This is expected to be the case for the dredge material from Berth 605 that includes coarse material from the CSD dredging of siltstone.

Table 2-7: Volume of dredging material (for assumed bulking factors of 1.20, 1.35 and 1.55) that has been disposed and subsequently accreted and/or eroded from the dredge disposal site for various time periods.

PERIOD	DISPOSED VOLUME UNBULKED (<i>in situ</i> m ³)	DISPOSED VOLUME BULKED (Onsite) (m ³)	ACCRETED VOLUME (Onsite) (m ³)	ERODED VOLUME (Onsite) (m ³)	NET ACCRETION (Onsite) (m ³)	% MATERIAL LEFT ONSITE
2005 – 2006 (between Aug 2005 and Jan 2006)* ¹	3 840 361*	4 608 433 (BF=1.20) 5 184 487 (BF=1.35) 5 952 560 (BF=1.55)	1 878 810	5 286	1 873 523	41% (BF=1.20) 36% (BF=1.35) 31% (BF=1.55)
2006-2007 (between Jan 2006 and July 2007)	285 908	343 090 (BF=1.55) 385 976 (BF=1.55) 443 157 (BF=1.55)	356 290	588084	-231 794	-68% (BF=1.20) -60% (BF=1.20) -52% (BF=1.20)
2005-2007 (between Aug 2005 and July 2007)	4 126 269	4 951 523 (BF=1.20) 5 570 463 (BF=1.35) 6 396 717 (BF = 1.55)	2 235 100	593	1 641 730	33% (BF=1.20) 29% (BF=135) 26% (BF=1.55)
2007-2021 (between Jul 2007 and Jun 2022)	13 593 397	16 312 076 (BF=1.20) 18 351 086 (BF=1.35) 21 069 765 (BF=1.55)	3 236 630	153 359	3 221 370	20% (BF=1.20) 18% (BF=135) 15% (BF=1.55)
2022-2025 (between Jun 2022 and Jan 2025)	estimated 1 800 000 for 2022-2025 (528 055 in 2022-2023)	2 160 000 (BF=1.20) 2 430 000 (BF=1.35) 2 790 000 (BF=1.55)	208 884 (between Jun 2022 and Jan 2025)	165 198	43 686	7% (BF=1.20) 6% (BF=135) 5% (BF=1.55)

*¹ Volumes of *in-situ* dredge material for the Berth 306 project assumed to have been disposed of at the offshore disposal site are those reported in van Ballegooyen *et al.* (2015). However, the volume actually disposed of at the offshore disposal site remains uncertain. Analysis of the sediment cores collected during the feasibility studies suggest a fines (mud) content of 80%, however analysis of 99 random samples taken from the *Lelystad* hopper during the dredging exercise, suggest that the dredge spoil contained a 56% mud and 44% sand content (Weerts, 2008). This discrepancy most probably arises from losses of fines at the dredging location and from hopper overflows. This fine material would not have made it to the offshore disposal site, resulting in the 3% to 41% initial retention on the disposal site reported in the table above constituting an underestimate of the percentage of material disposed of onto the disposal that is retained on the disposal site for the periods indicated.

However, even fine dredged material could remain on the disposal site for long periods. This was the case for the Berth 306 projects where the nature of the material and dredging operations (*JetSed*) seemed to generate material that, although it contained 56% fines (the remaining being sands), was seemingly slower to disperse off the disposal site than expected.

The above analysis of historical data indicates that material disposed of at the offshore disposal site is mostly lost during the actual disposal of the material onto the site. Maintenance dredging material (< 600 000 m³ per annum) seems to be fairly rapidly removed from the site (WSP, 2025).

Large volumes of capital dredging material disposal on the disposal site seemingly are slower to disperse off the site, possibly due to the nature of the material (*i.e.*, typically less fines than would be expected for material selected to offshore disposal rather than for maintenance of the northern shoreline), but more likely is due to the concentrated nature of the accumulation of material in mounds on the disposal site. This highlights the value of attempting to disperse the material as widely across the disposal site as possible.

Based on the above and assuming a similar loss of fines during the dredging process as occurred during the capital dredging for Berth 306, no more than approximately 40 % of sandy and silty material disposed of onto the existing Port of Richards Bay disposal site and possibly up to 60 % of overall dredge material (containing significant quantities of siltstone-derived gravels from the CSD-dredged siltstone), is estimated to remain on the disposal site upon cessation of the Berth 605 capital dredging activities. However, the estimated 15% increase in the dry mass of less mobile cohesive sediments and a 40% decrease in more mobile fine sediments being released onto the disposal site indicated by the re-assessment of the updated geotechnical data, suggests a slower dispersion of dredge material off the existing dredge spoil disposal site than suggested above. While the estimated approximately 40% of *in-situ* sandy and silty material being dredged and disposed of onto the existing Port of Richards remains valid, the approximate 15% increase in the mass of gravels generated from the CSD-dredged siltstone, suggests that perhaps more than 60% of overall dredge material (containing significant quantities of siltstone-derived gravels from the CSD-dredged siltstone), will remain on the disposal site upon cessation of the Berth 605 capital dredging activities. Given that the gravels generated from the siltstone are potentially degradable any such increase in the retention of dredged material on the site is likely to be short-lived.

This greater longevity of dredge material on the disposal site (constituting a longer duration of effective reduction in the capacity of the dredge spoil disposal site), increases the risk of there being limitations on the rate of maintenance dredge spoil disposal onto the disposal site in the short- to medium-term.

The assumption in the modelling study that the full volume of material from the Berth 605 capital dredging released onto the offshore disposal site remains on-site for an extended period, constitutes a very conservative assumption when assessing changing wave conditions and associated shoreline change impacts that typically occur over long time periods. However, the assumption in the *Wave Climate and Shoreline Change* study (WSP, 2025) and this study that all of the disposed dredge material remains on-site for such an extended period becomes a much less conservative assumption if the potential cumulative impacts of the disposal of dredge material from other potential capital dredging activities in the port are considered. The fact that up to half of the estimated bulked dredge material volume from the Berth 605 project (~ 4.3 million m³ or ~ 4.2 million m³, based on the most recent estimates) to be placed on the disposal site will be very rapidly dispersed from the

disposal site, means that the assessment of potential shoreline change impacts reported in both this study and the Wave Climate and Shoreline Change study (WSP, 2025) would remain sufficiently conservative even were another project of similar scale to occur within roughly the same period as the Berth 605 project.

The predicted dredge spoil disposal volumes for all the imminent proposed development projects within Richards Bay (PRDW, 2024) will produce lower capital dredge spoil disposal volumes than the Berth 605 project. The only exception possibly is the dredge spoil disposal volumes from development of Berth 210 where it is predicted that ~ 5 million m³ of *in-situ* dredge material will be dredged (PRDW, 2024) and potentially disposed of onto the existing offshore disposal site. Thus, the assessment of changing wave conditions and possible shoreline changes undertaken in WSP (2025), under the assumption that all material remains on the disposal site, could be considered to implicitly include possible cumulative impacts associated with the capital dredging for at least one further proposed development of a similar nature and magnitude as presently proposed for the Berth 605 development.

2.5.2 CUMULATIVE IMPACTS OF ELEVATIONS IN TURBIDITY

It is assumed that if the time elapsed between major capital dredging activities (~18 month to 2 years) will be sufficient for there to be no significant cumulative impacts due to elevations in water column turbidity. Further, sufficiently detailed dredging descriptions necessary for other projects to be included in a cumulative assessment of turbidity impacts typically, are not yet available or insufficiently detailed to allow for quantitative modelling assessment of cumulative turbidity impacts of more than the present project. Given the uncertainties in the timing of such other projects and the uncertainty in the associated dredge descriptions, such cumulative impacts are included in the present modelling assessment.

3 KEY ISSUES OF CONCERN

3.1 POTENTIAL IMPACTS OF DREDGING

The potential ecological impacts and impacts on the existing beneficial use of dredge material associated with capital dredging have been discussed in detail elsewhere (e.g. Dankers, 2002; Anchor Environmental, 2003; Bray, 2008; CSIR, 2013c; Manap and Voulvoulis, 2015). However, to provide context for this study, the potential ecological impacts of capital dredging are summarised briefly below:

- Long-term changes in hydrodynamics and water quality due to changes in port layout or deepening of channels or other areas within the port;
- Habitat destruction due to the removal of sediments;
- Smothering effects on benthos;
- Suppression of primary productivity due to light limitation due to increased water column turbidity;
- Effects of excessive suspended particulate matter on the feeding rate of invertebrate filter feeders, reducing their growth and productivity;
- Clogging of gills of fish and crustacea;
- Effects of increased turbidity on the feeding success of visual predators;
- Potential toxicity effects should the sediments to be dredged be contaminated with trace metals; and,
- Aesthetic impacts of dredge plumes.

These potential impacts are schematised in Figure 3-1 below.

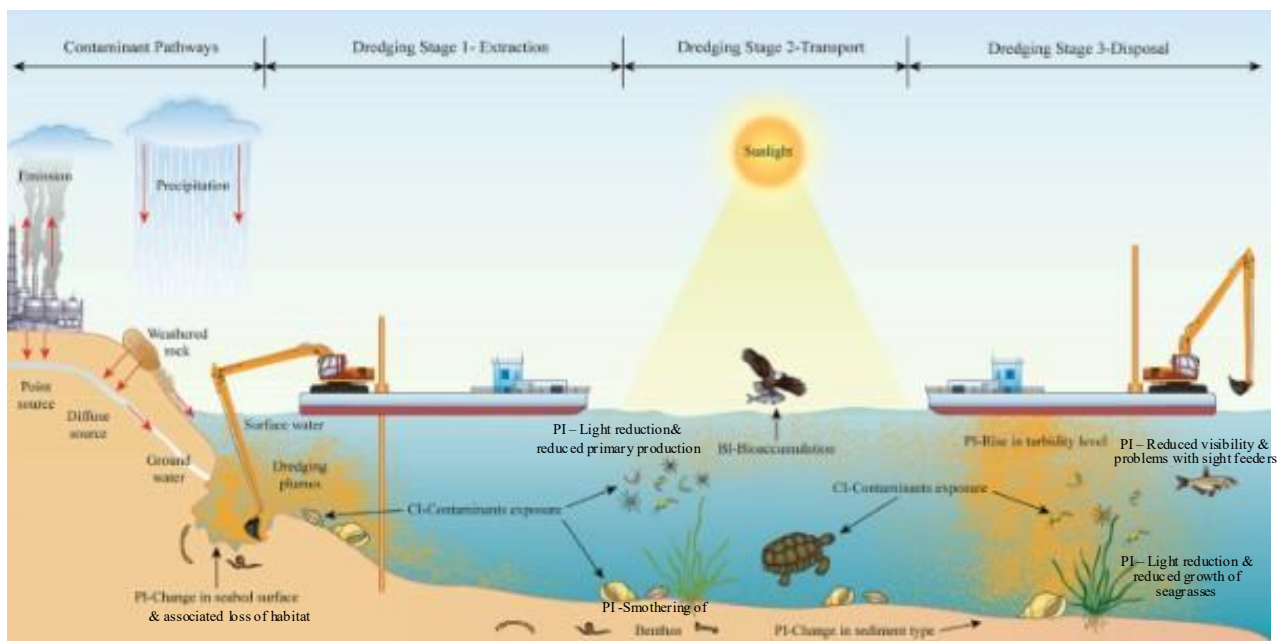


Figure 3-1 - Schematisation of the effects that dredging and dredge disposal activities may have on ecosystems (adapted from Manap and Voulvoulis, 2015).

This dredge and dredge spoil modelling study informs the above impacts, but not the dredge spoil disposal impacts on the adjacent shorelines which are addressed in the companion *Wave Climate and Shoreline Change* specialist study (WSP, 2025).

Additional issues of potential concern include the noise associated with dredging activities and potential introduction of alien species. Given the location of the dredging activities, noise issues are unlikely to be of concern, but to the extent relevant, are addressed elsewhere in the EIA reporting for this project.

If local dredging vessels are not utilised for the proposed dredging, the risks of introduction of alien species can be managed by standard ballast water management practices supplemented by dredger-specific operational procedures (e.g. procedures at the port of origin such as the washing of the hopper, flushing the discharge pipes, and inspection of the hopper, pipes and dredge head to ensure no material is retained that may transport organisms to location of the proposed dredging dredge spoil disposal activities).

3.2 ENVIRONMENTAL QUALITY OBJECTIVES

The environmental quality objectives of relevance for an assessment of potential dredging impacts primarily comprise guidelines for:

- Elevations in TSS concentrations in the water column (aesthetic and ecological impacts).
- Elevated concentrations of toxicants (typically metals) released into the water column from the sediments being dredged.
- Concentrations of a range of toxicants (typically metals) in the sediments being dredged.
- Changes in benthic habitats (typically grain sizes and organic material).
- Potential smothering impacts.

Of relevance to the analysis of the results of this Dredge and Dredge Material Disposal modelling study, is the elevation in water column turbidity, changes in benthic habitats and smothering effects.

While guidelines can be specified for the assessment of visual impacts and the impact of elevated turbidity (or suspended sediment concentrations) in the water column and potential toxicological effects, no clear guidelines exist for smothering effects and changes in grain size in benthic habitats. In previous ecological specialist assessments of capital dredging in the Port of Richards Bay (e.g. Cyrus and Vivier, 2014a,b) these impacts have been informed by literature and expert opinion, rather than specific guidelines.

The issues around toxicants possibly being released from the dredged material is addressed in Section 2.2.4. Given that these impacts are not being explicitly addressed in the modelling study no further discussion is provided around the relevant guidelines or thresholds of concern for toxicants in the water column. Similarly, there is no further discussion of sediment quality as these are also addressed in Section 2.2.4. For greater detail around these guidelines, refer to CSIR (2024).

3.2.1 AESTHETIC IMPACTS

No clear and specific guideline for assessing aesthetic impacts exists in the *South African Water Quality Guidelines for Coastal and Marine Waters – Natural Environment and Mariculture Use* (DFFE (2022)). Therefore, in assessing potential aesthetic (visual) effects, we have used the same conservative guideline for suspended sediment concentrations as was used in a similar dredging

study in Table Bay (where similar upwelling dynamics and inflows of bottom waters as are observed offshore of Richards Bay, can lead to low turbidity conditions in the water column). Thus, a conservative guideline of 10 mg/l elevation in suspended sediments in the upper water column has been assumed for a threshold above which plumes are likely to be visible in the marine environment (*i.e.*, to assess potential aesthetic impacts). This is an appropriate guideline in offshore waters influenced by the Agulhas Current.

However, in the nearshore waters off Richards Bay, sediment inputs due to upstream estuary inflows, erosion of the coastline and even from the outfalls in the region, can lead to significantly more turbid waters. Thus, a less conservative guideline of 25 mg/l (CSIR, 2005a,b) has also been used in the assessments of potential visual impacts of turbid plumes, albeit for plumes from dredge spoil disposal activities along the northern shoreline. However, for expediency we have selected a threshold of 20 mg/l as a more relaxed guideline for assessing aesthetic (*i.e.*, visual) impacts as it coincides with the most conservative guidelines for marine ecological impacts (see Section 3.2.2 below for more detail).

3.2.2 MARINE ECOLOGICAL IMPACTS RELATED TO ELEVATED TURBIDITY / TSS CONCENTRATION IN THE WATER COLUMN

The South African Water Quality Guidelines for Coastal and Marine Waters – Natural Environment and Mariculture Use (DFFE (2022) state that guideline values for water column turbidity / TSS concentrations must be derived from a reference system (data set) that is appropriate to the discharge locality. The specific requirement is that the median TSS concentration for the relevant period should not exceed the 80th percentile of the seasonal and/or event-driven distributions. Additionally, the natural euphotic depth (Z_{eu}) should not be permitted to change by more than 10%.

The application of these water quality guidelines generally require that the background (or ambient) suspended sediment concentrations are known. Relatively comprehensive turbidity and TSS concentration data exist for the Port of Richards Bay and also for areas surrounding the offshore disposal site (*e.g.*, CSIR, 2013a, 2013b, 2013c; Weerts, 2008; CSIR, 2025). However, the ambient suspended sediment concentrations are often difficult to define using individual field survey providing spatial but not temporal coverage, as short-term events such as storms can increase the suspended sediment concentration by two orders of magnitude for short periods, as can river inflows into the marine environment. Nearshore organisms therefore experience and survive large fluctuations in suspended sediment concentrations (*e.g.* CSIR, 1998c).

It is for this reason that simplified turbidity / TSS concentration guidelines are used to present the results of the modelling study that may need further interpretation in the marine and estuarine ecological impact assessment for this project (CSIR, 2025). The selection of the guidelines to use in the modelling study, are discussed below.

More site-specific guidelines targeting dredging operations developed for South African west coast systems (EMBECON, 2004) and from more detailed studies undertaken for Table Bay (Steffani *et al.*, 2003), are considered to also have a degree of relevance in the Richards Bay region. However, of greatest relevance are the thresholds identified in CSIR (2013c) that, if exceeded, would require management of dredging activities to reduce the turbidity and suspended solid concentrations to below these thresholds. Proposed guidelines for suspended solids in the water column from the above studies are:

- Steffani *et al.* (2003) established guidelines for suspended sediment concentrations for ecologically sensitive areas in and around Table Bay (e.g. the kelp beds found close to the shoreline around Robben Island, as well as the kelp beds of the Cape Point National Park). These guidelines, although derived for a West Coast system, have been used in several previous capital dredging studies in South Africa. These are considered sufficiently conservative, but perhaps overly so for the assessment being undertaken here due to the inflow of turbid waters into the nearshore environments on the KwaZulu-Natal coastline. The guidelines are as follows:
 - < 20 mg/l, low risk, monthly average goal;
 - 20 - 80 mg/l, medium risk, permissible for short periods, that is, 2-3 days;
 - > 80 mg/l, unacceptable high risk, requires mitigation action.
- EMBECON (2004) reviewed the scientific literature on the effects of varying suspended sediment concentrations on a range of biota and concluded that TSS concentrations < 100 mg/l represented limited risks for biota.
- The Operational Environmental Management Plan (TNPA, 2009) for dredging in the Port of Ngqura identified a thresholds of a suspended sediment concentration of 100 mg/l (50 mg/l for sensitive sites) as a warning threshold indicating that mitigation measures needed to be implemented and a threshold of a suspended sediment concentration of 150 mg/l (80 mg/l for sensitive sites), the exceedance of which would lead to cessation of dredging activities. The selection of thresholds would have had a scientific basis but could possibly be considered site-specific, *i.e.*, relevant for only Algoa Bay.
- Site specific thresholds suggested for use in managing dredging impacts in Richards Bay include:
 - thresholds utilised in the Richards Bay Berth 306 development (CSIR, 2004b);
 - Days of exceedance of a 25 mg/l and a 50 mg/l threshold;
 - Days of exceedance of a 100 mg/l shoreline discharges of dredge spoil;
 - and thresholds utilised in the Port of Richards Bay Capacity Expansion dredging studies (CSIR, 2013c) that include:
 - Turbidity of 93 NTU or TSS concentrations of 142 mg/l for location in the Bhizolo Canal or on the mudflats;
 - Turbidity of 66 NTU or TSS concentrations of 100 mg/l for all other locations in the Port of Richards Bay;
 - Turbidity of 10.2 NTU or TSS concentrations of 16.4 mg/l for offshore location in the vicinity of the dredge spoil disposal site. There however, exist some concerns around the validity of this threshold due to the limited temporal resolution of the profiling data used to derive this threshold and a likely resultant bias in the data (see Section 4.8.2) towards lower values.

The model results have been processed using percentage exceedance contours and days of exceedance per season of the following TSS thresholds of concern 10 mg/l, 20 mg/l, 50 mg/l, 80 mg/l, 100 mg/l and 150 mg/l at the sea surface, mid-water column and in the bottom waters.

Only the analyses and associated plots are reported for the following thresholds of concern / water quality guidelines:

- for 10 mg/l (conservative) and 20 mg/l (less conservative thresholds for the assessment of aesthetic (visual) impacts;
- for 20 mg/l (low risk) and 80 mg/l (high and possibly unacceptable high risk) thresholds for the assessment of marine ecological impacts.

The settling of sediments on the seabed can be expressed as threshold of concern related to the rate of sedimentation of material on the seabed and the thickness of the sediments on the seabed. A sedimentation thickness of 5 mm was suggested as a threshold of concern for general benthos for a tropical environment (WSP, 2020) where impacts of seagrasses and corals are important. Given the uncertainties involved no smothering (sediment thickness) guideline is specified for the analysis of the modelled deposition thickness of sediments both within the Port of Richards Bay and the offshore disposal site and its immediate surrounds.

4 ENVIRONMENTAL CONDITIONS

The marine and coastal environment encompassing the Port of Richards Bay has been extensively, and repetitively, described in the various EIAs, SEAs and specialist studies conducted as part of the overall port development (e.g. CSIR, 1998a, 2003, 2004a,b, 2009; van Ballegooyen *et al.*, 2015, van Ballegooyen and Jacobs, 2020). The synopsis below is taken mainly from these reports with additional data from the CSIR IPOSS measurements for the Port of Richards Bay. It focuses primarily on those coastal processes and areas where local marine ecosystems and beneficial uses or activities may be directly or indirectly affected by the capital dredging activities proposed for the Berth 605 development.

4.1 COASTAL MORPHOLOGY AND BATHYMETRY

In terms of this study the regional features of importance are indicated in Figure 4-1 below.

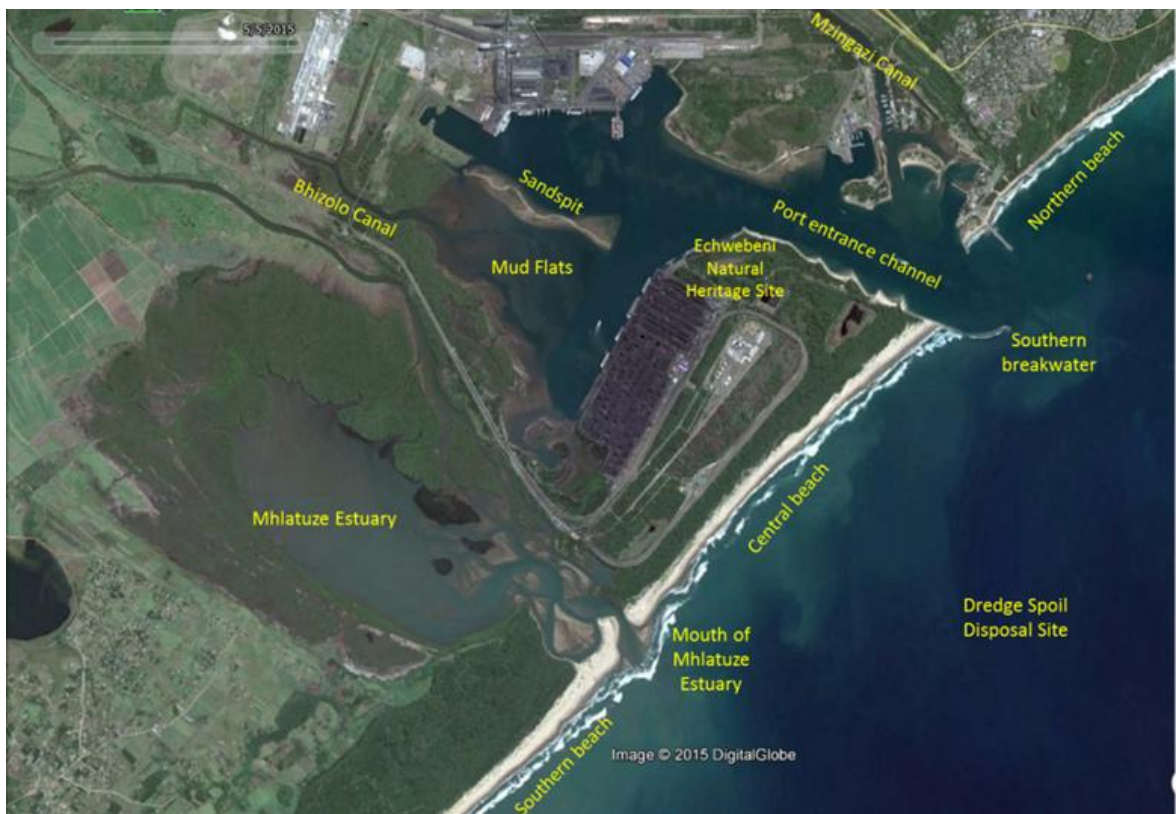


Figure 4-1 - Key physiographic features of the region.

The key features are:

- The Mhlathuze Estuary that constitutes an important habitat and through which turbid waters flow into the adjacent ocean during high rainfall events;
- The Port of Richards Bay and features within the port such as
 - the often-turbid mud flats,
 - the sandspit that separates the mud flats from the inner basins of the port,

- the freshwater inflows through the Mzingazi and Bhizolo Canals,
- the deep port entrance channel in which the flow is tidally dominated and where there is some exposure to swell.
- The beaches surrounding the port comprising:
 - the Southern Beach to the south of the mouth of the Mhlathuze Estuary,
 - the Central Beach located between the Mhlathuze Estuary mouth and the port entrance, and
 - the beaches to the north of the port entrance that are subject to fairly severe shoreline erosion.

The bathymetry in the vicinity of the Port of Richards Bay is fairly complex (Figure 4-2). In the offshore region the continental shelf break that is located close inshore (< 5 km from the coastline) at Cape St Lucia north of the port and is located further offshore on moving southwards (~ 20 km from the coastline opposite the Port of Richards Bay). The continental shelf break is located even further offshore in the vicinity of Durnford Point where the continental shelf break is more 35 km from the coastline. There exists a large shallow region to the south of Richards Bay known as the Durnford Shoals. These large-scale changes in bathymetry strongly influence the waves and currents in the region offshore of the Port of Richards Bay.

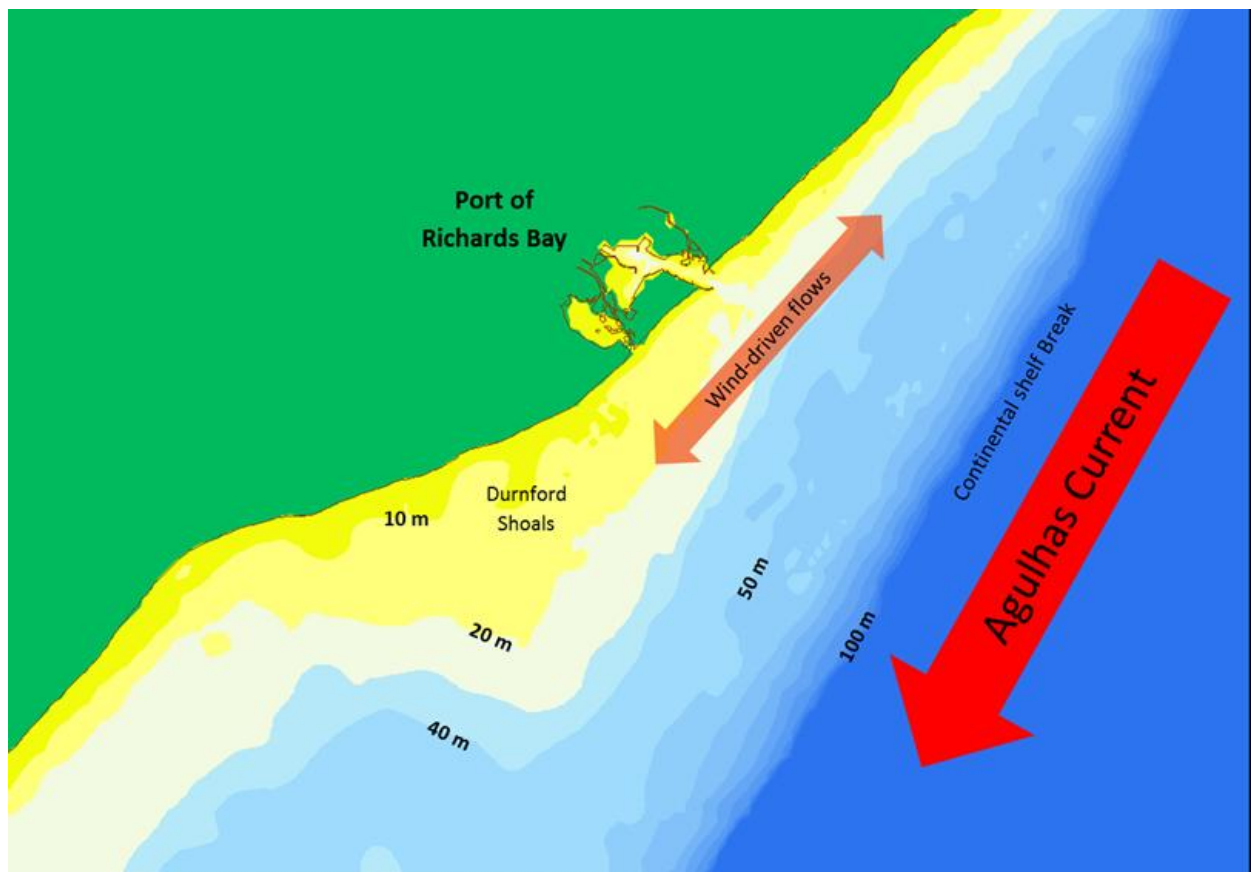


Figure 4-2 - Large-scale bathymetry offshore of the Porto of Richards Bay (Source: van Ballegooyen and Jacobs, 2020).

A more detailed bathymetry for the Port of Richards Bay and its immediate surrounds is provided in Figure 4-3 below. Important features within the port are the shallow mudflats, the sandspit that separates these shallow and often turbid waters of the mudflats from the deeper shipping basin to the north (Inner Basins 1 to 3 maintained to a depth of -18.9 m CD) and the basin to the southeast of the mudflats (Richards Bay Coal Terminal Basin maintained to a depth -19.4 m CD). The deeper navigation channel leading to the port entrance extends approximately 4 km seawards before the depth in the channel is the same as that of the continental shelf surrounding the channel. The adjacent Mhlathuze Estuary, in general, is shallow except for some of the braided channels and areas closer to the estuary mouth where depths of up to -2m CD occur.

An offshore bathymetric feature of relevance to this study is the dredge disposal mound that exists offshore of the Central beach in an approximate -20 m CD water depth. The present height of this dredge spoil disposal mound is approximately -13 CD (see Section 2.4.4.4) However, this mound on the disposal site was even shallower (-11 m CD) after the Berth 306 dredge spoil disposal operations and was considered a navigation hazard (Ramsay, *pers. comm.*). There is, however, evidence that much of the dredge spoil disposed of at this site during the Berth 306 capital dredging has been dispersed, resulting in a less significant bathymetric feature (van den Bossche *et al.*, 2007).

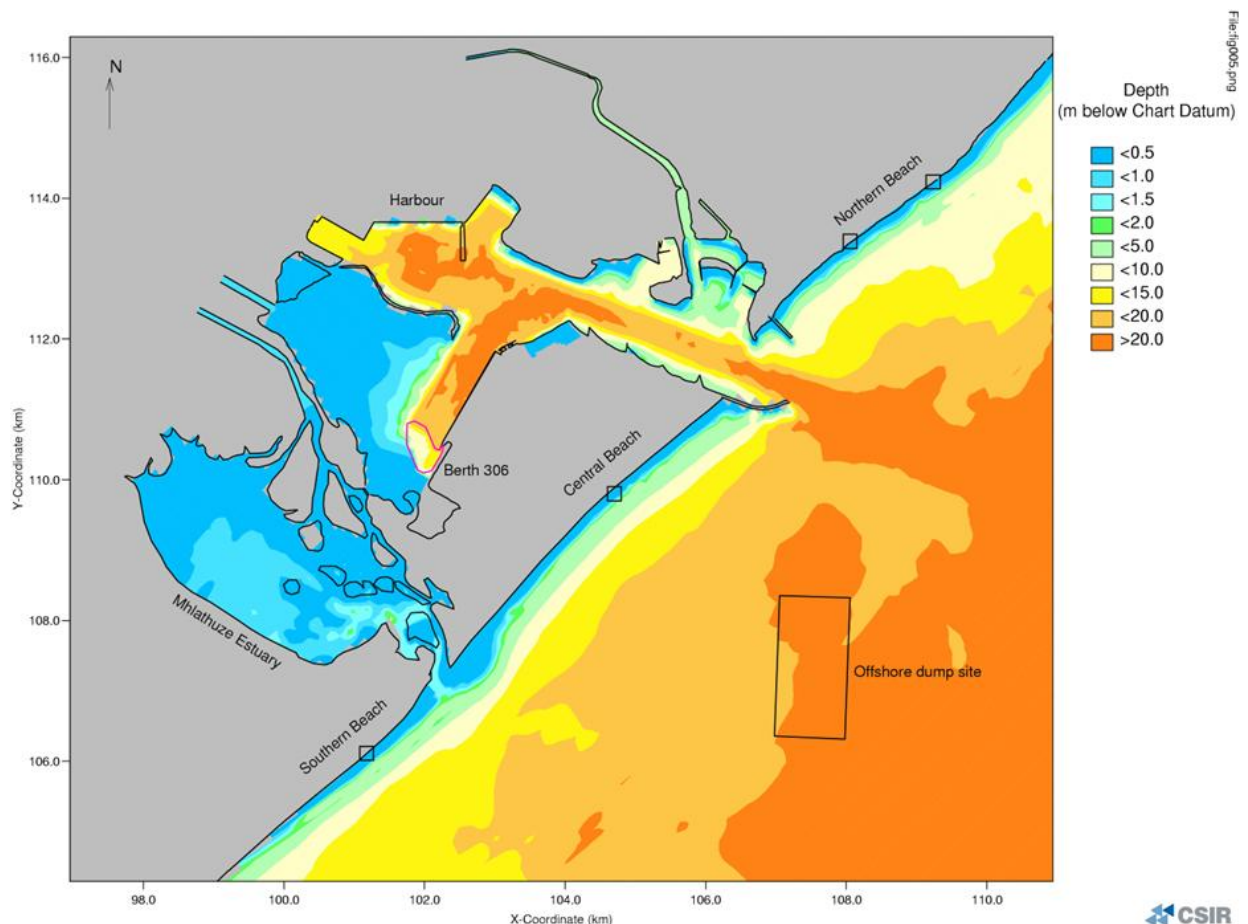


Figure 4-3 - Detail of the bathymetry in the immediate environs and within the Port of Richards Bay and the Mhlathuze Estuary (CSIR, 2004c, 2005a).

4.2 CLIMATE

4.2.1 SYNOPTIC CONDITIONS

Richards Bay is located within the subtropical high-pressure belt. Its climate is controlled largely by the seasonal north-south migration of this belt, but more specifically, its relative position to the Indian Ocean Anticyclone and the continental high-pressure cell located over the southern African interior. The resultant anti-cyclonic circulation with fine stable weather is dominant throughout the year. The position and intensity of the two high-pressure cells determines the extent to which tropical easterlies and the mid-latitude cyclones (cold fronts) moving eastwards past the subcontinent, interrupt the prevailing fine conditions. During the summer months, the high-pressure belt is weakest and moves southwards, allowing tropical easterly incursions over the region. The high-pressure belt intensifies and moves northward in winter when mid-latitude cyclones (cold fronts) strongly influence the region (CSIR, 1998a, 2003). The synoptic conditions determining wind conditions, are described in greater detail in Section 4.3 below.

4.2.2 INSOLATION

Sunshine duration of 70 % occurs during the winter months while cloudy weather is experienced during the summer months, resulting in a more limited sunshine duration of about 45 %. The average annual cloud cover is 50 %, 47.5 % and 61.25 % for 08h00, 14h00 and 20h00, respectively (Burger & Thomas, 2003). Insolation is important as it is a strong determinant of stratification in enclosed bodies of water.

4.2.3 PRECIPITATION

Richards Bay receives an annual average rainfall of 1 228mm (CSIR, 2004b, 2005b). The rainfall is seasonal and occurs mainly in summer, from October to March, with peak rainfall occurring in late summer (January and February). Rainfall in winter, associated with the passage of frontal weather from the south-west, is not uncommon. The mean monthly rainfall totals from the South African Weather Service (SAWS) 20-year climate record (SAWB, 1992) are presented in Table 4-1.

4.2.4 AIR TEMPERATURE

Air temperatures in Richards Bay are moderate to high for most of the year and the summers are humid. In summer the average daily maximum temperature is 28°C with extremes exceeding 40°C, while in winter the average maximum temperature is 23°C with extremes in the region of 34°C. Monthly averages and extreme temperatures from the SAWS 20-year climate record (SAWB, 1992) are presented in Table 4-1. Extreme temperatures frequently occur due to berg wind conditions. Annual average relative humidity levels are 82% (08h00) and 67% (14h00), respectively.

Table 4-1 - Mean monthly and monthly extreme temperatures at Richards Bay including average monthly rainfall (CSIR, 2005b).

MONTH	TEMPERATURE (°C)			RAINFALL (mm)
	Average	Maximum	Minimum	
Jan	25.2	29.2	21.1	172
Feb	25.0	28.9	21.2	167
Mar	24.6	28.9	20.4	107
Apr	22.5	27.0	18.1	109
May	20.0	24.8	15.2	109
Jun	17.7	23.1	12.3	57
Jul	17.6	23.0	12.3	60
Aug	19.0	24.0	14.1	65
Sep	20.3	24.9	16.0	77
Oct	21.3	25.4	17.3	105
Nov	22.7	26.7	18.6	114
Dec	24.5	28.7	20.4	86
Annual	21.7	26.2	17.3	1228

4.3 WINDS

A typical sequence of weather events along this section of the coast is as follows (e.g. Preston-Whyte, 1975). Before the arrival of the coastal low (and following cold front) along the coast, the wind generally blows from the northeast. Preceding the coastal low often are the occurrence of warm north-westerly berg winds. As the coastal low approaches, the barometric pressure starts dropping and the wind freshens. On the passing of the coastal low the wind rapidly (within an hour, depending on the speed and intensity of the coastal low) changes from north-easterly to often strong south westerly or south-south-westerly winds, the so-called “buster” (Hunter, 1988). Occasionally these SW or SSW winds reach gale force in summer, especially further offshore (Hunter, 1988). These strong south-westerly winds can persist for a day or more, before the wind direction backs to southeast and finally returns to north-easterly winds. Under extreme conditions the total change in wind velocity may exceed 20 m/s and are associated with significant drops in temperature (Schumann, 1984). The effect of the coastal low on offshore winds is uncertain but is considered to extend to between 50 km to 100 km offshore (CSIR, 1998a). It should be noted that not all coastal lows propagating along the southern African coastline reach KZN and even less the northern KZN region (i.e., Richards Bay).

The above basic weather pattern sometimes can be masked by more dominant synoptic situations (Hunter, 1998) that often lead to more extreme weather conditions, these being:

- cyclogenesis and an intense migratory high, a more intense development of the basic weather cycle described above that leads to gale force south-south-westerly winds and heavy swell conditions;
- A stationary low northeast of Durban that typically results in strong winds with a significant onshore component.
- A cut-off low that leads to strong southerly wind conditions and depending on its location may lead to a strong onshore wind component. Such events are often associated with flooding.
- The rare occurrence of tropical cyclones that lead to gale force south-westerly to south-easterly winds and flooding.

The three former sequences are expected to occur once or more annually, while the latter is a rarer occurrence (e.g., WSP, 2024d). These events are relevant to this study in that, not only do they lead to significant re-suspension and movement of sediments, but they also result in large volumes of sediment-laden waters entering the marine environment from the adjacent catchments.

Other than these synoptically driven winds, a complex pattern of thermo-topographically induced wind exists in the Richards Bay area that manifest as sea-land breezes by night and day, respectively (Langenberg, 1981; Boegman, 1993). There is a higher frequency of north-westerly winds during the night (land breeze) compared to a higher frequency of south-easterly / easterly winds during the day (sea breeze). Periods of calm are relatively infrequent in Richards Bay and occur approximately 7% of the time, with a higher frequency during the night (CSIR, 2003).

Unlike temperature and rainfall, a truly long-term wind record does not exist for Richards Bay. Numerous shorter to medium term records confirm that the prevailing winds in Richards Bay are predominantly north-easterly, associated with high-pressure systems and fine weather, and south-westerly winds that are associated with westerly waves and frontal weather.

Wind data for a site just north of the Port of Richards Bay (Arboretum) indicate an annual frequency of occurrence of north-easterly winds of more than 20%, with the combined frequency of south-westerly and south-south-westerly winds also exceeding 20% (CSIR, 2005b). The wind speeds from both of these sectors are generally moderate with strong south-westerly winds exceeding 8 m/s at times.

Wind records from the Integrated Port Operations Safety System (IPOSS) at Port Control and particularly the more exposed southern breakwater site (Figure 4-4), indicate a much stronger wind regime than that described above. The median wind speed on the southern breakwater is approximately 30 to 40% greater than that recorded at more inland sites surrounding the Port of Richards Bay and is considered more representative of the coastal and open water wind climate. It is for this reason that the winds measured on the southern breakwater have been used in this modelling study. The National Centre for Environmental Protection (NCEP) winds measured further offshore are deemed less appropriate for use as wind-forcing in the port and surrounding nearshore waters as, *inter alia*, the rapid changes in winds associated with more localised features such as the coastal low are not well-represented in these data.



Figure 4-4 - Location of the IPOSS wind measurement sites at Port Control and on the extremity of the southern breakwater

Winter and spring tend to be the stormiest months with strong SW winds being experienced in both seasons. In summer the more frequent winds are north-easterly winds which also are stronger than the NE winds observed in other seasons. The strongest winds in all seasons (less so in summer) are from SW to SSW (Figure 4-5 and Figure 4-6). The offshore winds increase in winter due to the increased occurrence of land-sea breezes (Figure 4-6) however these offshore wind components are much less obvious in the winds measured on the southern breakwater.

Wind roses reported in WSP (2024d) for a longer 22 year period (1994 to 2016) do not differ significantly from those reported in Figure 4-5 and Figure 4-6 which for only a 10-year period (2005 to 2015).

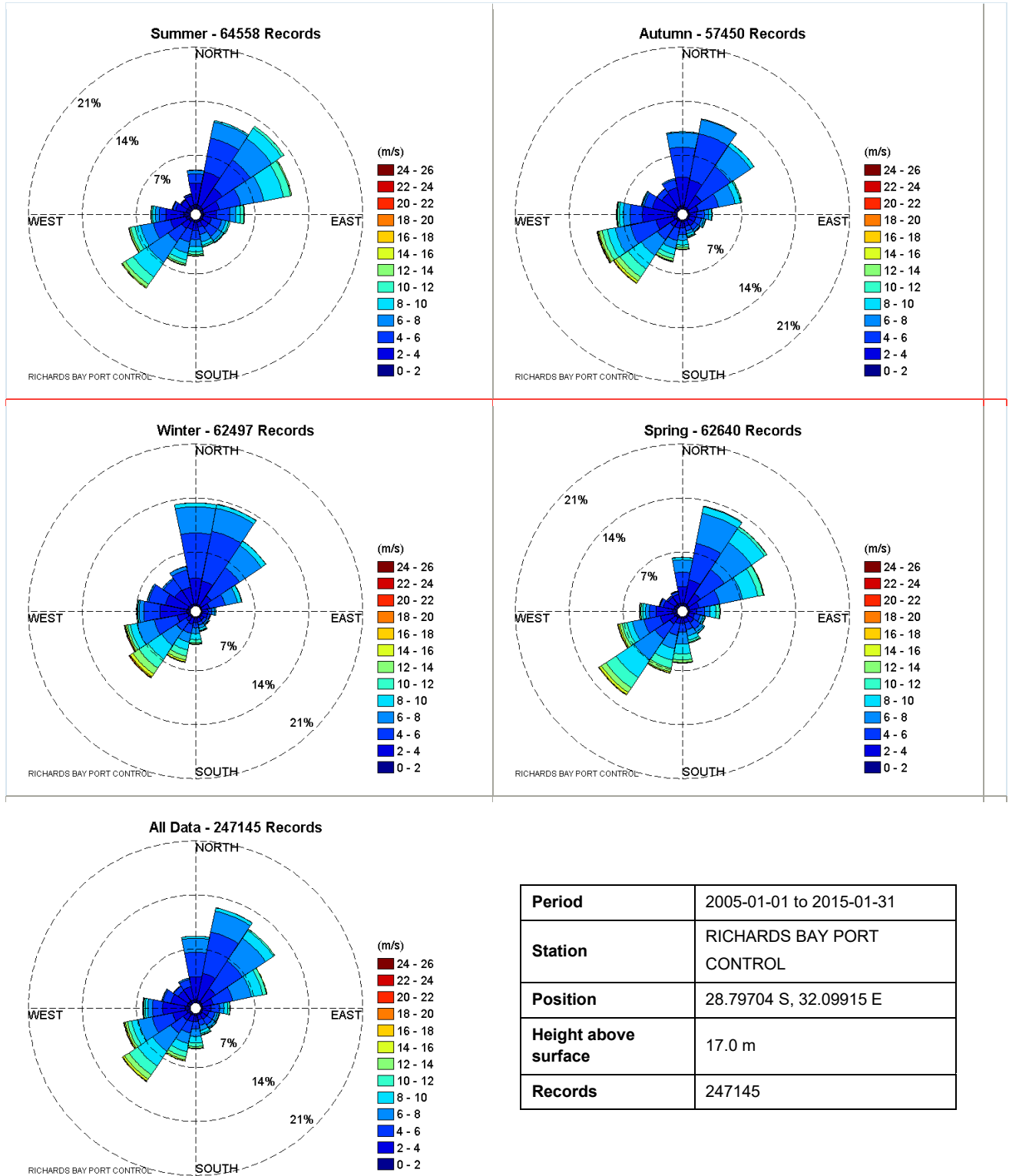


Figure 4-5 - Annual and seasonal wind roses for the wind measured at Richards Bay Port Control (Source: van Ballegooyen et al., 2015).

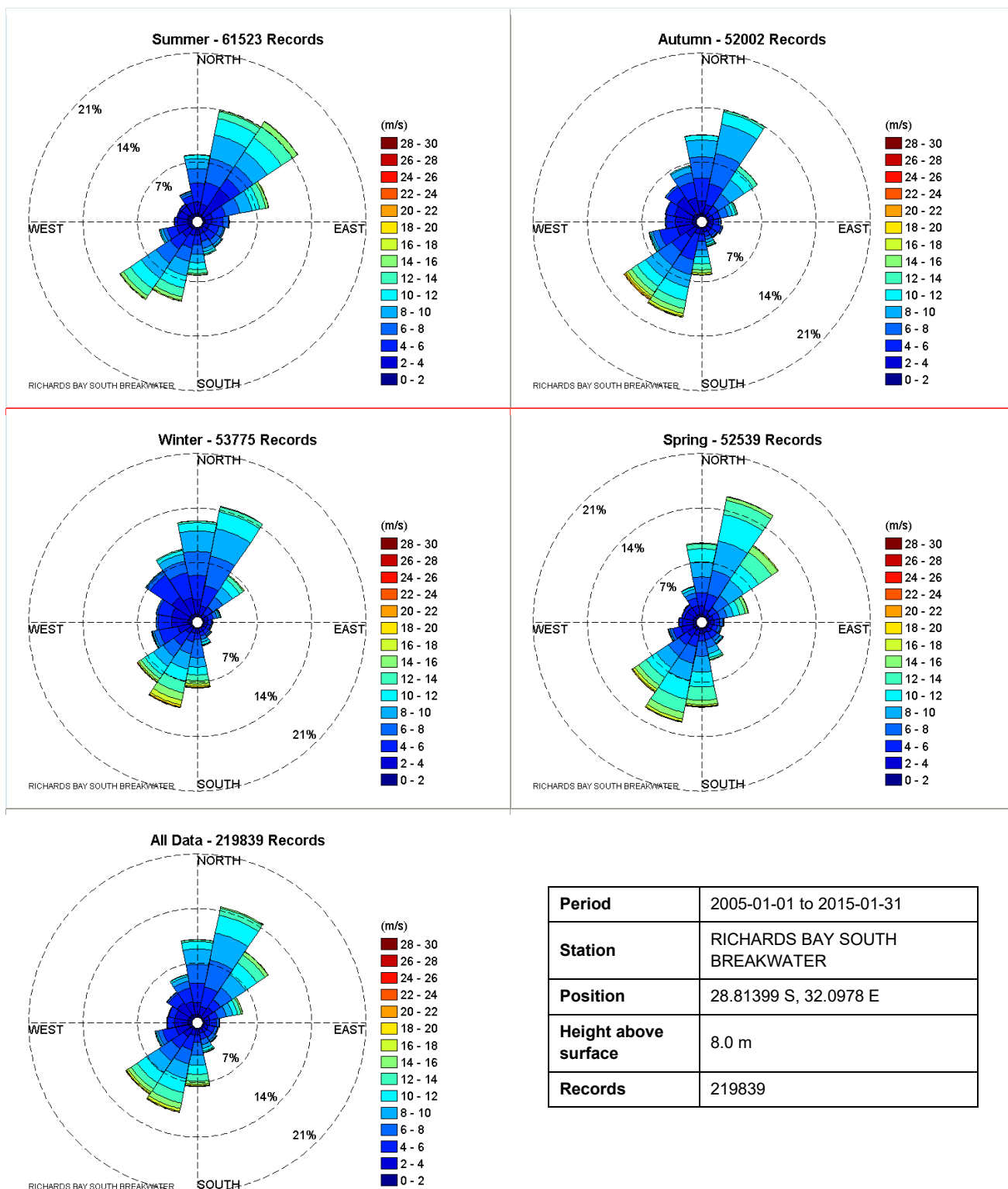


Figure 4-6 - Annual and seasonal wind roses for the wind measured on the southern breakwater of the Port of Richards Bay. (Source: van Ballegooyen *et al.*, 2015).

4.4 WATER LEVELS

4.4.1 TIDES

Tides around South Africa are classified as semi-diurnal microtidal, with a dominant M2 tide (*i.e.*, there are two high tides and two low tides per day) and tidal amplitudes generally below 2 m. A substantial spring-neap variation exists, with amplitudes as little as 0.5 m at neap tides and on occasion over 2 m at spring tides (South African Navy Tide Tables). The tides in Richards Bay thus are semi-diurnal and have a mean spring and neap tidal range of 1.86 m and 0.50 m, respectively (SAN Hydrographer, 2020).

The tidal period is 12 hours and 25 minutes, with a slight diurnal inequality. The tides propagate from west to east from an amphidromic point in the Southern Ocean. The tidal phase lag along the east coast of South Africa, however, is small and consequently irrelevant for the scale of modelling being undertaken here. The tidal characteristics for the Port of Richards Bay are listed in Table 4-2 below.

Table 4-2 – Port of Richards Bay Tidal Characteristics (WSP, 2024d).

Tide Level	m CDP	m CD	m MSL*
HAT (Highest Astronomical Tide)	+2.37	+2.47	+1.455
MHWS (Mean High Water Springs)	+2.01	+2.11	+1.095
MHWN (Mean High Water Neaps)	+1.38	+1.48	+0.465
ML (Mean Level)	+1.10	+1.2	+0.185
LLD (Land Levelling Datum)	+0.915	+1.015	0.00
MLWN (Mean Low Water Neaps)	+0.87	+0.97	-0.045
MLWS (Mean Low Water Springs)	+0.17	+0.27	-0.745
LAT (Lowest Astronomical Tide) = CD (Chart Datum)	-0.10	0.00	-1.015

* It is assumed that MSL = LLD. All model set-up and run using MSL / LLD.

Presently Chart Datum (CD) relative to Land Levelling Datum (LLD) is assumed to be -1.015 m and Mean Level (ML) is +1.2 m CD. Prior to 31 December 1997, CD relative to LLD was defined as -0.9 m and ML was defined as +1.09 m CD. A Chart Datum of CD = LLD – 1.015 m has been used in the modelling study.

Tidal currents are significant both within the Port of Richards Bay and the Mhlathuze Estuary, particularly in the vicinity of the harbour entrance, the mouth of the estuary and shallow regions both within the estuary and the harbour.

4.4.2 STORM SURGES AND LONGER PERIOD SEA LEVEL VARIABILITY

Longer-period water level variations also occur due to meteorological influences, particularly wind. Coastal trapped waves along the south coast have sea level amplitudes that on occasion are in excess of 0.5 m (Schumann and Brink, 1990), however these changes in water level associated with meteorological

conditions are less than for more southerly locations along the South African coastline (van Ballegooyen, 1996). These storm surge components have been assessed in a Metocean study undertaken for the Berth 605 project (WSP, 2024d) as follows.

A 10-year water level dataset over the 2014 – 2023 period was sourced from SANHO (South African Navy Hydrographical Office). The dataset is analysed by using *t_tide* (Pawlowicz, Beardsley, & Lentz, 2002), a tidal harmonic analysis program. By using *t_tide* the storm surge is obtained by predicting the tidal signal using *t_tide* and subtracting it from the original measured data. General extreme value analysis of the resulting storm surge component (WSP, 2024d) resulted in the estimated storm surge component of water level as summarised in Table 4-3 below,

There is an additional longer-term component (periods of 20 days or more) to the water level variability associated with larger-scale ocean variability such as perturbations of the Agulhas Current (5 cm and up to 20 day persistence) and also even larger-scale water level variability (5 cm to 10 cm) originating at the equator and propagating anti-clockwise around the South African coastline before reaching Richards Bay (van Ballegooyen, 1996).

Table 4-3 – Storm Surge Water Levels Extremes at Richards Bay WSP,2024d).

Return Period (years)	Storm Surge (m) + 1 std dev
1	0.34
5	0.41
10	0.44
25	0.48
50	0.51
100	0.54

4.5 WAVES

Knowledge of the offshore wave conditions at Richards Bay is important in that waves exert significant event scale effects on nearshore currents and sediment distributions both nearshore and in deeper water (*i.e.*, at the dredge disposal sites).

The currents in the surf-zone and the shallow nearshore region and, to a much lesser extent; the currents across the harbour entrance are determined by prevailing wave conditions. The direction of the wave-driven currents along the shoreline depends on the angle of incidence of the waves at the coastline. The more oblique the arrival of the waves at the shoreline, generally the stronger the alongshore flows. Furthermore, sediment transport at Richards Bay beaches (and at beaches inside the harbour mouth) is primarily driven by waves (WSP, 2024d).

As noted above waves are not only important for their role in driving currents, but also in determining the sediment movement and distributions, particularly of fine sediments, on the seabed at locations exposed to wave action. The swell and wind-generated waves typically generate bed shear stress at

the seabed that either maintain sediments in suspension or re-suspend sediments that have already been deposited on the seabed. The magnitude of the bed shear stress generated is a function of wave height and wave period, as well as current velocities where these are of sufficient magnitude.

In the harbour and adjacent estuary, the wave turbulence keeping the fine sediments in suspension is a consequence of both swell and longer waves penetrating into the port as well as locally generated wind-waves. Currents, particularly tidal currents, are also expected to play a role in limiting the deposition of sediments in these environments where these currents are of significant magnitude. Along the northern shoreline, the sediment dynamics are almost exclusively a consequence of wave forcing.

Further offshore, the wind-driven currents and those due to the influence of larger-scale flow associated with the close proximity of the Agulhas Current may constitute a significant contributory factor to the re-suspension and re-distribution of sediments. However, at the dredge spoil disposal site, the re-suspension in the sediments is expected to be largely due to wave turbulent stresses while the advection of the re-suspended sediments is determined predominantly by the wind-driven and larger scale flows.

NCEP hind cast wave data (from the NOAA/NCEP WAVEWATCH III Global Model) at position (29.00°S; 32.5°E), located beyond the continental shelf break, have been used to characterise the deep-water wave climate (Figure 4-7).



Figure 4-7 - Location of the NCEP wave and IPOSS waves measurement locations offshore of the Port of Richards Bay

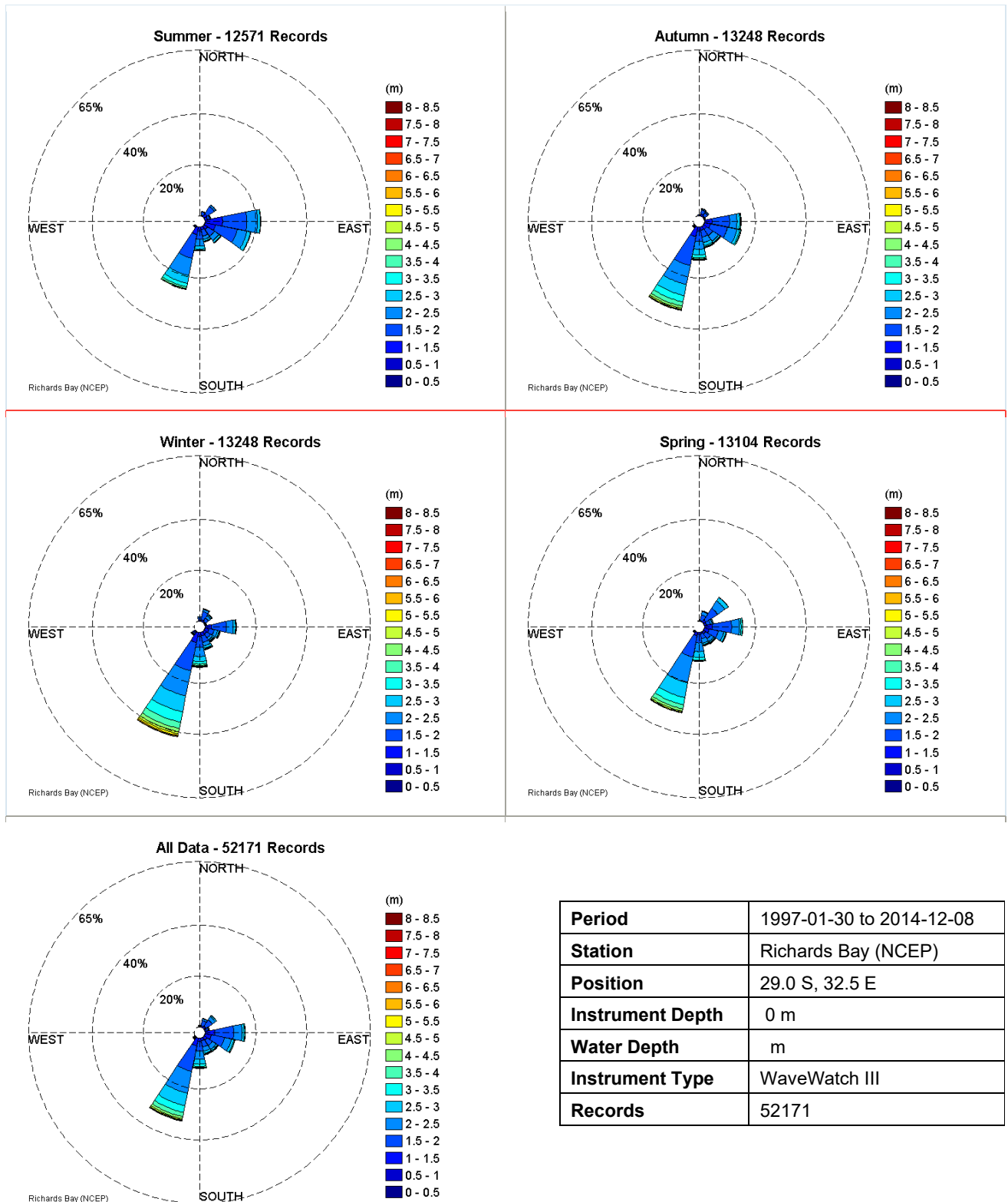


Figure 4-8 – Annual and seasonal wave roses for the NCEP wave data for a deep water location offshore of the Port of Richards Bay (see for the NCEP wave data “measurement” location. (Source: van Ballegooyen *et al.*, 2015).

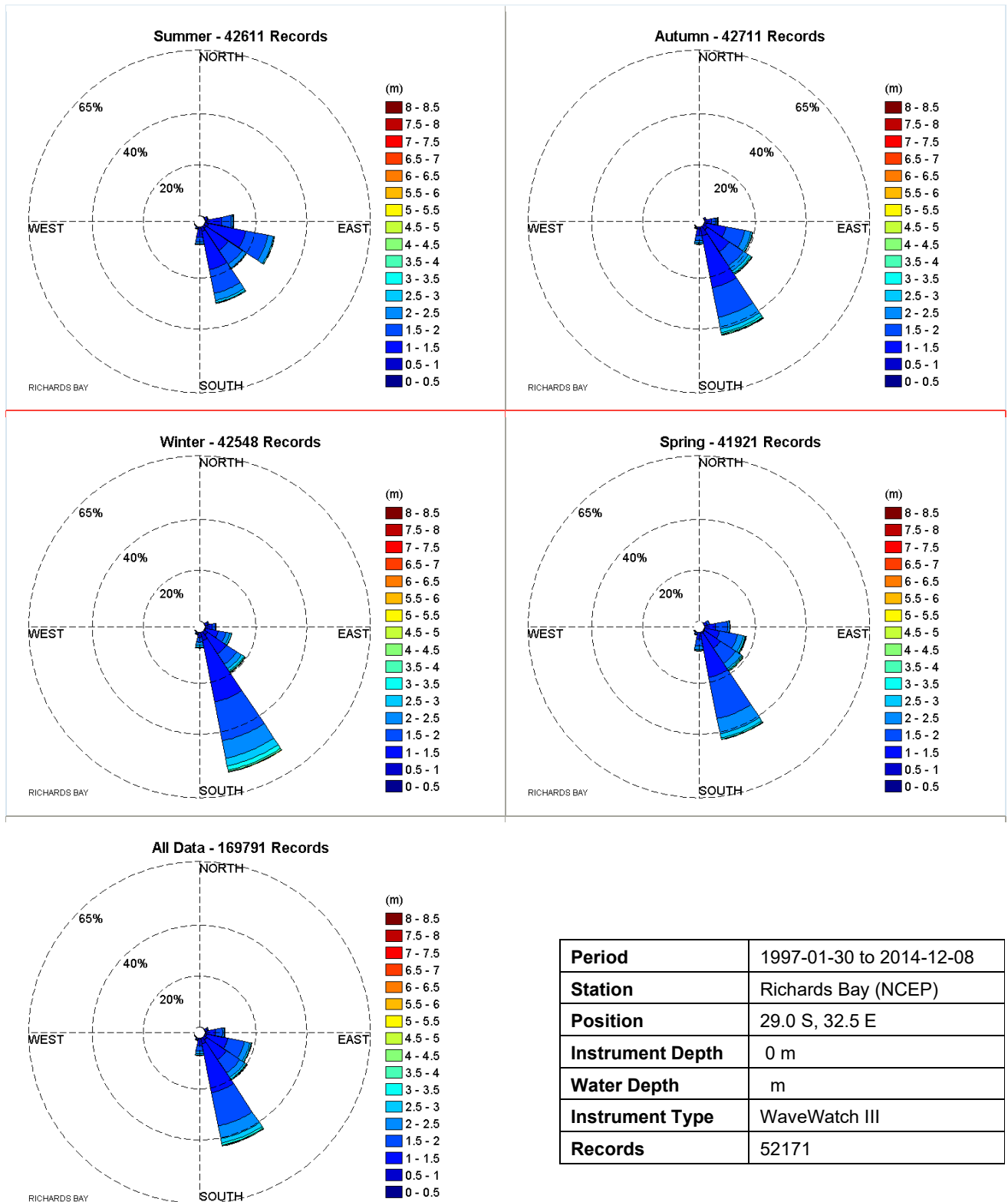


Figure 4-9 – Annual and seasonal wave roses indicating wave height (H_{mo}) vs wave direction for wave data from the Richards Bay IPOSS measurement. (Source: van Ballegooyen *et al.*, 2015).

These data show a clear predominance of SSW swell with a lesser occurrence of onshore wave conditions comprising predominantly easterly waves (Figure 4-8), especially in summer and autumn. A small NE wave component is observed during Spring. The highest wave conditions (SSW) occur during Winter and to a lesser extent Spring.

The deep-sea waves are refracted as they move landwards into shallower waters with all but the shorter period waves (sea as opposed to swell) becoming more shore normal in direction. The resultant nearshore wave distribution has been measured at a site some 2 km south of the southern breakwater in an approximate water depth of 19 m CD (Figure 4-7). At this location, the waves are predominantly from SSE, however SE and ESE wave components are not uncommon, particularly during the summer months (Figure 4-9). As expected, the highest waves are observed during the winter months and to a lesser extent in Spring.

Wave statistics based on approximately 16 years of IPOSS wave buoy data (WSP, 2024d), indicate median, 1% exceedance, 0,1 % exceedance and maximum observed wave heights of 1.5 m, 3.4 m, 4,5 m and 8,5 m, respectively. The peak wave period ranges generally from about 6 s to 18s, with dominant period between 10s and 14s.

The wave conditions in the Port of Richards Bay and the Mhlathuze Estuary have been simulated for a range of offshore wave and local winds condition (CSIR, 2000b). The results of these simulations (Figure 4-10 to Figure 4-13) provide some important insights into the wave conditions prevailing within the port environs, within the adjacent estuary, in the marine environment offshore of the Port of Richards Bay and along the northern shoreline.

For these studies, the offshore wave conditions imposed at the offshore boundary of the wave model were such that the simulated inshore wave conditions recovered from the model at the location of the IPOSS wave measurement locations are the same as those actually recorded. This is also the approach used in this modelling study due to deficiencies in the NCEP data recorded offshore of the Port of Richards Bay (see Section 5.1.3 on wave calibration).

Wave simulations for SSE wave conditions under low to moderate offshore wave conditions ($H_{mo} = 1.5$ m and $T_p = 10s^{*1}$) and moderate SW winds (wind speed = 7 m/s) indicate a minimal penetration of wave energy into the harbour (Figure 4-10) and a narrow surf zone along the coast. Waves from a SSE direction reach the shoreline at an oblique angle and will tend to drive a northward flowing surf zone current (Figure 4-11). The moderate SW wind generates wind waves that reach a height of approximately 0.20 m at the north-eastern side of the harbour (and the estuary). Simulations for high offshore wave conditions from the SSE ($H_{mo} = 3.0$ m and $T_p = 14s$) and strong SW winds (wind speed = 16 m/s) indicate a significantly increased surf zone width due to the increased incident wave height (Figure 4-12), while the strong SW wind generates wind waves that exceed 0.4 m at the north-eastern side of the harbour. Evident in both Figure 4-10 and Figure 4-11 is the important role that the sandspit has in providing protection to the 600 and 700 series of berths from such wind waves.

^{*1} H_{mo} denotes significant wave height and T_p the peak wave period.

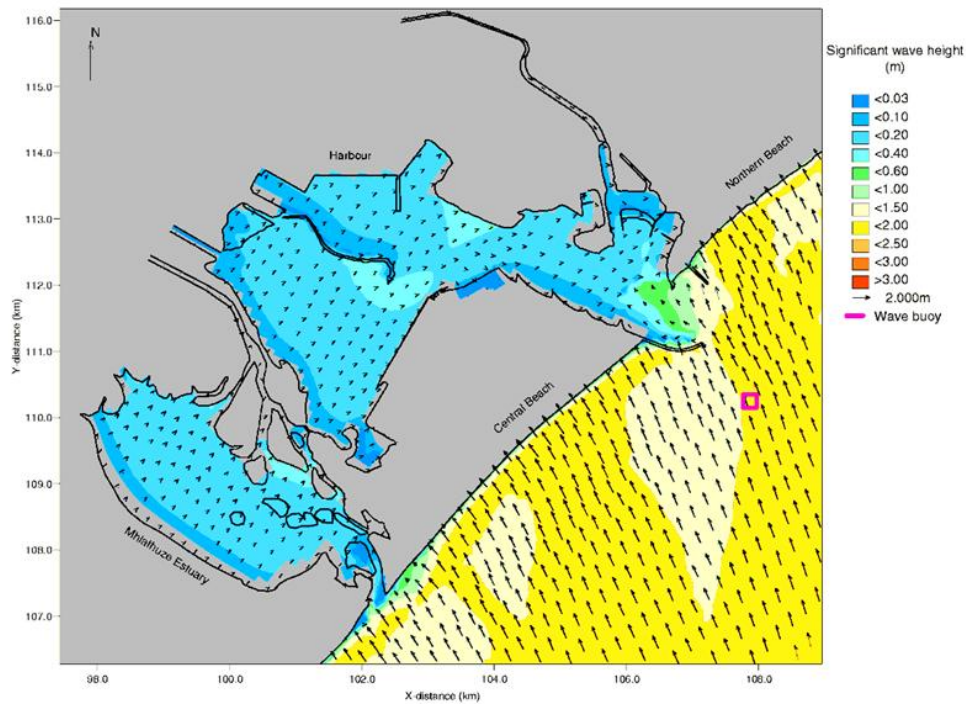


Figure 4-10 - Significant wave height and direction for low to moderate wave conditions at wave buoy ($H_{mo} = 1.5$ m $T_p = 10$ s, Direction SSE) and moderate SW winds (wind speed 7 m/s) (Source: CSIR, 2000b).

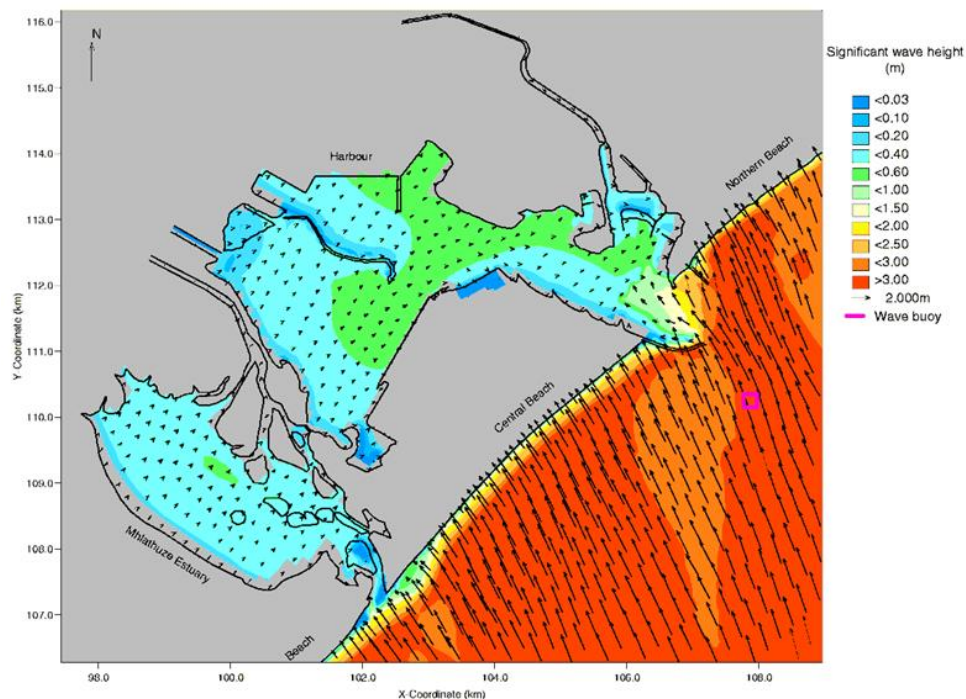


Figure 4-11 - Significant wave height and direction for high wave conditions at wave buoy ($H_{mo} = 3$ m $T_p = 14$ s, Direction SSE) and strong SW winds (wind speed 16 m/s) (Source: CSIR, 2000b).

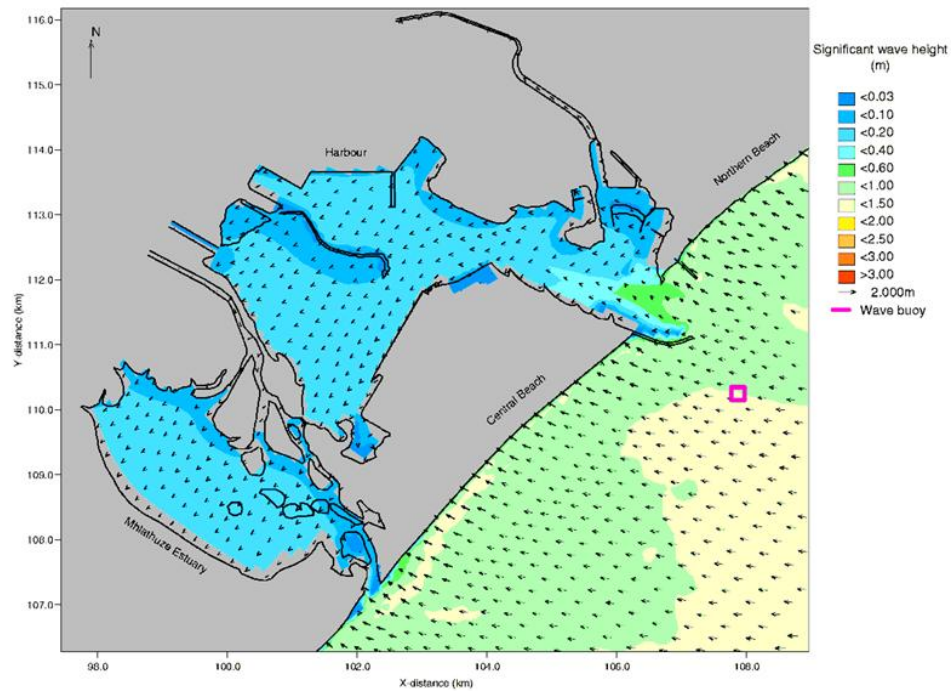


Figure 4-12 - Significant wave height and direction for low to moderate wave conditions at wave buoy ($H_{mo} = 1.5$ m $T_p = 10$ s, Direction ESE) and moderate NE winds (wind speed 6 m/s) (Source: CSIR, 2000b).

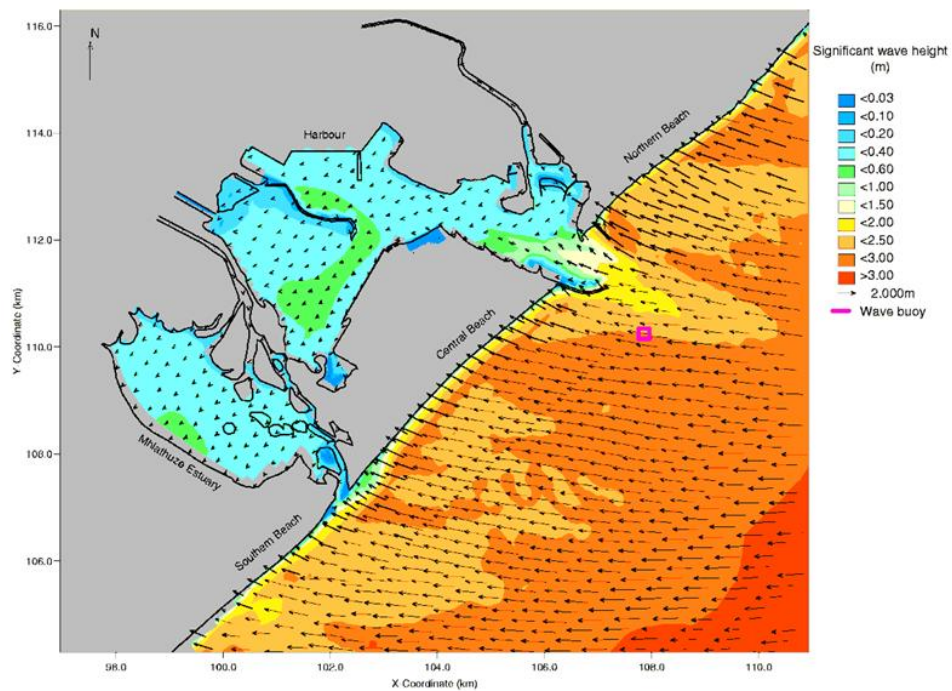


Figure 4-13 - Significant wave height and direction for high wave conditions at wave buoy ($H_{mo} = 3$ m $T_p = 14$ s, Direction ESE) and strong NE winds (wind speed 14 m/s) (Source: CSIR, 2000b).

Wave simulations for ESE wave conditions under low to moderate offshore wave conditions ($H_{mo} = 1.5$ m and $T_p = 10$ s) and moderate NE winds (wind speed = 6 m/s) indicate a significant penetration of wave energy into the harbour (Figure 4-12). Waves from an ESE direction reach the shoreline at an oblique angle and that will tend to drive a southward flowing surf zone current. A moderate NE wind generates wind waves that reach a height of approximately 0.18 m at the southwestern side of the harbour (and the estuary). Simulations for ESE wave conditions under high offshore wave conditions ($H_{mo} = 3.0$ m and $T_p = 14$ s) and strong NE winds (wind speed = 14 m/s) indicate a significantly increased surf zone width due to the increased incident wave height (Figure 4-13), while the strong NE winds generates wind waves that exceed 0.4 m at the southwestern side of both the harbour and Estuary. Evident in both Figure 4-12 and Figure 4-13 is the role of the sand spit in providing protection to the mudflats from wind waves under NE wind conditions. Strong wind conditions result in the waters overlying the mudflats becoming quite turbid. The existence of the sandspit provides a degree of protection from the wind waves being generated that stir up the bottom sediments to create turbid conditions.

Long wave energy is known to exist off the coast of KZN. Long waves have been recorded within Richards Bay (berth 609 and 701), however the occurrence of conditions leading to these long wave motions in the port are seemingly rare and most of the long wave energy recorded lies at periods exceeding 200 s (CSIR, 2005b). The existing long wave energy therefore is not expected to result in mooring motions and cargo handling problems of sufficient magnitude and regularity to be of major concern (CSIR, 1994b; Rossouw *et al.*, 2013). The sand banks, the sand spit and irregular shoreline of the existing port layout are considered to limit the long wave energy within the port and therefore an important part of the “infrastructure” of the port.

4.6 WATER COLUMN STRATIFICATION

Water column stratification is important in that it affects the oceans response to wind and current forcing and therefore the vertical distribution of flow velocities. Generally, the higher the water column stratification, the greater the vertical shear in the horizontal flow velocities and *vice versa*.

The description of water column stratification that follows is strongly based of the measurements reported for the Port of Richards Bay Capacity Expansion EIA (van Ballegooyen *et al.*, 2015) that were based on several field surveys undertaken for that project (CSIR, 2013a,b,c).

4.6.1 WATER COLUMN STRATIFICATION WITHIN THE PORT

Profiling measurements undertaken in the Port of Richards Bay during monitoring programme for the Berth 306 capital dredging project were mostly in shallow water and therefore not suitable for assessing the degree of temperature stratification within the Port of Richards Bay. However, more recent measurements at a number of sites around the port undertaken for the Richards Bay Capacity Expansion project (CSIR, 2013b), that included measurements in the deeper shipping channels, indicate an approximate 2 °C temperature difference between the surface and bottom waters over an approximate 20 m change in water depth (Figure 4-14 and Figure 4-15). This is consistent with other data measured within the port during summer months (e.g., Cyrus and Vivier, 2020). In winter it is expected that the water column will be largely isothermal.



Figure 4-14 - Map of Richards Bay showing the positions where in situ water quality measurements (i.e., temperature profiles) were made for the Richards Bay Capacity Expansion EIA.

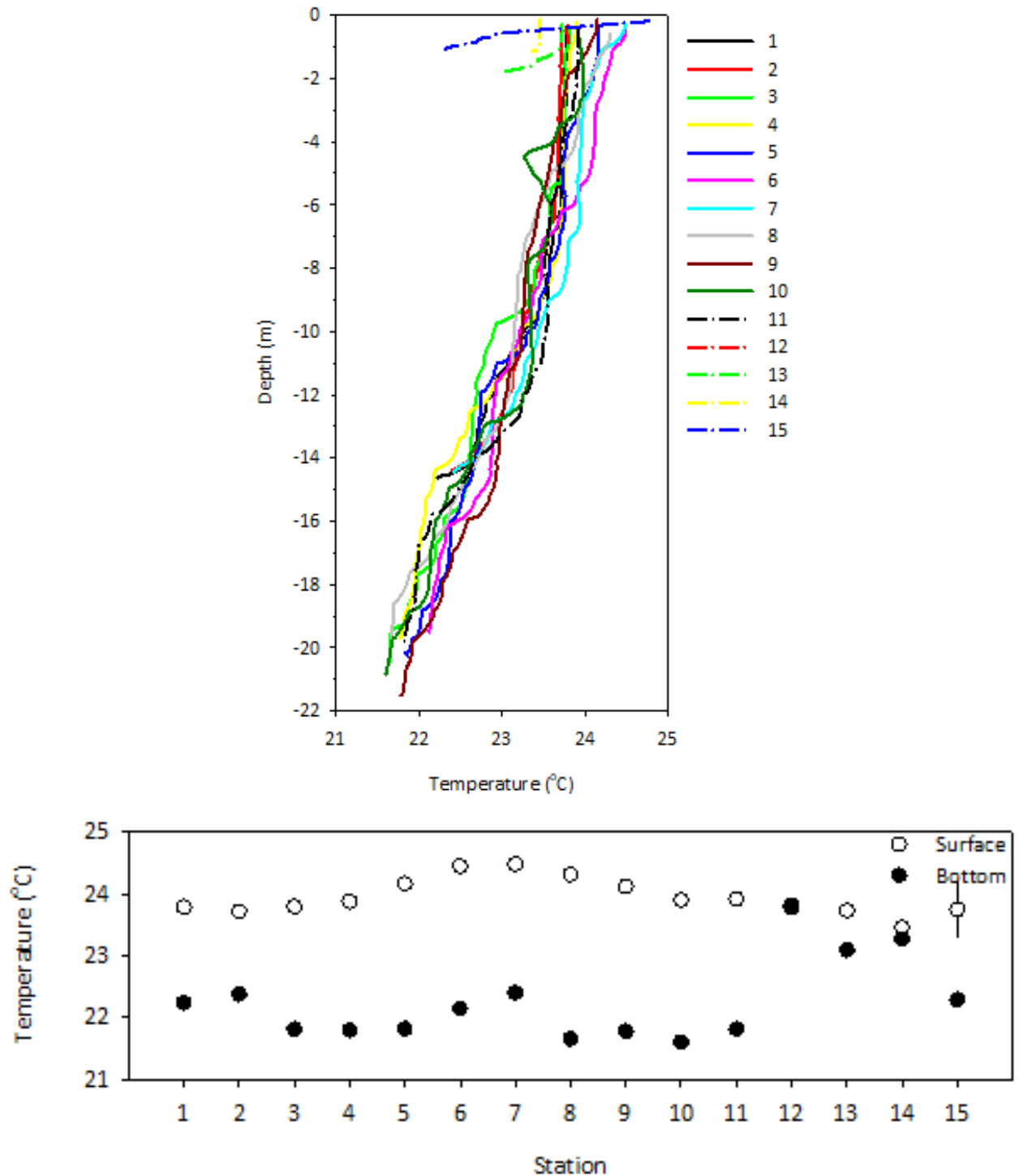


Figure 4-15 - Temperature profiles (upper panel) and temperature differences between the surface and bottom waters as measured on 13 February 2013 (CSIR, 2013b).

4.6.2 WATER COLUMN STRATIFICATION IN THE OFFSHORE WATERS

Water temperature in the region offshore of the Port of Richards Bay is strongly influenced by the close proximity of the Agulhas Current. It is in this region where the Agulhas current brings cold waters closer to the sea surface in a process that has been termed topographically driven upwelling (e.g. Roberts and Nieuwenhuys, 2016). Depending on the local winds, these cold waters may be exposed at the sea surface or remain subsurface. When the Agulhas Current is far offshore the seawater temperatures are generally lower and water column stratification is generally weaker than when the Agulhas Current is located closer inshore. When closer inshore the warmer surface waters of the Agulhas Current and the resultant upwelling that occurs on the inner edge of the Agulhas Current enhance the water column stratification. Similarly local winds may enhance or suppress the upwelling of colder deeper waters and depending on the circumstances may enhance or weaken the water column stratification.

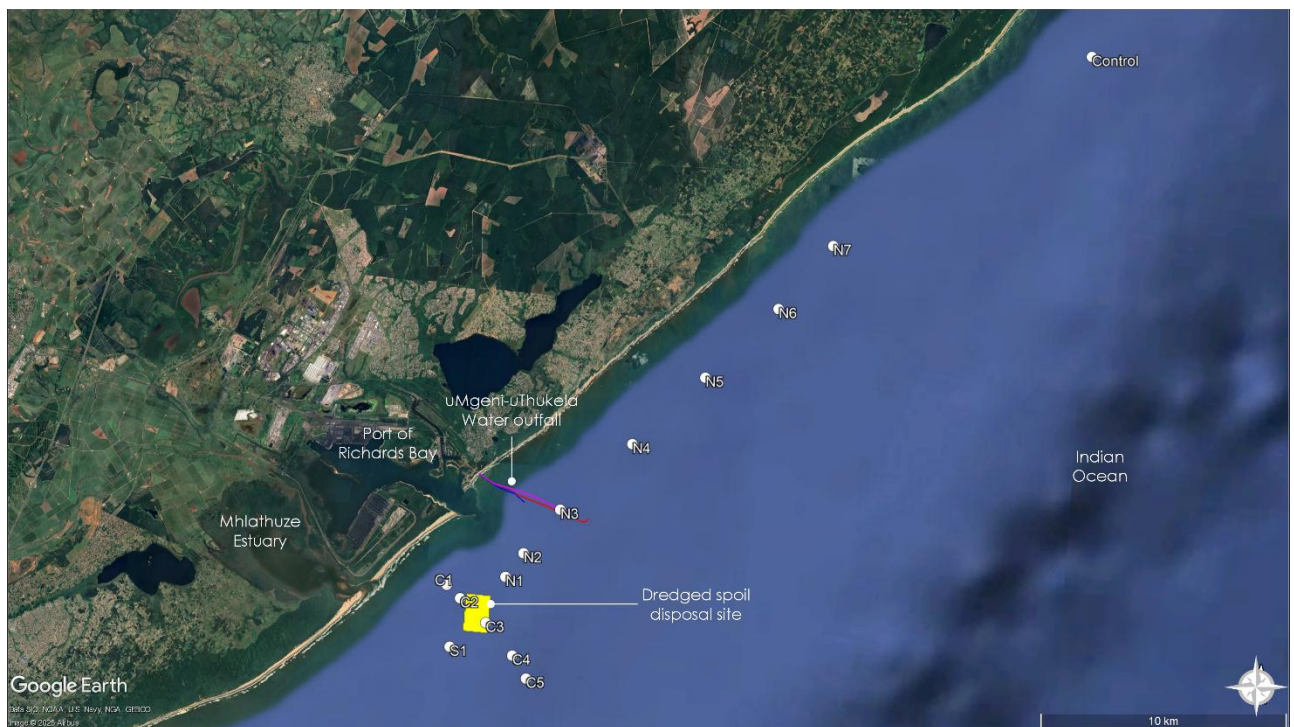


Figure 4-16 - Location of the offshore water and sediment quality measurement sites in 2005 and 2006 for the Berth 306 development at the Richards Bay Coal Terminal in the Port of Richards Bay. These are the sites at which temperature profiles shown in Figures 3.16 and 3.17 were measured.

While measurements further offshore (mid-shelf to shelf-break) indicate an often moderate to highly stratified water column, there are occasions (e.g. during fully developed upwelling conditions) when the water column is largely isothermal. Water column profiling measurements from the Berth 306 dredge monitoring programme (Figure 4-16), while displaying the expected seasonal variation, suggest that the water column offshore of Richards Bay is surprisingly weakly stratified given the nature of the flows and physical processes prevailing in the region (Pillay *et al.*, 2008a as reported in

Van Ballegooyen *et al.*, 2015). There were however two or three occasions in early to late summer when the water column stratification seemed to be significant, but less so for the sites in the immediate vicinity of the dredge spoil disposal site and more so for sites extending northwards from the dredge spoil disposal site (Figure 4-17 and Figure 4-18).

Historical measurements of surface and bottom salinity and temperature within the Port of Richards Bay (reported in CSIR, 2005b) indicate that significant vertical stratification of the water column occurred on a couple of occasions during the summer period. Given that the bottom temperatures observed on these occasions seemingly are similar to those measured at other times of the year and that the surface temperatures observed on these occasions are elevated compared to other times of the year, the observed stratification may simply be a consequence of local heating of the surface waters under relatively calm conditions and not necessarily indicative of cold bottom water intrusions into the harbour. (A cursory examination of wind conditions during these stratification episodes indicated that on one occasion the observations of significant stratification were made just prior to weak NE winds changing to strong SW winds. On the other occasion, no such clear relationship with the winds existed).

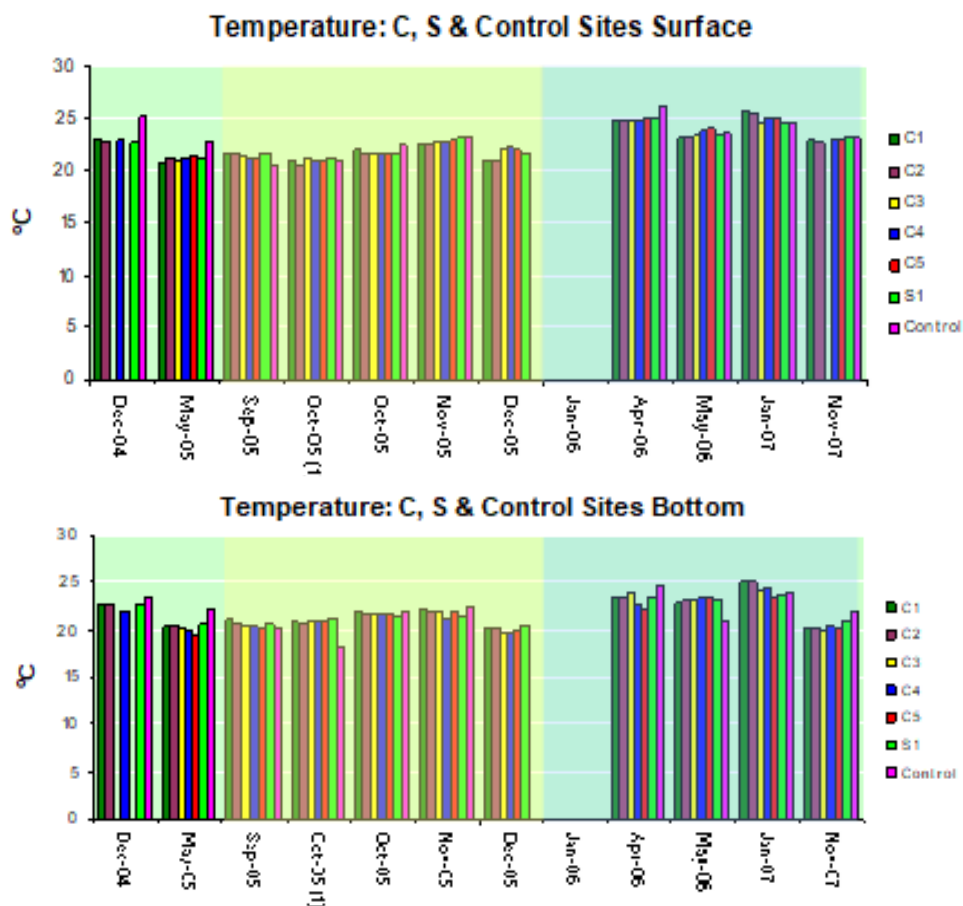


Figure 4-17 - Surface (upper panel) and bottom water (lower panel) temperatures in the vicinity of the dredge spoil disposal site and stretching southwards.

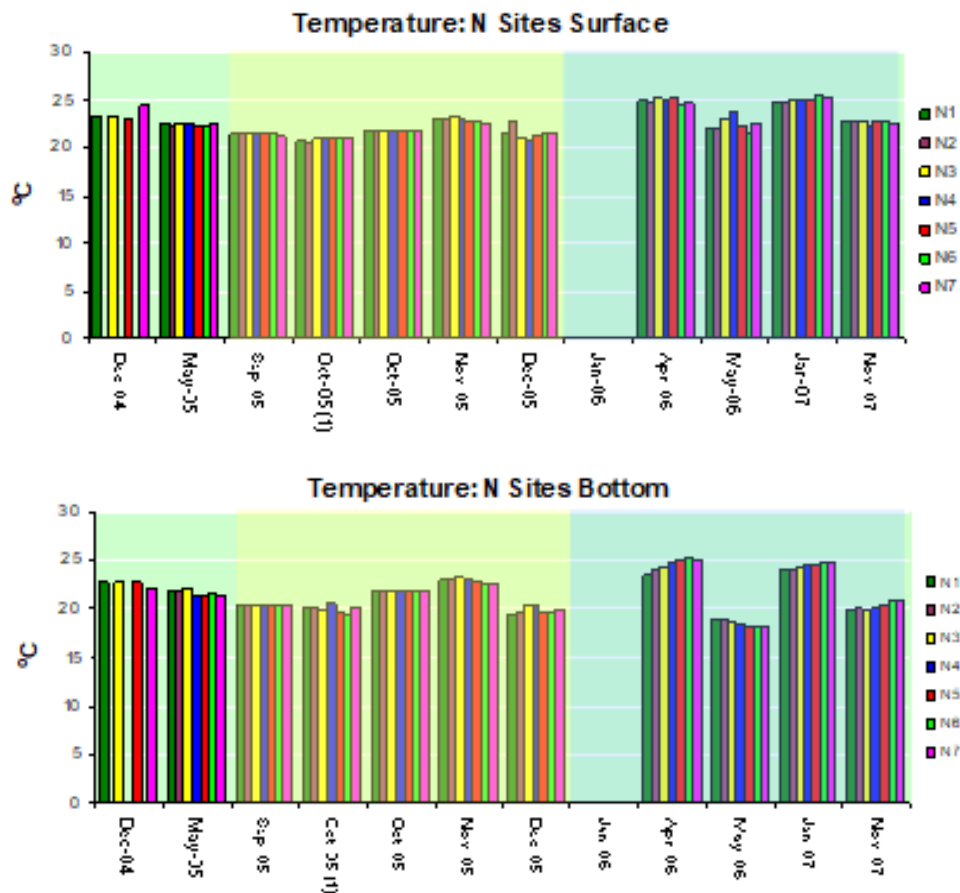


Figure 4-18 - Surface (upper panel) and bottom (lower panel) water temperatures for sites extending northwards from the dredge spoil disposal site

Based on the above observations, together with limitations in available data to inform the modelling study, it was decided not to include stratification effects in the modelling study. Water temperature near the seabed observed in the Acoustic Doppler Current Profiler (ADCP) mooring data at a location just to the southwest of the existing offshore dredge spoil disposal site show one or two significant events per month in late spring and summer, suggesting that the exclusion of stratification effects in the model may on occasion be significant (CSIR, 2009 as reported in van Ballegooyen *et al.*, 2015). However, given the manner in which the modelling was approached, if anything, this will result in a more conservative assessment in terms of turbidity impacts in the water column, *i.e.*, the vertical shear in the model will be less than occurs in reality during such stratification events, resulting in an overestimate of the potential for re-suspension of dredge spoil during these stratification events.

4.7 CURRENTS

For the Port of Richards Bay and its surrounds, three zones of current forcing may be identified upon moving offshore. In the inshore region, the currents are predominantly wave-driven except in the vicinity of the mouth of the harbour and the Mhlathuze Estuary where tidally driven flows predominate. In the zone between the surf zone and the inshore edge of the Agulhas Current (located approximately 10 to 30 km offshore), the currents are predominantly wind-driven (CSIR, 1981; Schumann, 1981) with an increasing influence of the Agulhas Current upon moving offshore. The Agulhas Current dominates at the shelf break and beyond.

The wind-driven currents have a periodicity of 4 to 6 days (Bang & Pearce, 1978) and lag the local winds by approximately 18 hours (Schumann, 1981). There is evidence in this region of the surface waters having a more offshore tendency with the deeper waters having an onshore tendency. This is consistent with dynamic upwelling that occurs at the inshore edge of the Agulhas Current (Lutjeharms *et al.*, 1989). The presence of cold upwelled water offshore of the mouth of Richards Bay has significance in that cold water on occasion may enter the deeper regions of the bay. The resultant water column stratification and associated potential for increased vertical shear in currents in the bay is expected to provide conditions for a more rapid flushing of the waters of Richards Bay than would normally be expected. This effect however is expected to be quite limited.

Several model simulations of the currents in Richards Bay have been undertaken (e.g. CSIR, 1998b, 1999, 2000b, 2004a,b). Only one of these studies considered the effects of water column stratification (CSIR, 1998b), however these model simulations were focussed on storm water discharges into the mouth of the Port of Richards Bay and did not report extensively on three dimensional flows within the port. Given the high-resolution modelling required (particularly in the surf-zone) and the fact that the focus was strongly on surf-zone processes, the modelling undertaken mostly comprised two-dimensional (2D) hydrodynamic simulations (CSIR, 2000b, 2004a,b). While such 2D modelling adequately simulates wave-driven currents (and to a large extent tidal currents), three dimensional (3D) processes such as vertical shear in currents (due to wind forcing and stratification effects) and local wind-driven re-circulation are excluded. Given the lack of measured data of currents in the Port of Richards Bay, the importance of these 3D processes in determining the water quality within the bay is uncertain. However, it is deemed prudent to include these processes in modelling studies that are focussed on detailed water quality processes with the harbour. In the present modelling study three-dimensional flows are modelled, however stratification effects and any influence that these may have in changing the vertical shear in horizontal flows are not included in the model.

The main circulation features within the Port of Richards Bay as indicated by these modelling studies (CSIR, 2000b, 2004a,b) and summarised in CSIR (2005a) are as follows:

- Strong tidal currents occur in the mouth of the Mhlathuze Estuary where predicted current speeds exceed 1.4 m/s at spring ebb and flood (e.g., Figure 4-19 and Figure 4-20). Tidal currents in entrance of the harbour are predicted to rarely exceed 0.2 m/s at spring ebb and flood, however for high wind conditions the spring flood and ebb flows in the port entrance may significantly exceed 0.2 m/s (Figure 4-21 and Figure 4-22). Tidal currents are also significant in shallow regions such as the mudflats on the south-west side of the bay and the mangrove regions, particularly the mangroves south of the Richards Bay Coal Terminal (RBCT).
- Under high SW winds and spring ebb flow conditions, current of up to 0.5 m/s may be generated on the northern side of the mudflats (Figure 4-21 and Figure 4-22) while under strong NE winds

the flows are somewhat reduced and concentrated on the southern side of the mudflats (Figure 4-23 and Figure 4-24);

- Under SW winds clockwise flows are generated on the mudflats both during spring flood and ebb conditions (Figure 4-19 to Figure 4-22). Conversely, under NE winds conditions an anticlockwise residual circulation develops over the mudflats during both spring flood and ebb conditions (Figure 4-23 and Figure 4-24). The magnitude of these residual circulations increases with increasing wind speeds.
- In general, the surf zone current follows the wave direction in all conditions modelled (*i.e.*, SSE waves drive the surf zone current northward and the ESE waves drive the surf zone current southward), except when winds are strong enough to reverse weaker inshore wave-driven currents associated with low wave conditions (*e.g.*, a northward inshore current due to the low to moderate SSE waves is reversed by strong NE winds). Consequently, surf-zone currents may flow in an opposite direction to the wind-driven currents prevailing further offshore (*e.g.* a combination of high ESE waves conditions and strong SW winds will result in southward flowing surf zone currents and northward flowing wind-driven currents further offshore).

Significant freshwater inflows into the Port of Richards Bay through the Bhizolo, Manzanymama and Mzingazi Canals occur on occasion. These inflows have the potential to set up locally significant flows within the harbour as well as affect locally water column stratification. Walmsley *et al.* (1999) report that there is no monitoring of the fresh water flowing into the Port of Richards Bay, however limited data on these inflows exists (see synthesis of stormwater inflows in van Ballegooyen *et al.*, 2020).

The key wind, wave, current and sediment transport processes within the Port of Richards Bay and its immediate surrounds have been schematised in Figure 4-25 (CSIR, 2005a). The major hydrodynamic features may be summarised as follows:

- Strong tidal currents occur in the narrow mouth of the Mhlathuze Estuary. The tidal currents in the mouth of the harbour are much smaller in magnitude and are considered to range from approximately 0.03 m/s during neap tides to approximately 0.17 m/s during spring tides (CSIR, 1998b). Under certain wind conditions the wind-driven component of the flow in the harbour mouth is expected to reinforce these tidal flows. The tidal flows diminish towards the inner recesses of the harbour.
- Strong wind-driven flows occur within the port under higher wind conditions, particularly in the shallow regions. Strong SW winds set-up a residual clockwise circulation on the mudflats on the south-west side of the harbour. Conversely, strong NE winds set up an anticlockwise residual circulation.
- Freshwater inflows via the Bhizolo Canal, the Manzanymama Canal and particularly the Mzingazi Canal are expected to set-up locally significant flows in the harbour.
- Accretion and erosion problems occur within the harbour due to wave action. Regions of shoreline erosion and accretion within the Port of Richards Bay are indicated in Figure 4-25;
- Wave action and wave-driven surf-zone currents result in significant sediment transport along the beaches. The magnitude and direction of these nearshore currents are variable and are determined by the prevailing near shore wave direction, however there is a strong net transport to the north.

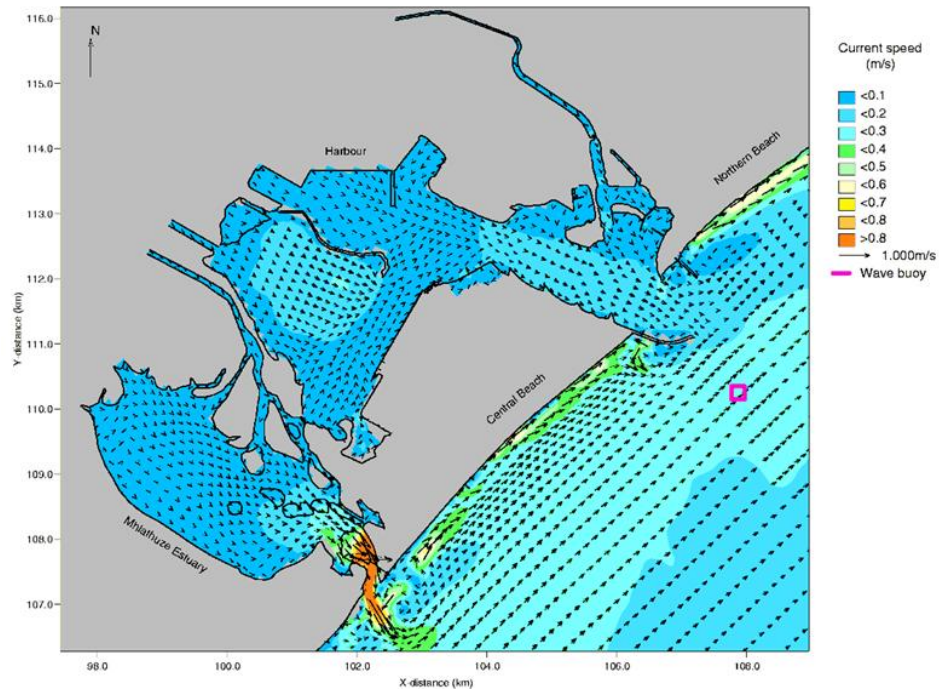


Figure 4-19 - Current speed and direction at spring ebb under low to moderate wave conditions ($H_{mo} = 1.5$ m $T_p = 10$ s, Direction SSE at wave buoy) and moderate SW winds (wind speed 7 m/s) (Source: CSIR, 2000b).

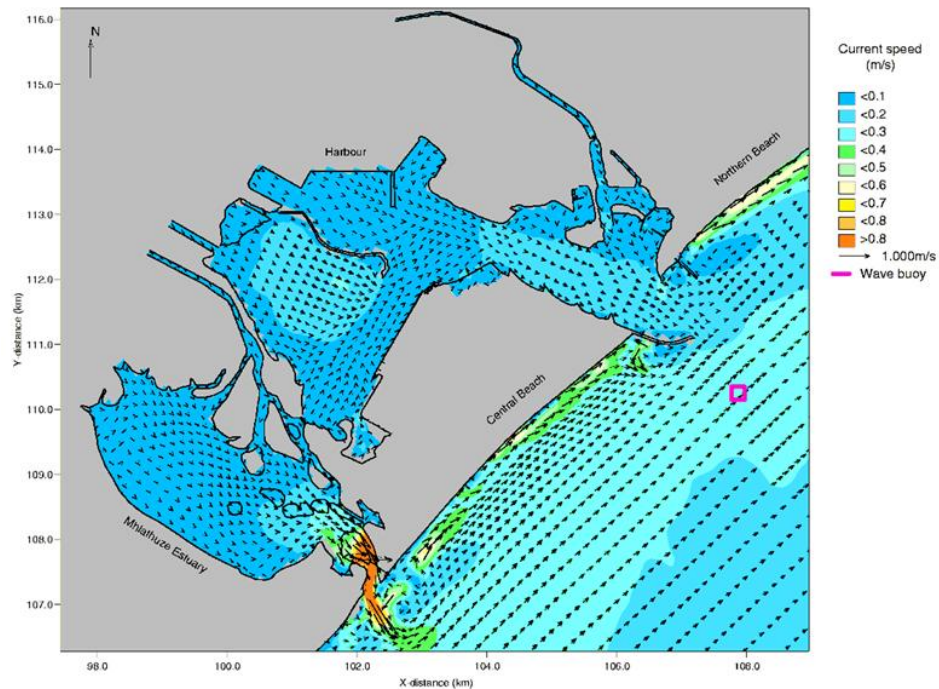


Figure 4-20 - Current speed and direction at spring flood under low to moderate wave conditions ($H_{mo} = 1.5$ m $T_p = 10$ s, Direction SSE at wave buoy) and moderate SW winds (wind speed 7 m/s) (Source: CSIR, 2000b).

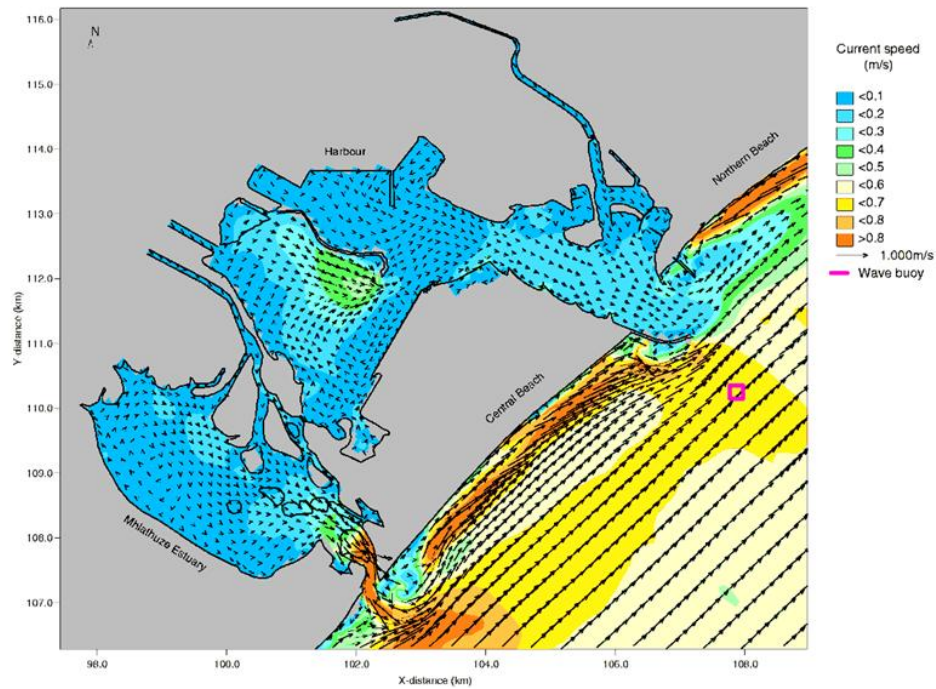


Figure 4-21 - Current speed and direction at spring ebb under low to moderate wave conditions ($H_{mo} = 3.0$ m $T_p = 14$ s, Direction SSE at wave buoy) and strong SW winds (wind speed 16 m/s) (Source: CSIR, 2000b).

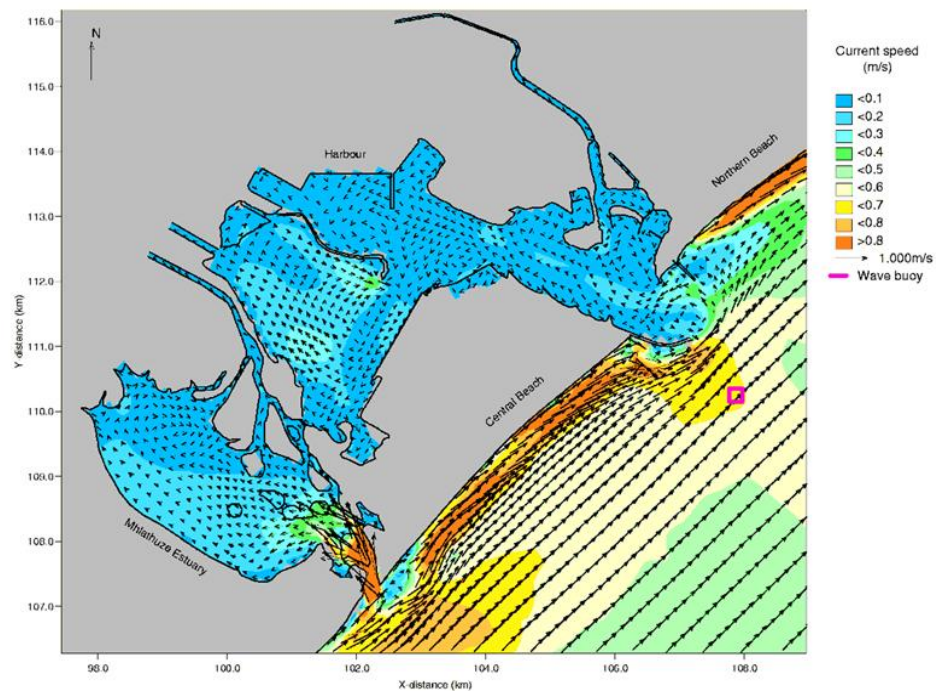


Figure 4-22 - Current speed and direction at spring flood under low to moderate wave conditions ($H_{mo} = 3.0$ m $T_p = 14$ s, Direction SSE at wave buoy) and strong SW winds (wind speed 16 m/s) (Source: CSIR, 2000b).

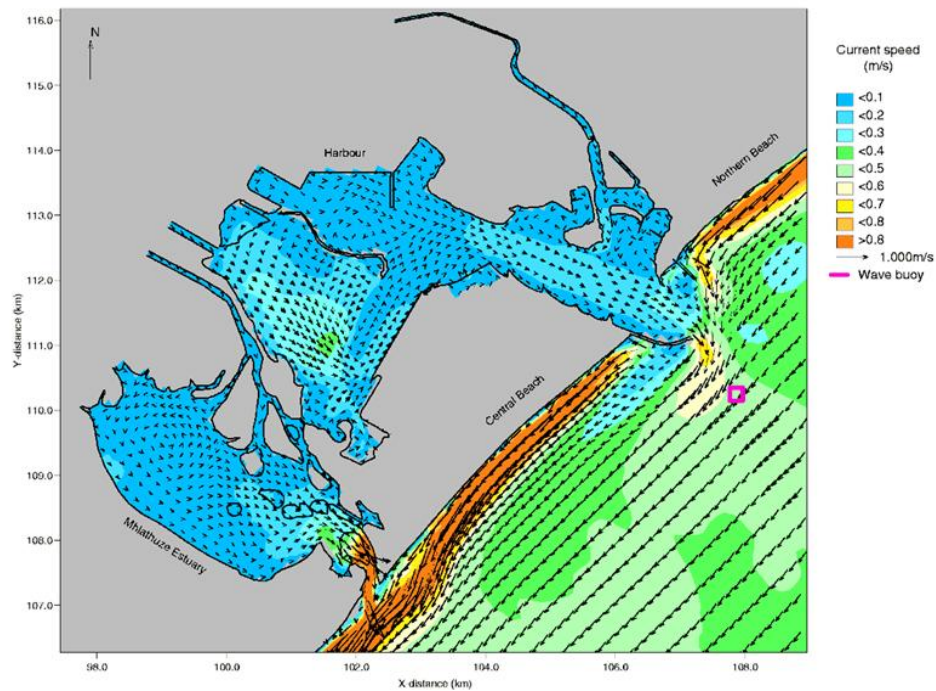


Figure 4-23 - Current speed and direction at spring ebb under low to moderate wave conditions ($H_{mo} = 2.5$ m $T_p = 11$ s, Direction ESE at wave buoy) and strong NE winds (wind speed 14 m/s) (Source: CSIR, 2000b).

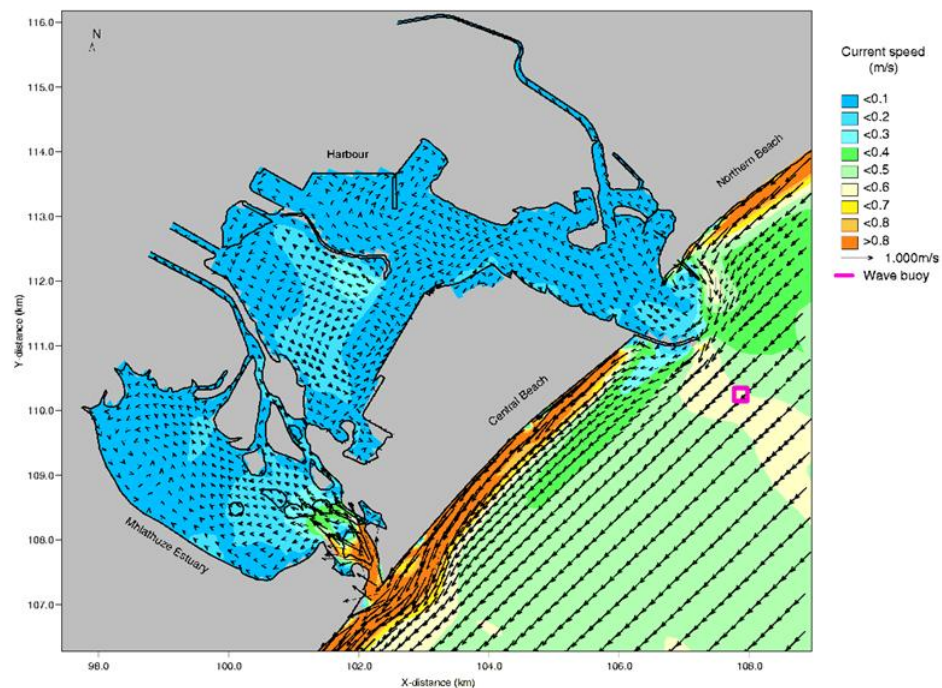


Figure 4-24 - Current speed and direction at spring flood under low to moderate wave conditions ($H_{mo} = 2.5$ m $T_p = 11$ s, Direction ESE at wave buoy) and strong NE winds (wind speed 14 m/s) (Source: CSIR, 2000b).



Figure 4-25 - Schematic of the major hydrodynamic processes (Source: (CSIR, 2005a)).

4.8 WATER QUALITY

The water quality within the Port of Richards Bay has been described in CSIR (2013b) where potential threats to water quality within the Port of Richards Bay have been identified. Subsequent water quality monitoring has further elaborated on the main aspects of water quality within the Port of Richards Bay (CSIR, 2013d, 2016, 2017, 2025).

The key variables of concern when assessing dredging activities, namely dissolved oxygen, turbidity and suspended sediment concentrations. Prior to the capital dredging monitoring programme for the Berth 306 development (e.g. Weerts, 2008), the available water quality sampling data were not adequate for developing an appropriate water quality baseline for dredging assessments due to their sparse coverage and limited sampling of the sensitive areas within the port and the offshore environment surrounding the existing dredge spoil disposal site. Subsequent water quality data measurements undertaken for the Port of Richards Bay Capacity Expansion specialist dredging studies (CSIR, 2013a-c), other proposed developments within the port (e.g., Cyrus and Vivier, 2020)

and for ongoing water quality monitoring by the CSIR, have been used to develop an environmental baseline for the Berth 605 development project (CSIR, 2025).

The most critical measurements when assessing potential dredging impacts are turbidity and total suspended sediment (TSS) concentrations in the water column thus only the turbidity and TSS concentrations measurements are reported here. Although turbidity and total suspended solids concentrations in the water column, in principle, should display a strong relationship to one another this is not always the case (CSIR, 2013c). Poor relationships may come about because the total weight of particles in suspension is a direct function of their number, size and specific gravity, but turbidity is a direct function of the number, surface area and refractive index of the particles but an inverse function of their size. Dissolved substances, which are not part of the suspended solids load, affect turbidity but not the suspended solids concentration as they pass through a 45 µm pore size filter (*i.e.*, the filter generally used when determining total suspended solids concentrations). This also may contribute to a poor relationship between turbidity and total suspended solids concentrations. It is for this reason that both turbidity and suspended sediment concentrations are reported here.

4.8.1 TURBIDITY / TSS CONCENTRATIONS WITHIN THE PORT OF RICHARDS BAY

The turbidity and TSS concentration measurements for the Port of Richards Bay have been summarised for the period prior to 2014 (CSIR, 2013a-c, van Ballegooyen *et al.*, 2015) and for the period from 2015 to the present (CSIR, 2025). A synthesis of these results is provided in the environmental baseline developed for the Berth 605 project (CSIR, 2025).

The turbidity and TSS concentrations reported for the Richards Bay Port Expansion project (CSIR, 2013a-c and van Ballegooyen *et al.*, 2015) were for data measured at the locations indicated in Figure 4-26.



Figure 4-26 - Locations in the Port of Richards Bay of turbidity profiling and water sampling for the laboratory measurement of turbidity and analysis of suspended sediment concentrations.

The turbidity and suspended sediment concentrations observed in the Mhlathuze Estuary, in the Port of Richards Bay (and its immediate environs) and offshore in the vicinity of the dredge spoil site and beyond, have been summarised by Weerts (2008) and in CSIR, 2013a-c).

In the Mhlathuze estuary turbidity typically ranges from 10 NTU to more than 60 NTU on occasion, however typical values are in the 15 to 30 NTU range (Figure 4-27). Using the relationships developed in CSIR (2013c), this translates into typical suspended sediment concentrations of between approximately 25 and 50 mg/l.

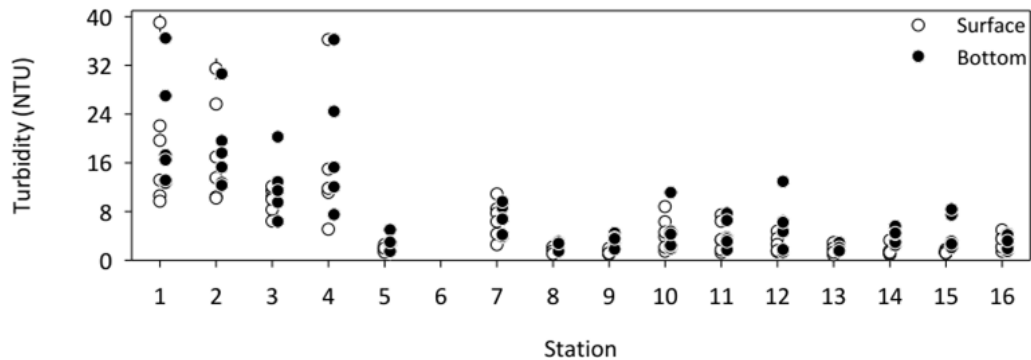


Figure 4-27 - In-situ measurements of turbidity at the surface and near the bottom at the locations indicated in Figure 3.28.

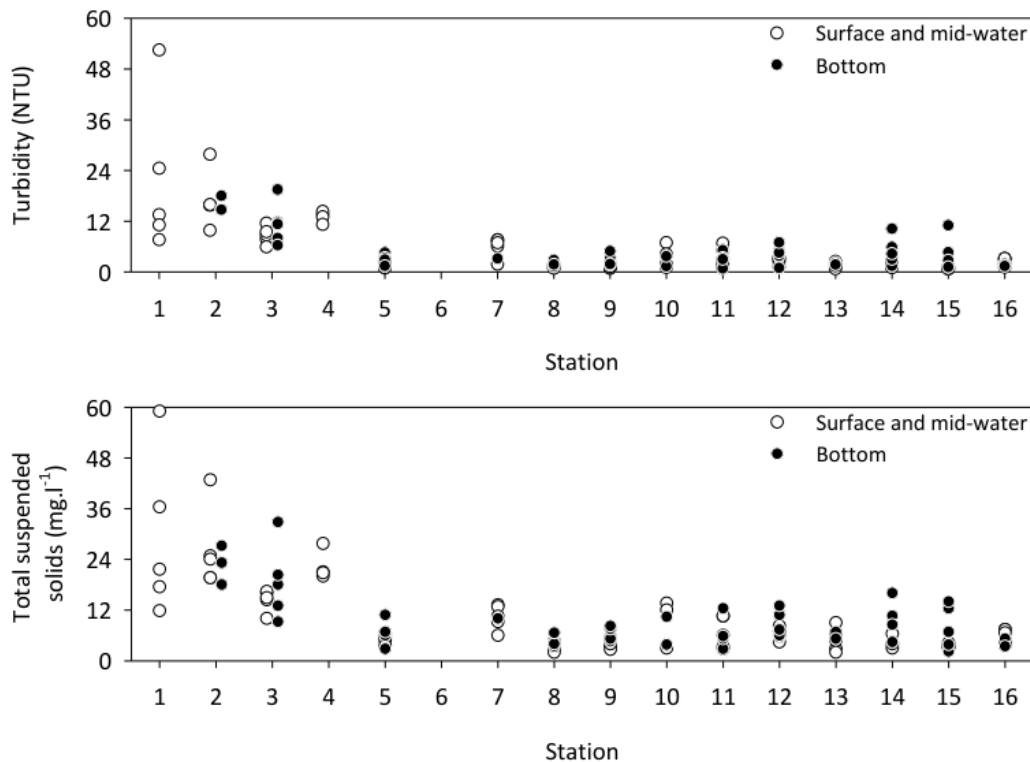


Figure 4-28 - Measurements of turbidity (in laboratory) and TSS concentrations from samples obtained at the sea surface and near the bottom at the locations indicated in Figure 4-26

The above data show, in the Port of Richards Bay, that there is a strong spatial variation in the turbidity observed with the highest turbidity being observed on the mudflats, increasing towards the Bhizolo Canal (Weerts, 2008). The observed turbidity is much lower through most of the water column in the deeper waters of the shipping canals and berths; however, the turbidity measured near the seabed may be high due to the increased fines content of the sediments in these deeper waters.

The measured distribution of the observed in-situ turbidity (measured in the field using a profiler) and turbidity and suspended solid concentrations obtained in the laboratory from field samples are presented in Figure 4-28 (CSIR, 2013c). The location of the profiling and the sampling are indicated in Figure 4-26 above. It is these measurements that were used to develop the relationship between turbidity and TSS concentrations reported in Section 7.2.2.1.

Water quality data were measured over a 15-year period between 2015 and 2024 at the locations indicated in Figure 4-29 below. The measured turbidity of the surface and bottom water waters at these locations during this period, are summarised in Figure 4-30.

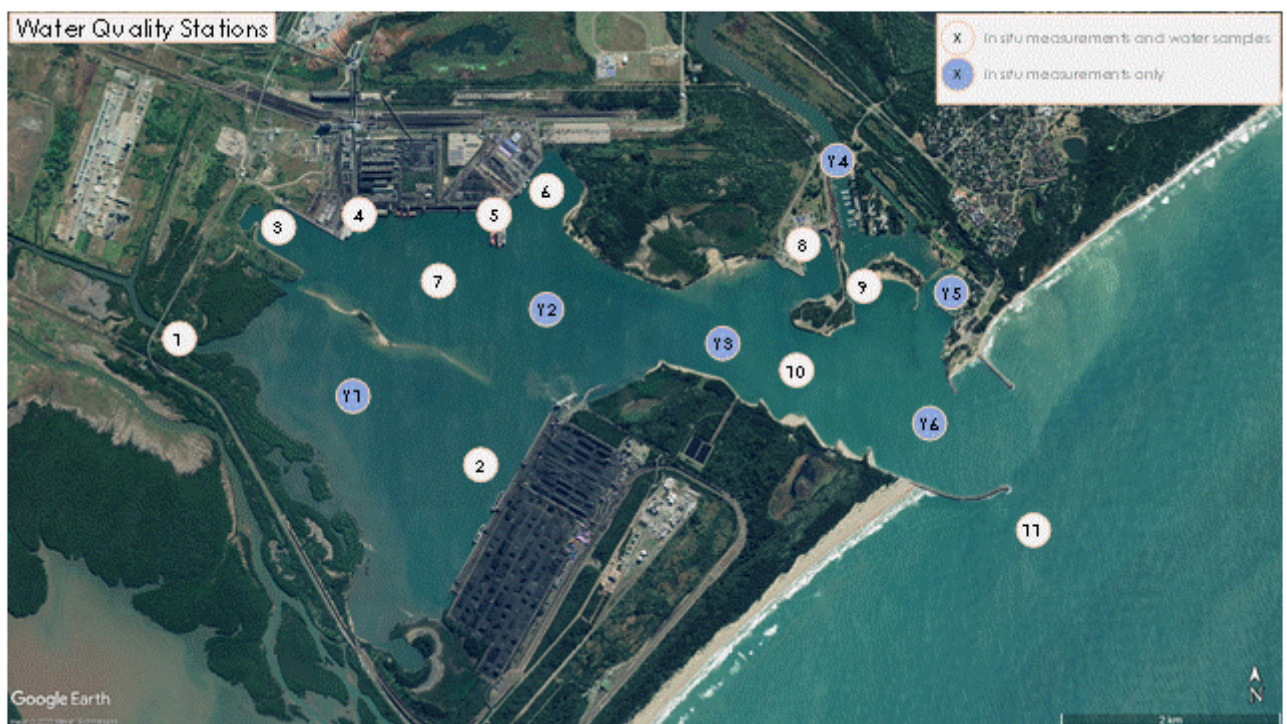


Figure 4-29 - Aerial view of the Port of Richards Bay showing the stations where water quality was monitored in situ and surface water samples were collected by the CSIR for physical, chemical, and biological analysis and toxicity testing in the laboratory in 15 surveys between 2015 and 2024 (CSIR, 2025).

These data show the turbidity in the Port of Richards Bay to be typically low (<10 NTU), particularly in deeper water channels and basins, but is often higher in shallower parts of the port such as on the Kabeljous Flats, in the Bhizolo-Manzanyama Canal complex, and in Mzingazi Canal (see also Cyrus and Vivier, 2021a,b). As observed in CSIR (2025), wind driven waves and currents combined with a relatively muddy substrate and shallow water column are an important driver of the higher suspended

sediment concentrations and related turbidity of the water column on the Kabeljous Flats. Freshwater inflows also account for elevated suspended sediment concentrations and related turbidity in the Bhizolo-Manzanyama Canal complex and in Mzingazi Canal, but these flows have little effect on the larger port waterbody. However, even in the Bhizolo-Manzanyama Canal complex and in Mzingazi Canal the turbidity is usually not especially high.

There is evidence of high turbidity in the vicinity of the port entrance. Such observations could be due to re-suspension of sediments in the surf-zone and nearshore that propagate into the area surrounding the port entrance but also could be due to maintenance dredging activities (see Figure 6-11).

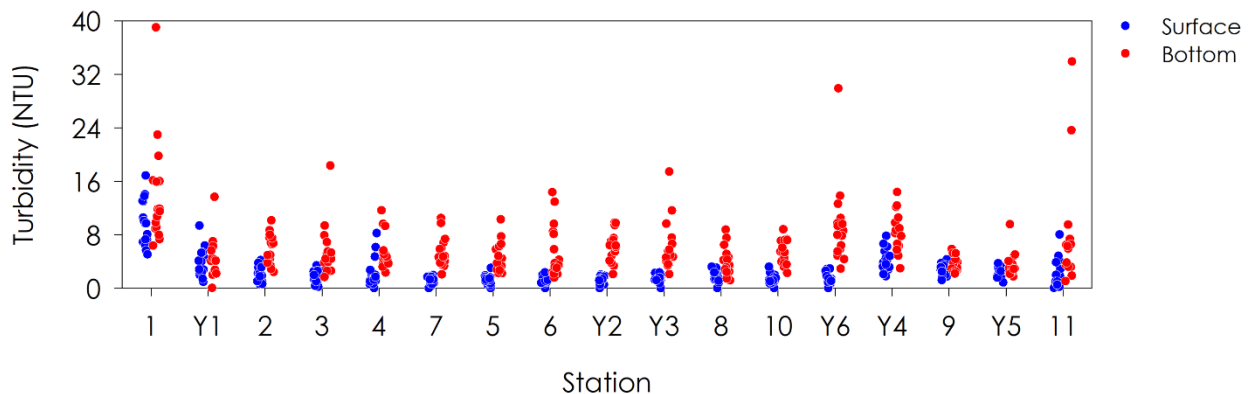


Figure 4-30 - The turbidity measured in surface and bottom water in the Port of Richards Bay in 15 surveys between 2015 and 2024 (CSIR, 2025).

In general, the port can be regarded as a low turbidity (although not necessarily clear water) system, since the turbidity in the deeper water channels and basins that constitute the largest water expanse in the port are generally low. However, the turbidity and TSS concentrations in the water column can increase sharply when large vessels are manoeuvred by tugs due to vessel propeller wash disturbance of bottom sediment, with near-bottom turbidities of 86.5 and 77.8 NTU being at sites near vessel berthing operations in the Richards Bay Coal Terminal Basin. Similarly, maintenance dredging also contributes to an increase in the suspended sediment concentration and related turbidity in the water column in the port (see Figure 6-6). However, the increase in the suspended solids concentration and related turbidity associated with vessel propeller wash and maintenance dredging operations is usually short-lived, returning to the baseline within tens of minutes (CSIR, unpublished data; S Weerts (CSIR), B Newman (CSIR), personal observation).

The last capital dredging programme in the Port of Richards Bay occurred for the development of Berth 306 at the Richards Bay Coal Terminal in the latter part of 2005. Dredging activities had a clear impact on water column turbidity (and TSS concentrations) within the port that increased from an average of 8.3 NTU across 18 stations in the Richards Bay Coal Terminal Basin before dredging to 42.0 NTU during dredging (Figure 4-31 and Figure 4-32). The highest turbidities were observed at the dredging location but nevertheless remained on average approximately 60% above pre- and post-dredging measurements at a station ~3.6 km from dredging operations and in the Bhizolo-Manzanyama Canal complex (CSIR, 2025). Near the dredging operations, turbidities >100 NTU in the water column were not uncommon and were on occasion >300 NTU. However, within a week of the last dredging operation the turbidity had returned to the baseline established before dredging.

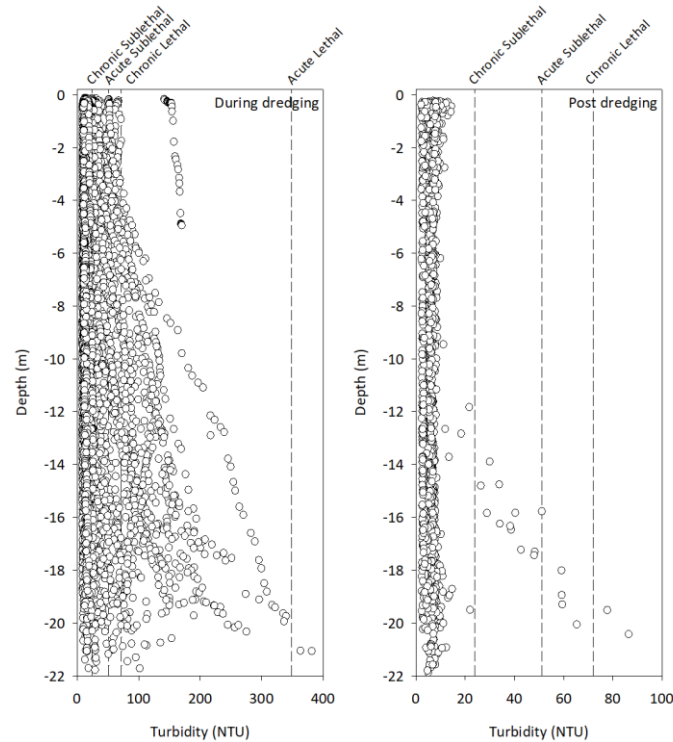


Figure 4-31 - Turbidity profiles measured during (left) and after (right) dredging for the Richards Bay Coal Terminal expansion programme (CSIR, 2025).

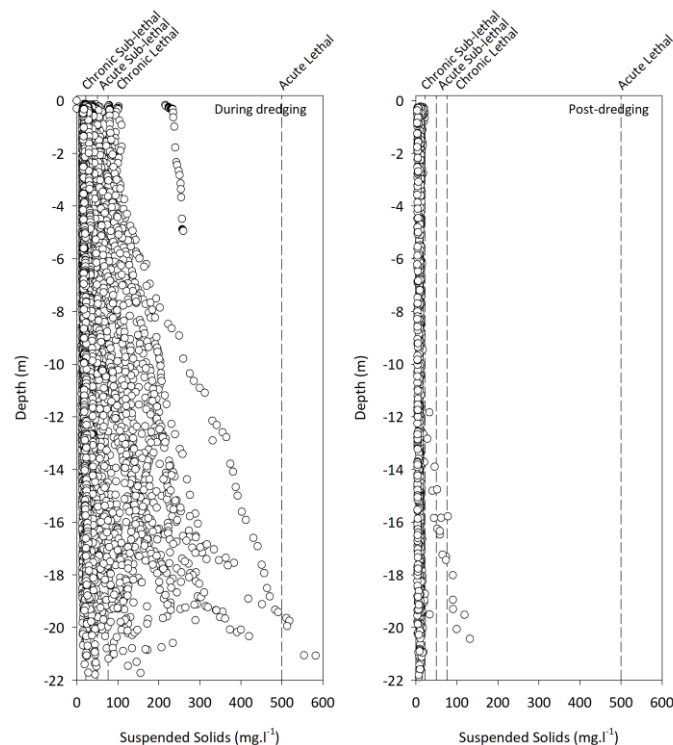


Figure 4-32 – TSS concentration profiles measured during (left) and after (right) dredging for the Richards Bay Coal Terminal expansion programme (CSIR, 2025).

4.8.2 TURBIDITY / TSS CONCENTRATIONS IN THE OFFSHORE REGION

Suspended sediment concentrations and related turbidity in the water column off Richards Bay are highly variable, influenced by flows from the Mhlathuze River, maintenance dredging (including the sand trap just south of the port entrance), dredged material disposal at the dredged spoil disposal site, the pumping of sediment onto beaches to the north of the port entrance as part of a beach nourishment programme, erosion of the shoreline where it is characterised by clay outcrops, and wastewater discharge through the uMgeni-uThukela Water outfalls.

Turbidity measurements undertaken during the Berth 306 capital dredging monitoring programme, suggest that water column turbidity in the vicinity of the proposed dredge spoil disposal site and along an SW to NE axis through the site typically ranges between 2 and 8 NTU in the surface waters and 2 NTU and 16 NTU near the seabed (Weerts, 2008). Using the relationships between NTU and suspended sediment concentrations in mg/l reported in CSIR (2013c), this translates into a range of suspended sediment concentrations of between 3 and 12 mg/l for the surface waters and 3 and 24 mg/l for the near bottom waters. It should be noted that the higher values were observed both before and during dredge spoil disposal activities.

The depth-averaged turbidity measured in the vicinity of the dredge spoil disposal site are presented in Figure 4-33 below. If these are to be interpreted as suspended solid concentrations, the NTU value need to be multiplied by approximately a factor of 1.53 (CSIR, 2013c). It is interesting that these turbidity values did not display clear and unequivocal evidence of the expected elevation in turbidity associated with dredge spoil disposal, possibly due to the confounding effects of seasonality with respect to the sediment-laden inflows into the marine environment that occur in this region. However, there exists periods during the dredging when there seemingly was elevated turbidity in the vicinity of the dredge spoil disposal site, including one occasion (27/11/2005) where elevated turbidity (~ +5 NTU compared to pre-dredging values) was observed stretching some 12 km north of the dredge spoil disposal site (Weerts, 2008).

While these depth-averaged turbidities provide an insight into the overall turbidity in the water column, it is more likely that elevation in turbidity and TSS concentration will be more easily observed in surface, mid-water and near bottom turbidity and TSS concentration measurements, rather than measurements integrated throughout the water column. Turbidity and suspended sediment measurements made off Richards Bay before, during, and after dredged material disposal for the Berth 306 Project, are plotted for the surface waters, mid-water column and near bottom waters in Figure 4-34 (Northern sites) and Figure 4-35 (Southern and Central sites and a Control site), respectively.

These turbidity and TSS concentration measurements undertaken during surveys before, during, and after dredged material disposal for the Berth 306 Project in the Port of Richards Bay are highly variable and not easily attributable to dredge material disposal activities. For example, suspended solids concentrations as high as 43.5 mg/l were recorded primarily at or near the disposal site prior to dredging commencing (CSIR, 2008). These high turbidities were widely observed across most sites during this period, suggesting that they were attributable to high wind and waves conditions. The low turbidities observed after the cessation of dredging also could be due seasonal effects, *i.e.*, generally more calm conditions.

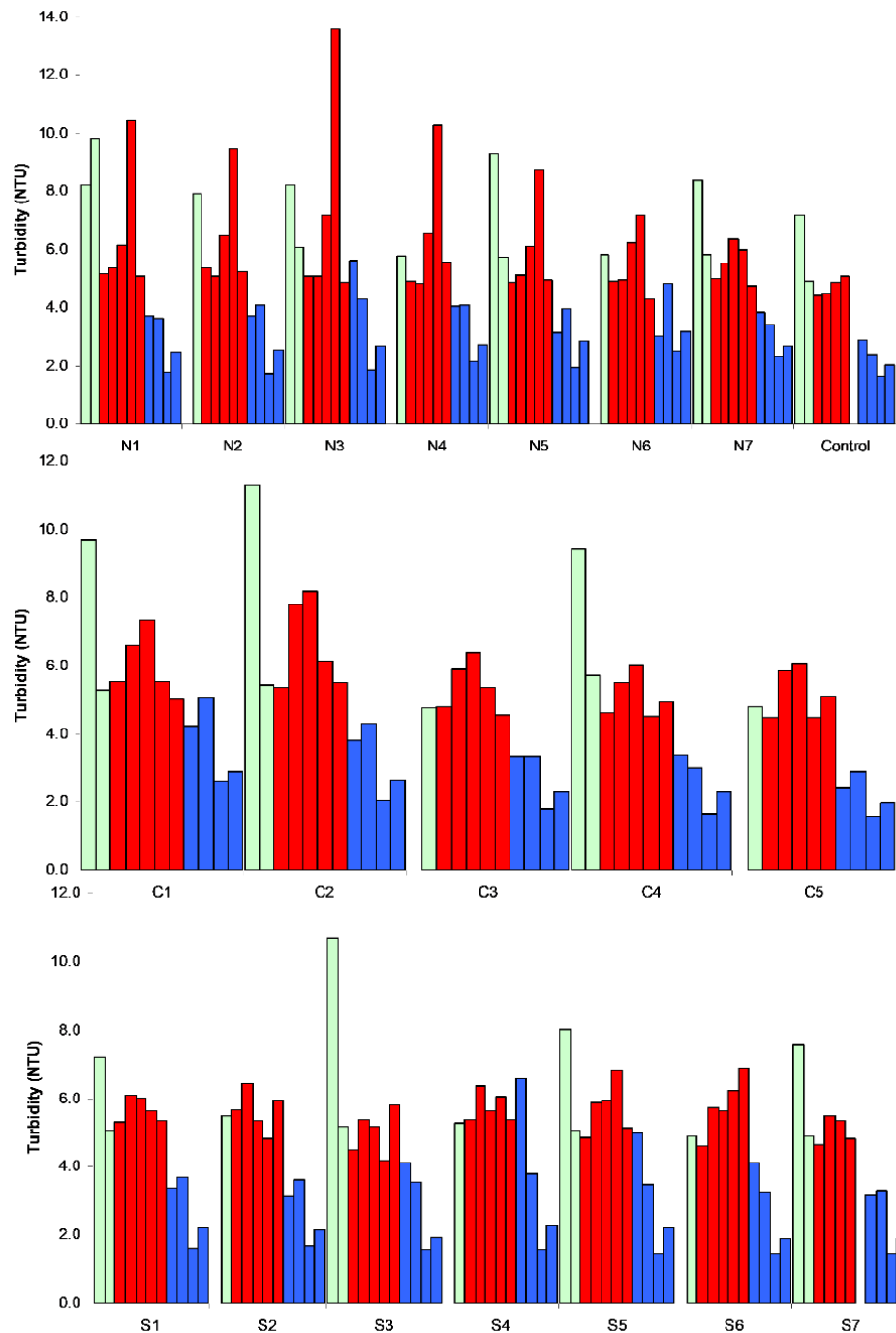


Figure 4-33 - Water column averaged turbidity measured at the offshore locations indicated in Figure 4-16 (Source: Weerts, 2008).

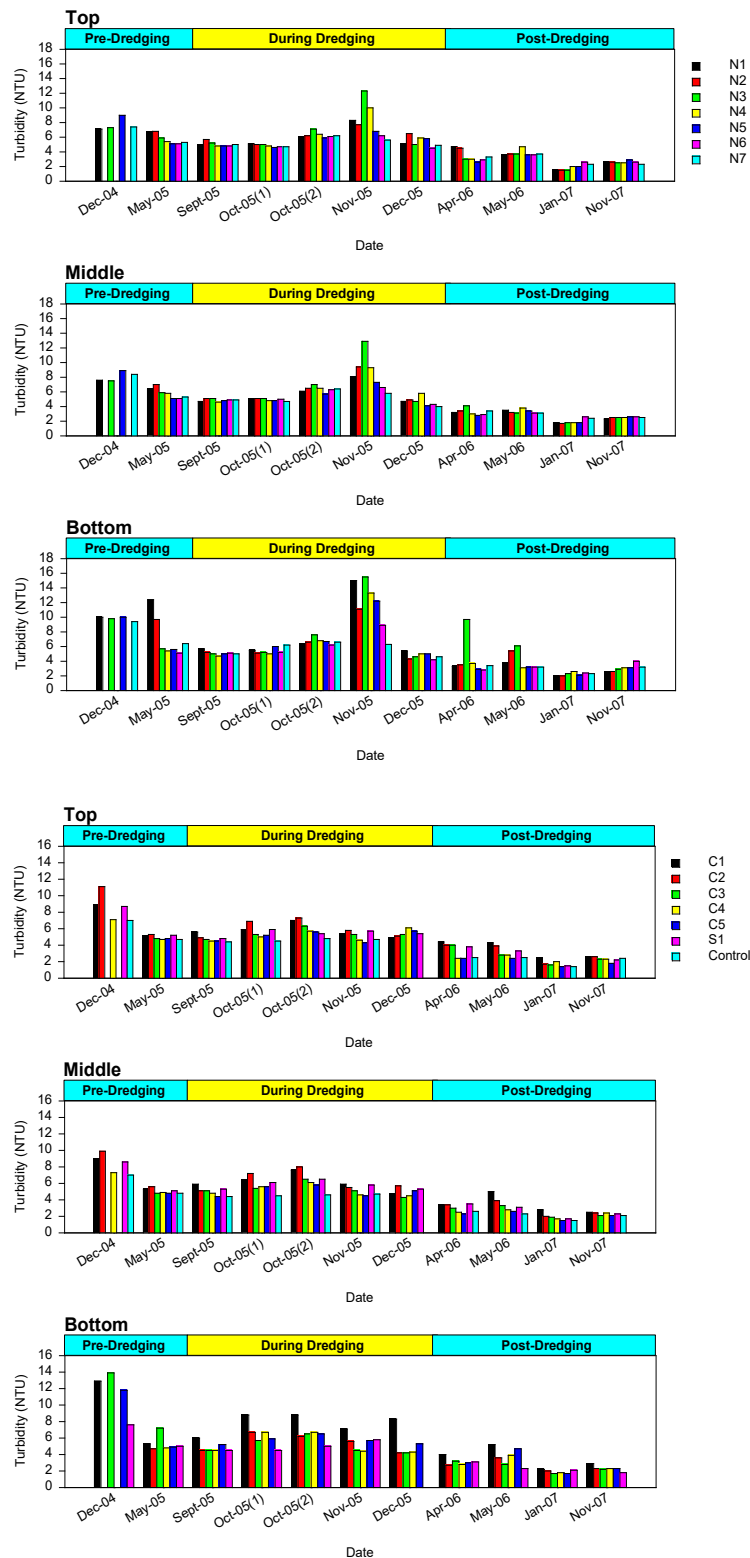


Figure 4-34 - Turbidity measurements in surveys made by the CSIR in the marine environment off Richards Bay before, during, and after dredged material disposal for the Berth 306 development in the Port of Richards Bay: North Sites (N) in upper panels and Southern (S), disposal site (C) and Control sites in lower panels. Data gaps reflect no data.

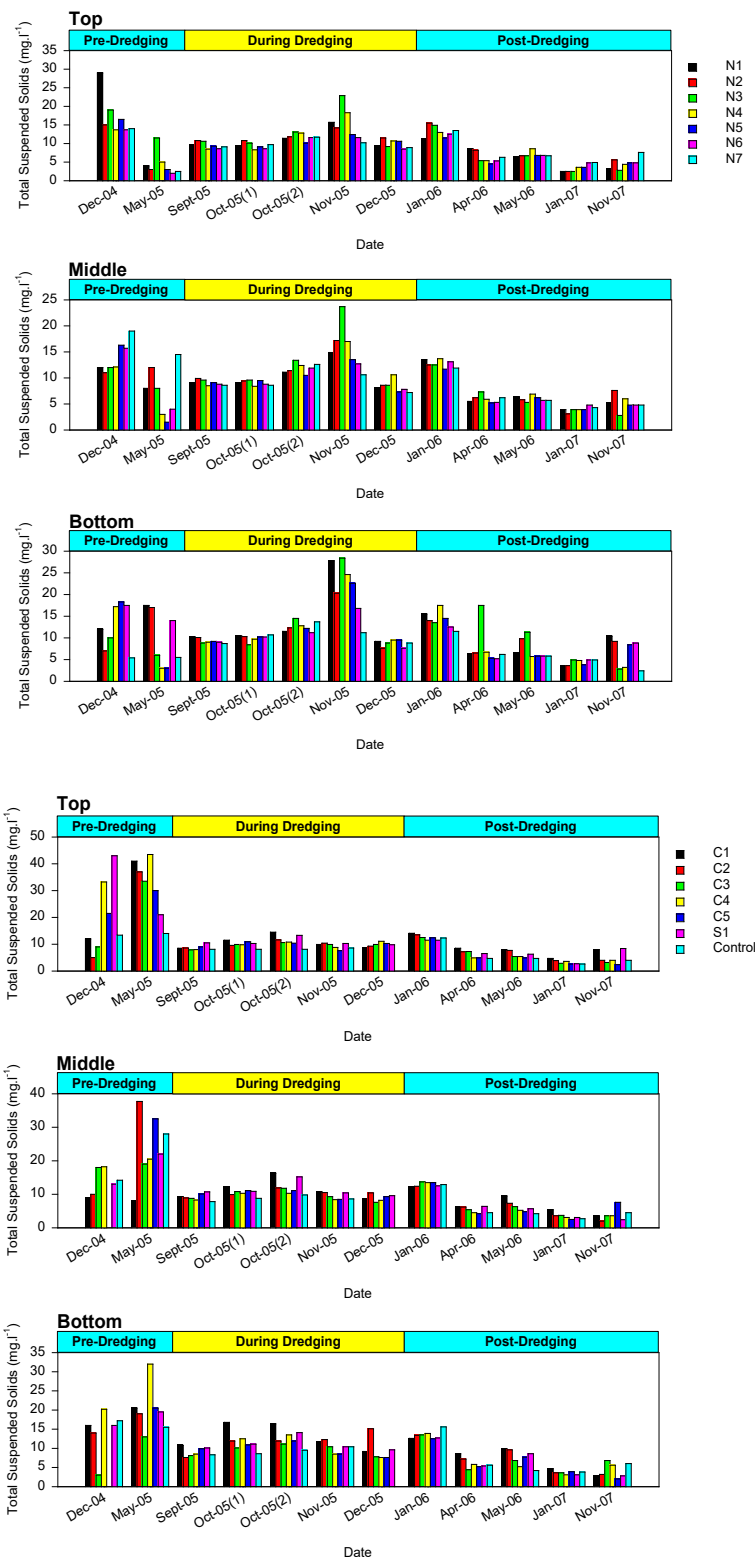


Figure 4-35 – TSS concentration measurements in surveys made by the CSIR in the marine environment off Richards Bay before, during, and after dredged material disposal for the Berth 306 development in the Port of Richards Bay: North Sites (N) in upper panels and Southern (S), disposal site (C) and Control sites in lower panels. Data gaps reflect no data.

Continuous measurements of turbidity using optical backscatter (OBS) instrumentation on moorings located both to the north (location K) and the south (location L) of the dredge spoil disposal site (Figure 4-37) indicate a number of occasions where there is significant elevation of water column turbidity. While there were issues with the bio-fouling and subsequent calibration of these instruments, there is reasonable confidence in the limited periods of data presented in Figure 4-37. These observations indicate the expected temporal variability in turbidity associated with wind, wave and current events. Significant is that the profiling from the field exercises reported in Weerts (2008) only coincided with the period of valid OBS time series data on two occasions. Furthermore, on only one of these occasions did the turbidity profiling from the field surveys coincide with a period of elevated turbidity identified in the OBS mooring data (26-27/11/2005). This is the occasion identified in Weerts (2008) when the most extreme elevations in turbidity were observed stretching northwards of the dredge spoil disposal site. The above suggests that if the monitoring of the offshore region were to have been more regular, the chances are that more such events would have been observed in the data from the offshore profiling surveys.



Figure 4-36 - Locations of the OBS moorings K and L during the Berth 306 Dredge monitoring programme

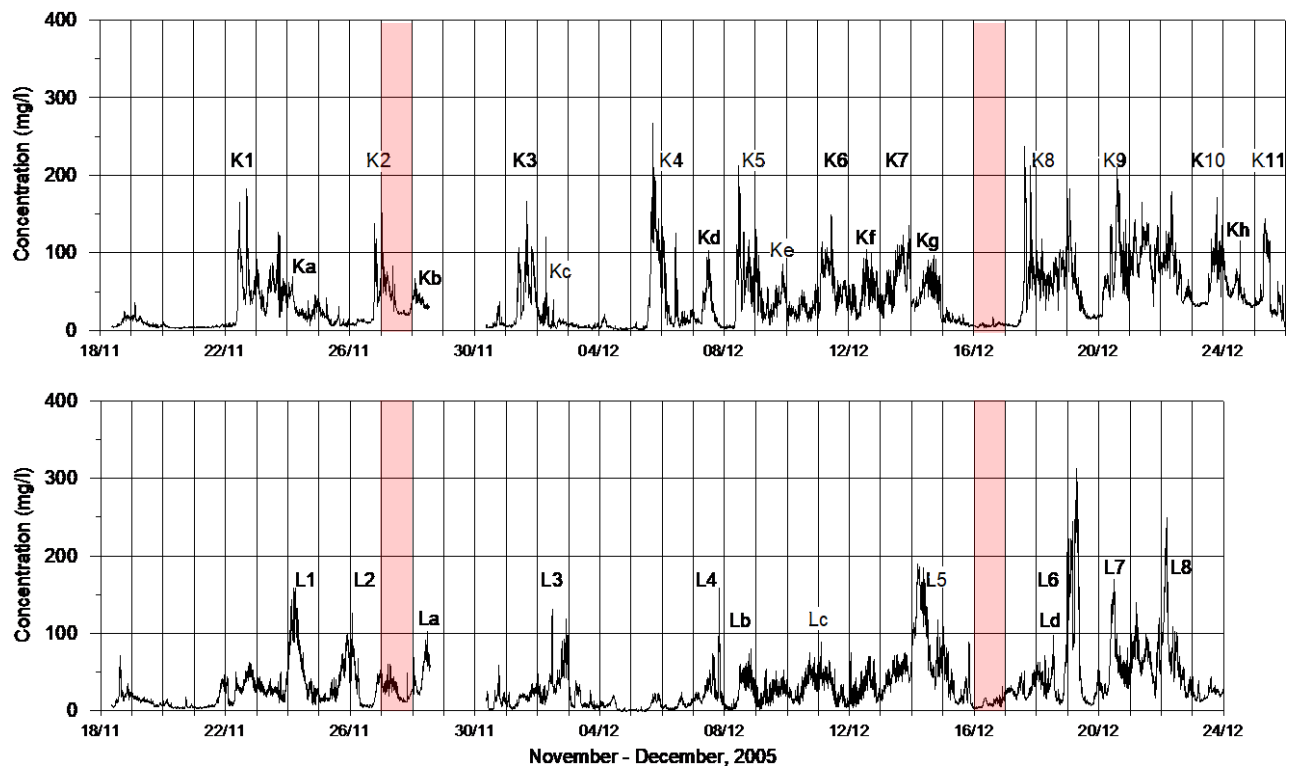


Figure 4-37 - Time series of turbidity recorded by OBSK (top) and OBSL (bottom) for the data of Period A. The “significant” events have been marked (K1 – K11 and L1 – L8), while smaller events are also indicated (Ka – Kh and La – Ld). There is very little visual correlation between the significant events of the two records which is not unexpected as the two measurement sites were on opposite sides of the dredge spoil disposal site. The shaded area represents the days when concurrent turbidity profiling was undertaken in the offshore region (Source: CSIR, 2009).

The implication of these observations is that care should be taken in using the profiling data alone to develop an environmental baseline for turbidity in the offshore region. Furthermore, even greater care should be taken in using only the profiling data (that has limited temporal resolution) to set thresholds for compliance monitoring and management of dredging activities as has been done in CSIR (2013c).

5 NUMERICAL MODELLING

5.1 WAVE MODELLING

The waves for the modelling study are simulated using the DELFT3D-WAVE (SWAN – Simulating Waves Nearshore) refraction module. The results are used in the coupled DELFT3D-FLOW hydrodynamic module to simulate the wave-driven currents in addition to wind-driven and tidal currents. The following processes need to be accounted for in the wave model to transform a deep-water incident wave condition into the nearshore and surf-zone environments:

- Refraction (*i.e.*, change in wave direction in shallow water);
- Depth-induced wave breaking;
- Depth-induced shoaling (*i.e.*, increase in wave height in shallow water); and,
- Bottom friction (*i.e.*, seabed effects that reduced wave height).

Included in the model simulations are locally generated seas both in the offshore and within the Port of Richards Bay, as it is expected that wave generated turbulence and resultant enhanced bottom stresses are likely to be important over the tidal flats.

5.1.1 DESCRIPTION OF THE WAVE MODEL

The third-generation wave-generation and refraction model SWAN was applied (Deltares, 2017a). SWAN is run within DELFT3D-WAVE environment, which provides a convenient interface for pre- and post-processing and for including wave-current interactions.

The SWAN-model is based on the discrete spectral action balance equation and is fully spectral (in all directions and frequency), implying that short-crested random wave fields propagating simultaneously from widely different sources can be accommodated (*e.g.*, a swell with superimposed wind sea). SWAN computes the evolution of random, short-crested waves in coastal regions with deep, intermediate and shallow water and ambient currents. The SWAN model accounts for refractive propagation due to currents and depth and can represent the processes of wave generation by wind, dissipation by white-capping, bottom friction and depth-limited wave breaking and non-linear wave-wave interactions (quadruplets and triads) explicitly with state-of-the-art formulations. Wave blocking by currents is also explicitly represented in the model. However, diffraction (*i.e.*, the lateral transfer of energy along the wave crest) is not explicitly modelled in SWAN.

5.1.2 WAVE MODEL SET-UP

The computational grid, bathymetry and wave conditions used in the wave model are described below.

5.1.2.1 Computational Grid

For the wave modelling, two computational grids were used. The larger outer computational grid extended beyond the limits of the hydrodynamic model. This ensures that:

- Wave conditions were available over the full extent of the hydrodynamic model, and
- Wave conditions at the offshore boundary are applied in water depths where refraction has not yet occurred.

The lateral boundaries are also located far from the region of interest to prevent inaccuracies in boundary conditions affecting the simulations in the area of interest. The large wave grid and the high-resolution nested grid used for wave and hydrodynamic modelling is presented in Figure 5-1.

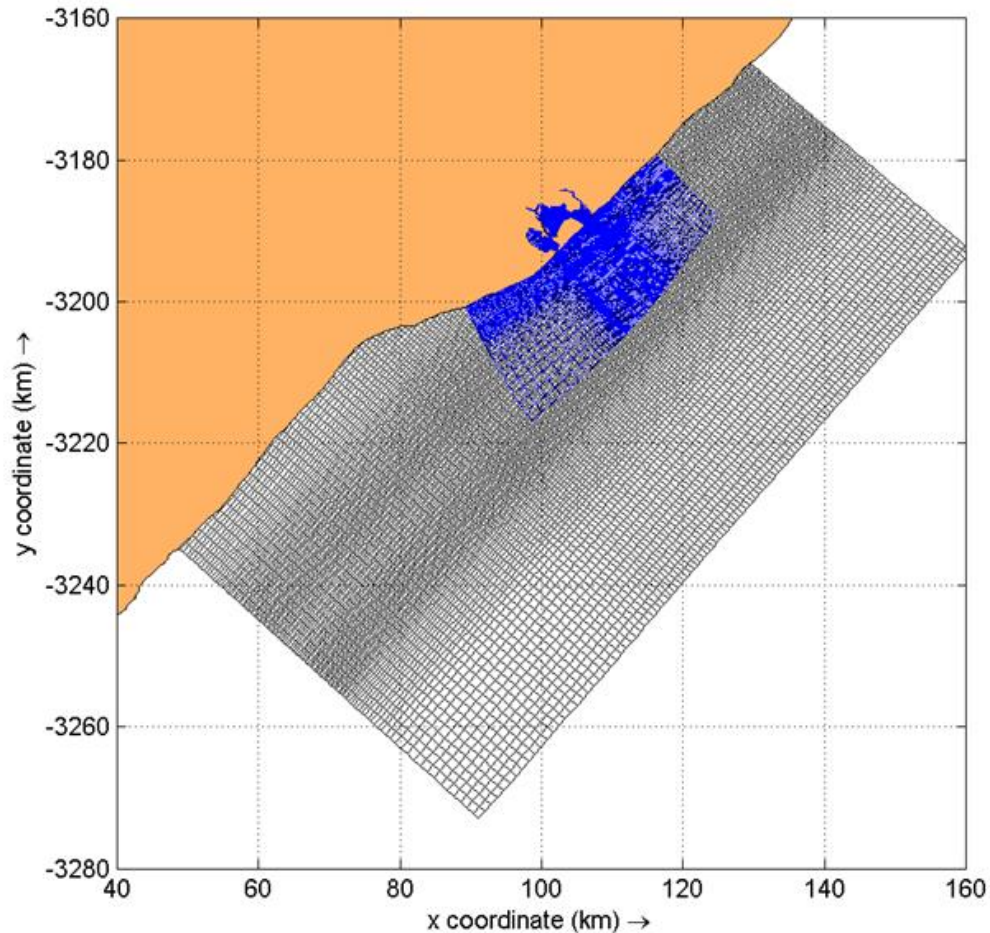


Figure 5-1 - Large wave grid (black) and detailed flow and wave grid (blue)

5.1.2.2 Bathymetry

The bathymetry used in the large grid is presented in Figure 5-2, with the detailed flow grid bathymetry presented in Figure 5-3. A wider area around the disposal was updated with a 2007 bathymetric survey (van den Baossche *et al.*, 2007) survey and the immediate dumpsite extent updated with the most recent January 2025 bathymetric survey data (TNPA, 2025) and the resultant bathymetry presented Figure 5-4.

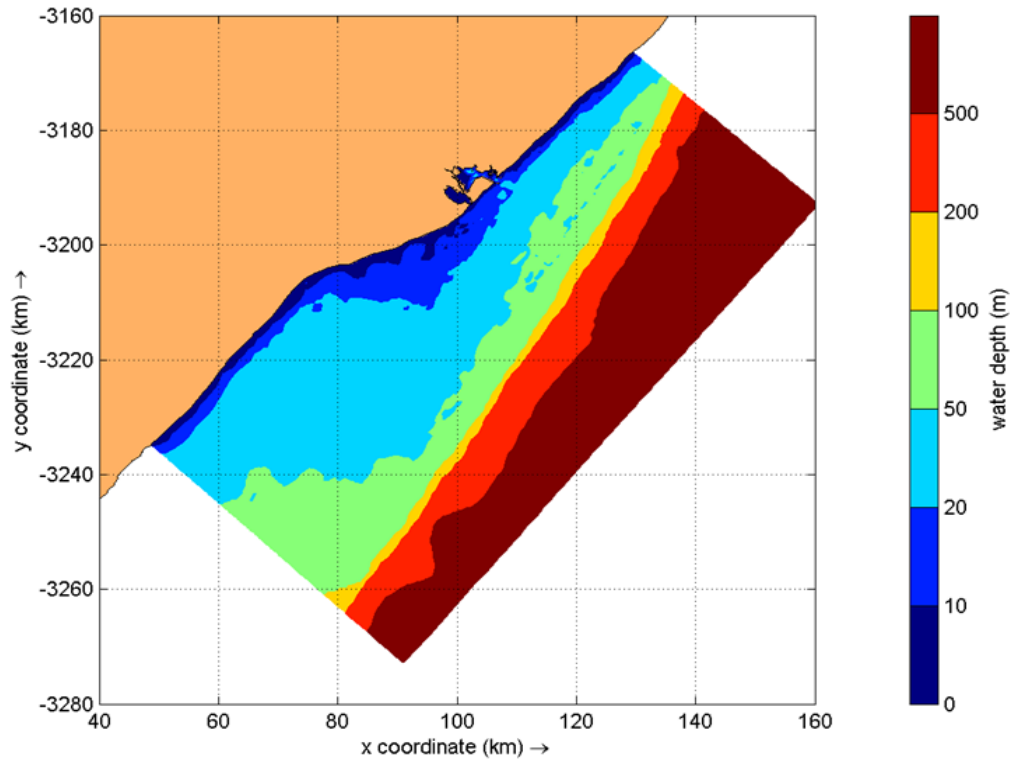


Figure 5-2 - Large wave grid bathymetry

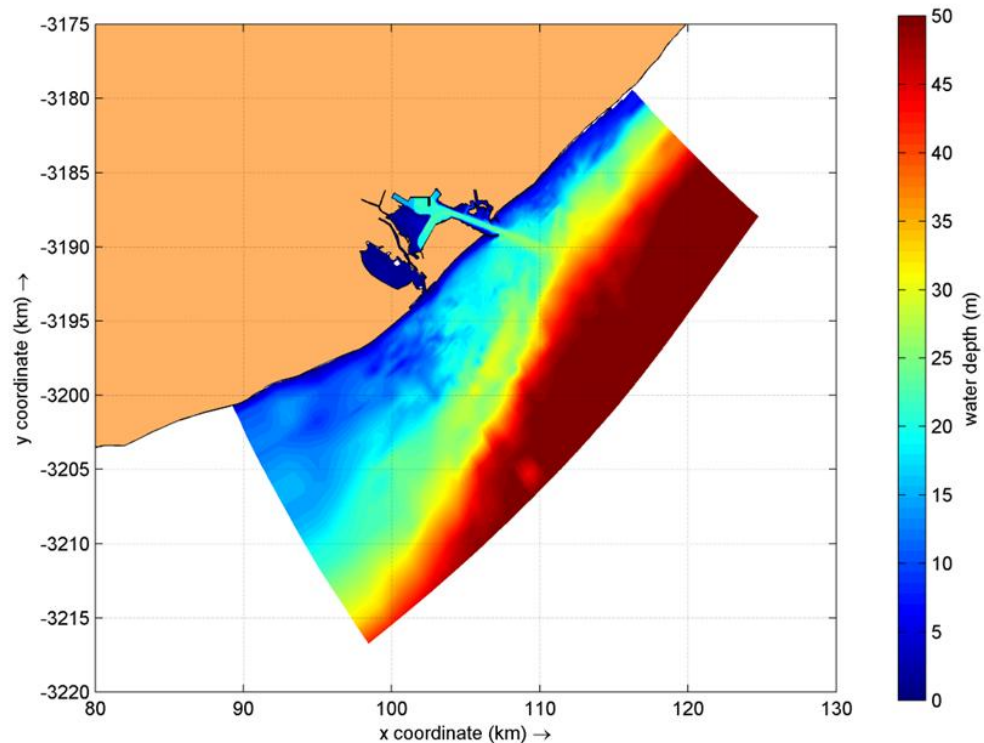


Figure 5-3 – Detailed flow and wave grid bathymetry: overview

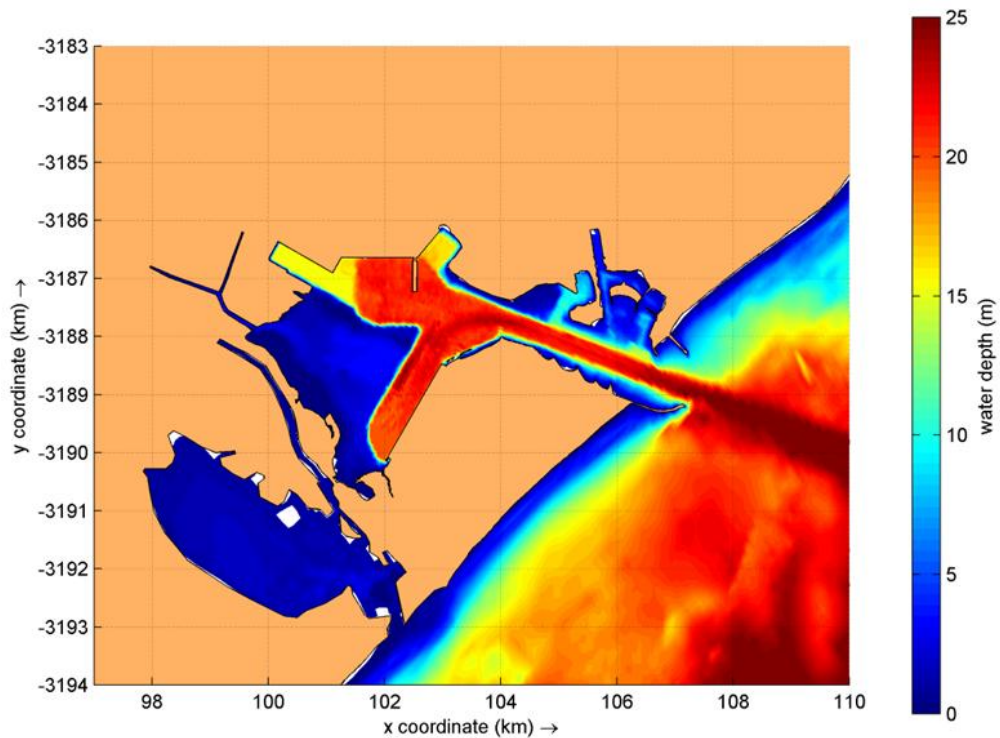


Figure 5-4 – Detailed flow and wave grid bathymetry in the immediate area of interest

5.1.2.3 Wave Conditions at the Offshore Open Boundary

To execute Delft3D-WAVE, the model requires the specification of an offshore wave climate. Initially wave data obtained from National Centre for Environmental Prediction (NCEP) for the offshore location 29.0 S; 32.5 E was used in the modelling study, this being the closest NCEP data point to Richards Bay. However, it proved difficult to calibrate the wave model using these data. Therefore, the data used for the wave model calibrations are those measured for the Transnet IPOSS system at a location some 1.5 km South-east of the southern breakwater of the Port of Richards Bay (see Figure 4-7 for the location of the wave buoy).

A more detailed analysis of the model results using the NCEP wave forcing indicated several reasons for the deficiencies in the wave model calibrations. These included the fact that the NCEP wave data tended to indicate peak wave periods that often were substantially less than those indicated in the calibration times series, *i.e.*, the NCEP data often underestimates the peak wave periods. Furthermore, the NCEP data contained much more easterly wave energy than is suggested by the measured data.

For this reason, a different approach was taken to specifying appropriate wave conditions at the open boundary of the wave model. This same approach has been taken in a number of the previous studies (*e.g.*, van Ballegooyen *et al.*, 2015, van Ballegooyen and Jacobs, 2020) whereby a database of model results is developed by running all possible offshore wave conditions that could lead to the wave characteristics measured at the IPOSS wave buoy, *i.e.*, the wave calibration time series measurement point. A look-up table was developed that allowed the synthesis of an

appropriate wave time series to apply at the model boundary that would result in the modelled data at the IPOSS wave buoy time series measurement point matching the measured data at this location. This is deemed appropriate since the aim is to provide the correct wave forcing for the hydrodynamic model at locations of interest, particularly the disposal site.

5.1.3 WAVE MODEL CALIBRATION

Time series of the modelled wave characteristics versus the measured data at the Transnet IPOSS wave buoy measurement location are plotted in Figure 5-5 to Figure 5-10 below. The data indicate a close correspondence between the modelled and measured data; however, a few small discrepancies occur that are associated mostly with occasions when the winds swing rapidly from north-easterly to south-westerly (*i.e.*, the south-westerly buster). During this transition, the intermediate period NE waves (*i.e.*, swell with short to medium wavelengths) cease and there exists a very short period when the measured waves comprise local seas from the SW generated by the high winds. These quickly give way to long period SW swell.

The look-up table method is not well-suited to handling this short period wave energy from the SW. It is generally under these circumstances that there exists a discrepancy between the modelled results and the measured data. The wave input times series at the open boundaries of the wave model therefore needed to be adjusted to ensure accurate wave predictions under these circumstances. It should be noted that these differences in predicted wave height and direction generally occur only for peak wave periods of less than 6 seconds.

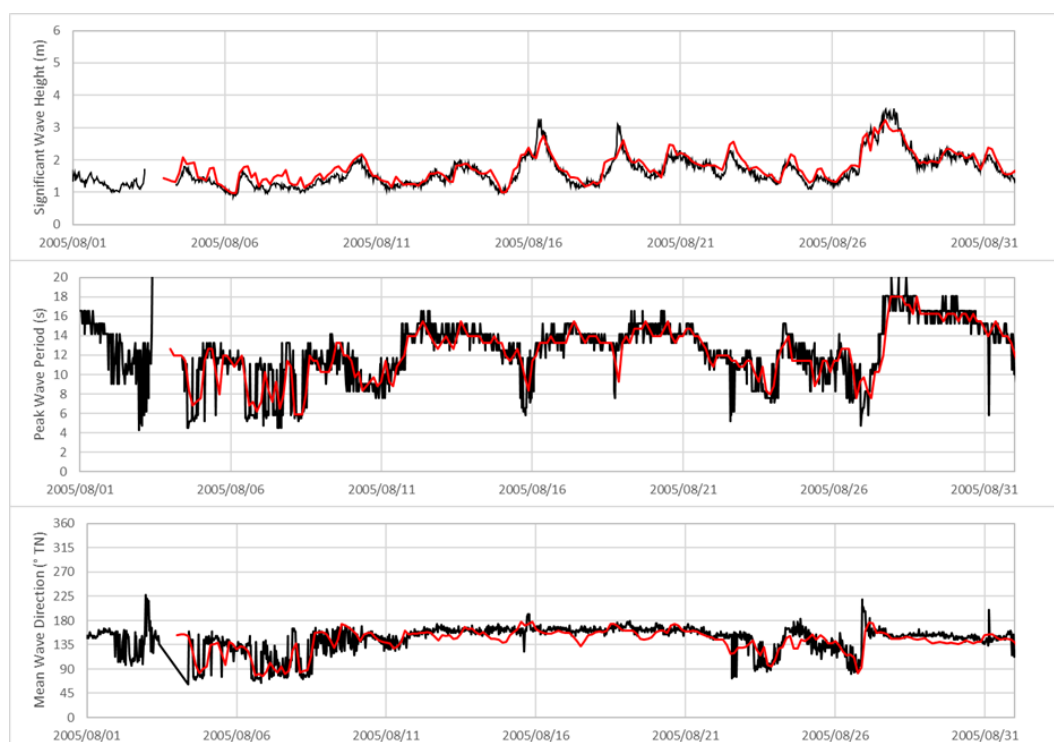


Figure 5-5 – Measured (black) and modelled (red) wave parameters at Waverider buoy during August 2005.

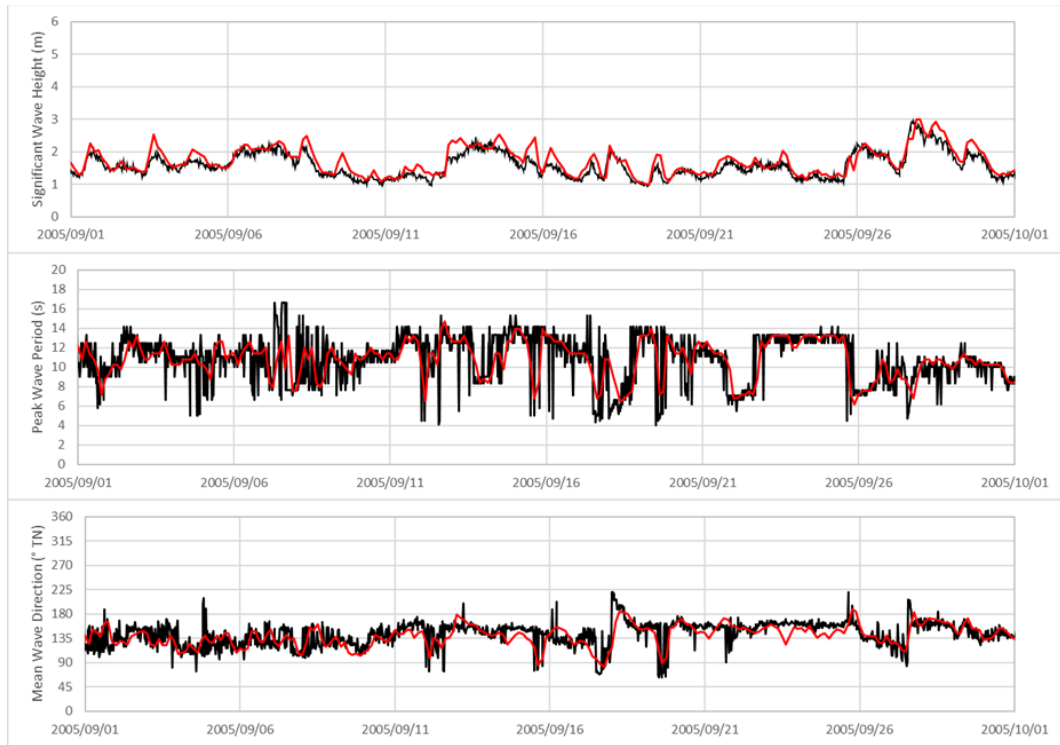


Figure 5-6 – Measured (black) and modelled (red) wave parameters at Waverider buoy during September 2005.

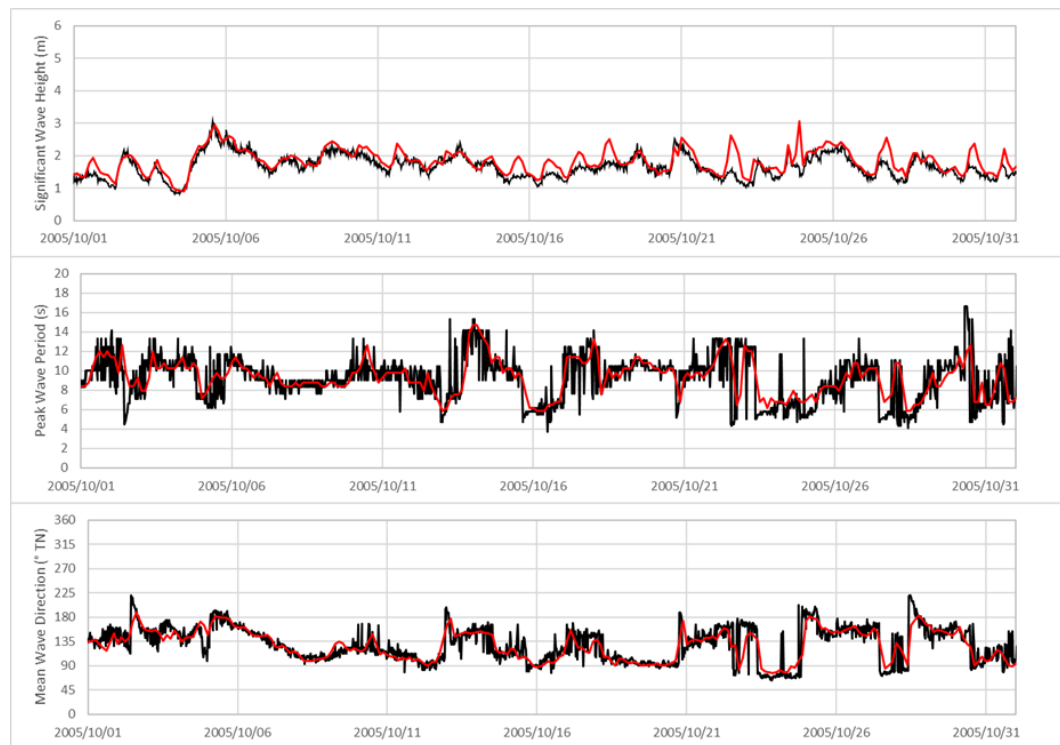


Figure 5-7 – Measured (black) and modelled (red) wave parameters at Waverider buoy during October 2005.



Figure 5-8 – Measured (black) and modelled (red) wave parameters at Waverider buoy during November 2005.

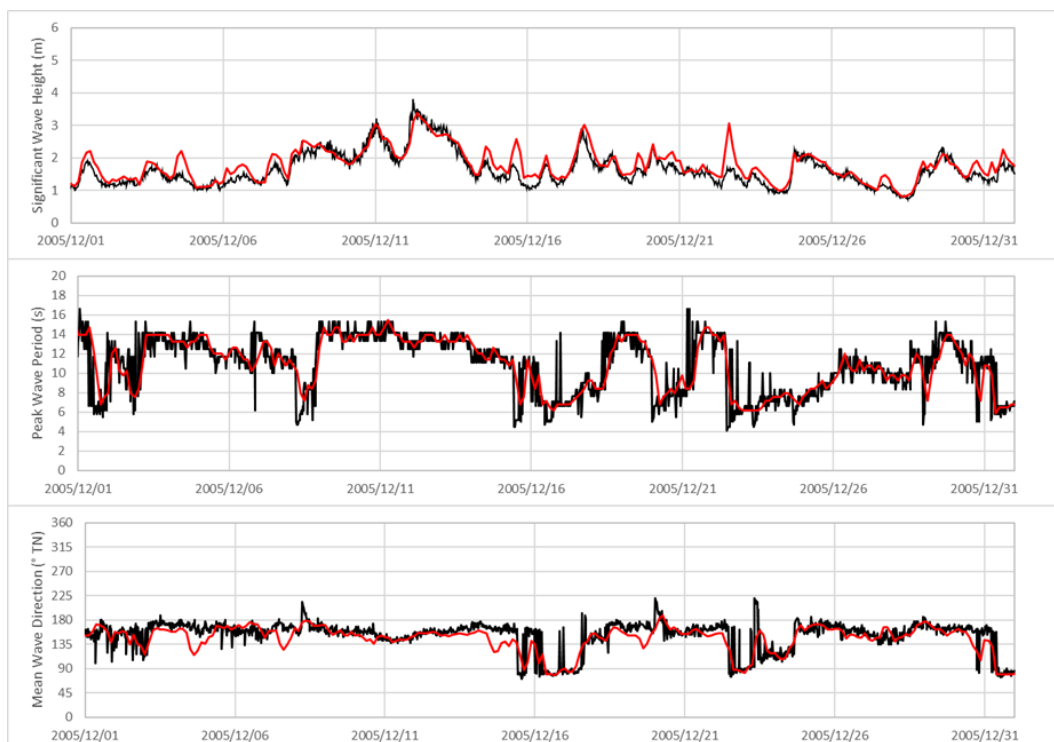


Figure 5-9 – Measured(black) and modelled (red) wave parameters at Waverider buoy during December 2005



Figure 5-10 – Measured (black) and modelled (red) wave parameters at Waverider buoy during January 2006.

5.2 HYDRODYNAMIC MODELLING

The objective of the hydrodynamic flow modelling is to accurately simulate the flow both within the Port of Richards Bay and those in the offshore region. This will be in used in any used that will influence the re-suspension and re-distribution of sediments from the dredge spoil disposal sites. Considering that the main forcings of water movement are wind, waves, tides, the Agulhas Current and to a lesser extent water column stratification; the following processes need to be adequately simulated in the hydrodynamic model:

- tidal forcing;
- wind forcing;
- wave forcing in the surf-zone;
- the influence of the Agulhas Current;
- baroclinic effects (*i.e.*, on currents and vertical mixing), insofar as they affect vertical shear in horizontal velocities;
- the effect of the earth's rotation (Coriolis force), and;
- combined bed shear stresses due to currents and waves.

Since many of these processes are strongly three-dimensional, a three-dimensional hydrodynamic model, as described below, is required for this study. Note however that stratification effects are not simulated in the model.

5.2.1 DESCRIPTION OF THE HYDRODYNAMIC MODEL

Delft3D-Flow is a three-dimensional hydrodynamic model that includes formulations and equations that take into account the processes listed above. The system of equations in Delft3D-FLOW comprise the horizontal momentum equations and the continuity equation, the equation of state and the advection-diffusion equation for heat, salt and other conservative tracers which are solved using the Alternating Direct Implicit scheme. Vertical turbulence is modelled using the k- ϵ turbulence closure model. The equations and their numerical implementation are described in Lesser *et al.* (2004). The wave-forcing is obtained from the wave energy dissipation rate computed by the wave refraction model (Delft3D-WAVE). Enhanced bed stresses due to wave effects are incorporated in the model using the friction formulation of Fredsøe (1984).

5.2.2 HYDRODYNAMIC MODEL CALIBRATION

The currents were measured in an approximate 20 m water depth at a location southwest of the dredge spoil disposal site ((Figure 5-17) during the Berth 306 Dredge Monitoring programme. The initial calibration of the model was undertaken without including wave effects. The calibration was relatively straightforward, however, once the waves were included in the flow model results, the calibrations deteriorated somewhat due to the influence of the waves on the bottom friction in the flow model. The model thus needed to be re-calibrated once such wave effects were included.

Comparisons of the measured and modelled currents at the ADCP site are plotted in Figure 5-11 to Figure 5-16. The current speeds are presented as easterly and northerly components of the measured and modelled currents at an approximate -14 m CD water depth (*i.e.*, the depth most likely to represent the depth integrated flow at the ADCP measurement location).

The measured and modelled currents compare well, except for a few occasions where the model over-predicted the magnitude of the north-easterly wind-driven flows and a couple of occasions where the model under predicted the strong south-westerly flows in the measured data (that most probably were due to the influence of the Agulhas Current).

There exists no bias in representing the more extreme flows which are the most likely to affect sediment re-suspension and subsequent advection. The model therefore is deemed adequate for the purposes of simulation water column turbidity and the movement of dredge spoil in the offshore environment.

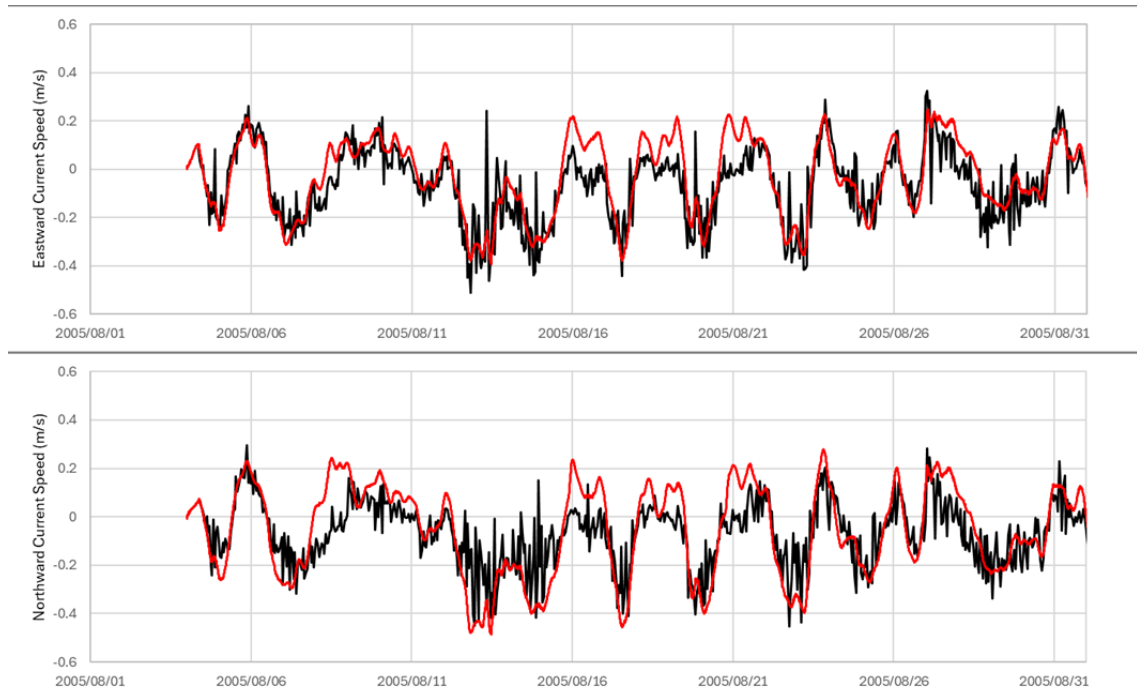


Figure 5-11 – Measured (black) and modelled (red) current at -14m MSL at ADCP location during August 2005.

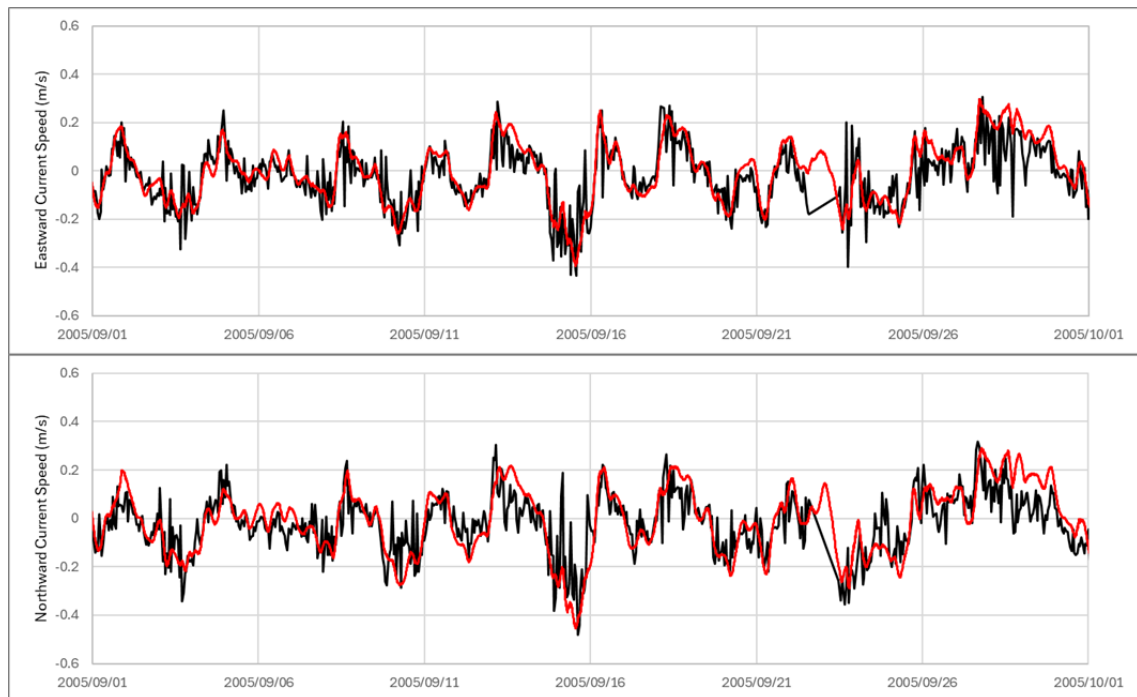


Figure 5-12 – Measured (black) and modelled (red) at -14m MSL at ADCP location during September 2005.

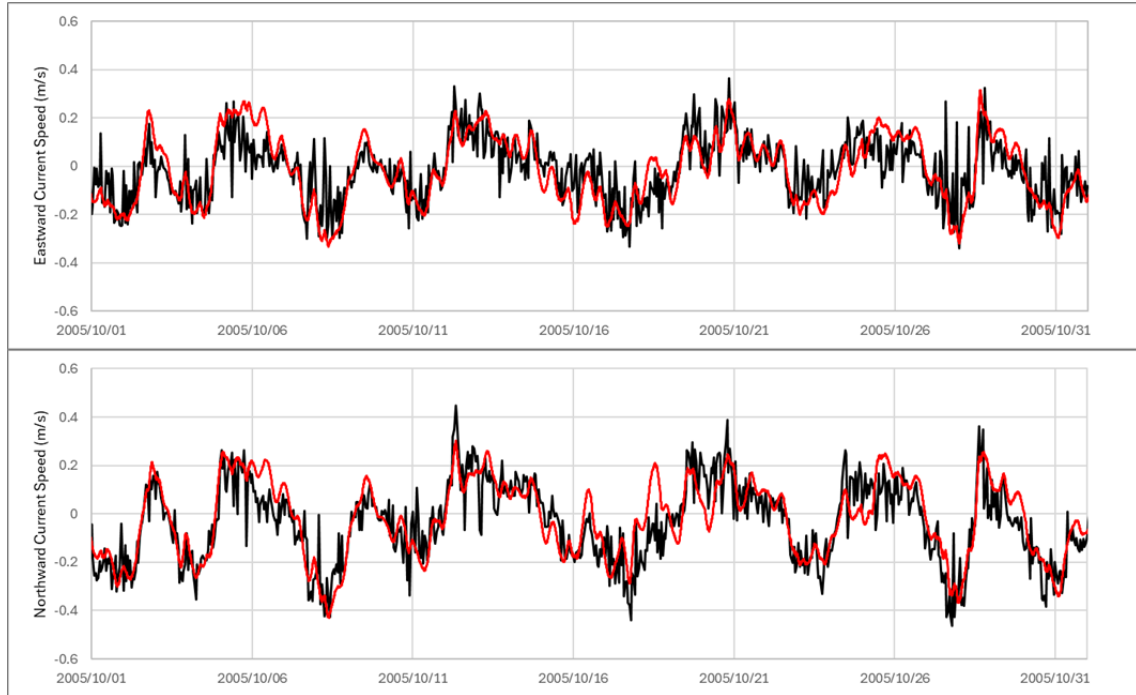


Figure 5-13 – Measured (black) and modelled (red) at -14m MSL at ADCP location during October 2005.

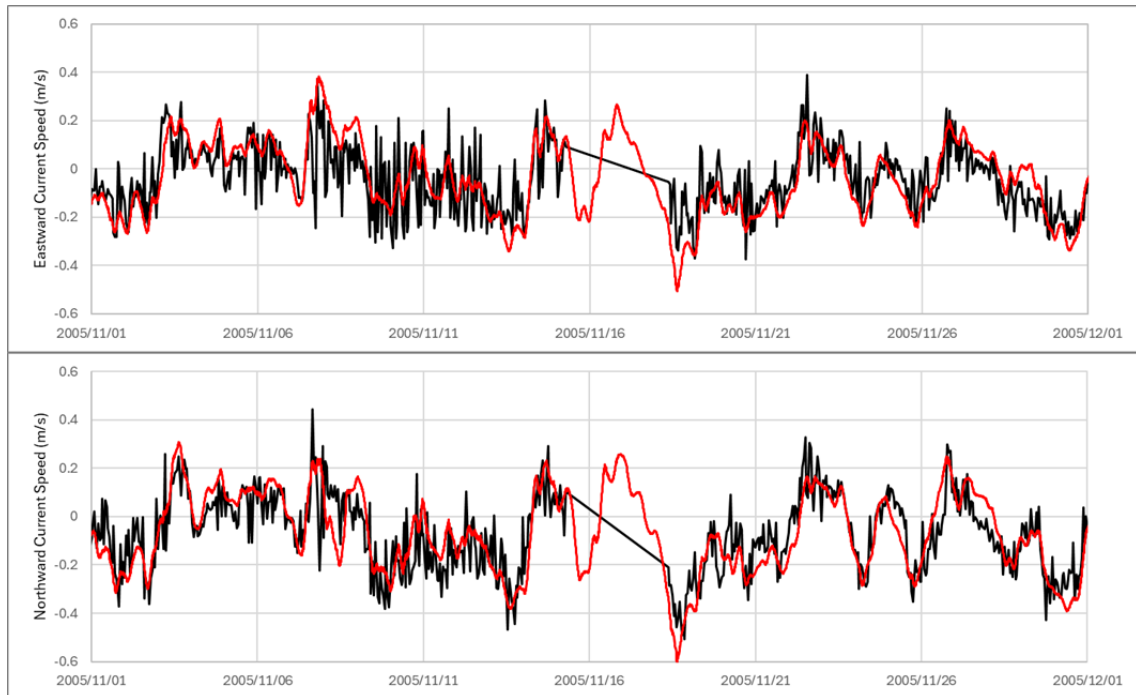


Figure 5-14 – Measured (black) and modelled (red) at -14m MSL at ADCP location during November 2005.

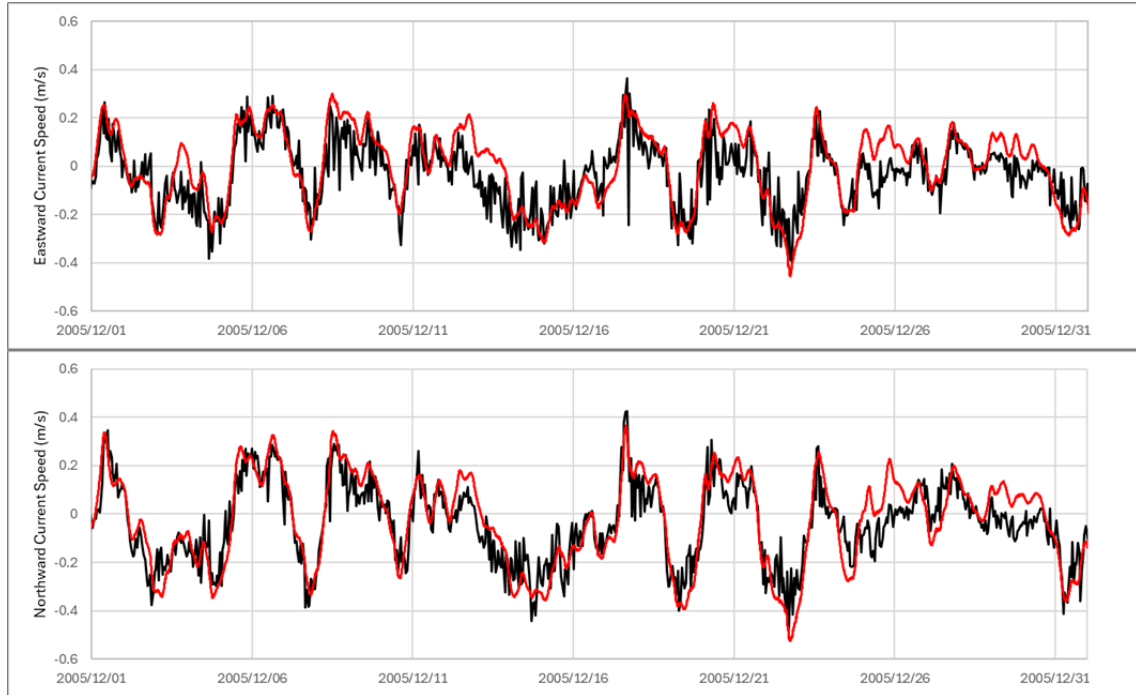


Figure 5-15 – Measured (black) and modelled (red) at -14m MSL at ADCP location during December 2005

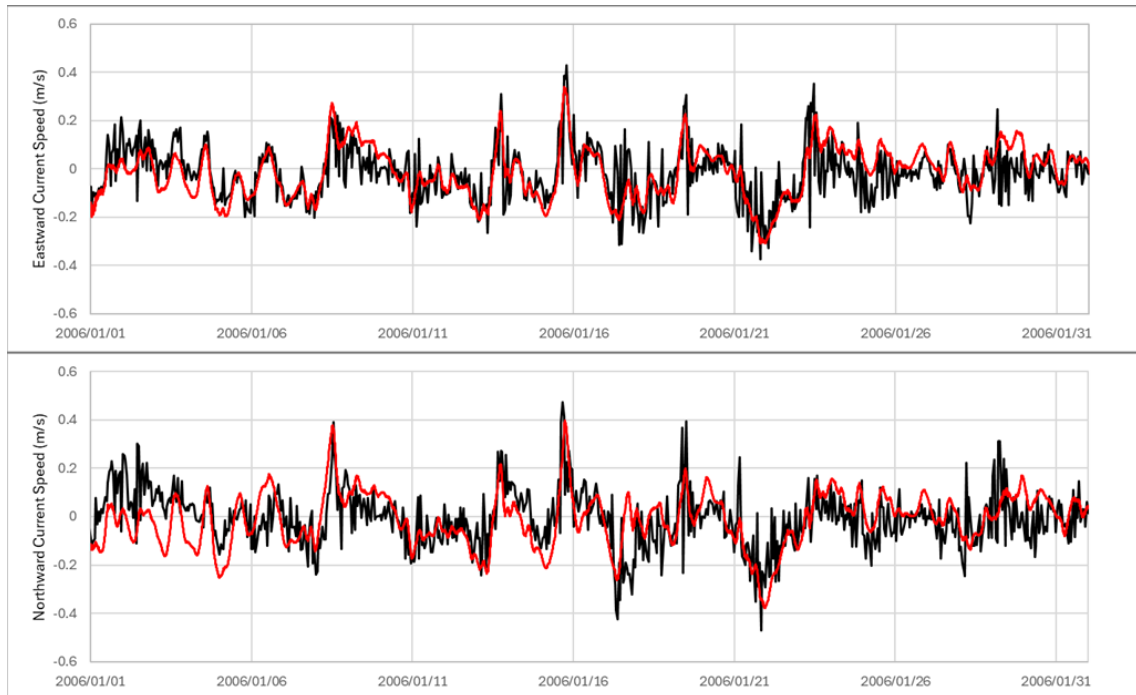


Figure 5-16 – Measured (black) and modelled (red) at -14m MSL at ADCP location during January 2006.

5.3 TURBIDITY AND SEDIMENTATION MODELLING STUDY

The modelling of dredging and dredge spoil disposal impacts has been undertaken using the calibrated and coupled Delft3D-Wave model (described in Section 5.1) and Delft3d-FLOW/MOR model (described in Section 5.2) that includes the necessary sediment modelling capability (Booi *et al.*, 1999; Lesser *et al.*, 2004, Deltares, 2017b) to undertake the dredging and dredge material disposal assessments for this study.

The objective of the modelling is to simulate the transport and fate of the predominantly the fine component of the dredged material, both at the site of dredging inside the port and at the dredge disposal site. The model accounts for the dominant physical processes:

- Refraction of deep-water waves to determine the wave conditions throughout the model domain, particularly at the offshore dredge spoil disposal site and in the surf zone along the northern shoreline;
- The effect of waves on wave-driven currents in the surf-zone and on sediment transport processes via enhanced turbulence and enhanced bed shear stress;
- Generation of wind-waves inside the port and the estuary;
- Generation of tidal currents in the port and the estuary;
- Generation of wind-driven currents (and, to the extent relevant, the influence of large-scale offshore flows) in the port, estuary and offshore;
- Vertical mixing processes and possibly water column stratification;
- The introduction of one or more sources of suspended sediment and the advection-dispersion of the resulting turbid plume; and,
- The settling-deposition-resuspension of the sediment particles and the evolution over time of the dredge spoil mound at the offshore spoil disposal site.

5.3.1 DESCRIPTION OF THE SEDIMENT TRANSPORT/ MORPHOLOGY MODEL

The coupled wave and hydrodynamic – sediment transport morphological model has been used to simulate sediment concentrations, sediment transport rates (suspended and bedload) and morphology of cohesive and non-cohesive sediments released into the water column at the dredging and offshore disposal site.

A clear and logical discussion of sediment transport and morphological capability of the Delft3D-Flow/Mor hydrodynamic-morphology software module is presented by Lesser *et al.* (2004). Additional information regarding the transport of cohesive sediments is presented by Van Ledden *et al.* (2004). Computationally, the three-dimensional transport of sediments is determined in a similar manner as the transport of any other conservative constituent such as heat and salinity. However, there are some critical differences between sediment and other constituents such as the exchange of sediment between the bed and the overlying water column and the settling velocity of sediment under the action of gravity. The sediment also influences the local water column density at the sediment water interface that may cause turbulence damping. In the Delft3D-Flow/Mor hydrodynamic-morphology software module these processes are described by different formulations depending on whether cohesive or non-cohesive sediment fractions are being modelled.

Some of the processes and features of the Delft3D-Flow/Mor hydrodynamic-morphology software module are:

- Cohesive and non-cohesive sediment fractions may be modelled separately and/or simultaneously;
- Suspended and bed load transport of non-cohesive sediments are computed using Van Rijn's (1993) approach;
- The standard Delft3D-FLOW advection-diffusion solver is used for the transport of the suspended sediment;
- The bedload is adjusted for bed slope effects;
- For cohesive sediment fractions (e.g., mud) the fluxes between the water phase and the bed are calculated from the well-known Partheniades-Krone formulations (Partheniades, 1965),
- Settling velocities are adapted due to hindered settling;
- The effect of flocculation of the cohesive sediment on the settling velocity is taken into account; and
- The effect of sediments concentrations on fluid density are included in the formulations.

A potential limitation of the present model implementation is that for the calculation of the deposited sediment thickness, the contribution from each fraction is considered independently from the other fractions.

In the present study, the model was applied in fully three-dimensional-horizontal mode, but the model option to dynamically update the bed during the simulation was not used (to avoid potential feedback complexities at the dredge spoil disposal locations). Not explicitly updating the seabed in the model could lead to decreases in the local mobility of sediments at the dredge spoil discharge locations where a minor reduction in the re-distribution of sediments is likely. However, the accumulation of sediments on the seabed (*i.e.*, relative change in local water depths) in the model simulations are sufficiently modest for such effects to be considered negligible in terms of determining the ultimate impacts of dredging and dredge spoil disposal activities,

5.3.1.1 MODEL SETUP

The in-situ material quantities and qualities to be dredged for the Berth 605 projects are summarised in Table 2-3 in Section 2.2.3 of this report. The transformation of this material (siltstone component) is described in in Section 2.4.2 where it is estimated that the mass fractions of the in-situ material once dredged would comprise 21% coarse material/gravels ($D_{50} = 6\text{mm}$), 20% coarse sand ($D_{50} = 350\text{ }\mu\text{m}$), 18% medium sand ($D_{50} = 275\text{ }\mu\text{m}$) and 41% silts and clays (grain size $< 63\text{ }\mu\text{m}$). These are the four sediment size fractions used for the sediment loading in the model. The model parameters for the non-cohesive size fractions are provided in Table 5-1 and those for the cohesive size fraction (silts and clays) in Table 5-2.

Table 5-1 - Model parameters assumed for non-cohesive sediment fraction in the model.

Model Parameters	Parameter Values		
	Coarse Gravel	Coarse Sand	Medium Sand
Median grain size (D_{50})	6 mm	350 μm	275 μm
Minimum Depth for sediment calculation	0,1	0,1	0,1
Van Rijn's reference height factor	1	1	1
Ripple height factor	2.0	2.0	2.0
Longshore bed gradient factor	1.0	1.0	1.0
Transverse bed gradient factor	1.0	1.0	1.0
Current-related reference concentration factor	1.0	1.0	1.0
Current-related transport vector magnitude factor	1.0	1.0	1.0
Wave-related suspended transport vector	0.2	0.2	0.2
Wave-related bedload transport factor	0.2	0.2	0.2
Minimum depth for sediment calculations	0.05m	0.05m	0.05m
Dry cell erosion factor	1.0	1.0	1.0

Table 5-2 - Model parameters assumed for cohesive sediment fraction in the model.

Model Parameter	Value
Settling velocity	0.5 mm/s
Critical bed shear stress for sedimentation	1000 Pa
Critical bed shear stress for erosion	0.25 Pa
Erosion parameter	0.00001 $\text{kg/m}^2/\text{s}$
Initial sediment thickness	0.0 m

The settling, deposition and re-suspension behaviour of the cohesive component of the sediments is characterised by the settling velocity, the critical shear stress for deposition, the critical shear stress for re-suspension, and the re-suspension rate. While settling velocities can be measured relatively easily, the remaining parameters are significantly more difficult to measure experimentally.

In determining the sediment parameters listed in Table 5-2, provision was made for the different influences of silt and clay on the behaviour of the muds. The critical shear stress for erosion of muds increases (up to a factor of 2) with the addition of sand and reaches a maximum for approximately 50% sand (Mitchener and Torfs, 1996; Dankers, 2002). The addition of sand to muds also may dramatically reduce the erosion rate from the seabed (Mitchener and Torfs, 1996). However, the sand fraction in the material to be disposed of at the offshore dredge spoil disposal site is expected to be approximately 38%, suggesting reduced erosion rates from the seabed of the offshore dredge spoil disposal site compared to those expected for muds only.

During disposal of large volumes of dredge material at the offshore dredge spoil disposal site, the deeper layers of the cohesive sediments may initially settle on the bed and will only be suspended after the surface material has eroded. To simulate this process, the critical shear stress for sedimentation selected in the modelling study is relatively high.

The remainder of the sediment parameters have been based on those reported in the literature (Van Ledden *et al.*, 2004; Dankers, 2000; Torfs *et al.*, 1996; Mitchener and Torfs, 1996; Deltares, 2017b; CSIR, 1995a,b, 2000b). Specifically, the critical bed shear stress for erosion used in the modelling is based on the work of Van Ledden *et al.* (2004) and the concept that the muds dumped at the offshore sites will be unconsolidated and relatively loosely packed. The erosion parameter has been calculated by considering the shear stresses where the erosion rate exactly balances the deposition rate for various sediment fall rates and critical bed shear stress for erosion parameters.

This balance occurs when the shear stress is given by

$$\tau = \tau_{crit} + w_s C / M_E$$

where

- τ is the shear stress at the seabed (Pa)
- τ_{crit} is the critical shear stress for erosion (Pa)
- w_s is the settling velocity (m/s)
- C is the sediment concentration (kg/m³) and
- M_E is the erosion rate.

Preliminary sensitivity tests based on one month model simulations indicated that the model results are relatively sensitive to the selected erosion rates (M_E values). These parameters specified in Table 5-2 are consistent with those generally accepted for model studies such as this one (*i.e.*, $M_E = 10^{-6}$ to 10^{-4} kg/m²/s and τ_{crit} (erosion) = 0.1 to 0.3 Pa for unconsolidated and relatively loose muds in sand/mud mixtures). Using the specified value for settling velocity and critical shear stress for erosion specified in Table 5-2 and considering the different sediment concentrations expected near the seabed at the offshore dredge spoil disposal site, the erosion parameter has been selected so that net erosion from the seabed occurs for bottom shear stresses of 0.3-0.7 Pa for low suspended sediment concentrations near the seabed (~ 10 mg/l) and >2.5 Pa for suspended concentrations of approximately 50 mg/l at the seabed.

The material that is deposited on the bottom will begin to consolidate, which is the process whereby the deposited grains are compacted under the influence of gravity, leading to the expulsion of the pore water and the increase in density of the material and a reduction in the deposition thickness. To

compute the deposition thickness in the model, a typical consolidation condition after one month has been assumed for the offshore disposal site. Previous modelling studies assessing the disposal of sand and mud mixtures onto the disposal site (van Ballegooyen *et al.*, 2017, van Ballegooyen and Jacobs assumed an effective porosity of ~75%, a wet density of ~1 425 kg/m³ and a dry density of ~650 kg/m³ (Van Rijn, 1989). For largely sandy material being discharged onto the northern shoreline (van Ballegooyen and Jacobs, 2020), the sand and mud fractions were assumed to have dry density of 1 600 kg/m³ and 465 kg/m³ and porosities of approximately 47.2 % and 82.5 %, respectively (e.g., Winterwerp (1996) as reported in van 't Hoff and van der Kolff (2012); van Rijn and Barth, 2019). This results in an assumed dry density of ~1 300 kg/m³ for the predominantly sandy sediments that were discharged and settling along the northern shoreline. In the present study the coarse material (21%) and sand material (38%) were assumed to have dry density of 1 600 kg/m³ and the mud material (41%) to have a dry density of 465 kg/m³, resulting an assumed dry density of ~1 310 kg/m³ for material settling on the disposal site (see discussion in Section 2.4.2).

A sensitivity analysis where the above parametrisations were varied, suggest that the above parametrisations are appropriate for this study as they resulted in water column turbidity and TSS concentrations of a similar magnitude to those measured for the Berth 306 capital dredging (see Section 4.8.2) and also material volumes on the disposal site immediately after dredging that matched roughly those estimated for the Berth 605 capital dredging (see Table 2-7 in Section 2.5.1).

5.3.2 HYDRODYNAMIC MODEL SET-UP

The computational grid, bathymetry and wave conditions used in the hydrodynamic model are described below.

5.3.2.1 Computational Grid

The computation grid used in the flow modelling is the same as the nested (high-resolution) grid used in the wave model (Figure 5-1) and comprises an irregularly spaced, orthogonal, curvilinear grid in the horizontal and a sigma coordinate grid in the vertical. The advantage of using the same grid for the wave and flow simulations is that there is no loss of information due to interpolation between the different modules because the Delft3D-FLOW grid coincides with the Delft3D-WAVE grid.

The nested (high-resolution) hydrodynamic grid has been refined both in the vicinity of the mouth of the Mhlathuze Estuary and the entrance to the Port of Richards Bay.

5.3.2.2 Bathymetry

The bathymetry used in the DELFT3D-FLOW model is the same as that used for the nested (high resolution) wave model (Figure 5-3).

5.3.2.3 Model forcing at the offshore open boundaries

The winds measured at the extremity of the southern breakwater were used to force the model. High frequency “noise” in these data was removed using a 5-point Hanning filter. Measured currents from the ADCP deployed as part of the Berth 306 monitoring programme were used to force the model using a “reduced physics” approach (Shabangu, 2015). This approach calculates and applies the

appropriate water levels at the open boundaries of the model that allows the model to produce the same predicted currents as those at the ADCP measurement site (Figure 5-17). In this approach it is assumed that:

- The alongshore spatial variations are small compared to the cross-shore variations (both in the bathymetry and the scales of motion), and
- The characteristic time scales of the dominant offshore flows under consideration exceed significantly the inertial period (~ 25 hours) at this latitude.

This “reduced physics” approach uses the following input data to generate the appropriate water levels to be applied at the model boundaries:

- the measured currents at an offshore location (ADCP location in Figure 5-17)
- wind data (deemed representative of the marine environment) and
- predicted tides using constituents previously supplied by the South African Navy Hydrographic Office.

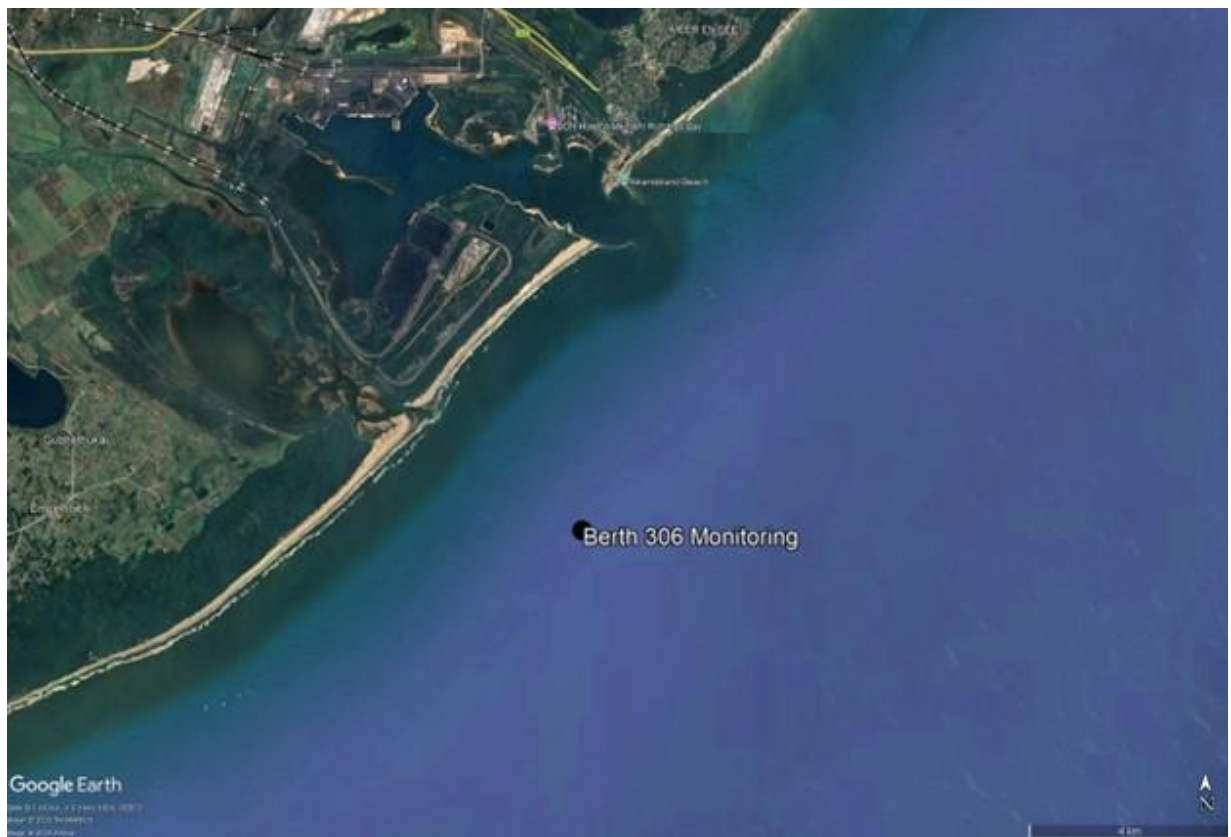


Figure 5-17 – ADCP measurement site

5.4 MODEL SCENARIOS

5.4.1 ENVIRONMENTAL SCENARIOS

Using the calibrated model for the period of August 2005 to January 2006, an environmental scenario was set-up that covered the period of dredging as well as a short period after the dredging had ceased. The environmental scenarios simulated comprised a 155-day period running from 4 August 2005 to the 31 January 2006. This period was selected to only include the period for which the offshores currents measurements used to generate open boundary conditions in the hydrodynamic model using a “reduced physics” approach were available.

The relevant time series of winds, currents, waves and tidal water levels used to run this scenario are plotted in two month periods, namely 1 August 2005 to 30 September 2005 (Figure 5-18 and Figure 5-21), 1 October 2005 to 30 November 2005 (Figure 5-19 and Figure 5-22) and 1 December 2005 to 31 January 2006 (Figure 5-20 and Figure 5-23).

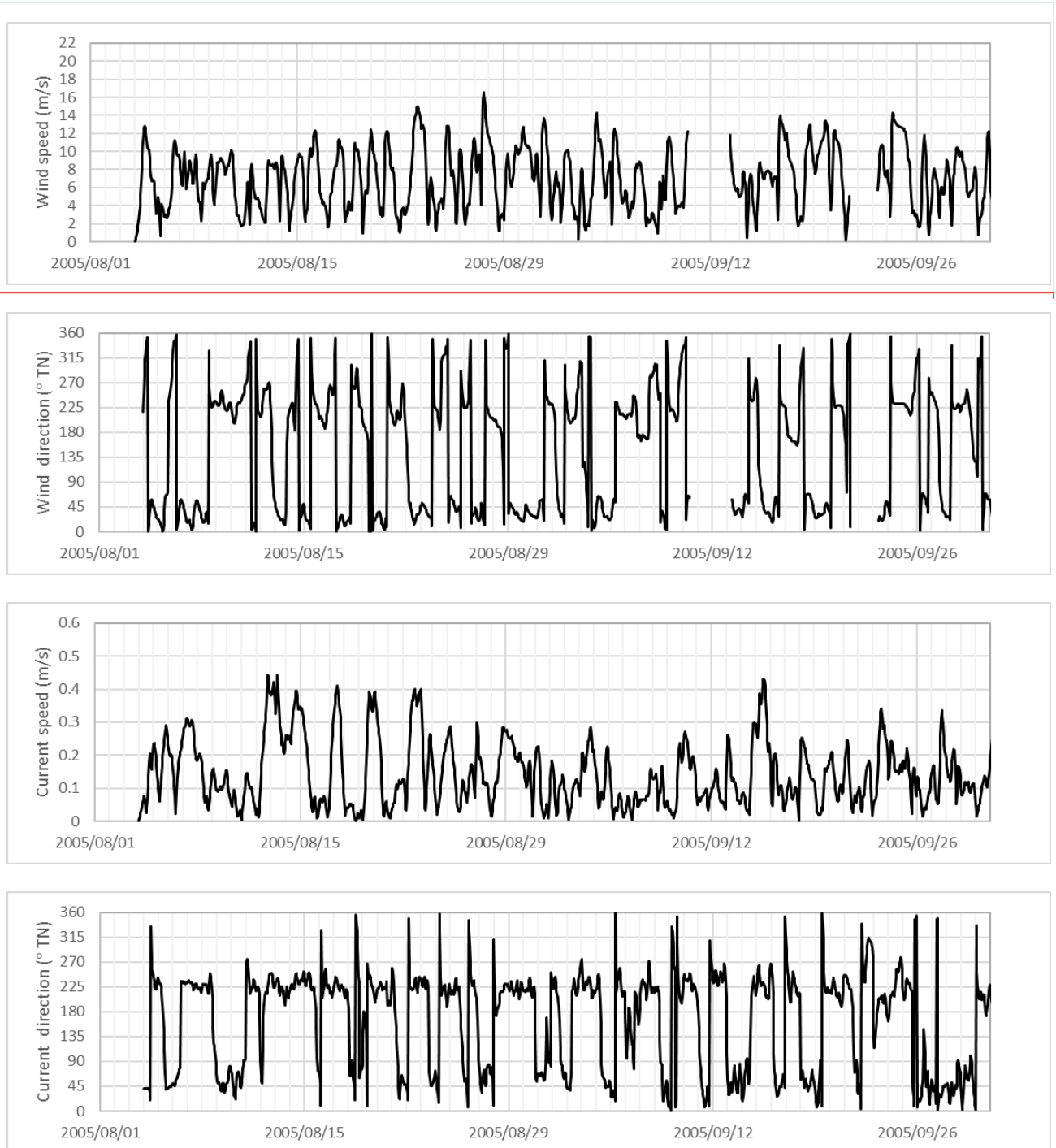


Figure 5-18 - Wind speed, direction and current speed and direction

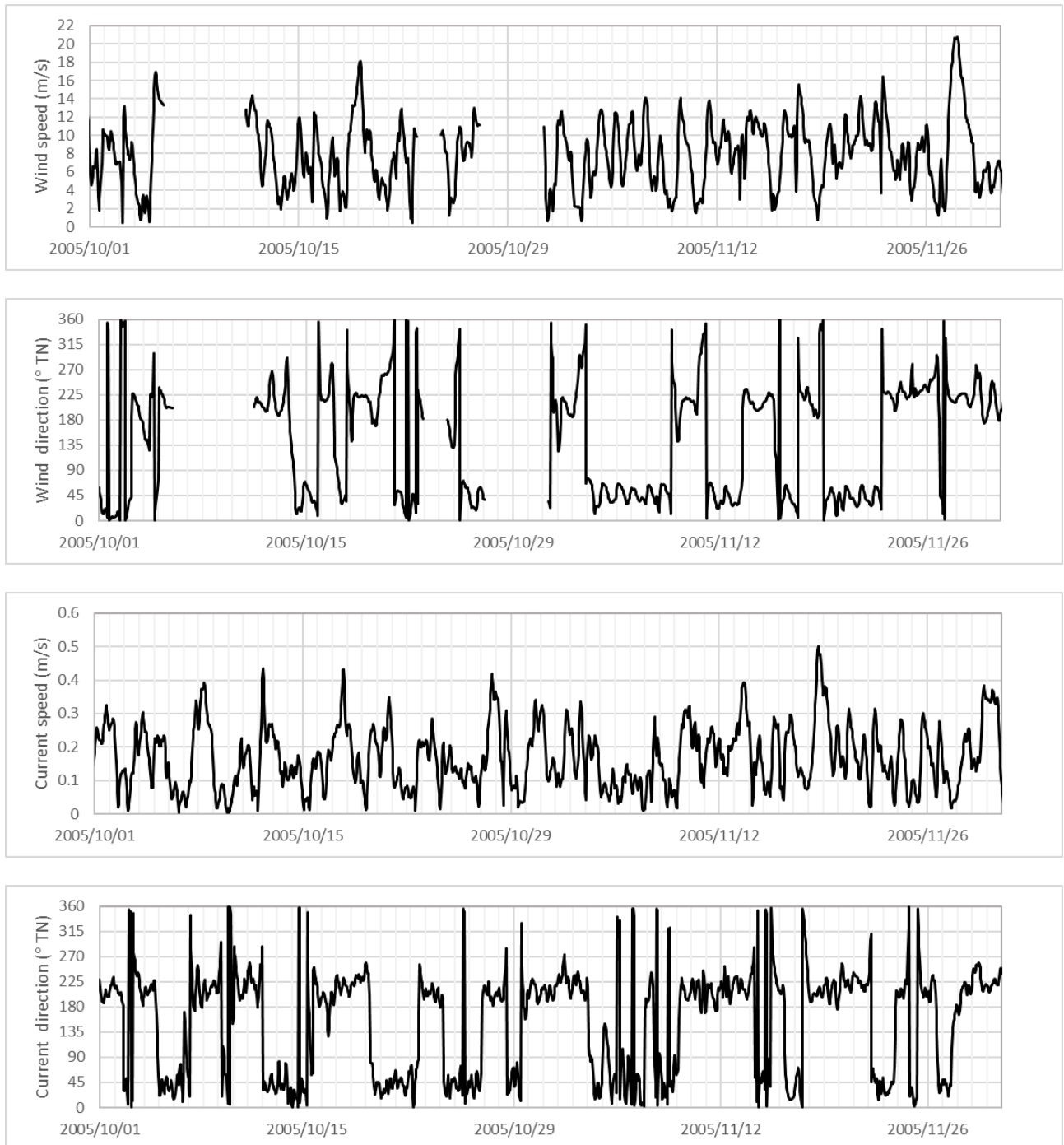


Figure 5-19 - Wind speed, direction and current speed and direction

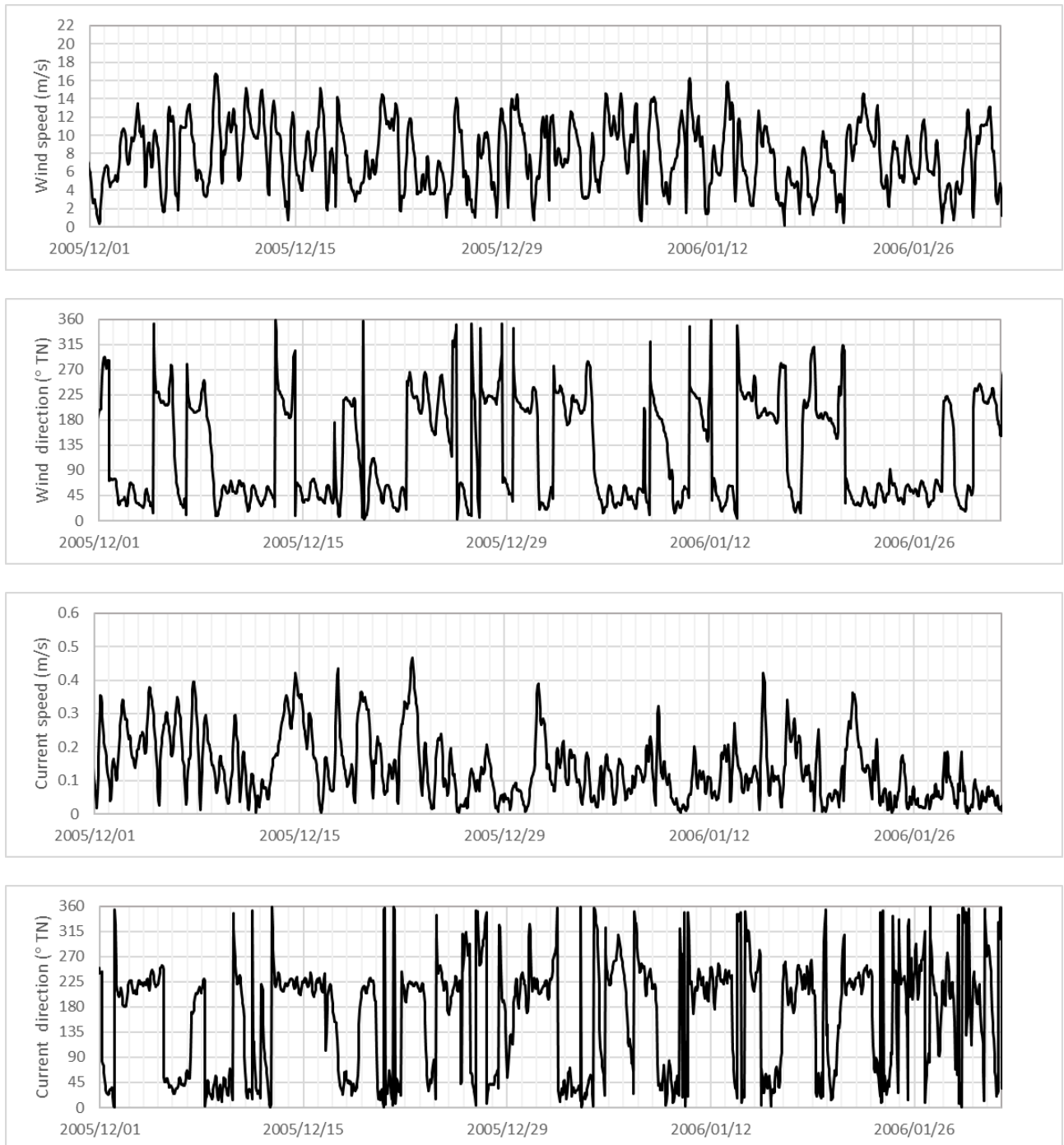


Figure 5-20 – Wind speed, direction and current speed and direction

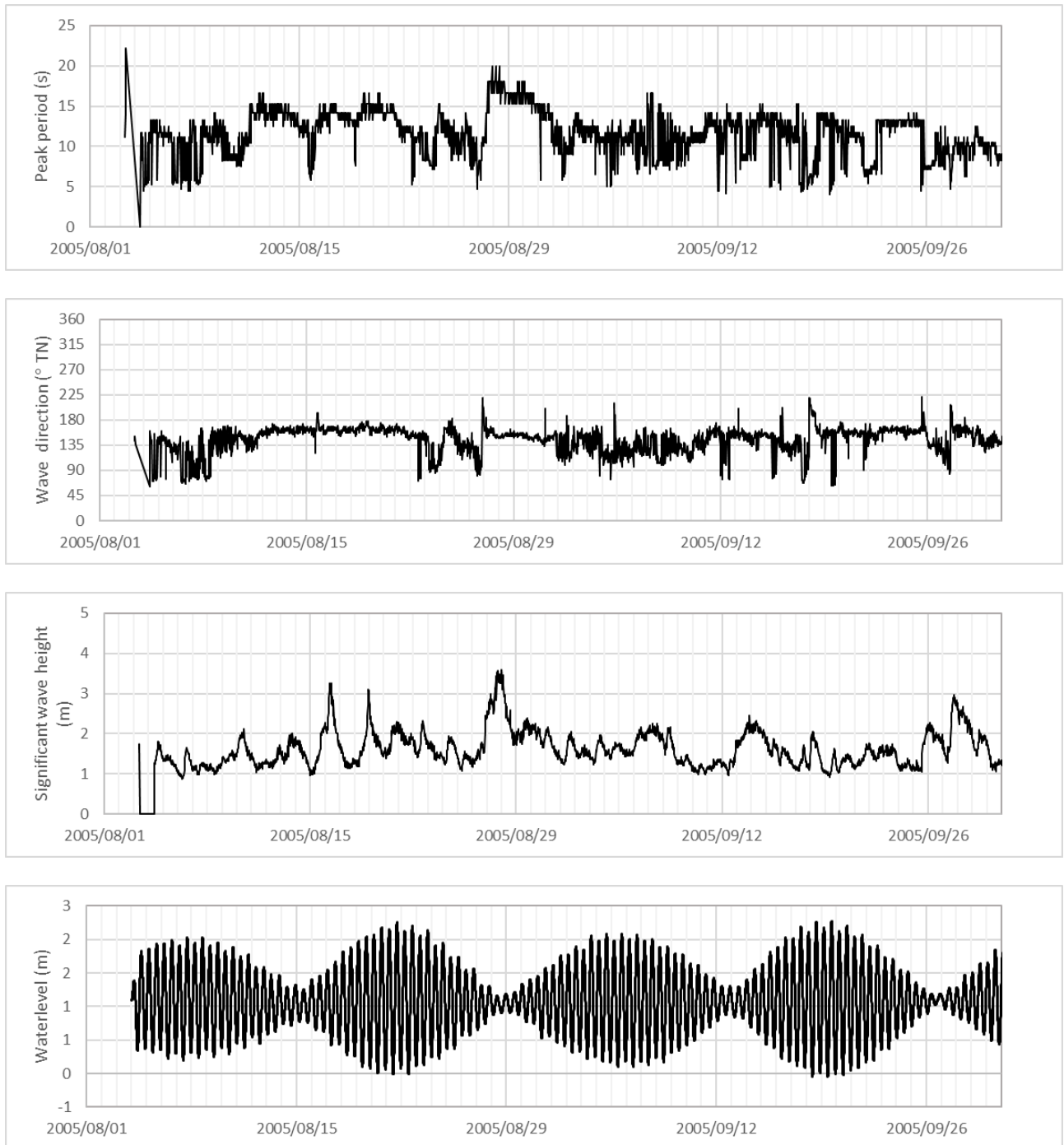


Figure 5-21 – Wave peak period, direction and significant wave height and waterlevel

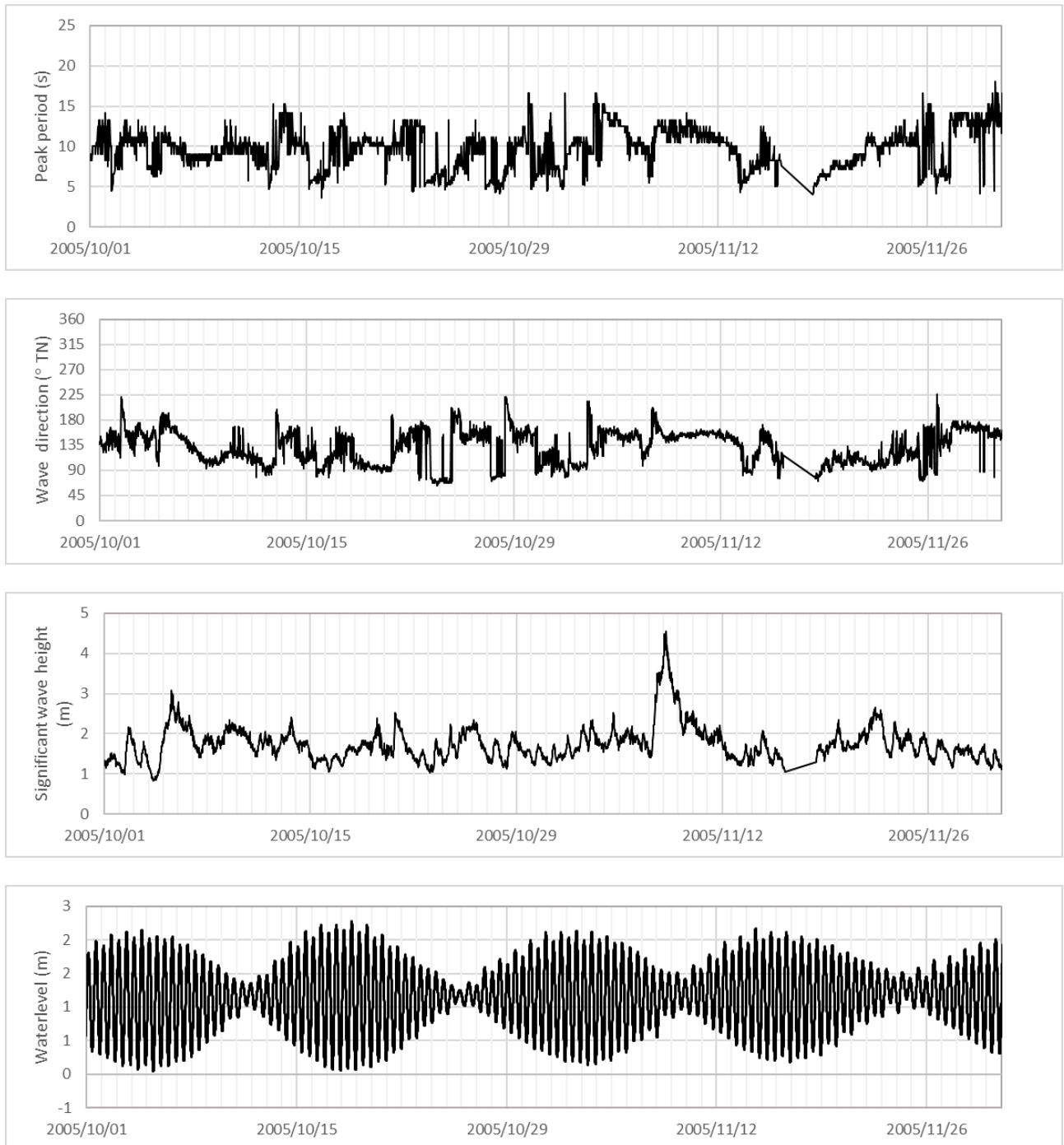


Figure 5-22 – Wave peak period, direction and significant wave height and waterlevel

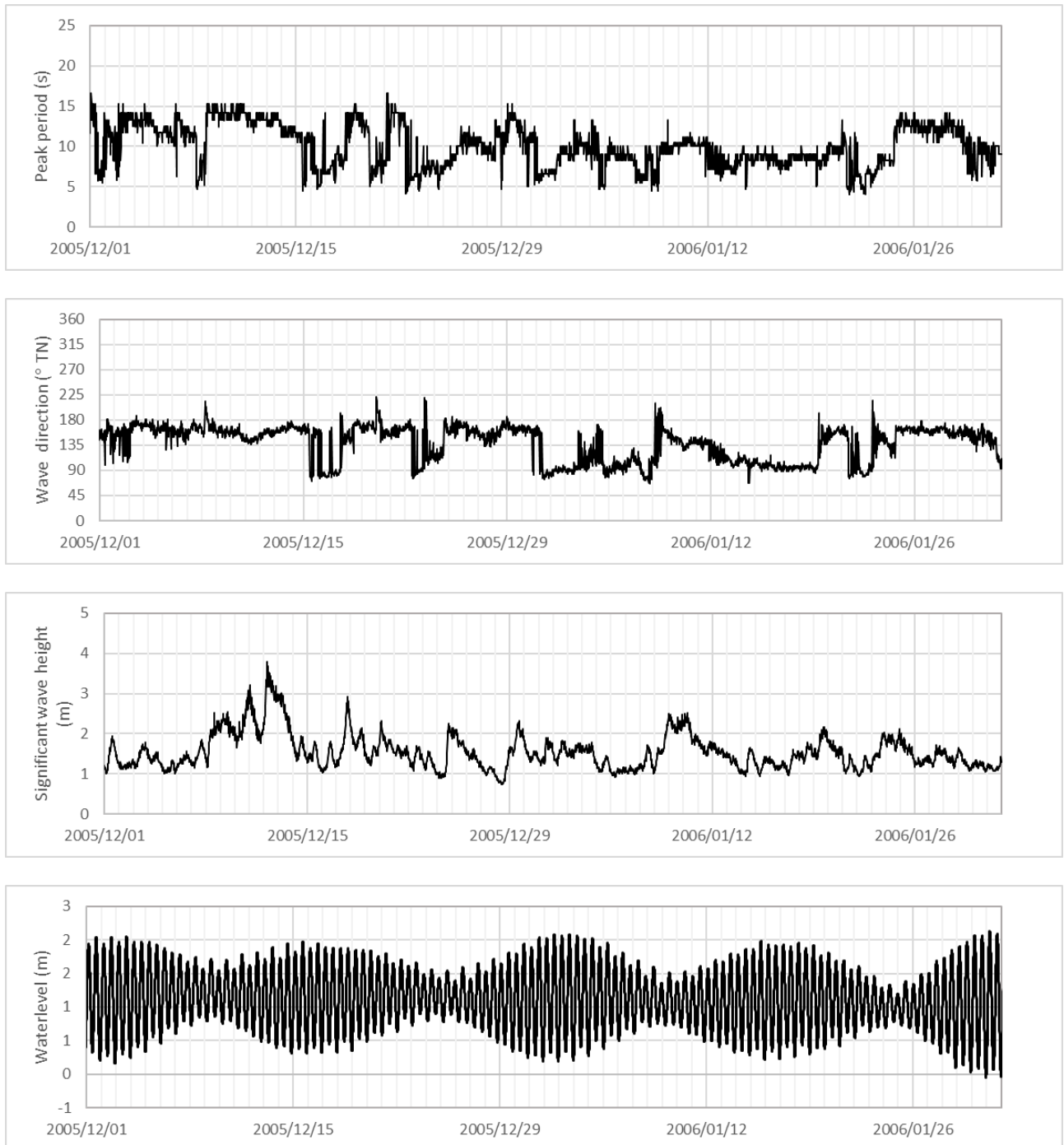


Figure 5-23 – Wave peak period, direction and significant wave height and waterlevel

5.4.2 DREDGING SCENARIOS

Using the calibrated model for the period of August 2005 to January 2006, an environmental scenario was set-up that covered the period of dredging as well as a short period after the dredge scenario was simulated.

The model loadings used in the model are those described in Section 2.4.3.

5.5 ASSUMPTIONS AND LIMITATIONS OF THE MODELLING STUDY

The assumptions made in the modelling study and the limitations of the modelling study are as follows:

- The project description is as known at the commencement of the study in March 2025 when there existed a degree of uncertainty around the volume and exact physical nature of the material to be dredged as the full geotechnical reporting was not yet available. Should this change significantly this may affect the validity of the model outcomes. However, the dredge volumes and material types have subsequently re-assessed using the updated geotechnical survey information and engineering design information available at the time of revising this report. While there remains a residual uncertainty in the material types, the re-assessment has indicated that the modelling outcomes remain representative in terms of the volume of material placed on the dredge spoil disposal site and the predicted TSS concentrations and turbidity surrounding the dredging site within the port, however the predicted TSS concentrations at the offshore dredged spoil disposal site are likely to be moderately to possibly highly conservative given the changes in dredge material types indicated by the updated geotechnical survey information.
- The model calibration is adequate for the purposes of this study. To the extent that there exist any discrepancies between measured data and modelled results, the discrepancies, in general, result in a more conservative assessment (*i.e.*, flows are over-predicted leading to greater potential for re-suspension of sediments and therefore elevated water column turbidity);
- The assumed behaviour of sediment in the model is based on several parameterisations that have associated with them a degree of uncertainty. These parameters have been selected based on observed water column turbidity measurements of a previous capital dredging operation in the region (Berth 306 development in 2005 to 2006) that suggested a much lower rate of re-suspension of sediments and re-distribution of dredge spoil from the offshore dredge spoil disposal site than predicted by previous modelling studies. A similar conclusion has been reached based on the assessment made in Section 2.5.1 of this study.
- The model sensitivity assessments undertaken indicate that changes in the modelling outcomes using a range of probable parameterisations are of a nature that they are unlikely to affect significantly the conclusions drawn from the analyses of the model results.

The model outcomes should be assessed based on the assumptions and limitations listed above.

6 MODEL RESULTS

The model results have been analysed and presented in a manner considered suitable to inform typical marine ecology impact assessments specialist studies as undertaken for both this project (CSIR, 2024, 2025) and previous dredging impact assessment studies (e.g., Weerts, 2008; MER, 2013; Cyrus 2014a,b, Cyrus and Vivier, 2020) for Port of Richards Bay. The approach taken in the analysis and presentation of the model results largely follows that undertaken of the proposed Port of Richards Bay Capacity Expansion project (van Ballegooyen *et al.*, 2015) that was focussed on development in much the same area as Berth 605.

6.1 METRICS OF IMPACT

The measures of impact applied to the model results comprise:

- Exceedance contours (99th, 95th, 90th and 80th percentile) of elevations in TSS concentrations where the exceedances are calculated only for the period that dredging occurs (approximately 139 days of the full 155-day model simulation period) as TSS concentrations decrease rapidly upon cessation of dredging and dredge spoil disposal activities. The reported 95th, 90th and 80th percentile exceedance contours of elevation in TSS concentrations represent TSS concentrations that are exceeded for a cumulative duration of 4,5 days, 9 days and 18 days per season, respectively. The 99th percentile exceedance contour is deemed to represent the maximum TSS concentration likely to occur within a season (here deemed to be 90-day period). However, given the 139-day duration of the dredging activities simulated in the model, the same 95th, 90th and 80th percentile exceedance contours represent elevations in TSS concentrations that are exceeded for 7 days, 14 days and 28 days, respectively, over the full duration of the dredging and dredge spoil disposal activities planned for Berth 605. The 80th percentile contour of elevation in TSS concentration therefore can be considered indicative of more “chronic” rather than short-term “acute” impact. These contours of days of exceedance of the threshold of concern have been determined for the surface waters, the mid-column waters and the near-bottom waters.
- Cumulative days of exceedance per season of the threshold of concern (or guideline value) for elevations in TSS concentrations in the water column relevant to the impact under consideration (e.g., visual impacts, marine ecological impacts in the water column, *etc.*). These contours of days of exceedance of the threshold of concern have been determined for the surface waters, the mid-column waters and the near-bottom waters. These days of exceedance contours provide an insight into the cumulative persistence and/or likely regularity with which turbid plumes will be observed in these environments.
- Maximum sedimentation thickness occurring during the full model simulation of 155 days.

6.2 VISUAL IMPACTS

Potential visual (aesthetic) impacts are associated with the generation of visible sediment plumes both at the dredging location within the Port of Richards Bay and possibly at the offshore dredge spoil disposal site. The exceedance of a relatively conservative threshold of a 10 mg/l elevation in TSS concentration above ambient in the surface waters is assumed to indicate the presence of visible sediment plumes in the marine environment (refer to Section 3.2.1). As the model results do not include background turbidity, in reality, it is assumed that plumes become visible when the TSS concentrations are increased by 10 mg/l or more above ambient or background levels. The same

threshold is assumed for both offshore waters and those within the Port of Richards Bay. The use of a TSS concentration threshold of 10 mg/l to indicate visual turbidity impacts is conservative in the port and offshore environments being assessed. However, such a threshold is deemed overly conservative in nearshore and shoreline environments. Historically, a threshold of 25 mg/l for visual impacts has been assumed to be more appropriate for such environments, e.g., for nearshore and shoreline to the north of Richards Bay where ongoing coastal erosion and associated sediment inputs result in high turbidity surf-zone and nearshore waters (CSIR, 2004a, 2005a). As no discharges into nearshore environments are simulated in the model (e.g., the discharge of dredge material onto Alkanstrand using the existing sand bypass infrastructure), only the results for the conservative 10 mg/l threshold and a less conservative of 20 mg/l are reported.

6.2.1 POTENTIAL VISUAL IMPACTS WITHIN THE PORT

The model results for potential visual impacts within the port are provided in Figure 6-1 to Figure 6-3 below. The 99th percentile (or deemed maximum) exceedance contours of elevation in TSS concentrations in the surface waters surrounding the dredging activities of the Berth 605 basin and berthing area (Figure 6-1), indicate that the visual impacts will extend beyond the 600 series basin (albeit for only very short periods). The 80th percentile contours of elevation in TSS concentrations in the surface waters (Figure 6-2) suggest that these more chronic visual impacts are well constrained within the 600 series basin. The days of exceedance per season of the 10 mg/l threshold (Figure 6-3) indicate that this visual threshold will be exceeded continuously in close proximity to the CSD dredger and for 45 to 50 days per season in the inner half of the 600 series basin. The 10 mg/l threshold of concern is only likely to be exceeded for a couple of days per season beyond the 600 series basin. The days of exceedance of a less conservative threshold of 20 mg/l do not significantly differ from those for a 10 mg/l threshold.

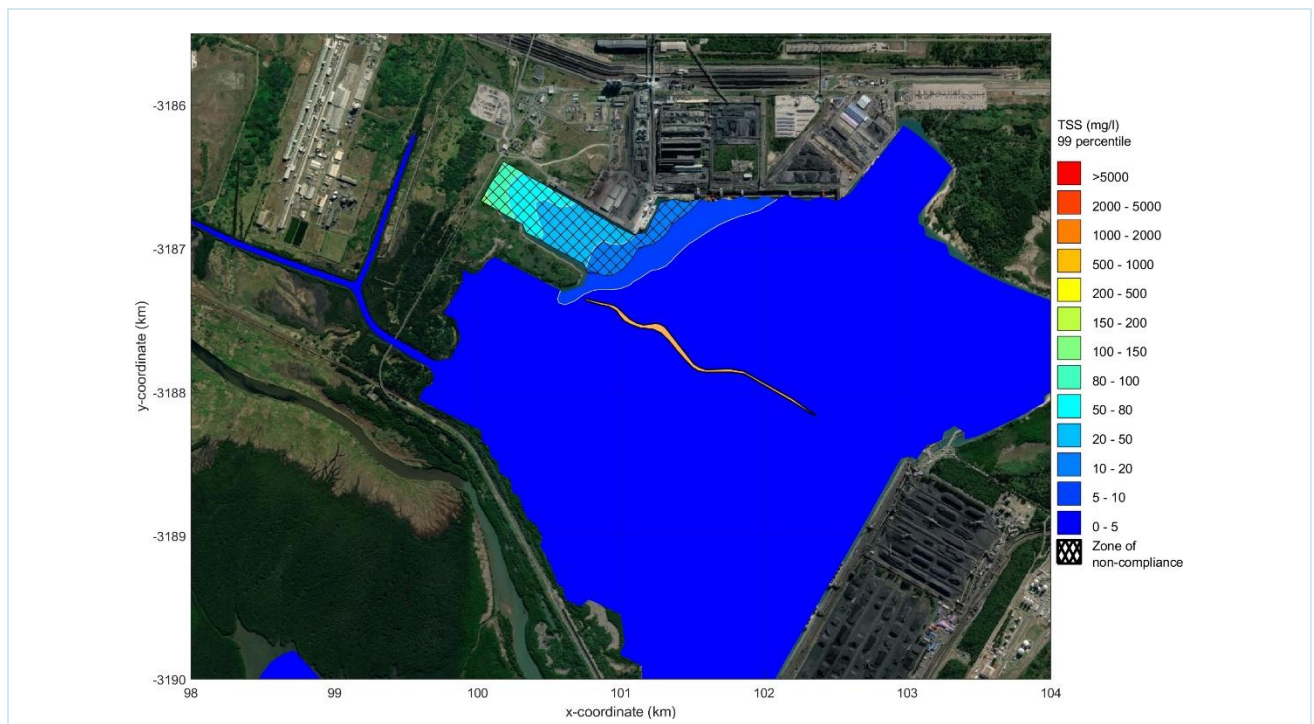


Figure 6-1 - 99th percentile exceedance contours of elevation in TSS concentration in surface waters within the port.



Figure 6-2 - 80th percentile exceedance contours of the elevation in TSS concentration in surface waters within the port.

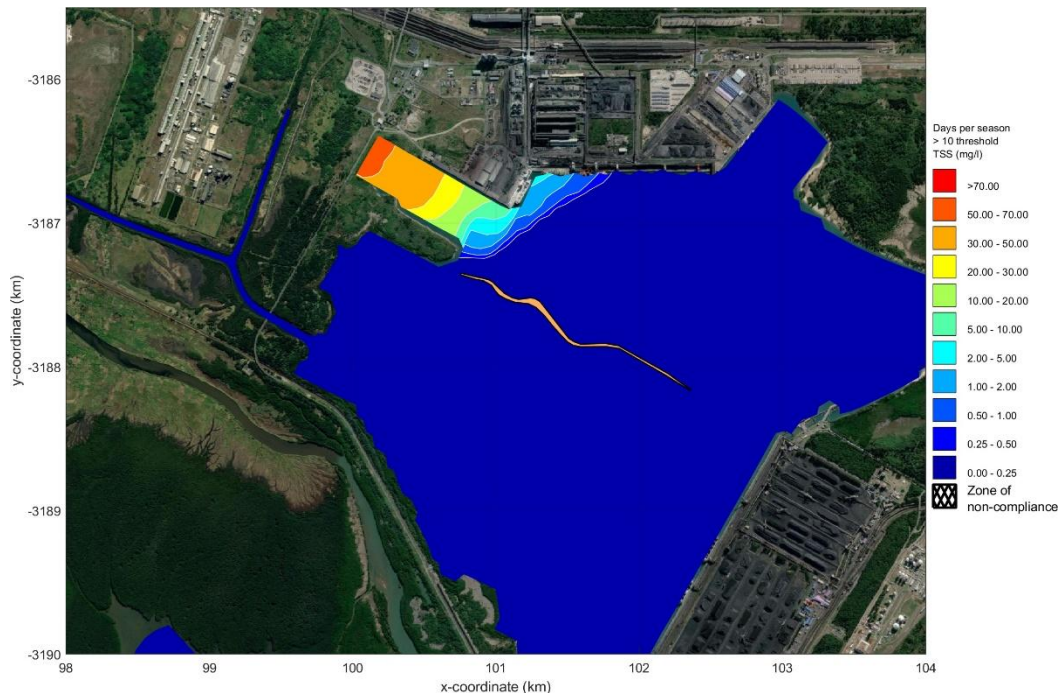


Figure 6-3 –Days per season that the elevation in TSS concentrations exceeds 10 mg/l in surface waters within the port.

There are significant elevations in TSS concentration in the surface waters associated with the shipping activities. Some examples of this are provided in Figure 6-4 to Figure 6-6. The available images seemingly indicate that visible surface plumes of sediments “stirred up” by shipping are most prevalent in the winter months, presumably when the water column is less stratified and more easily vertically mixed. Visible plumes are therefore common in the Port of Richards Bay. The big difference is that the visible plumes from dredging are likely to occur more often and have a much greater persistence.



Figure 6-4 - Sediments driven into suspension by ship berthing activities in the 600 series basin on 27 March 2016 (upper panel) and 9 August 2016 (lower panel) in the Port of Richards Bay (Source: GoogleEarth).

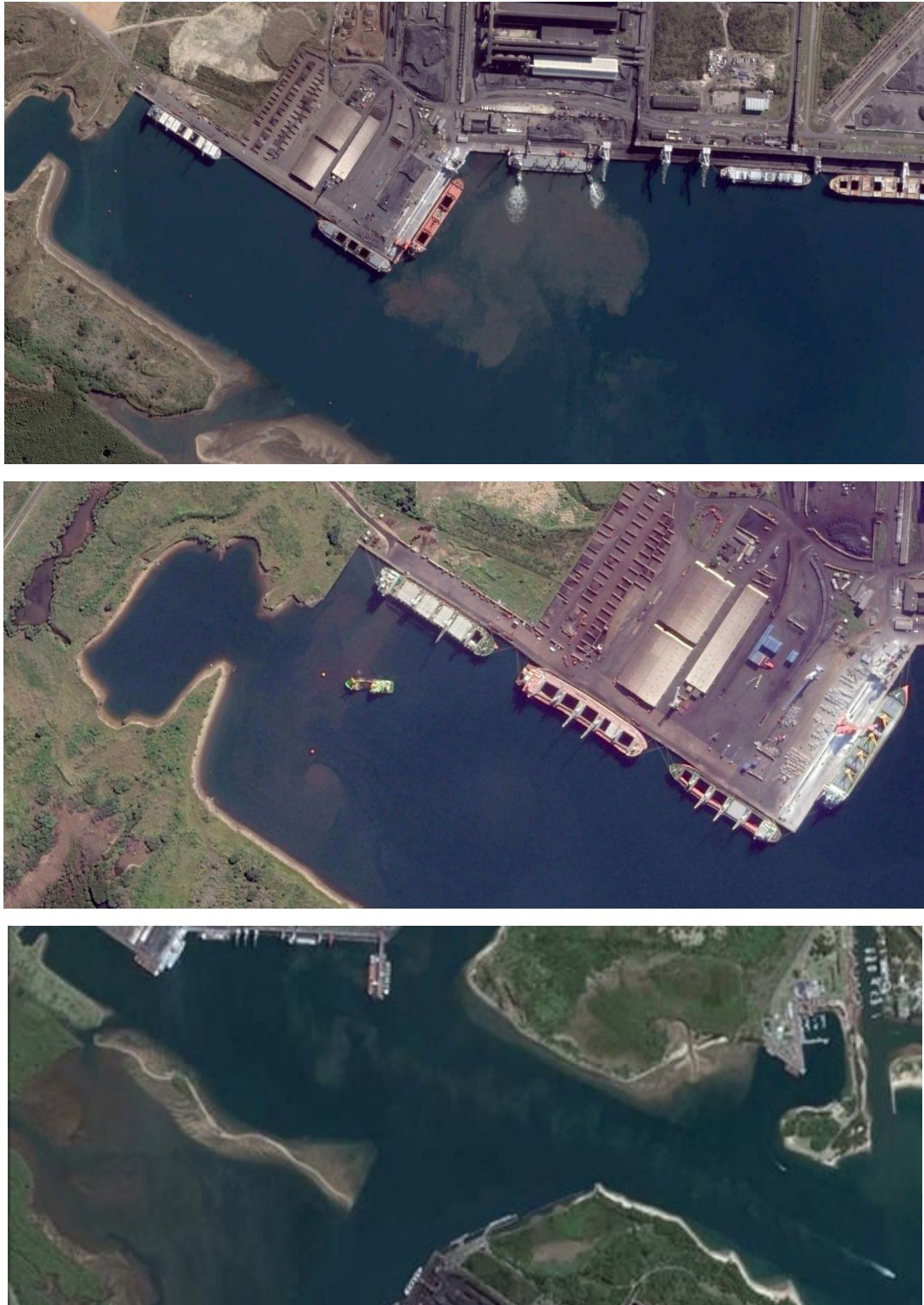


Figure 6-5 - Sediment driven into suspension by dredging in the 600 series basin on 15 May 2016 (upper panel). ship berthing activities at the 700 series berth on 19 May 2015 (middle panel) in the Port of Richards Bay and in the inner entrance channel of the port of Richards Bay on 3 May 2014 (middle panel). (Source: GoogleEarth).



Figure 6-6 - Sediment driven into suspension by ship berthing activities in the coal basin in the Port of Richards Bay on 3 May 2014 (upper panel) and in the coal basin and entrance channel the Port of Richards Bay on 29 July 2015 (lower panel). (Source:GoogleEarth)

6.2.2 POTENTIAL VISUAL IMPACTS OUTSIDE THE PORT

The visual impacts are somewhat more extensive at the offshore dredge spoil disposal site. While short period elevations in TSS concentrations are expected in the surface layers when dredge spoil disposal occurs, significant and more persistent elevated TSS concentrations (turbidity) in the surface layers are only expected during storm conditions. It is expected that the potential for the discoloration of the surface waters at the offshore disposal site will decrease significantly once dredge spoil disposal operations cease, as the readily exposed fine material on the seabed is relatively rapidly eroded from the dredge spoil disposal site. As time passes, only the more significant storm conditions will result in elevations in TSS concentrations in the surface waters.

The 99th percentile contours (maxima) of elevations in TSS concentrations in the surface waters around the offshore disposal site (Figure 6-7) are fairly extensive and indicate an alongshore distribution associated primarily aligned with the prevailing wind-driven flows with a lesser influence of the large-scale Agulhas Current flows further offshore. The 80th percentile contours of elevation in TSS concentrations (Figure 6-8) indicate potential “chronic” aesthetic impacts that extend approximately 3 km northeast and 2km southwest of the disposal site.

The plot indicating the days of exceedance per season of the 10 mg/l threshold of concern (Figure 6-9) suggest that this threshold will be exceeded for more than 10 days in a season for distances of 8 km NE of the disposal site and 6km to the SE of the site. The days of exceedance of the 10 mg/l shows a peak approximately 3 km NE of the disposal site.

The asymmetry of the aesthetic impacts suggests that the elevations in TSS concentration are primarily linked to the strong north-eastward flows and higher wave conditions associated with the predominantly SW winds that occur with the passage of mid-latitude cyclones (*i.e.*, a period when there is likely to be generally elevated TSS concentrations over the inner shelf and possibly sediment inputs from adjacent catchments). This is consistent with the measured elevations in TSS concentration near the seabed during the dredge spoil disposal activities associated with the Berth 306 capital dredging (see Figure 4-37 in Section 4.8.2).

The days of exceedance of a less conservative 20 mg/l threshold of concern per season (Figure 6-10) suggest that this threshold is unlikely to be exceeded for more than 5 to 10 days in a season at distances of 3 km NE of the disposal site and 2 km to the SE of the site.

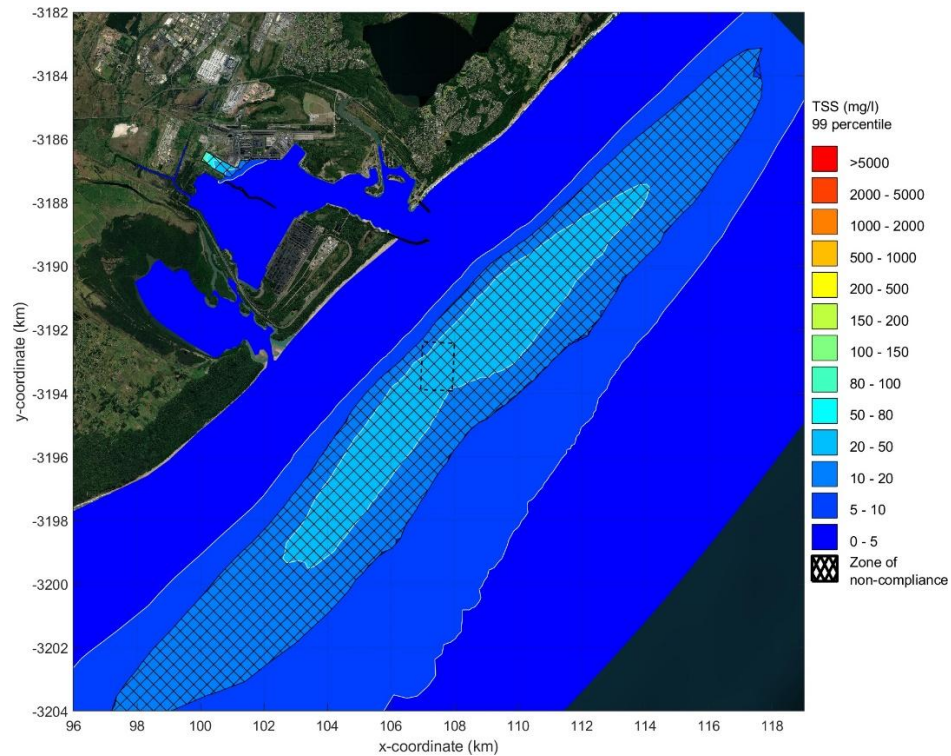


Figure 6-7 - 99th percentile exceedance contours of elevation in TSS concentration in surface waters around the offshore dredge spoil disposal site.

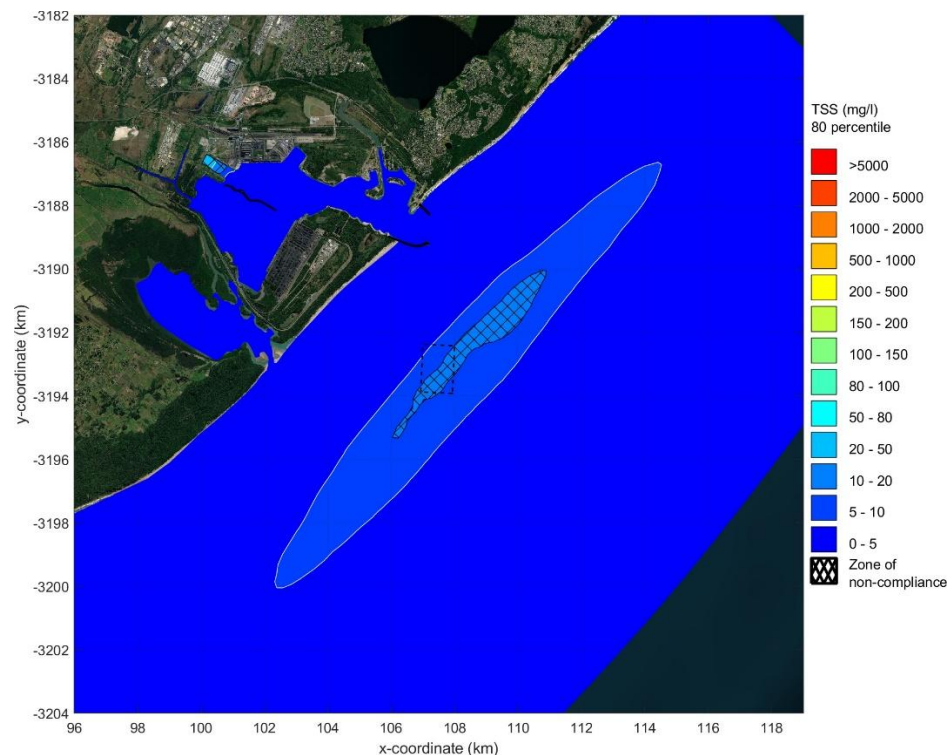


Figure 6-8 - 80th percentile exceedance contours of elevation in TSS concentration in surface waters around the offshore dredge spoil disposal site.

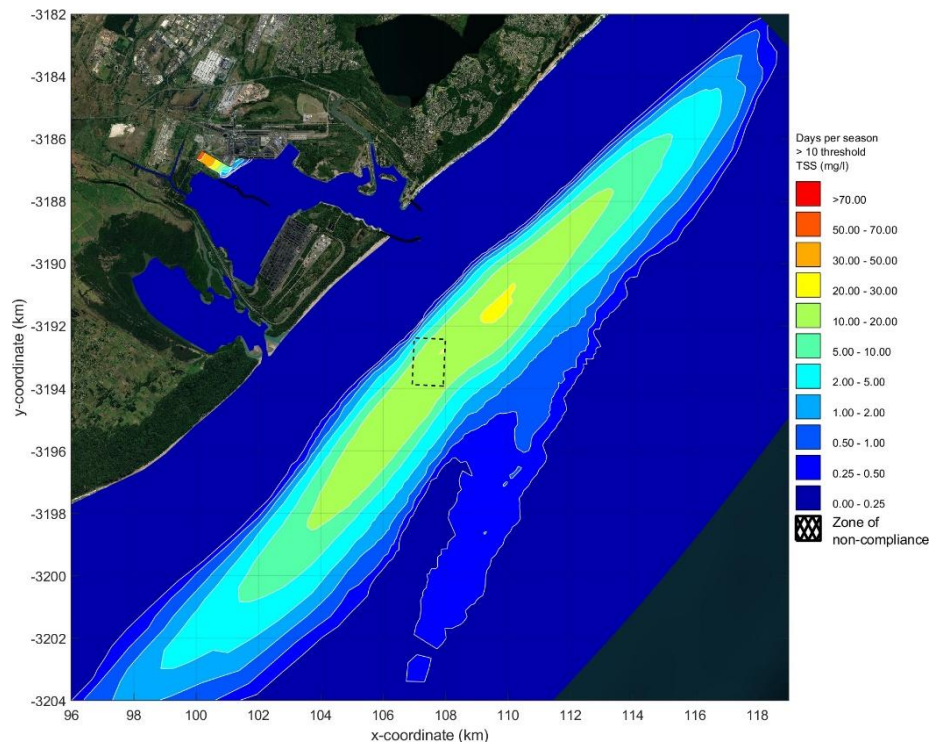


Figure 6-9 –Days per season that TSS concentration exceeds 10 mg/l in surface waters

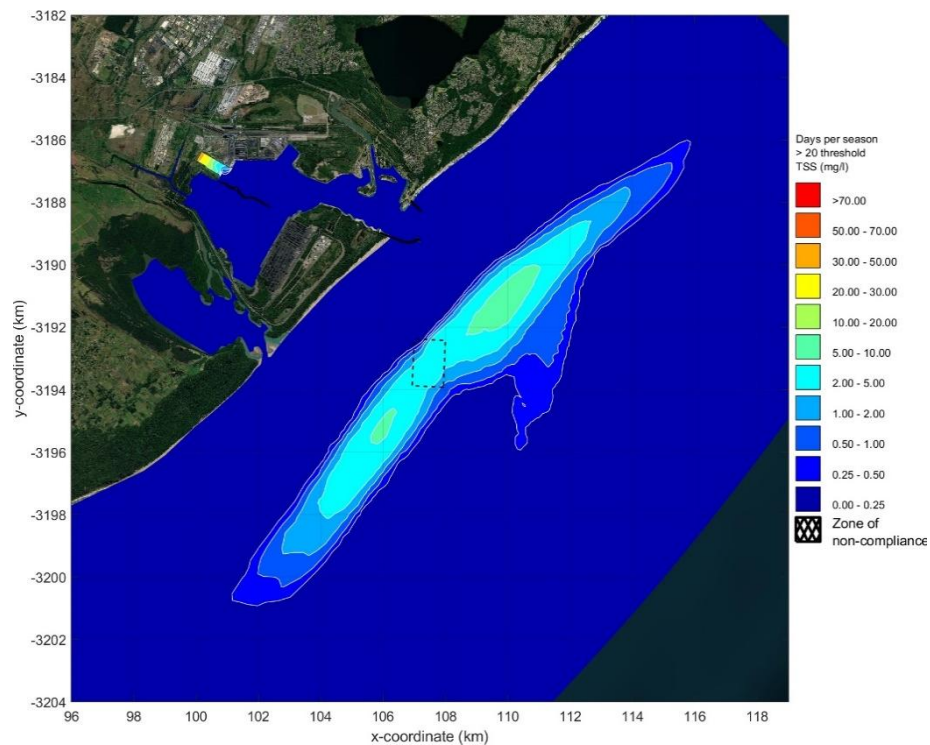


Figure 6-10 –Days per season that TSS concentration exceeds 20 mg/l in surface waters

The discoloration of nearshore waters to the south of the port entrance (e.g., at the entrance to the Mhlathuze estuary) is predicted to not occur. However, were such impacts to occur, they would be difficult to discern amongst the already high turbidity events such as the turbid inflows into the Mhlathuze Estuary and then into the nearshore waters, as well as the turbidity associated with ongoing maintenance dredging (Figure 6-11). CSIR (2025) provides additional examples of extensive elevations in turbidity associated with inflows to the marine environment from the Mhlathuze Estuary (Figure 6-12), the influence which can extend to disposal site particularly under high rainfall storm events. Satellite imagery shows the sediment inputs from the rivers and associated wind and wave conditions to increase the TSS concentrations not only in the inshore region of the Kwa-Zulu Natal Bight but also beyond (Smith and Bernard, 2011), which will influence significantly the elevations in TSS concentrations at the disposal site on such occasions.



Figure 6-11 – Elevated water column turbidity due to dredging activities at the port entrance and re-suspension of sediments in the nearshore environment (Photo courtesy of Mr C.J. Ward as reported in Weerts, 2008).



Figure 6-12 - Sediment plumes in the nearshore environment with evidence (lower panel) of naturally elevated turbidity in the surface waters extending as far as the offshore disposal site (CSIR, 2025).

6.3 ECOLOGICAL IMPACTS ASSOCIATED WITH ELEVATED TURBIDITY AND TSS CONCENTRATIONS

Several environmental thresholds exist (see Section 4.3) for assessing ecological impacts. Those selected for presentation are:

- A <20 mg/l TSS concentration guideline suggested by Steffani *et al.* (2003) that represents a conservative lower threshold below which impacts are not expected to occur in ecologically sensitive areas in Table Bay and also in Algoa Bay (see also TNPA, 2009). This < 20 mg/l threshold constitutes a low risk, monthly average goal that was used in a previous capital dredging study for the Port of Richards Bay (van Ballegooyen *et al.*, 2015);
- A >80 mg/l TSS concentration guideline also suggested by Steffani *et al.* (2003), that they considered to represent a high-risk situation (albeit for environments where strong river/estuarine inflows are not expected) and one that is likely to require mitigation. The applicability of this threshold in this project is uncertain and is likely to be overly conservative;
- A <100 mg/l target value for TSS concentrations in the water column that, based on a literature review (EMBECON, 2004), represents limited risks for biota. This is also the threshold suggested in CSIR (2013c) for assessing potential dredging impacts within the Port of Richards Bay and used in CSIR (2004b) to assess impacts in nearshore environments for shoreline discharges of dredge spoil;
- A < 150 mg/l threshold for TSS concentration suggested in CSIR (2013c) as being applicable for assessing impacts in the mudflats within the port and in the Bhizolo Canal.

In addition, a threshold of an elevation in TSS concentration < 25 mg/l has also been utilised in previous studies (van Ballegooyen and Jacobs, 2020) but utilised mainly to assess potentially turbidity impacts of dredge spoil disposal onto the northern shoreline in an attempt to mitigate ongoing shoreline erosion of these northern beaches (WSP, 2025). This represents one of the guidelines (CCME, 2002) reported in the proposed new SA Water Quality guidelines (DFFE, 2022).

6.3.1 POTENTIAL TURBIDITY / ELEVATED TSS IMPACTS WITHIN THE PORT

The metrics used to summarise the modelling results in terms of potential ecological impacts within the Port of Richards Bay and associated figure number references are summarised in Table 6-1 below.

No time series of elevations in TSS concentration are plotted for sensitive areas such as the tidal flats as the time series of elevation in TSS concentration in both surface and bottom waters for all monitoring locations beyond the 600 series basin and its immediate surroundings are predicted to not exceed 2 mg/l.

Table 6-1 - Figure references for the various metrics used to assess the spatial extent of potential ecological impacts within the Port of Richards Bay

Description of Metric	Depth of Observation	Figure Reference
80 th percentile contours of TSS concentration (showing area of non-compliance with a 20 mg/l TSS concentration threshold)	Surface	Figure 6-13
	Bottom	Figure 6-14
99 th percentile contours of TSS concentration (showing area of non-compliance with a 20 mg/l TSS concentration threshold)	Surface	Figure 6-15
	Bottom	Figure 6-16
80 th percentile contours of TSS concentration (showing area of non-compliance with an 80 mg/l TSS concentration threshold)	Surface	Figure 6-17
	Bottom	Figure 6-18
99 th percentile contours of TSS concentration (showing area of non-compliance with an 80 mg/l TSS concentration threshold)	Surface	Figure 6-19
	Bottom	Figure 6-20
Day of exceedance of 20 mg/l TSS concentration threshold	Surface	Figure 6-21
	Bottom	Figure 6-22
Day of exceedance of 80 mg/l TSS concentration threshold	Surface	Figure 6-23
	Bottom	Figure 6-24

Figure 6-13 to Figure 6-16 show the 80th and 99th percentile TSS concentrations for surface and bottom waters in the port where the zone of non-compliance with a 20 mg/l threshold is indicated by cross-hatching. Figure 6-17 to Figure 6-20 show the same metrics but with the zone of non-compliance with an 80 mg/l threshold indicated.

The 80th percentile contours of TSS concentration (representing an approximate two week cumulative period of exposure) (Figure 6-13) indicate that the TSS concentrations typically remain < 5 mg/l in the surface waters beyond the 600 series basin, only exceeding 20 mg/l in the inner basin in close proximity to the dredging activities. The 80th percentile concentrations in the bottom waters typically are < 20 mg/l (Figure 6-14 and Figure 6-18). The elevated TSS concentrations are mostly restricted to the areas being dredged.

The 99th percentile contours of TSS concentration (representing an approximate < 1 day cumulative period of exposure) indicate that the TSS concentrations typically remain < 20 mg/l in the surface waters (Figure 6-15) but in the bottom waters extend beyond the 600 series basin to Berth 609 and even 701 (Figure 6-16). Within the inner recesses of the 600 series basin the 99th percentile TSS concentrations (maxima) in the bottom waters are predicted to exceed 200 mg/l (Figure 6-16).

The contour plots of (cumulative) days of exceedance per season of a 20 mg/l threshold indicate that this threshold is not exceeded in the surface waters beyond the 600 series basin for more than 2 days (Figure 6-21) but in the inner recesses of the 600 series basin remains above this threshold for almost 50% of the time. Contours of the days of exceedance per season of a 20 mg/l threshold show that this threshold is exceeded in the bottom waters beyond the 600 series basin to the Berths 609 and 701 where this threshold is exceeded for up to 10 days per season (Figure 6-22). The same plot shows a persistent and continuous exceedance of a 20 mg/l threshold in the bottom waters.

The contour plots of (cumulative) days of exceedance per season of a 80 mg/l threshold indicate that this threshold is not exceeded in the surface waters beyond the inner half of the 600 series basin for more than 2 days (Figure 6-23) but exceeds this 80 mg/l threshold for up to 20 days in the inner recesses of the 600 series basin. Contours of the days of exceedance per season of an 80 mg/l threshold show exceedance of this threshold in the bottom waters is well confined within the 600 series basin (Figure 6-24).

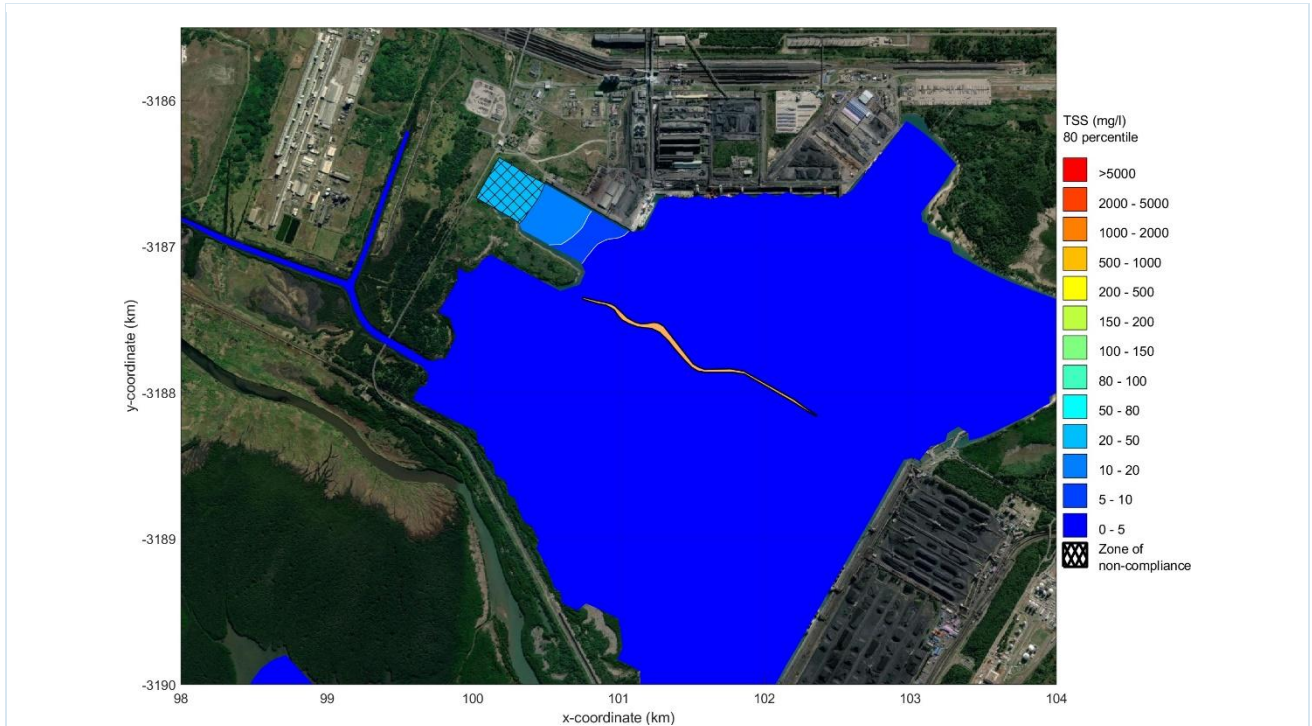


Figure 6-13 – 80th percentile exceedance contours of TSS concentration in surface waters within the port, indicating the zone of non-compliance with a 20 mg/ℓ threshold.



Figure 6-14 – 80th percentile exceedance contours of TSS concentration in bottom waters within the port, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

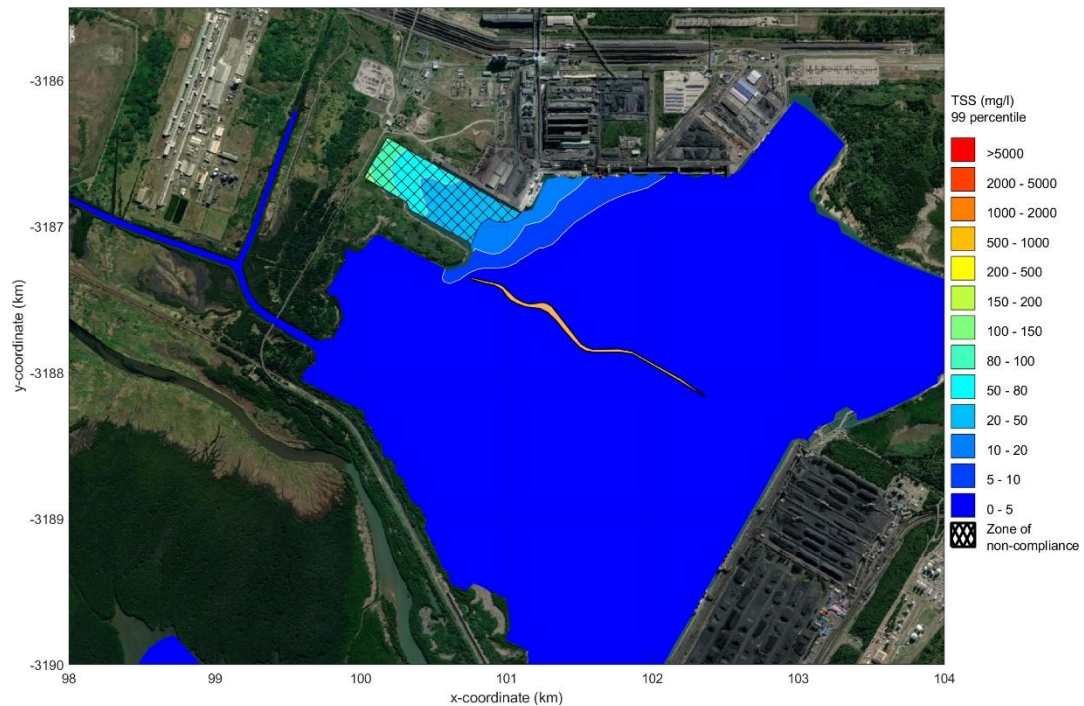


Figure 6-15 – 99th percentile exceedance contours of TSS concentration in surface waters within the port, indicating the zone of non-compliance with a 20 mg/ℓ threshold.



Figure 6-16 – 99th percentile exceedance contours of TSS concentration in bottom waters within the port, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

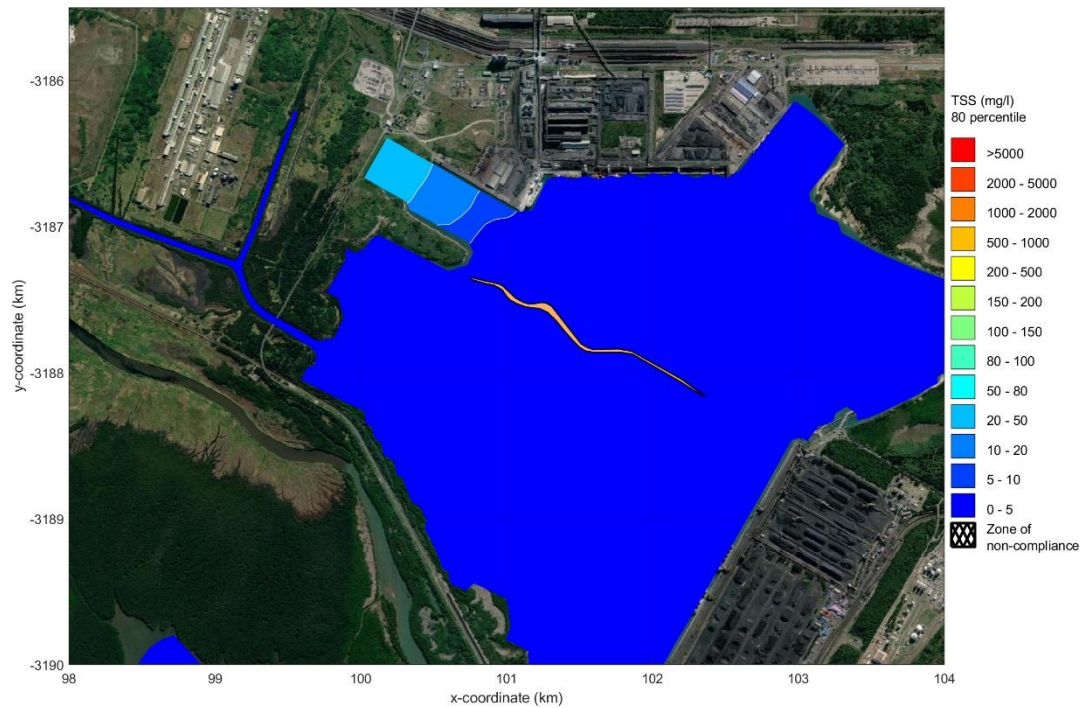


Figure 6-17 – 80th percentile exceedance contours of TSS concentration in surface waters within the port, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

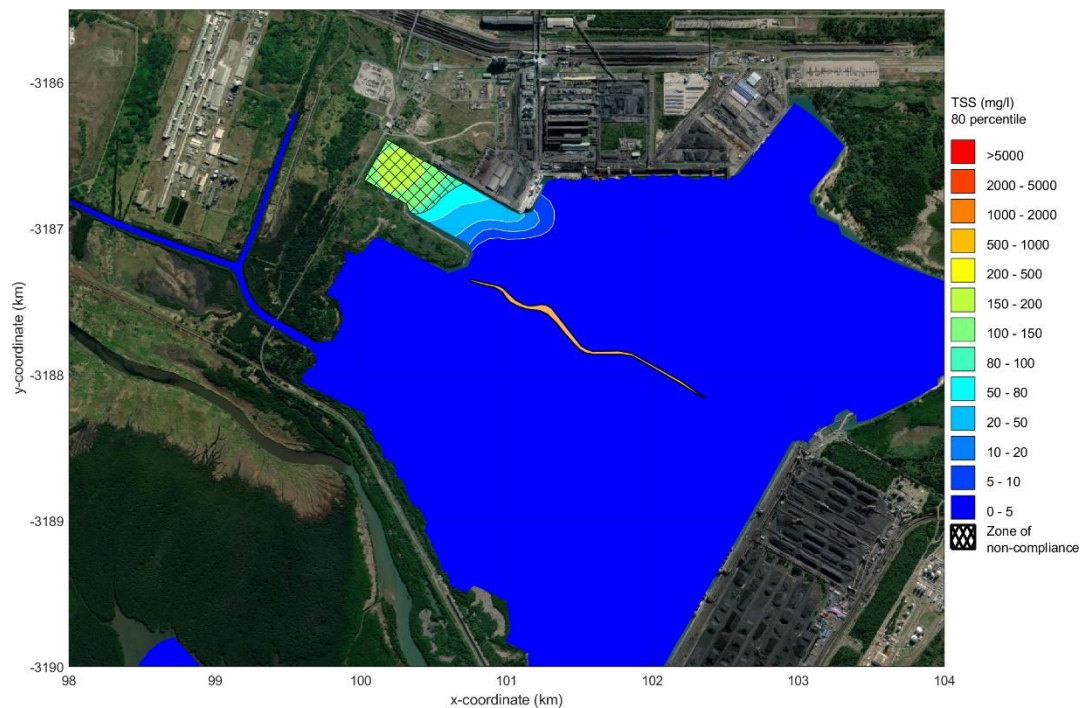


Figure 6-18 – 80th percentile exceedance contours of TSS concentration in bottom waters within the port, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

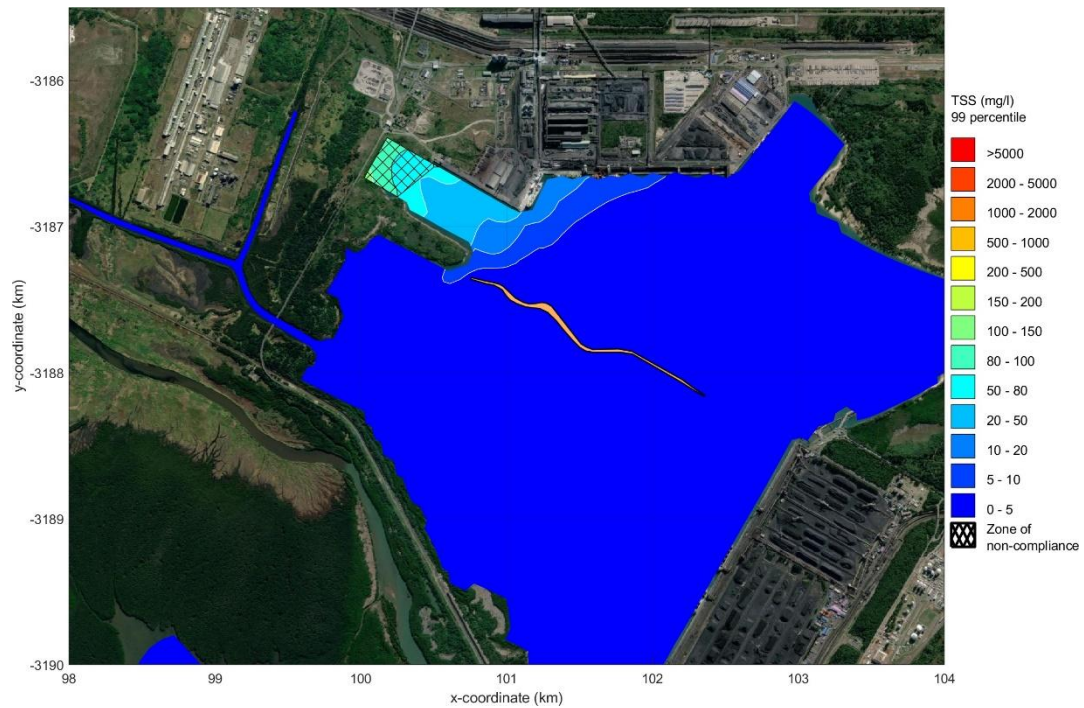


Figure 6-19 – 99th percentile exceedance contours of TSS concentration in surface waters within the port, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

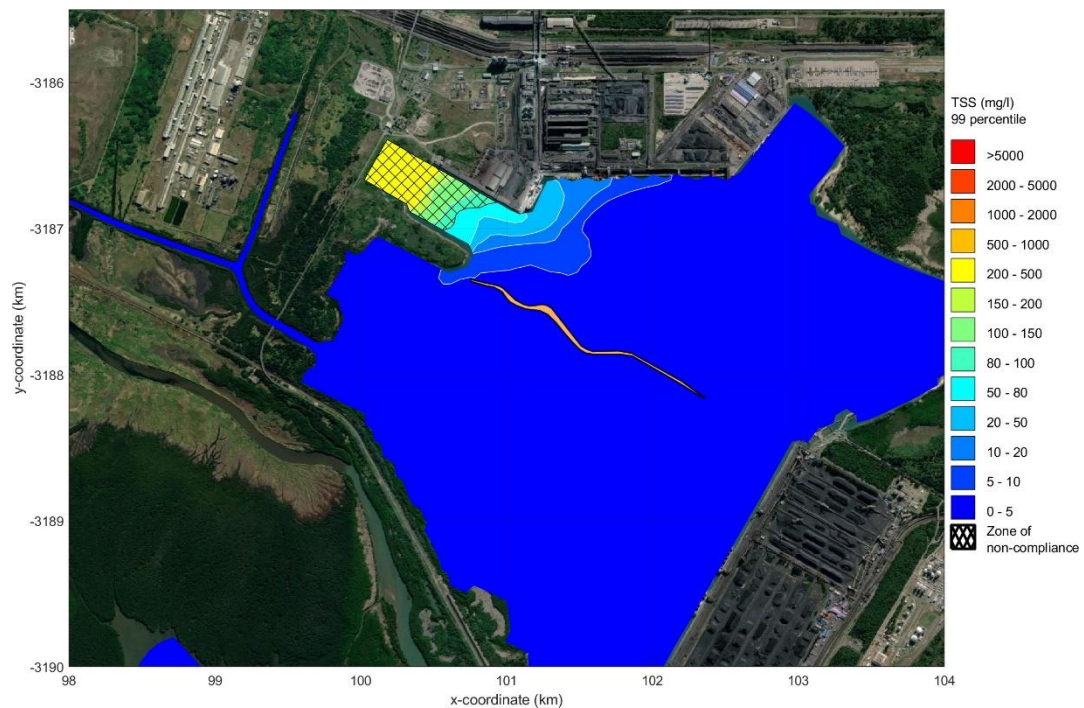


Figure 6-20 – 99th percentile exceedance contours of TSS concentration in bottom waters within the port, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

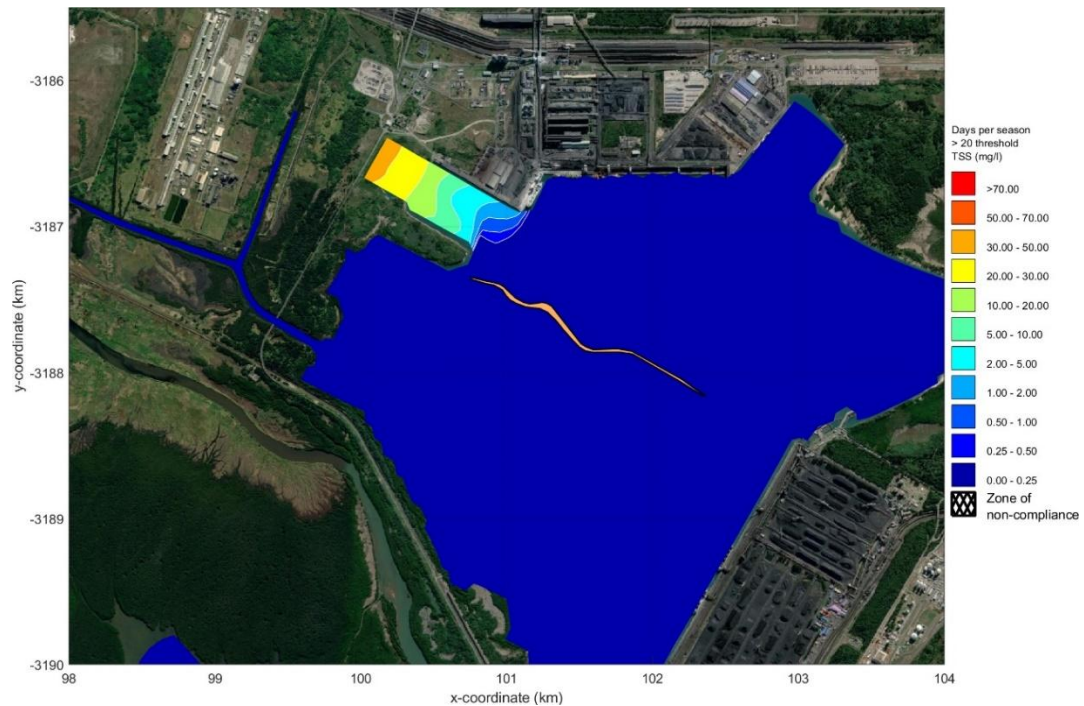


Figure 6-21 – Days of Exceedance of TSS concentration threshold of 20 mg/l in surface waters within the port.

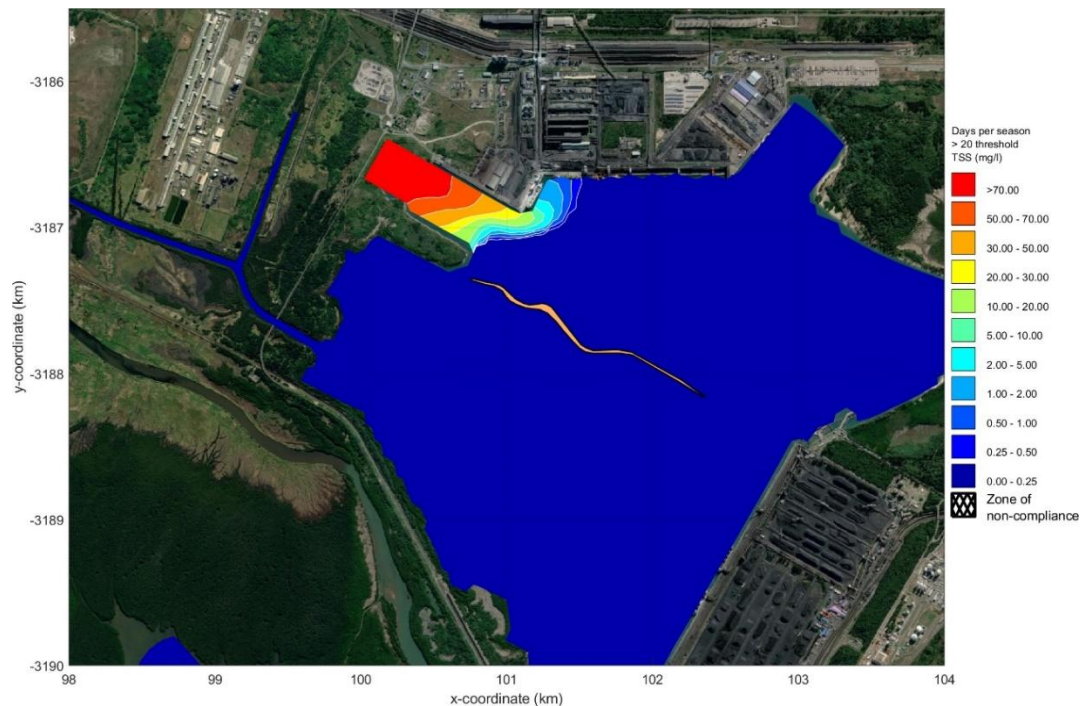


Figure 6-22 – Days of Exceedance of TSS concentration threshold of 20 mg/l in bottom waters within the port.

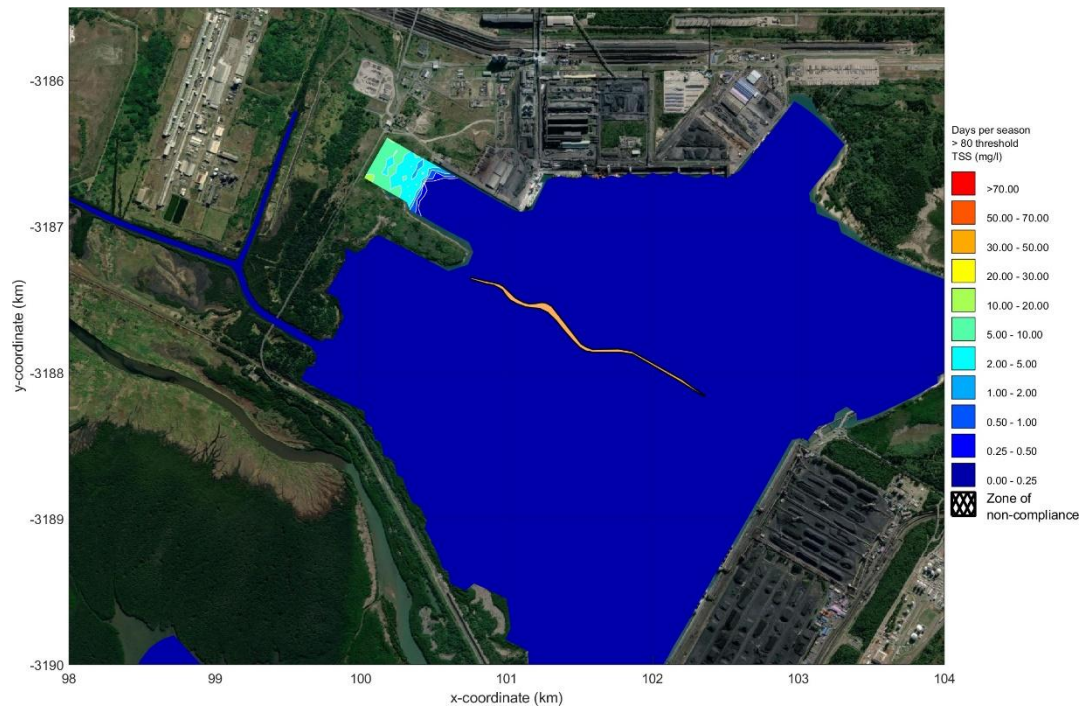


Figure 6-23 – Days of Exceedance of TSS concentration threshold of 80 mg/l in surface waters within the port.

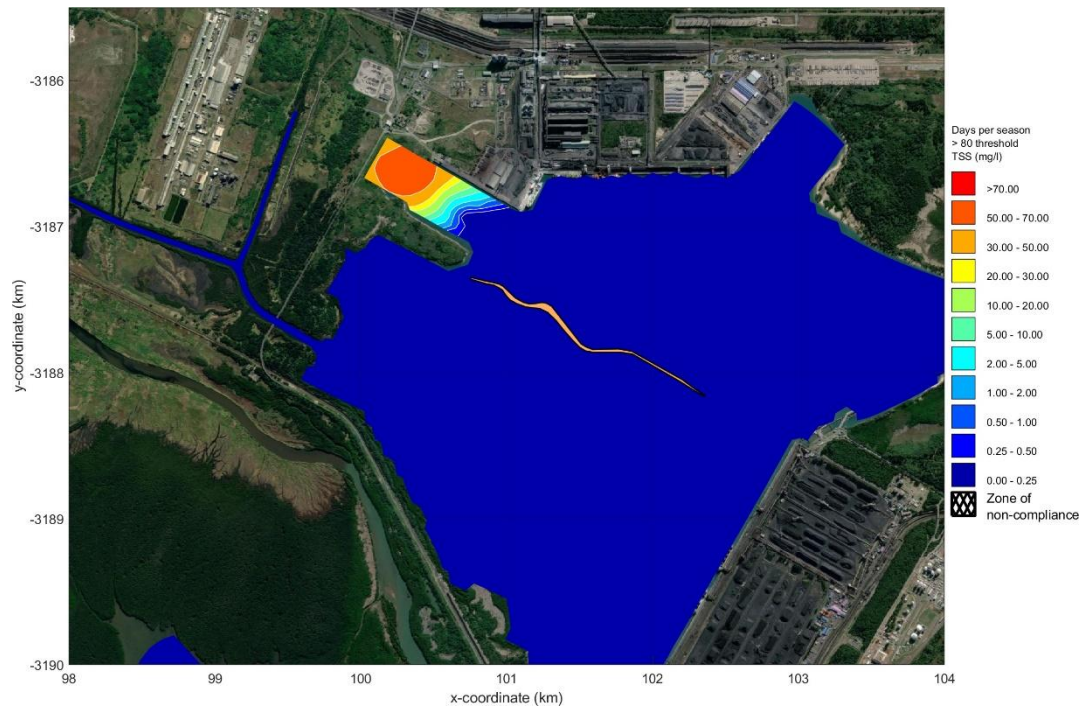


Figure 6-24 – Days of Exceedance of TSS concentration threshold of 80 mg/l in bottom waters within the port.

6.3.2 POTENTIAL TURBIDITY / ELEVATED TSS IMPACTS OUTSIDE THE PORT

The metrics used to summarise the modelling results in terms of potential ecological impacts in the offshore region and associated figure number references are summarised in Table 6-2 and Table 6-3 below.

Table 6-2 - Figure references for the various metrics used to assess the spatial extent of potential ecological impacts offshore of the Port of Richards Bay.

Description of Metric	Depth of Observation	Figure Reference
80 th percentile contours of TSS concentration (showing area of non-compliance with a 20 mg/l TSS concentration threshold)	Surface	Figure 6-26
	Bottom	Figure 6-27
99 th percentile contours of TSS concentration (showing area of non-compliance with a 20 mg/l TSS concentration threshold)	Surface	Figure 6-28
	Bottom	Figure 6-29
80 th percentile contours of TSS concentration (showing area of non-compliance with an 80 mg/l TSS concentration threshold)	Surface	Figure 6-30
	Bottom	Figure 6-31
99 th percentile contours of TSS concentration (showing area of non-compliance with an 80 mg/l TSS concentration threshold)	Surface	Figure 6-32
	Bottom	Figure 6-33
Day of exceedance of 20 mg/l TSS concentration threshold	Surface	Figure 6-34
	Bottom	Figure 6-35
Day of exceedance of 80 mg/l TSS concentration threshold	Surface	Figure 6-36
	Bottom	Figure 6-37
Day of exceedance of 100 mg/l TSS concentration threshold	Surface	Figure 6-38
	Bottom	Figure 6-39
Day of exceedance of 150 mg/l TSS concentration threshold	Surface	Figure 6-40
	Bottom	Figure 6-41

Table 6-3 - Figure references for the locations at which TSS concentrations near the seabed have been plotted to inform of potential ecological impacts offshore of the Port of Richards Bay.

Location	Depth of Observation	Figure Reference
D05 (located approximately 0.3 km E of the disposal site)	near seabed	Figure 6-42
D06 (located approximately 1.0 km SE of the disposal site)	near seabed	Figure 6-43
D09 (located approximately 0.8 km SW of the disposal site)	near seabed	Figure 6-44
D12 (located approximately 1.2 km NE of the disposal site)	near seabed	Figure 6-45

The location of the stations for which time series have been plotted are given in Figure 6-25. No time series of elevations in TSS concentration are plotted for the inshore area around the Mhlathuze Estuary or within the estuary itself as the time series of elevation in TSS concentration in both surface and bottom waters for all such monitoring locations are predicted to not exceed 2 mg/l.



Figure 6-25 - Location of the stations for which time series of elevations in TSS concentrations have been plotted (see Table 6-3) with existing dumpsite in black.

The potential impacts in the offshore region, particularly around the offshore disposal site are described below. Figure 6-26 to Figure 6-29 show the 80th and 99th percentile TSS concentrations for surface and bottom waters in the port where the zone of non-compliance with a 20 mg/l threshold is indicated by cross-hatching. Figure 6-30 to Figure 6-33 show the same metrics but with the zone of non-compliance with an 80 mg/l threshold is indicated.

The 80th percentile contours of TSS concentration (representing an approximate two week cumulative period of exposure) (Figure 6-26) indicate that the TSS concentrations do not exceed 20 mg/l in the surface waters at the offshore dredge spoil disposal site. The 80th percentile contours of TSS concentrations in the bottom waters (Figure 6-27, and Figure 6-31) show that:

- TSS concentrations > 20 mg/l are exceeded for up to 4 km NE and 1.5 km SW of the disposal site (Figure 6-27)
- TSS concentrations > 80 mg/l are exceeded for less than 1 km NE of the disposal site (Figure 6-31, and
- TSS concentrations exceeding 200 mg/l occur at the centre of the offshore dredge spoil disposal site (Figure 6-31)

The 99th percentile contours of TSS concentration (representing an approximate < 1-day cumulative period of exposure) (Figure 6-28) indicate that the TSS concentrations exceed 20 mg/l in the surface waters for up to 8km north and south of the disposal site. There is no exceedance of an 80 mg/l threshold by the maximum (99th percentile) TSS concentration (99th percentile) in the surface waters (

The 99th percentile contours of TSS concentrations in the bottom waters (Figure 6-29 and Figure 6-32) show that:

- TSS concentrations > 20 mg/l are exceeded for more than 10 km NE and up to 8 km SW of the disposal site (Figure 6-29)
- TSS concentrations > 80 mg/l are exceeded for approximately 2 km NE and up to 1 km SW of the disposal site (Figure 6-33) and
- TSS concentrations exceeding 1 000 mg/l occur at the centre of the offshore dredge spoil disposal site (Figure 6-33).

The contour plots of (cumulative) days of exceedance of a 20 mg/l threshold indicate that this threshold is exceeded in the surface waters for a cumulative total of more than two days per season for distances up to 6 km NE and SW of the disposal site with a peak exceedance of more than 5 days at a distance of approximately 3 km NE and SW of the disposal site (Figure 6-34). In the bottom waters the cumulative days of exceedance per season of 20 mg/l threshold extends up to 7 km NE and just less than 3 km to the SW of the disposal site, with a peak of 30 to 50 days over an area roughly as large as the site but slightly to the east of the disposal site (Figure 6-35).

The contour plots of (cumulative) days per season indicate that thresholds 80 mg/l are not exceeded in the surface waters (Figure 6-36, Figure 6-38 and Figure 6-40) .For thresholds of 80 mg/l and larger, a cumulative 20 day exceedance of the threshold in the bottom waters decreases to typically 2 km to the NE of the site and from 1 km to the SW of the disposal site, with a peak of 30 to 50 days over an area roughly as large as the site, but slightly to the east of the disposal site (Figure 6-36). With increasing thresholds from 100 mg/l to 150 the area over which the threshold is exceeded for

30 to 50 days decreases substantially to 1 km to the NE and ~500m to the SW of the disposal site (Figure 6-38 and Figure 6-40).

Time series of TSS concentration at a location DS05 (Figure 6-42) approximately 0.3 km to the east of the disposal site indicate modest TSS concentrations in the surface waters but high TSS concentrations in the bottom waters, presumed to be partially due to:

- the proximity of dredge material disposal activities
- the elements of fluid mud-like flows into deeper waters, and
- re-suspension of sediments by storm events.

The TSS concentrations in the bottom waters typically last for a day or two, suggestion a strong correlation if both wave and wind-driven current events. However, more persistent elevations in TSS concentrations as observed in late September was most probably primarily due to the close proximity of dredge spoil disposal events. A location (DS06) in deeper waters approximately 1.0 to the SE of the site (Figure 6-43), indicates the same short peaks in TSS concentration but at much lower concentrations, *i.e.*, very rarely exceeding 50 mg/l.

Sites located 0.8 km to the SW of the disposal site (DS09) and approximately 1.2 to the NE of the disposal site (DS12) indicate the same peakiness south of TSS concentration in the bottom waters compared to the surface waters. The TSS concentrations are generally low with weather event scale elevations in TSS concentration in both the surface and bottom waters. At times the TSS concentrations in the surface waters are similar to those of the bottom waters, but generally the TSS concentrations in the bottom waters during such peaks are almost an order of magnitude larger than those at the surface.

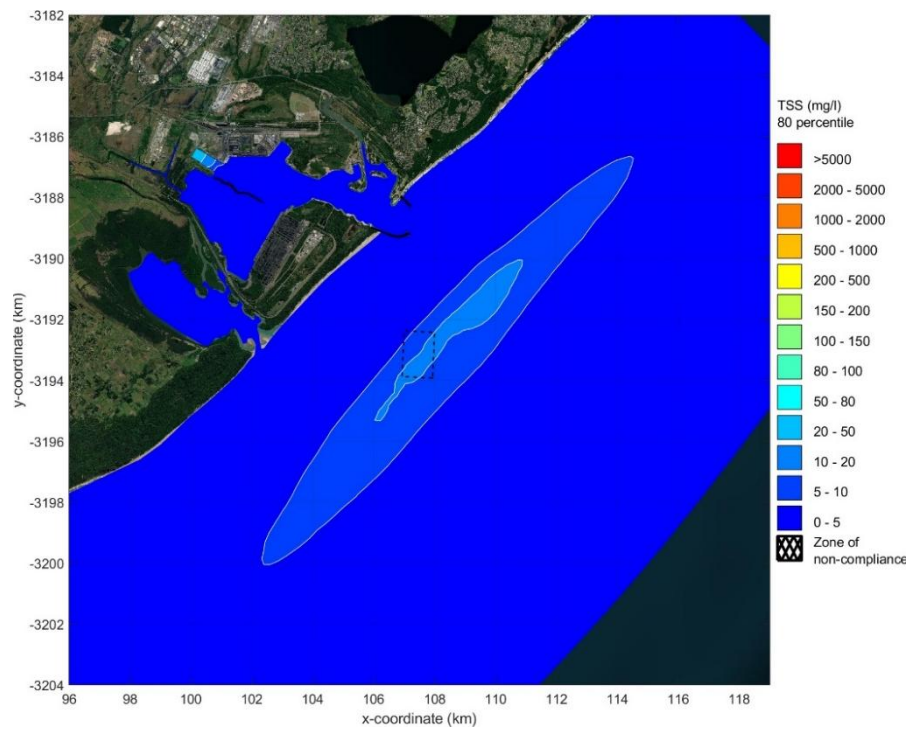


Figure 6-26 – 80th percentile exceedance contours of TSS concentration in the surface waters, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

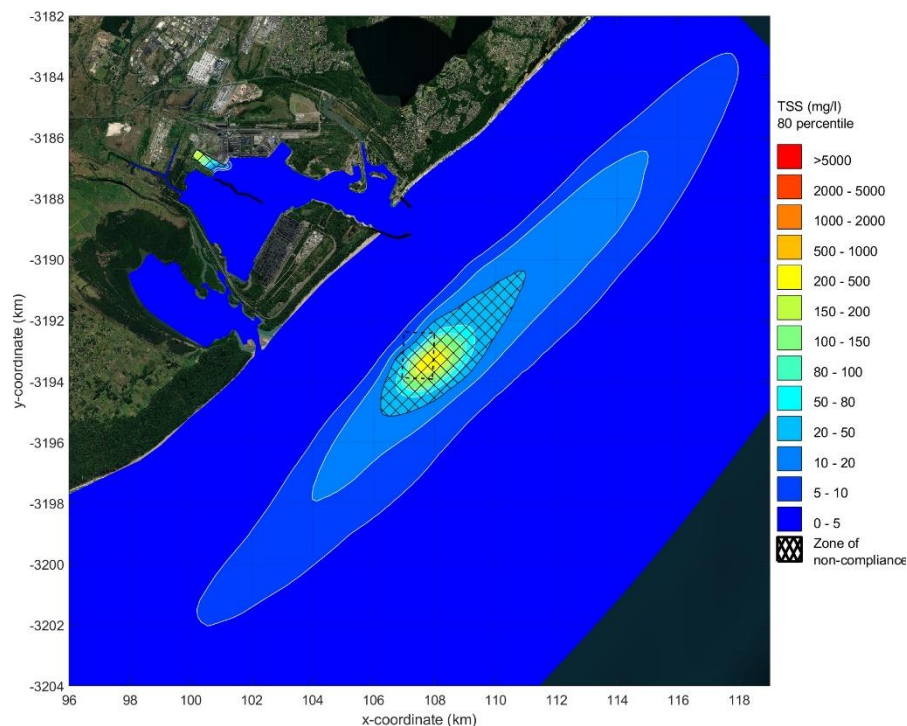


Figure 6-27 – 80th percentile exceedance contours of TSS concentration in the bottom waters, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

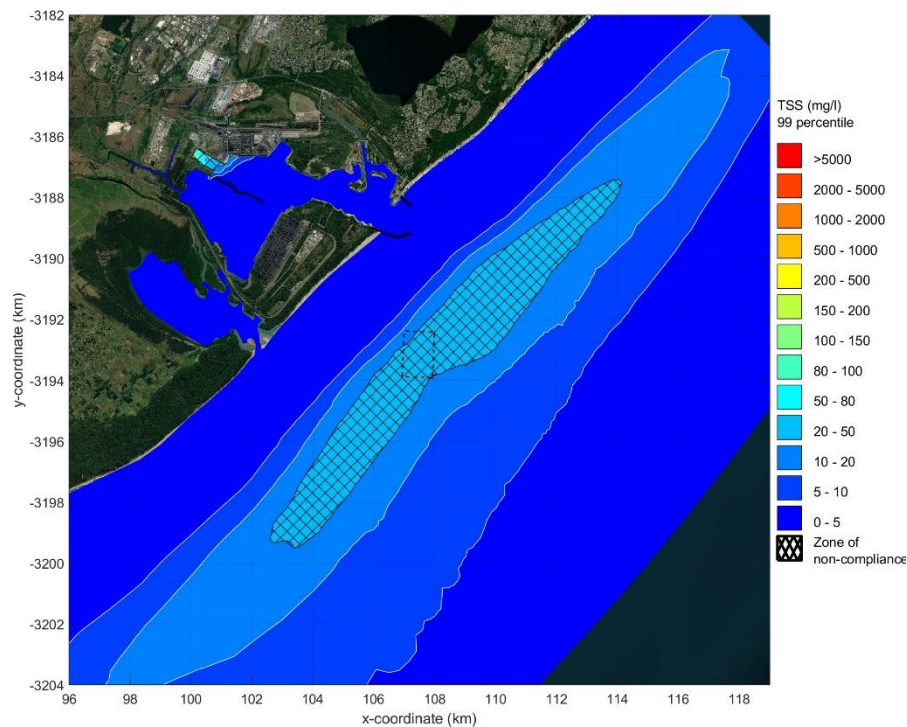


Figure 6-28 – 99th percentile exceedance contours of TSS concentration in the surface waters, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

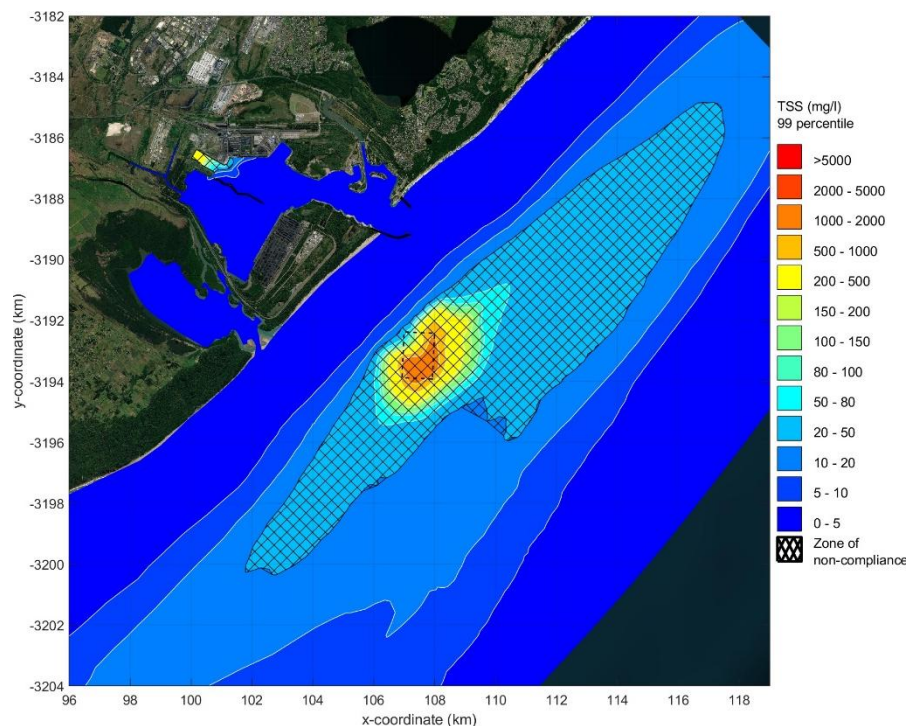


Figure 6-29 – 99th percentile exceedance contours of TSS concentration in the bottom waters, indicating the zone of non-compliance with a 20 mg/ℓ threshold.

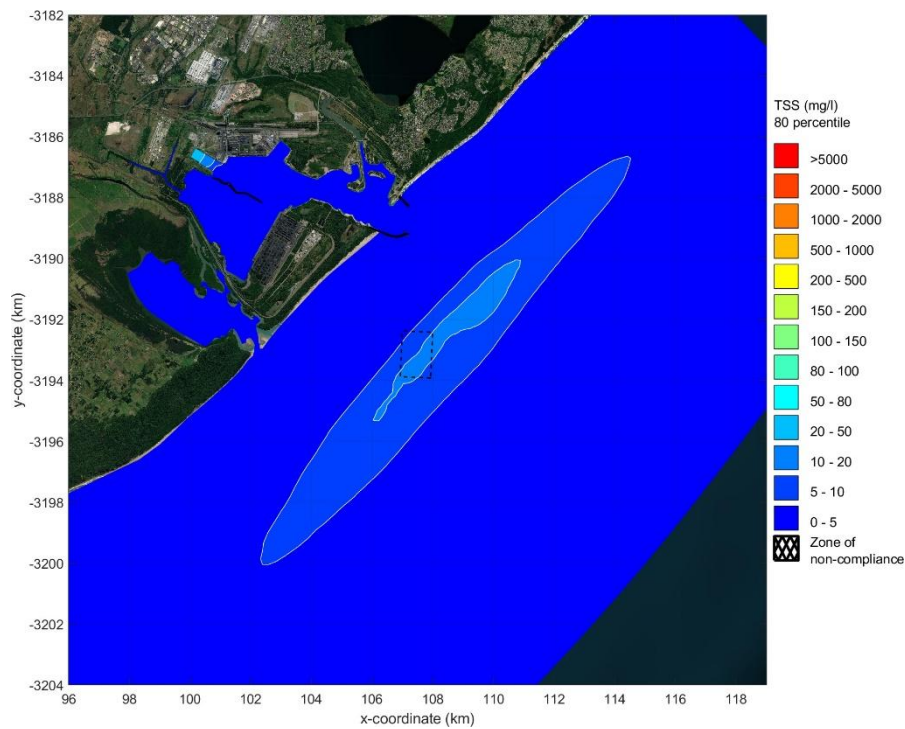


Figure 6-30 – 80th percentile exceedance contours of TSS concentration in the surface waters, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

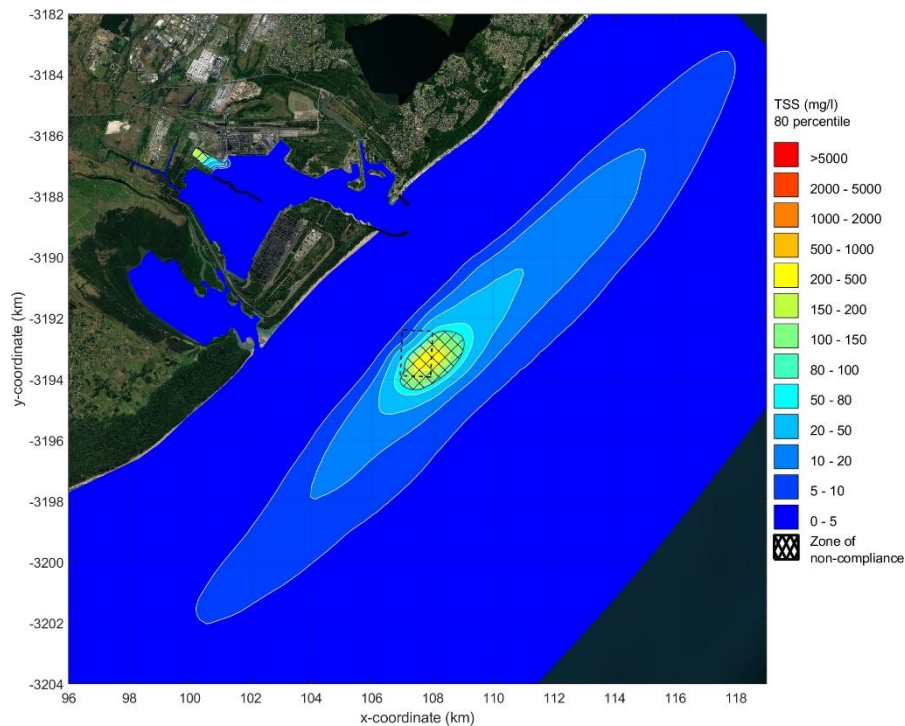


Figure 6-31 – 80th percentile exceedance contours of TSS concentration in the bottom waters, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

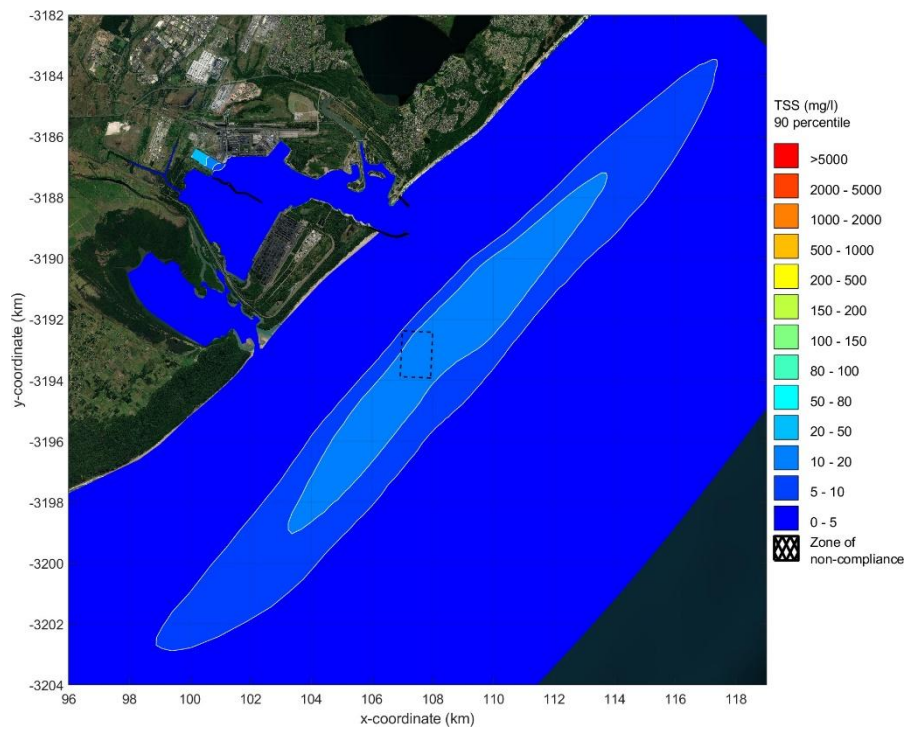


Figure 6-32 – 99th percentile exceedance contours of TSS concentration in the surface waters, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

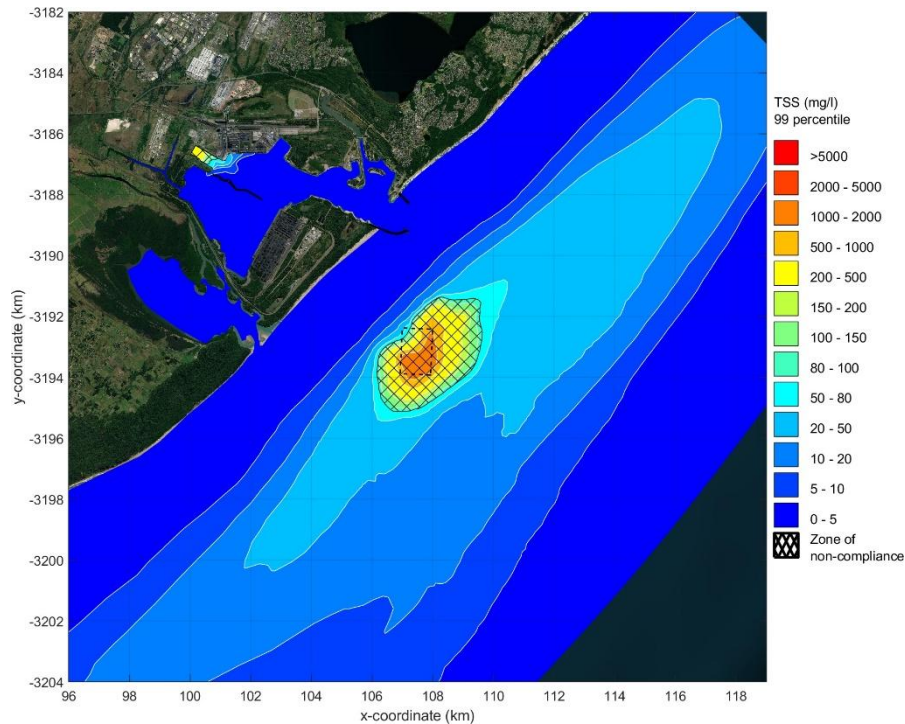


Figure 6-33 – 99th percentile exceedance contours of TSS concentration in the bottom waters, indicating the zone of non-compliance with a 80 mg/ℓ threshold.

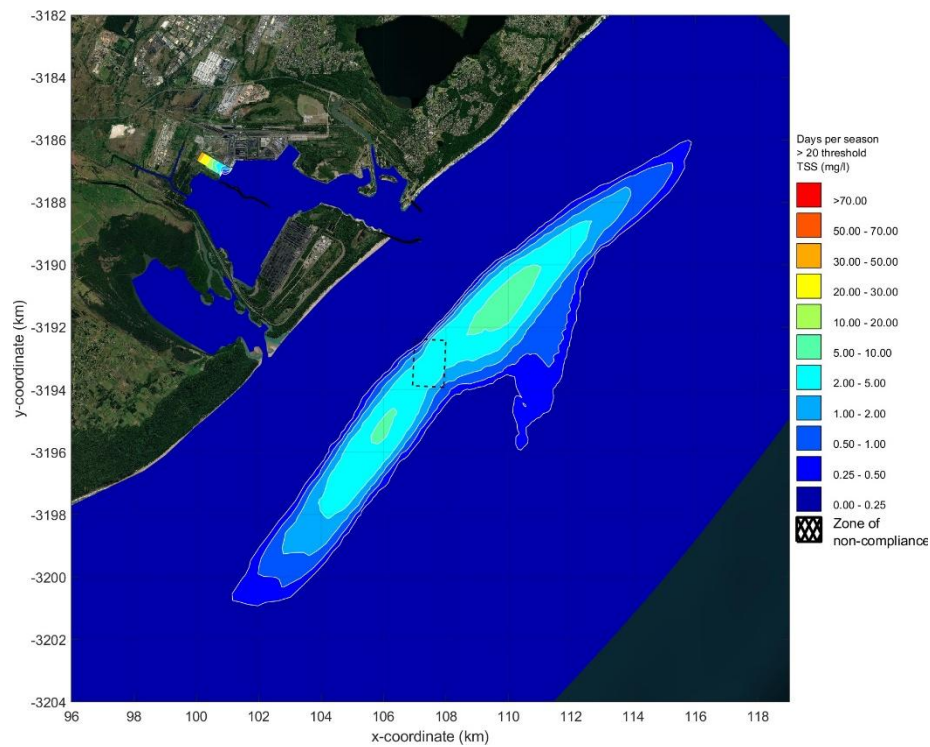


Figure 6-34 – Days of Exceedance of TSS concentration threshold of 20 mg/l in surface waters, indicating the zone of non-compliance with a 20 mg/l threshold.

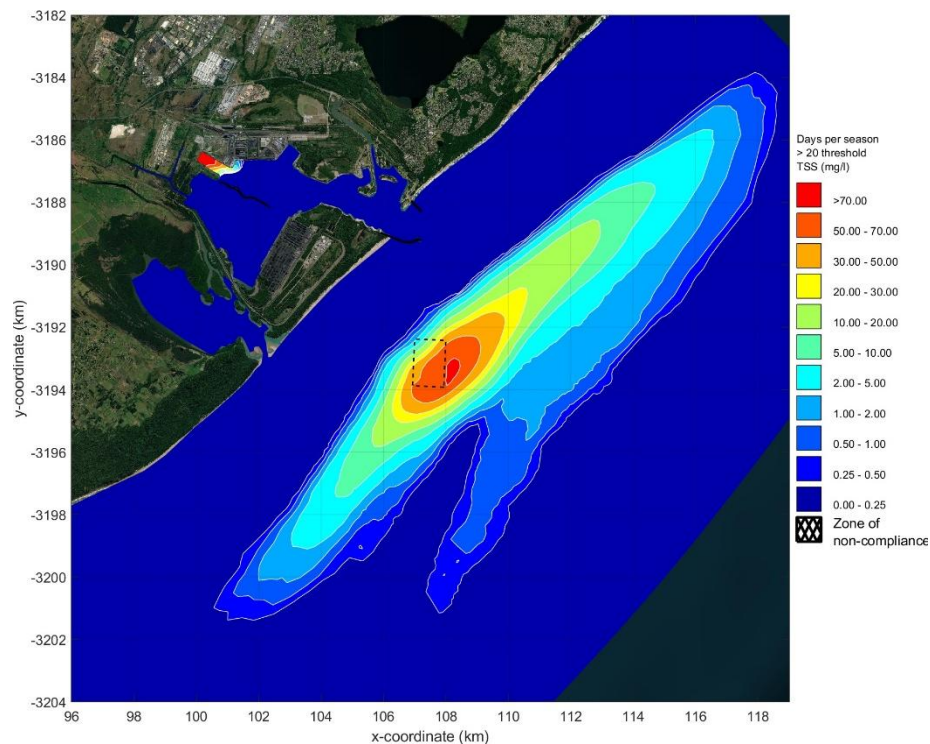


Figure 6-35 – Days of Exceedance of TSS concentration threshold of 20 mg/l in bottom waters.

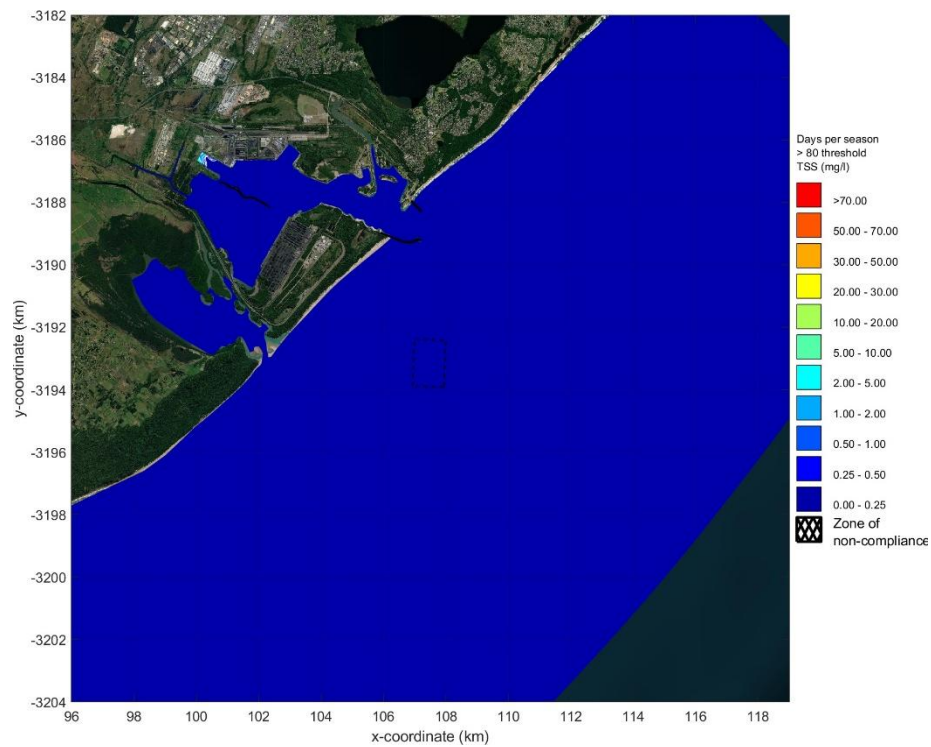


Figure 6-36 – Days of Exceedance of TSS concentration threshold of 80 mg/l in surface waters.

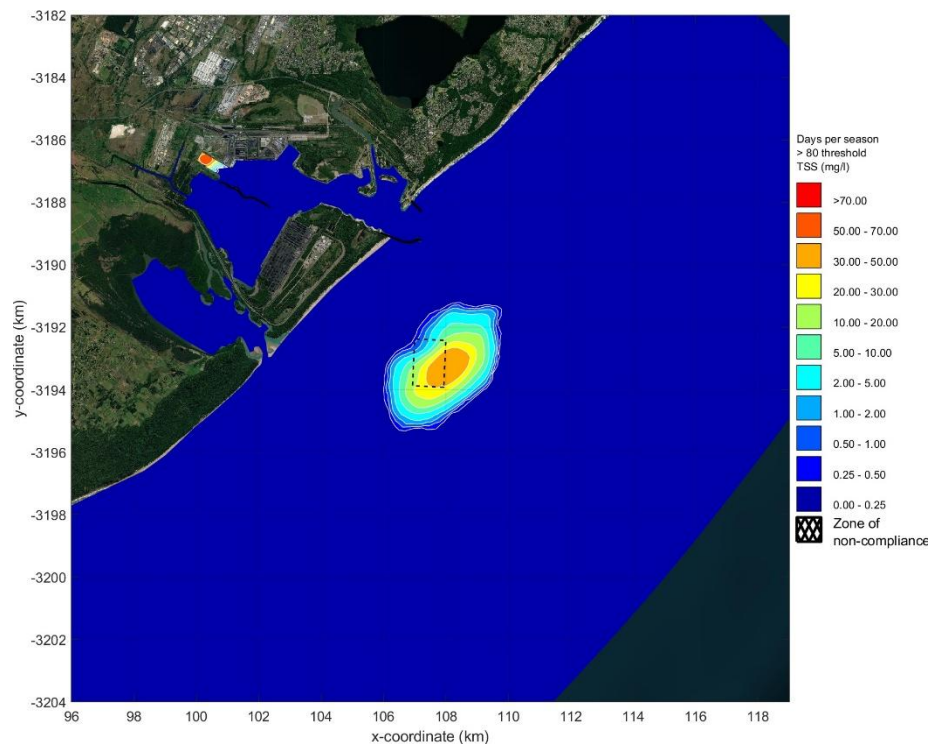


Figure 6-37 – Days of Exceedance of TSS concentration threshold of 80 mg/l in bottom waters.

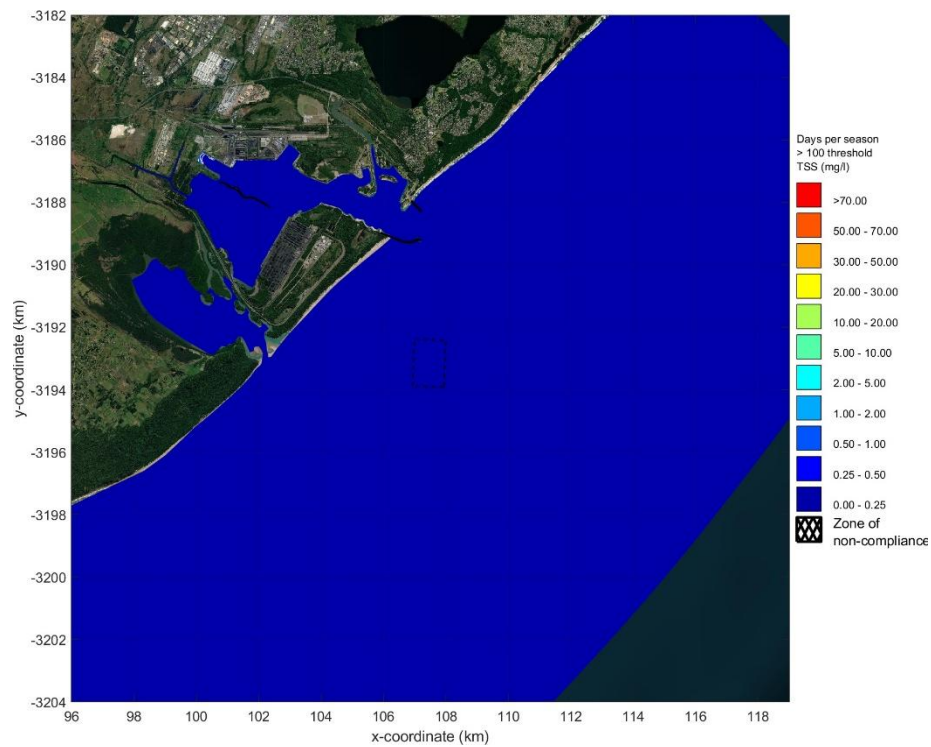


Figure 6-38 – Days of Exceedance of TSS concentration threshold of 100 mg/l in surface waters.

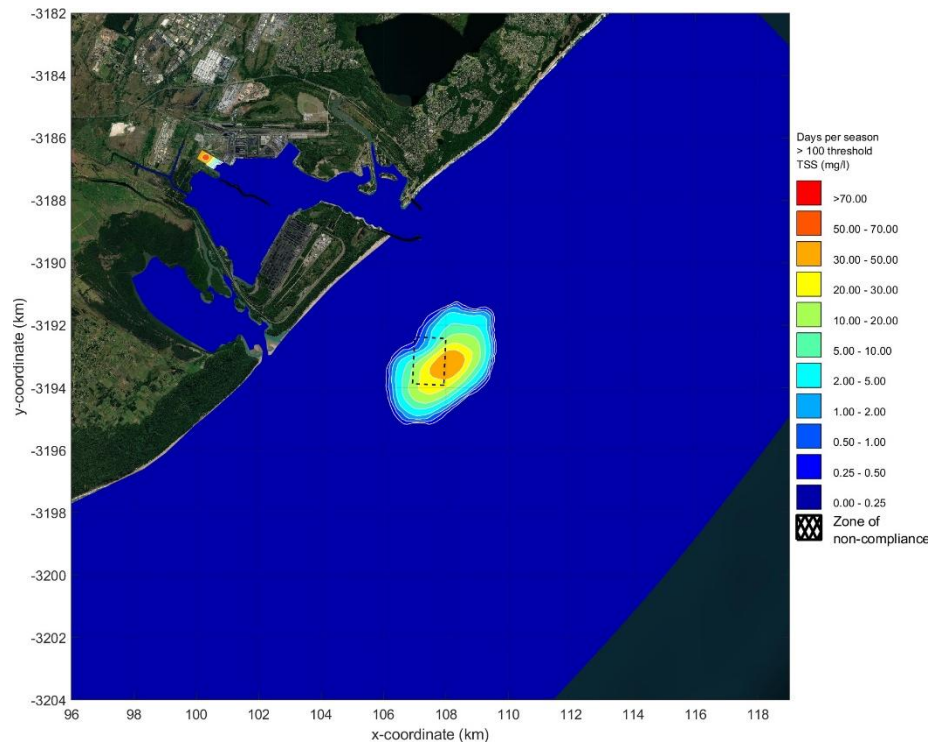


Figure 6-39 – Days of Exceedance of TSS concentration threshold of 100 mg/l in bottom waters.

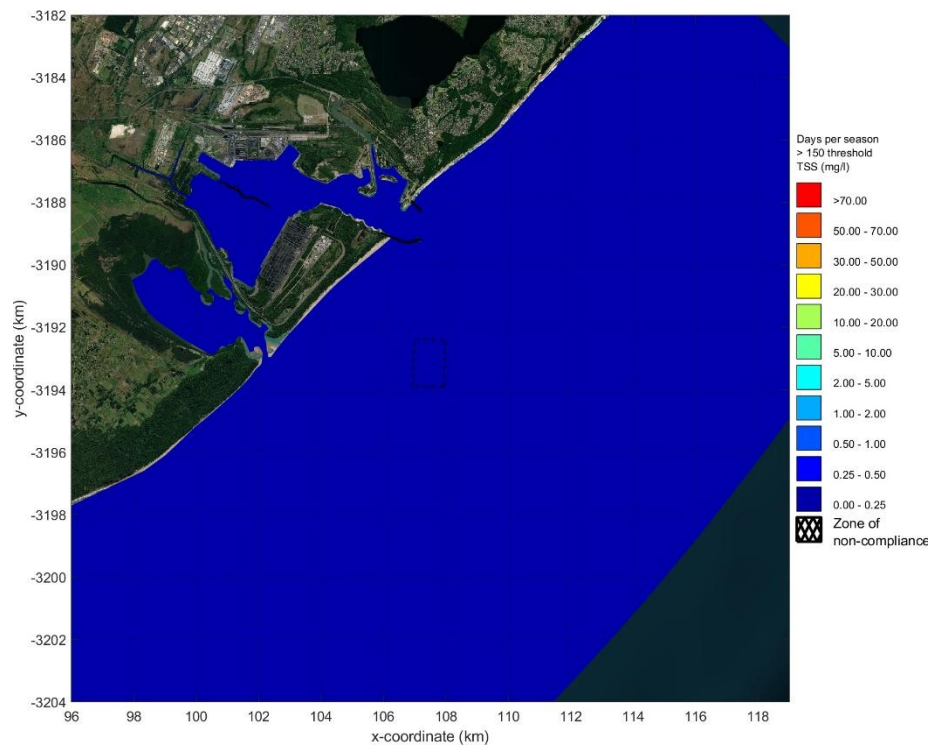


Figure 6-40 – Days of Exceedance of TSS concentration threshold of 150 mg/l in surface waters.

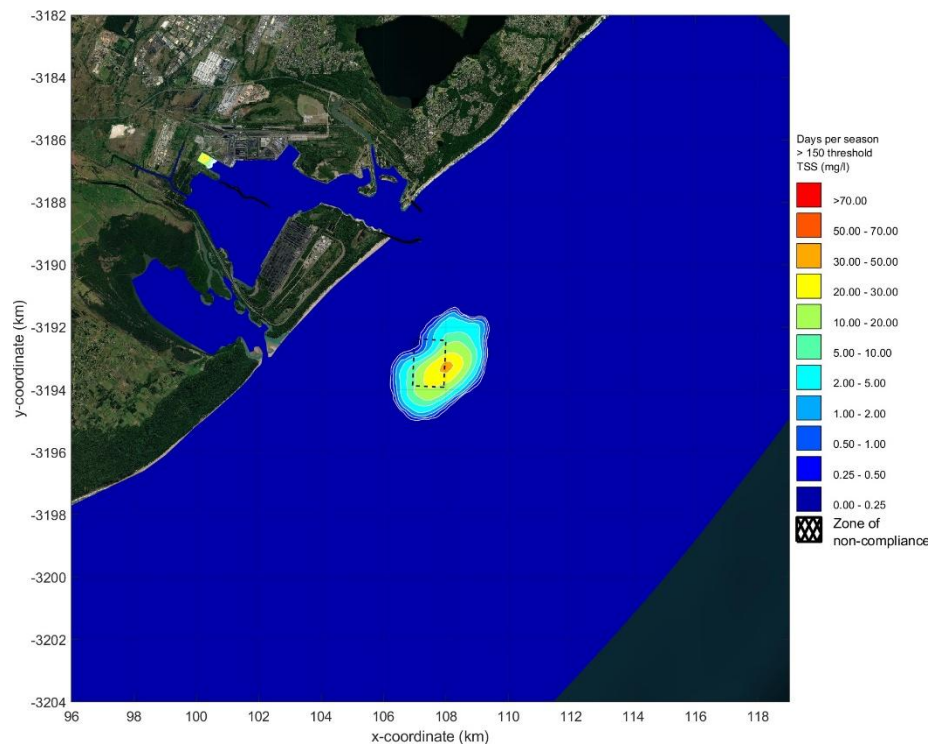


Figure 6-41 – Days of Exceedance of TSS concentration threshold of 150 mg/l in bottom waters.

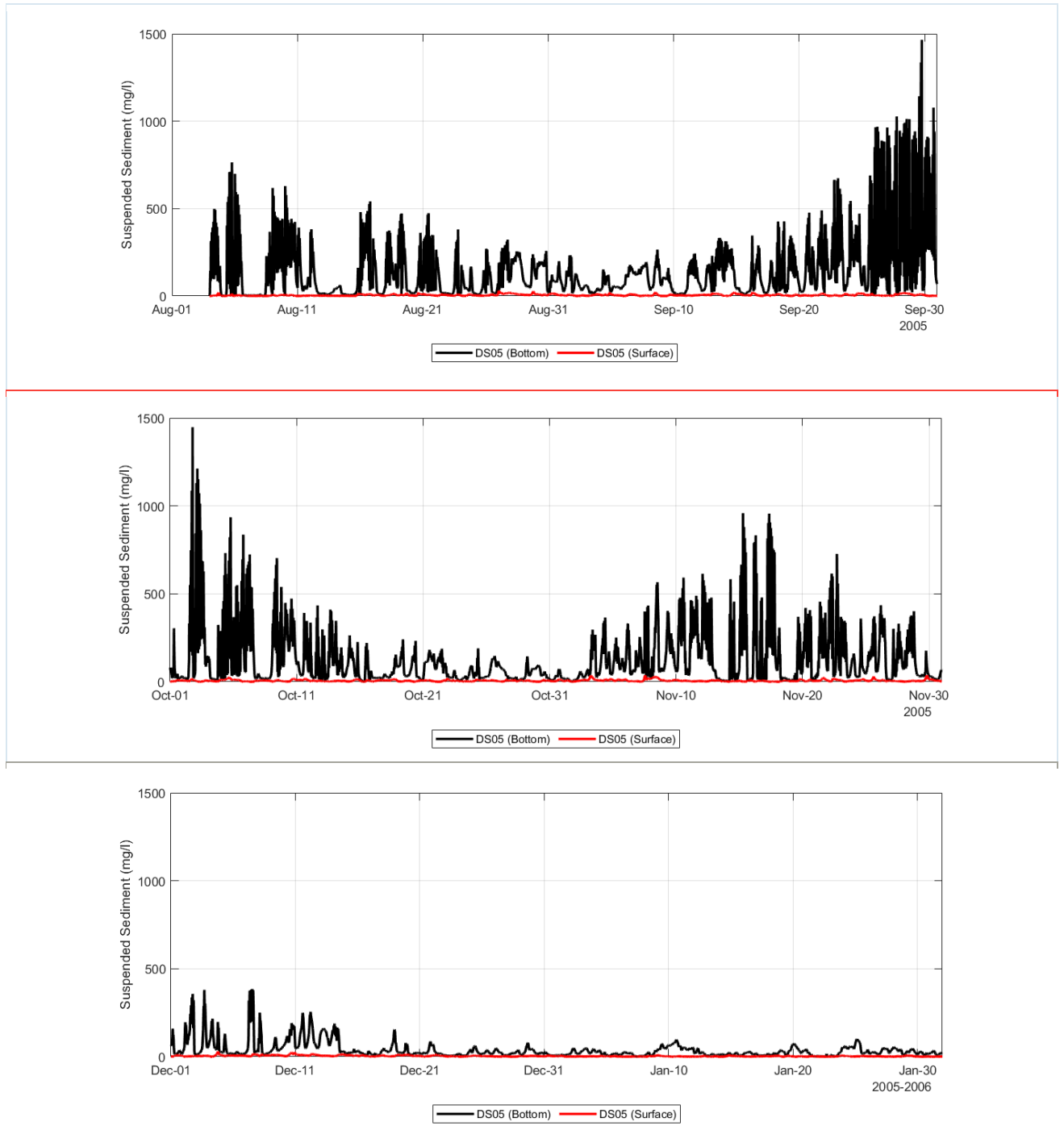


Figure 6-42 – Time series of TSS concentration at Stn DS05 (approximately 0.3 km East of the disposal site location)

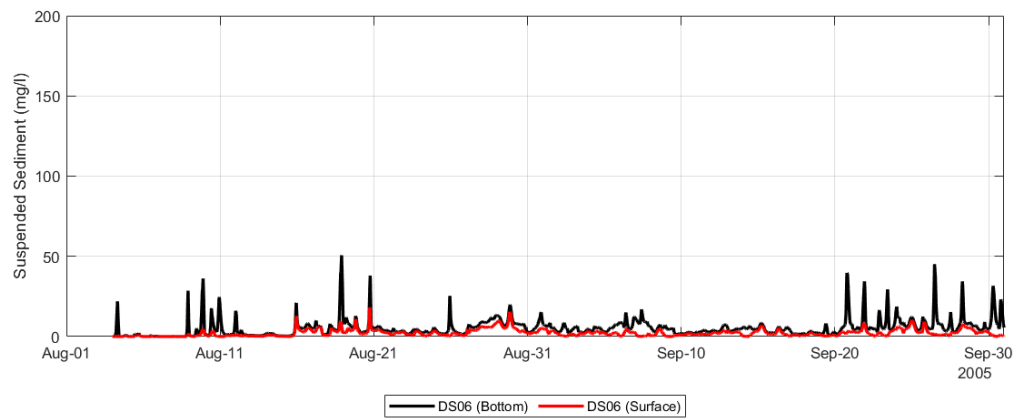
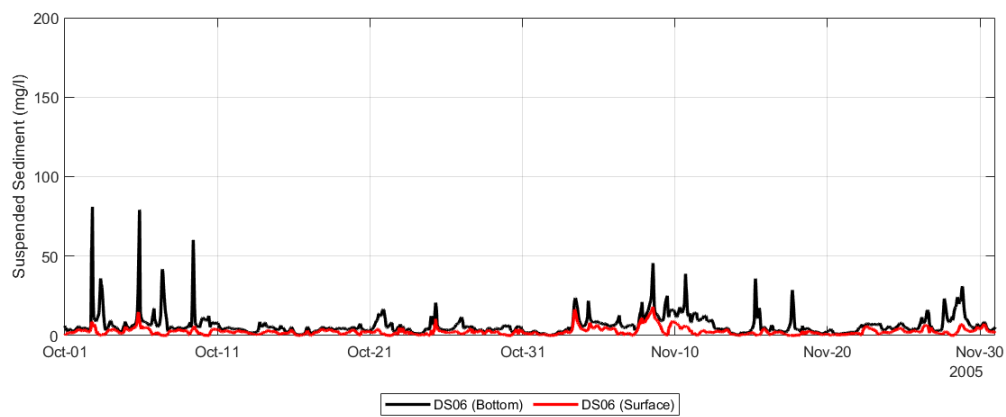
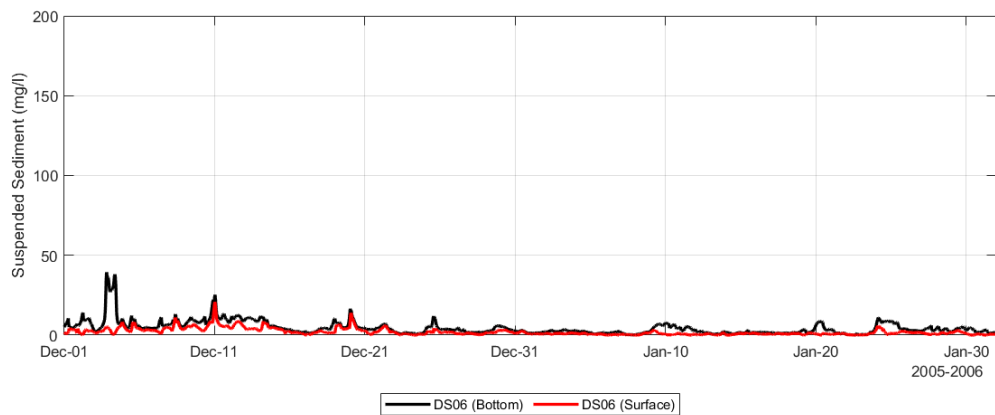


Figure 6-43 – Time series of TSS concentration at Stn DS06 (approximately 1.0 km SE of the disposal site location)

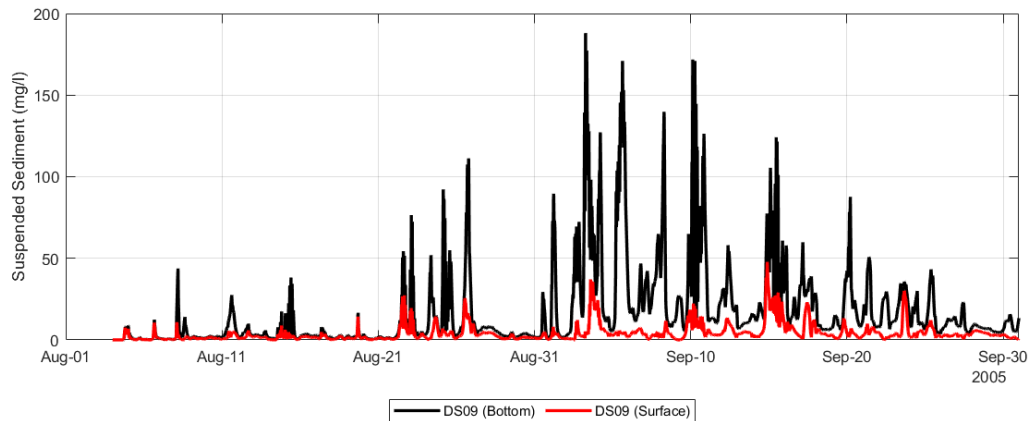
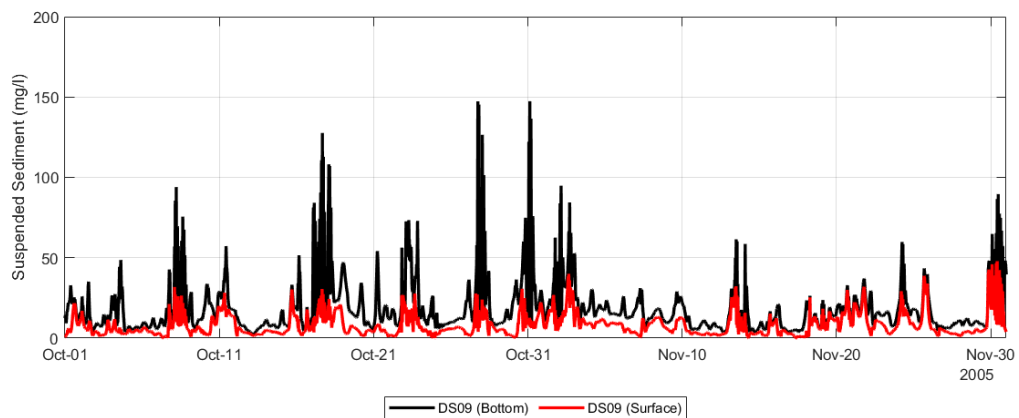
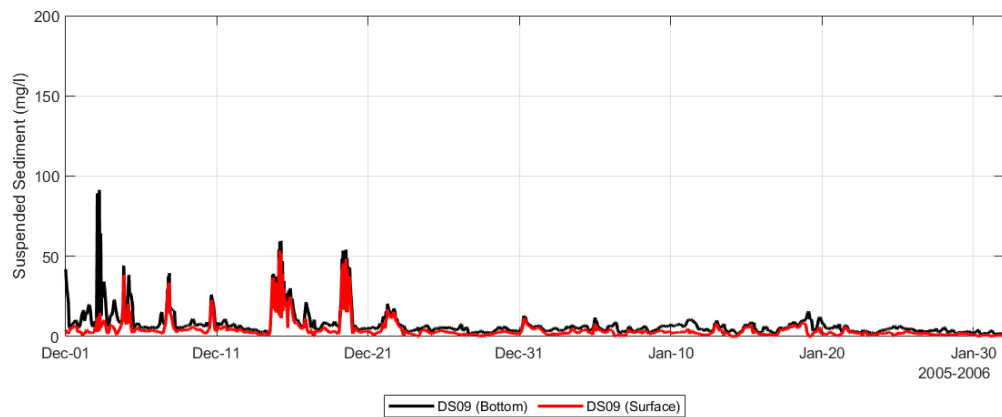


Figure 6-44 – Time series of TSS concentration at Stn DS09 (approximately 0.8 km SW of the disposal site location)

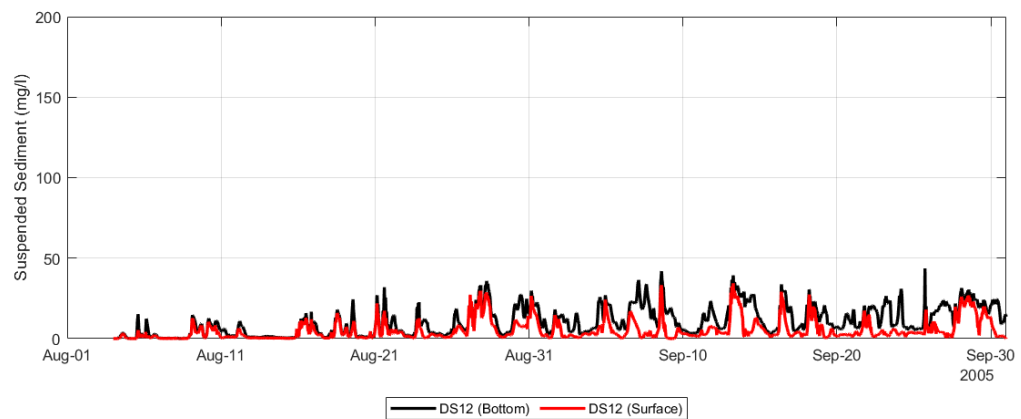
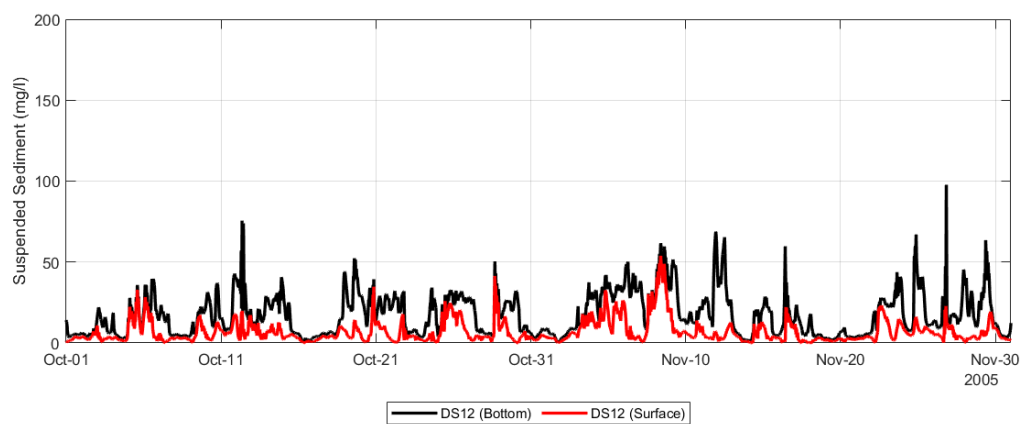
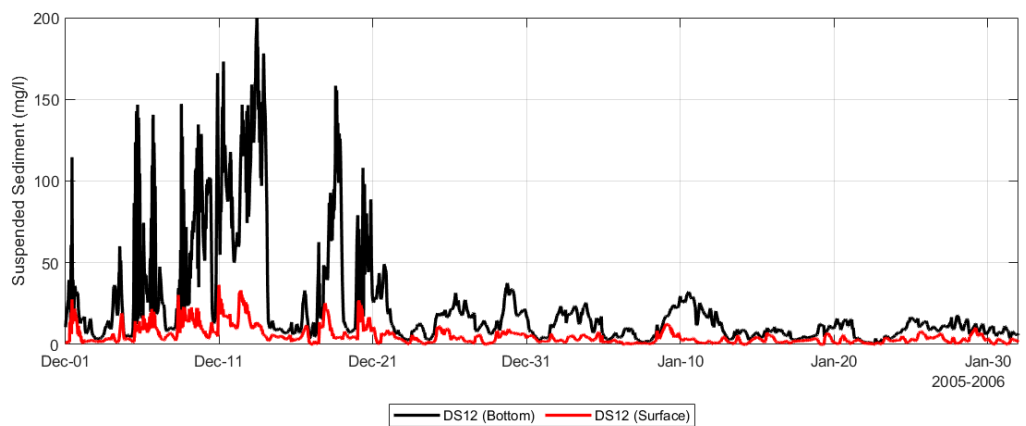


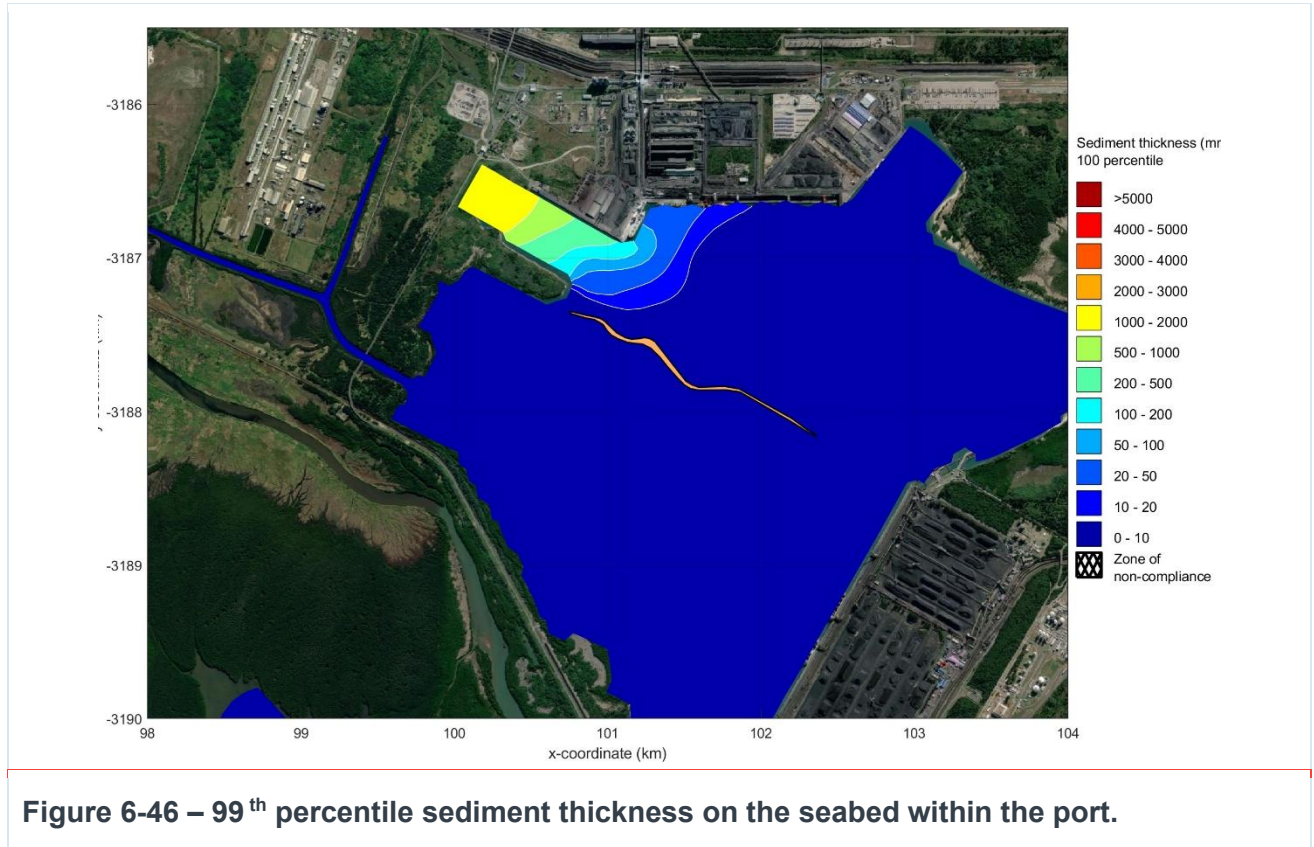
Figure 6-45 – Time series of TSS concentration at Stn DS12 (approximately 1.2 km NE of the disposal site location)

6.4 ECOLOGICAL IMPACTS ASSOCIATED WITH SMOTHERING EFFECTS AND THE DISTRIBUTION OF CONTAMINATED SEDIMENTS

To assess the potential marine ecological impacts associated with distribution of contaminated sediments and smothering effects, the model results are presented as the near maximum (99th percentile) thickness of sediments deposited at the seabed based on the full simulation period of 155 days. This allows for about a three-week period of re-distribution of the sediments from the dredging location into the surrounding water in the port (to the extent that this occurs) and also off the disposal site onto the surrounding seabed. This provides a conservative assessment of smothering impacts in the long term. It is not possible to run the long-term simulations that would provide a better insight into the wider distribution of sediment of the disposal site into the surrounding waters. However, a comprehensive account of the re-distribution of sediments off the disposal site is provided in a companion specialist assessment of the changes in wave climate and adjacent shorelines (WSP, 2025), based on available data and insights from modelling studies.

6.4.1 POTENTIAL SMOTHERING IMPACTS WITHIN THE PORT

The maximum sediment thickness predicted for the full simulation period indicated that there will be an accumulation of relatively unconsolidated muds up to a metre thick on the seabed within the inner third of the 600 series basin, decreasing to 10 to 20 cm at the outer edges of the 600 series basin and basin and < 1 to 2 cm toward the turning circle and into the 700 series basin (Figure 6-45). These deposited sediments comprise mainly fines from the assumed lean mixture overboard releases assumed in the modelling study. Comprising relatively unconsolidated fine material (assumed in the model to have a dry density of 465 kg/m³ and wet bulk density of the order of 1 300 kg.m³), this layer of fine unconsolidated material will be easily mobilised by shipping activities and lead to chronic and relatively high elevations in TSS concentrations in the water column until such time as this material is removed to the offshore disposal site. This will presumably occur as a final clean-up operation as part of the capital dredging operations but possibly, more cost-effectively, as part of maintenance dredging should this be allowed by existing permitting of maintenance dredging and associated allowable disposal volumes on the existing disposal site). The detailed assessment of such operations is not included in the present study.



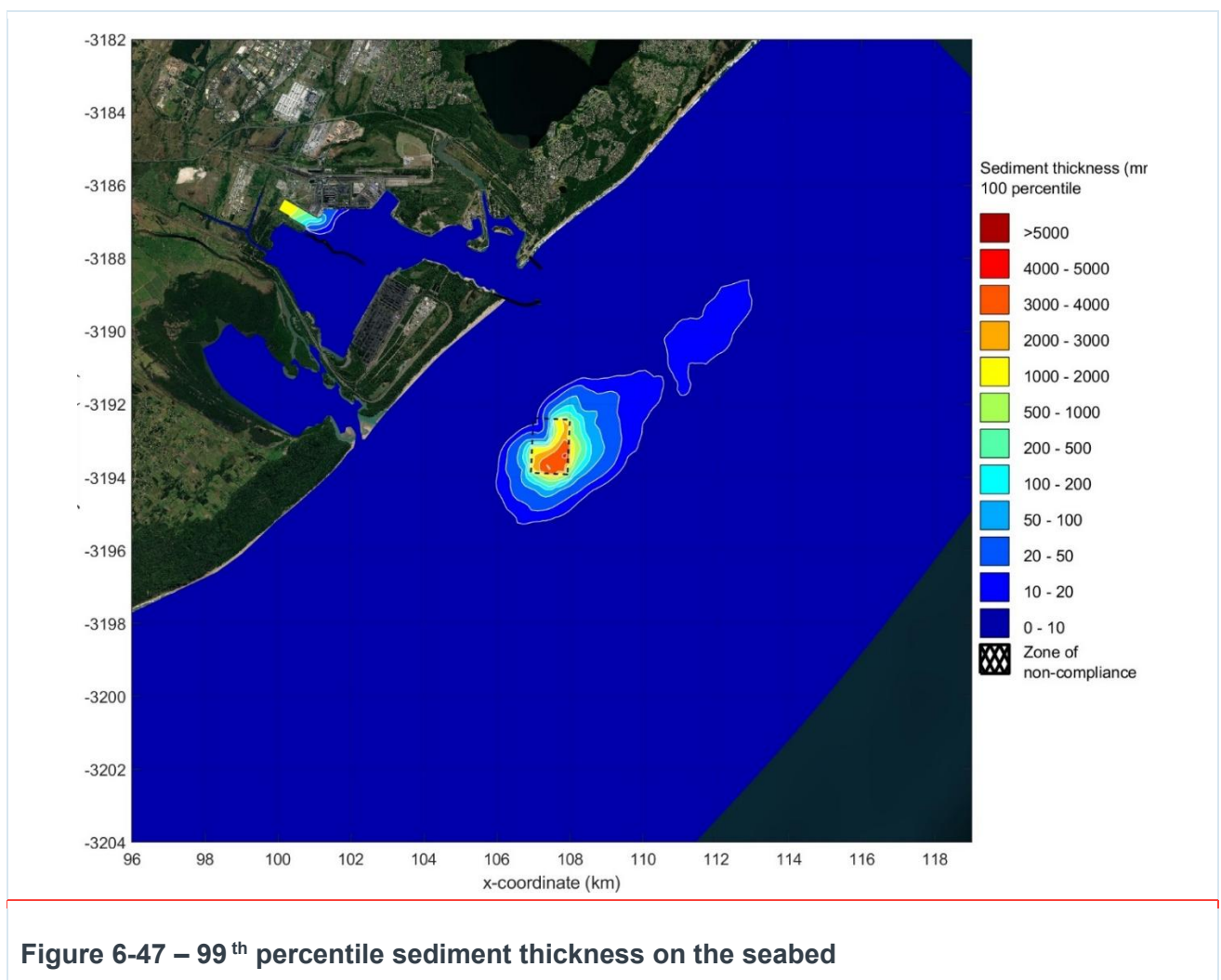
6.4.2 POTENTIAL SMOTHERING IMPACTS OUTSIDE THE PORT

The maximum sedimentation thickness reported in Figure 6-47 provides an insight into the likely smothering effects in the offshore region. The maximum sediment thickness of accumulated sediments predicted is approximately 3 to 4 m over the southeastern half of the site where it is intended to deposit most of the dredged material. In the modelling study no material was released onto the northwestern corner of the site as bathymetry data show that the water depths on this portion of the site are less than -13 m CD (indicating an accumulation of ~7 m of material) in places and consequently already a potential navigational hazard.

The typical sediment thickness within 500m to 1 km of the site is predicted in the model to be between 10 and 20 cm. However, the dispersion of material from the site is a complex and long-term process. What is certain is that the movement of sediments will be primarily into the water surrounding the disposal site, with much of the material of dredged material being deposited into deeper waters (WSP, 2025; van den Bossche *et al.*, 2007), typically in response to major storms.

A detailed assessment of the dispersal of material of the dredge spoil disposal site indicates fairly rapid removal of dredge material from maintenance dredging from the site but a much lower rate of dispersion of material off the disposal site for capital dredging. The lower rate of removal of material from the disposal site for dredge material disposal from capital dredging is:

- possibly due to the large quantities disposed of on the site leading to mounding of material that will be less easily removed from the site
- that dredged material from capital dredging typically contains less fines than material from maintenance dredge and also may contain significant quantities of rock or coarser material derived from the dredging of rock. The dispersion of such rock and coarser material will be much slower to be dispersed off the site, if at all.



6.4.3 POTENTIAL TOXICITY EFFECTS OF CONTAMINANTS RELEASED FROM THE SEDIMENTS

The toxicity effects from potential contaminants released into the water column were not simulated in the model as the potential impacts of such releases have been addressed in CSIR (2024). See also Section 2.2.4.

6.5 SUMMARY OF MODEL RESULTS

6.5.1 VISUAL IMPACTS

The visual impacts of dredging plumes in the surface waters within the port are predicted to be negligible, with visual plumes only very rarely extending beyond the 600 series basin and likely to be largely indiscernible from turbidity elevations in the Berth 609 and 701 due to shipping and berthing activities. However, the increased turbidity at depth within the 600 series basin is likely to increase the surface plumes from such shipping and berthing activities for the duration of active dredging activities and for a couple of months thereafter.

Based on a 10 mg/ℓ threshold for visual impacts, visual plumes are predicted to extend large distances from the disposal site (8km to the north and 6km to the SE). A higher threshold of 20 mg/ℓ possibly more appropriate for the conditions when such plumes are generated suggest less extensive plumes typically less than 2 to 3 km from the site. Even then, the generally turbid surface water may mask the presence of such dredging-related plumes.

6.5.2 ECOLOGICAL IMPACTS ASSOCIATED WITH ELEVATED TURBIDITY & TSS CONCENTRATIONS

6.5.2.1 POTENTIAL TURBIDITY / ELEVATED TSS IMPACTS WITHIN THE PORT

Exceedance of a 20 mg/ℓ threshold: The contour plots of (cumulative) days of exceedance of a 20 mg/ℓ threshold indicate that this threshold is not exceeded in the surface waters beyond the confines of the 600 series basin for more than a cumulative 2 days per season but shows a high persistence (50% of the time) above this threshold in the inner half of the 600 series basin. The cumulative days of exceedance of this 20 mg/ℓ threshold indicate an almost continuous exceedance of this guidelines in the bottom waters of the full extent of the full 600 series basin and up to a cumulative 10 days per season exceedance of this guidelines at Berth 609 and 701. There is predicted to be very little exceedance of the 20 mg/ℓ thresholds in the bottom water beyond these berths.

Exceedance of an 80 mg/ℓ threshold: The contour plots of (cumulative) days of exceedance per season of an 80 mg/ℓ threshold indicate that exceedance of this threshold in the surface waters is limited to the inner half of the 600 series basin while any exceedance of this threshold in the bottom waters is limited to the 600 series basin.

6.5.2.2 POTENTIAL IMPACTS AT THE OFFSHORE DREDGE SPOIL DISPOSAL SITE

Exceedance of a 20 mg/l threshold: The maxima (99th percentile) of TSS concentrations in the surface waters exceed a 20 mg/l threshold for distance up to 8 km north and south of the disposal site, while more persistent (80th percentile) exceedance of this threshold is predicted to not occur in the surface waters. For a higher exceedance threshold of 20 mg/l, the maxima (99th percentile) of TSS concentrations in the bottom water waters exceed this 20 mg/l threshold up to 8 to 10 km from the site. While more persistent (80th percentile) exceedance of this threshold is predicted to occur for up to 4 km NE and 1.5 km SW of the disposal site.

Exceedance of an 80 mg/l threshold: The maxima (99th percentile) of TSS concentrations in the surface waters do not exceed an 80 mg/l threshold. Consequently, there is also no persistent exceedance of this threshold in the surface waters. The maxima (99th percentile) of TSS concentrations in the bottom water waters exceed an 80 mg/l for 1 to 2 km from the site, while more persistent (80th percentile) exceedances typically occur for < 1 km from the site. The dimension of these exceedances in the bottom waters reduce significantly upon increasing the threshold from 20mg/l (~ 8 km or more) to 80 mg/l (typically 1 to 2 km), but not more upon increasing the threshold further to 100 mg/l or even 150 mg/l (500 m to 1 km). There is an approximate maximum of 30 to 50 days exceedance of the 80 mg/l and larger thresholds in the TSS concentrations of bottom waters, the area of these days of exceedance decreasing with an increasing threshold.

Time series if TSS concentrations: TSS Time series plotted at a location approximately 0.8 km SW and 1.2 km NE of the site indicate similar peaks in TSS concentrations of 100 mg/l to 200 mg/l. At times the TSS concentrations in the surface waters are similar to those of the bottom waters, but generally the TSS concentrations in the bottom waters during such peaks are almost an order of magnitude larger than those at the surface. Offshore of the disposal site, a site (DS05) 300m from the site indicates high TSS concentrations in the bottom waters, with short term peaks exceeding 500 mg/l with little elevation in TSS concentration in the surface waters. These peaks in TSS concentration are related to the close proximity of the dumping of dredge material onto the disposal site. At a site just a bit further offshore (DS06) approximately 1 km from the disposal site indicates the same short peaks in TSS concentration occur in the bottom waters but at much lower concentrations, *i.e.*, very rarely exceeding 50 mg/l. These time-series plots for locations within approximately a kilometre of the disposal site show that the persistence of such exceedances comprise many occasions of short duration exceedances of the thresholds during weather events.

Note that the impacts related to elevations in TSS concentrations and turbidity at the offshore disposal sites are likely to be moderately to possibly highly conservative given the changes in the dredge material types (*i.e.*, a significant reduction in fines) indicated by the updated geotechnical survey information, compared to those used in the modelling study.

6.5.3 IMPACTS DUE TO ACCUMULATION OF SEDIMENTS ON THE SEABED

6.5.3.1 WITHIN THE PORT OF RICHARDS BAY

A maximum accumulation of relatively unconsolidated muds is predicted to be up to a metre thick on the seabed within the inner third of the 600 series basin, decreasing to 10 to 20 cm at the outer edges of the 600 series basin and basin and < 1 to 2 cm toward the turning circle and into the 700 series basin (Figure 6-45). These deposited sediments comprise mainly fines from the assumed

lean mixture overboard releases assumed in the modelling study. Their presence is expected to lead to chronic and relatively high elevations in TSS concentrations in the water column until such time as this material is removed to the offshore disposal site.

6.5.3.2 OFFSHORE DREDGE SPOIL DISPOSAL SITE

The maximum sediment thickness of accumulated sediments predicted is approximately 3 to 4 m over the southeastern half of the site where it is intended to deposit most of the dredged material. The typical sediment thickness within 500m to 1 km of the site is predicted in the model to be between 10 and 20 cm. However, the dispersion of material from the site is a complex and long-term process. What is certain is that the movement of sediments will be primarily into the water surrounding the disposal site, with much of the material of dredged material being deposited into deeper waters. While the dredge material from maintenance dredging that is placed on the site is expected to be eroded fairly rapidly from the site, the dredged material from capital dredging typically contains less fines than material from maintenance dredge and also may contain significant quantities of rock or coarser material derived from the dredging of rock. The dispersion of such rock and coarser material will be much slower than material from maintenance dredging. While more competent rock such as granites may not leave the disposal site at all, fortunately the siltstone-derived gravels placed on the disposal site is not that stable and is likely to break down upon exposure offshore waves and current conditions. In the short to medium term, the increased longevity of some of the dredge material potentially could be problematic in terms of the long-term capacity of the disposal site for receiving dredge material from both maintenance and other capital dredging projects.

The predicted rate of sediment dispersion from the offshore dredge spoil disposal site is significantly greater than the originally predicted annual removal/loss of sediments from the offshore dredge spoil disposal that ranged between 10 000 m³ (CSIR, 2005a) and 13 000 m³ (Coppoolse and Schoonees, 1991). However, it is also substantially less than that predicted in CSIR (2004b), that ultimately was shown by Berth 306 pre- and post-dredging surveys (van den Bossche *et al.*, 2007; Smith *et al.*, 2010) to be a significant overestimate of the rate of “recovery” as the dredge spoil disposal site. It is for this reason that so much effort has been placed on assessing the dispersion of material from the disposal site in this study and the *Wave Climate and Shoreline Change specialist study* (WSP, 2025).

6.5.4 POTENTIAL TOXICITY EFFECTS OF CONTAMINANTS RELEASED FROM THE SEDIMENTS

Based on the evidence provided in Section 2.2.4, the simulation and assessment of the release of metals into the water column and potential toxicity effects were considered superfluous in the modelling undertaken for this study. The one sample location of concern (site 15) where toxicity was indicated to be of concern will only require minimal dilution (~ 2 dilutions) to prevent the toxicity of metals released into the water column. Such a dilution will be achieved at the dredging location and easily achieved at the offshore disposal site (CSIR, 2025).

6.5.5 LONG-TERM CHANGES IN HYDRODYNAMIC FLOWS AND COASTAL PROCESSES

The long-term changes in flow and reduced flushing within the port are predicted to be largely confined to the immediate project area (*i.e.*, the 600 series berth area and its immediate surrounding) and, having negligible effect on benthic habitats beyond the immediate project area. The extension of the 600 series basin inland, however, may exacerbate any water quality or sediment issues that may already exist for the 600 series basin; however, any such changes are unlikely to be significant given the scale of the physical changes in basin extent (and depth).

The changing depth at the disposal site will result in local modifications of flows and possible wave conditions. Of potentially greater concern are change in wave climate over a wider area and potential shoreline change. These potential concerns are addressed in a companion Wave Climate and Shoreline Change study (WSP, 2025). However, these impacts in the offshore region will reduce as dredged material is dispersed from the disposal site over time.

6.6 CLIMATE CHANGE EFFECTS ON MODEL OUTCOMES

Climate change is expected to have significant consequences for coastal ecosystems as a result of sea level rise, increased storminess, changes in ocean temperatures, ocean acidification, etc. However, of relevance to this study are primarily the effects of sea level rise, changes in storminess (*e.g.*, winds and waves) and possible long-term changes in circulation patterns.

The model simulations are relevant to the period of the proposed dredging activities, extending to approximately 5 years following the dredging activities when the remobilisation of sediments from the offshore disposal site is likely to be of a magnitude that would no longer significantly affect water column turbidity and/or benthic habitats near the dredge spoil disposal site.

On such time scales the anticipated effects of sea levels rise and/or changes in storminess on the model outcomes will be very limited and more than likely negligible. Furthermore, the consequences of any anticipated changes in ocean circulation, at this stage, would be speculative at best.

Were sea level rise effects to be explicitly considered in the modelling study they would:

- result in an expected increase in the erosion of the northern shoreline (Mather and Stretch, 2012), however the changes may be more nuanced (Rautenbach and Theron, 2019).
- likely, reduce the mobility of sediments from the offshore disposal site due to the increase in water depth. Conversely, any increased storminess would serve to increase the number of occasions and extent to which sediments would be remobilised at the offshore dredge disposal site.

However, as noted above, the anticipated changes in sea level and storminess will be limited and likely not discernible from natural variability over the short- to medium-term when potential dredging impacts associated with the Berth 605 dredging activities are likely to be observed.

7 ENVIRONMENTAL MONITORING PROGRAMME

Monitoring associated with dredging activities needs to be integrated into the full project cycle and includes:

- the development of an appropriate environmental baseline against which to assess potential impacts should such a baseline not already be in existence;
- measurements in support of impact assessment and any associated modelling studies;
- compliance monitoring; and
- monitoring to validate and/or verify impact assessment and associated modelling.

In general, the environmental baseline necessary to assess potential impacts of dredging and dredge spoil disposal activities is adequate (see Section 7.1), thus the focus here is on the monitoring requirements associated with:

- Compliance monitoring (Section 7.2) to ensure the proposed environmental objectives for dredging activities are met during dredging operations; and,
- Monitoring for impact verification (Sections 7.3 and 7.4), which comprises biophysical measurements characterising stressors (drivers of impact) and associated direct ecological impacts, but could also include data to support the verification of modelling studies that typically are used to characterise the drivers of ecological impacts (e.g. high turbidity, low oxygen concentrations, etc.) in dredging impact assessment studies.

Accordingly, an Environmental Monitoring Programme has been developed primarily for monitoring for compliance and verification of impact assessments associated with dredging and dredge spoil disposal activities. This includes:

- Compliance monitoring based on TSS concentration thresholds of concern;
- Monitoring of physical changes in benthic habitats;
- Monitoring of potential shoreline changes;
- Monitoring to verify impact assessments and associated modelling activities.

In this study, we address only the abiotic monitoring requirements. The detail of ecological and ecosystem monitoring will need to be provided by the Estuarine and Marine Ecology specialists study (CSIR, 2025).

7.1 ENVIRONMENTAL BASELINE MONITORING

Abiotic monitoring programs required to develop an appropriate environmental baseline and to support robust impact assessment and typically include:

- monitoring of water quality (primarily turbidity and TSS concentrations) in the environment(s) likely to be affected by dredging and dredge spoil disposal activities;
 - pre-dredging bathymetric surveys of the dredge site(s) and dredge spoil disposal site;
 - sediment quality (biogeochemical) characterisation of the dredge site(s) and dredged spoil disposal site prior to dredging;
 - measurements to support modelling studies undertaken as part of the assessment of environmental impacts
-

Such monitoring typically needs to be (and mostly has been) executed prior to the completion of the impact assessment for the EIA.

Sufficient water quality data are available within the Port of Richards Bay to provide the requisite baselines for turbidity and TSS concentrations (CSIR, 2013b,c, 2024) in the water column for the present NIFPP dredging and dredge spoil disposal EIA specialist studies. However, the environmental baseline for turbidity and suspended solids developed for the offshore region has associated with it a degree of uncertainty due to observational biases in the historical data used to develop the baseline (see Section 4.8.2), but again is deemed adequate for the purposes of this dredging assessment.

The sediment quality of the material to be dredged has been characterised in CSIR (2024). These data indicate contamination in some of the soil and surficial marine sediments; however, a suite of toxicity assessments indicate that the bioavailability of toxicants in the sediments is such that it will be acceptable to dredge these sediments and dispose of them on the offshore disposal site. The detail of the sediment quality assessment and associated toxicity tested is provided in CSIR (2024) and summarise in Section 2.2.4 of this study. No further biogeochemical characterisation of the sediments to be dredged is deemed necessary.

No recent biogeochemical characterisation of the offshore dredge spoil disposal site could be located. However, were such a characterisation to exist it is not clear how representative it would be of present conditions as the dredge spoil disposal site is used for ongoing disposal of limited quantities of maintenance dredging spoil. Whilst such a characterisation is indicated as being a requirement in the waste assessment guidelines for the London Convention and 1996 Protocol, it is not deemed necessary here, given the ongoing disposal of spoil from maintenance dredging at the offshore dredge spoil disposal site. Whilst a characterisation of grain sizes on the offshore dredge spoil disposal site exists (Newman and Weerts, 2008), these grain sizes are highly variable and are unlikely to be representative of existing conditions given that the dredge spoil disposal site is used for ongoing disposal of dredge spoil from maintenance dredging activities.

Typically required are pre-dredging surveys of both the dredging location and also the offshore disposal sites. Both lidar surveys and bathymetric surveys (Tritan, 2025; GeoAfrica, 2025) of the dredging location have been undertaken as part of the concept design engineering studies for the Berth 605 project. Recent bathymetric surveys have also been undertaken of the offshore disposal site by TNPA, the most recent of these being January 2025 bathymetric survey (see Section 2.5.1).

Typically, bathymetric in-surveys are undertaken just prior to the commencement of dredging activities. For the Berth 306 capital dredging, such in-surveys were undertaken for both the areas to be dredged as well as the offshore disposal site. The existing maintenance dredging related bathymetric surveys for the offshore disposal have been restricted to only the site and not its immediate surrounds. For a capital dredging for Berth 605, the larger dredge material volumes involved require a more extensive coverage for the bathymetric in-survey to be undertaken, *i.e.*, a similar extent to the bathymetry surveys undertaken for the Berth 306 capital dredging (see Figure 7-1).

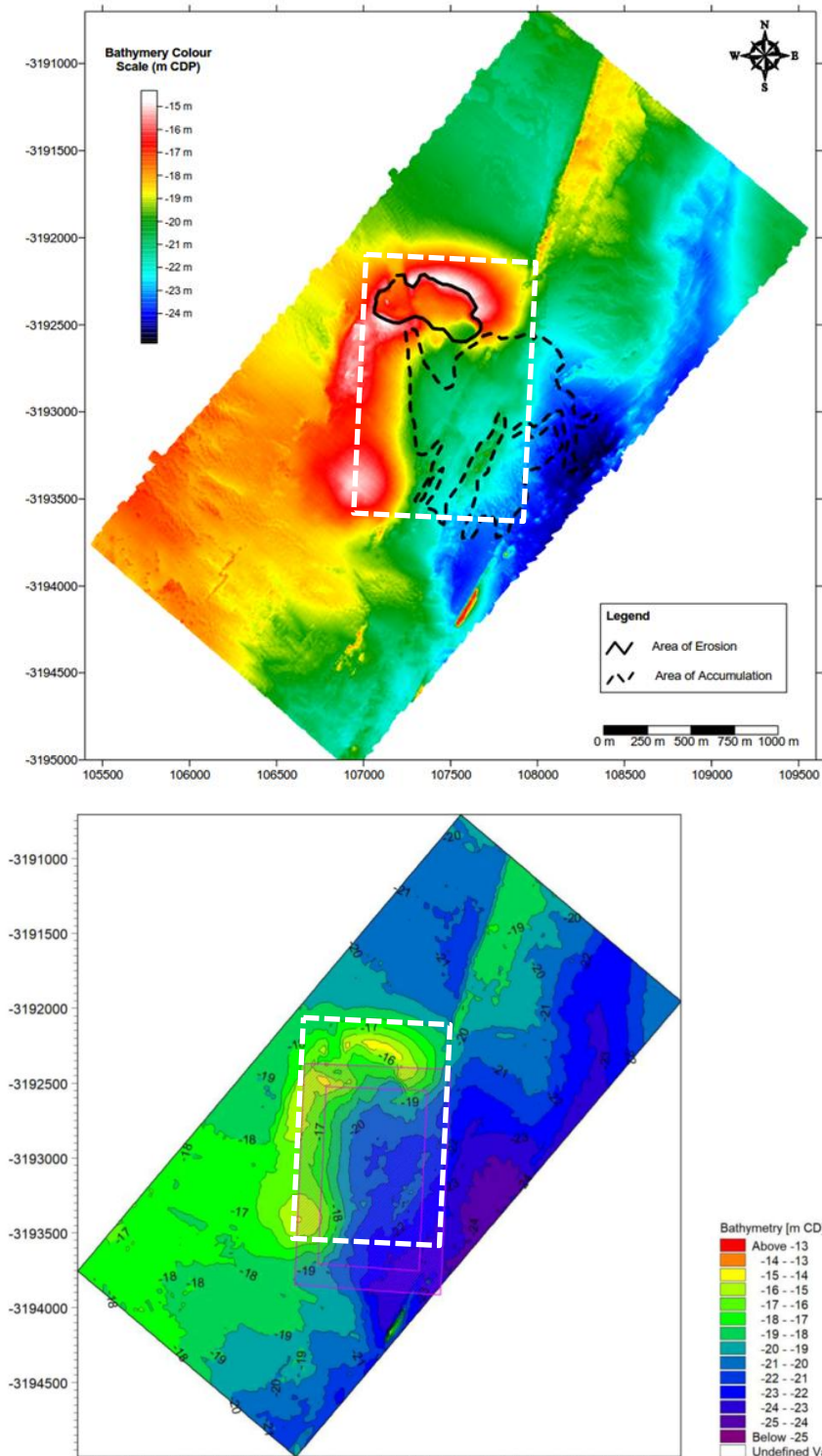


Figure 7-1 - Multibeam bathymetry map showing dredge spoil mounds that existed immediately after the completion of the Berth306 capital dredging (upper panel - van den Bossche *et al.*, 2007) and the bathymetric survey undertaken in July 2007 some 18 months later (PRDW, 2024) both showing the outline of disposal site (white dashed line).

7.2 MONITORING FOR COMPLIANCE

7.2.1 DREDGE SPOIL DISPOSAL

The designated dredge spoil disposal site offshore of Richards Bay can be conceived as a sacrificial zone for receiving dredge spoil and any contaminants it may hold. However, it is essential that all spoil disposal occurs within the confines of the specified area and preferably occurs so as to ensure minimal mounding across the site, *i.e.*, occurs mostly in the deeper waters of the site as indicated in Figure 2-7 resulting in a more or less uniform water depth over the whole disposal site.

Therefore, all navigation tracks for spoil disposal round trips and locations of spoil release must be supplied by the dredge operator to the designated Environmental Control Officer on at least a weekly basis. This officer should then check that spoil is being released within the confines of the designated spoil disposal site, as planned, and advise the dredge operator(s) when apparent mounding of material on the site is developing. These data are to be reported to an Environmental Monitoring Committee (or similar entity auditing the dredge monitoring) or, alternatively, the relevant regulatory authority.

Should there be any impacts of the dredging and/or validation of the predicted impacts this will require detailed knowledge of dredge spoil disposal activities. Records thus need to be kept for each dredge disposal event. The information to be reported should include start of the disposal (*i.e.*, “doors open”), the conclusion of the disposal (*i.e.*, “doors closed”), and approximate hopper volumes. These records need to be stored for safe-keeping after dredging operations have ceased (*i.e.*, preferably indefinitely but at least for a minimum of 2 to 3 years).

7.2.2 TURBIDITY AND SUSPENDED SOLIDS COMPLIANCE MONITORING PROGRAMME

Reference is often made to both pre-cautionary and compliance monitoring. Here, pre-cautionary and compliance monitoring are assumed to be one and the same since in both cases the intention is to identify and avoid situations where adverse dredging impacts are likely to occur. As the most pervasive and definite environmental risks during dredging operations are associated with increases in turbidity and TSS concentrations in the water column, these variables are well-suited for compliance monitoring.

7.2.2.1 Development of a relationship between turbidity and TSS concentrations

The imposition of a limit on the concentration of TSS in the water column at specified locations near dredging operations or open-water dredge disposal sites rather than a turbidity limit, is common for dredging projects in most parts of the world. This is because TSS concentrations correlate well with environmental impact and are broadly comparable from site to site and sediment-type to sediment-type, however this is not necessarily the case for turbidity.

The major problem with imposing a limit on the concentration of TSS in the water column for dredging compliance monitoring is that TSS concentrations cannot be determined quickly. This is because the water samples require transport to and subsequent analysis in a specialised laboratory. Depending on the location of the laboratory relative to the dredging operation, it can take anywhere between 12 to 72 hours to receive the results. In the meantime, the TSS concentration in the water body of interest will have changed. TSS concentrations cannot, therefore, be easily used to detect and correct short-term problems or dredging permit violations. It also becomes difficult to regulate a

dredging operation because the economic ramifications are significant when a dredging contractor is required to cease operations based on the potential violation of a TSS concentration limit, but which must be verified based on results that may only be forthcoming several days later (Earheart, 1984). Due to these problems a turbidity limit is often substituted for a TSS concentration limit in dredging permits. This is because turbidity can be measured quickly (within a few minutes) using any one of numerous *in situ* or on-site laboratory/vessel-based turbidimeters by dredging personnel, and importantly because there is often a strong relationship (usually linear) between these variables (CSIR, 2013c). Thus, if the relationship between turbidity and TSS concentration is defined (as has been done in CSIR, 2013c), then turbidity measurements can be used to estimate the TSS concentration to determine if there is compliance with permit limits.

A study was undertaken in 2013 to develop the requisite relationship between turbidity and TSS concentration for dredging activities in and near the Port of Richards Bay (CSIR, 2013c). The resultant relationship developed and recommended for use in compliance monitoring is

$$\text{TSS concentration (mg/l)} = 1.525 \times \text{Turbidity (NTU)}$$

This relationship can be used to calculate TSS concentrations in the water column for dredging compliance monitoring, based on the measurement of turbidity. However, care should be taken when using this relationship as factors such as the change in sediments being dredged could influence the slope of the relationship. For this reason, ideally the relationship needs to be verified by analysing water samples collected in close proximity to dredging operations for turbidity and TSS concentrations. A more detailed account of this relationship and associated caveats in its application is given in CSIR (2013c).

7.2.2.2 Purpose of the Monitoring

The purpose of the compliance monitoring is to determine whether dredging and dredge spoil disposal activities associated with the Berth 605 project are causing unacceptably high turbidity and TSS concentrations in the water column, both in the Port of Richards Bay and the marine environment offshore of Richards Bay. As noted above, only turbidity and TSS concentrations are referred to in the compliance monitoring as they are good proxies for other environmental impacts. Any data collected during the compliance monitoring will also have the dual purpose of supporting the assessment of dredging-related environmental impacts upon completion of dredging activities. This may, however, require an extension of the duration of the proposed compliance monitoring.

7.2.2.3 Monitoring parameters

The parameters that need to be monitored are turbidity (as NTU) and TSS concentrations (as mg/l). While turbidity will be used as the primary measure to ensure compliance of dredging activities with environmental limits imposed by regulatory authorities, the opportunity should be taken, whenever possible, to obtain concurrent turbidity and suspended solids concentration measurements to ensure validation of the turbidity TSS relationships used. If possible, other parameters such as temperature, salinity, dissolved oxygen concentration and pH should be measured at the same time that turbidity and TSS concentrations are measured. These data, while not required for compliance monitoring, typically provide context for observed ecological effects that may be due to natural variability in water quality rather than the effects of dredging. While the measurement of dissolved inorganic nutrient concentrations may aid the interpretation of these data, such measurements are not deemed as strictly necessary.

Given the discussion around the quality of the sediments being dredged, the measurement of contaminants in the water column (*i.e.*, dissolved metals, hydrocarbons) is not considered a necessary requirement.

7.2.2.4 Environmental Thresholds

Suggestions have been made for dredging at other locations in South Africa (Lwandle, 2013) that “pre-cautionary” monitoring be undertaken based on the control thresholds defined by Probyn (2000). However, it was stated that these control thresholds should be applied only for the upper portion of the water column (*i.e.*, if suspended sediment concentration exceeds 20 mg/l for three consecutive days the dredging should be halted or management interventions made to allow the concentration to decrease below the threshold 20 mg/l level). If turbidity exceeds 80 mg/l for more than 6 hours continuously then dredging should either be halted or other management interventions, such as the emplacement of silt screens, should be implemented to allow concentrations to decrease below the set level. Such requirement (thresholds) developed for the monitoring of dredging activities at the Port of Ngqura are overly conservative in more turbid environments such as those of the Port of Richards Bay and its surrounds.

It is better that site-specific thresholds be developed for compliance monitoring. In this regard, the site-specific environmental thresholds suggested for the Port of Richards Bay Expansion project (CSIR, 2013c, 2014) are possibly the most appropriate for application within the Port of Richards Bay. There exist two thresholds, namely “warning thresholds” and “intervention” thresholds. Should the “warning” thresholds be exceeded then the monitoring should be undertaken on a more regular basis (*e.g.*, daily, if possible) until the threshold is no longer exceeded. Should the “intervention” thresholds be exceeded at any stage then immediate high-level intervention would be required to reduce the turbidity and suspended sediment concentrations to below relevant thresholds.

The relevant “warning” thresholds are indicated in Table 7-1 below. Relevant “intervention” thresholds for the different locations in the Port of Richards Bay are as follows:

- a turbidity of 93 NTU or TSS concentration of 142 mg/l for monitoring stations situated on the Mudflats and in Bhizolo Canal,
- a turbidity of 66 NTU or suspended solids concentration of 100 mg/l for stations situated elsewhere in Richards Bay.

Such thresholds are not deemed applicable in the immediate vicinity of dredging activities in the port., *i.e.*, a “sacrificial zone” around the dredger.

Table 7-1 - Location of monitoring stations and relevant “warning” and “intervention” thresholds provided as turbidity (NTU) or equivalent TSS concentrations (mg/l).

Monitoring Station	“Warning” threshold		“Intervention” threshold	
	Surface	Bottom	Surface	Bottom
M1	38 NTU / 57 mg/l		93 NTU / 142 mg/l	
M2-M4	28 NTU / 43 mg/l		93 NTU / 142 mg/l	
B1 – B5	22 NTU / 33 mg/l	26 NTU / 39 mg/l	66 NTU / 100 mg/l	

Suggested locations for compliance monitoring are provided in Figure 7-2. It is important that the station indicated initially are all monitored to provide certainty that the observed elevations indeed are related to the dredging activities. Should compliance consistently be demonstrated, the number of stations monitored could be rationalised (e.g., only stations B1 and M1) or monitoring could occur less frequently or even be stopped.

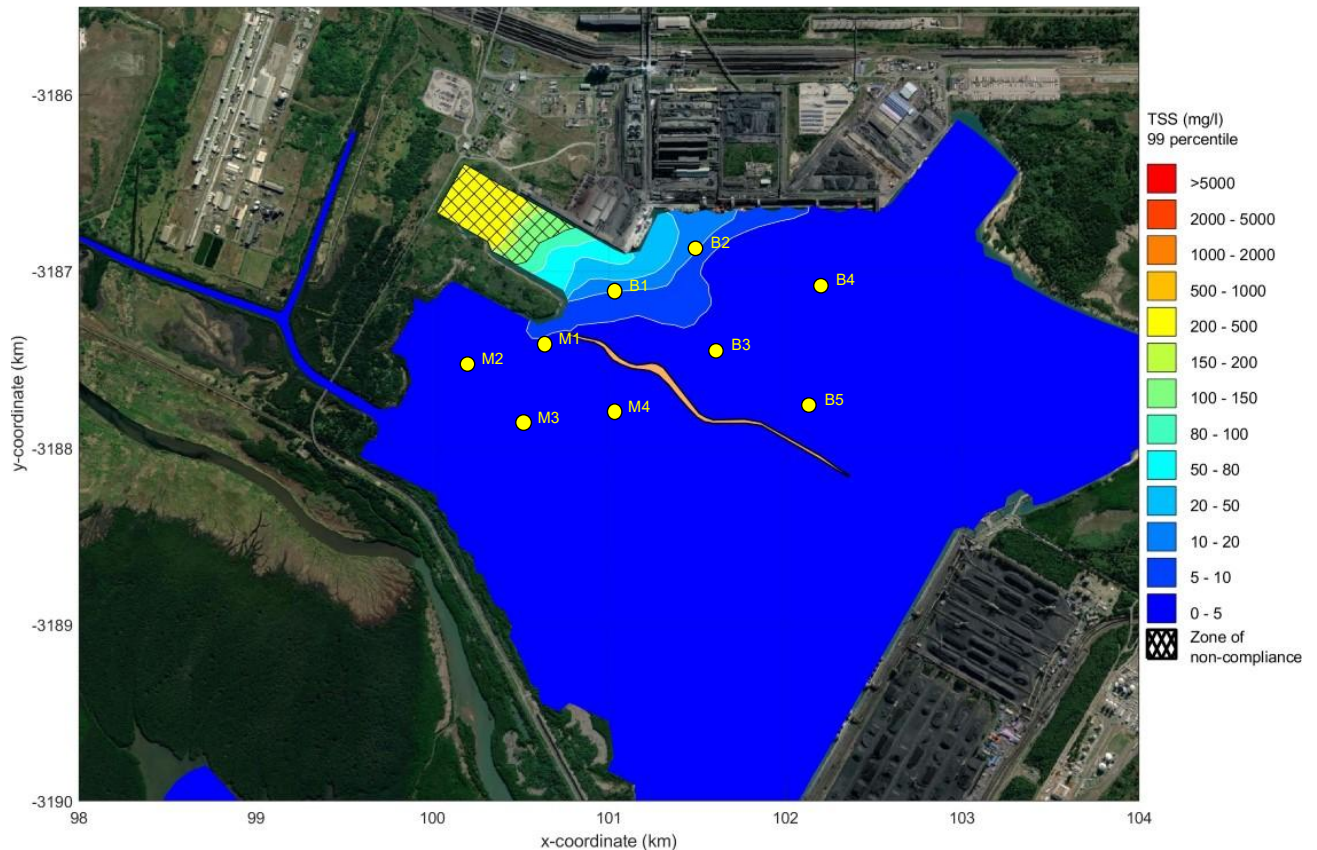


Figure 7-2 - Location of monitoring stations and relevant “warning” and “intervention” thresholds provided as turbidity (NTU) or equivalent TSS concentrations (mg/l).

Greater care needs to be taken when specifying compliance monitoring at the offshore dredge spoil disposal site. Unlike the situation at the dredging location (Berth 605), the stopping of dredging activities will not necessarily immediately result in lower turbidity at the dredge spoil disposal site. This is due to the fact that the dredge spoil that has already been disposed of at the dredge spoil disposal site constitutes a “reservoir” of sediments that are available for re-suspension should environmental conditions occur that generate enough turbulence and bottom stress to re-suspend the material. Consequently, a more pragmatic approach to management of disposal activities at the offshore dredge spoil disposal site is appropriate. A detailed monitoring protocol for the offshore dredge spoil disposal site was proposed for the Port of Richards Bay Capacity Expansion dredging and dredge spoil disposal activities. These are detailed in van Ballegooyen *et al.* (2015).

It is suggested in (2013c) that compliance monitoring at the offshore dredge spoil disposal site be performed by profiling turbidity through the water column at distances of 500, 1000 and 1500 m to the north-northeast and south-southwest of the spoil disposal ground as these are the likely predominant current and hence also suspended sediment dispersion directions. However, this assumption should perhaps be revisited as the present model results indicate higher bottom turbidities in the deeper waters offshore of the site Figure 6-43. This approach assumes that a sacrificial zone extending 500 m in any direction from the margin of the spoil disposal ground is appropriate. However, the hydrodynamic modelling results and Optical Backscatter Observations (OBS) (turbidity sensor) mooring results from the previous Berth 306 dredge monitoring and the results of the present modelling study suggest that spatial extent of 1 000m would be more appropriate. It is therefore proposed that any relevant thresholds be applied to this greater distance. A threshold of 66 NTU corresponds to a suspended solids concentration of 100 mg/l, which corresponds to the 10th percentile of the Acute Sub-lethal endpoint for suspended solids concentration. This could therefore be considered a threshold that is applicable for managing dredging activities in the offshore region. However, the OBS mooring measurements (made in the bottom waters at least 1 000 m beyond the dredge spoil disposal site during the Berth 306 project) suggest that this threshold should be substantially higher if applied at a distance of 1 000 m from the disposal site or alternatively should be applied at a greater distance (*i.e.*, a greater assumed sacrificial zone). Clearly greater care needs to be taken when attempting to specify compliance monitoring at the offshore dredge spoil disposal site.

For the reasons above, it is felt that any requirement to undertake monitoring of the offshore dredge spoil disposal site for the present project would be too uncertain. Such monitoring also may not be able to unequivocally discern the impacts from the capital dredging underway from the impacts associated with material already on the site, further exacerbated by on-going maintenance dredging activities and natural variability in turbidity associated with metocean conditions in sediments released into the offshore region from the Mhlathuze Estuary.

It should be noted that the above thresholds and protocols are to be revised should additional data or projects insights be obtained prior to the authorisation and permitting of dredging activities.

7.2.2.5 Monitoring Protocol

It is proposed that the monitoring within the port commence approximately one month prior to the commencement of dredging activities. Upon commencement of dredging activities, it is proposed that the profiling within the port be executed daily for approximately 5 - 7 days, such monitoring commencing after approximately 10 days of dredging and disposal activities. Thereafter the monitoring can take place once every one or two weeks; reducing to monthly or even a less regular basis should the results of the initial monitoring indicate this is acceptable. However, should the “warning” thresholds be exceeded then the monitoring should be undertaken on a more regular basis (e.g. daily if possible) until the threshold is no longer exceeded. Furthermore, should the “warning” thresholds be exceeded for more than 4 days then high-level intervention would be required. Similarly, should the “intervention” thresholds be exceeded at any stage then immediate high-level intervention would be required to reduce the turbidity and suspended sediment concentrations to below relevant thresholds. This could include reduced dredging rates or possibly even the deployment of silt curtains although not necessarily deemed practical for the present proposed operations.

All compliance monitoring must be done under the direct supervision of an independent environmental control officer and the results audited episodically by an Environmental Monitoring Committee, or where required, by the relevant competent authority.

7.3 MONITORING TO SUPPORT THE VERIFICATION OF IMPACT ASSESSMENTS

Should ecological effects be observed in the marine environment that are considered deleterious, certain minimum information will be required to determine whether such effects are attributable to dredging activities or not. This information will include wind, wave and current data that is both representative of the likely source of high turbidity or TSS concentrations as well the potential impact locations, as well as turbidity or TSS measurements at or near the site of impact.

Required in the Port will be appropriate profiling data. The locations of potential impact within the Port of Richards Bay to be monitored will need to be specified in collaboration with the marine and estuarine ecology specialist. These data can be collected at the same time as the compliance monitoring data but may need to extend beyond the duration of the active dredging activities.

Detailed monitoring to support impact assessment is not proposed for the offshore dredge spoil disposal site. Were such monitoring to be required, the necessary protocols as discussed in van Ballegooyen *et al.* (2015) are as follows.

In addition to profiling stations to be set up to monitor the consequences of dredge spoil disposal, it is proposed that:

- an Acoustic Doppler Current Profiler (ADCP) mooring (or equivalent instrumentation) be deployed offshore to measure waves, currents and bottom temperatures at a similar location to that used for the Berth 306 study, providing coverage of at least the period of dredging but preferably one month preceding the commencement of dredging activities and two to three months after dredging activities cease.
- two moorings measuring near bottom turbidity be set up at the same locations as the K and L mooring sites of the Berth306 monitoring (Figure 4-36) or at a location 1 000m distant from the dredge spoil disposal site boundary in both a NE and SW direction. Ideally these moorings need to be maintained for a one-month period prior to dredging through to one month after dredging has ceased. However, given that dredging can occur over a long period and that the maintenance and servicing of such moorings may be onerous and costly, it is recommended that the mooring duration be limited to possibly the first 2 - 3 months of dredging (or the most intensive period of dredging). Based on an analysis of the data at that stage, such monitoring may be rationalised or discontinued.

Such a mooring duration should be sufficient to characterise physical and water quality parameters that could be drivers of any ecological changes of concern. Water column profiling and water sampling to determine TSS concentrations for calibration purposes should be measured at the time of deployment, servicing and retrieval of the moorings. An alternative to such moorings would be more regular water quality profiling in the offshore region than indicated for compliance monitoring alone. However, such boat-based water column profiling of turbidity can be costly and difficult to implement should it be required at a high temporal resolution. Furthermore, due to practicalities, such profiling is often biased towards calmer conditions when the water column turbidity is likely to be low. This implies

that the full range of turbidity variability, particularly the temporal variability, may not be successfully sampled without the use of moorings.

7.4 MONITORING PHYSICAL CHANGES IN BENTHIC HABITATS

There are two aspects to monitoring change in benthic habitats, namely potential smothering impacts and changes in the morphology and sediments constituting those habitats (e.g. changes in grain size). For example, there could be significant (even medium-term or progressive) changes/impacts in the seafloor in the areas surrounding the offshore dredge spoil disposal site.

7.4.1 BATHYMETRIC SURVEYS

Generally pre- and immediate post-dredging bathymetric surveys are recommended for dredge disposal sites to monitor sediment erosion and deposition at and in the vicinity of these sites as these provide a good proxy for a number of potential impacts. Such pre-dredging surveys are required for engineering design and planning. Often the post-dredging survey is also required for verification of dredged and dumped volumes. These pre- and immediate post-dredging surveys should, therefore, not be considered as an additional cost attributable to environmental monitoring requirements alone. Such “in-“ and “out-surveys” have been undertaken for previous dredging programmes for developments within the Port of Richards Bay. When such surveys are taken for the offshore region, there should be adherence to the aerial extent of such surveys as outlined in Section 7.1.

7.4.2 CHARACTERISING CHANGES IN BENTHIC HABITATS

It is expected that the grain size distribution and organic content of the sediments at and surrounding the dredge spoil disposal site will change. While the monitoring of changes in benthic habitat may have some value within the port and surrounding the proposed development site (to be advised by the marine and estuarine ecology specialist), it is expected to have limited value at the dredge spoil disposal locations and therefore is not recommended. Previous monitoring of changes in grain sizes on and around the offshore dredge spoil disposal site undertaken for the Berth 306 dredging and dredge spoil disposal activities, provided equivocal results (Newman and Weerts, 2008).

7.4.3 MONITORING OF POTENTIAL SHORELINE CHANGE IMPACTS

Monitoring of potential shoreline changes associated with accumulation of sediments on the offshore dredge spoil disposal site and resultant effects on the wave climate can be adequately assessed using Satellite imagery as has been recommended in the Wave Climate and Shoreline Change study (WSP, 2025) for the Berth 605 project.

7.5 SUMMARY OF PROPOSED MONITORING ACTIVITIES

The **monitoring** suggested in Sections 7.1 to 7.4 should be sufficient to assess the extent of physical changes leading to impacts of potential concern.

Whilst not strictly an environmental monitoring activity, if any impact assessment is going to be made and validated, the exact nature of the dredging operations needs to be recorded. This includes the nature and duration of dredging (*i.e.*, dredging technology used, hopper size, down-time, number of dumps, location of dumps, *etc.*). Typically, it is the absence of these data that makes it difficult, if not impossible, to robustly interpret the monitoring data. The need to ensure a comprehensive record of the dredging operations cannot be overemphasized. The recording of such information is considered essential.

The proposed monitoring requirements are summarised in Table 7-2 below.

Table 7-2 – Summary of Required Monitoring Activities

DESCRIPTION	LOCATION	COMMENT
Environmental baseline monitoring		
Turbidity Profiling and sampling to determine TSS concentrations	Port of Richards Bay	Not necessary as adequate data exists
	Offshore dredge spoil disposal site	Not necessary as adequate data exists
Pre-dredging bathymetric surveys / shoreline surveys	Berth 605 dredging footprint	Project-specific surveys have been completed
	Offshore dredge disposal site	Adequate data presently exists, but a bathymetric in-survey will be required before dredging commences
	Southern, Central and Northern shorelines	Available from satellite imagery (see analyses in WSP, 2025)
Monitoring for Compliance		
Dredging spoil disposal records	Berth 605 dredging footprint	Not applicable
	Offshore dredge spoil disposal site	Essential
Turbidity and TSS concentration compliance monitoring (other variables to be included in the profiling if possible)	Potentially impacted areas within the Port of Richards Bay	Initial monitoring required but can be reduced or stopped once compliance is confidently established
	Offshore dredge disposal site	Not required

DESCRIPTION	LOCATION	COMMENT
Monitoring to support verification of impact assessments		
Turbidity and TSS concentration monitoring (other variables to be included in the profiling if possible)	Potentially impacted areas within the Port of Richards Bay	As per turbidity and TSS compliance monitoring, but possible of longer duration.
	Offshore dredge disposal site	Optional
Shoreline change	Southern, Central and Northern shorelines	Available from satellite imagery (see WSP, 2025)
Monitoring Physical Changes in Habitat		
Post-dredging bathymetric and shoreline change surveys a	Potentially impacted areas within the Port of Richards Bay	Not required for environmental purposes
	Offshore dredge disposal site	Required for environmental purposes (immediately after end of dredging and then approximately 18 months later)
	Southern, Central and Northern shorelines	Available from satellite imagery (see WSP, 2025)
Physical and biogeochemical changes in benthic habitats	Potentially impacted areas within the Port of Richards Bay	Recommended (however contaminant (metals) characterisation of the sediments not deemed essential) – could form part of on regular (annual) monitoring activities in the port
	Offshore dredge disposal site	Optional
	Southern, Central and Northern shorelines	Not required
Dredging Records		
Detailed records of dredging operations	Dredging Footprint	Detailed dredging and dumping records are essential
	Offshore dredge disposal site	

8 CONCLUSIONS AND RECOMMENDATIONS

The conclusion and key recommendations of the modelling study are provided below; however, conclusions related to the actual marine impacts, informed by this study, are provided in CSIR (2025) where they have been assessed in detail.

8.1 CONCLUSIONS OF THE STUDY

8.1.1 VISUAL IMPACTS

The visual impacts of dredging plumes in the surface waters within the port are predicted to be negligible, with visual plumes only very rarely observable beyond the 600 series basin. However, the increased turbidity at depth is likely to increase the surface plumes from shipping and berthing activities within the 600 series basin and its immediate surrounds.

Elevations in turbidity exceeds the threshold assumed for aesthetic (visual) impacts for large distance SW and more so NE of the disposal site resulting from the re-suspension of sediments and from the disposal site and the mixing of such sediment throughout the water column. These elevated turbidity and TSS concentrations in the surface layers are associated with storm conditions when there is a general elevation of turbidity and TSS concentrations in the water column that are likely largely to mask the presence of such dredging-related plumes.

8.1.2 ECOLOGICAL IMPACTS ASSOCIATED WITH ELEVATED TURBIDITY & TSS CONCENTRATIONS

From the modelling results for TSS concentrations in the water column we can conclude that:

- The exceedance of the relevant guidelines for elevation in TSS concentrations in the water column within the port remain relatively constrained to the 600 series berth area and its immediate surroundings, no matter which threshold for elevations in TSS concentration is used. No sensitive sites on the tidal flats are indicated to be impacted upon.
- In the offshore region the predicted maximum elevations in TSS exceed a lower precautionary 20 mg/l threshold over fairly extensive distances from the disposal site in both the surface (~ 8km) and bottom waters (8 to 10 km). However, more persistent elevations in TSS concentrations only occur in the bottom waters for more limited distances from the disposal site (4 km to the NE and 1.5 km to the SW).
- In the offshore region the predicted maximum elevations in TSS exceed an upper high risk 80 mg/l threshold only in the bottom waters and then only for a more modest 1 to 2 km from the disposal site while persistent exceedances of this threshold typically remain within 1 km of the disposal site. Elevations in TSS concentration are predicted not to be of concern in the inshore area, particularly at the mouth of the Mhlathuze Estuary. Time series plots for locations within approximately a kilometre of the disposal site show that the persistence of such exceedances comprise many occasions of short duration exceedances of the thresholds during weather events.

8.1.3 IMPACTS ASSOCIATED WITH ACCUMULATION OF SEDIMENTS ON THE SEABED

From the modelling results for sediment accumulation on the seabed, we can conclude that:

- Within the port, major sediment accumulation largely comprises relatively unconsolidated fines and is restricted largely to the 600 series basin. Their presence is expected to lead to chronic and relatively high elevations in TSS concentrations in the water column until such time as this material is removed to the offshore disposal site.
- The maximum sediment thickness of accumulated sediments predicted is approximately 3 to 4 m over the southeastern half of the disposal site where most of the dredged material it is intended to be placed. The typical sediment thickness within 500m to 1 km of the site is predicted in the model to be between 10 and 20 cm in the short-term. However, historical records indicate a more extensive distribution of sediment from the disposal site, albeit on time scales that would mitigate some of the likely impacts of smothering and changes in benthic habitats.

8.1.4 POTENTIAL TOXICITY EFFECTS OF CONTAMINANTS RELEASED FROM THE SEDIMENTS

The simulation and assessment of toxicity effects from potential contaminants released into the water column was not assessed in the modelling study as this was deemed superfluous based on analyses undertaken in CSIR (2024) that suggest that such impacts are of limited concern as the required dilution of contaminants released in the water column will be achieved within the port and more so in the offshore region.

8.1.5 LONG-TERM CHANGES IN HYDRODYNAMIC FLOWS.

The long-term changes in flow and reduced flushing within the Port of Richards Bay will be modest and any such impacts will be confined to the 600 series basin and immediate surrounds. The changing depth at the disposal site will result in local modifications of flows and possible wave conditions. However, of potentially greater concern are changes in wave climate over a wider area and potential shoreline change. These are addressed in a companion Wave Climate and Shoreline Change specialist study (WSP, 2025). The impacts in the offshore region will reduce as dredged material is dispersed from the disposal site over time.

8.1.6 CLIMATE CHANGE EFFECTS

Climate change may affect some of the environmental baseline conditions and also the coastal processes of relevant to this study. However, the anticipated changes in key processes such as sea level and storminess will be extremely limited and largely not easily discernible from natural variability over the short to medium term when potential dredging impacts associated with the Berth 605 dredging activities are likely to be observed. The issues around long-term climate change effects on wave climate and possible shoreline change are addressed in a companion Wave Climate and Shoreline Change specialist study (WSP, 2025).

8.2 RECOMMENDATIONS AND MITIGATION MEASURES

The Port of Richards Bay is a working port. Therefore, any mitigation measures proposed require careful consideration and should be practically achievable within this context.

Within the port the only mitigations that could be considered are to limit hopper overflows or that silt curtains or a similar measure be deployed (if necessary) to limit the spread of fine sediments through the port. The requirement for such measures, their practicality and efficacy need to be carefully assessed before committing to such measures.

There are no obvious mitigation measures for the offshore dredge spoil disposal site, since elevated turbidity and the redistribution of sediments beyond the confines of the dredge spoil disposal site, are largely determined by previous disposal of dredge material and prevailing environmental conditions, neither of which can be managed/controlled. It is unlikely that any specific mitigation measures are warranted.

The material being deposited on the disposal site will comprise coarse material with a $d_{50} = 6$ mm (from the dredging of rock by the CSD) that will not easily be dispersed from the site, if at all. It is recommended that the implication of this for the long-term capacity of the disposal site to accommodate dredge material disposal from maintenance dredging needs to be carefully assessed. This issue was also raised in the studies for the Port Expansion Project (van Ballegooyen et al., 2015)

The only other substantive requirement/recommendation is that the compliance monitoring procedures and management options (see Section 7) be followed diligently and to adhere to the normal due diligence measures associated with dredging. These are expected to include standard ballast water management practices, supplemented by dredger-specific operational procedures (e.g. procedures at the port of origin such as the washing of the hoppers, flushing the discharge pipes, and inspection of the hopper, pipes and dredge head to ensure no material is retained that may transport organisms to location of the proposed dredging dredge spoil disposal activities) should local dredging vessels not be utilised for the proposed dredging. Where compliance monitoring and management procedures are suggested to be options, careful assessment of the requirement for such measures, their practicality and efficacy need to be carefully assessed before committing to such measures (e.g., in the Dumping at Sea permit application and/or any relevant tender documentation.

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Appendix A

HISTORICAL MAINTENANCE DREDGING VOLUMES



Table A-1 - Maintenance dredging volumes (sands and muds) (Sources: Smith, 2005a, Celliers *et al.*, 2008 and TNPA, 2025).

VOLUMES DREDGE					DREDGE SPOIL DISPOSAL		INFO SOURCE	COMMENT
Year	Sandtrap (m ³)	Chanel (m ³)	Basin (m ³)	Sum (m ³)	Northern Beach (m ³)	Offshore Disposal (m ³)		
1977	8 500	5 500	37 200	51 200	0	51 200	CSIR, 1994	Basin - used avg. from 1989-2003
1978	413 600	298 300	37 200	749 100	0	749 100	CSIR, 1994	Basin - used avg. from 1989-2003
1979	841 030	271 400	37 200	1 149 630	9 000	1 140 630	CSIR, 1994	Basin - used avg. from 1989-2003
1980	604 300	591 550	37 200	1 233 050	264 000	969 050	CSIR, 1994	Basin - used avg. from 1989-2003
1981	583 017	114 300	37 200	734 517	361 277	373 240	CSIR, 1994	Basin - used avg. from 1989-2003
1982	1 117 944	692387	37 200	1 847 531	679 374	1 168 157	CSIR, 1994	Basin - used avg. from 1989-2003
1983	722 609	1 348 763	37 200	2 108 572	808 134	1 300 438	CSIR, 1994	Basin - used avg. from 1989-2003
1984	630 257	1 417 197	37 200	2 084 654	649 621	1 435 033	CSIR, 1994	Basin - used avg. from 1989-2003
1985	985 199	1 365 646	37 200	2 388 045	776 198	1 611 847	CSIR, 1994	Basin - used avg. from 1989-2003
1986	320 089	1 233 945	37 200	1 591 234	810 569	780 665	CSIR, 1994	Basin - used avg. from 1989-2003
1987	5 557	1 609 283	37 200	1 652 040	484 543	1 167 497	CSIR, 1994	Basin - used avg. from 1989-2003

VOLUMES DREDGE					DREDGE SPOIL DISPOSAL		INFO SOURCE	COMMENT
Year	Sandtrap (m ³)	Chanel (m ³)	Basin (m ³)	Sum (m ³)	Northern Beach (m ³)	Offshore Disposal (m ³)		
1988	346 009	1 128 816	37 200	1 512 025	560 767	951 258	CSIR, 1994	Basin - used avg. from 1989-2003
1989	372 206	697 204	34 814	110 4224	525 541	578 683	TNPA (D Bevis)	Sandtrap similar to CSIR,1994b channel & N Beach values differ
1990	531 956	887 361	34 447	1 453 764	574 435	879 329	TNPA (D Bevis)	Similar to CSIR,1994b
1991	618 470	720 324	11 789	1 350 583	593 763	756 820	TNPA (D Bevis)	Similar to CSIR,1994b
1992	696 688	490 591	11 222	1 198 501	708 209	490 292	TNPA (D Bevis)	N Beach value less than CSIR,1994b
1993	648 523	593 351	51 651	1293525	624 319	669 206	TNPA (D Bevis)	
1994	698 201	499 764	44 596	1 242 561	760 777	481 784	TNPA (D Bevis)	
1995	698 248	568 043	18 283	1 284 574	656 277	628 297	TNPA (D Bevis)	
* ³ 1996	167 800	2 210 803	25 750	2 404 353	124 477	2 279 876	TNPA (D Bevis)	
* ³ 1997	338 113	1 294 934	6 985	1 640 032	412 718	1 227 314	TNPA (D Bevis)	
* ³ 1998	371 308	717 277	26 130	1 114 715	826 034	288 681	TNPA (D Bevis)	
1999	425 347	1 370 740	45 234	1 841 321	598 715	1 242 606	TTNPA (D Bevis)	

VOLUMES DREDGE					DREDGE SPOIL DISPOSAL		INFO SOURCE	COMMENT
Year	Sandtrap (m ³)	Chanel (m ³)	Basin (m ³)	Sum (m ³)	Northern Beach (m ³)	Offshore Disposal (m ³)		
2000	524 958	638 285	100 443	1 263 686	724 109	539 577	TNPA (D Bevis)	
2001	678 410	670 804	37 665	1 386 879	873 380	513 499	TNPA (D Bevis)	
2002	796 099	683 644	44 480	1 524 223	824 014	700 209	TNPA (D Bevis)	
2003	652 805	681 368	64 505	1 398 678	757 703	640 975	TNPA (D Bevis)	
*4 2004	-	-	-	no data	no data	no data		
*4,5 2005	-	-	-	no data	no data	no data		
*1 2006	-	-	-	1069047	783 139	285 908	TNPA (2025)	
*1 2007	-	-	-	2 200 000	1 200 000	1 000 000	TNPA (2025)	
*1 2008	-	-	-	3 075 000	1 485 000	1 590 000	TNPA (2025)	
*1 2009	-	-	-	1 420 000	420 000	1 000 000	TNPA (2025)	
*1 2010	-	-	-	1 130 000	510 000	620 000	TNPA (2025)	
*1 2011	-	-	-	1 822 017	662 017 *2	1 160 000	TNPA (2025)	
*1, 2012	-	-	-	2 047 911	7533 98 *2	1 294 513	TNPA (2025)	

VOLUMES DREDGE					DREDGE SPOIL DISPOSAL		INFO SOURCE	COMMENT
Year	Sandtrap (m ³)	Chanel (m ³)	Basin (m ³)	Sum (m ³)	Northern Beach (m ³)	Offshore Disposal (m ³)		
^{*1} 2013	-	-	-	1 331 776	252 834 ^{*2}	1 078 942	TNPA (2025)	
^{*1} 2014	-	-	-	360 203	290 593 ^{*2}	69 610	TNPA (2025)	
^{*1} 2015	-	-	-	1 364 445	414 046	950 399	TNPA (2025)	
^{*1} 2016	-	-	-	1 792 974	934 509	858 465	TNPA (2025)	
^{*1} 2017	-	-	-	1 627 399	887 267	740 132	TNPA (2025)	
^{*1} 2018	-	-	-	689 569	229 893	459 676	TNPA (2025)	
^{*1} 2019	-	-	-	1 501 619	412 445	1 089 174	TNPA (2025)	
^{*1} 2020	-	-	-	847 351	111 263	736 088	TNPA (2025)	
^{*1} 2021	-	-	-	1 113 154	166 756	946 398	TNPA (2025)	
^{*1} 2022	-	-	-	1 410 955	882 900	528 055	TNPA (2025)	

^{*1} TNPA (2025) dataset provided contained volumes for 'Actual Sand' and 'Actual Silt'. In the absence of information to the contrary, it is assumed that all the 'actual sand' was disposed on the northern beaches (Alkanstrand), and the 'actual silt' was disposed on the offshore dredge spoil disposal site. Furthermore, the received data was categorised by financial year (e.g., March 2011 to March 2012). In the above table, each financial year is labelled according to the calendar year in which the majority of its months fall; for example, the period from March 2011 to March 2012 is recorded as the 2011 volume.

^{*2} CSIR (2015) dredging volumes shows the sand portion was reclaimed to Alkantstrand (*i.e.*, the northern beaches). These values concur with the TNPA (2025) dataset justifying the above assumption as reasonable.

- *3 Between 1996 and 1998 approximately 5 998 429 m³ of dredge spoil was disposed of onto the Central beach area at P3 located to the south of the port entrance (see Figure A-1). Cyrus *et al.* (2008) report that in 1996 a total volume of 3 705 800 m³, and in 1997 a total volume of 1 609 800 m³ and in 1998 a total volume of 682 900 m³ was released onto the beach near location P3. It is understood that this disposal is related to the dredging of the 600 series quay basin at that time, as assessed in earlier literature, e.g., Coppoolse *et al.* (1994). It is understood (but somewhat uncertain) that the values reported in the table do not include these capital dredging volumes. Note that these values do not fully concur with the capital dredging volumes reported in Table 2-5.
- *4 No data was provided for this period. It is unknown if such data exists or not. Similarly, the dredge volumes for the various areas (sandtrap, channel and basins) for the period from 2004 onwards may be available but were not explicitly requested for this study.
- *5 It is confirmed in van Ballegooyen *et al.* (2015) that for the Berth 306 development that a total of 3 840 361 m³ of *in-situ* dredge material was dredged and disposed of at the offshore dredge spoil disposal site in 882 barge trips (average of 4 354 m³ of *in-situ* dredged sediment per 10 330 m³ hopper load) over a period of 22 weeks. Goussard (2009) reports a value of 3.8 million m³ for the dredge spoil disposal volumes and that 0.53 m³ of material was dredged from a borrow pit. de Waal *et al.* (2007) report a higher volume for the material dredged from the borrow pit, possibly a planned rather than an actual volume dredged. These capital dredging volumes are understood to not be included in the Table above.

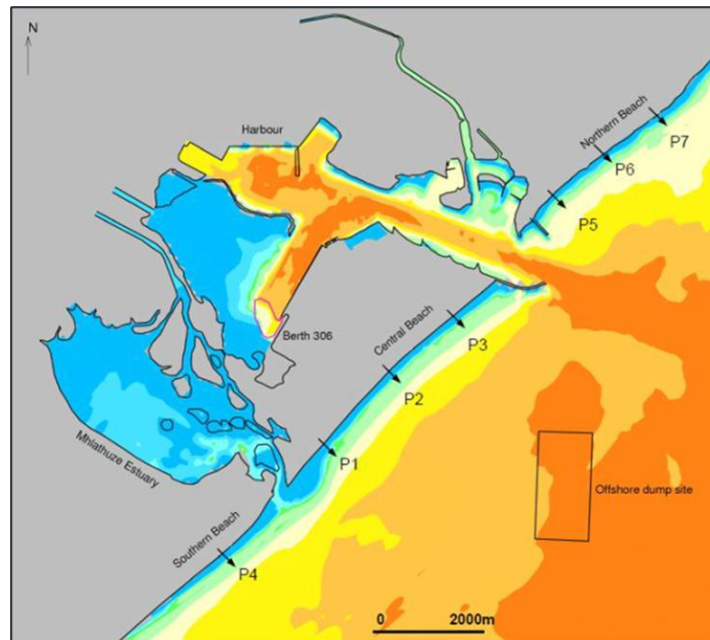


Figure A-1 - Locations of disposal sites (P1 to P7) [source: CSIR, 2004a in BKS, 2013]



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