

Impacts on sediment transport of proposed expansion of the Port of Tauranga shipping channels and wharves

2019

ERI report number 123

Prepared for the Port of Tauranga Ltd

By Julia C. Mullarney and Willem P. de Lange

Environmental Research Institute
The University of Waikato, Private Bag 3105
Hamilton, New Zealand



Cite report as:

J.C. Mullarney & de Lange, W.P. 2019. Impacts on sediment transport of proposed expansion of the Port of Tauranga shipping channels and wharves. *Environmental Research Institute Report No 123*. Client report prepared for Port of Tauranga. Environmental Research Institute, Faculty of Science and Engineering, The University of Waikato, Hamilton. 11 pp.

Reviewed by:



Prof. Karin Bryan
Director, Environmental Research Institute
University of Waikato

Approved for release by:



Assoc. Prof. Jo Lane
Acting Dean, School of Science
University of Waikato

Table of Contents

Table of Contents.....	3
Table of Figures.....	3
Introduction.....	4
Numerical modelling – set up.....	4
Results.....	6
Conclusions.....	9
References.....	10

Table of Figures

Figure 1: Proposed extensions to the Mount Maunganui and Sulphur Point Wharves, and Stella Passage shipping channel under the Port of Tauranga Ltd Stella Development Plan.	4
Figure 2: Bathymetries for the two scenarios modelled for the Stella Passage development, Port of Tauranga. The colour bar shows depth in m. (a) Base run, (b) Future development model which includes dredging of the southern end of Stella Passage to 16 m water depth, land reclamations and wharf extensions. In (b), the black lines show the approximate location of the thin dams representing land reclamation and wharf extensions, the precise locations of which are shown in (c).	5
Figure 4: Change in bed level over duration of scenario (negative values correspond to scour, positive to accretion) for simulations with $D_{50}=0.375$ mm (medium sand). The colour bar shows the depth change in m. (a) Base Run. (b) Future Development Model. (c) Differences between the base run and the future development model.	6
Figure 5: Change in bed level over duration of scenario (negative values correspond to scour, positive to accretion) for simulations with $D_{50}=0.75$ mm (coarse sand). The colour bar shows the depth change in m. (a) Base Run. (b) Future Development Model. (c) Differences between the base run and the future development model.	6
Figure 6: Magnitude of bed shear stress ($N.m^{-2}$) in the area of proposed port developments for the runs with $D_{50}=0.375$ mm (medium sand). Results from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.	7
Figure 7: Magnitude of bed load transport ($m^3.s^{-1}.m^{-1}$) in the area of proposed port developments for the simulations with $D_{50}=0.375$ mm (medium sand). Results presented are from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide, and, therefore, represent maximum transport rates. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.	8
Figure 8: Magnitude of depth-averaged suspended sediment load transport ($m^3.s^{-1}.m^{-1}$) in the area of proposed port developments for the runs with $D_{50}=0.375$ mm. Results presented are from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide, and, therefore, represent maximum transport rates. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.	9

Introduction

We report results of an examination of the effects of proposed dredge-channel and wharf extensions in the Port of Tauranga (Figure 1). In previous work, we undertook a calibration and validation of a hydrodynamic model for Tauranga Harbour. The work used the hydrodynamic package Delft3D in depth-averaged mode (see Mullarney and de Lange, 2018, for details). The effects of the proposed developments on the hydrodynamics within the Harbour were examined and compared to flows with present-day bathymetry and wharf configurations. The key result from this previous work was that flow speeds within the proposed dredged channel within Stella Passage were significantly reduced (by up to 0.5 m.s⁻¹ during spring tide peak ebb flows) as a consequence of mass conservation (i.e. the same amount of water being pushed through a larger cross-sectional area). However, these effects were highly localised: significant changes (0.3 to 0.5 m.s⁻¹) in flow speeds were limited to the area in the immediate vicinity (<40 m) of the proposed dredging site, with smaller changes (<0.05 m.s⁻¹) in flow speeds observed up to 250 m away (Mullarney and de Lange, 2018).

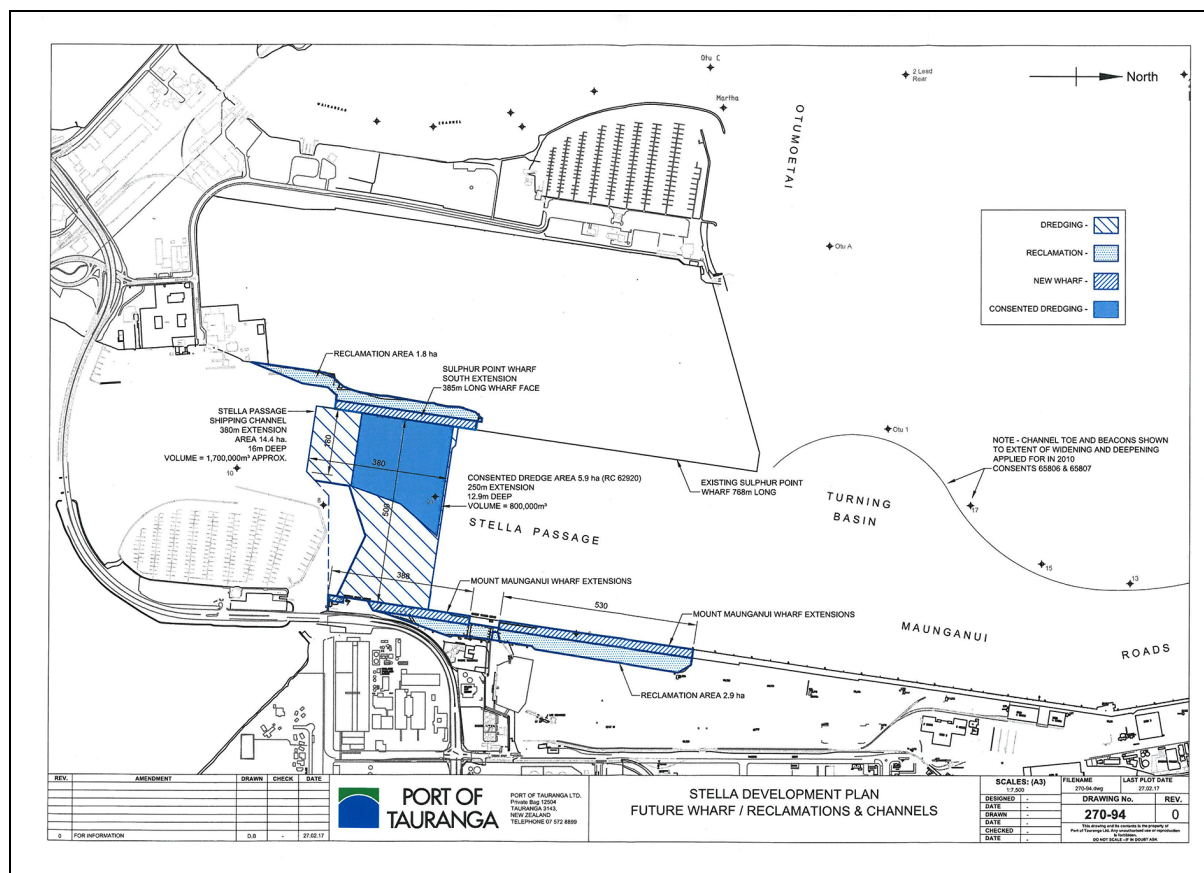


Figure 1. Proposed extensions to the Mount Maunganui and Sulphur Point Wharves, and Stella Passage shipping channel under the Port of Tauranga Ltd Stella Development Plan.

In this report, we present results from numerical modelling scenarios to examine the potential impact of the proposed dredging and wharf extensions on sediment transport, including sediment erosion and deposition patterns.

Numerical modelling – set up

Numerical modelling was undertaken using the previously calibrated and validated Delft3D hydrodynamic model for Tauranga Harbour (Mullarney and de Lange, 2018). To examine

sediment transport and deposition patterns, the hydrodynamic model was coupled to the Delft3D morphological module (Deltares, 2017). The model used non-cohesive sand with a specific density of 2650 kg.m^{-3} and a dry bed density of 1600 kg.m^{-3} . The initial sediment layer thickness was set at 10 m to ensure adequate availability of sediment throughout the entire domain.

A constant grain size value was used throughout the model domain. As the focus of the study was to examine transport patterns in and around the proposed port dredging and wharf expansions, the grain size was selected based on the grain size within this region. Grain size values were taken from the map compiled by McKenzie (2014) (his Figure 7.6), which was constructed based on surficial sediment samples and literature values from Park (2003), Black (2007), Sneddon and Clark (2007), Hancock *et al.* (2009), and Boulay (2012). The proposed dredging area is composed of grain diameters of 0.38 to 1.5 mm, corresponding to medium sand to very coarse sand on the Udden–Wentworth scale.

For the primary modelling runs, we selected the smallest value in this range (a median grain size value of $D_{50}=0.375 \text{ mm}$) to provide an estimate of the maximum transport that may be expected in the area. However, simulations were also conducted with a larger value ($D_{50}= 0.75 \text{ mm}$, corresponding to coarse sand) to examine the sensitivity of the results to the choice of this parameter. The coarser shell lag deposits present in higher velocity areas north of the harbour bridge (Boulay, 2012) were not modelled, as these deposits are not mobile under present or predicted future flow conditions.

The model simulations were undertaken with a *morfac* or morphological scale factor of 20 (for details on the use of a *morfac*, see Roelvink and Reniers, 2011), and a ‘spin up’ time of 12 hr was used before morphological changes were applied. The model was subsequently run for 14.5 days to capture a spring-neap cycle (thus representing 290 days of bed elevation change).

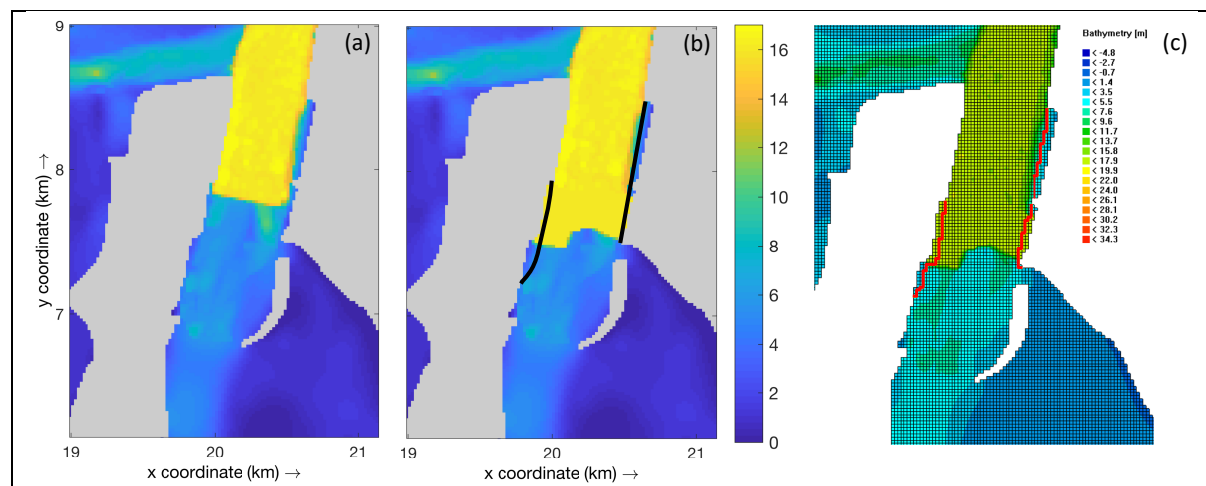


Figure 2: Bathymetries for the two scenarios modelled for the Stella Passage development, Port of Tauranga. The colour bar shows depth in m. (a) Base run, (b) Future development model which includes dredging of the southern end of Stella Passage to 16 m water depth, land reclamations and wharf extensions. In (b), the black lines show the approximate location of the thin dams representing land reclamation and wharf extensions, the precise locations of which are shown in (c).

Two sets of scenarios were simulated: scenarios were run using the existing bathymetry and wharf configuration (hereafter referred to as the “Base Run”); and secondly, scenarios were run with proposed changes implemented (“Future Development Model”, Figure 2).

Results

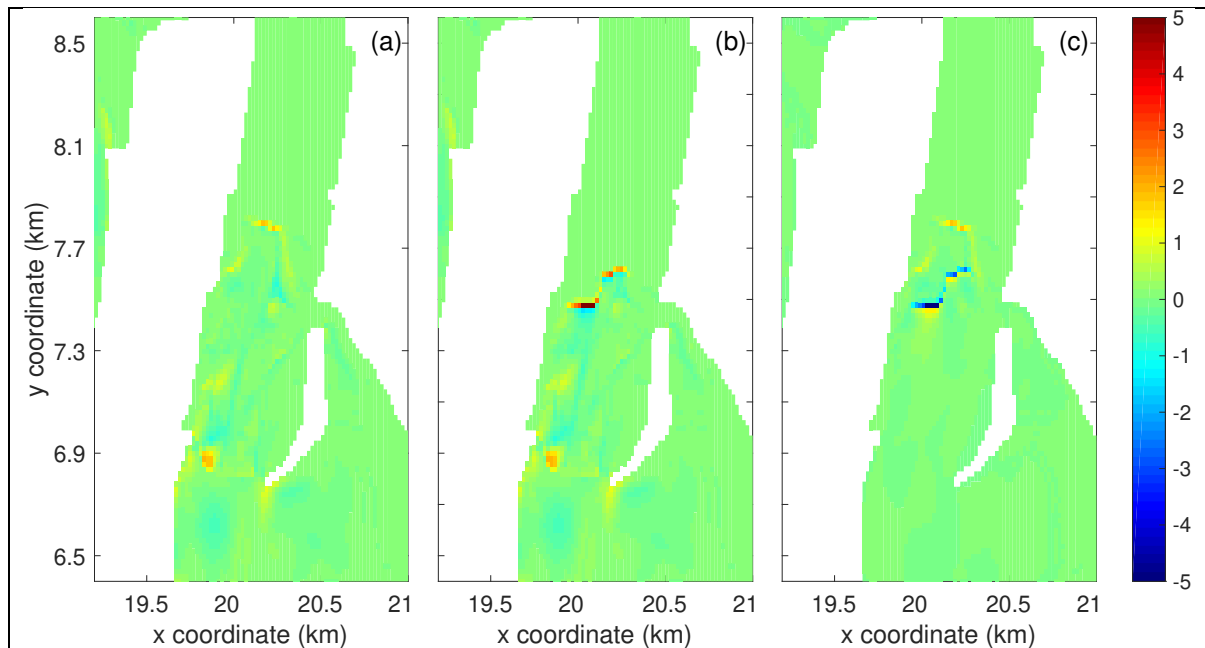


Figure 4: Change in bed level over duration of scenario (negative values correspond to scour, positive to accretion) for simulations with $D_{50}=0.375$ mm (medium sand). The colour bar shows the depth change in m. (a) Base Run. (b) Future Development Model. (c) Differences between the base run and the future development model.

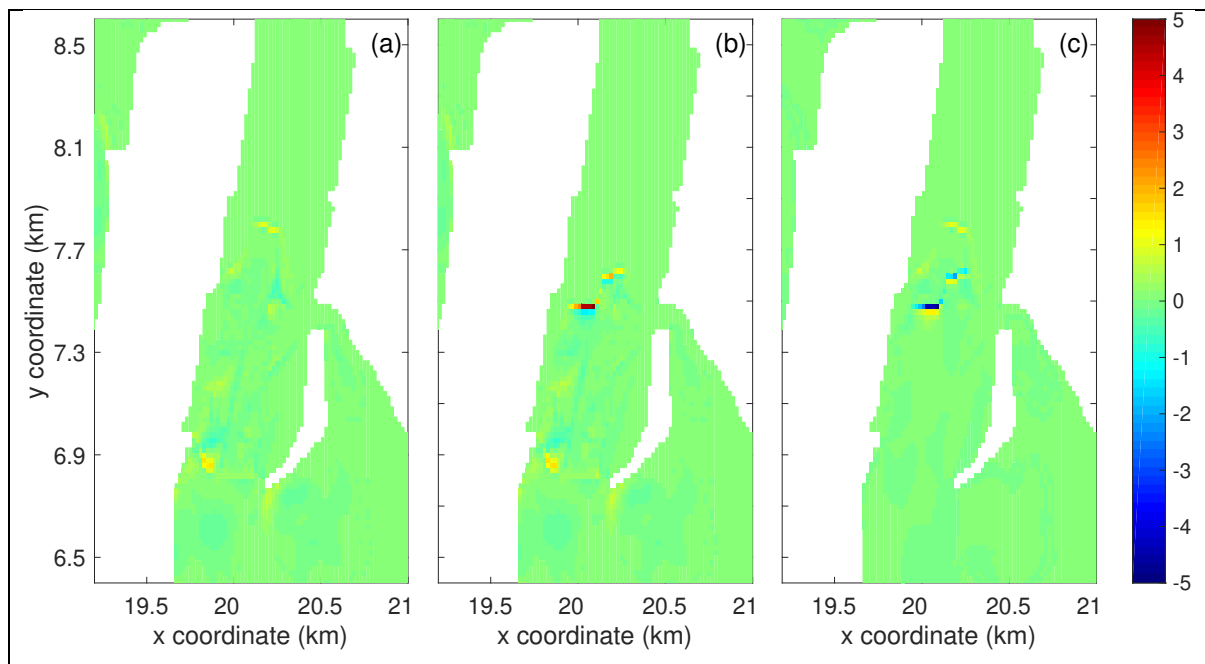


Figure 5: Change in bed level over duration of scenario (negative values correspond to scour, positive to accretion) for simulations with $D_{50}=0.75$ mm (coarse sand). The colour bar shows the depth change in m. (a) Base Run. (b) Future Development Model. (c) Differences between the base run and the future development model.

The bed level changes in the vicinity of the port developments over the duration of the simulation, with the imposition of a uniform grain size of $D_{50} = 0.375$ mm (medium sand), are shown in Figure 4. The results show the adjustment of the bathymetry after 290 days produced by the flow patterns before and after development. While the Base Run model shows some small areas with changes (e.g. at x-y coordinates 19.8, 6.9 close to the Harbour Bridge), overall

changes are minimal. Some regions of the channel are covered with shell lag (Boulay, 2012) and these areas are not represented in the model due to use of a constant grain size.

However, it is the differences between the two models which is critical to discerning the effects of the proposed port developments. These differences are shown in panel (4c). Differences between the two runs are minimal with the exception of a small band (<20 m wide) of accretion at the southern edge of the dredged channels (red-yellow band in panel 4a and red band in panel 4b). These changes represent a narrow region of smoothing out of the abrupt change in bathymetry at the end of the dredged region, and are consistent with the observed changes following previous capital dredging of Stella Passage (*viz.* Boulay, 2012).

The corresponding results for a uniform median grain size of $D_{50} = 0.75$ mm (coarse sand) are shown in Figure 5 and show the same pattern. However, the magnitude of the bed level change is around 40 % smaller, consistent with larger grain size requiring higher bed stresses to be mobilised.

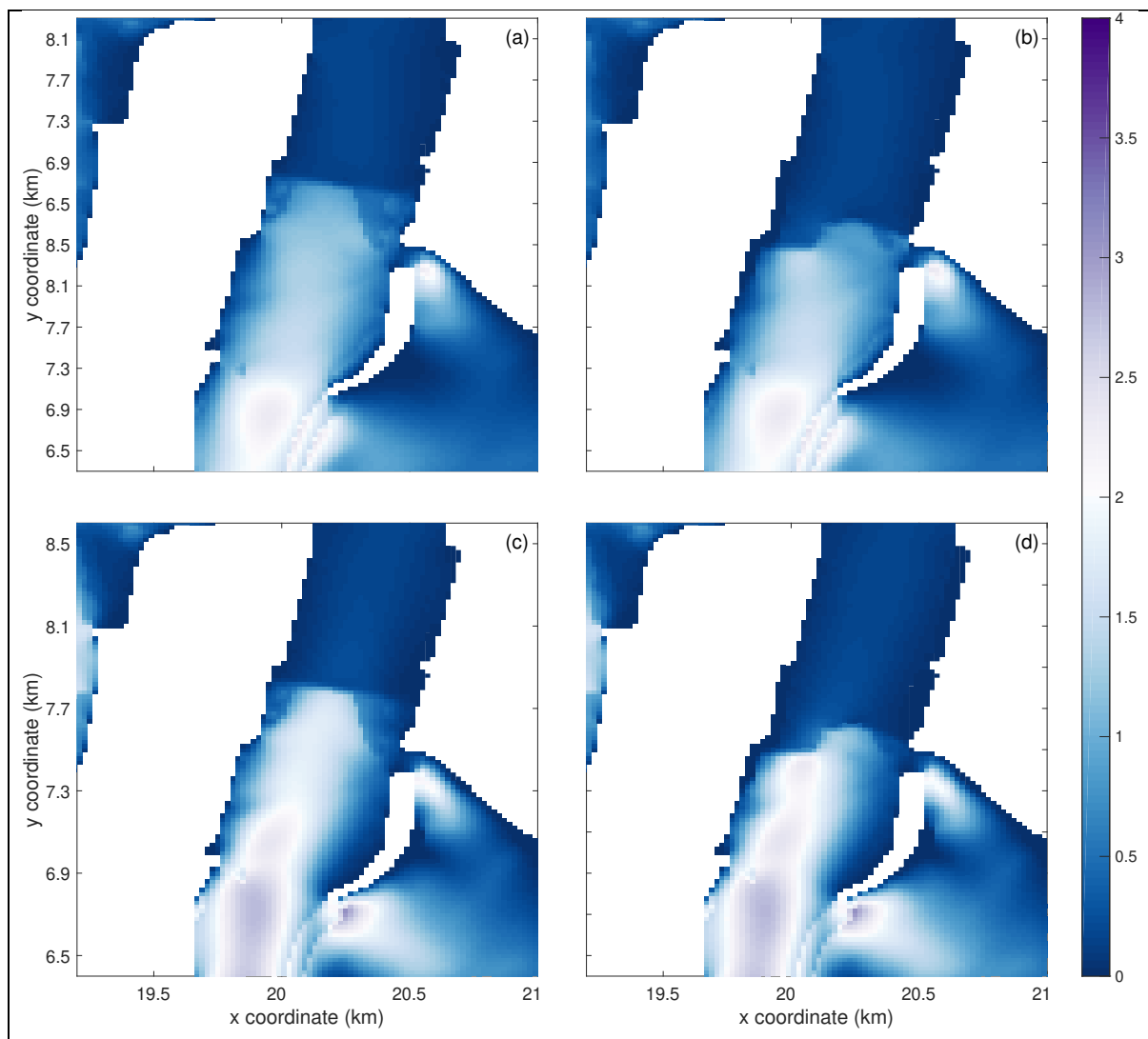


Figure 6: Magnitude of bed shear stress ($N.m^{-2}$) in the area of proposed port developments for the runs with $D_{50}=0.375$ mm (medium sand). Results from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.

Bed shear stresses during peak flood and ebb tides are shown in Figure 6 for the two sets of scenarios. As anticipated, based on the predicted changes in the flow speeds, changes in bed

shear stress are minimal. In both simulations the bed shear stresses are significantly lower in the dredged channel than in the shallow region to the south, particularly north of the Bridge Marina. The maximum values in Stella Passage are around 2.9 Nm^{-2} in both simulations, and these maximums occur about 750 m south of the end of the dredged channel.

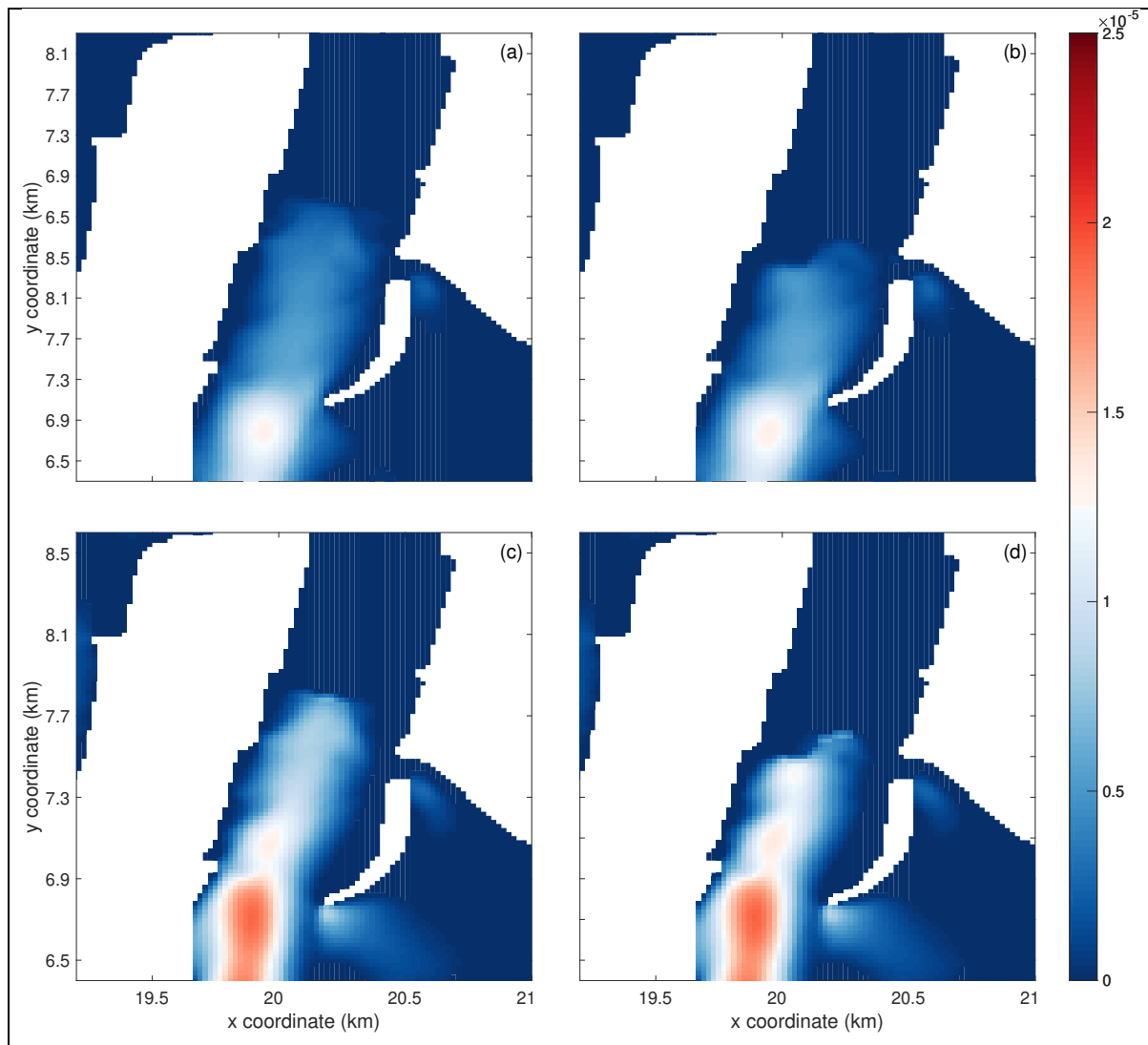


Figure 7: Magnitude of bed load transport ($\text{m}^3 \cdot \text{s}^{-1} \cdot \text{m}^{-1}$) in the area of proposed port developments for the simulations with $D_{50}=0.375 \text{ mm}$ (medium sand). Results presented are from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide, and, therefore, represent maximum transport rates. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.

In the Future Development Model, the sea floor immediately south of the end of the dredged region is subjected to a slightly larger bed shear stress. However, this change is confined to around 500 m from the end of the channel. Such an increase change in bed shear stress is anticipated based on the slight increase (0.05 to 0.1 m/s) in flow speeds in this area (Figure 16, Mullarney and de Lange, 2018). Therefore, in the immediate region of the extensions to the dredged channel, sediment transport is reduced to close to zero, while in the region south of the dredged channel, there is a corresponding localised and slight increase in bed load and depth-averaged suspended sediment loads (Figures 7 and 8, respectively).

Bed stress and both bedload and suspended sediment transport rates increase either side of the harbour bridge in the Base Run. This change is in response to flow acceleration induced by the constriction of the causeway (further constrictions result from the bridge piers, but these were

not included in the model). The effect of the proposed development of the flows close the harbour bridge is negligible, which is evident in Figures 6, 7 and 8. Hence, although the bridge piers were not specifically modelled, it is very unlikely that the proposed development will have any detectable impact on scour around the piers.

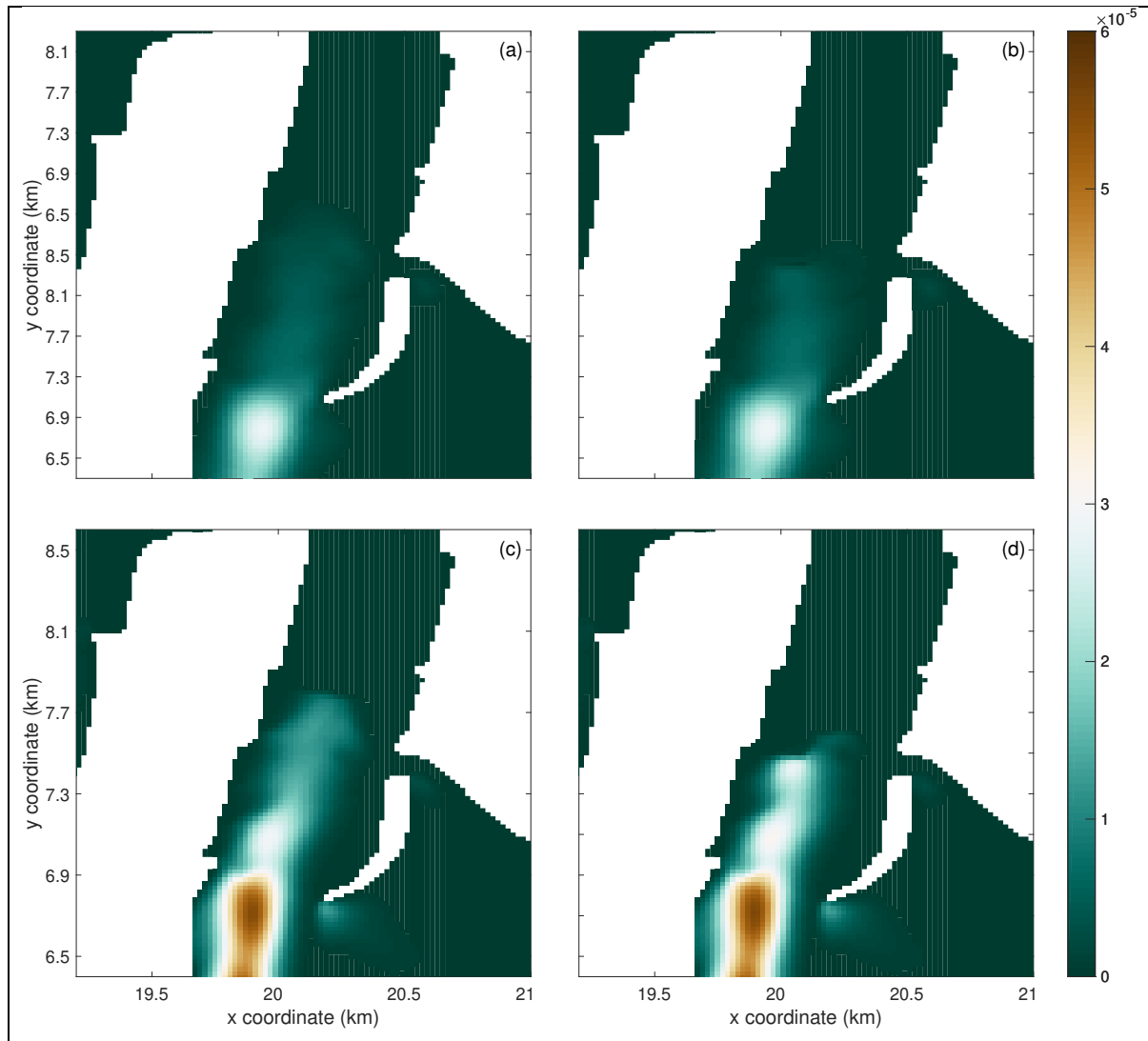


Figure 8: Magnitude of depth-averaged suspended sediment load transport ($\text{m}^3 \cdot \text{s}^{-1} \cdot \text{m}^{-1}$) in the area of proposed port developments for the runs with $D_{50}=0.375$ mm. Results presented are from times closest to peak flood tide (a and b) and peak ebb tide (panels c and d) for a spring tide, and, therefore, represent maximum transport rates. The left-hand column (a and c) shows the Base Run and the right-hand column (b and d) shows results from the Future Development Model.

Similarly the bridge and channel at the northern end of the causeway are associated with accelerated flows between Whareroa Point and Whareroa Marae. These result in increased bed stress within the channel upstream of the bridge (to the east of the causeway) as evident from the Base Run during flood and ebb tide (Figure 6a & c). There is also a zone of increased bed stress at the southern end of the causeway associated with the other tidal channel draining Waipu Bay. The higher bed stress results in increased sediment transport at either end of the causeway relative to the rest of Waipu Bay, with a tendency to transport sediment into Waipu Bay (which is dependent on the availability of sediment). Modelling did not show any change to this behaviour as a consequence of the proposed development.

Due to the shallow depths within Waipu Bay, sediment transport patterns are likely to be modified by locally generated waves. The proposed development is not likely to alter wave generating

conditions within Waipu Bay, and, therefore, waves were not included in this modelling. McKenzie (2014) did investigate the effect of waves in Waipu Bay, and concluded that they rarely were capable of transporting sediment. He indicated that in combination with tidal currents, waves contributed to movement of sediment from the northern shoreline of Waipu Bay into the channel connecting to Stella Passage. This process will continue after the proposed development with no likely changes in rate or extent.

For the simulations with the larger grain size (coarse sand), the sediment transport patterns remain very similar. However, the total transport rate is approximately halved, and a greater portion is transported as bed load rather than suspended load. These results are not shown.

Conclusions

Comparisons between Base Run and Future Development Model simulations predict that changes in sediment transport due to development are minimal and highly localised. The simulations represent a worst-case situation as they have focussed on the most mobile medium sand component of the sediment, and do not account for reduced sediment availability due to shell lags within shallow areas of the Stella Passage.

The impacts predicted in the immediate vicinity of Stella Passage and Waipu Bay are unchanged from the earlier modelling undertaken by McKenzie (2014) to assess the impacts of breakwater construction at Bridge Marina, and Watson (2016) to assess the impacts of wharf extensions. Further up harbour from Stella Passage, impacts on sediment transport are negligible and any observed variations are most likely in response to local factors; as previously found for the Railway Bridge and Southern Pipeline Crossing (Black et al., 2007), and Waimapu Estuary, and Rangataua and Welcome Bays (Watson, 2016).

References

- Black, K., Mathew, J., & Borrero, J., 2007. *Southern Pipeline. Estuarine and Hydrodynamic Physical Process Assessments (Report 72)*. Raglan, New Zealand: ASR Ltd.
- Boulay, S.O.C., 2012. *Analysis of multibeam sonar data for benthic habitat characterization of the port of Tauranga, New Zealand*. M.Sc. thesis, University of Waikato, Hamilton, New Zealand. 200 pp.
- Deltares (2017). *Delft3D-FLOW User Manual*, version 3.15.49946. Deltares.
- Hancock, N., Hume, T., & Swales, A., 2009. *Tauranga Harbour Sediment Study: Harbour bed sediments*, NIWA Client Report: HAM2008-123. Hamilton, New Zealand: NIWA.
- McKenzie, J. S., 2014. *Predicted hydrodynamic and sediment transport impacts of breakwater construction in Tauranga Harbour*, New Zealand. M.Sc. thesis, University of Waikato, Hamilton, New Zealand. 281 pp.
- Mullarney, J.C & de Lange, W., 2018. *Hydrodynamic modelling of proposed expansion of the Port of Tauranga shipping channels and wharves*. Environmental Research Institute Report No 119. Client report prepared for Port of Tauranga. Environmental Research Institute, Faculty of Science and Engineering, The University of Waikato, Hamilton. 30 pp.

- Park, S., 2003. *Marine Sediment and Contaminants Survey (2001-03) of Tauranga Harbour*, Environmental publication 2003/20. Whakatane, New Zealand: Environment Bay of Plenty.
- Roelvink, J.A. & Reniers, A.J.H.M, 2011. *A Guide to Modeling Coastal Morphology*, World Scientific: Singapore. 274 pp.
- Sneddon, R., & Clark, K., 2007. Benthic Ecological Survey for the Proposed Tauranga Southern Pipeline. Cawthron Report No. 1259. Nelson, New Zealand: Cawthron.
- Watson, H.M., 2016. *Potential impacts of wharf extensions on the hydrodynamics of Stella Passage and upstream regions of Tauranga Harbour, New Zealand*. M.Sc. thesis, University of Waikato, Hamilton, New Zealand. 193 pp.