Review of coastal process impacts of proposed Tuahine Crescent Seawall

2 June 2020

Competency

My full name is Willem Pieter de Lange, and I am a Senior Lecturer in the School of Science, Division of Health, Engineering, Computing and Science, University of Waikato. I hold the following qualifications from the University of Waikato:

- BSc (1981) in Computer Science and Earth Sciences;
- MSc (Hons) (1983) with first class honours in Computer Science and Earth Sciences;
- DPhil (1989) with a thesis on wave-induced sediment transport.

My training was in Earth and Ocean Sciences, particularly in sedimentology and coastal processes, and Computer Science, particularly numerical modelling, data analysis and visualisation. My MSc thesis examined tsunami hazard in the Bay of Plenty, and involved numerical modelling of tsunami generation, propagation and impacts along the coastline and within Tauranga Harbour. My DPhil thesis dealt specifically with the behaviour of dredge spoil used to renourish Pilot Bay Beach, Mt Maunganui, but also compared the performance of the two numerical models (2DD and DHI System 21). My DPhil also assessed the contribution of wave-induced sediment transport, particularly over the flood tidal delta (Centre Bank) and intertidal flats, to the total sediment transport within the Harbour.

I am a member of the Coasts, Oceans, Ports and Rivers Institute (COPRI) of the American Society of Civil Engineers (ASCE), the Coastal Education and Research Foundation (CERF), The Oceanographic Society (TOS), and the NZ Coastal Society and NZ Society for Earthquake Engineering technical groups of Engineering New Zealand.

Since 1984, mostly at the University of Waikato, I have undertaken research into fundamental coastal processes and management pertaining to New Zealand estuaries and the coast. My research has concentrated on the characterization and mitigation of coastal hazards, including tsunamis, storm surges, meteo-tsunamis, extreme waves, waterspouts, sea level variations, climate fluctuations, and coastal erosion. I have also participated in and reviewed various lifelines vulnerability assessments for major urban areas around New Zealand.

I have published more than 200 peer-reviewed scholarly publications including 110 journal papers and book chapters, and 107 conference papers. I have also supervised more than 150 graduate and postgraduate student theses to completion including 30 PhD projects. My teaching has been focused on coastal geomorphology, processes, engineering and management. Until the establishment of a BE Civil degree at the University of Waikato, the engineering component has not included the design of structures; instead dealing with constraining design parameters and impact assessment.

Review

4Sight Consulting have prepared an application on behalf of Simon Cave and Annabel Reynolds for the replacement of a portion of an existing seawall fronting 4, 6 and 8 Tuahine Crescent, Wainui Beach. A larger replacement structure was included in a series of proposed works in 2016-2017 (Gisborne District Council references LU-2017-107788-00, LL-2017-107789-00, CC-2017-07790-00, CO-2017-107791-00), which I provided evidence on coastal process impacts for the consent hearing in February 2017.

The proposed seawall in this application has been redesigned based on the outcome of the 2017 consent hearing, with the structure being smaller than the options I previously considered. As was raised in the consent hearing, the main impacts on coastal processes in the affected coast in front of 4 to 8 Tuahine Crescent are due to:

- The concrete groin located close to the boundary between 6 and 8 Tuahine Crescent (Figure 1); and
- An offshore reef between the beach access (located between 2 and 4 Tuahine Crescent) and Tuahine Point (Figure 1).

Figure 1 – Google Earth image of Tuahine Crescent showing the pattern of incident and reflected waves interacting with the bathymetry and shoreline structures. The existing concrete groyne is labelled, and a rock revetment seawall is present along the length of the shoreline shown. A rocky reef occurs south of the reef edge marked on the image, with sand dominating north of the line. The boundary appears to be a fault, with the southern side upthrown relative to the north.

The pattern of incident and reflected swell wave crests near mid-tide is evident in Figure 1. The waves approaching the site for the wave approach direction (SE) are strongly refracted by the submerged rocky reef producing steep peaked crests. There are waves reflected by reefs further south travelling northward almost perpendicular to the incident waves. Between the groyne and the beach access the wave pattern is chaotic, reflecting increased turbulence as waves reflected by the groyne and shoreline collide with incident waves. In this area, the waves are being reflected from the toe of the existing seawall. Under these conditions sand is eroded, which is evidenced by the absence of a subaerial sandy beach at this location. For waves approaching from a more easterly to north-easterly direction longshore transport replaces the sand and the beach accretes.

The pattern in Figure 1 and discussed above corresponds to the situation illustrated in Figure 7 in Appendix H of the application (reproduced below as Figure 2). The effective and affected lengths determined by 4Sight are comparable to the patterns of disturbed water between the groyne and the beach access, and therefore, in my opinion, are realistic and reasonable. It is also evident that due to refraction, diffraction and reflection, the groyne shadow illustrated has little impact on wave action. This does not materially affect the interpretation of the impact of the proposed seawall.

The larger seawall proposed in 2017 would have extended further offshore, encroaching on the CMA and increasing the reflection of wave energy over a wider range of conditions. The proposed seawall in this application appears to extend to the seaward row of iron rails of the existing seawall. Hence, it should have the same impact on coastal processes as the existing seawall (as illustrated in Figure 1). Arguably, a smaller structure located further inland would reduce the existing impact. However, in my opinion, due to the influence of the groyne and reef, it is likely that the shoreline would adjust landward to the toe of the seawall, cancelling the benefits of moving the seawall landward.

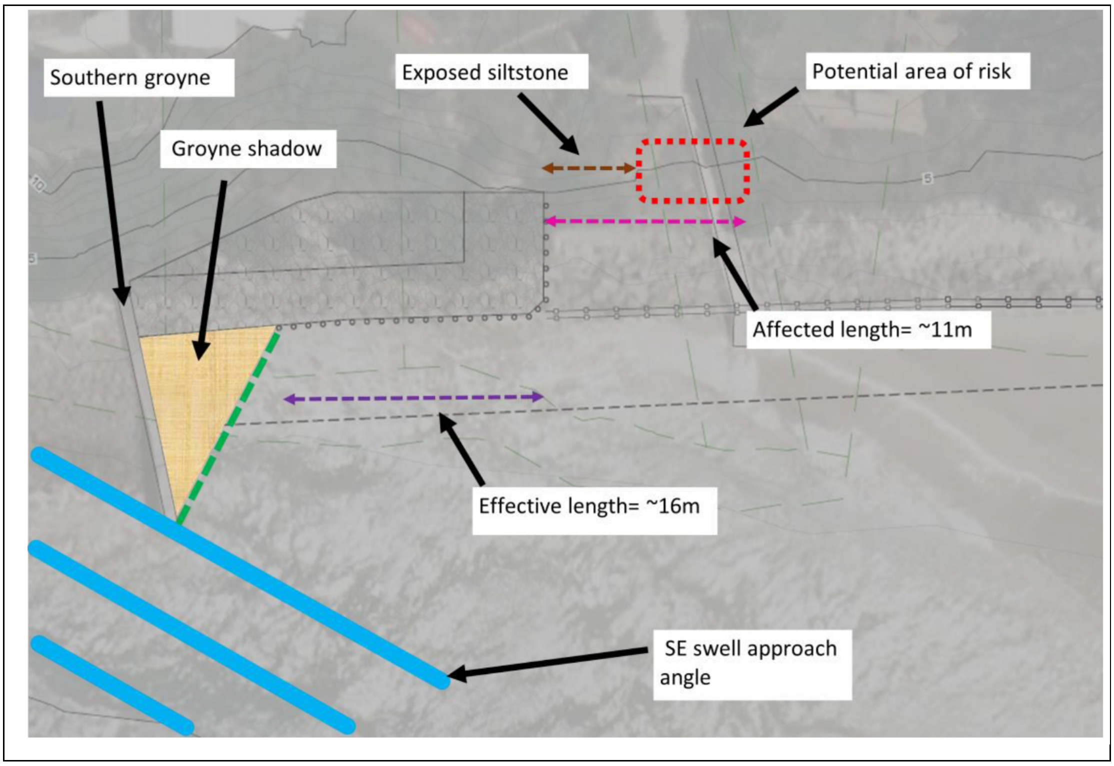

Figure 2 – Copy of Figure 7 from Appendix H: 4Sight Coastal Processes memo. Comparison with Figure 1 herein indicates that the calculated effective and affected lengths are realistic and reasonable.

The dimensions of the seawall are primarily determined by the crest height, which is based on expected maximum sea level, storm surge and wave setup. It is considered that planting of the slope above the seawall with salt tolerant coastal vegetation will provide sufficient protection from episodic storm wave runup. In my opinion, this is a reasonable assumption.

Storm surge and wave setup are driven primarily by atmospheric pressure and wind stress, with a minor effect from bathymetry through changes in phase velocity with changing water depth. Ministry for the Environment (2018) summarise projected impacts of climate change on weather out to AD 2120. The largest impacts for Poverty Bay are associated with the exceptionally unlike RCP8.5 scenario, but these are negligible to minor; involving a slight increase in the seasonal variation of mean sea level pressure and the frequency of extreme winds. The magnitude of these increases was not specified in their report.

Hence, in my opinion, it is reasonable to use the present day 1%AEP storm surge and wave setup values as indicative of the AD 2120 conditions. Table 2 in Appendix H of the application indicates that the storm tide (Storm surge + maximum tidal elevation) was derived from Stephens *et al* (2014). An offset of 0.208 m appears to have been added to the values in Table F-1 to adjust them to the GVD-26 datum, followed by rounding to 2 significant figures.

Wave setup is a function of beach slope and Stephens *et al* (2014) note that they didn't use actual beach slope data for their calculations for Wainui Beach; instead using fixed slopes of 1:15. Figure 1 above suggests this is not a reasonable value for the site. However, a fixed value of 0.9 m determined by Tonkin and Taylor Ltd has been used instead of the calculated values in Stephens *et al* (2014). The wave setup also scales with offshore wave height, so there should be different values for each of the wave heights listed in Table 1 of Appendix H, unless the 100 y significant wave height is the only value being considered in combination with the 1%AEP storm tide and 0.9 corresponds to that wave height?

With no climate change related adjustments to storm surge and wave conditions, the only allowance for climate change is the projected sea level in a century, which is taken as 1 m. This corresponds to a Category C development in Table 12 of Ministry of Environment (2017), which defines transitional minimum national SLR allowances up to AD 2120. This is intended for planning purposes involving habitable existing coastal developments and assets. In my opinion, Category D (Non-habitable short-lived assets with a functional need to be at the coast, and either low-consequences or readily adaptable) is more appropriate for a replacement seawall. The application indicates that the structure has low consequence and is intended to be readily adaptable. In my opinion, it is also short-lived relative to the minimum of century-scale climate change assessment and non-habitable.

The Category D recommended transitional sea level value is 0.65 m, which aligns with the extended RCP4.5 scenario out to AD 2120. In my opinion, RCP4.5 or RCP6.0 are more realistic projections than the exceptionally unlikely RCP8.5 scenario that is the basis of the 1 m Category C minimum transitional value. The national transitional values also do not consider site specific vertical land movement, which can increase or reduce the projected sea level by AD 2120.

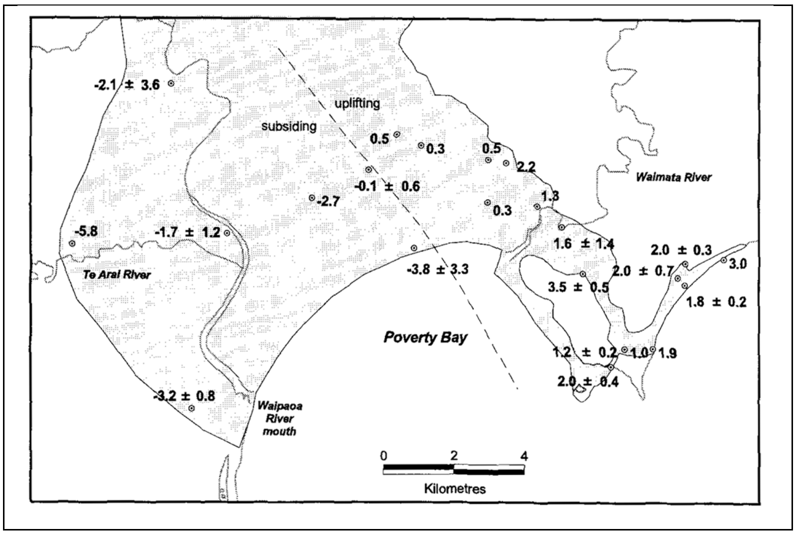

Figure 3 – Uplift (+) and subsidence (-) rates for the Poverty Bay flats. Where multiple estimates were available, they were averaged and the mean and standard deviation are shown. (Figure 2, Berryman *et al*, 2000)

Berryman *et al* (2000) assessed the effects of tectonics and climate on the formation of terraces within the Waipaoa River catchment. They identified broad regional uplift of 0.5-1.1 $\mathrm{mm.y^{-1}}$. However, there was a clear change in behaviour between northern and southern Poverty Bay (Figure 3). The north-eastern Poverty Bay flats were found to be uplifting, while the south-western flats were subsiding. Their analysis also showed that Wainui Beach near Tuahine Crescent has been rising at an average rate of 1.9 $\mathrm{mm.y^{-1}}$, with the rate increasing to 3 $\mathrm{mm.y^{-1}}$ towards Makorori. The rates of coastal deformation are of comparable magnitude to the 20th Century global rate of sea level rise (1-2 $\mathrm{mm.y^{-1}}$).

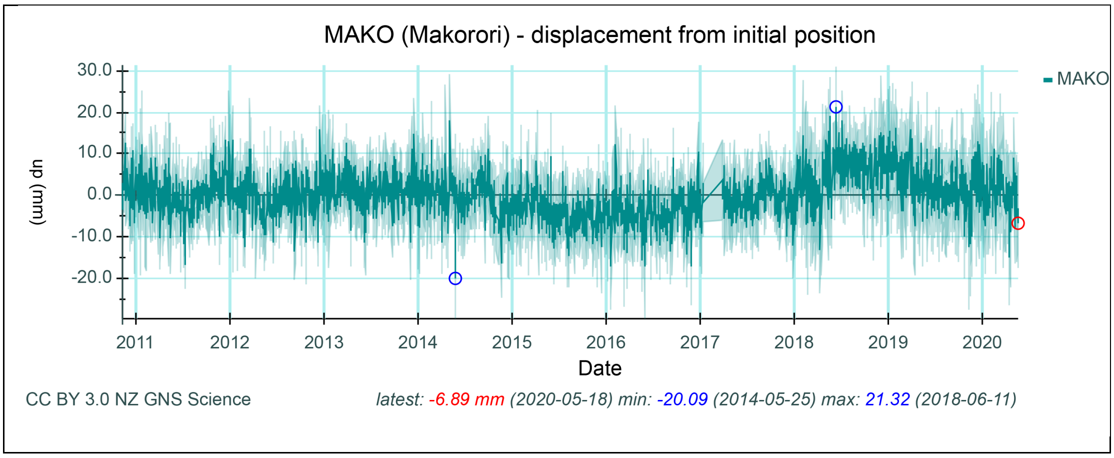

Figure 4 – Continuous GPS record for site MAKO at Makorori. The latest, minimum, and maximum values are labelled with coloured circles, and their corresponding values listed below the plot.

A more recent analysis based on continuous GPS measurements of earth deformation confirmed the change from subsidence to uplift heading northwards along the Poverty Bay coastline (Beavan

& Litchfield, 2012). This study attributed 0.32 $mm.y^{-1}$ of regional uplift to the glacio-isostatic adjustment (GIA) following deglaciation after the Last Glacial Maximum (LGM). The remainder of the deformation was attributed to tectonic processes. Their analysis only considered the GISB continuous GPS site located on the Poverty Bay flats to the west of the hinge (subsiding at 2.1 ± 3.6 $mm.y^{-1}$), and the PUKE site at Puketiti near Tokomaru Bay (rising). No assessment was undertaken for the MAKO site at Makorori (Figure 4).

The continuous GPS record is still quite short, and while it shows ongoing uplift, there are significant fluctuations over short time scales (Figure 4). In my opinion, the measurements to date indicate that the uplift reported by Berryman et al (2000) is likely to continue for the next century, and it would be reasonable to deduct the vertical land movement from the projected sea level. Alternatively, the vertical land movement at Tuahine Crescent provides additional justification for the use of the Category D transitional sea level of 0.65 m, instead of the Category C value of 1 m.

The effect of using a lower sea level value for AD 2120 would be to allow the maximum crest height to be reduced, which will reduce the footprint, volume of additional rock material required, and the visual impact relative to the present structure. As discussed briefly above, this is unlikely to material affect the impact of the structure on coastal processes, particularly if the toe remains at the location proposed.

Summary

In conclusion, in my opinion, the proposed replacement seawall is likely to have the same effect on coastal processes as the existing structure, which is minimal. There is scope to reduce the size of the proposed replacement seawall, if it is treated as a Category D development following the Ministry for the Environment (2017) guidance.

References

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