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EROSION HAZARD ASSESSMENT: 37 BEACH ROAD, WAI-ITI, TARANAKI

1.0 Introduction

The following report was requested by the Taylors (the Client) in early September 2018 to accompany their resource consent application for building modifications to 37 Beach Road, Wai-iti (Figure 1). This followed New Plymouth District Council (NPDC) concern that part of the proposed modifications would lie within the Current Erosion Risk Zone as defined by T&T (2018)[1] and incorporated in the Proposed District Plan (Figure 1). However, the T&T assessment was a conservatively-based district-wide study designed to "red-flag" areas potentially at risk of erosion. Proposed developments within such "high risk areas" then require detailed site-specific assessments to more accurately define the spatial extent of the current and future local erosion hazard, and if need be prepare an adaptation pathway for managing future risk.

The terms of reference for this assessment are as follows:

1. A cliff stability analysis be carried out based on a site survey;
2. Determine the long-term erosion rate utilizing historical survey plans and aerial photographs;
3. Estimate the erosive effect from predicted sea-level rise;
4. Carry out erosion hazard modelling using information from 1,2 and 3 above;
5. If necessary, prepare an adaptive management programme to mitigate any future erosion threat, and
6. The investigation follows guidance and directives contained in NZCPS (2010)[2], DOC (2017)[3], and MFE (2017)[4].

This assessment has been peer reviewed by Mr Patrick Knook, Coastal Engineer, Tonkin and Taylor on behalf of the council. The review thread is available upon request.

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1. T&T (2018). First Pass Coastal Erosion Assessment and Identification of High Risk Areas. A report prepared by Tonkin and Taylor Ltd for the New Plymouth District Council. 43 p plus Appendices
2. NZCPS (2010). New Zealand Coastal Policy Statement. Department of Conservation. 28p.
3. DOC (2017). A guide to implementing the New Zealand Coastal Policy Statement 2010: Policies 24, 25, 26 & 27. Prepared by the Department of Conservation. 99p.
4. MFE (2017). Coastal Hazards and Climate Change: Guidance for Local Government. Prepared for the Ministry for the Environment. 279 p.

A site visit was carried out by the author on 21 September 2018; this included observation and sampling of the geology and geomorphology, profile surveys and ground and aerial (drone) photography.

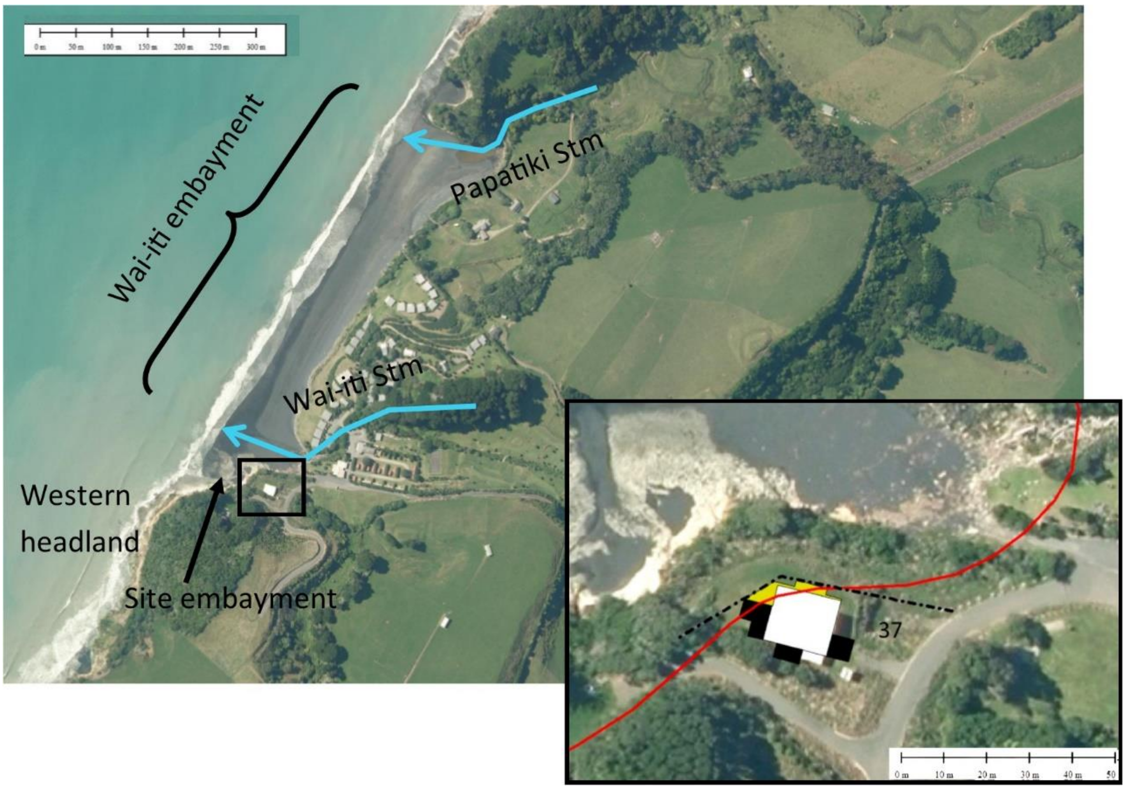

Figure 1 *Wai-iti Beach features and site (inserted) where the existing building is shown white, proposed modifications in black with proposed deck in yellow. The seaward property boundary is depicted by the black dash-dotted line, while the red line defines the current Area Susceptible to Coastal Erosion (ASCE) as defined in T&T (2018).*
. *2012 aerial photo supplied by LINZ*

2.0 Background

Wai-iti embayment is situated between two headlands with streams entering the sea adjacent to each. The sandy inter-tidal beach is approximately 550 m long and up to 100 m wide. A smaller embayment lies between the western headland and the Wai-iti Stream, and as this feature fronts the Taylor property it will be referred to as the "site embayment" (see Figure 1). The western headland is ~30 m high and is fronted by an inter-tidal platform about 20 m wide (Figure 2A) which increases in with in front of the site embayment. The site embayment is backed by an active cliff with the Taylor property being about 10.5 m above MSL and relatively flat (Figure 2B). The building is set back some 20 m from the clifftop. Note that while the inter-tidal platform within the site embayment appears to be more fragmented in Figure 2B (taken during the site visit); the in the 2012 aerial photo (Figure 1 insert) indicating the beach has a more abundant sand supply at present.

The southern headland is composed of siltstone (papa) beds of the Urenui Formation (grey in Figure 2A)) which dip seaward and eastward at approximately 3 degrees. The upper (horizontal) surface comprises an ancient marine platform cut by wave processes. This platform is topped by "coverbeds" (yellow-brown in Figure 2A) composed of sand, peat and tephra (ash) amongst other materials. At the base of the cliff the siltstone formation includes particularly resistant "concretionary beds", remnants of which form the fronting platform.

Much of the Taylor property is directly underlain by about 7 m of ash-dominated tephra (yellow/brown in Figure 2B) which is more susceptible to wave attack than the papa. However, the ash deposit is itself underlain by the concretionary siltstone bed (grey in Figure 2B) which is about 1 to 1.5 m above the current beach sand level and appears to provide wave protection. The ash is capped by about 0.5 m of soil bound by a dense root system from well-established vegetation. As can be seen in Figure 2B, the ash deposit pincers out such that the western portion of the Taylor property is underlain entirely by siltstone.

Aspects of these physical characteristics are elaborated upon/quantified in the following sections.

3.0 Hazard assessment components

The erosion hazard assessment process involves computing three components: (1) the slope stability adjustment, (2) long-term historical shoreline retreat, and (3) erosion from projected future sea-level rise. These components are discussed further below and are combined as follows to generate current and future hazard areas.

$$ASCE\ current = SS \qquad eq\ 1$$

$$ASCE\ future = LT + RSLR \qquad eq\ 2$$

Where:
ASCE = Area Susceptible to Coastal Erosion
SS = Slope stability adjustment
LT = long-term shoreline retreat
RSLR= retreat caused by sea-level rise

LT and RSLR are time-dependent and computed by multiplying the time period of interest (in years) by the annual rate of change for each parameter.

While the present assessment utilizes component values relevant to the Wai-iti site, the underlying methods used to determine those values will be the same as used in the more general T&T (2018) assessment. Points of difference between the present assessment and the T&T (2018) assessment lie in the use of some mid-range values rather than exclusive use of high-end of worst-case component values. The reason being that the proposed development is for minor modifications where *adaptation* is feasible so a likely level of erosion hazard risk is appropriate (NZCPS 2010, Policy 27). By contrast, for new developments/subdivisions where scale means adaptation is more difficult, hazard *avoidance* is a requirement of the official guidance (NZCPS 2010. Policy 25) so a lower likelihood of occurrence is used when determining the erosion hazard.

Figure 2   *Southern headland is depicted in photo A and the "site-embayment" fronting the Taylor property in photo B which also shows survey transects (red line) and the vegetated bank used to determine the stable slope angle for volcanic ash is marked by the white line   (Photos taken on 2-9-2018)*

1. Slope stability adjustment

After a section of cliff collapses following wave erosion at the base, the typically over-steepened scarp subsequently reduces in slope until a stable angle (of repose) is achieved, i.e. the cliff edge retreats landward.

Stable angles for papa have been identified as ranging between 55 and 65 degrees in T&T's 2013 erosion hazard assessment for Onaero. A vegetated (hence stable) section of siltstone cliff at the site was measured at 55 degrees during the site visit. A mid-range value of 60 degrees was selected for siltstone and 50 degrees for a higher end value.

No previously used value is available for the angle of repose for tephra ash. Slope measurements along the vegetated eastern margin of the Taylor property (white line in Figure 2B) were found to range between 55 and 66 degrees. As noted earlier, the cliff is capped by a soil layer and it appears that the high stability angle of the ash is linked to the root-bound soil protecting against water and weathering; and base protection of the tephra-ash against wave action is afforded by the siltstone/conglomerate footing. For tephra-ash, a high-end value of 40 degrees will be used in the present analysis, this being the value used in the T&T 2018 assessment for composite cliff faces. And a mid-range value of 50 degrees will be used, this being midway between the observed site values and the T&T composite value.

Computation of the slope stability adjustment (SS) is given by equation 3

$$SS = [hc/\tan\alpha] \qquad (eq\ 3)$$

Where:
hc = height of cliff (m)
α = stable angle of repose (degrees)

Cliff height fronting the Taylor property was obtained from two profiles surveyed during the site visit (transect locations shown in Figure 2B), with the resulting profiles shown in Figure 3. The survey was carried out using a Nikon lazer rangefinder which output both vertical and horizontal distances. The transect locations were selected to represent tephra-ash (Profile A) and siltstone-papa (Profile B).

Cliff height was measured from where the face joints the conglomerate platform. For the eastern (tephra-ash) profile the height is 7.05 m and the cliff-top surface is uniform right across to the property boundary. Cliff height for the western (siltstone-papa) profile is 8.55 m which reduces to 6.75 m closer to the structure (see Figure 3).

2 Historical shoreline change

The North Taranaki Coast is an erosional coast and the underlying trend is defined using historical data: survey plans and aerial/satellite images. For the Taylor site, survey plans were available form 1866, 1918, while vertical aerial photos from 1943, 1967, 1984, 1995 along with a range of aerial and satellite images thereafter.

LINZ were not able to locate the field book for the 1866 plan so it is not known if the shoreline (cliff top) had been measured by offsets or estimated. The plan was georeferenced but the shoreline was not consistent with the later reliable shorelines so this survey was discarded.

The 1918 plan was detailed and could be verified using by the original field book. The plan was and accurately georeferenced against LINZ spatial data and had a measured offset at the site. The eastern transect was located to correspond with the offset.

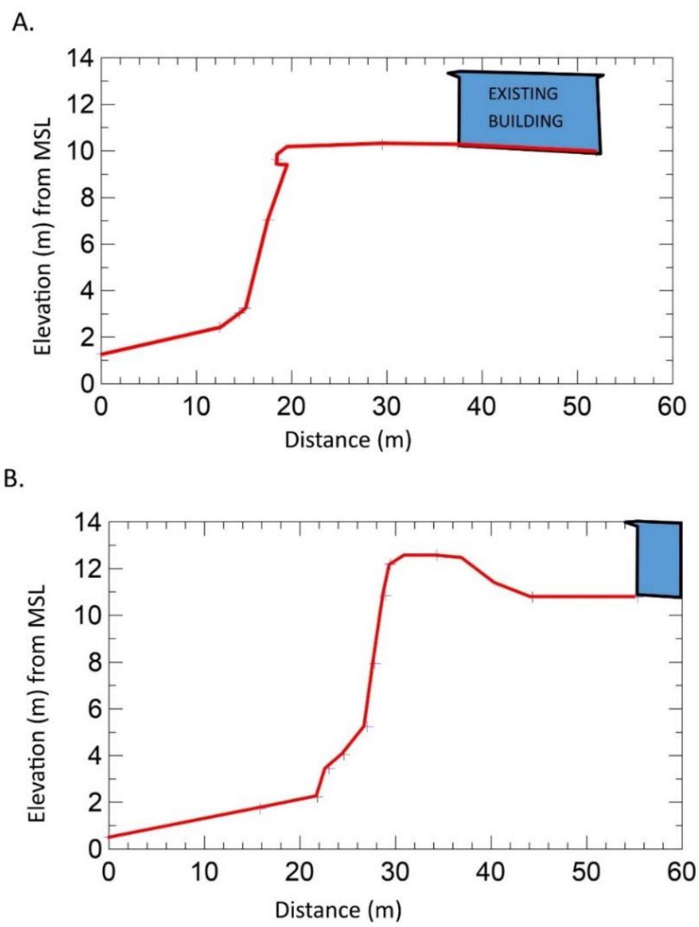

Figure 3 *Profiles for the eastern transect (A) composed primarily of volcanic ash, and the western transect (B) composed primarily of siltstone..*

The 1943 vertical aerial photography (1:16,000), were georeferenced to within one metre and stereo analysis helped to accurately identify ground features. The 1967, 1984 and 1995 aerials were too higher scale to be accurately georeferenced and features defined. The LINZ 2012 aerial imagery was already georeferenced and was suitable to detect some main features.

The 1918 survey plan, the 1943 aerial image, 2012 aerial imagery and the 2018 CSL surveyed profile data provide the most accurate information for analysis.

Vegetation (mainly tree) overhang was found to obscure the cliff-top fronting the site so the 1918 measurement (which aligned with the eastern transect) was used for the base measurement and this was compared with the measurement made during the September 2018 site survey. These two very accurate values indicated 0.6 m of erosion in 100 years - an average rate of change of only 0.006 m/yr. However, if the 0.9 m overhang facilitated by the soil/root capping was discounted then the rate increased to 0.015 m/yr.

Nonetheless, to further investigate the historical erosion rate, attention turned to the headland as this feature could indicate a potential maximum rate of erosion of landward features. Two types of measurement were made. Firstly, the 1918 survey had several measured offsets to locate the clifftop around the headland which coincided with an area on the 2012 aerial photos for which cliff-top vegetation was minimal. This lack of vegetation is illustrated in the headland photo of Figure 2A. The difference indicated 3 m of clifftop retreat over the intervening 94 years which gave an average rate of change of 0.032 m/y.

The second method compared the papa-coverbed boundary (again shown in Figure 2A) which showed up clearly in the 1943 and 2012 aerial images. Change over this 69 year period was 0.036 m/yr.

These results indicate the headland rate to be about twice the site embayment rate. A mid-range value of 0.025 m/yr and an upper value of 0.04 m/yr were chosen for application in the erosion hazard modelling..

3. Retreat from sea-level rise (RSLR)

Sea-level rise is expected to increase retreat rates of softer cliffed shorelines as more wave energy is able to reach the cliff base increasing hydraulic erosion and the removal of toe-protecting debris.

Projected sea-level rise (SLR) for New Zealand was recently published in MFE (2018) for four emission mitigation pathways or representative concentration pathways (RCP). The moderate mitigation pathway (RCP 4.5) is considered appropriate for the Wai-iti erosion assessment and the MFE (2018) guidance values are 0.36 m to 2070 and 0.67 m to 2120. However, for use in coastal erosion hazard assessments, these values require discounting to account for the 1986-2005 baseline that MFE use (0.07 m), and also to account for historical SLR (1.7 mm/y), the effect of which has already been incorporated into the historical shoreline change value. The final SLR values used in the present assessment are thus 0.21 m to 2070 (average 0.0042 m/yr) and 0.43 m to 2120 (average 0.0043 m/yr).

Recession rates of sea cliffs are controlled by the geological composition of the cliffs and the configuration of the fronting beach as well as other lesser influences. The computation method currently used for predicting cliff erosion from SLR is expressed by equation 4.

$$R_2 = R_1\left(\frac{S_2}{S_1}\right)^m \qquad \text{(eq 4)}$$

Where:
R_2 is the future rate of retreat (incorporating Lt and RSLR), R_1 is the current rate of retreat, S_2 is the future rate of sea-level rise, S_1 is the past rate of sea level rise, and m is a feedback coefficient determined by the response system.

So RSLR itself is expressed by equation 5

$$RSLR = (R_2 * T) - LT \qquad \text{(eq 5)}$$

Where:
T is the prediction period in years

In the T&T 2018 districtwide assessment, a negative feedback of m=0.25 was used for para cliffs. However, for the Taylor site the occurrence of tephra-ash some 1 m above the present sand intersection, means SLR could have an increasing impact over time. The T&T assessment used m=0.5 for softer laha cliffs and this more conservative value will be applied for the Taylor site.

4. Erosion hazard distances

Hazard distances for three temporal scenarios (current, 50 yr and 100 yr) and two likelihood of exceedance scenarios (an average ~50%, and a low ~5 %) have been modelled using equations 1 and 2 for different component values. In particular, the 50% scenario uses mid-range values for all parameters, while the lower probability combination uses upper range values for SS and LT and a mid-range value S_2 in equation 4. However, it is noted that use of R_1 = 0.04 m/yr and m = 0.5 in equation 4 are conservative so the resulting RSLR value has a lower likelihood of occurrence than the mid-range value in the 50% scenario even though a higher-level (RCP 8.5) SLR scenario was not applied.

The computed hazard distances for the different scenarios as computed for the eastern (tephra/ash) and the western (papa/siltstone) transects are listed in Table 1. All distances are related to the cliff base on each transect (eastern datum point = 1727652.145 5690521.232 NZTM, western datum point = 1727639.821 5690509.038 NZTM). The property boundary is also marked in Figure 4 - this coincides with the seaward limit of the proposed modified dwelling as shown in Figure 1 inset.

The mid-range (50% exceedance) 100 year results show the hazard line to be 12.4 m (east profile) to 7.6 m (west profile) short of the property boundary as illustrated in Figure 4. The lower probability (~10%) 100 year prediction results are 7.6 m seaward of the property boundary on the eastern profile and 4.5 m seaward on the western profile.

Table 1 Erosion Hazard Distances (metres) for average (~50% exceedence likelihood) and extreme (~5% exceedence likelihood) scenarios

Average	Current		50 years		100 years	
	East	West	East	West	East	West
Slope Stability (mid-range)	5.91	4.93	5.91	4.93	5.91	4.93
long term (mid-range)	0	0	1.25	1.25	2.5	2.5
Retreat SLR (mid-range)	0	0	0.75	0.75	1.5	1.5
TOTAL	**5.91**	**4.93**	**7.91**	**6.93**	**9.91**	**8.93**
Extreme	Current		50 years		100 years	
	East	West	East	West	East	West
Slope Stability (upper value)	8.4	7.17	8.4	7.17	8.4	5.66
Long term (upper value)	0	0	2	2	4	4
Retreat SLR (mid-range)	0	0	1.14	1.14	2.36	2.36
TOTAL	**8.4**	**7.17**	**11.54**	**10.31**	**14.76**	**12.02**
Property boundary (Modified dwelling)	22.3	16.5	22.3	16.5	22.3	16.5

Distance datum is cliff-base for east (ash-tephra) and west (papa-siltstone) profiles
Property boundary is seaward limit of proposed dwelling modifications (Figure 1)

Finally, it is noted that the hazard lines have not been calculated and extended along the eastern side of the property (see Figure 4) as this side is not highly exposed to wave forcing so is not critical to this assessment in that there is enough land to survive until erosion on the seaward (northern) side reaches the building.

5.0 Conclusions

These results show the site will not present an erosion hazard to the proposed building under average to low probability of exceedance scenarios and over 50 and 100 year time frames. This contrasts with the potential erosion hazard red flagged in the recent T&T district wide/high-level hazard assessment due to a lower (measured) cliff height and unique geology which is more resistant to marine and cliff processes than occurs elsewhere on the North Taranaki Coast.

For the purposes of the present Taylor resource consent application for modifications to an existing building, the site is not considered to be erosion-prone and there is thus no requirement for an erosion adaptation management plan.

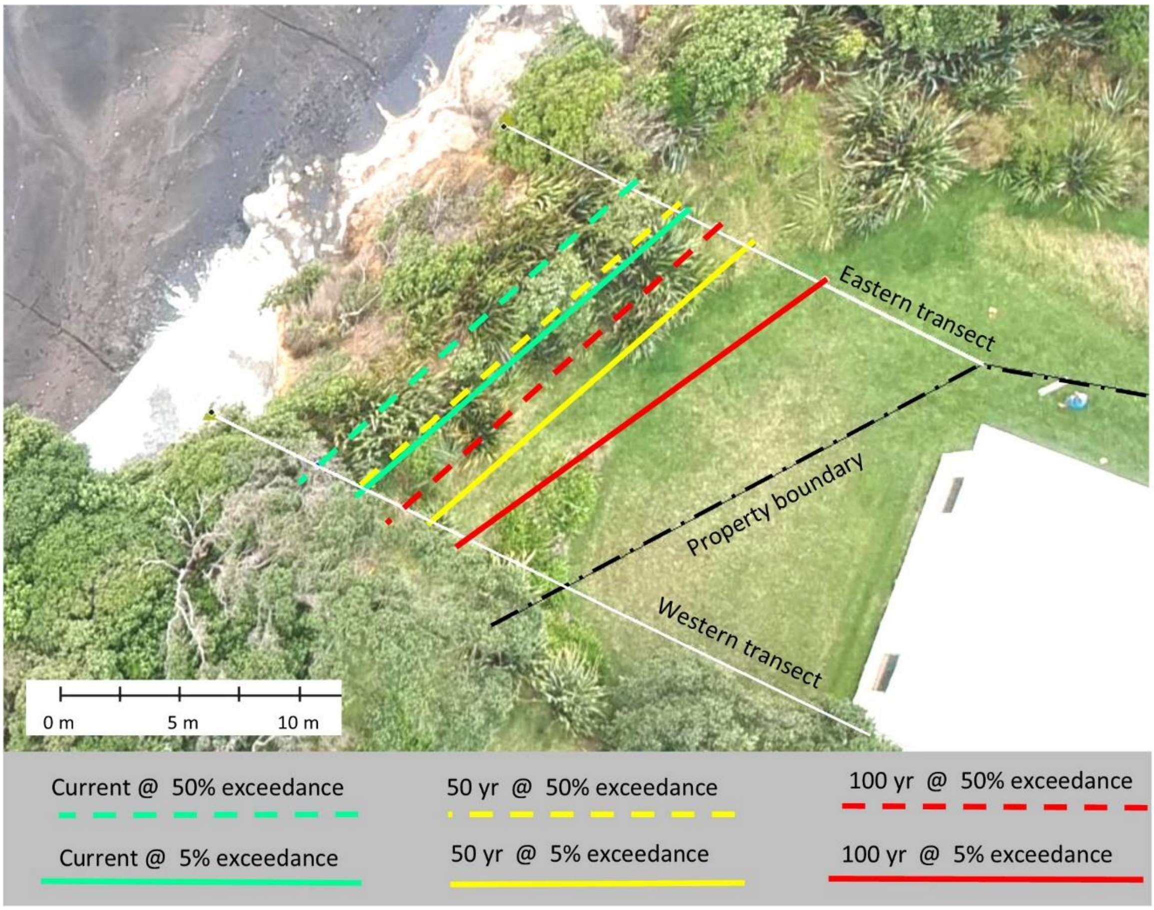

Figure 4 *Areas susceptible to coastal erosion for current, 50 and 100 year scenarios under 50% and 5% likelihood of exceedance options. Note the proposed building modifications extend out to the property boundary (see Figure 1).*

Aerial photo CSL September 2018

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