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Prepared for:
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Preliminary Erosion Hazard Assessment for Whangapoua Harbour fronting Matarangi Drive LOT 1 DP 405557

Terms of references: To carry out a desktop erosion hazard assessment for that section of Whangapoua Harbour fronting Matarangi Drive (LOT 1 DP 405557). To determine a building setback incorporating long-term change and allow for 1 m of sea-level rise over a 100 year prediction period. No site inspection or field investigation was to be undertaken. Deliverables by 3 December, 2014 are for a report covering methodology and results, together with an electronic file of the resulting hazard line.

Information provided by the client consisted of scanned (NZAM) 1945 aerial photographs, a 1988 aerial photo (Aerial Surveys), and (NZAM) 2012-13 electronic georeferenced orthophotos at 0.5 m pixel resolution, and NZAM Ltd's2012-13 LIDAR. In addition Coastal Systems identified three relevant survey plans from the LINZ data-base which provided useful information: ML15834 survey estimated 1870s, SO 45862 surveyed in 1893 and LTS 56122 surveyed in 1989.

Erosion hazard assessment in areas subject to coastal processes (waves, tide and associated currents etc), are typically based on a model that incorporates values for the following components: longer-term (systematic) shoreline change, shorter-term (fluctuating) shoreline change, retreat associated with predicted sea-level rise, subsequent adjustment to a stable slope following an erosive event and inclusion of a safety margin to account for measurement error and uncertainties (NIWA, 2012). The general model was modified for an inlet/estuary environment after the method of CSL (2014). For the present exercise, assessment data was obtained from 9 transects located so as to represent the varying physical characteristics along the 1700 m long study area (see Figure 1).

A geomorphological assessment should be part of any coastal erosion hazard assessment, especially about inlets due to their process interactions and complexity with such assessments defining and explaining the evolutionary history, present landforms, sediment regime and vegetation. While the present study precludes a detailed morphological assessment, based on an inspection of the materials supplied, it appears that a sand barrier developed across the entrance to the large Whangapoua River embayment sometime following the last post glacial marine transgression, perhaps 6000 yrs ago. This barrier forms the Matarangi spit which is attached to the eastern headland and extends westward to form the eastern bank of the Whanagapoua Rivermouth. The spit appears to have undergone systematic seaward accretion evident in the 1945 aerial

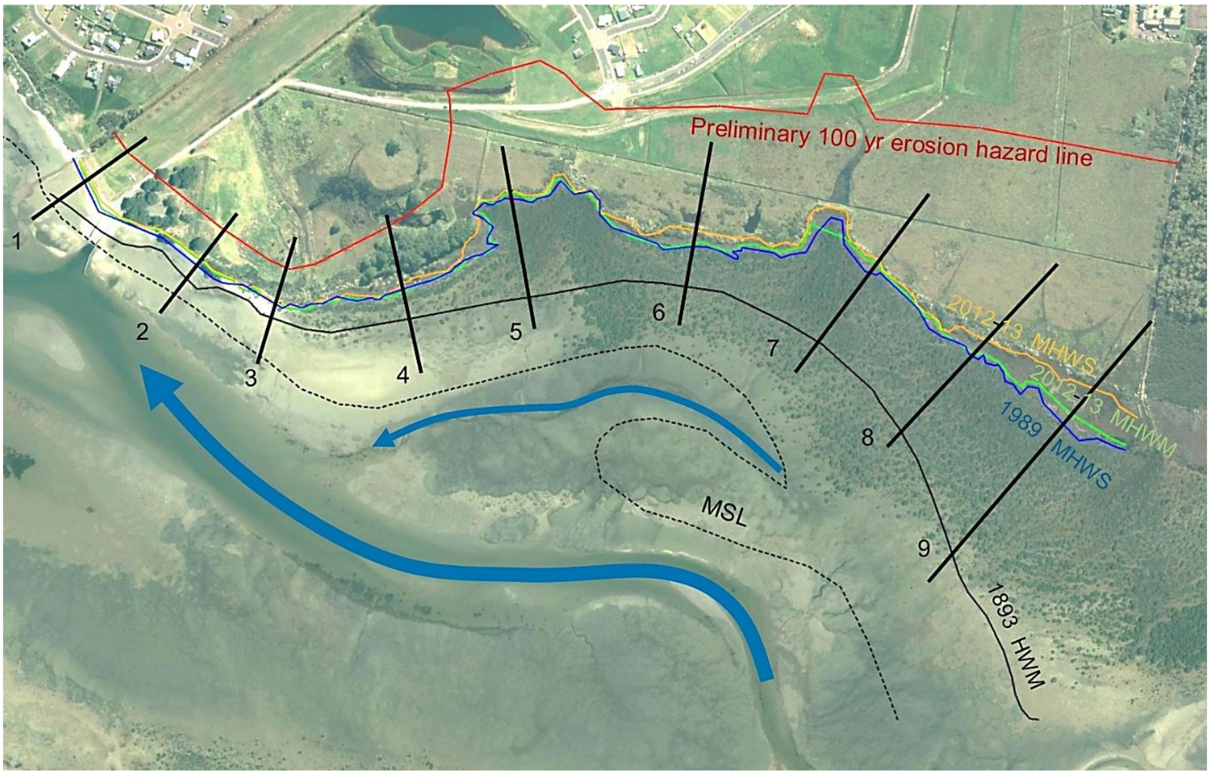

Figure 1 *The study area with locally representative measurement transects marked 1 to 9. Shorelines based on various high water lines from 1893, 1989 and 2012-13 are marked (see text for further description). The thick blue arrow marks the main channel which connects to the Mapauriki Stream, while the thin blue arrow marks a secondary channel.*

photography by a series of shore-parallel ridges (relict foredunes), while morphological signatures indicate episodes of both erosion and accretion of its estuary shoreline. In addition, the available historical materials suggests significant variation in sediment volumes occur around the periphery including the area fronting the study site, while the channel locations appear relatively stable.

The topography across the study area in the western sector (transects 1 to 4) varies between 1 and 3 m RL closer to the shoreline with this elevated region having apparently impeded drainage and lakes occur along with lower subdued relief (1.5m RL) toward the rear. The central sector (transects 5 and 6) is characterised by several water courses cutting into a continuance of the same subdued topography described for the western sector along with higher relied (3 m) at the rear. The eastern sector (transects 7 to 9) is relatively free of drainage channels with the subdued topography extending from the shoreline (1 to 1.5 m RL) across most of LOT 1 with slow increase in elevation to 3 m at the rear. Without knowing the terrestrial sediment composition it is not possible to determine erosive resistance so this assessment assumes a sand base.

"Upper estuary" slopes (between the 0.5m and 1.25 m contours) decrease from 2 to 5.6 degrees in the western sector, to 0.4 to 2 degrees in the central sector and from 0.4 degrees down to 0.2 degrees across the eastern sector. With the exception of the westernmost part of the western sector, mangroves cover the estuary above 0.5 m, and extend down to MSL in the central sector (see Figure 1). While this is a relatively recent occurrence (the 1988 aerial photo shows minimal establishment and no such vegetation is evident on the 1945 photos), symbols possibly indicative of mangrove trees do appear above the HWM on the 1893 survey plan. The survey Field and Traverse Books were obtained from LINZ but unfortunately did not elaborate on the vegetation present. Mangroves may modify sedimentation and shoreline erosion processes, and the data presented in this report (Table 1) indicates lower rates in the more recent data. However, the process change and likely response to predicted climate change is not clear so such effects are not incorporated into the present hazard assessment.

The 1945 and 1988 aerial photographs were scanned and geo-referenced from the 2012-13 orthophoto imagery. However, while the output provided useful geomorphological information, without 3D photogrammetric software/equipment (presently unavailable) and a site investigation, consistent shoreline signatures (slope change defining the top or bottom of embankments or recognized vegetation boundaries controlled by estuary processes), could not be identified.

The 1893 and 1889 survey plans contained high water lines that could be compared with the current equivalent water-levels determined from the 2012-13 LIDAR. These plans were georeferenced using well constrained control and their shorelines digitzsed (see Figure 1) for use in a shoreline analysis.

The 1893 survey shows the high water mark (HWM). At the time surveyors typically located the previous HWM to the time of their survey, and this is problematic in that it depends upon a range of water level controls (neap/spring tide, bathymetric pressure, wind, river discharge etc). While the 1893 shoreline thus likely contains an unresolvable systematic error, it will be accounted for by the uncertainty component in the hazard analysis. For contemporary comparison, the most likely high water mark is the mean high water mark (MHWM) and this was accurately defined in the 2012-13 LIDAR at 1.0 m (AVD-46).

The 1989 survey located the mean spring high water mark (MHWS), and while the accompanying reference books (obtained from LINZ) did not elaborate on the actual datum, it is here assumed to be AVD-46 and thus 1.25 m above MSL; with the current line being defined from the LIDAR.

Longer-term (LT) shoreline change utilised the differences between the 1893 HWM and the 2013 MHWM shorelines (Table 1A), and the differences between the 1989 and 2013 MHWS shorelines (Table 1B). One hundred year extrapolations were made using the observed shoreline change less corresponding (historical) sea-level rise over corresponding sampling periods (see Table 2), these being 0.2 m for the 1893 to 2013 period, i.e. 120 yrs * 0.0017 m/yr (MFE 2008), and 0.07 m for the 1989 to 2013 period, i.e. 23 yrs * 0.003 m/yr (Nicholls and Cazenave, 2010).

Results for the shoreline change data sets (Tables 1A and 1B) are qualitatively similar and depict an increasing trend from west to east. The exception is for transect 5 with 93.2 m predicted for the longer data set but only 18.3 m for the more recent data; this appears related to morphological change associated with drainage. Given that the more recent rate probably better reflects likely future behaviour this was used for the final LT 100 value (Table 3). For all other sites the final LT values were the average value from both data sets, the rational being that the longer set captures greater variation while the shorter set is likely based on more accurate data and captures more recent processes which be more likely to occur in the future.

Finally, it is noted that without a thorough investigation, it must be assumed that the variations defined by the shoreline differences do in fact represent an ongoing trend, whereas it is possible the system experiences cyclicity at century time scales, so the shorelines may revert to accretion over long time periods and if so the LT values would reduce during the prediction period.

Shorter-term change was not required as such estuary shoreline change is considered more likely systematic rather than fluctuating and in this case the **reference shoreline** (from which the final hazard distances are measured landward) is taken as the MHWS which is currently located landward of the earlier shorelines (CSL, 2014).

Table 1A Long-term (LT) shoreline change analysis 1893 to 2013

Transect	Dist (m)	1893 to 2013	Hist RSLR	Net change	Net rate	LT 100 yrs
1	25	44.5	3.1	41.4	0.345	34.5
2	222	27.7	1.6	26.1	0.218	21.8
3	350	21.3	4.2	17.1	0.142	14.2
4	521	37.4	7.1	30.3	0.252	25.2
5	739	133.0	21.1	111.9	0.932	93.2
6	1008	60.0	18.0	42.0	0.350	35.0
7	1287	127.0	23.6	103.4	0.862	86.2
8	1474	146.0	42.4	103.6	0.863	86.3
9	1630	254.0	76.0	178.0	1.483	148.3

Table 1B Long-term (LT) shoreline change analysis 1989 to 2013

Transect	Dist (m)	1989-2013	Hist RSLR	Net change	Net rate	LT 100 yrs
1	25	8.4	1.1	7.3	0.318	31.8
2	222	11.2	0.5	10.7	0.463	46.3
3	350	5	1.5	3.5	0.153	15.3
4	521	8.1	2.5	5.6	0.244	24.4
5	739	11.6	7.4	4.2	0.183	18.3
6	1008	18	6.3	11.7	0.509	50.9
7	1287	15	8.2	6.8	0.294	29.4
8	1474	23	14.9	8.1	0.354	35.4
9	1630	54	26.6	27.4	1.191	119.1

Table 2 Retreat from sea-level rise (RSLR) analysis

Transect	Dist (m)	Dist 0.5 to 1.4	TanB	Degrees	RSLR (0.2m)	RSLR (0.07m)	RSLR (1m)
1	25	14	0.064	3.7	3.1	1.1	15.6
2	222	7	0.129	7.4	1.6	0.5	7.8
3	350	19	0.047	2.7	4.2	1.5	21.1
4	521	32	0.028	1.6	7.1	2.5	35.6
5	739	95	0.009	0.5	21.1	7.4	105.6
6	1008	81	0.011	0.6	18.0	6.3	90.0
7	1287	106	0.008	0.5	23.6	8.2	117.8
8	1474	191	0.005	0.3	42.4	14.9	212.2
9	1630	342	0.003	0.2	76	26.6	380.0

Shoreline retreat associated with sea-level rise (RSLR) was based on a variation of the Bruun Rule (Bruun, 1988). The Bruun Rule was developed for open coastal environments characterised by sand availability, waves and sediment transport continuity with no structures, reefs or other means to constrain potential sediment movement. Briefly, the model translates a “critical” profile section landward and upward by the predicted change in water level and computationally this equals the reciprocal of the average (“critical”) slope.

This model can be applied to non-open coastal environments such as estuaries, but attention must be paid to the assumption constraints. In particular, in this estuary waves only impact the shoreline during higher tides so the slope values used in the model relate to the uppermost part of the profile (CSL, 2014). For the study site a section of profile between 0.5 and 1.4 m RL was used to derive average slope (recorded in Table 2) as this range adequately bounds the neap to spring high tide range. With further regard to model assumptions, the output may over predict future erosion as vegetation cover along the estuary banks and below the high tide mark, along with the possibility of more cohesive bank materials (c.f. sand) may occur at the study site thereby increasing resistance. However, based on available information and no site investigation such possibilities cannot be assessed and incorporated into this hazard assessment. The RSLR analysis is summarised in Table 2

The scarp adjustment component was not incorporated because of its minimal values due to low bank relief, and besides, the uncertainty factor (see below) applied to LT and RSLR covers this component.

The 100 year predicted erosion hazard distances are listed in Table 3, along with final component values of LT and RSLR and a 30% allowance for measurement error and uncertainty. A factor of safety (FOS) value of 1.3 is typically applied in coastal hazard assessments. As discussed above, a more thorough assessment may enable both the LT and/or RSLR component values to be reduced and the associated reduction in uncertainty would also allow for a reduction in the FOS. The resulting hazard distances from the present preliminary assessment increase from west to east and ranged between about 50 to 80 m in the western sector, up to about 150 to 200 m in the central sector and from 200 to 350 m at the eastern end of LOT 1. Note that the particularly high hazard value for transect 9 does not actually impact on LOT 1 as this transect crosses the boundary after some 120 m.

Table 3 Hazard analysis summary for the 100 yr prediction period

Transect	Dist (m)	LT	RSLR	30% FOS	Hazard dist
1	25	33.1	15.6	14.6	63.3
2	222	34.1	7.8	12.6	54.4
3	350	14.8	21.1	10.8	46.6
4	521	24.8	35.6	18.1	78.5
5	739	18.3	105.6	37.2	161.0
6	1008	42.9	90.0	39.9	172.8
7	1287	57.8	117.8	52.7	228.2
8	1474	60.9	212.2	81.9	355.0
9	1630	133.7	380.0	154.1	667.9

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