Mowhanau Coastal Landslip Hazard Zone Assessment

Prepared for

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Table of Contents

Table of Figures

1. Introduction

This study follows on from a review of cliff line retreat rates at Mowhanau (Atkin, 2013). A recommendation of the previous work was to construct new Coastal Landslip Hazard Zones (CLHZs) using the latest available datasets, following the methodology of Gibb (1999), and compare the new CLHZs with those established by Gibb in 1999 (Figure 1.1). The objective of this study is to fulfil that recommendation.

Mowhanau is located on the North Island of New Zealand in the district of Wanganui (Figure 1.2). Gibb (1999) split the CLHZ at Mowhanau in to three zones: Extreme Risk Zone (ERZ), High-Moderate Risk zone (HMRZ) and a Safety Buffer Zone (SBZ). The ERZ is or is likely to be subject to adverse effects from catastrophic landslip at any point in time in any one year. Landward of the ERZ, the HMRZ is or is likely to be subject to long term retreat based on a 100 year projection. The SBZ is or is likely to be subject to the adverse effects from natural hazards, should the rates of erosion accelerate and/or cliff slope angle reduces.

To calculate the width of the CLHZ, Gibb (1999) uses the following:

$$CLHZ = F(D + [R.T]) \quad (1)$$

where D is the horizontal distance of retreat of the cliff top (m), in relation to the cliff base to attain a stable slope, R is the average rate of long-term retreat (m/yr), T is a given planning horizon, and, F is a safety factor that is expressed on a scale from 1 (0%) to 2 (100%). D is calculated by:

$$D = \frac{h}{2\mathrm{Tan}(\alpha)} \quad (2)$$

where *h* is the height of the cliff top above mean sea level (MSL) and *α* is the angle required for a stable slope.

From the toe line of a cliff, the ERZ width is equivalent to D, the HMRZ width is equivalent to R x T (erosion rate multiplied by planning horizon), and the SBZ width is a percentage of the ERZ and HMRZ width combined (*D + (R x T)*) that is a function of F.

Gibb (1999) used a total of 15 locations to estimated CLHZs at Mowhanau. At 9 of the locations, profiles of the cliff face and top where used to estimate *D* instead of Eq 2. For all locations a safety factor of 1.2 (20%) was used.

From the 9 cliff face profiles Gibb (1999) observed that the stable slope angle of the overlying unconsolidated coastal-marine sediments is 36º and that talus slopes at the base of the cliff ranged from 42º to 45º. Gibb concluded that an equilibrium state would be reached with a cliff slope of 40º.

Here the same methodology is undertaken using the most recent data available (Atkin, 2013).

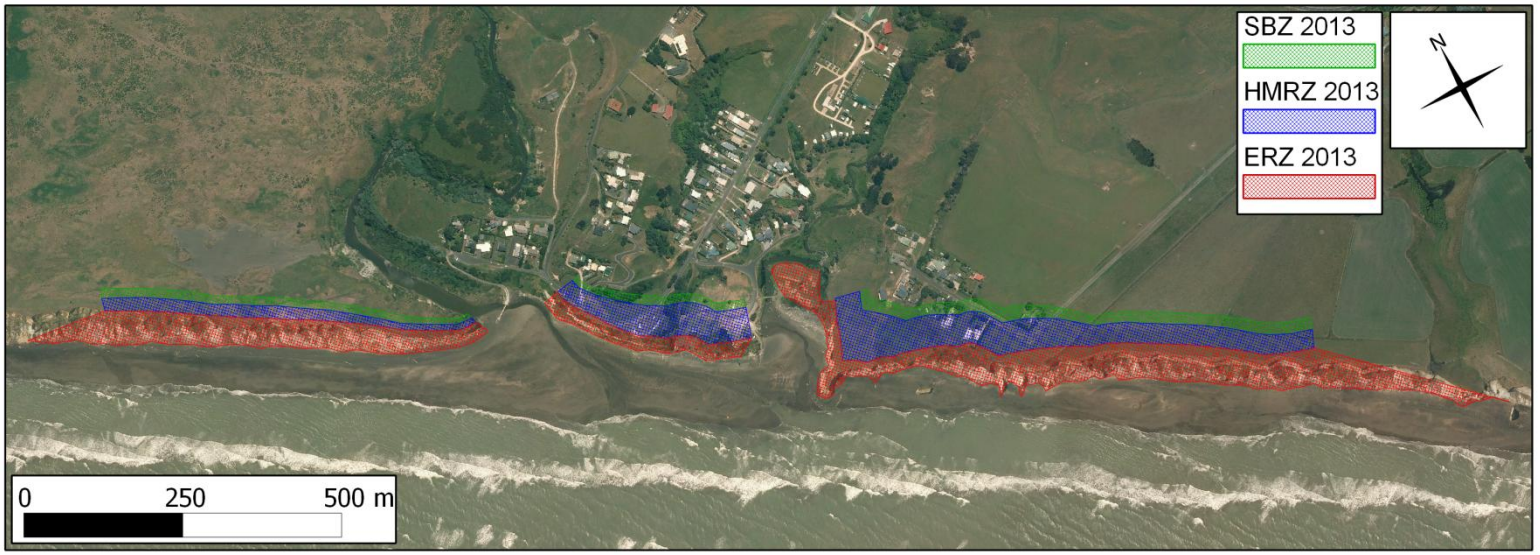

Figure 1.1. Ortho-rectified 2011 image of the study site with the current Coastal Landslip Hazard Zones, as established by Gibb (1999).

Figure 1.2. Study site location

2. Method

Cliff line data for both the top and toe of the cliff was collected on 30th May 2013. Elevation data was collected relative to the ellipsoid. For the data to be used in Eq. 2, the elevation data was converted to the local MSL datum of Taranaki 1970.

As per the cliff line erosion rate review (Atkin, 2013), the coast was sub-sectioned in to 5 areas: Northwest Cliff; Kai Iwi; Beach; Mowhanau Cliff; and Southeast Cliff, as shown in Figure 2.1 and Figure 2.2. Analysis of the Kai Iwi and Beach sections was omitted. This was for two reasons, firstly, from the cliff line review (Atkin, 2013) the toe of the cliff appears stable since the installation of rip-rap armour; secondly, no cliff top data was collected in the 2013 survey (with the exception of the very east end of the Beach section).

Figure 2.1. Ortho-rectified 2011 image of Mowhanau Village with prominent features and cliff line sections annotated

Arrays of Easting's (X) and Northing's (Y) are converted to polar coordinates and rotated by 29°, the exception to this was the Mowhanau section, which was rotated 137.5°. XY values were converted back to a Cartesian format, the result was a cliff line that essentially runs parallel to the x axis (Figure 2.3).

Y and Z values at 5m intervals along the x axis were calculated by linear interpolation, creating 72, 12 and 79 nodes in the Northwest Cliff, Mowhanau Cliff and Southeast Cliff sections, respectively. At each node the Z value was used in Eq 2 (as *h*). The long term erosion rate (R) is calculated at each node using the 1942 cliff top data (Atkin, 2013) by processing and interpolating the data using the same method. In addition, a mean erosion rate value for each cliff section was calculated. At nodes where the erosion rate was less than the mean value, the erosion rate was replaced with the mean value. This method was chosen for the following reasons:

- It is prudent to assess CLHZs with a conservative approach;
- In line with, but expands on, the method of Gibb who used few locations and used the same value across large sections of cliff;
- In the lee of the stacks adjacent to Peat Avenue the erosion rates are low but will increase with erosion of the remaining stack

From the values for D and R, combined with the safety factor of 1.2 and planning horizon (T) of 100 yrs (Gibb, 1999), CLHZ widths at each node and new corresponding XY values were calculated. The new Y values were smoothed using a 5 point moving average to erase sharp discontinuities created by the high resolution sampling, and to enhance the aesthetics of the resulting CLHZ boundaries for easier interpretation. The XY data was then re-orientated

back to the original coordinate reference system. The new XY data was used to create polygons of the CLHZs and ultimately shapefiles for incorporation in to a GIS database.

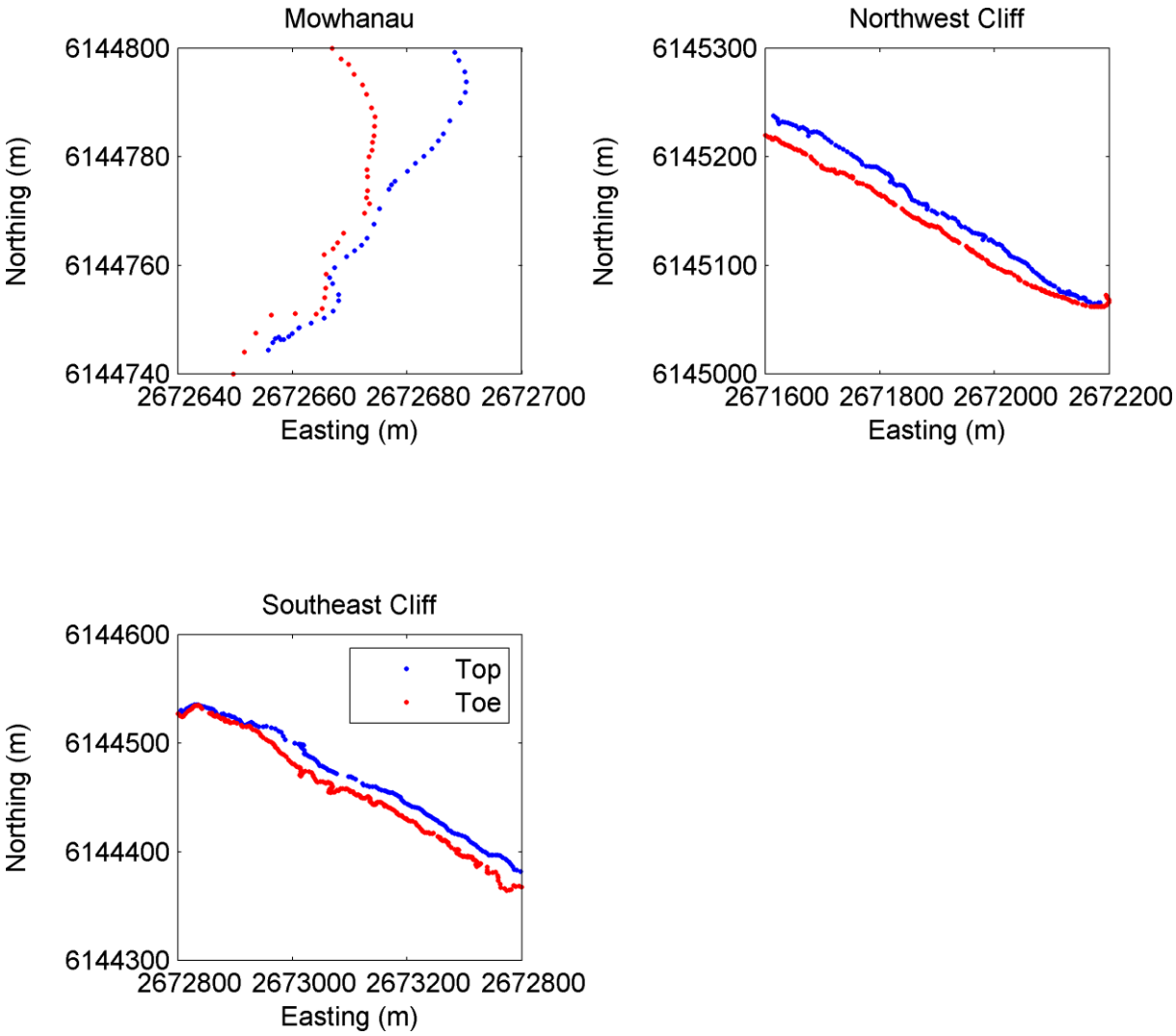

Figure 2.2. Top and toe cliff line data broken into different study sections.

In the Beach and Kai Iwi sections the current CLHZ data was used, and was incorporated in to the CLHZs created here. However the seaward edge of the ERZ was replaced with the 2013 cliff toe data, as opposed the 1999 survey data. Finally, there was a lack of data in the 2013 dataset north of the Mowhanau section; therefore data from the current ERZ was appended to the ERZ created here.

The shapefiles produced from the automated process are then edited by hand to ensure there is consistency in the zone coverage and to match the natural landscape (i.e. not covering unsuitable areas, e.g. streams). Changes were made on the landward side at the eastern end of the Northwest Cliff section; the eastern end of the Beach section, and at the junction between the Mowhanau Section and the appended 1999 ERZ data.

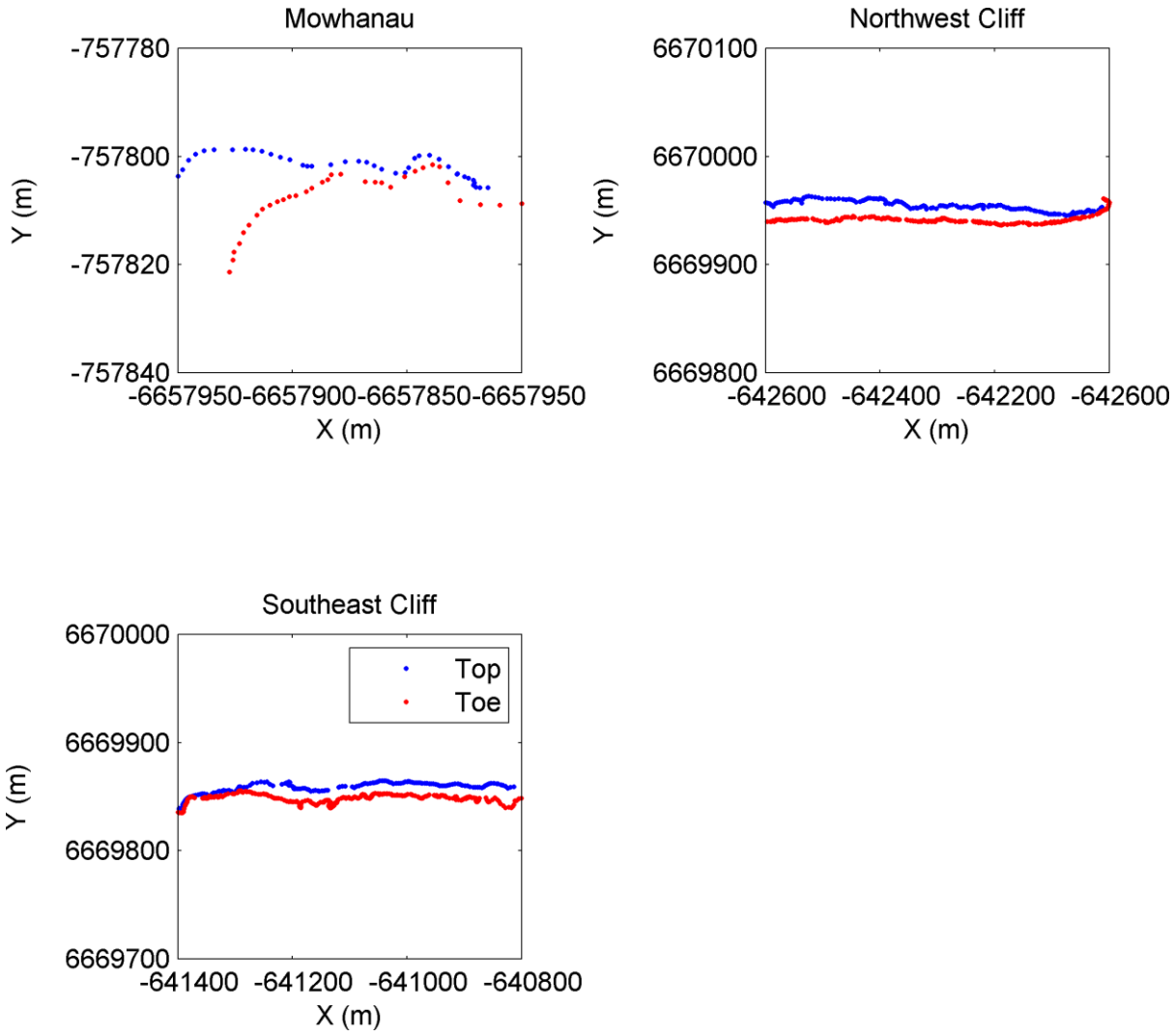

Figure 2.3. Study section data rotated.

3. CLHZ

Figure 3.1 shows an overview of the CLHZs developed from the 2013 dataset. A comparison with Figure 1.1 indicates that the extent of the 2013 ERZ to the southeast is much reduced. This is because no cliff data was collected for this area. Figure 3.2 through Figure 3.11 show the Northwest Cliff section, Kai Iwi and Beach sections combined; and Mowhanau and Southeast Cliff sections combined with comparisons for each of the new ERZ, HMRZ and SBZ with the 1999 CLHZs.

Figure 3.2 to Figure 3.5 show that overall, the 2013 CLHZs in the Northwest Cliff section are landward of the 1999 CLHZs. Much of the inland edge of 2013 ERZ is landward of the 1999 ERZ location, reaching up to ~20 m in places. Central to the Northwest Cliff section the seaward and landward edges of the 2013 ERZ maintain a similar location to that of the 1999 ERZ. At the eastern end, the HMRZ is much wider, a result of the accelerated erosion rates in this area (Atkin, 2013). However the HMRZ is narrower toward the west compared to the 1999 HMRZ

Figure 3.6 and Figure 3.7 show that in the Kai Iwi and Beach sections the CLHZs are largely the same, which was expected as the 1999 footprints were adopted for the 2013 CLHZs. The 2013 ERZ has been extended seaward and at the eastern end to incorporate the toe line location from the 2013 survey data.

In the Mowhanau Cliff section (Figure 3.3), the landward side of the ERZ line is consistent with the 1999 ERZ line, with the exception of the area northeast of the main cliff (Figure 3.9). Here the 2013 ERZ is much narrower. This is a function of the 2013 data showing very low cliff slopes in this area, which following Gibb's (1999) formula, suggest the cliff is tending toward a stable slope. The HRMZ (Figure 3.10) follows this pattern, but the 2013 SBZ covers much the same area as in 1999 (Figure 3.11).

In the Southwest Cliff Section, the 2013 ERZ follows the same outline of the 1999 ERZ, but with a general shift landward (Figure 3.9). The exceptions to this are the areas to the western end of the section and west of the Peat Avenue corner, where the ERZ is extended landward by some 15 metres. The HMRZ is on the whole landward of the 1999 position, but is narrower in the area southwest of the dwellings at the end of Peat Avenue, with the landward edge up to 25 m seaward of the 1999 position (Figure 3.10).

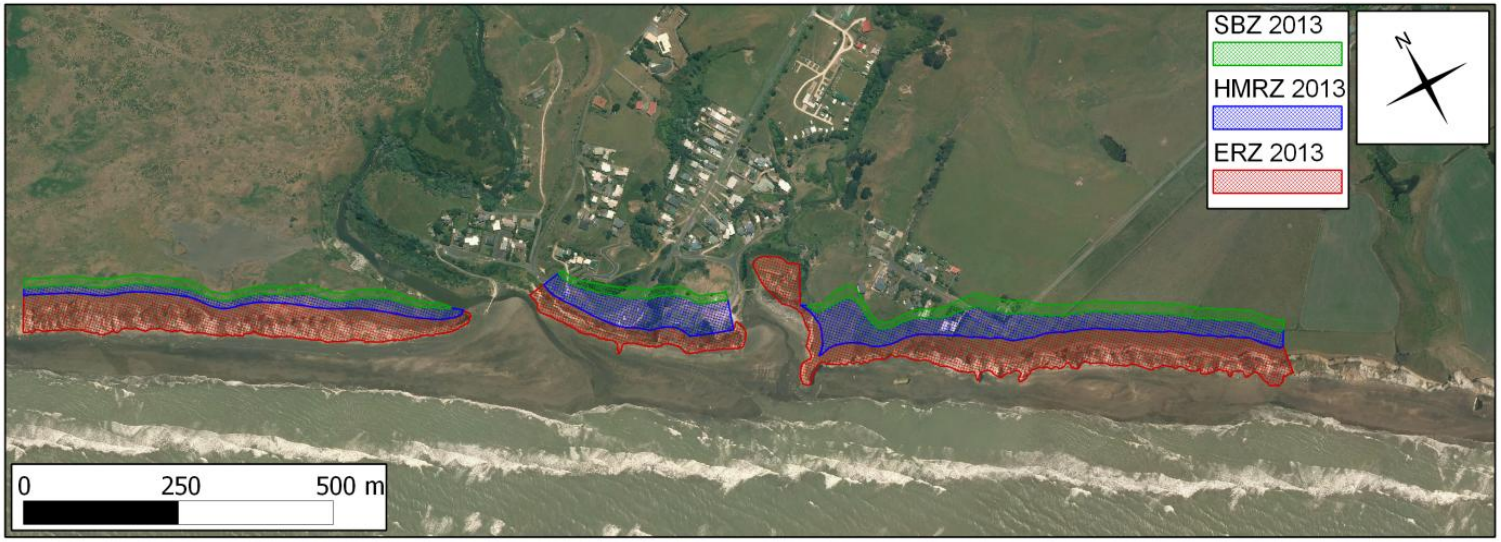

Figure 3.1. Overview of 2013 CLHZs

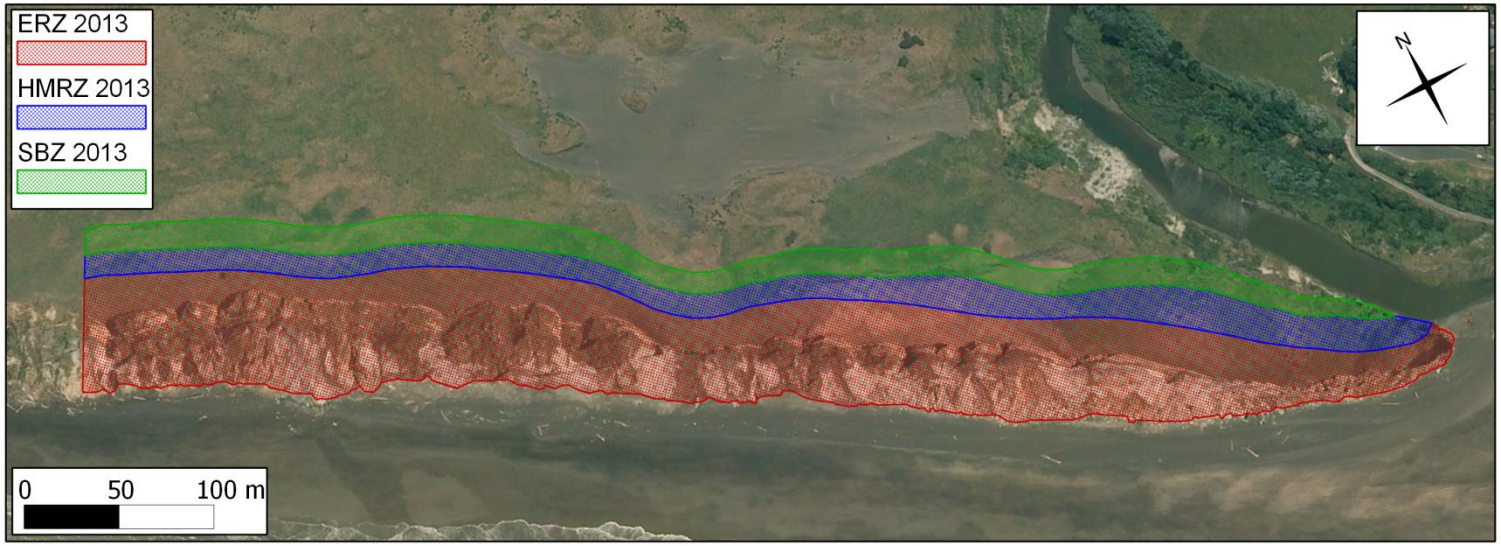

Figure 3.2. Northwest Cliff section CLHZs

Figure 3.3. Northwest Cliff section ERZ

Figure 3.4. Northwest Cliff section HMRZ

Figure 3.5. Northwest Cliff section SBZ

Figure 3.6. Kai Iwi and Beach section CLHZs

Figure 3.7. Kai Iwi and Beach section ERZ

Figure 3.8. Mowhanau Cliff and Southeast Cliff section CLHZs

Figure 3.9. Mowhanau Cliff and Southeast Cliff section ERZ

Figure 3.10. Mowhanau Cliff and Southeast Cliff section HMRZ

Figure 3.11. Mowhanau Cliff and Southeast Cliff section SBZ

4. Conclusions and Recommendations

Coastal Landslip Hazard Zones for the Mowhanau coastal area have been re-constructed following the method of Gibb (1999). RTK survey data collected on the 5th May 2013 has been used along with historical data in the form of digitised cliff line data from 1942 (Atkin, 2013). This study does not account for episodic mass failures which can distort long term erosion rates (Hall, 2002; Runyan and Griggs, 2003).

The CLHZ seaward edge is that of the 2013 survey data, which in most places has moved landward from the 1999 position. This landward movement has also shifted the landward edge of the CLHZ zones landward. However compared with the 1999 CLHZs some areas are significantly landward with the updated and higher resolution estimates of long term erosion rates increasing the width of the ERZ.

It is recommended that before implementing the latest CLHZs that consultation with planning, policy and administrative parties of Wanganui District Council (WDC) is undertaken. This will provide the opportunity for slight adjustments, if required, to ensure the CLHZ coverage is suitable for use, and meet the requirements of both WDC and the public.

5. References

Atkin, 2013. Mowhanau Cliff Line Retreat Review. eCoast technical report prepared for Wanganui District Council.

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Hall, J.W., 2002. Stochastic Simulation of Episodic Soft Coastal Cliff Recession. Coastal Engineering, 46 (3), p. 159–174.

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