PART III – CHZ REVIEW

5. NATURAL COASTAL HAZARDS

A ***natural hazard*** is defined by Varnes (1984) as the "*probability of occurrence within a specified period of time and within a given area of a potentially damaging natural phenomenon*". According to S.2 (RMA-91), such phenomena include;

> "*any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire, or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment*".

Although the term 'adverse effects' is not precisely defined in the RMA-91, under S.3 the term may mean;

> "*any temporary or permanent effect; any past, present, or future effect; any cumulative effect which arises over time or in combination with other effects regardless of the scale, intensity, duration or frequency of the effect. Any potential effect of high probability and any potential effect of low probability which has a high potential impact*".

6. 2001 WAINUI BEACH CHZ

Both the 1995 and 2001 Wainui Beach ***CHZ's*** identify land that "*is or is likely to be subject to*" (S.106, RMA-91) the identified hazards of marine erosion and flooding, and landslip. In total therefore, the ***CHZ*** incorporates a Coastal Erosion Hazard Zone (***CEHZ***), a Coastal Flood Hazard Zone (***CFHZ***), and a Coastal Landslip Hazard Zone (***CLHZ***). GIS plots of the 2001 Wainui Beach ***CHZ*** are provided in Appendix III.

6.1. CEHZ ASSESSMENT

Set out below are the same factors used to assess the 1995 Wainui Beach ***CEHZ***, that were used to assess the 2001 Wainui Beach ***CEHZ***:

R = Rate of long-term (historic) trend of net shoreline advance, retreat or dynamic equilibrium (m^3/m).

S_{max} = Volume of sand involved in maximum potential short-term duneline fluctuations (m^3/m).

F = Safety factor that is expressed on a scale from 1.0 (0%) to 2.0 (100%).

T_{50} = Planning horizon up to 2050 A.D. (years).

T_{100} = Planning horizon up to 2100 A.D. (years).

X = Rate of shore retreat (m/year) from local relative sea-level rise (SLR) calculated by the

$$X = \frac{la}{h + d} \qquad \text{Eqn [1]}$$

Where: a_{50} = Rate of local relative SLR up to 2050 (m/year).

a_{100} = Rate of local relative SLR up to 2100 (m/year).

d = Average closure depth below MSL (m).

h = Height of foredune above MSL (m).

l = Horizontal distance from the crest of the foredune to the contour representing the closure depth (m).

D = Eventual stable angle reached by the eroded dune scarp as determined directly by measurement from GDC profiles.

The GIS model used the following empirical equation incorporating the above factors to assess the extent of a ***Coastal Erosion Hazard Zone*** (***CEHZ***), and ***Risk Zones*** within the ***CEHZ***, where:

$$CEHZ = [(S_{max} + D) + (X_{50} + R)\,T_{50} + (X_{100} + R)\,T_{100}]\,F \qquad \text{Eqn [2]}$$

Factor S**:** For ***S***, the following parameters were adopted for the GIS model from measurements.

105m^3/m - Tuahine Crescent to Wainui Stream.

110m^3/m - Wainui Stream to Wainui School.

Northern Wainui Beach from Hamanatua Stream.

155m^3/m - Wainui School to Hamanatua Stream.

Factor D**:** For ***D***, the following parameters were adopted from measurements.

40^0 - Southern Wainui Beach from Hamanatua Stream.

33^0 - Northern Wainui Beach from Hamanatua Stream.

Factor R**:** For ***R***, the following shoreline surveys were adopted for the GIS model to quantify the long-term trend of erosion of the main foredune.

1942-1999 - Tuahine Crescent to Wainui Stream.

Northern Wainui Beach from Hamanatua Stream.

1942-1982 - Wainui Stream to Hamanatua Stream.

Factor X**:** For ***X***, the following parameters were adopted for the Bruun Rule.

a_{50} - 0.00267 – 0.0013 = 0.00137m/year.

a_{100} - 0.00364 – 0.0013 = 0.00234m/year

d - -10m MSL.

l - Measured by GIS model from the 1999 dunecrest to the 1999 -10m depth contour.

h - Measured by GIS model from the 1999 DTM to decimetre accuracy.

Note that the mid range IPCC-2001 most likely SLR projections of 160mm and 400mm above 1990 sea-level were adopted for 2050 and 2100, respectively. The historical Auckland value for 1899-1990 of 130mm was subtracted from the IPCC-2001 values to avoid double counting as Factor R already includes the effects of historical SLR of at least 130mm (1.3mm/year).

Factor T*:** For ***T, the following parameters were adopted.

$\mathbf{T_{50}}$ - Planning horizon of 50 years (2000-2050).

$\mathbf{T_{100}}$ - Planning horizon of 100 years (2000-2100).

Factor F*:** For ***F, the present GIS model adds the Safety Factor to the dune volume adopted for Factor ***S*** to determine ***F***. For ***F***, a value of 50% (1.5) was adopted to produce the following parameters.

$105 \times 1.5 = 158 m^3/m$ - Tuahine Crescent to Wainui Stream.

$110 \times 1.5 = 165 m^3/m$ - Wainui Stream to Wainui School.

Northern Wainui Beach from Hamanatua Stream.

$155 \times 1.5 = 233 m^3/m$ - Wainui School to Hamanatua Stream.

Appendix III has GIS maps produced by GDC showing the extent of the ***CEHZ*** along Wainui Beach***.***

6.2. CLHZ ASSESSMENT

For Wainui Beach, the ***CLHZ*** applies to both Tuaheni and Makorori Points over a total length of coast of approximately 2km. In this review, the ***CLHZ*** assessed in 1995 was found to adequately identify land that "*is or is likely to be subject to*" adverse effects from coastal landslip hazard. The only changes made to the 1995 Wainui Beach ***CLHZ*** were at the North and South ends of Wainui Beach where the 1995 ***CLHZ*** was spliced on to the 2001 ***CEHZ*** using GDC's GIS. In the light of recent landslip (see Figure 14) some adjustments were made to the 1995 ***CLHZ*** near Tuahine Crescent.

The following equation was adopted in 1995 (Gibb 1995) and in this study to assess the extent of the ***CLHZ*** for the unstable seacliffs and coastal hillslopes of weathered and deformed Late Tertiary sandstone-siltstone rocks along both Tuaheni and Makorori Points:

CLHZ = [S + R.T]F Eqn [3]

Where; **S** = Extent of seaward slope subject to slope failure (m).

R = Rate of long-term (historic) retreat of cliffline (m/year).

T = Planning horizon up to 2100.

F = Safety Factor of 1.3 (30%)

(Adapted from Gibb 1995)

Appendix III has GIS maps produced by GDC showing the extent of the ***CLHZ*** around Tuaheni Point and most of Makorori Point. Both headlands are fully encompassed by the ***CLHZ,*** as they are entirely susceptible to actual and potential landslip hazard this century.

6.3. RISK ZONATION

The term "*risk*" is where "*a given element or set of elements is exposed to chance of injury or loss from the occurrence of a natural hazard*" (Sykes 1984; Varnes 1984). Risk Zonation refers to the division of the land surface into areas and the ranking of these areas according to degrees of actual or potential hazard from natural phenomena. It does not necessarily imply legal restriction or regulation by zoning ordinances or laws (Varnes 1984).

As for the 1995 ***CHZ*** assessment for Wainui Beach, the 2001 assessment adopted the same structure of risk zonation for both the ***CEHZ*** and ***CLHZ***. The ***CEHZ*** was subdivided into ***Extreme***, ***High*** and ***Moderate Risk Erosion Zones*** and a ***Safety Buffer Zone***. The ***CLHZ*** was subdivided into ***Extreme*** and ***Moderate Risk Landslip Zones*** and a ***Safety Buffer Zone***.

The ***Extreme Risk Erosion Zone*** (***EREZ***) lies adjacent to the coast along the 4.2km-long Wainui Beach and encompasses the area that "*is or is likely to be subject to*" adverse effects from short-term duneline fluctuations and storm cuts. The ***EREZ*** includes Factors ***S*** and ***D***, encompasses most of the foredune complex and has a high probability of being adversely affected at any point in time but more particularly during a 20 to 30 year-long negative IPO phase. The ***EREZ*** ranges in width from about 20 to 45m along Wainui Beach being widest just South of the Hamanatua Stream where it includes the recently accumulated incipient foredune, a temporary feature.

The ***Extreme Risk Landslip Zone*** (***ERLZ***) lies adjacent to the coast along both Tuaheni and Makorori Points and encompasses land that "*is or is likely to be subject to*" slope failure at any point in time. The ***ERLZ*** ranges in width from about 50 to 300m along Tuaheni and Makorori Points.

The ***High Risk Erosion Zone*** (***HREZ***) lies adjacent and landward of the ***EREZ*** and encompasses the area that "*is likely to be subject to*" a net shoreline retreat from the combination of a mid-range "*most likely*" SLR of 0.16m above 1990 levels by 2050 A.D., and any historical long-term retreat. The ***HREZ*** encompasses the period from the present to 2050 A.D., and has a high probability of being adversely affected at any time over the next 50 years. The ***HREZ*** ranges in width from 0 to 25m along Wainui Beach being widest where there is a relatively higher historical long-term erosion rate coupled with forecast erosion from sea-level rise. Where there is no ***HREZ***, just South of the Hamanatua Stream, the historic rate of net accretion (1942-1982) has neutralised the predicted erosion from sea-level rise.

The ***Moderate Risk Erosion Zone*** (***MREZ***) lies adjacent and landward of the ***HREZ*** and encompasses the area that "*is likely to be subject to*" a net shoreline retreat from a

predicted mid-range "*most likely*" SLR of 0.40m above 1990 levels by 2100 and any historical long-term retreat. The ***MREZ*** encompasses the period from 2050 to 2100, and ranges in width from 0 to 30m along Wainui Beach being widest in the area of the greatest historic erosion coupled with forecast erosion from sea-level rise. Where there is no ***MREZ*** the historic rate of accretion has neutralised predicted erosion from SLR.

For both Makorori and Tuaheni Points, the ***Moderate Risk Landslip Zone*** (***MRLZ***) lies adjacent and landward of the ***ERLZ*** and encompasses the area that "*is likely to be subject to*" net retreat of the seacliffs coupled with landslip over the next 100 years. As the *Bruun Rule* does not apply to seacliffs no provision was made for the effects of SLR and there is no ***HRLZ***. The ***MRLZ*** ranges in width from 10 to 50m being widest where there is a relatively higher rate of historical seacliff retreat.

The ***Safety Buffer Zone*** (***SBZ***) lies adjacent and landward of the ***MREZ*** and the risk to elements within this zone is considered to be relatively low. The ***SBZ*** ranges in width from 4 to 10m along Wainui Beach and 10 to 90m along Tuaheni and Makorori headlands. Landward of the ***SBZ***, the risk from the identified natural coastal hazards of marine erosion and landslip is considered here to be very low until after the year 2100.

6.4. CFHZ ASSESSMENT

The ***CFHZ*** is limited to those low-lying areas along the 4.2km-long Wainui Beach where the hinterland "*is or is likely to be subject to*" temporary inundation from either storm wave runup (SWRU) or tsunami wave runup (TWRU). Based on the work of Komar (1996), maximum SWRU elevations of 7-8m above MSL are adopted in this study for Wainui Beach. These elevations approximate a severe wave storm with a return period of approximately 50-100 years. These elevations are higher than the 6m suggested for the 1995 Wainui Beach ***CHZ*** (Gibb 1995) but are based on better information.

For TWRU, no new information on maximum potential tsunami and frequency of such events has become available since the 1995 ***CFHZ*** assessment. For the 1995 assessment, Gibb (1995) adopted a maximum TWRU value of 11m above MSL, based on the well-reported 26 March 1947 event. Although there is a high probability that further tsunami will be generated from the same local source area as the 1947 event, little is known about the potential frequency or magnitude of such events. Size and frequency of tsunami generating slope failures along the Pacific-Australian Plate boundary are not known at this point in time. Maximum TWRU elevations of 10-11m above MSL are adopted in this study as a potential scenario rather than a definitive forecast on the basis of the locally generated March 1947 event.

The Wainui Beach area was contoured at 0.5m intervals by Air Logistics in 1999. The contours provide the basis for determining the ***CFHZ*** as scenarios. In this study, the 10 and 11m contours were identified on GDC's GIS as a scenario to explore how much land would be at potential risk from a tsunami of this magnitude.

For Northern Wainui Beach, a 10-11m tsunami wave, which is significantly higher than maximum potential SWRU of 7-8m, would inundate parts of Moana Road (SH-35) but would not reach any of the residential properties on the landward side of the road. Most of the flooding would be confined to the sand dunes seaward of Moana Road which are a public reserve.

For Southern Wainui Beach, the situation is different. Both the Hamanatua and Wainui Streams would act as conduits for tsunami. Although much of the foredune complex exceeds 10m, flooding would occur along Northern Wairere Road including the adjacent residential properties. Around Wainui Stream, flooding would extend across all the roads and residential properties along most of Pare Street, Murphy Road, Tuahine Crescent, Cleary Road and Lloyd George Road. Depending on the number of tsunami waves generated by a particular event, flooding could extend several kilometres inland in this area as it is less than 10m above MSL. Tsunami flood hazard is probably more appropriately dealt with as a Civil Defence matter.

7. DISCUSSION

In general, the review of the 1995 Wainui Beach ***CHZ*** has resulted in a reduction in width of the ***CEHZ*** and some changes to the ***CFHZ*** parameters and no change to ***CLHZ*** widths. Table 6 highlights the differences between the 1995 and 2001 ***CEHZ*** assessments along Wainui Beach at each of the 15 GDC Beach Profile monitoring sites.

Table 6 shows that the 2001 Wainui Beach ***CEHZ*** ranges in width from 35 to 83m, generally averaging 53m. In comparison, the 1995 Wainui Beach ***CEHZ*** ranges in width from 53 to 114m, generally averaging 91m. Although the same methods were used for both assessments, the significant reduction in ***CEHZ*** widths between 1995 and 2001 can be explained by the use of different parameters for some of the factors (Table 6).

Potential erosion from sea-level rise (Factor ***X***) is virtually halved from 1995 to 2001, mostly because of a significant reduction in the rate of local relative SLR (Factor ***a***, Table 6). The reduction has resulted from both a reduction in forecast global SLR by the IPCC from mid-range values of 0.66m in 1990 to 0.40m in 2001, and better data from the Auckland tide gauge recognised as the most reliable record in New Zealand. Otherwise, the other factors used in the *Bruun Rule* to assess Factor ***X*** in 1995 and 2001 are remarkably similar (Table 6). Both the closure depth (Factor ***d***) and dune heights (Factor ***h***) were re-surveyed during the 2001 review showing excellent agreement with the parameters measured in 1995.

Actual erosion (Factor ***R***) is generally reduced as well in the 2001 assessment as a result of a number of factors. The reduction in erosion rates reflects firstly, the effects of property protection works along Southern Wainui Beach slowing erosion rates, secondly, the general trend of beach accretion during the positive IPO phase (1976-1997), and thirdly, the very precise photogrammetric techniques used by Air Logistics Ltd to fix the exact position of dunelines in 1942, 1965, 1982 and1999.

The ***Safety Buffer Zone*** (Factor ***F***) is significantly reduced also as a result of the workings of the GIS model. The model takes the topography into account in assessing both the ***Extreme Risk Erosion Zone*** (Factors ***S*** + ***D***) and the ***Safety Buffer Zone*** (Factor ***F***). In general, the review was worthwhile as the 2001 ***CHZ*** assessment is far more precise than the 1995 assessment being based on a much higher quality of data for each of the parameters used for the review and a GIS computer model that takes all the parameters into account every 4m along Wainui Beach.

		GDC PROFILES														
	FACTORS	1	2	3	4	5	6	7	8	8A	9	10	11	12	13	14
	a	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234	0.00234
	I	770	790	800	800	800	780	730	630	620	580	580	500	600	620	740
	h	12.0	7.0	6.4	4.8	10.5	10.5	9.6	11.1	11.9	10.8	16.1	13.7	10.5	10.5	8.6
	d	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
2001	X	-0.08	-0.11	-0.11	-0.13	-0.09	-0.09	-0.09	-0.07	-0.07	-0.07	-0.05	-0.05	-0.07	-0.07	-0.09
	R	-0.18	-0.14	-0.12	0.05	0.00	0.00	-0.35	-0.08	0.35	-0.07	-0.16	-0.25	-0.25	0.00	-0.11
	T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	(X+R)T	26	25	23	8	9	9	44	15	0	14	21	30	32	7	20
	S+D	23	22	22	26	20	21	30	28	45	28	28	26	24	29	27
	F	4	6	8	10	6	6	9	9	8	7	4	6	6	10	7
	2001 CEHZ	53	53	53	44	35	36	83	52	53	49	53	62	62	46	54
	a	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
	I	750	800	850	800	750	650	600	600	600	550	550	550	600	650	700
	h	12.0	8.0	5.5	4.5	10.5	10.5	9.5	10.5	10.5	10.7	7.0	12.0	9.1	10.5	8.0
	d	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
1995	X	-0.16	-0.2	-0.25	-0.25	-0.17	-0.15	-0.14	-0.14	-0.14	-0.12	-0.15	-0.12	-0.14	-0.15	-0.18
	R	-0.39	-0.26	-0.22	-0.1	-0.18	-0.14	-0.06	0.08	-0.24	-0.37	-0.1	-0.35	-0.26	-0.37	-0.37
	T	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	(X+R)T	58	48	49	37	37	31	21	6	40	52	26	49	42	55	58
	S+D	27	22	20	18	27	25	35	35	40	32	33	33	27	32	30
	F	25	21	21	17	19	16	17	12	24	25	18	25	21	26	26
	1995 CEHZ	110	91	90	72	83	72	73	53	104	109	77	107	90	113	114

• **Table 6**: Comparison of 1995 and 2001 *CEHZ* widths at GDC Beach Profile sites 1 to 14 along Wainui Beach. 1995 data from Gibb (1995, table 7). *Bruun Rule* was used to calculate *X* = erosion from SLR; *R* = long-term erosion rate; *S* + *D* = Maximum short-term duneline fluctuation or storm cut; *F* = Safety Factor; *T* = Planning horizon of 100 years; *CEHZ* = *[(X+R)T+S+D]*F.

8. CONCLUSIONS

1. The review of the 1995 Wainui Beach ***CHZ*** was timely and successful and has resulted in a significant reduction in width of the ***Coastal Erosion Hazard Zone*** (***CEHZ***) along the 4.2km-long Wainui Beach, virtually no change in width of the ***Coastal Landslip Hazard Zones*** (***CLHZ***) along both Tuaheni and Makorori Headlands along about 2km of coast, and small changes to the parameters for the ***Coastal Flood Hazard Zone*** (***CFHZ***) that affect parts of the 4.2km-long Wainui Beach.

2. The ***CFHZ*** encompasses storm-wave runup (SWRU) levels up to 7-8m above MSL and tsunami wave runup levels up to 11m. Although there is more certainty about the probable occurrence of maximum SWRU elevations, there is much uncertainty about the frequency and magnitude of TWRU elevations, thus suggesting a scenario approach be adopted for tsunami. The area most at risk from marine flooding is around both the Hamanatua and Wainui Streams, especially the latter.

3. The ***CLHZ***, especially the ***Extreme Risk Landslip Zone*** (***ERLZ***) near Tuahine Crescent, is currently active and could pose a significant risk to some houses along the seaward side of the Crescent at any point in time. At this location, the weathered and disrupted sedimentary strata dip seawards which along with continual coastal erosion provides the ideal conditions for generating slope failure.

4. The significant reduction in ***CEHZ*** widths by up to 60% from 1995 to 2001 is due to a significant reduction in forecast sea-level rise (SLR) by the Intergovernmental Panel on Climate Change between 1990 and 2001, very good historical SLR trends from the Port of Auckland tide gauge since 1899, a general reduction in erosion rates and finally, a reduction in the ***Safety Buffer Zone*** width reflecting more reliable data and computer based GIS ***CEHZ*** assessment techniques.

5. The identified and quantified geological hazards of marine erosion and flooding, and coastal landslip, are irreversible and are forecast in this review to worsen this century placing public and private property and assets at ever increasing risk of damage or destruction along Wainui Beach. It is important for the Wainui Beach community that planning and management approaches take this into account

9. RECOMMENDATIONS

It is recommended that Gisborne District Council, after due consideration of this report and accompanying Coastal Hazard Maps:

i. **ADOPT** the ***2001 Wainui Beach Coastal Hazard Zone*** between Tuaheni Point and Makorori Point for the purposes of controlling coastal subdivision, use and development and alerting the public of the risks to coastal property from the identified natural coastal hazards of marine erosion and flooding, and coastal landslip.

ii. **INCORPORATE** the ***2001 Wainui Beach Coastal Hazard Zone*** into Council's ***Proposed Regional Coastal Environment Plan*** and ***Proposed Gisborne District***

combined Regional Land and District Plan to replace the 1995 Wainui Beach Coastal Hazard Zone.

iii. **PROVIDE** for public seminars and open days at Wainui and Okitu to disseminate both the findings of this study and Council's decisions with respect to managing subdivision, use, and development within the ***2001 Wainui Beach Coastal Hazard Zone***.

iv. **MONITOR** and quantify the identified coastal hazards of marine erosion and flooding, and coastal landslip, to the extent that the data collected by Council can be utilised from time to time to review the ***2001 Wainui Beach Coastal Hazard Zone***.

v. **REVIEW** the ***2001 Wainui Beach Coastal Hazard Zone*** using similar methods either once every 10 years, **OR** after occurrence of significant hazardous events such as large storms, tsunami, or large earthquakes, **OR** after significant changes in global climate change forecasts including potential sea-level rise, by the Intergovernmental Panel on Climate Change.

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