9 Te Puna

9.1 Site description

Te Puna is located in the southern basin of Tauranga Harbour, approximately 1 km south from Motuhoa Island. The shoreline comprises around 1.5 km of coastal cliffs and 0.3 km of unconsolidated shoreline. The site is split into 6 cells based on differences in exposure, morphology and shoreline elevation (Figure 9-1).

Figure 9-1 Location and cell extent for the Te Puna shoreline within Tauranga Harbour.

At the western end, the shoreline is characterised by low cliffs, ranging in elevation from RL 4 to 9 m (Cell 9A). Several residential dwellings are located along the cliff crest. Further east the cliffs continue to rise in elevation to approximately 20 m RL (Cell 9B) (Figure 9-2A). While most of the cliff face is vegetated with shrubs and trees, there are sections of bare cliff face, where recent slips have occurred and the debris has extended out onto the shore platform. The shoreline is exposed to an average fetch of 2 km from northeast and a maximum fetch of 10 km from east. In addition, the main harbour channel which circulates Motuhoa Island is approximately 100 m from the cliff toe.

South from Waipa Road is another section of coastal cliffs, ranging in elevation from RL 15 to 20 m (Cell 9C). The cliffs are orientated with a north-easterly aspect and are well-vegetated with no evidence of recent slips. A high-tide sandy beach that is approximately 2 to 5 m wide occurs along the entire cliff toe (Figure 9-2B). The shoreline is exposed to an average fetch of 4 km from the east.

The shoreline continues south to a section of unconsolidated shoreline which ranges in elevation from RL 0.8 to 1.7 m (Cell 9D) (Figure 9-2C). The backshore is low and is vegetated with shrubs and grasses. The high-tide beach continues along from the cliff section.

Further south the shoreline topography rises again to coastal cliffs, ranging in elevation from RL 14 to 16 m (Cell 9E). The cliffs are mostly well-vegetated with protection structures along the toe. At the southernmost extent the cliffs gradually decrease in height, down to Pitua Road which is elevated approximately RL 1.3 m (Cell 9F) (Figure 9-2D).

Figure 9-2 Site photos for Te Puna. (A) Exposed cliffs (Cell 9B), (B) stable cliffs with high tide beach (Cell 9C), (C) unconsolidated shoreline (Cell 9D), (D) low cliffs with rip rap (Cell 9F).

9.2 Geology

The geological map of the area[10] indicates that the site comprises:

- Matua Subgroup: Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess.
- Holocene river deposits: Alluvial gravel, sand, silt, mud and clay, with local peat.
- Holocene fan deposits: Alluvial and colluvial fan deposits consisting of poorly sorted gravel, sand and clay.

Field observations of cliff exposures are in line with the published geology and include interbedded ash layers to the top of the cliffs and reworked ignimbrites at the base of the cliffs.

The existing slope angles in this area are between 3° to 20° along unconsolidated areas, and between 20° to 55° in areas of banks or low cliffs. The range of stable slope angles for Te Puna are shown in Table 9-1 below.

The failure types observed around Te Puna were typically shallow surface failures. The likelihood of deep seated movement is low to moderate.

[10] Leonard, G.S.; Begg, J.G.; Wilson, C.J.N. (compilers) 2010: *Geology of the Rotorua area*. Institute of Geological & Nuclear Sciences 1:250,000 geological map 5. 1 sheet + 102 p. Lower Hutt, New Zealand. GNS Science.

9.3 Coastal processes

The Te Puna shoreline is exposed to wind waves generated from northwest around to east and strong tidal currents, particularly at the western end where the large tidal channel runs adjacent to Cell 9B. Based on regression analysis the long term erosion rate within Cell 9B is between -0.08 and -0.2 m/yr, which is also consistent with the erosion estimate by Opus (2015). Field observations indicate that tidal energy readily removes slip debris from the cliff toe and contributes to the shoreline retreat. Tree cover and structures makes it difficult to determine long term rates for Cell 9A. Based on the similar exposure and proximity to the tidal channel to Cell 9B it is assumed that Cell 9A has similar erosion rates as Cell 9B.

Cell 9C is not exposed to the same strength of tidal currents as Cell 9B and the site is fronted with intertidal flats which are likely to dampen wave energy reaching the shore. The reduced exposure at Cell 9C is evident in the field observations. The formation of the high-tide beach indicates tidal currents are weaker, the cliffs are also at a more stable state with dense vegetation, which is in part due to the protection afforded by the beach. Regression analysis indicates the average long term erosion rate is -0.06 m/yr for Cell 9C.

Historically, the unconsolidated shoreline within Cell 9D has shown large fluctuation, with long term erosion rates up to -0.5 m/yr. Results from Healy (2010) also suggest erosion rates are high for the unconsolidated section. Based on a 4 km fetch from the northeast, the theoretical significant wave height is estimated to be 1.1 m. Based on model results the short term storm cut is estimated to range from 5 to 9 m.

The cliffs within Cells 9E and 9F show lower erosion rates than the adjacent unconsolidated shoreline, with the average rate being -0.12 m/yr. There is evidence of scour and overtopping along the structures at the base of the cliff which indicates harbour waves do periodically reach the site.

Due to the exposure to large fetches, the SLR response factors for all consolidated cells around Te Puna range from 0.2 to 0.4.

9.4 Local considerations

Along the toe of the cliffs, just west from Pitua Road, is approximately 0.3 km of revetment (Figure 9-3B). The revetment is approximately 0.5 to 1 m high and is mostly well-structured, however there is evidence of overtopping in the lower sections. A small section of ad-hoc seawall also occurs along the toe of the cliffs further north (Figure 9-3A).

Figure 9-3 Examples of coastal protection structures around Te Puna. (A) Ad-hoc seawall along the base of northeast-facing cliffs (Cell 9B), (B) revetment with groynes along the base of east-facing cliffs (Cell 9E).

9.5 Adopted component values

Adopted component values are presented within Table 9-1. The short term values are equal to zero for the consolidated cells as short term erosion is not applicable for consolidated shorelines (see section 4.6.2 in main report).

Table 9-1 Adopted component values for the cells along Te Puna.

Site		**9. Te Puna**					
Cell		**9A**	**9B**	**9C**	**9D**	**9E**	**9F**
Cell centre (NZTM)	**E**	1870264	1870712	1871266	1871532	1871797	1871944
	N	5827804	5827737	5827607	5827384	5827259	5827175
Morphology		Consolidated	Consolidated	Consolidated	Unconsolidated	Consolidated	Consolidated
Geology		Matua Subgroup	Matua Subgroup	Matua Subgroup	Holocene fan deposits	Matua Subgroup	Matua Subgroup
Exposure (average fetch/direction)		2.5 km (NW)	2 km (NE)	4 km (NE)	4 km (NE)	4 km (NE)	4 km (NE)
State		Partially protected	Natural	Natural	Natural	Partially protected	Protected
Short-term (m)	Min	0	0	0	5	0	0
	Mode	0	0	0	7	0	0
	Max	0	0	0	9	0	0
Dune/Cliff elevation (m above toe or scarp)	Min	4.2	18.9	15.9	0.8	14	2
	Mode	5.5	19.6	18	1.3	15	2.3
	Max	9.2	20.1	20	1.7	16	2.5
Stable angle (deg)	Min	24	24	24	30	24	24
	Mode	26	26	26	32	26	26
	Max	40	40	50	34	55	40
Long-term (m)	Min	-0.2	-0.2	-0.1	-0.5	-0.13	-0.13
	Mode	-0.15	-0.15	-0.06	-0.3	-0.12	-0.12
	Max	-0.08	-0.08	-0.03	-0.1	-0.1	-0.1
Closure slope (beaches)/SLR response factor (cliffs)	Min	0.2	0.2	0.2	0.05	0.2	0.2
	Mode	0.3	0.3	0.3	0.06	0.3	0.3
	Max	0.4	0.4	0.4	0.08	0.4	0.4

9.6 Coastal erosion hazard assessment

Coastal erosion hazard distances for Te Puna are presented within Table 9-2 and an overview map in Figure 9-4. Histograms of individual components and resultant erosion hazard distances using a Monte Carlo technique are shown in Appendix B. For the purpose of this assessment all coastal erosion protection structures have been ignored (refer to main report Section 4.5.4).

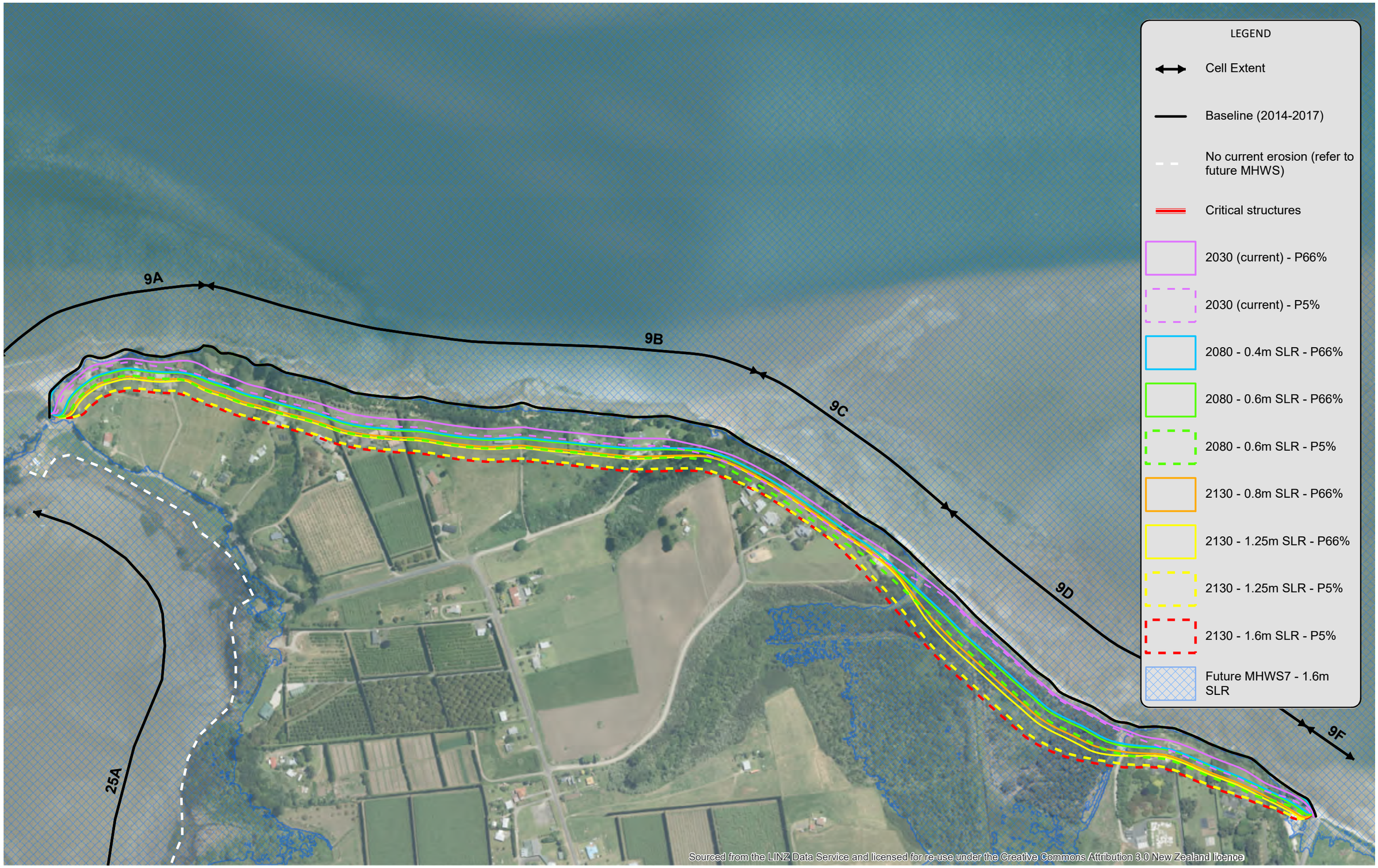
For the cliffs the current $P_{66\%}$ erosion hazard ranges from -5 m to -34 m. The current $P_{66\%}$ erosion hazard for the beach within Cell 9D is -12 m.

The future $P_{5\%}$ for 1.6 m SLR in 2130 ranges from -33 m to -76 m along the cliffs and -80 m for the beach within Cell 9D, where historic erosion rates have been high.

Table 9-2 Coastal erosion hazard widths (m) for current, 2080 and 2130 timeframes.

Site	Cell	Timeframe	SLR (m)	Probability of Exceedance					
				Max	$P_{66\%}$	$P_{50\%}$	$P_{5\%}$	$P_{1\%}$	Min
Te Puna	9A	Current	0.03	-7	-12	-13	-17	-19	-22
		50yr (2080)	0.12	-12	-19	-20	-25	-27	-31
			0.2	-13	-20	-22	-27	-29	-33
			0.4	-14	-23	-24	-30	-32	-36
			0.6	-15	-24	-26	-32	-35	-39
		100yr (2130)	0.22	-16	-26	-27	-34	-36	-41
			0.6	-19	-31	-33	-41	-44	-49
			0.8	-20	-33	-35	-44	-46	-52
			1.25	-21	-36	-39	-48	-52	-58
			1.6	-22	-38	-41	-51	-55	-62
	9B	Current	0.03	-25	-34	-36	-43	-45	-47
		50yr (2080)	0.12	-30	-41	-43	-51	-53	-56
			0.2	-31	-42	-45	-53	-55	-58
			0.4	-32	-45	-47	-56	-58	-61
			0.6	-33	-46	-49	-58	-60	-65
		100yr (2130)	0.22	-34	-48	-50	-60	-62	-65
			0.6	-37	-53	-56	-66	-69	-76
			0.8	-38	-55	-58	-69	-72	-80
			1.25	-40	-59	-62	-73	-77	-87
			1.6	-41	-61	-64	-76	-80	-91
	9C	Current	0.03	-15	-24	-27	-38	-41	-44
		50yr (2080)	0.12	-17	-27	-31	-41	-44	-48
			0.2	-17	-28	-31	-42	-45	-49
			0.4	-18	-29	-32	-43	-46	-51
			0.6	-19	-30	-33	-44	-47	-53

Site	Cell	Timeframe	SLR (m)	Probability of Exceedance					
				Max	$P_{66\%}$	$P_{50\%}$	$P_{5\%}$	$P_{1\%}$	Min
Te Puna	9C	100yr (2130)	0.22	-19	-31	-34	-45	-48	-52
			0.6	-20	-33	-36	-48	-51	-57
			0.8	-21	-34	-37	-49	-52	-58
			1.25	-21	-36	-39	-51	-54	-61
			1.6	-22	-37	-40	-52	-56	-63
	9D	Current	0.03	-8	-12	-13	-15	-16	-17
		50yr (2080)	0.12	-14	-25	-27	-37	-39	-42
			0.2	-15	-26	-29	-38	-40	-43
			0.4	-18	-30	-32	-41	-43	-47
			0.6	-21	-33	-35	-44	-47	-50
		100yr (2130)	0.22	-19	-38	-43	-58	-63	-66
			0.6	-24	-44	-49	-64	-69	-72
			0.8	-27	-48	-52	-67	-72	-76
			1.25	-33	-55	-59	-75	-79	-85
			1.6	-37	-60	-64	-80	-85	-92
	9E	Current	0.03	-12	-19	-22	-32	-34	-37
		50yr (2080)	0.12	-18	-25	-28	-38	-40	-43
			0.2	-18	-26	-29	-39	-41	-44
			0.4	-20	-28	-31	-41	-44	-46
			0.6	-21	-30	-32	-43	-45	-48
		100yr (2130)	0.22	-23	-31	-33	-44	-46	-49
			0.6	-26	-36	-38	-49	-51	-54
			0.8	-27	-37	-40	-51	-53	-57
			1.25	-29	-40	-43	-54	-57	-62
			1.6	-30	-42	-45	-56	-59	-64
	9F	Current	0.03	-4	-5	-6	-7	-7	-7
		50yr (2080)	0.12	-9	-11	-11	-13	-13	-14
			0.2	-10	-12	-13	-14	-14	-15
			0.4	-12	-14	-15	-16	-17	-18
			0.6	-13	-16	-16	-18	-19	-20
		100yr (2130)	0.22	-14	-17	-17	-19	-19	-20
			0.6	-17	-22	-22	-24	-25	-26
			0.8	-18	-23	-24	-26	-27	-29
			1.25	-19	-26	-27	-30	-31	-34
			1.6	-20	-27	-28	-33	-34	-37



Notes: Aerial photograph sourced from the LINZ Data Service (dated 2015)

A3 SCALE 1:5,000

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Tauranga Harbour Coastal Erosion Assessment

Erosion Hazard Overview

Site 9: Te Puna

FIGURE No. Figure 9-4

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