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Legend

Set Back Distances
(Set back distance from bank/river interface.)

25 m
50 m
100 m
130 m

Steep Bank -
Setback may be reduced with site specific investigation.

Chainage (m)

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A

Scale 1 : 35,000 at A1

Map D2a
Mid Waikato Bed Degradation Development Set Back

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Legend

Set Back Distances

(Set back distance from bank/river interface.)

25 m
50 m
100 m
130 m

Steep Bank -
Setback may be reduced with site specific investigation.

Chainage (m)

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A

Environment Waikato REGIONAL COUNCIL

Scale 1 : 35,000 at A1

Map D2b
Mid Waikato Bed Degradation Development Set Back

Appendix E

Stakeholder Preferred Outcomes (interviews)

KEY STAKEHOLDER PREFERRED OUTCOMES FROM STAGES I, II, III & IV

Mid-Waikato Bed Degradation Investigations Stages III & IV - EW Contract No. AM20004/05-30

STAKEHOLDER ORGANIZATION	INTERVIEW DATE	REPRESENTATIVE	DEPARTMENT	PREFERRED OUTCOMES
Environment Waikato	27 May 2005	Murray Mulholland Senior Rivers Engineer Project Manager	Asset Management	*Natural river environment is maintained and enhanced. *Environmental stewardship. A zoned hazard map for bank stability including effects of predicted bed degradation over 100 years in alignment with EW regional responsibilites for natural hazard management. *Risk assessment based on hazard mapping and identified property and assets. *Management strategy for the use of the resource (waterway). *Definition of Capital Works options for including cost estimates for the LTCCP. *Cost benefit assessment of options, and peferred options to feed in to both the management strategy and the LTCCP.
Mighty River Power	27 May 2005	Mark Henry Environmental Advisor		*Maintenance of existing operational flexibility from Karapiro. *Understanding of others' perceptions about contribution from ramping. *Develop common understanding of the impact that structures built 50 years ago have had on sediment entrapment. *Decisions are based on agreed/appropriate science.
Hamilton City Council	02 June 2005	Leroy Leach Manager	Water & Waste Services	* Ensure that the bed degradation is fully understood and predicted over the next 100 years and that best management strategies are put in place to protect the banks, tributaries, public infrastructure, public access, public and private property *Establish agreement on future equitable cost sharing for capital works, bank protection and management of the waterways. *Establish suitable riverbank and tributary set backs for future community developments *Resolution of the MRP consent appeal by HCC and MRP
		Bill Featherstone Manager	Parks & Gardens	*Being able to comply with the RMA and Reserves Act and meet community aspirations for future development and protection of the reserves adjacent to the river as expressed through community consultation. *Ultimate goal is to hand over the reserves to the next generation in the same or better shape than exists at present. This includes maintaining continuous and safe access to waterways, protecting cultural sites, protecting infrastructure, maintaining existing natural environment especially through plant diversity (no Rome or London concrete lined waterways) and successfully limiting/reducing liability for HCC through protection and maintenance of the riverside reserves.
Waikato District Council	02 June 2005	Allan Turner Environmental Planner		* Define slope bank stability limit that accounts for bed degradation as predicted over the next 100 years. *Understand downstream impacts from potential upstream in-river works *Gain agreement on future equitable cost sharing for capital works, bank protection and management of the waterways. *Understand vulnerability of 'no-grow' zone that is present within the range of fluctuating river level changes *Establish suitable riverbank set backs for future community developments as framework for sub-divisions or building consent applications, preferably with clear parameters for site specific investigations.
Waipa District Council	06 July 2005	Tim Harty Water Services Manager	Utility Services	* Bed degradation and slope stability risk are understood over the 100 years timeframe so that a common ground is established for making priority and systematic decisions under the umbrella of Environment Waikato. * Have supporting documentation to deliver a common approach to respective councils that describe the proposed management strategies to protect the near-bank infrastructure. * Develop a consistent approach by each affected organization to manage the details of specific bank areas that require attention. *Understand the impact of future consent applications and reapplications such as for storm water discharge to the River.
Tainui	10 August 2005	Tim Manukau Environmental Manager	Environmental Unit Waikato Raupatu Trustee Company	* Improve and enhance the health and well-being of the river, physically, culturally and spiritually * Improve and enhance the natural environment of the river channel as much as possible. Use wood for construction over concrete/steel where appropriate. * Encourage responsible sustainable development, all solutions need to be considered in this context. *Access to the waterway is compulsary, especially at the Marae. Involve manawhenua on local matters of importance. *Tainui view with importance the need to protect, enhance and restore all waterways.

▪ Appendix F

River Section Priority Ranking

River Section Priority Ranking

	Distance from river mouth (km)				50 years	
Ref no.	From	To	Bank	Location	Bank Hazard (0 - 1.5m degradation)	Infrastructure
136	119.75	120.4	R	Hamilton East Cemetery	Severe	Walkway, park/rural, cemetery, timber landing.
125	118.41	118.48	L	Cobham Bridge	High	Bridge
64	108.72	108.92	L	Braithwaite Park, Pukete Sewer Bridge	High	Water, bridge, sewer pipe, parkland.
4	95.7	95.98	R	Regent Street, Turangawaewae Marae	High	Marae, residential property.
29	101.5	101.8	L	Affco Horotiu Meatworks	High	Meatworks & associated water treatment.
53	107.92	108.02	L		High	Water, stormwater outfalls, residential property.
48	107.2	107.37	L	Opposite Featherstone Park	High	Residential/rural property, stormwater, water, stormwater outfalls
49	107.37	107.55	L	Opposite Featherstone Park	High	Rural/park
61	108.68	108.72	L	Braithwaite Park	High	Parkland
87	111.85	112	L	St Andrews Terrace	High	Stormwater outfall, walkway?, residential property
107	115.8	116	L		High	Commercial property, stormwater outfall.
110	116.37	116.6	R	Hamilton East Shopping Centre	High	Stormwater outfalls, water, walkway, commercial property
129	118.64	118.85	R	Rogers Rose Gardens	High	Park, stormwater outfalls.
145	121	121.42	R	Hammond Park	High	Parkland, stormwater outfalls.
82	111.4	111.6	R	Donny Park - Perindale Road	High	Water, stormwater, residential property.
97	113.64	114.08	L	Fairfield Esplanade	High	Stormwater outfalls, water, residential property, timber landing, Waitawhiriwhiri Stream outfall.
134	119.3	119.75	R	Hamilton Gardens	High	Walkway, park, Waikato Institute of Technology Gardens Campus
11	97.7	98.14	L	Waikato Esplanade, Ngaruawahia (south)	High	Residential property, walkway/park
89	112.06	112.1	L	Matakanohi Reserve (Beerescourt)	High	Water, stormwater outfall, residential property.
92	112.54	112.55	R	Waikato Diocesan School for Girls	High	Residential
183	128.88	128.97	R		High	Rural/residential
35	103.26	103.27	R		High	Residential, rural.
57	108.45	108.6	R	Braithwaite Park	High	Rural/residential property.
68	109.12	109.17	R	Pukete	High	Residential property
146	121.03	121.11	L		High	Rural
158	124.08	124.16	L		High	Rural
21	99.3	99.33	R		High	Rural
26	100.93	101.08	L	Affco Horotiu Meatworks	High	Meatworks, water intake.
37	104.2	104.24	L	Hutchinson Road	High	Rural
119	117.57	117.71	L	Graham Park	High	Park, Hospital Drain outfall.
124	118.27	118.41	L	Yendall Park	High	Parkland
152	123.1	123.6	R	Newell Road	High	Rural
156	123.65	123.77	R		High	Rural
3	95.67	95.7	R	NIMT Railway Bridge 267 and SH1 Road Bridge, Ngaruawahia	Medium	Bridges
104	115.3	115.8	L	ECMT Railway Bridge 6 and Claudelands Bridge - Ferrybank	Medium	Stormwater outfalls, bridge, water, commercial property.
106	115.7	116.37	R	New Memorial Park - Victoria Bridge (Bridge Street)	Medium	Bridge, stormwater outfall, parkland, bridge, walkways
1	95.3	95.96	L	Waipa Confluence, Lower Waikato Esplanade, SH1 Bridge, Ngaruawahia.	Medium	Water, bridge, walkway.
2	95.3	95.67	R	Waipa Confluence, Rail Bridge	Medium	Residential property, water, bridges
28	101.49	102.63	R	Horotiu Road Bridge	Medium	Quarry, bridge, rural.
63	108.71	109.12	R	Pukete Sewer Bridge	Medium	Residential property, sewer, outfall structure
69	109.17	110.42	R	Pukete Road Bridge, Te Hikuwai Reserve (Flagstaff)	Medium	Bridge, reserve, stormwater outfalls, water.
70	109.59	109.6	L	Pukete Road Bridge	Medium	Bridge
94	112.79	114.12	R	Fairfield	Medium	Water, stormwater, stormwater outfalls, residential property, Fairfield Bridge, timber jetty.
96	113.29	113.64	L	Milne Park, Fairfield Bridge	Medium	Bridge, stormwater, residential property.
98	114.08	115.3	L	Boundary Road Bridge (Whitiora)	Medium	Bridge, stormwater outfalls, water, residential property
105	115.33	115.7	R	ECMT Railway Bridge 6 and Claudelands Bridge - Ferrybank, Jesmond Park	Medium	Bridge, stormwater outfalls, water, parkland, walkways.
109	116.2	116.86	L	Victoria Bridge (Bridge Street), Swimming Pool	Medium	Bridge, stormwater outfalls, water, commercial property.
127	118.5	118.64	R	Cobham Bridge - Rogers Rose Gardens	Medium	Bridge, park, stormwater outfall.
214	140.43	142.15	R	Grey Street	Medium	Bridge, residential, stormwater, stormwater outfalls, water, pipe bridge
6	95.98	96.15	R	Turangawaewae Marae, Ahurei Drive	Medium	Marae, residential property, stormwater outfall
101	114.5	115.03	R	Miropiko Reserve	Medium	Stormwater outfalls, residential property, water, timber landing
169	126.22	126.26	R		Medium	Rural
116	117.26	117.9	R	Hayes Paddock	Medium	Reserve, walkways.
181	127.51	130.3	L	Mystery Creek National Field Days Site	Medium	Golf course, rural/buildings, water intake
24	100.17	100.87	R	Perry's Quarry/Landfil	Medium	Quarry/landfill
22	99.33	99.43	R	Perry's Quarry/Landfil	Medium	Rural/quarry/landfill
27	101.08	101.5	L	Affco Horotiu Meatworks	Medium	Meatworks & associated water treatment.
30	101.8	102	L	Affco Horotiu Meatworks	Medium	Meatworks & associated water treatment.
32	102.6	104.2	L	Quarry	Medium	Quarry
45	106.3	106.38	L	Pukete Boat Ramp	Medium	Boat ramp - jetty and retaining walls, stormwater outlet
114	117.01	117.27	L		Medium	Water, stormwater outfalls, commercial property.
132	118.98	119.32	L	Mangakotukutuku Stream confluence, Sandford Park	Medium	Rural, water mains on pipe bridge.
217	142.6	142.97	R	Fergusson Bridge	Medium	Bridge, water, golf course.
14	98.25	98.3	L		Medium	Rural, walkway/park.
52	107.55	107.92	L	Pukete	Medium	Park/walkway
60	108.62	108.68	L	Braithwaite Park	Medium	Parkland
62	108.69	108.71	R	Pukete	Medium	Walkway/parkland
79	110.42	110.9	R	Opposite St Andrews Golf Course	Medium	Residential property, stormwater outfalls, water, private boat landing
85	111.65	111.85	L	St Andrews Terrace	Medium	Water, stormwater outfalls, residential property.
88	112	112.06	L	St Andrews Terrace	Medium	Water, stormwater outfalls, residential property, footbridge.
93	112.55	112.79	R	Waikato Diocesan School for Girls	Medium	Residential, stormwater outfall, boat ramp.
95	113	113.29	L	Milne Park	Medium	Parkland, stormwater outfalls, water.
108	116	116.2	L	Rowing Club	Medium	Commercial property, stormwater outfall.
111	116.6	116.89	R	New Memorial Park	Medium	Stormwater, water, parkland, walkways.
112	116.86	117.01	L	Roose Commerce Park	Medium	Stormwater outfalls, water, walkways
115	117.14	117.26	R		Medium	Stormwater outfall, walkways.
117	117.27	117.47	L	Hamilton Skills Centre (old pumping station)	Medium	Skills centre, stormwater outfall.
121	117.9	117.95	R	Dillicar Park/Graham Island	Medium	Park, walkways.
131	118.85	119.12	R	Hamilton Gardens	Medium	Walkway, park.
8	96.2	97.7	L	Waikato Esplanade, Martin Street - Thomas Street	Medium	Walkway/park, residential, water, stormwater outfall, wastewater
13	98.14	98.25	L	Waikato Esplanade	Medium	Walkway/park, residential property.
54	108.02	108.23	L		Medium	Stormwater outfall.
58	108.6	108.62	L	Braithwaite Park	Medium	Parkland
72	109.7	109.72	L		Medium	Walkway, residential.
76	109.99	110.06	L		Medium	Walkway, residential, stormwater outfalls.
78	110.12	111.22	L	St Andrews Golf Course	Medium	Residential, golf course, walkway, outfall structure
80	110.9	111.4	R	Queenwood, Wymer Road	Medium	Stormwater, water, residential property, Swarbicks Landing
84	111.6	111.65	R	Days Park (Chartwell)	Medium	Parkland
90	112.1	113	L	Matakanohi Reserve (Beerescourt)	Medium	Residential property, walkway?
118	117.47	117.57	L	Graham Park	Medium	Park, stormwater.
120	117.71	118.27	L	Graham Park	Medium	Park, stormwater.
122	117.95	118.1	R	Dillicar Park	Medium	Park, walkways.
133	119.12	119.3	R	Hamilton Gardens	Medium	Walkway, park, Hamilton Gardens building at ch1193
140	120.4	120.99	R		Medium	Walkway, stormwater.
221	143.3	143.5	L	Leamington	Medium	Residential property, stormwater outfall, water
66	108.99	109	L	Braithwaite Park	Medium	Residential property, water, stormwater outfall
99	114.12	114.2	R		Medium	Water, stormwater, residential property.
159	124.15	124.55	R	Redwood Grove	Medium	Rural/residential
167	125.92	126	L		Medium	Residential/rural, buildings
176	126.85	126.92	L		Medium	Rural/residential.
182	128.8	128.88	R		Medium	Rural/residential
185	129.4	129.55	R		Medium	Rural/residential
220	143.13	143.3	L		Medium	Residential
7	96.15	96.28	R	Porotaka Place	Medium	Rural/residential property.
20	99.3	100.93	L	Ngaruawahia Golf Course - Anzac Street East	Medium	Golf course, residential property, rural.
34	103.18	103.26	R		Medium	Residential, rural.
36	103.27	104.9	R		Medium	Residential, rural.
55	108.18	108.45	R	Pukete	Medium	Rural/residential property.
65	108.92	108.99	L	Braithwaite Park	Medium	Residential property, water.
91	112.15	112.54	R	Days Park (Chartwell) - Braithwaite Street	Medium	Residential property, stormwater, water, stormwater outfalls.
149	121.6	122.55	R		Medium	Rural/residential.
168	126	126.33	L		Medium	Residential/rural, buildings
175	126.55	126.85	L		Medium	Rural/residential, buildings, floating pontoon with access walkway
177	126.92	127.31	L		Medium	Rural/residential.
184	128.97	129.4	R	Blue Heron Place	Medium	Rural/residential
186	129.55	129.6	R		Medium	Rural/residential
219	143	143.13	L		Medium	Residential
148	121.42	121.6	R		Medium	Stormwater, rural/industrial.
38	104.24	105.25	L	Te Rapa Dairy Factory	Medium	Factory, rural, water intake.
46	106.38	107.2	L	Pukete Farm Park Equestrian Centre, Water Pollution Control Plant	Medium	Equestrian Centre, rural/industrial, wastewater outlet

River Section Priority Ranking

	Distance from river mouth (km)				50 years	
Ref no.	From	To	Bank	Location	Bank Hazard (0 - 1.5m degradation)	Infrastructure
213	140.31	142.3	L	Marlowe & Fletcher Streets.	Medium	Rural/industrial, stormwater.
40	105.25	105.43	L		Medium	Rural
126	118.48	118.6	L	Yendell Park	Medium	Parkland
130	118.7	118.98	L	Sandford Park	Medium	Park
135	119.32	119.8	L	Sandford Park to Peacockes Rd Esplanade	Medium	Rural
138	120.15	120.4	L		Medium	Rural
141	120.58	120.67	L	Peacockes Rd Esplanade	Medium	Rural
143	120.99	121	R		Medium	Parkland
144	121	121.03	L		Medium	Rural
160	124.16	124.4	L		Medium	Rural
163	124.72	124.8	L		Medium	Rural
165	124.81	125.53	R		Medium	Rural
171	126.33	126.37	L		Medium	Rural
187	129.6	130.3	R	Opposite the Mystery Creek National Field Days Site	Medium	Rural
188	130.3	130.54	L		Medium	Rural
193	131.76	132.45	R	Hooker Road	Medium	Rural
197	133.35	133.48	R	Duncan Road	Medium	Rural
199	134.17	134.62	L		Medium	Rural
201	135.55	135.6	L		Medium	Rural
203	136.25	136.3	R		Medium	Rural
10	97.12	97.8	R		Medium	Rural
15	98.3	98.47	L		Medium	Rural
17	98.6	99.3	R		Medium	Rural
18	98.75	98.81	L		Medium	Rural
41	105.43	105.9	L		Medium	Rural
42	105.72	106.65	R	Horsham Downs Golf Club	Medium	Golf course, rural.
44	106.19	106.3	L		Medium	Rural
59	108.6	108.69	R	Pukete	Medium	Stormwater outfall, rural
113	116.89	117.14	R	New Memorial Park	Medium	Water, stormwater, parkland.
128	118.6	118.7	L	Yendell Park	Medium	Parkland
137	119.8	120.15	L	Peacockes Rd Esplanade	Medium	Rural
139	120.4	120.58	L		Medium	Rural
147	121.11	123.46	L		Medium	Rural
151	122.62	123.1	R	Riverglade Drive	Medium	Rural
154	123.56	124.08	L		Medium	Rural
155	123.6	123.65	R		Medium	Rural
157	123.77	124.15	R		Medium	Rural
161	124.4	124.72	L		Medium	Rural
162	124.55	124.81	R		Medium	Rural
164	124.8	125.92	L		Medium	Rural
166	125.53	126.22	R		Medium	Rural
170	126.26	126.38	R		Medium	Rural
174	126.51	127.2	R		Medium	Rural, golf course.
179	127.3	128.8	R		Medium	Golf course
190	130.54	131.04	L		Medium	Rural
192	131.45	131.99	L	Kaipaki	Medium	Rural
195	132.45	133.35	R		Medium	Rural
196	133	134.17	L		Medium	Rural
198	133.48	136.25	R	Pukeroro	Medium	Rural
200	134.62	135.55	L		Medium	Rural
202	135.6	137.53	L		Medium	Rural, water intake.
204	136.3	138.2	R		Medium	Rural
207	138.6	138.78	R		Medium	Rural
223	147.24	147.75	L		Medium	Rural
225	148.73	148.76	L		Medium	Rural
227	149.31	149.38	L		Medium	Rural
100	114.2	114.5	R	Boundary Road Bridge (Whitiora)	Low	Bridge, residential property, water, stormwater.
31	102	102.6	L	Horotiu Road Bridge	Low	Bridge, rural.
67	109	109.59	L	Pukete Road Bridge	Low	Bridge, water, stormwater outfall, residential property
172	126.37	126.55	L	The Narrows	Low	Bridge, rural.
205	137.53	139.11	L	Pukerimu	Low	Electricity (high power), rural/industrial, water intake
208	138.78	140.43	R		Low	Rural, electricity (high power)
218	142.97	149.6	R	Cambridge Golf Course	Low	Electricity (high power), golf course, rural, stormwater outfalls, wastewater, water
224	147.75	148.73	L		Low	Rural, electricity (high power)
23	99.43	100.17	R	Perry's Quarry/Landfil	Low	Quarry/landfill
212	140.2	140.31	L		Low	Rural, water, wastewater.
216	142.3	143	L	Fergusson Bridge	Low	Bridge, water, stormwater, wastewater, residential.
74	109.76	109.81	L		Low	Walkway, residential.
211	140	140.2	L	Cambridge Wastewater Treatment Plant	Low	Treatment plant, water, wastewater,
5	95.96	96.2	L	Market Street	Low	Residential, water, stormwater outfall
56	108.23	108.6	L	Braithwaite Park	Low	Parkland
71	109.6	109.7	L		Low	Water, stormwater outfall, walkway.
73	109.72	109.76	L		Low	Walkway, residential.
75	109.81	109.99	L		Low	Walkway, residential.
77	110.06	110.12	L		Low	Walkway, residential.
86	111.65	112.15	R	Days Park (Chartwell)	Low	Parkland
123	118.1	118.5	R	Dillicar Park	Low	Residential property, stormwater outfall, walkways
215	142.15	142.6	R	Victoria Bridge (Cambridge)	Low	Walkways, water
102	115.03	115.18	R		Low	Residential property
103	115.18	115.33	R	North of Claudelands Bridge	Low	Residential property, stormwater outfall, water
180	127.31	127.51	L		Low	Rural/residential.
209	139.11	139.24	L	Cambridge Wastewater Treatment Plant	Low	Wastewater treatment plant, rural.
210	139.24	140	L	Cambridge Wastewater Treatment Plant	Low	Wastewater treatment plant, rural.
50	107.38	107.42	R		Low	Rural
83	111.5	111.65	L	St Andrews Golf Course	Low	Golf course, stormwater outfall.
142	120.67	121	L		Low	Rural
189	130.3	131.76	R	Pencarrow Road	Low	Rural
9	96.28	97.12	R		Low	Rural
12	97.8	98.6	R		Low	Rural
16	98.47	98.75	L		Low	Rural
19	98.81	99.3	L	Ngaruawahia Golf Course	Low	Rural, golf course.
25	100.87	101.49	R		Low	Rural
33	102.63	103.18	R		Low	Rural
39	104.9	105.72	R	Horsham Downs Golf Club	Low	Golf course
43	105.9	106.19	L		Low	Rural
47	106.65	107.38	R	Featherstone Park	Low	Rural
51	107.42	108.18	R	Featherstone Park	Low	Rural, stormwater outfall at ch1072.
81	111.22	111.5	L	St Andrews Golf Course, Swarbricks Landing	Low	Golf course, stormwater outfall.
150	122.55	122.62	R		Low	Rural
153	123.46	123.56	L	Nukuhau Pa	Low	Rural
173	126.38	126.51	R		Low	Rural, golf course.
178	127.2	127.3	R		Low	Golf course
191	131.04	131.45	L		Low	Rural
194	131.99	133	L		Low	Rural
206	138.2	138.6	R		Low	Rural
222	143.5	147.24	L	Opposite Cambridge Golf Course	Low	Rural
226	148.76	149.31	L		Low	Rural
228	149.38	149.6	L	Karapiro Dam	Low	Rural, dam.

▪ Appendix G

Options to Manage Bed Degradation

G1 – Directly Control or Slow Bed Degradation

1 Degradation projections and mechanisms

The bed degradation in the mid-Waikato reach is assessed by Graeme Smart in *Degradation of the Waikato River, Karapiro to Ngaruawahia, Review of existing knowledge and recommendations for future work*, prepared for Environment Waikato, August 2003. He projects degradation in the bed through Hamilton as a tilting plane with an imaginary hinge in the vicinity of Karapiro Dam. His projections are given in Table G1-1.

Table G1-1

Future mean bed levels predicted by extrapolating present trends

Location	River distance	Rate of fall in mean bed	Fall below present by 2050
Bed plane below Narrows	km 126.0	17.3 mm/yr	0.8 m
Victoria Bridge mean bed level	km 116.3	28.2 mm/yr	1.3 m
Bed plane below Hamilton (XS 140)	km 106.3	32.3 mm/yr	1.5 m

Source: Smart, August 2003.

Smart discusses the mechanisms which could contribute to the degradation in *Analysis of Degradation. Waikato River Karapiro to Ngaruawahia*, prepared for Environment Waikato, August 2005.

Smart assesses that the present degradation is primarily due to upstream hydro dams:

> *"The hydro dams upstream of Cambridge currently trap bed material that would have been transported past Karapiro prior to construction of the dams. The trapped volume is estimated to be over 100,000 m^3/yr, which is similar to the average annual volume of degradation between Karapiro and Ngaruawahia. This indicates that the river is degrading downstream of Karapiro in order to recover the deficit of bed material created by the upstream hydro lakes (Hicks, 2003)."*

Smart reports that Stage II investigations indicate that, at the sites measured, the entrainment process is episodic, only taking place during and following flood surges. Very rapid ramping moved but did not break a protective surface layer of gravel on the bed. Without the protective gravel, ramping waves could move enormous volumes of sand. Ramping therefore has the potential to significantly affect degradation rates, depending on the composition of the river bed surface.

Smart assessed the effect of other degradation mechanisms as minor. His summary is given in Table G1-2.

Table G1-2

Relative importance of factors causing the present degradation in the middle Waikato River

Process	Lower estimate	Upper estimate
Upstream hydro dams	85%	100%
Ramping of flows	2%	20%
Sand mining	0%	10%
Tongariro diversions	2%	5%
Land use changes	0%	10%
River management	0%	5%
Geomorphologic processes	-10%	0%

Notes:

1. As all lower (or upper) estimates in the table will not coincide, the columns do not add up to 100%.
2. Source: Smart, August 2005.

2 Global options

Possible remedial measures to address the bed degradation over the length of the Hamilton reach are listed below. These are only global options – local options to protect particular structures are considered in Appendix G2.

a. Restore sediment supply:

   1. Decommission / remove dams
   2. Release sediment past the dams
   3. Sacrificial bank erosion

b. Reduce sediment mobilisation through operating rules:

   4. Operate dams to reduce flood surges
   5. Operate dams to reduce ramping surges

c. Reduce sediment mobilisation through engineering works:

   6. Submerged rock sills
   7. Control weirs
   8. Erosion protection

These options have not been studied, but a preliminary assessment of each is discussed below.

Economic costs are taken as the construction cost plus other costs such as lost power generation and lost land, but do not include the benefit from controlling bed degradation.

2.1 Decommission / remove dams

Decommissioning and/or removal of the dams would ultimately restore the sediment supply to the middle Waikato reach. However, this would be at very high economic and environmental cost, due to loss of hydro generation and decades of river instability.

Mighty River Power prepared a report *Taupo Waikato Resource Consents Application: "No Consents" Baseline,* May 2002. This considers a regime in which all structures would remain on the bed of the river channel, but they would not be used to generate electricity or control flow.

Under this regime, fine sediments trapped behind the dams would be mobilised and flushed downstream. The system would be highly unstable for many decades. The river below the Karapiro dam would be highly impacted by sediment remobilisation and significantly reduced water clarity for decades.

Removal of the dams is expected to have similar unacceptable environmental effects.

Summary:

Technical effectiveness	High
Construction cost	Moderate
Economic cost	High
Social impact	High
Environmental impact	High
Cultural impact	High
Warrants further study?	No

2.2 Release sediment past the dams

Another way to restore the sediment supply downstream of Karapiro would be to release sediment past the dam.

Lake Karapiro is some 25 km long, and most of any sediment in the Waikato River would deposit at the upstream end, so it is not practicable to release the sediment by flushing from the dam. In practice there will be little sediment passing down the river into Lake Karapiro, due to the chain of dams on the river (most constructed since Karapiro Dam).

Any attempt to pass sediment through Lake Karapiro would require dredging from the head of the lake and from the mouth of the main tributary streams. The costs of this dredging operation would be high, and the quantity of sediment available would be insufficient to meet the sediment deficit in the river downstream, therefore the operation is unlikely to be worthwhile.

Summary:

Technical effectiveness	Low
Construction cost	High
Economic cost	High
Social impact	Low
Environmental impact	Moderate
Cultural impact	Low

Warrants further study? No

2.3 Sacrificial bank erosion

Smart (2003) quotes a technique used successfully in Europe. Removing bank vegetation at appropriate locations can encourage erosion at these sites. A resulting increase in bed load will then help reduce degradation of the bed.

The deficit in sediment supply downstream of Karapiro is some 100,000 m^3/year (Smart, 2003), which would need to be replaced by bank erosion, in order to control bed degradation.

For this technique to address the bed degradation in the Hamilton reach of the Waikato River, a suitable bank erosion site would be required between the Narrows and Hamilton (upstream of the narrows the river banks tend to be steeper and less likely to erode). Assuming erosion from 5 km of 20m high bank in this reach would require an annual loss of 1 m of bank to meet the sediment deficit: this is unlikely to be acceptable.

Summary:

Technical effectiveness	High
Construction cost	Moderate
Economic cost	Moderate
Social impact	High
Environmental impact	High
Cultural impact	Moderate/high
Warrants further study?	No

2.4 Operate dams to reduce flood surges

Stage II investigations indicate that degradation is primarily taking place during and following flood surges. One approach to controlling degradation is therefore to reduce the flood surges downstream of Karapiro dam.

This would require lower normal operating levels in Lake Taupo and the hydro lakes, so as to provide increased flood detention storage. The effect of this would be reduced generation, due to lower head at the power stations and to reduced storage for low inflow periods.

Restrictions on the permitted lake operating ranges may mean that the floods that cause most bed degradation cannot be attenuated significantly.

We recommend preliminary investigation of the likely feasibility of this option. Detailed study would be required to optimise the dam flood control operating rules with respect to bed degradation.

Summary:

Technical effectiveness	Moderate
Construction cost	Low
Economic cost	High
Social impact	Low
Environmental impact	Moderate/high (due to increased lake level range)
Cultural impact	Low

Warrants further study? Yes

2.5 Operate dams to reduce ramping surges

Ramping has the potential to significantly affect degradation rates, depending on the composition of the river bed surface. Smart (2005) suggests that ramping may be responsible for between 2% and 20% of bed degradation.

Elimination of ramping would convert the Waikato hydro system to meeting only base load, and not the twice daily peak electricity demand. The effect would be to cause electricity prices to rise significantly.

More realistically, operation rules could be developed to reduce the ramping rate downstream of Karapiro dam, in order to reduce the effect of ramping on bed degradation.

We understand that ramping operation rules have been studied in detail for the re-consenting of the hydro schemes, but these studies would not have taken account of the Stage II degradation studies. We recommend preliminary investigation of the implications of the Stage II studies for the ramping regime.

Summary:

Technical effectiveness	Low
Construction cost	Low
Economic cost	High
Social impact	Low
Environmental impact	Positive
Cultural impact	Low
Warrants further study?	Yes

2.6 Submerged rock sills

Sills have been used successfully to control degradation at bridges in degrading cobble and gravel bed rivers. They are less suitable in the Waikato River reach under consideration, because of the flat river gradient, and because the bed is predominantly fine material under a gravel armour layer.

The rock sills are envisaged as a layer of rock over the bed and banks of the river, to control the bed profile at intervals down the river. The sills would not be high enough to have a significant effect on the hydraulic profile of the river. The sills would therefore not prevent flood flows from breaching the gravel armour layer and re-suspending the finer material, which would be carried over the sills. Under normal ramping, unless the sills were placed flush with the armour layer, the sills would restrict the downriver movement of the armour gravel: this would result in the armour layer being breached immediately downstream of each sill, where increased degradation would result.

We consider it unlikely that submerged rock sills would be effective as a global solution to bed degradation. They could be considered for local bed control, however, to protect a specific structure (eg bridge or submerged pipe crossing), with suitable arrangements to control downstream degradation.

Summary:

Technical effectiveness	Low
Construction cost	Moderate
Economic cost	Moderate
Social impact	Low
Environmental impact	Low
Cultural impact	Low
Warrants further study?	No

2.7 Control weirs

Control weirs could be used to raise the flood water level so that the sediment transport capacity of the river is reduced. Depending on the selected arrangement and operation, the weirs may also raise normal water levels and thereby control bed degradation due to ramping.

A control weir would be most useful just downstream of Hamilton, to control bed degradation through the city, and avoid the impacts of that degradation on the Hamilton infrastructure.

The effect of a weir at Hamilton would be reduced bedload downstream of the weir, with consequently increased bed degradation in the downstream reach. To avoid this, a second weir would be required just downstream of the bridges at Ngaruawahia, at the confluence with the Waipa River. (A single weir at Ngaruawahia would not raise levels at Hamilton sufficiently to control bed degradation there without causing flooding near Ngaruawahia.)

A third weir to raise water levels upstream of the Narrows is unlikely to be justifiable, because the upstream reach has less bed degradation, and less infrastructure at risk.

The weirs at Hamilton and Ngaruawahia would reduce the sediment load in the river downstream. Detailed study would be required to assess the effects of this on downstream bed levels. The sediment load from the Waipa River would to some extent offset the impact downstream.

Appropriate arrangements and levels for the weirs would be the subject of detailed study, considering implications on existing infrastructure, flood levels and sediment transport. We envisage that the weirs would raise water levels by about two metres. There are three sub-options for the control weir arrangement:

a. Gated or inflatable weir

This structure would be on the bed of the river and would not affect normal water levels. Under normal conditions boat and fish passage would not be affected. The gates would only be raised or the weir inflated in advance of flood flows.

b. Fixed weir with boat lock and fish passage

A fixed weir would create a permanent rise in water level upstream of the weir, would eliminate any degradation due to ramping, and in time sedimentation could reverse some of the historic bed degradation. Negative effects are interference with river traffic and fish migration: these would be addressed by providing a boat lock and a fish passage.

c. Fixed weir with power station, boat lock and fish passage

This is functionally the same as sub-option b above, but generation from a low-head hydroelectric power station would offset some or all of the weir cost.

Summary:

	a) Gated or inflatable weirs	b) Fixed weirs	c) Fixed weirs with small hydro
Technical effectiveness	High	High	High
Construction cost	High	High	High
Economic cost	High	High	Low
Social impact	Low	Moderate	Moderate
Environmental impact	Low	High	High
Cultural impact	High	High	High
Warrants further study?	Yes	Yes	Yes

2.8 Erosion protection

Local bed degradation control can be provided by bed and bank armouring, eg using rock or articulated concrete block mattress. This could be extended to become a global option.

As with the control weirs option, the effect of bed armouring is to reduce the bed mobilisation, and therefore the sediment load passing downstream, and thus to increase bed degradation downstream. Therefore if bed armouring were planned for the Hamilton reach, it should be continued down to the Waipa confluence at Ngaruawahia, and detailed study would be required to assess the effects on downstream bed levels.

The river length from upstream of Hamilton to Ngaruawahia is some 24 km. Assuming 100 m mean lined perimeter and 600 mm rock armour layer thickness, that represents 1.44 million cubic metres (2.6 million tonnes) of rock.

The rock would need to be placed under water, after trimming the bed profile using pontoon-mounted plant. Suitable rock is not available locally, so the costs would be very high.

Alternatively one could use 2.4 million square metres of mattress. The mattress would be lowered in strips from a pontoon, but divers would probably be required to join adjacent strips. This alternative would also be high cost.

Total lining of 24 km of river would have a high environmental impact.

Summary:

Technical effectiveness	High
Construction cost	High
Economic cost	High
Social impact	Low
Environmental impact	High
Cultural impact	Moderate
Warrants further study?	No

3 Summary and recommendations

The options are summarised in Table G1-3.

None of the Options 1-3 to restore the sediment supply to the river is seen as practicable.

We recommend further study of Options 4 and 5, concerning the operating regime for the existing dams. This has presumably been subject to earlier studies taking account of flooding and bank erosion, but perhaps not of the impact on bed degradation. We therefore recommend preliminary studies to consider the implications of the Stage II degradation studies, and further optimisation studies if appropriate. Neither of these options is likely to arrest the bed degradation, but they could reduce the rate of bed degradation.

Option 7, control weirs, is the only global option with high technical effectiveness that warrants further study. Option 7a (gated or inflatable control weirs) has the lowest social, environmental and cultural impacts, while Option 7c (including small hydroelectric power stations) has the lowest economic cost. Subject to political acceptability, we recommend further study of all three sub-options (7a, 7b and 7c).

Table G1-3 Global options preliminary assessment

	Option	Technical effectiveness	Construction cost	Economic cost	Social impact	Environmental impact	Cultural impact	Warrants further study?
a. Restore sediment supply								
1	Decommission / remove dams	High	Moderate	High	High	High	High	No
2	Release sediment past the dams	Low	High	High	Low	Moderate	Low	No
3	Sacrificial bank erosion	High	Moderate	Moderate	High	High	Moderate/high	No
b. Reduce sediment mobilisation through operating rules								
4	Operate dams to reduce flood surges	Medium	Low	High	Low	Moderate	Low	Yes
5	Operate dams to reduce ramping surges	Low	Low	High	Low	Positive	Low	Yes
c. Reduce sediment mobilisation through engineering works								
6	Submerged rock sills	Low	Moderate	Moderate	Low	Low	Low	No
7a	Gated or inflatable control weirs	High	High	High	Low	Low	High	Yes
7b	Fixed control weirs with boat locks and fish passages	High	High	High	Moderate	High	High	Yes
7c	Fixed control weirs with power stations, boat locks and fish passages	High	High	Low	Moderate	High	High	Yes
8	Erosion protection	High	High	High	Low	High	Moderate	No

G2 – Manage the Effects of Bed Degradation

1 Introduction

The bed degradation in the mid-Waikato reach is assessed by Graeme Smart in *Degradation of the Waikato River, Karapiro to Ngaruawahia, Review of existing knowledge and recommendations for future work*, prepared for Environment Waikato, August 2003. Projected mean bed degradation in the Hamilton reach over the next 100-years is of the order of 3 metres. The projected drop in low flow water levels is less, about one metre, due to narrowing of the riverbed and to local high sills. These changes will have a significant impact on existing infrastructure.

The local bed degradation may be substantially more than the 3 metres mean bed degradation, due to varying bed materials, changing river cross-section, and the effect of bends in the river.

Smart (2005) concludes there is evidence of local widening at a number of locations but overall the river is narrowing (as measured at average annual flood level). The river morphology is highly dynamic and cyclic with previously widening reaches now narrowing and vice-versa. Degradation is greatest at narrow sections of the river. Continued bed degradation must eventually lead to bank collapse in many reaches.

The types of infrastructure at risk are given in the table below, with the nature of the risk:

Table G2-1

Risks to infrastructure

Infrastructure at risk	Risk factor		
	Bed degradation	Bank failure	Water level lowering
Bridge piers in river	Loss of lateral restraint, and possible undermining of piles		
Bridge piers on bank		Foundation failure	
Bridge abutments		Foundation failure Loss of embankment fill	
River bank walkways		Collapse into river	
Landings and boat ramps		Collapse into river	Insufficient water depth. Water further from bank.
Stormwater outfalls		Collapse into river	Scour channel to river
Water intakes		Collapse into river	Insufficient water depth. Water further from bank.
Buried pipe crossing	Scour/ exposure to damage	Collapse into river	

Identified infrastructure is on the photographs and spreadsheet, and river distances are marked on the GIS (see Appendices A, B and J). River distances are nominally from the river

mouth: they have been set to match the km 126.4 used by Smart at Narrows Bridge: there are minor differences in river distance upstream and downstream of this point.

Global options to address the degradations have been discussed Appendix G1. This Appendix G2 considers local options that may be required if a global option is not pursued.

The local options include:

- Install or extend bank protection (rock armour, sheet pile walls, timber pile walls, gabions, stone masonry, sprayed concrete)
- Underpin bridges
- Bed armouring at bridge piers and the buried pipe crossing (but see Sections 3.1 and 3.6)
- Replace bridges
- Relocate infrastructure beyond zone of risk (if not water-linked), and allow banks to collapse.
- Relocate infrastructure so that access to water is maintained (landings, stormwater outfalls, water intakes).

2 Bank protection options

It is to be expected that bed degradation will lead to bank failure along significant portions of the river: particularly at the outside of bends, but also along straight reaches. Lengths where bank protection has previously been installed are likely to require additional protection.

Where land is available, the cheapest solution will be to allow the banks to collapse as the river degrades. Within urban areas, however, some form of protection is likely to be required. Options for this protection are given in Table G2-2. In most situations, the recommended option is to use rock armour, because of its flexibility, and the possibility of adding additional rock to top up the protection as required by ongoing bed degradation. In specific cases, other methods will be appropriate, but rigid linings will not be acceptable over extended length of bank, because they restrict the habitat for plant and fish life.

Table G2-2

Bank protection options

Bank protection	Type	Comments
Vegetation	Flexible lining	Low cost; only protects above normal water level.
Rock armour	Flexible lining	Easily extended. Recommended where space available and direct access to river not required.
Rubble armour	Flexible lining	Easily extended. Visually undesirable.
Gabions	Flexible lining	20-year life. Difficult to construct below water level.
Sprayed concrete lining	Rigid lining	Liable to toe failure. Cannot be applied below low water level.
Steel sheet piling	Rigid wall	High cost. Could be retrofitted in front of existing walls, or where ready access to the river is required (e.g. boat ramps).
Timber piled retaining wall	Rigid wall	Liable to toe failure. Possibility of adding extra wall later to protect toe.
Concrete block wall	Rigid wall	Liable to toe failure. Difficult to construct below water level.
Stone masonry wall	Rigid wall	Liable to toe failure. Difficult to construct below water level.

3 Local options to address bed degradation

3.1 Bridges

There are 15 bridges over the Waikato River in the reach under consideration, and also two bridges over tributaries at their confluence. Most have piers in the river. These will be exposed to increased scour risk due to bed degradation. The loss of lateral support may be an issue for some bridges. Those with abutments or piers close to the riverbanks may be vulnerable to bank instability caused by bed degradation.

Recommendations:

- Monitor riverbed cross-section at each bridge every 5-10 years.
- Review record drawings and bridge design for the impact of bed degradation on foundation stability.
- Underpin bridge piers or replace bridge if necessary.

Bed armouring at piers has not been recommended, because the projected extent of bed degradation would be likely to lead to break up of any armouring layer.

Submerged rock sills are discussed in Appendix G. They are not recommended, because of the potential degradation downstream of the sill.

3.2 River bank walkways

Walkways extend along both banks of the river through most of Hamilton City over a total riverbank length of some 29 km: from approximately km 106, near Pukete Boat Ramp, to Sandford Park (km 119.5 left bank) and Mangaonua Stream (km 121.6 right bank). These banks are presently protected by a mixture of natural vegetation, flexible revetments (rock or rubble armour, and gabions) and rigid protection (steel sheet piling, timber-piled retaining walls, stone masonry walls, and sprayed concrete lining).

The walkways will be vulnerable to bank collapse triggered by bed degradation. Bank instability can be addressed by the methods described in the Section 2. At some locations it may be possible to relocate the footpath to avoid bank collapses, or to put the footpath onto an elevated timber walkway.

3.3 Landings and boat ramps

Landings and boat ramps are at risk from bank collapse triggered by bed degradation, as well as from the water level lowering leaving the structures in inadequate water depth.

Bank instability can be addressed by the methods described in the Section 2.

Inadequate water depth at landings will normally require the landing to be relocated in deeper water, by adding an extra flight of timber steps. In some cases it may be appropriate to excavate the bank at the landing to provide sufficient water depth

Inadequate water depth at boat ramps will normally require the ramp to be extended into deeper water. Sometimes it may be preferable to reconstruct the ramp at a lower level.

3.4 Stormwater outfalls

Stormwater outfalls are at risk from bank collapse triggered by bed degradation, as well as from the water level lowering leaving the structures vulnerable to erosion and more visible.

Bank instability can be addressed by the methods described in the Section 2.

Outfalls will need new or extended toe erosion protection to deal with falling river levels. Rock armour, gabions or steel sheet piling are suitable methods: the selection will depend on any existing protection at the structure, or adjacent bank protection. Alternatively outfalls may be lowered and extended.

3.5 Water intakes

Water intakes are at risk from bank collapse triggered by bed degradation, as well as from the water level lowering affecting the operation of the intake.

Bank instability can be addressed by the methods described in the Section 2.2.

Irrigation intakes are typically mounted on floating pontoons, which may need to be moved into deeper water, but will otherwise be unaffected by bed degradation.

There may be a need to relocate fixed intakes at lower level, further out. Intakes for Hamilton water supply, the dairy factory and the meat works are all fixed structures. It will be necessary to review the record drawings for these structures to assess the impact of falling water levels: e.g. ability to capture water and pump suction head.

3.6 Buried pipe crossing

A buried pipe crossing close to the Hamilton Water Treatment Station may be vulnerable to bed degradation. We are not aware of other buried pipes or cables crossing the river.

Recommendations:

- Monitor riverbed at the site every 5-10 years
- Review record drawings for the impact of bed degradation
- Use a submerged rock sill if necessary. This is likely to be cheaper than reconstructing a deeper crossing, but there are river morphology issues, see Section 2.6 of Appendix G. Ongoing monitoring would be required.

G3 – Six Engineered Options for High Priority Sites at Risk from Predicted Future Bed Degradation

1 Priority Areas and Actions

Priority areas have been identified that should be addressed in the short term (1-3 years) at the same time the acceptability of bed degradation is being assessed. Stage III of the study investigated the areas of bank instability hazard and matched this with the priority rankings formulated by the Bed Degradation project group. The result is a priority table of sites (Appendix F). The highest priority sites are those where the combined risk of bank stability hazard and where assets/infrastructure and/or public safety is at risk (ranked as highest priority by Bed Degradation Project Team). The following section outlines possible site-specific engineered options for the top six priority sites if passive or soft-engineered options are not deemed appropriate.

Cost Estimates

The estimates presented in this report have been provided to indicate a very rough order of cost, and have been based on visual observations only. It must be appreciated that the final installed costs could vary significantly from these estimates once more investigation and design solutions are explored. The estimates presented should not be used for any purpose other than to indicate a probable cost guide.

Initial enquiries suggest that any work carried out which requires barge access is subject to very limited availability. All estimates that include such costs will be subject to significant variation should either local availability or size prove restrictive or unavailable. It is likely that segmental barges may have to be transported from external sources to suit this purpose with an unknown cost at present, which is not covered within the estimate values given below.

1. Hamilton East Cemetery (km 119.7 – km 120.4, RB)

Existing Situation/Problem

This 700-metre length is on the outside of a bend below a moderately steep and high slope, vegetated with tree and bush species. There is evidence of large-scale historical slope movement.

Behind the riverbank are a riverside walkway, parkland and Hamilton East Cemetery.

Resolution

To stabilise this slope, construction of a rock-armoured fill toe to the slope is recommended. The top of the fill would be a 3-m wide berm at RL 13.0 m, which is the top of the ramping range. A 5-m wide rock blanket extending beyond the toe of the slope (at existing bed level RL 6.5 m) would drop down providing protection as the bed degrades.

Cost Estimate $6 - $8m

2. Cobham Bridge (km 118.5)

Existing Situation/Problem

Cobham Bridge takes SH1 over the Waikato River, and is the major crossing on the south side of Hamilton.

Two of the bridge piers are in the river, with pile caps just above water level. The piers are exposed to increased scour risk due to bed degradation. The loss of lateral support may be an issue.

Failure of the bridge due to bed degradation would lead to severe traffic disruption.

Resolution

The susceptibility of the bridge to bed degradation is not known. We recommend:

- Monitor the riverbed cross-section at the bridge every 5-10 years.
- Review the record drawings and bridge design for the impact of bed degradation on foundation stability.
- Underpin the bridge piers or replace the bridge if necessary.

Cost Estimate $5,000

3. Braithwaite Park, Pukete Sewer Bridge (km 108.7 – km 108.9, LB)

Existing Situation/Problem

a. Bridge

The Pukete Sewer Bridge is a significant part of the Hamilton infrastructure.

Two of the bridge piers are in the river. The piers are exposed to increased scour risk due to bed degradation. The loss of lateral support may be an issue.

Failure of the bridge due to bed degradation could have severe environmental effects.

b. Revetments

Gabion revetments have been used to protect the riverbank walkway and access to timber steps adjacent to Braithwaite Park. Between portions of gabion revetment, the bank is protected by trees and bush. The gabions do not extend below low water level, and show evidence of undermining at the toe.

c. Landing

Water level lowering as the result of bed degradation will mean that the water depth at the landing will be too shallow in future.

Resolution

a. Bridge

The susceptibility of the bridge to bed degradation is not known. We recommend:

- Monitor the riverbed cross-section at the bridge every 5-10 years.
- Review the record drawings and bridge design for the impact of bed degradation on foundation stability.

- Underpin the bridge piers or replace the bridge if necessary.

b. Revetments

The existing gabions that are not already undermined can be stabilised by armouring the slope below the gabions with rock. Where the existing gabions are already undermined, we recommend that they be removed and replaced by rock armouring.

We recommend continuous rock armouring of this reach, including below the areas of existing trees and bush, which should be left in place.

A 5-m wide rock blanket extending beyond the toe of the slope (at existing bed level RL 7.0 m) will drop down providing protection as the bed degrades.

c. Landing

The landing will need to be extended into deeper water in future.

Cost Estimate $750K - 1.0m (revetment only)

4. Turangawaewae Marae (km 95.6 – km 96.0, RB)

Existing Situation/Problem

This 400-m reach is at the outside of the bend upstream of the Ngaruawahia bridges (NIMT rail bridge and SH1 road bridge). The 200 metres below Regent Street, immediately upstream of the bridges, are vegetated with trees and bush. Further upstream, below the marae, the bank is primarily grass-covered.

Bank erosion due to bed degradation at this site could affect the bridge abutments and piers at the bank (with serious consequences for transport links), Regent Street and the marae.

Resolution

To stabilise this slope, we propose rock-armouring the slope. Some fill would be required to extend the armour to the top of the ramping range. A 5-m wide rock blanket extending beyond the toe of the slope (at existing bed level RL 6.5 m) will drop down providing protection as the bed degrades.

Cost Estimate $2.5 - $3m

5. Affco Horotiu Meat works (km 101.5 – km 101.8, LB)

Existing Situation/Problem

This site is on a straight section of river, below a treatment pond associated with the meat works.

The 5 hectare treatment pond is set back some 60 m from the edge of the river. The 300 m by 60 m area between the pond and the river is at a shallow slope and primarily grassed, but includes a 140 m by 40 m block of trees.

There would be severe environmental effects if the side of the treatment pond were breached by river bank erosion.

Resolution

There is low risk of river bank erosion extending to the treatment pond, therefore we do not consider rock armouring of the bank to be justified at this stage.

We recommend planting trees in the area between the treatment pond and the river, to lower the risk of bank erosion at this site. Rock armour could be added later if monitoring indicated that the treatment pond was at risk.

Cost Estimate $100K - $150K (Depends on maturity and tree spacing)

6. NIMT Railway Bridge 267 and SH1 Road Bridge, Ngaruawahia

Existing Situation/Problem

These two bridges are important as part of the national transport infrastructure.

Their northern (right bank) abutments are at the downstream end of an outside bend, so could be vulnerable to bank instability caused by bed degradation.

Both bridges also have piers located at the bank, which could be vulnerable to bank instability.

Both bridges have two piers in the main river channel. The piers are exposed to increased scour risk due to bed degradation. The loss of lateral support may be an issue.

Resolution

Bank instability can be addressed by rock lining, included above under Turangawaewae Marae.

The susceptibility of the bridge piers to bed degradation is not known. We recommend:

- Monitor the riverbed cross-section at the bridges every 5-10 years.
- Review the record drawings and bridge designs for the impact of bed degradation on foundation stability.
- Underpin the bridge piers or replace the bridges if necessary.

Cost Estimate $10,000

Appendix H

Statutory Responsibilities Related to Bed Degradation

Appendix H – Statutory Responsibilities Related to Bed Degradation

1 Statutory Context

As a strategic document, the purpose of the Bed Degradation Management Strategy is to provide direction to both the Territorial Authorities and the Regional Council when managing the bed degradation hazard. It is a non-statutory document prepared to highlight management approaches of bed degradation in the river, to minimise risks of hazards to public health and safety, community wellbeing, infrastructure and private properties. Although a non-statutory document, the Statutory Context of the strategy is important in highlighting the drivers behind the work. It is also important to recognise the influence that national, regional and district strategic and policy documents and past community consultation provide to the Bed Degradation Management Strategy.

1.1 Local Government Act 2002

The purpose of the local Government Act 2002 (LGA) is to provide a framework for local authorities to decide which activities they undertake and the manner in which they will undertake them; promote the accountability of local authorities to their communities; and provide for local authorities to play a broad role in promoting the social, economic, environmental, and cultural well-being of their communities, taking a sustainable development approach. One stated purpose of Local government is *to promote the social, economic, environmental, and cultural well-being of communities, in the present and for the future (section 10(b))*. The LGA sections that relate to the strategy are discussed in more detail in the technical appendices accompanying this report.

Section 93 of the Local Government Act 2002 states that a local authority must have, at all times, a long-term council community plan (LTCCP). LTCCPs must state community outcomes, which are a desired future position or state (similar to a vision). The community outcomes currently identified in the Regional Council and Territorial Authorities LTCCP development processes are discussed briefly below:

Environment Waikato LTCCP

The Environment Waikato LTCCP identifies the main community outcomes that relate to hazards as

- Risks to people and property from natural hazards and accidents are minimised.
- Communities are more aware of Regional hazards and their risks and they are better prepared to respond appropriately.
- The public amenity values associated with rivers and streams will be secured and enhanced.

Waipa District LTCCP

Community Outcomes identified from the Waipa District Council LTCCP are: 1) Sustainable Waipa, 2) Healthy community, 3) Economic security, 4) Liveable Waipa (quality services and infrastructure) and 5) Vibrant and strong community.

Hamilton City LTCCP

The community's overall vision for Hamilton as outlined in Hamilton's Strategic Plan 2002–2012 is that:

"*Hamilton will continue to develop in a sustainable way, using fewer resources to achieve more social, economic, and environmental benefits for everyone in the city*".

There are six community outcomes identified: 1) Sustaining Hamilton's Environment, 2) Growing Hamilton, 3) Promoting Hamilton, 4) Experiencing Arts, Culture and Heritage in Hamilton, 5) Living in Hamilton and 6) Enjoying Hamilton.

Waikato District LTCCP

The Waikato District Council has identified nine community outcomes following two rounds of consultation. They are:

1) Accessible Waikato - a district where the community's access to infrastructure, transport and technology meets its needs;

2) Active Waikato - a district that provides a variety of recreation and leisure options for the community;

3) Educated Waikato - a district where education options are varied, and allow our community to be skilled for work and life;

4) Green Waikato - a district where our natural resources are protected, developed and enhanced for future generations;

5) Sustainable Waikato - a district where growth is effectively managed;

6) Thriving Waikato - a district where business and industry are encouraged and supported and employment contributes to a successful local economy;

7) Vibrant Waikato - a district where our heritage and culture are recognised, protected and celebrated;

8) Well Waikato - a district where people can access quality community health and care services; and,

9) Safe Waikato - a district where people feel safe and supported within their communities, and where crime is under control.

1.2 Resource Management Act 1991

The Resource Management Act 1991 (RMA) provides a framework for the integrated and sustainable management of natural and physical resources. Avoidance or mitigation of hazards must be undertaken in a manner that achieves the purpose and principles of the RMA, and must be consistent with the provisions of the relevant statutory documents which derive from it. Explicit provisions relating to the management of river and lake beds are found within s13 of the RMA.

Part IV of the RMA relates to functions, powers and duties of central and local government. Section 30 states that Regional Councils must "*control of the use of land for the purpose of the avoidance or mitigation of natural hazards*." Section 31 sets out the functions of territorial authorities which includes the "*control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards….*" Under Sections 62, 65, 68, 75 and 76 of the RMA, regional policy statements, regional plans and district plans shall include policies, methods and rules to manage the effects of natural hazards, and the effects of land use on natural hazards where this is considered a "*significant resource management issue*".

Waikato Regional Policy Statement

The Waikato Regional Policy Statement (RPS) summarises the significant resource management issues relating to natural hazards as follows:

1. The roles and responsibilities of local authorities and other agencies for the management of natural hazards in the Waikato Region have not been agreed or clearly identified. Until this is done, inefficiencies and/or a duplication of functions may occur.

2. A lack of public awareness of the causes and potential effects of natural hazard events increases the likelihood of adverse effects when these events occur.

A number of implementation methods are proposed that outline EWs role managing hazards in the beds of rivers through the Regional Plan, identifying and prioritising hazards in the region and developing and undertaking mitigation plans and actions in conjunction with territorial authorities

Specifically relating to bed degradation management, the RPS sets the objective of "*a net reduction in the adverse effects of the destabilisation of river and lake beds*." An implementation method proposed to achieve this objective is to advocate to territorial local authorities that surface water activities are managed in a manner that avoids the destabilisation of the beds and banks of lakes and rivers. There is no specific policy that addresses bed degradation caused by activities other than surface water activities.

Waikato Regional Plan

The Waikato Regional Plan (WRP) outlines the important relationship Tangata whenua have with river and lake beds and specifically mentions the relationship of Waikato Tainui with the Waikato River who derive their identity, their health and their strength from the Waikato River (Section 2.2.3 of the WRP).

Section 4 of the WRP is the River and Lake module. In this section the WRP notes that "*destabilisation may cause changes in the course of rivers and streams, resulting in loss of land, damage to property and damage to infrastructural assets such as roads, bridges, flood protection and drainage works*".

The WRP has policies that seek to manage the effects structures may have on bed stability. The WRP states that Environment Waikato will also use environmental education programmes to inform the community and resource users of methods that protect the beds and banks of rivers and lakes from destabilisation.

It is noted that rule 4.2.15.1 of the WRP permits erosion protection measures in the River. Conditions around the structures look to control construction materials (i.e. not

corrodible objects and no steel visible in final construction) and ensure that the cross sectional area of the river is not reduced as a result of the structure location and lengths. The permitted activity rule highlights the fact that structures for the purpose of erosion control are deemed necessary in some situations and, if designed to minimise effects, are considered appropriate within the context of the river environment.

District Plans

a. Waipa District Plan

Of relevance to this strategy, the Waipa District Plan has a Policy (AD3) that requires state of the environment monitoring and activities in the District for the purposes of avoiding or mitigating natural hazards and to take necessary action as may be required.

The Waipa District plan does not have a natural hazards section. However Rule 1.7.1 requires land to be suitable for the proposed building or use. When deciding what land is suitable, hazard areas on planning maps and areas liable to flooding, erosion or landslip are specifically mentioned.

b. Hamilton City Proposed District Plan

The Hamilton City Proposed District Plan (HCDP) has an Environmental Protection Overlay (EPO) that identifies restrictions on development in areas that are adjacent to the Waikato River. The EPO closely coincides with and has been adjusted to incorporate identified potential natural hazard areas, particularly in terms of flooding and land instability (accelerated erosion).

Objective 3.2.1 of the HCDP aims to identify and mitigate the impacts from natural hazards on people, property, and the environment. The associated policies relate to avoiding or limiting intensification of development in hazard prone areas and ensuring stormwater disposal does not contribute to flooding, erosion and land instability. The HCDP implements these objectives and policies through the Environmental Protection Overlay, Reserves contributions (making provision for esplanade reserve to be acquired in hazard prone areas) and through subdivision and development rules that provide extra controls in hazard prone areas.

The Riverside Reserve Management Plan also contains objectives and policies to maintain the stability of the riverbanks. There is also a "Maori Landmarks on Riverside Reserves Management Plan (Nga Tapuwae O Hotumauea) " that has been developed for riverside reserves within Hamilton city and that is consistent with the Riverside Reserves Management Plan. This Management Plan also discusses European heritage sites in the Hamilton area. The 17 sites identified are not specifically recognised in the HCDP.

c. Proposed Waikato District Plan

Waikato District Council have an operative District Plan (WDP) and have prepared a new Proposed Waikato District Plan (PWDP) which was notified in September 2004. Section 41 of the WDP has objectives and Policies that relate to natural hazards avoidance. Subdivision and development in hazard-prone areas are discouraged to protect health, safety and property from unnecessary risks.

The PWDP planning maps for the study area indicate flood hazard areas where development is discouraged. However these areas are not exhaustive. Extensive areas of

the district are subject to some flood, erosion or subsidence hazards, but these areas are not shown on the Planning Maps. The Council has little site-specific knowledge of these.

1.3 Civil Defence Emergency Management Act 2002

The Civil Defence Emergency Management Act 2002 (CDEM) updates and redefines the duties, functions and powers of central government, local government, emergency services, lifeline utilities and the general public. The purpose of the CDEM is to improve and promote the reduction of risks, reduce community disruption from avoidable hazards and risks, reduce fiscal risks from the costs of disruption and promote more effective and efficient emergency readiness, response and recovery through the integrated activities of responsible agencies. The CDEM requires Environment Waikato and District and City councils in the Waikato Region to form a Waikato Civil Defence and Emergency Management Group (CDEM Group). Section 17 of the CDEM states the functions of a Civil Defence Emergency Management Group in relation to relevant hazards and risks is to identify, assess, and manage those hazards and risks, consult and communicate on risks and identify and implement cost-effective risk reduction.

▪ Appendix I

Valuations

1 Scope

The scope of the exercise was to assess the value attributed to assets within 100m of the banks of the mid-Waikato River. Assets include land, buildings, improvements, and infrastructure (bridges, roading, water reticulation, power reticulation).

2 Purpose

The purpose of the valuation is to provide an indication as to the dollar value of assets that may be affected by bed degradation of the river.

3 Methodology

3.1 Property Valuations

The Rating Valuations were used as a base. These are divided into rating units, which are the individual properties. These valuations are as at 2002 and 2003 depending on the local authority. They are made up of Land Value and Capital Value. By definition the Value of Improvements (buildings and site development) is the Capital Value less the Land Value.

The values were adjusted to 2005 values through analysis of current sales information by property type (category) and by local authority.

GIS was used to determine whether rating units were in or out of the 50 m and 100 m band distances from river. The area of each property within these bands was also determined using GIS.

The distance along the river was also calculated using GIS to enable grouping into hazard zones.

The property values reported are the capital values. The values are for property which is in the relative 50m or 100m band. Where a property is not wholly in the bands, the values were split on a pro-rata basis, using the area in the band compared to the total area of the valued parcel of property.

This assumes that the value in the improvements and the land is spread evenly over the parcel of property. To get a more accurate estimate would require the sighting of every individual property which is outside the scope of this project.

3.2 Infrastructure Valuations

The length of road within each band was assessed using GIS. The road width varies depending on the category and type. Area calculations of each section of road affected were determined and a unit rate was applied to assess replacement costs. Unit rates were varied depending on the type of road construction. The types identified include rural, urban, state highway and bridges.

Road widths were assumed to be between 6m and 8m depending on the type of road. Rural was split into either sealed or metalled road. Urban roads were assessed as having a footpath associated with them and this replacement cost was calculated using the length of the road within the buffer areas.

The replacement costs of other infrastructure was based on the assumption that major waste water, storm water, water supply and electrical reticulation use roadways as their conduits.

The lengths of the roads were used as a basis for the lengths of the reticulated infrastructure. Unit rates were assessed on average costs for each type of infrastructure and applied to assess a replacement cost estimate for each buffer zone.

Rural roads and state highways were assessed as having open drains for storm water and no water or waste water reticulation.

Karapiro dam and the associated generation station were not included in this assessment due to the complexity of the structures and the view that the dam would need to be treated as a separate exercise given the scope of this project.

3.3 Values Reported in the Table

The table lists the distance from/to of each hazard zone identified from the mouth of the river, which side of the river the assets are on, the general name of the location (where known), the hazard rating, the assets at risk, and the values of assets within the 50m and 100m buffer areas.

The attached table totals the following:

Pro-rata capital value in each hazard zone and distance from river band for the properties affected, based on the area in each band compared to the total area of each rating unit.

The infrastructure for each hazard zone was summed and added to the property valuations to form a total value for each hazard zone by 50m and 100m buffer areas.

4 Assumptions

No assessment was made of the environmental or structural soundness of any building or infrastructure and it has been assumed that the construction conforms to current building, fire, occupational health & safety etc regulations & codes.

Where information has been supplied by another party, this information has been taken to be reliable.

5 Limitations

This assessment encompasses only those assets identified in the scope.

The assessments and schedules have been compiled on the basis stated for the purpose stated herein.

The assessment information shall not be used for any other purpose. Any party that relies upon it for an alternative purpose without reference to Beca does so at their own risk.

Neither the entire nor any individual part of this report may be referred to or included in any published document, circular or statement without our written approval of the form and context in which it may appear.

Beca responsibility for this assignment is limited to Environment Waikato and to Environment Waikato only. Beca disclaim all responsibility and will accept no liability to any other party.

Beca reserve the right, but not the obligation, to review all calculations included or referred to in this report and, if considered necessary, to revise its opinion in the light of any information existing at the date of valuation which becomes known to Beca after the date of this report.

This was a desktop exercise only; no site surveys were carried out to reconcile the schedules and no responsibility can be accepted for errors, omissions or inclusion of assets no longer in existence. Furthermore, this report does not constitute an environmental audit.

Unless otherwise stated, no account has been taken of the effect on value due to contamination or pollution or of the possible effect on value of possible increases in standards for noise, emissions or waste disposal.

The values reported are assessed on a summary level and were completed as a desktop exercise. To this extent, they cannot be deemed reliable for use in determining reinstatement costs following a partial or full loss of the assets.

Distance From (m)	Distance To (m)	River Side	Location	Hazard	Types of Assets At Risk	Values of Assets within 50m (NZ$)	Values of Assets within 100m (NZ$)
95200	95950	Left	Lower Waikato Esplanade	Medium	Water, bridge	1,441,882	2,976,014
95200	95700	Right	Waipa confluence - North of SH1 bridge, Ngaruawahia	Medium	Residential property, water, bridge	4,491,302	8,169,086
95700	95900	Right	Regent Street	High	Residential property, water	208,833	2,069,561
95900	96050	Right	Turangawaewae Marae	Severe	Marae	134,201	1,144,817
96050	96150	Right	Ahurei Drive	High	Residential property, stormwater outfall	725,486	10,047,887
96150	96300	Right	Porotaka Place	Medium	Rural/residential property	35,257	744,794
96200	96500	Left	Martin Street	Medium	Residential, water, stormwater outfall	1,185,800	1,358,280
96300	97150	Right		Low	Rural	556,819	5,584,881
96500	97000	Left	Jordan Street - Ellery Street East (Waikato Esplanade)	High	Residential property, wastewater, water	306,425	1,617,636
97000	97300	Left	Belt Street - North Street	Medium	Residential property, wastewater, water	806,029	2,868,164
97300	97600	Left	North Street	Low	Residential property, wastewater, water	27,515	818,807
97350	97650	Right		High	Rural	223,986	445,765
97600	98150	Left	Ngaruawahia (south).	High	Residential property	904,314	4,393,943
97650	97750	Right	Driver Rd West	Medium	Rural property, some buildings	38,501	95,317
97750	98100	Right		Low	Rural	147,525	328,955
98100	99200	Right		Medium	Rural property, some buildings	1,314,708	3,682,320
98150	99000	Left	North of Ngaruawahia Golf Course	Medium	Rural/residential	383,448	1,051,488
99200	99350	Right	Opposite Ngaruawahia Golf Course	High	Rural property, some buildings	287,199	578,277
99350	100950	Right	Perry's Quarry/Landfill	Medium	Quarry/landfill, rural	397,679	831,488
99600	100850	Left	Ngaruawahia Golf Course	Medium	Golf Course	1,274,440	3,154,192
100850	100950	Left	Horotiu Meatworks	High	Meatworks	164,707	164,937
100950	101100	Left	Horotiu Meatworks	Severe	Meatworks	1,611,127	3,454,563
101100	101700	Right		Medium	Rural/quarry	21,701	42,452
101700	102050	Right		High	Rural/quarry	139,349	276,652
102050	102500	Right	Sullivan Road	Medium	Rural	-	-
102300	105500	Left	Horotiu Bridge	Medium	Bridge, quarry	1,775,557	2,190,918
102500	103200	Right	Horotiu Bridge	Low	Bridge, rural	1,569,510	2,098,219
103200	105300	Right	River Downs	Medium	Residential/rural property	5,165,580	13,554,246
104250	0	Left	Hutchinson Road	High	Rural	8,570,870	17,242,940
105500	106100	Left		Low	Rural	207,743	449,133
105500	105750	Right	Horsham Downs Golf Club	Medium	Golf Course	196,882	418,687
105800	106700	Right		Medium	Rural/residential property, water	4,627,133	9,360,891
106700	106950	Left	Water Pollution Control Plant	High	Stormwater, rural/industrial	315,188	853,091
106700	108050	Right	Featherstone Park	Low	Rural/residential property, water, stormwater outfalls	4,111,341	10,285,214
106950	107200	Left		Medium	Residential	403,200	588,800
107200	107550	Left	Opposite Featherstone Park	Severe	Residential property, stormwater, water Stormwater outfalls at ch1072 and ch1079	649,926	5,596,887
107550	107900	Left	Pukete	High	Residential	79,072	5,646,193
107900	108050	Left		Severe	Water, stormwater outfalls, residential property	1,317,008	8,383,053
108050	108700	Left	Braithwaite Park	Medium	Park	1,212,685	10,645,000
108050	108350	Right		Medium	Stormwater outfall	347,462	787,244
108350	108550	Right	Pukete	High	Stormwater outfall, water, residential property	560,310	2,881,619
108550	110450	Right	Pukete Road Bridge	Medium	Bridge, residential property, water, stormwater, stormwater outfalls	2,334,906	7,502,396
108700	109000	Left	Braithwaite Park	High	Water, Pukete Sewer Bridge	3,844,405	7,035,115
108700	0	Right		High	Residential property	3,059,368	12,931,113
109000	110350	Left		Medium	Water, stormwater outfalls, residential property	22,296,465	48,719,796
109100	0	Right	Pukete/ Flagstaff	High	Residential property	6,944,485	13,718,267
109650	0	Right	Te Hikuwai Reserve (Flagstaff)	High	Reserve	9,536,770	19,869,703
110350	110950	Left	St Andrews Golf Course	High	Golf course, stormwater outfall	958,944	2,057,282
110450	110950	Right	Opposite St Andrews Golf Course	High	Residential property, stormwater outfalls, water, private boat landing	8,354,492	16,309,975
110950	111200	Right	Queenwood	Medium	Stormwater, water, residential property	2,445,657	5,787,613
111200	111400	Right	Wymer Road	High	Water, stormwater, stormwater outfall, residential property, Swarbricks Landing	699,483	3,382,896
111400	111500	Right	Donny Park - Perindale Road	Severe	Water, stormwater, residential property	564,265	2,868,515
111500	111850	Left	St Andrews Terrace	Medium	Water, stormwater outfalls, residential property	2,082,985	7,464,832
111500	111650	Right		High	Residential property, stormwater, water	1,230,559	5,162,495
111650	112100	Right	Days Park (Chartwell)	Low	Park	582,342	1,026,275
111850	112250	Left		High	Water, stormwater outfalls, residential property, footbridge	6,025,335	15,959,768
112100	112500	Right	Days Park (Chartwell) - Braithwaite Street	Medium	Residential property, stormwater, water, stormwater outfalls	115,074	1,384,574
112250	113700	Left	Matakanohi Reserve (Beerescourt)	Medium	Water, stormwater outfalls, residential property, bridge, wastewater pumpstation and outfall	18,515,010	38,215,775
112250	0	Right	Days Park (Chartwell)	High	Park/residential property	3,540,598	7,372,759
112500	112800	Right	Waikato Diocesan School for Girls	High	Stormwater outfalls, residential property, boat ramp	6,847,381	12,838,654
112800	114150	Right	Fairfield	Medium	Water, stormwater, stormwater outfalls, residential property, Fairfield Bridge, timber jetty	27,291,661	47,657,394
113300	0	Left	North fo Milne Park	High	Stormwater, residential property	3,682,343	12,210,673
113700	114050	Left	Fairfield Esplanade	High	Stormwater outfalls, water, residential property, timber landing	8,848,959	19,318,678
114050	115000	Left	Boundary Road (Whitiora) Bridge	Medium	Bridge, stormwater outfalls, water	10,732,944	31,643,863
114150	114500	Right	Boundary Road (Whitiora) Bridge	Low	Bridge, residential property, water, stormwater	4,638,899	10,569,618
114500	115000	Right	Miropiko Reserve	Medium	Stormwater outfalls, residential property, water, timber landing	8,026,931	20,986,659
115000	115200	Left	Liverpool Street	Low	Stormwater outfall	2,198,180	8,265,271
115000	115200	Right		Low	Residential property	2,791,580	6,420,066
115200	115300	Left	Hamilton Street	Medium	Commercial property, stormwater	1,294,224	11,009,264
115200	115350	Right	North of Claudelands Bridge	Medium	Residential property, stormwater outfall, water	2,421,775	5,139,312
115300	115800	Left	Claudelands Bridge - Ferrybank.	High	Bridge, stormwater outfalls, water, commercial property	30,300,026	111,442,667

Distance From (m)	Distance To (m)	River Side	Location	Hazard	Types of Assets At Risk	Values of Assets within 50m (NZ$)	Values of Assets within 100m (NZ$)
115350	116500	Right	Jesmond Park to New Memorial Park	High	Residential property/park, stormwater, stormwater outfalls, water, Victoria (Bridge St) Bridge	5,622,671	11,343,109
115650	0	Right	North of Parana Park	Medium	Water	9,847,019	20,992,296
115800	115900	Left		Severe	Commercial property, stormwater outfall	2,999,523	9,687,251
115900	116200	Left		High	Commercial property, stormwater outfalls, water	5,758,909	33,776,601
116200	116900	Left		Medium	Stormwater outfalls, water, commercial property	4,554,066	18,376,945
116500	116600	Right	Hamilton East Shopping Centre	Severe	Commercial property, water, stormwater outfalls	591,473	3,523,580
116600	117000	Right	New Memorial Park	High	Park, water, stormwater outfalls, boat ramp	5,995,850	29,651,419
116900	117000	Left	Roose Commerce Park	High	Stormwater outfalls, water	907,877	2,592,543
117000	117300	Left		Medium	Water, stormwater outfalls, commercial property	3,020,607	8,441,810
117000	117800	Right	Hayes Paddock	Medium	Reserve	185,358	3,455,224
117200	0	Right		High	Stormwater outfall	2,675,975	7,667,497
117300	117700	Left		High	Park, Hamilton Skills Centre (old Pumping Station) Stormwater outfalls, Hospital drain outfall	982,003	1,714,629
117700	118250	Left	Graham Park	Medium	Park, stormwater	1,165,121	1,929,720
117800	118100	Right	Dillicar Park	High	Park, residential property	354,070	1,240,272
117900	0	Right	Graham Island	Severe	Park, residential property	1,096,538	3,614,288
118100	118600	Right		Medium	Residential	3,472,085	9,749,814
118250	118600	Left		High	Park	-	1,455,876
118500	0	Left	Cobham Bridge	Severe	Bridge	3,959,540	4,313,149
118600	118850	Left	Yendell Park	Medium	Park	-	48,825
118600	118950	Right	Rogers Rose Gardens	High	Gardens, stormwater outfall	247,536	699,553
118850	119150	Left	Sandford Park	High	Park, stormwater outfall, Mangakotukutuku Stream confluence, crossed by twin 450 dia water mains on pipe bridge	61,378	271,102
119150	119350	Left		Medium	Rural, water treatment plant intake	1,643,216	4,996,229
119350	120000	Left	Sandford Park - Peacockes Rd Esplanade	High	Park/rural	521,789	1,367,463
119350	120450	Right	Hamilton East Cemetery	Severe	Gardens (building at ch1193), cemetery, residential property Walking track adjacent to river, timber landing	2,984,585	9,339,903
120000	120700	Left	Peacockes Rd Esplanade	Medium	Rural	163,745	540,726
120450	120550	Right		Medium	Residential/reserve	627,479	3,037,133
120550	120800	Right		Low	Water, stormwater, residential property	564,476	3,865,836
120700	121000	Left	Weston Lea Drive	Low	Rural	374,043	753,000
120800	121000	Right		Medium	Stormwater	850,776	5,361,992
121000	121600	Right	Hammond Park	High	Residential/industrial, stormwater outfalls, park	4,479,892	15,389,626
121550	122400	Left	Peacockes Rd	High	Rural	466,747	909,768
121600	123050	Right		Medium	Industrial/residential property, stormwater	5,127,565	12,961,444
122400	124050	Left	Nukuhau Pa	Medium	Rural	434,985	875,001
122650	0	Right	Riverglade Drive	Low	Residential property	563,919	1,799,022
123050	123800	Right	Newell Road	High	Rural/residential property	762,695	1,555,391
123700	0	Right		Severe	Rural/residential property	190,259	404,848
124050	124300	Left		High	Rural	-	50,244
124200	125550	Right	Redwood Grove	High	Rural/residential	2,104,451	4,045,443
124300	125400	Left		Medium	Rural	689,639	1,571,669
124700	0	Left		High	Rural	89,343	266,699
125550	126000	Right		Medium	Rural	291,300	560,318
126000	126250	Right	North of Narrow's Bridge	High	Residential/rural, buildings	1,641,372	4,328,270
126250	126400	Right		Medium	Golf course	110,839	234,489
126400	126550	Left	The Narrows	Low	Bridge	789,663	904,619
126500	127200	Right		Medium	Golf course	351,122	776,556
126550	126900	Left	South of Narrow's Bridge	High	Rural/residential, buildings, floating pontoon with access walkway	1,130,072	1,668,546
126900	127300	Left		Medium	Rural	712,550	1,533,795
127300	127650	Left		Low	Rural/residential	282,977	576,230
127300	127800	Right		Medium	Golf course	8,907	8,907
127650	127800	Left		High	Rural	114,333	221,769
127800	128250	Left		Medium	Rural	173,690	346,950
127800	128800	Right		High	Rural/residential?	1,953,640	4,887,335
128250	128800	Left	Mystery Creek (Golf Course)	High	Rural/golf course	183,325	485,778
128800	128950	Right		Severe	Rural/residential?	957,340	2,355,350
128950	129100	Right	Blue Heron Place	High	Rural/residential	150,224	400,753
129100	129500	Left		High	Rural/golf course, water intake	294,322	601,407
129100	129450	Right		Medium	Rural/residential	1,212,574	2,928,293
129450	129700	Right		Severe	Rural/residential	630,117	1,404,472
129700	0	Left		High	Rural/golf course	594,974	1,226,954
129700	130450	Right	Opposite Mystery Creek National Field Days Site	High	Rural/residential	341,405	666,224
130200	130950	Left		High	Rural/buildings	241,413	574,886
130850	130950	Right		High	Rural	253,226	489,601
130950	131450	Left		Medium	Rural	82,246	185,270
131200	131350	Right	Pencarrow Road	High	Rural	99,498	196,931
131350	131750	Right		Medium	Rural	194,769	360,832
131450	131900	Left	Kaipaki	High	Rural	156,890	319,783
131750	132250	Right	Hooker Road	High	Rural	290,926	665,821
132000	132400	Left		Low	Rural	111,354	217,632
132250	132400	Right		Severe	Rural	271,117	731,909
132400	133000	Left		Medium	Rural	6,635	16,712
132400	133350	Right	Duncan Road	High	Rural	694,342	1,369,191
133000	133350	Left		High	Rural	81,297	156,484
133350	133650	Right		Severe	Rural	119,008	296,599
133800	134200	Left		High	Rural	120,646	248,030
133950	134450	Right		High	Rural	234,038	454,471
134200	134650	Left		Severe	Rural	476,501	862,334
134450	135600	Right		Medium	Rural	117,749	229,878

Distance From (m)	Distance To (m)	River Side	Location	Hazard	Types of Assets At Risk	Values of Assets within 50m (NZ$)	Values of Assets within 100m (NZ$)
134650	135000	Left		High	Rural	170,821	359,856
135550	0	Left		High	Rural	373,260	725,526
135600	135900	Right		High	Rural	312,669	618,533
136100	137900	Right		High	Rural	77,621	155,377
136500	137500	Left	North of Cambridge Wastewater Treatment Plant	High	Rural/industrial, water intake	370,233	755,666
137500	138250	Left	Pukerimu	Medium	Rural/residential, water intake	153,805	580,508
137850	0	Left		Low	Rural/residential	100,981	280,968
138000	138200	Right		High	Rural	289,081	539,935
138050	0	Left		Low	Rural/residential	214,994	632,474
138500	139100	Left	Cambridge Wastewater Treatment Plant	Medium	Rural, wastewater treatment plant	305,741	654,849
138600	138750	Right		High	Rural	21,205	39,827
138750	140450	Right		Medium	Rural	430,480	836,777
139300	140300	Left	Cambridge Wastewater Treatment Plant	Medium	Rural/industrial/residential, wastewater, water, stormwater outfall, pipe bridges, Victoria Bridge	215,664	1,893,242
140300	141250	Left		High	Rural	2,367,742	7,964,117
140900	141250	Right		High	Residential, stormwater, stormwater outfall, wastewater, water	1,900,680	6,213,858
141250	142000	Left	Marlowe, Fletcher Streets	Severe	Rural/industrial/residential, wastewater, water, stormwater outfall, pipe bridges, Victoria Bridge	1,080,121	6,884,919
141250	141500	Right		Medium	Residential, wastewater, stormwater	1,150,372	2,888,297
141500	141700	Right		High	Residential, stormwater outfall	12,884	3,169,103
141700	142550	Right	Victoria Bridge	Medium	Residential, stormwater, wastewater, water, bridge	3,366,173	7,838,886
142000	143100	Left	Fergusson Bridge	Medium	Bridge, water, stormwater, wastewater, residential	1,157,862	7,179,165
142550	0	Right		Low	Residential, water, wastewater	167,628	820,641
142700	143000	Right	Fergusson Bridge	High	Bridge, water	1,563,937	2,372,680
143100	143400	Left	Leamington	Severe	Residential property, stormwater outfall	2,300,726	7,747,675
143400	145700	Left	Opposite Cambridge Golf course	Medium	Rural	175,567	1,043,060
143400	149600	Right	Cambridge Golf Course - Karapiro Dam	Medium	Golf course/rural	499,373	1,243,154
145000	0	Left		Low	Rural	374,272	758,800
145700	146050	Left		High	Rural	171,406	353,401
146100	0	Right		High	Golf course/rural	50,602,109	80,309,189
147650	148000	Left		Severe	Rural, electricity (high power)	121,169	235,661
148000	148700	Left		Medium	Rural	249,491	497,837
148950	149450	Left		High	Rural	95,106	277,940
149450	149600	Left	Karapiro Dam	Medium	Rural, dam	22,206	52,383
					Totals	412,172,733	1,084,208,302

▪ Appendix J

GIS

Metadata for Waikato Degradation Shape File

Metadata Type		Description
Description		Predicted degradation along Waikato River
Purpose		For use in determining requirement for more detailed investigation on degradation along Waikato River and gaining an understanding of the potential for degradation along the Waikato River
Projection		New Zealand Transverse Mercator (NZGD2000)
Accuracy		Data has been captured using a number of datasets with varying degrees of spatial accuracy. Information used to define the location of particular instances was obtained from sources including photo interpretation, field inspections and hard copy reports. The data captured is not an accurate representation of the riverbank and is more closely related to the parcel boundaries. Data is designed to be viewed at 1:75,000 and should not be used at scales beyond which it was prepared for. The spatial accuracy of the data is estimated to be no better than +/- 50 m for located features.
Object Type		Polyline
Attributes	UniqueID	Unique ID of the record
	IsectID	ID used in working
	Class100y	100-year classification. Used to derive the 100-year rating. Valid values are 0-0.5,0.5-1, 1-2 and >2
	Rating100y	100-year rating. Used in calculation of values for the hazard score incorporating bias for degradation. Valid values are 0.50, 0.65,0.85 and 1.00,
	HzScoreDeg	Hazard score incorporating bias for degradation. Range: 1.50 to 11
	Hzscore	Hazard score not incorporating bias for degradation. Used as basis for calculating the Hazard Score incorporating bias for degradation for 100year, 50 year and 10 year scenarios. Calculated from values recorded for vegetation classification, vertical classification, river classification and bends classification. Range: 2.50 – 12.00