

*Middle Waikato Bed Degradation
Investigation Stages III & IV.*

Contract number: AM2004/5-30



**Proposed Middle Waikato River
Bed Degradation Management
Strategy**

May 2006

▪ report

Proposed Middle Waikato River Bed Degradation Strategy

Prepared for
Environment Waikato

By
Beca Infrastructure Ltd

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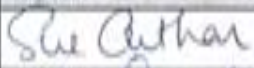
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1 Synopsis

This is the Proposed Middle Waikato River Bed Degradation Management Strategy including EW and stakeholder review and input. The proposed strategy is intended for further refinement with the community, particularly in regards to the vision and actions. Technical details supporting the development of the strategy are provided in separate appendices.

The Mid-Waikato Bed Degradation Investigation was initiated in 2003 under the leadership of the broader Project Watershed established to fund river management issues throughout the Waikato River Catchment. The purpose of the four sequential Stages of the Bed Degradation Investigation project was to increase the technical understanding of the nature and effects of bed degradation in the Mid-Waikato reach between Karapiro and Ngaruawahia (see Figure 1), and to develop a strategy to manage bed degradation into the future. Stages III and IV herein build on the earlier two Stages prepared by Smart (2003).

At this time we know that bed degradation is actively occurring in this reach, that the primary cause is the presence of the dams upstream of Cambridge and that the deep sequence of floodplain materials the river passes through below the Narrows is easily eroded. Within the floodplain bed degradation and bank instability will occur in a relatively consistent manner. However, the impacts will vary significantly as a consequence of discrete concentrations of development at various locations along the banks. It is clear that different management approaches to protect assets and to preserve the natural environment of the river are required as components of an effective strategy.

There are several locations along the reach that require immediate attention to confirm that existing infrastructure is not at risk such as bridge foundations. Flood/flow events will accelerate deterioration of the riverbed and riverbanks and the effects may need to be managed reactively at those times. In general however, there is time to proactively assess and develop management approaches in a systematic manner.

Because there is doubt as to the predicted degradation that will occur and because the actions to be taken are directly a consequence of the amount of degradation, the strategy will need to be reviewed on a regular basis to confirm the relevance of the various actions and in particular the timing for implementation. The region already has established groups and/or committees that could embrace this systematic review responsibility.

The key elements of the 50 to 100 year strategy to manage the effects of bed degradation are:

- Protect existing essential urban and lifeline assets along the riverbanks.
- Protect and maintain public access to the River.
- Limit new development to beyond risk areas defined by preliminary bank stability setback distances.
- Preserve and protect the natural environment and amenity of the river as far as practicable.
- Increase the understanding of the rate and amount of bed degradation that is occurring.
- Options to manage bed degradation directly by slowing or stopping the active bed erosion process are not practical and therefore not recommended in general.
- Manage the ongoing active bed degradation and associated bank instability by sequentially considering the following:
 - Passive management – monitor and allow the river to take its course until some trigger condition is reached, and restricting development within risk areas.
 - Implement ‘soft’ proactive options, such as tree planting, restrict access, relocate assets, improve surface run-off management, etc.
 - Implement physical works options to enhance bank instability using construction materials that preserve the natural appearance of the river valley as practical.

The already developed urban land areas require special consideration to both retain the established community and private assets as well as including a focus on ‘natural’ solutions. Infrastructure renewals need to consider both relocation as well as designing in long-term suitability within the dynamic river environment.

The effects of bed degradation are two-fold. Firstly, it contributes to progressively destabilizing the riverbanks and secondly it results in a lower river level. For the most part, riverbanks adjust intermittently as localized surficial slope failures that tend to be triggered by elevated rainfall and/or river flows events. River level lowering is a virtually imperceptible trend over time, obscured by normal fluctuations of the river. Flood management coordinated between MRP and EW provides protection for the valley for lower level flood events through controlled release of floodwaters. Once the integrity of the dams is in question however, flood flows are passed. Larger flood events will accelerate bed degradation and its associated effects will possibly be immediate and measurable. EW may have to respond to flood effects in a reactive manner in the earlier stages of the management strategy, but over time the proactive implementation of management options may reduce the impacts of flood scouring.

Under the present conditions, bed degradation will continue at different rates at different sections of the reach. The rate of degradation at several locations has been estimated based on data gathered (2002/2004 and historical). These have been used to predict longer-term behaviour, in

particular, 1.5m just downstream of Hamilton by 2050. Little data are available in the section between Hamilton and Ngaruawahia but it is expected that the behaviour closer to Ngaruawahia will be somewhat influenced by the supply of sediment from the Waipa River, so a maximum bed drop of 1.5m was assumed in the assessment herein. Predictions of bed degradation up to and beyond 50 years will be improved with riverbed surveys and observations over time.

From Karapiro to the Narrows, the ground conditions through which the river flows are generally stronger, so the rate of bed degradation is not as great as predicted for below the Narrows. The effects of the ramping waves from MRP's operations at Karapiro lessen as the wave height attenuates and so the region where the wave energy could have the most impact is where the bed material tends to be stronger.

In many locations along the reach there is room for the river to take its course and for the authorities to accept and monitor ongoing bank erosion and adjustment in river level. A regular river reconnaissance with photographic records taken at set locations will aid in understanding changes occurring with time.

However, bed degradation itself, or the effects of bed degradation will need to be managed in sections where the riverbanks have assets with a high degree of perceived social, economic, environment and cultural values. In such sections, letting the river take its course is unlikely to provide an optimal solution to protecting these assets and other proactive approaches including physical works may need to be contemplated.

Several options were considered to manage bed degradation directly, including introducing fixed or inflatable weirs, supplying sediment and armouring the riverbed. As a solution to the overall reach between Karapiro and Ngaruawahia, these are impractical for economic, cultural and social reasons and we recommend these not be implemented. However, on a localized scale through highly built-up areas, some modification, combination or reduced form of these options may provide the optimal solution to protect the assets of such areas.

The Proposed Bed Degradation Management Strategy including a Vision and related Actions are presented.

Consultation with the community at large and with key interest groups will be required to establish mutual agreement for future management approaches in the Mid Waikato reach and to develop the necessary District Plan changes that will enable the authorities to undertake positive actions into the future to protect the river environment.

2 Background

2.1 What is bed degradation?

Riverbed degradation is a process by which the bed of the river or stream is eroded to a new lower level at a much faster rate than occurs naturally, usually as a result of a reduced sediment supply or scouring following flood events. Bed degradation is actively occurring in the Mid Waikato River reach. Bed degradation and its effects have been identified as an issue through Environment Waikato’s Project Watershed, and more recently through the Mighty River Power resource consent process to alter flow conditions for their Waikato River Hydro Electric Power Scheme operations at Karapiro.

2.2 Stages I and II Bed Degradation Research

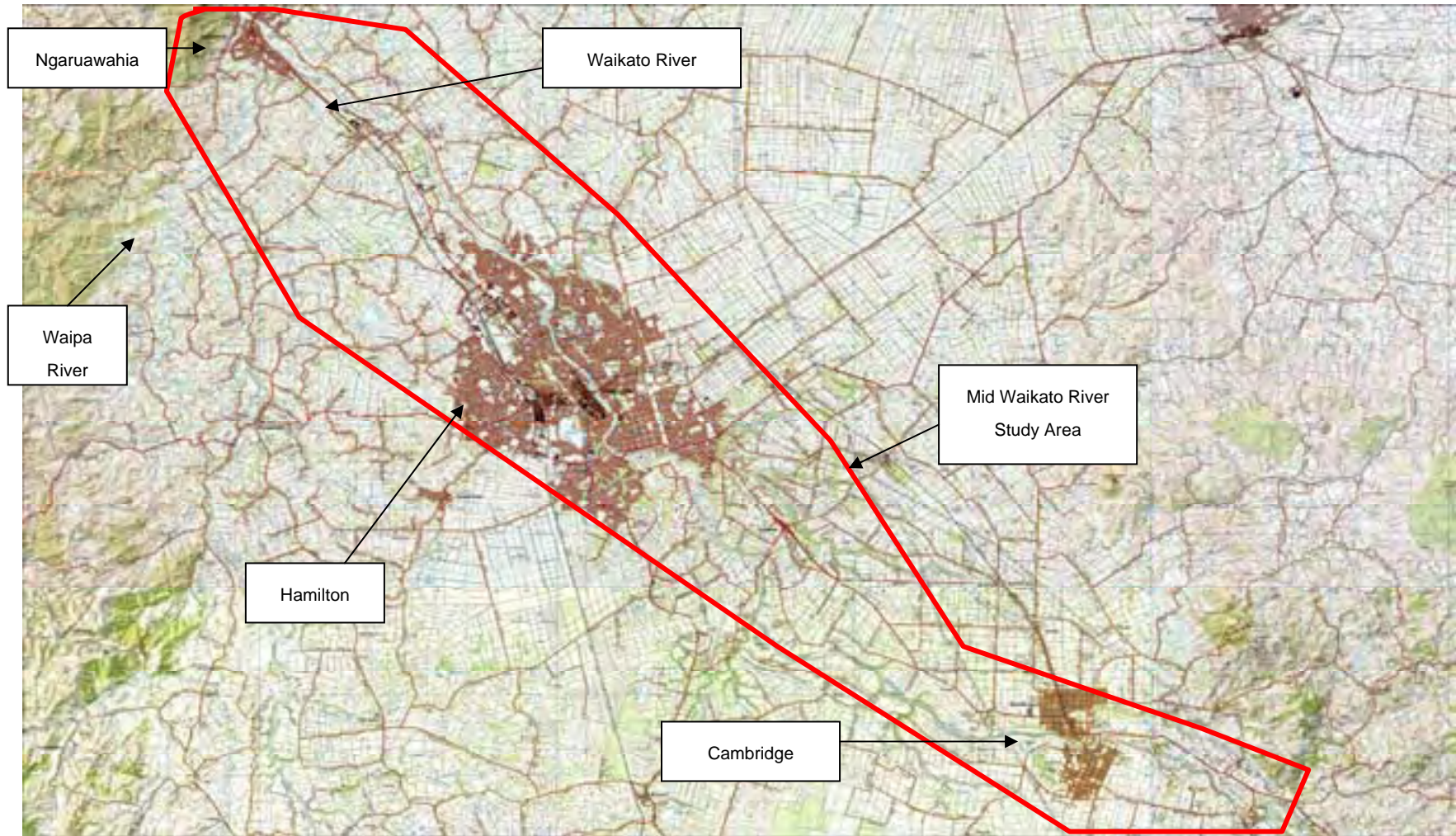
The bed degradation in the mid-Waikato River reach (Figure 1) has been assessed by Graeme Smart in *Degradation of the Waikato River, Karapiro to Ngaruawahia, Review of existing knowledge and recommendations for future work*, prepared for Environment Waikato in August 2003. Smart describes the pattern of degradation in the bed through Hamilton as a tilting plane with an imaginary hinge in the vicinity of Karapiro Dam. His projections as given in Table 1 are taken as input to the present investigation stages. Smart cautions the use of the trends and in particular beyond 50 years.

Table 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.

Figure 1: Mid Waikato River (showing study area between Karapiro Dam and the confluence with Waipa River)



3 Stage III Bed Degradation Investigations

3.1 Commentary Regarding Bed Degradation Predictions

While there is general acceptance the predicted 50-year bed degradation could be realised, and while it is accepted that bed degradation will be ongoing, Smart cautions against extrapolating to 100-year levels by assuming the same trends will continue. The Bed Degradation Management strategy herein has been developed based on no degradation occurring at Karapiro and increasing to 1.5m at and below Hamilton in a 50-year timeframe. The River section below Hamilton to Ngaruawahia has few data available to understand or predict bed degradation behaviour and is most impacted by extrapolating a tilting plane assumption beyond Hamilton. For this reason it has been assumed that 1.5m occurs in the Hamilton to Ngaruawahia reach. Primary actions within the strategy are to monitor and confirm actual bed degradation levels, adjust longer-term predictions and related impacts then adjust the timetable for implementing various management actions.

Supporting technical work and photos for the bed degradation investigations are included in the separate Appendices.

3.2 Why do we need to manage bed degradation?

3.2.1 Statutory Requirements

The Regional Council and Territorial Local Authorities (TLAs) within the study area have statutory responsibilities to manage the effects of bed degradation under the Resource Management Act (1991), the Local Government Act (2002) and the Civil Defence Emergency Management Act (2002). These responsibilities include the control of the land to minimise risk of hazards and avoidance or mitigation of natural hazards. The statutory responsibilities are detailed in Appendix H.

3.2.2 What is at risk?

Bed degradation has two broad effects: lowering river water levels and contributing to destabilising adjacent riverbanks. The impacts associated with bed degradation vary throughout the reach of the Mid Waikato River depending on a number of factors, but particularly the degree of urbanization, proximity to the riverbank crest, public access to and use of the river. Most existing development adjacent to the Valley is focussed around the main urban areas of Cambridge, Hamilton and Ngaruawahia.

3.3 Stage III Technical Investigations

The effects from lowered water levels are considered qualitatively through management actions shown on Figure 2. The impacts on riverbank stability is interpreted through analysis and summarized in a bank stability hazard map corresponding to 50-years of predicted degradation as described in Section 3.1.

The information gathered, evaluated and developed during the Stage III Investigation is presented in appendices to this report and include:

- Bank stability attributes.
 - This involved a river reconnaissance exercise in combination with desktop studies. Both were used to interpret the existing riverbank condition in terms of soil/rock type, slope height and angle, vegetation cover, river morphology and past instability with each being weighted and summed to identify relative risk.
 - The influence of a 50-year bed degradation profile (with maximum 1.5 m erosion) was then included. The results are summarized on the riverbank stability hazard map (Appendix D) and zones along the riverbank are classified as being at low, medium, high or severe risk of instability in 50 years time if the predicted bed degradation is realized.
- Setback distances.
 - The contributors to slope instability have been used in conjunction with the projected 50-year bed degradation to define preliminary “set-back” distances from the toe of the riverbank. This setback distance varies along the reach depending on the assessed conditions. Within this setback zone there is judged to be an unacceptably high risk that movement could occur over the period in which the projected bed degradation occurs. A “set-back” is identified with the aim of assisting decision makers in planning future land use and identifying both long-term esplanade reserve widths and also suitable setback zones within private land for private development. Specific investigations of bank slope stability are required to accurately define these setbacks. The preliminary “set-backs” are mapped in Appendix D.
- Preferred outcomes for key stakeholders.
 - Key stakeholders were consulted with to identify preferred outcomes for managing bed degradation on behalf of their respective organisations (Appendix E). Preferred outcomes are embodied in the proposed vision and actions.
- Combined riverbank crest hazard condition and in-river assets; land value
 - Sections along the river have been grouped according to their bank stability hazard ranking after 50 years. Known infrastructure and other assets are listed for reference. Authorities may choose to use this ranking in setting up their approach to managing bed degradation effects in areas where they carry responsibilities. (Table in Appendix F).

- Land value has been assessed for within 50m and 100m of the riverbank, broken into the corresponding sections in the riverbank stability hazard map (see Appendix I)
- Evaluation of options to control or stop bed degradation or to manage effects of bed degradation (Appendix G).

3.4 What are the issues?

There are a number of current and potential future issues and challenges that arise from ongoing bed degradation in the Mid Waikato River. From the analysis of the community outcomes, discussions with key stakeholders the issues fall into the following categories:

- 1) Environmental
- 2) Economic
- 3) Cultural
- 4) Social

The following describes challenges and considerations related to the river as it is now and possible issues for the river in 50-100 years. Actions to address these challenges have been embedded into the bed degradation management strategy presented in Figure 2.

Environmental

- It is important to maintain or enhance the river environment for continued community use. Recreational areas are at risk from erosion caused by riverbank instability e.g. walkways, reserves, etc. Walkways extend along both banks of the river through most of Hamilton City over a total riverbank length of some 29 km: from approximately 106 kilometres from the river mouth, near Pukete Boat Ramp, to Sandford Park (119.5 km from the river mouth on the left bank) and Mangaonua Stream (121.6 km from the river mouth on the right bank). These banks are presently protected by a mixture of natural vegetation, flexible revetments (riprap, rubble, 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 and increasing protection will be required to maintain current walkway systems.
- 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 and difficult or unsafe to access and use.
- Some small areas of remnant bush on steep isolated riverbanks at the upstream end of the study area may be at threat from bank instability and erosion. In some areas, these are the best remaining examples of original bush within the central Waikato area and are important to be preserved.

- Willows on riverbanks are one of the most effective plants in stabilising river edges and managing erosion since early European settlement. Iwi and other interest groups support 'best planting for protection' strategies in conjunction with native plantings wherever stability is not compromised.
- Slumping banks reduce the visual amenity of some riverbank areas.
- Ongoing erosion in the Waikato River at tributaries/gullies confluence locations. The gully discharge characteristics are changing over time as upgradient land-use changes over time (clearing, development with irrigation).

Economic

- The Waikato River is an essential source of hydro-power. There is a need to recognise the presence of the hydro system and the contribution it has to the regional and national social and economic development.
- The effects of bank instability may threaten important lifelines such as roads, rail, water and wastewater pipelines.
- There are 15 bridges over the Waikato River in the reach under consideration, and also two bridges over tributaries at their confluence. Many 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.
- 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.
- 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.
- 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. Access issues may affect tourism operators that rely on these access points to the river.
- Water level lowering may impact on the use of commercial vessels on the River such as the Waipa Delta and includes impacts on navigability.
- Loss of landscape/vegetation, historic sites etc that may form the basis of commercial operations will impact on the long-term viability of these commercial operations.

Cultural

- Cultural sites of significance adjacent to the river may be at risk from bank instability, and protection is likely to be the desirable outcome for these areas of significance.

- Territorial Local Authorities (TLAs) are able to acquire riverside land through acquisition and reserves contributions from subdivision and development. One of the criteria on setting priorities for reserve acquisition is the preservation of archaeological sites and sites important to Maori. It is therefore important to have a good understanding of these areas and where they may be at risk from the effects of bed degradation. There is a lack of information on the exact location and number of cultural sites outside of urban areas at risk from the effects of bed degradation.
- Waikato-Tainui considers they have a duty to themselves and future generations to protect the Waikato River. Waikato-Tainui wishes the River to be protected, and restored to its former health and strength.
- Access to the River at Turangawaewae Marae may be threatened by continued bed degradation and river level lowering in the long term.
- Waikato-Tainui has an unresolved claim to the Waikato River that has the potential to have an important role in determining the future management regime for the Mid Waikato River.
- Nga Tapuwae O Hotumauea – Maori Landmarks on Riverside Reserves Management Plan (2003) provides specifically for the management of seventeen historic pa sites located within riverside reserves in the Hamilton City area.
- Potential loss of significant historic heritage assets adjacent to the River from bank instability. There is little information on the location of such assets within the margins of the Mid Waikato River, which hinders protection.

Social

- Erosion and bank instability can cause hazard to public safety.
- Communities may suffer property damage, economic disruption and risk injury or death if the erosion risk is not identified and mitigated.
- There is a lack of public understanding of areas of potential instability and pressure falls on TLAs to protect existing assets close to riverbanks.
- Slope stability set-back distances need to be imposed on new developments adjacent to river banks. TLAs will need to adopt protocols for implementing such requirements that balance the needs of each interested party.
- Tree removal to enhance views of the river from properties may exacerbate localised bank instability.
- Information, technology and community needs and expectations are constantly changing. Plans and information, which do not keep up with these changes will be ineffective in achieving their aims.
- Need to manage impacts of degradation on long-term community aspirations for the area.

4 Draft Bed Degradation Management Strategy

There are a number of management issues facing the Mid Waikato River both now and in the future such as competing uses and values of the river, recreation and visual amenity, cultural and historic values, natural hazards and environmental quality. It is considered that riverbed degradation is just one issue that should be managed under an overarching River Strategy. A draft River Strategy vision has been developed to suggest a desired outcome for this section of the river over the next 50 years and beyond to provide a framework for options to manage bed degradation and the associated bank instability the Mid Waikato River reach. The draft vision has been developed based on community outcomes identified through the respective Council Long Term Council Community Plan (LTCCP) processes and also through consultation with key stakeholders. It is anticipated that the draft Vision and associated Actions in this strategy will be further refined through consultation with the community as the respective LTCCPs are finalised.

The following Management Strategy comprises an overarching Vision for the Mid Waikato River, under which Actions for managing bed degradation are developed. The draft Vision and Actions are presented below and collectively in Figure 2 (see pocket at end of document). The concepts underpinning the actions have been described in Section 3.4 above and are described in the following sections.

4.1 Draft River Vision

This Vision seeks to protect the unique values and sense of place inherent to the Waikato River and its surrounds and looks to protect long-term availability for all existing and potential future uses consistent with the concept of sustainable development.

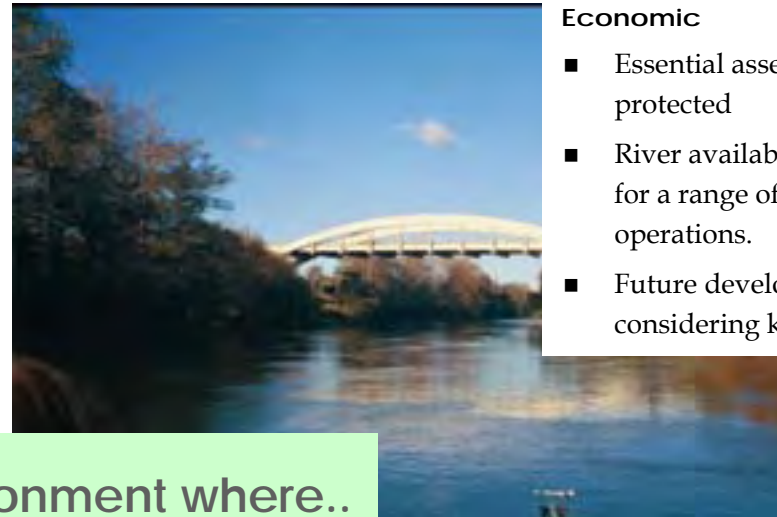
Social

- Maintain public access to the river
- Public safety is provided for as a priority
- Protect existing urban development



Economic

- Essential assets and lifelines are protected
- River availability is maintained for a range of commercial operations.
- Future development undertaken considering known risks.



A river environment where..

Environmental

- Natural character is retained in rural and semi-urban areas and retained as far as practicable in urban areas
- Bank protection is actively undertaken in a consistent and visually pleasing way
- Amenity and aesthetic values are protected and, where appropriate, enhanced in urban and semi-urban areas



Cultural

- Significant cultural and historic sites and values are protected

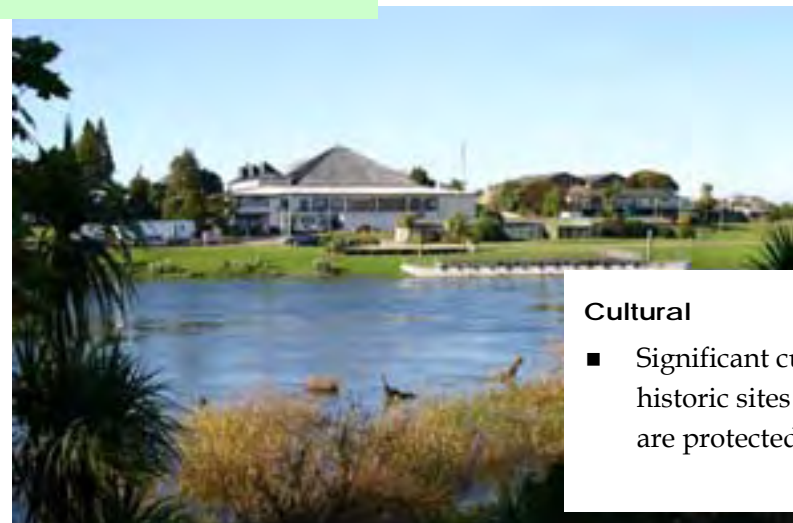


Photo source: Beca

4.2 Actions to Manage Bed Degradation

To achieve the Vision and related community outcomes we have considered bed degradation from two perspectives as follows:

a) Slow or stop bed degradation (Section 4.3).

Several approaches were considered in this category and are discussed briefly in Section 4.3 with details provided in Appendix G. The outcome is that halting bed degradation is not considered practical from economic, social and cultural perspectives at this time. However in areas where the risk to infrastructure and other assets is too costly to protect on an individual basis, such approaches may have merit.

b) Manage the effects of bed degradation (Section 4.4).

Managing the effects of bed degradation is the primary focus of the management strategy. The approach is to protect existing urban and essential assets, and adopt a passive-first approach in more rural conditions as follows:

- i. Use passive management approaches (such as monitor and allow the river to take its course, restricting development within risk areas);
- ii. Implement 'soft' proactive options (such as tree planting, restrict access, relocate assets (especially when programmed upgrades / changes are made), improve surface run-off management, etc.), and/or
- iii. Implement physical works options using construction materials that preserve the natural appearance of the river valley as practical and where required to protect existing essential and lifeline infrastructure and where economical to do so.

There are several types of actions in the Bed Degradation Management Strategy. For clarity they are identified as follows:

- **Partnership** – with the Councils, key stakeholders and community working together to undertake/implement the identified action;
- **Research** – refining knowledge of the nature and scale of degradation and its impacts, generally undertaken and led by organisations with hazards management responsibilities for the Mid Waikato River area;
- **Physical Works** – Constructed options for managing bed degradation, typically developed for specific sites to provide intervention where doing so is needed to minimise risks and effects of degradation. It is noted that non-structural options should be considered in preference to engineered structures.

- **Education** – Measures to improve the information and knowledge available to the wider community about actions they can take to mitigate and manage the impacts of bed degradation; and
- **Statutory** – Specific recommendations for consideration about changes to policy and planning documents like Regional Policy Statement and Plans, District Plans, Long-term Council Community Plans, Asset Management Plans and changes to By-Laws and other agencies statutory documents.

4.3 Slow or Stop Bed Degradation

Possible measures to stop or minimise the bed degradation over the length of river from Karapiro to Ngaruawahia were considered that broadly embrace three broad schemes (details are provided in Appendix G):

- a. Restore sediment supply:
 1. Decommission / remove dams
 2. Release sediment past the dams
 3. Encourage 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 riprap sills
 7. Control weirs
 8. Erosion protection

From a regional perspective we consider that restoring sediment supply to the river is not practical.

Photo 3: Karapiro Dam



Photo source: Mighty River Power

MRP is already maximizing management of flood flows through operational controls in collaboration with EW. The river valley below Karapiro benefits from the presence of the series of dams since they hold all lower level flood events and can take the peak off larger flood flows. Once the integrity of the dams is in question however, the flood flows must be passed and progressively larger flood flows produce correspondingly increasing scouring energy that erodes the riverbed. These intermittent flood events induce the most scouring impacts. The present operational ramping regime has relatively limited impact on bed degradation (Smart 2005). Ongoing studies related to the operating regime for the existing dams are required and are underway as a condition to the MRP consent. The studies include monitoring of the riverbed profiles and developing strategies regarding protection of riverbank stability. These studies will lead to better understanding of the rate and amount of bed degradation. Such operational controls will not arrest bed degradation, but could reduce its rate.

From an engineering perspective control weirs provide the only option to slow or stop bed degradation with high technical effectiveness that may warrant further study. We believe however that public acceptability would be low at this time. Social, environmental, economic and cultural acceptability of options will need to be canvassed in light of any projected benefits of the work. Particular consideration would need to be given to impacts on community use and private land with river level increase, and impact on cultural sites and values (with structures being placed in the river bed).

While it may be impractical to implement any of the above solutions on a broad scale, some localized version or combination may provide an optimal solution to areas where the risk to collective infrastructure and assets is too costly to protect on an individual basis.

4.4 Manage the Effects of Bed Degradation

The river valley can be adequately protected by a management approach as described in Section 4.2 above that accepts ongoing bed degradation and addresses instead, the effects on the river valley banks and on lowering water levels. The following concepts form a basis for action and are discussed in further detail in Appendix G2:

- **Monitoring:**

The Bed Degradation Management Strategy is based on the information developed during the initial Stages I, II and III of the bed degradation project that focus on estimating riverbed and bank behaviour over the next 50 to 100 years. It is necessary to continue to obtain accurate data regarding the rate and predicted amount of bed degradation that may occur, and to identify gaps in the present understanding particularly within the lower section of the study area. It is also appropriate to adjust the monitoring frequency to reflect improved understanding.

Mighty River Power, as component of its operating consent and in conjunction with Hamilton City Council, is in the process of undertaking further riverbed monitoring and technical investigations into the causes of riverbank erosion in the Mid- Waikato River reach.

■ **Riverbank Crest Setbacks:**

All new developments adjacent to the riverbank should be located outside risk areas defined by setback distances that permit the river to take its course and to limit future capital expenditure in protecting such locations. Responsible Authorities may develop protocols to allow assets to be constructed within this preliminary setback distance provided sufficient supporting evidence is presented to support such requests.

■ **River Access**

Where practical, protect and promote public access to the river environment. Locations where access to the river is difficult or unsafe may be managed by restricting passage.

■ **Future Proof Infrastructure:**

A number of sites in the urban areas have infrastructure and assets that would lie within the preliminary setback distances as presented herein. In the future these would not be permitted or would go through a rigorous evaluation process to allow the present locations. As these sites and structures are maintained, retrofitted or renewed in the future, they will need to be appropriately protected or designed to accommodate predicted changes (e.g. height of stormwater pipes outfall, depth of bridge piles).

■ **Physical Works Solutions:**

These are second and third tier approaches where active decisions are taken to introduce riverbank or riverbed protection such as bank armouring.

4.5 Proposed Actions

Prioritisation of Actions

An important part of implementing the Bed Degradation Management Strategy is prioritising the actions. The timing of actions needs to be programmed and staged to make sure capacity and cash-flow issues are addressed. Simple prioritisation criteria have been devised and actions have been grouped into the following time periods:

H = High - within 1 - 3 years (2006 to 2009).

M = Medium - within 3-10 years (2009 to 2016).

L = Low - beyond 10 years (2016 to 2055).

O = Ongoing - continuing over the 50-year implementation period. The level of activity is likely reassessed over time.

Prioritisation criteria

The following criteria have been used to help prioritise recommended actions for the Proposed Bed Degradation Management Strategy. For the purposes of this report the criteria are qualitative, however, there is the ability to refine these through the use of more quantitative scoring methods where this may be required for specific groups of actions. The criteria used are:

- Will the action result in an immediate reduction of the level of risk to the social (e.g. safety, accessibility etc), cultural or physical environment?
- Is there existing or planned work being undertaken that can be linked with the action to make delivery more efficient?
- To what extent will the action achieve the objectives of the Bed Degradation Strategy and the wider vision for the river?

In addition to the above, it is anticipated that the propose vision and actions will be discussed with the community as part of the LTCCP processes and eventually as part of a specific, overarching strategy for the Mid Waikato River. Community consultation may identify an immediate community need to undertake particular actions and may therefore change the priority of some actions.

Photo 1: Pukete Wastewater Bridge



Photo source: Beca (2005)

Photo 2: Horotiu Meatworks Water Intake



Photo source: Beca (2005)

General Framework

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
<p>GF1. Partnership: Facilitate a co-ordinated approach to managing the effects of bed degradation hazard between Council, communities, Tangata Whenua and key stakeholders.</p>	<p>Set up a Bed Degradation Working Group with representatives from key stakeholder groups and Waikato Lifelines Group that meets regularly to discuss management of bed degradation.</p>	EW	O	5% 1 FTE staff member time for duration of project. (\$10K/year)
<p>GF2. Research: Evaluate the practical options available to manage bed degradation directly by stopping or limiting bed degradation (see Technical Appendix G).</p>	<ul style="list-style-type: none"> ■ Undertake preliminary feasibility assessment of Options 4 (operate dams to reduce flood surges) and 5 (operate dams to reduce ramping surges). Obtain agreement on effects of ramping. ■ Undertake preliminary feasibility assessment of Option 7 (weirs). 	EW / MRP	M	<p>\$20K</p> <p>\$20 - \$30K</p>
<p>GF3. Research: Develop timetable to sequentially manage the riverbank sections identified to be most at future risk to effects of bed degradation</p>	<ul style="list-style-type: none"> ■ Continually update bed degradation data to reflect riverbed cross section monitoring (link to Action GF4). ■ Update the riverbank slope hazard map and priority riverbank areas (Technical Appendices D & F) for revised risk with updated bed degradation behaviour and programme when actions should be implemented. ■ Assess the type of management approach to be implemented at the river section in question: ■ Use a tiered approach in the selection of site-specific options for bed degradation management. <ol style="list-style-type: none"> 1. Passive management allowing the river to take its course 2. Non-structural management options (tree planting, access restrictions, land-use restrictions, relocate assets, etc) 3. Physical works options (preserving the natural appearance of the River Valley where practical). 	EW	O	<p>\$10K</p> <p>\$20K each 5 years</p> <p>\$5 - \$10K per site plus engineering costs</p>

PROPOSED MIDDLE WAIKATO RIVER BED DEGRADATION MANAGEMENT STRATEGY

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
<p>GF4. Research: Monitor river cross-sections for actual bed degradation effects over time.</p>	<ul style="list-style-type: none"> ■ Liaise with key stakeholder organisations to establish optimum programme of river cross sections that will be monitored for on going bed degradation and identify critical data gaps. ■ Survey riverbed levels at existing cross-section sites on 5-year cycle with option to reduce monitoring frequency at sites where confidence in future performance can be established. Establish baseline data as soon as possible. ■ Establish monitoring data baseline at cross sections where critical data are needed to identify an appropriate management programme. ■ Allow yearly contingency to resurvey the riverbed cross sections after a 10-year flood event. ■ Complete systematic photographic records on regular time intervals from river reconnaissance ■ Consult with landowners in high-risk areas to get an idea of the rate of erosion and/or other effects. 	EW	<p>H</p> <p>O</p> <p>H</p> <p>O</p> <p>O</p> <p>M</p>	<p>\$25K</p> <p>\$75 - \$100K/survey set.</p> <p>\$5 - 8K / new cross section established</p> <p>\$75K Contingency</p> <p>\$10 - 20K per set</p> <p>\$5 - \$10K</p>
<p>GF5. Research: Develop protocols for using slope stability setback guidelines.</p>	<p>Develop guidelines for new developments and for existing assets that are present within the setback limits (link to Action E11)</p>	EW	H	\$25-50K
<p>GF6. Partnership: Finalise the Bed Degradation Strategy and implement District Plan changes</p>	<p>Consult with the community and interest groups to finalise the strategy. Formulate appropriate District Plan changes.</p>	EW	H	<p>30% 1 FTE staff member time for 1-3 years (\$60K/year)</p>

Environmental

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
<p>EN1. Physical Works: Amenity of the river environment is maintained as far as practicable by using appropriate design of engineered options when they are considered to be necessary.</p>	<ul style="list-style-type: none"> ■ Structural options for bed degradation management shall be selected to minimise effects on public access, natural character, amenity values. ■ Provide consistency in appearance. 	EW	H	Cost of engineered options selected.
<p>EN2. Research: Identify important recreational sites subject to potential future bed degradation hazard</p>	<ul style="list-style-type: none"> ■ District Councils to collect information relating to current and potential future use and demand for recreational areas adjacent to the Waikato River. Create a list of important recreational sites with present and future erosion risk to be protected from the effects of bed degradation. 	TLAs	H	15% 1 FTE staff member time for 6 months. (\$15K)
<p>EN3. Physical Works: Protect and maintain access to the River at important recreational sites identified in EN2 above.</p>	<ul style="list-style-type: none"> ■ Consider engineering options for the protection of important recreational sites identified in EN2 above. 	TLAs	M	Dependent on extent of protection required and design.
<p>EN4. Research: Investigate existing walkway systems that are at risk from bank instability and either divert the walkway inland or implement engineering protection.</p>	<ul style="list-style-type: none"> ■ Consider relocation walkways inland to avoid areas of bank instability. ■ Develop a walkway development plan, looking 20+ years based on bank stability hazard information (link to reserves management plans, structure plans and Nga Tapuwae O Hotumauea). ■ Where inland diversion of walkways is not possible or desirable, investigate vegetation/engineering options to stabilise banks. 	TLAs	H	<ul style="list-style-type: none"> ■ \$20k per site (preliminary investigation only). ■ 10% of 1 FTE staff member time for 2 years (\$20K / year). ■ \$5 - \$10K / site.
<p>EN5. Research/Statutory: Investigate what walkways are needed adjacent to the river in the long-term and acquire public reserve land where required to enable inland diversion of walkways at risk from present and future bank instability.</p>	<ul style="list-style-type: none"> ■ Designate in District Plans existing and strategic requirements for walkway routes taking into account areas of identified bank stability risk. ■ Include rules in District Plans for acquiring land for public accessways in these preferred walkway routes at the time of subdivision. 	TLAs	M	<ul style="list-style-type: none"> ■ \$40-50k. ■ 20% of 1 FTE staff member time for 2 years (\$40K / year)

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
EN6. Statutory: Prevent further construction of access structures to the river (e.g. boat ramps, jetties) in areas of present and future high bank instability risk (see Technical Appendix D).	<ul style="list-style-type: none"> ■ Add to Regional Plan assessment criteria the consideration of whether an area for a proposed access structure is an identified present or future high bank instability risk (Technical Appendix D) and require information on appropriateness of the structure in that area given the bank instability. 	EW	M	5% 1 FTE staff member time for duration of project (\$10K / year)
EN7. Research: Investigate native plant species that can survive fluctuating river levels whilst providing bank stabilisation.	<ul style="list-style-type: none"> ■ Commission an ecological report to identify bank stabilising native plant species that are suitable for the Waikato River environment. ■ Link to work previously done by Landcare Trust on stabilising native species. 	EW	H	\$10-20k
EN8. Partnership: Implement soft (non-engineered) options for bed degradation management at sites with low bank stability hazard risk (see Technical Appendix D).	<ul style="list-style-type: none"> ■ Do nothing, monitor. ■ Planting of stabilising species identified as suitable in EN7 above. 	All	O	\$5 - 20K
EN9. Education/Partnership: Provide information to Riverside property owners on the erosion effects of removing trees and provide information on native stabilising plant species	<ul style="list-style-type: none"> ■ Prepare a pamphlet with information on appropriate stabilising plant species identified from Action EN7 above and provide a local contact for more information. ■ Implement planting programmes in conjunction with the community. ■ Encourage the replacement of willows with native bank stabilising plant species progressively over time (recognising that willows provide an important stabilising role as native species establish and take over). 	TLAs/EW	H O	<ul style="list-style-type: none"> ■ 5-10% 1 FTE staff member time for duration of project. (\$15K / year). ■ \$5k for plants.
EN10. Research: Identify trees that are causing instability of river banks and remove and replace with appropriate stabilising plant species (identified in EN7 above).	<ul style="list-style-type: none"> ■ Identify trees that are causing instability. ■ Replace identified trees in river sections where public health and safety and/or lifelines are affected with appropriate plant species identified in EN7 above to aide in stabilisation of banks. 	TLAs	M	\$10-20k per TLA

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
EN11. Research: Identify and retain areas of significant vegetation adjacent to the River that are at risk.	<ul style="list-style-type: none"> Identify areas of significant vegetation adjacent to the river and monitor these areas for effects from bank erosion. Investigate the use of options that will provide protection to areas of significant vegetation that may be at risk from erosion. 	EW	M	5% 1 FTE staff member time for duration of project (\$10K / year)

Economic

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
EC1. Statutory: Restrict further development within setback areas (see Technical Appendix D) and sustainably control development in greenfield sites within the setback areas.	<ul style="list-style-type: none"> District/City Plan changes to include slope stability setback areas (Technical Appendix D) and rules to control further development within those areas. Include rules for access to the River. Plan change to include rules to limit development of greenfield sites within defined slope stability setback area. Require detailed subsurface assessment as part of resource consent where development is proposed within setback areas. 	TLAs	H	15-20% 1 FTE staff member time for 2 years (\$40K / year)
EC2. Research: Identify lifeline utilities at threat from the effects of bed degradation.	<ul style="list-style-type: none"> Condition/risk assessments of infrastructure based on priority ranking of river sections (Appendix L). Review the record drawings for water intake structures to assess the impact of falling water levels. If necessary, relocate water intake structures into deeper water. 	TLAs in association with Waikato Lifelines Group.	H	\$30 - 50K
EC3. Physical Works: Develop options to protect important lifeline utilities identified in EC2 above.	Assess appropriate options for the protection of lifeline utilities identified in EC2 above (link to GF3).	EW		Will depend upon extent of impact and type of infrastructure.

PROPOSED MIDDLE WAIKATO RIVER BED DEGRADATION MANAGEMENT STRATEGY

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
EC4. Physical Works: Protect high value development from the effects of bed degradation (see Technical Appendices I & F).	Structural options may need to be considered where high value development is at risk only when non-structural options are shown to be ineffective at minimising effects of bed degradation or to integrate with existing structural protection works in the area.	TLAs	M	Will depend on impact and infrastructure at risk.
EC5. Research: Confirm that the fifteen river bridges are managed for the effects of bed degradation.	Confirm with Transit that bridge condition assessments are current or underway.	TLAs /Transit	H	-
EC6. Partnership: Support the Waikato Engineering Lifelines Group in encouraging a co-ordinated approach to risk reduction for lifeline utilities.	Involve a representative of Waikato Lifelines Group in the Bed degradation steering group (link to Action GF1).	EW	O	-
EC7. Physical Works: Protect stormwater outfalls from the bank collapse triggered by bed degradation as well as bed level lowering	Place new or extended toe erosion protection around stormwater outfalls to mitigate against effects of falling river levels. Investigate the use of riprap, gabions or sheet piling as suitable methods for protection. Alternatively, lower or extend the outfall structure.	TLAs	M	\$5k per investigation Engineering costs vary depending on option chosen.
EC8. Physical Works: Focus remediation measures after flood events in areas of high priority.	Focus remediation efforts following floods to areas where public safety, lifelines, key infrastructure or community/ cultural sites of significance are at risk.	EW/TLAs	O	-
EC9. Statutory: Limit development that must be located adjacent to the river to those areas of low erosion risk or require significant bed degradation protection (Link to EC1).	<ul style="list-style-type: none"> ■ Restrict inappropriate development within setback areas through rules in District Plans (link to Action EI1). ■ Determine what is considered appropriate development for locations adjacent to the river. ■ Put erosion hazard information on LIMs for high risk properties. 	TLAs	M	5-10% 1 FTE staff member time for duration of the project (\$15K / year)
EC10. Physical Works: Upgrade/redesign existing landings/boat ramps required and used by commercial vessels.	<ul style="list-style-type: none"> ■ Extend landings into deeper water by adding an extra flight of steps, or alternate to provide sufficient water depth. ■ Extend boat ramps into deeper water as required, or reconstruct boat ramp at lower level. 	TLAs in association with commercial operators.	L	Depends on final design and number of structures

Social

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
S1. Research: Visually monitor the river and tributaries following all flood events to assess changing levels of bed degradation hazard.	<ul style="list-style-type: none"> ■ Visually assess the river and main tributaries in urban areas following any flood events for impact on hazard levels (Link to Action GF4). ■ Maintain a systematic photographic record. 	EW	O	5% 1 FTE staff member time (but dependant on number of flood events). (\$10K / year).
S2. Research / Partnership: Update priority areas / actions following flood events.	Reassess priority areas / actions (in Technical Appendix F) using the results of post flood monitoring (link to Action S1) and discuss with Bed Degradation Management (link to GF1)	EW	O	5% 1 FTE staff member time for duration of project. (\$10K / year).

Cultural

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
C1. Research: Identify all significant cultural/heritage sites adjacent to the river at risk from the effects of bed degradation.	Commission a cultural and heritage report for the Mid Waikato river to identify sites of significance and map these against areas subject to present or future high risk from the effects of bed degradation.	EW and Tangata Whenua	M	\$50K
C2. Physical Works: Project significant cultural/heritage sites adjacent to the river at risk from the effects of bed degradation with protection options that do not affect the values of the sites.	<ul style="list-style-type: none"> ■ Investigate, in conjunction with mana whenua, the use of options that will provide protection to areas of significant cultural and heritage value from erosion, without detracting from these values. ■ Where necessary, use engineering solutions that are in keeping with the natural environment as a first preference (I.e. wooden structures with native plantings instead of concrete mass blocks etc.) 	EW /TLAs Tangata Whenua	M	Depends on option selected. \$5 - \$10K per site investigation.

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
C3. Research: Monitor the effects of bed degradation on the Turangawaewae Marae river access and bank stability.	<ul style="list-style-type: none"> ■ Protect Turangawaewae Marae as a priority site. ■ Set up appropriate monitoring programme of riverbank areas adjacent to Turangawaewae Marae (Link to GF4). 	EW/Tangata Whenua	M O	5 – 10% 1 FTE staff member time for duration of project (\$15K/year). 5% FTE staff member time (but dependant on number of floor levels (\$10K/year).
C4. Partnership: Investigate the establishment of a Mid Waikato River Bed Degradation Management Mana Whenua Group.	<ul style="list-style-type: none"> ■ Assemble relevant Mana Whenua groups to discuss possible collaboration on future bed degradation management decisions for the Mid Waikato River (link to GF1). ■ Hold regular meetings with the Mana Whenua Group throughout the duration of the project to discuss the management of bed degradation in the Mid Waikato River. 		O	5% 1 FTE staff member time for duration of project (\$10K/year).

4.6 Where to From Here

The primary uncertainty underlying the management strategy is the estimated rate of ongoing bed degradation that will occur and the predictions to 50 years and beyond. These predictions underpin the development of the riverbank stability hazard map (Appendix D) and any resulting prioritization of locations along the riverbank that are at risk in the future. This in turn affects the timeframe within which actions should be implemented and this timing will need to be reset in response to research and river cross section monitoring data that unfold in the future. The management strategy should remain a living document. The following items would support such a target:

- Responsible authorities would develop working protocols related to riverbank setback margins that respect the inputs from affected users to provide optimal protection against the risks of bank instability.
- Continue to monitor the riverbed degradation over time. Increase or decrease the monitoring frequency, as the behaviour becomes more understood. Develop a formal Monitoring Plan with inputs from Councils, Tangata Whenua and Mighty River Power.
- Maintain the strategy to manage bed degradation as a working document, adapted with on-going monitoring.

- As time passes communities change, as do development, priorities and perceptions of the river environment. As the strategy is focussed around a shared community vision, this should be reviewed and changed as necessary to reflect the community's values of the river.
- There are a number of significant issues and options for the manner in which the Mid Waikato River could be managed over the short, medium and long term (50 year +). Actions being taken and strategies being developed by public and private agencies and individuals within the study area will increase competing interests which conflict with each other on this stretch of the Waikato River. An example of one such strategy is Hamilton City Council's 20-year CBD plan, which has implications for growth of the city in relation to the River and likely increased diversity and use of the area as it is implemented.

Development of an overarching River Strategy is suggested as a means to pull all of the different stakeholders and community aspirations together to enable the long-term development of uses in and alongside this stretch of the river to be undertaken in a sustainable manner, and one that recognises the significance of the River's contribution to the social, cultural, economic and environmental wellbeing at local, regional and national levels. The objective would be to confirm the long term Vision for the river, and provide guidance for planning and management decisions that are taken over the short, medium and long term. While bed degradation is identified as a significant issue for river management it is envisaged that it is only one of the issues requiring management as part of a holistic strategy for this stretch of River over the next 20 to 50 years.

- It is noted that no community consultation has been undertaken as part of this strategy. The draft vision will need to be further refined through the LTCCP process to confirm the issues and priorities. Further consultation is also necessary to test the recommended bed degradation management against public opinion to enable the suggested actions to be accommodated within respective LTCCPs.

Actions to Manage Bed Degradation

In the action tables below we have included an indication of who we think the lead agency should be based on the requirement of each particular action. However, we anticipate that all of the partner agencies involved in the development of this strategy will discuss and agree on who should be the lead agency for each action. You note that the lead agency is not necessarily the agency that should bear the most, or all of the cost of undertaking the particular action. The decision of where costs should fall is outside of the scope of this study. Staff costs are estimated at a rate of \$130/hour.

General Framework

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
G1. Partnership Facilitate a co-ordinated approach to managing the effects of bed degradation hazard between Council, communities, Tangata Whenua and key stakeholders.	Set up a Bed Degradation Working Group with representatives from key stakeholder groups and Waikato Lifelines Group that meets regularly to discuss management of bed degradation.	EW	O	\$5-11FF1 staff member time for duration of project (\$50k/year)
G2. Research Evaluate the practical options available to manage bed degradation directly by stopping or limiting bed degradation (see Technical Appendix G).	Undertake preliminary feasibility assessment of Options 4 (operate dams to reduce flood events) and 5 (operate dams to reduce ramping events). Obtain agreement on effects of ramping. Undertake preliminary feasibility assessment of Option 7 (weirs).	EW / MRP	M	\$50k
G3. Research Develop timetable to sequentially manage the riverbank sections identified to be most at river risk to effects of bed degradation.	Continually update bed degradation data to reflect riverbed cross section monitoring (link to Action G4). Update the riverbank slope hazard map and priority riverbank areas (Technical Appendix D & E) for riverbed risk with updated bed degradation behaviour and programme when actions should be implemented. Assess the need for management actions to be implemented at the river section to question. Use a tiered approach to the selection of site-specific options for bed degradation management. 1. Passive management allowing the river to take its course. 2. Non-structural management options (low clearing, access restrictions, and use restrictions, etc). 3. Engineered options (preventing the natural appearance of the River Valley where practical).	EW	O	\$20k each 5 years
G4. Research Identify river cross-sections for actual bed degradation effects over time.	Work with key stakeholder organisations to establish optimum programme of river cross sections that will be monitored for on-going bed degradation and identify critical data gaps. Survey riverbed levels of existing cross-section sites on 5-year cycle with option to reduce monitoring frequency at sites where confidence in future performance is not established. Establish baseline data as soon as possible. Establish monitoring data baseline at cross sections where critical data are needed to identify an appropriate management programme. Allow yearly contingency to resurvey the riverbed cross sections after a 10-year flood event. Complete systematic photographic records on regular time intervals from river reconnaissance. Consult with landowners in high-risk areas to get an idea of the rate of erosion and/or other effects.	EW	H	\$25k
G5. Research Develop protocols for using slope stability software guidelines.	Develop guidelines for new developments and for existing areas that are assessed within the current limits (link to Action F11).	EW	H	\$5-10k
G6. Partnership Review the Bed Degradation Strategy and implement District Plan changes	Overall with the community and relevant groups to finalise the strategy. Formulate appropriate District Plan changes.	EW	H	30% 11FF1 staff member time for 1-3 years (\$20k/year)

Environmental

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
E1. Physical Works Identify the river environment to be maintained as far as practicable by using appropriate design of engineering options when they are considered to be necessary.	Structural options for bed degradation management shall be selected to minimise effects on public access, natural character, amenity values. Provide consistency in appearance.	EW	H	Low or engineered options only
E2. Research Identify appropriate recreational sites subject to potential future bed degradation hazard.	Historic Councils to collect information relating to current and potential future use and demand for recreational sites adjacent to the Waikato River. Create a list of important recreational sites with present and future resource risk to be protected from the effects of bed degradation.	TLAs	H	15% 11FF1 staff member time for 4 months (\$15k)
E3. Physical Works Protect and maintain access to the River at important recreational sites identified in E2 above.	Consider engineering options for the protection of important recreational sites identified in E2 above.	TLAs	M	Dependent on extent of protection required and design
E4. Research Investigate existing walkway systems that are at risk from bank instability and either divert the walkway inland or implement engineering protection.	Conduct risk assessment walkways inland to avoid areas of bank instability. Develop a walkway development plan, looking 20+ years based on bank stability hazard information (link to riverbank management plans, structure plans and NFA or Resource Consent). Where inland diversion of walkways is not possible or desirable, investigate engineering options to stabilise banks.	TLAs	H	\$20k per site (preliminary investigation only)
E5. Research/Strategy Investigate what walkways are needed adjacent to the river in the long-term and acquire public reserve land where required to stabilise inland diversion of walkways at risk from present and future bank instability.	Discharge in District Plans existing and strategic requirements for reserve reserve taking into account areas of identified bank stability risk. Include rules in District Plans for acquiring land for public accessways in long-term walkway areas at the time of subdivision.	TLAs	M	\$40-\$50k
E6. Strategy Prevent further construction of access structures to the river (e.g. boat ramps, jetties) in areas of present and future high bank instability risk (see Technical Appendix D).	Add to Regional Plan assessment criteria the consideration of whether an area for a proposed access structure is identified present or future high bank instability risk (Technical Appendix D) and require information on appropriateness of the structure in that area given the bank instability.	EW	M	5% 11FF1 staff member time for 2 years (\$40k/year)
E7. Research Investigate native plant species that can survive fluctuating river levels while providing bank stabilisation.	Commission an ecological report to identify bank stabilising native plant species that are suitable for the Waikato River environment. Link to work previously done by Landcare Trust on stabilising native species.	EW	H	\$20-\$30k
E8. Partnership Implement will (non-engineered) options for bed degradation management at sites with low bank stability hazard risk (see Technical Appendix E).	Do nothing, monitor. Planting of stabilising species identified as suitable in E7 above.	All	O	\$5-20k
E9. Research/Partnership Provide information to community priority areas on the erosion effects of removing trees and provide information on native stabilising plant species.	Prepare a pamphlet with information on appropriate stabilising plant species adjacent to riverbank and provide a local contact for more information. Implement planting programmes in conjunction with the community.	TLAs/EW	H	5-10% 11FF1 staff member time for duration of project (\$15k/year)
E10. Research Identify trees that are causing instability of river banks and remove and replace with appropriate stabilising plant species (identified in E7 above).	Encourage the replacement of willows with native bank stabilising plant species progressively over time (recognising that willows provide an important stabilising role as native species establish and take over).		O	
E11. Research Identify and retain areas of significant vegetation adjacent to the River that are at risk.	Identify areas of significant vegetation adjacent to the river and monitor how these areas are affected with appropriate plant species identified in E7 above to aid in stabilisation of banks. Investigate the use of options that will provide protection to areas of significant vegetation that may be at risk from erosion.	EW	M	5% 11FF1 staff member time for duration of project (\$15k/year)

Economic

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
E12. Strategy Restrict further development within setback areas (see Technical Appendix D) and sustainably control development in generalised areas within the setback areas.	District/CCP Plan changes to include slope stability setback areas (Technical Appendix D) and rules to control further development within these areas. Include rules for access to the River. Plan change to include rules to limit development of generalised areas within defined slope stability setback areas. Require detailed subsurface assessment as part of resource consent where development is proposed within setback areas.	TLAs	H	5-20% 11FF1 staff member time for 2 years (\$40k/year)
E13. Research Identify lifetime utilities at threat from the effects of bed degradation.	Condition/risk assessments of infrastructure based on priority ranking of river sections (Appendix L). Review the recent drawings for water intake structures to assess the impact of falling water levels. If necessary, relocate water intake structures into deeper water.	TLAs in association with Waikato Lifelines Group	H	\$50-\$5k
E14. Physical Works Develop options to protect important lifetime utilities identified in E13 above.	Assess appropriate options for the protection of lifetime utilities or structures in E13 above (link to G2).	EW		Will depend upon extent of impact and type of infrastructure.
E15. Physical Works Protect high value development (see Technical Appendix D) and sustainably control development in generalised areas within the setback areas.	Structural options may need to be considered where high value development is at risk only when non-structural options are shown to be ineffective at minimising effects of bed degradation or to integrate with existing structural protection works in the area.	TLAs	M	Will depend on impact and nature of infrastructure at risk.
E16. Research Confirm that the E16 river bridges are managed for the effects of bed degradation.	Consult with Transport that bridge condition assessments are current or underway.	TLAs / Transit	H	-
E17. Partnership Support the Waikato Engineering Lifelines Group in encouraging a community approach to risk reduction for lifetime utilities.	Involve a representative of Waikato Lifelines Group in the bed degradation steering group (link to Action G2).	EW	O	-
E18. Physical Works Protect stormwater outfalls from the bank collapse triggered by bed degradation as well as low level flooding.	Raise new or extended low erosion protection around stormwater outfalls to prevent or reduce effects of falling river levels. Investigate the use of riprap, gabions or sheet piling to stabilise outfalls to protect stormwater outfalls, lower or extend the outfall structure.	TLAs	M	\$5k per investigation. Engineering costs vary depending on option chosen.
E19. Physical Works Riverbank consolidation measures after flood events in areas of high priority.	Place riprap, gabions, key infrastructure or community/whenua sites of significance at risk.	EW/TLAs	O	-
E20. Strategy Limit development that must be located adjacent to the river in those areas of low erosion risk or require significant bed degradation protection (link to E1).	Determine what is considered appropriate development for sections adjacent to the river. Put erosion hazard information on LDMs for high risk properties.	TLAs	M	5-10% 11FF1 staff member time for duration of project (\$15k/year)
E21. Physical Works Upgrade/reduce existing (low) boat ramps required and used by commercial vessels.	Extend landings into deeper water by adding an extra flight of steps, or otherwise to provide sufficient water depth. Extend boat ramps into deeper water as required, or reconstruct boat ramp at lower level.	TLAs in association with commercial operators	L	Depends on final design and number of structure vessels.

Cultural

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
C1. Research Identify all significant cultural/heritage sites adjacent to the river at risk from the effects of bed degradation.	Commission a cultural and heritage report for the Mid Waikato River to identify sites of significance and map those sites adjacent to the river at present or future high risk from the effects of bed degradation.	EW and Tangata Whenua	M	\$55k
C2. Physical Works Protect significant cultural/heritage sites adjacent to the river at risk from the effects of bed degradation with protection options that do not affect the value of the sites.	Investigate, in conjunction with mana whenua, the use of options that will provide protection to areas of significant cultural and heritage value from erosion, without detracting from these values. Where necessary, use engineering solutions that are in keeping with the natural environment as a first preference (i.e. wooden structures with native plantings instead of concrete mass blocks etc.).	EW / TLAs Tangata Whenua	M	Depends on option selected. \$5-\$10k per site investigation.
C3. Research Monitor the effects of bed degradation on the Tangata Whenua Maori river access and bank stability.	Protect Tangata Whenua Maori as a priority site. Set up appropriate monitoring programme of riverbank erosion adjacent to Tangata Whenua Maori (link to G2).	EW / Tangata Whenua	M	5-10% 11FF1 staff member time for duration of project (\$15k/year)
C4. Partnership Investigate the establishment of a Mid Waikato River Bed Degradation Management Maori Whenua Group.	Assemble relevant Mana Whenua groups to discuss possible collaboration on future bed degradation management decisions for the Mid Waikato River (link to G2).	All	H	5% 11FF1 staff member time for duration of project (\$15k/year)
C5. Research/Partnership Hold regular meetings with the Mana Whenua Group throughout the duration of the project to discuss the management of bed degradation on the Mid Waikato River.	Hold regular meetings with the Mana Whenua Group throughout the duration of the project to discuss the management of bed degradation on the Mid Waikato River.		O	

Social

Actions	How we will do it	Who will lead?	Priority	Indicative Cost
S1. Research Visually monitor the river and tributaries following all flood events to assess changing levels of bed degradation hazard.	Visually assess the river and main tributaries in urban areas following all flood events for impact on hazard levels (link to Action G4). Maintain a systematic photographic record.	EW	O	5% 11FF1 staff member time (but dependent on number of flood events) (\$10k/year)
S2. Research/Partnership Update priority areas / actions following flood events.	Review priority areas / actions (in Technical Appendix D) using the results of post-flood monitoring (link to Action S1) and discuss with Bed Degradation Management (link to G2).	EW	O	5% 11FF1 staff member time for duration of project (\$10k/year).

Vision

Social

- Maintain public access to the river.
- Public safety is provided for as a priority.
- Protect existing urban development.

Environmental

- Natural character is retained in rural and semi-urban areas and retained as far as practicable in urban areas.
- Bank protection is actively undertaken in a consistent and visually pleasing way.
- Amenity and aesthetic values are protected and, where appropriate, enhanced in urban and semi-urban areas.

A river environment where...

Economic

- Essential assets and lifelines are protected.
- River availability is maintained for a range of commercial operations.
- Future development undertaken considering known risks.

Cultural

- Significant cultural and historic sites and values are protected.

MID WAIKATO RIVER BED DEGRADATION MANAGEMENT STRATEGY FIGURE 2 - PROPOSED VISION AND ACTIONS

