Appendix F Geomorphology memo on channel widening/berm lowering

Tonkin+Taylor

Memo

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From:	Ian Fuller	Date:	7 March 2025
cc:	Mark Hooker		
Subject:	Waipoua Geomorphic Advice		

This memo provides a high level, qualitative assessment of possible geomorphic responses in the Waipoua River through Masterton to:

- Proposed berm lowering
- Proposed channel widening under the Colombo Road bridge
- Potentially extensive rock lining of riverside stopbanks
- A proposed high flow secondary flow path/back channel upstream of Mawley Park

These are all options that have been proposed by the Waipoua Project Group (WPG) as part of its work to reduce the flood risk to Masterton. The WPG, through GWRC, has asked for high-level advice on the potential geomorphological considerations that could arise from these.

The location of this assessment is clarified in Figure 1.1. Velocities and depths of flood flow (Q_{100}) have been modelled by Land River Sea Consulting, with the resulting changes in depths mapped (Figure 1.2) and cross-channel velocities plotted at each cross-section (Figure 1.1). This memo considers the possible geomorphic responses to these proposed changes during large (modelled) flood events and lower energy flows.

Geomorphic responses in flood events

Modelled results indicate that while Q_{100} flood depths are reduced by berm lowering, in-channel velocities increase in all sections. Using the Hjulström curve as a means of estimating critical velocities of entrainment, the modelled velocities in a Q_{100} flood exceed those required for entrainment of boulders (Figure 1.3).

The geomorphic effects of berm lowering, and channel widening are related to the energy of flows in the channel and the substrate lining the bed and banks. Changes to the cross-sectional form of the river as a result of berm lowering and widening of the cross-sections (Figure 1.1) will result in lowered flow depths (Figure 1.3) because the enlarged channel has an increased capacity to convey flows. In turn this means that more water is retained within the Waipoua channel, rather than spilling out onto the adjacent berms. In this scenario, water is conveyed very efficiently since channel boundary resistance is reduced as wetted perimeter is reduced. The energy of these flows will increase as a result of this greater flow efficiency because less energy is dissipated by roughness effects.

Lowering of the berms in the Waipoua River through Masterton will increase the energy of flows in the river that would otherwise have spilled onto the berms. Increased energy means more stream power is available for geomorphic work, i.e. sediment transport, bed, and bank erosion. Without any other structural interventions, increased potential for bed scour and bank erosion are therefore likely to result from the proposed lowering, because there will be more energy to accomplish these processes.

The Waipoua channel through this reach has been classified as an artificially confined, low sinuosity gravel bed river (T+T 2024[1]). The bed of the river through Masterton has been identified as degrading using Mean Bed Level (MBL) analysis undertaken by WSP Opus in 2019. It is believed this degradation trend reflects a combination of gravel extraction, bed sediment exhaustion, headward incision in the lower reaches of the Waipoua adjusting to lowering of the Ruamāhanga river channel, as well as narrowing of the channel (confining flood flows). The planform of this reach of river historically was much broader and the river behaviour more dynamic (Figure 1.4). Historically the Waipoua through Masterton was a laterally active wandering gravel bed river with a large, wetted perimeter, which served to dissipate flood energies, albeit effecting change in the channel course in this reach. The point of making this comparison is that the Waipoua River will naturally erode its bed and banks, and stream powers are now elevated by artificial confinement (T+T 2024) and will be further elevated by berm lowering. Lowering of the berms will not solve the issues of bed degradation in the Waipoua here, if anything the problem could be exacerbated because bed scour and the potential for lateral erosion are already likely to be significant through this reach during a large flood and the proposed berm lowering is likely to worsen this.

Given the potential for enhanced energy and therefore erosion of the bed and banks in the Waipoua during large flood events, structural intervention will likely be required if no other way of mitigating flows can be deployed. Alternative approaches to flow mitigation would require catchment level interventions, including increasing flood detention/storage within the catchment (e.g. via wetlands and floodplain re-engagement), reducing runoff speeds and volumes (e.g. via land cover changes), and providing 'room for the river' where feasible in upstream reaches (see T+T 2024). These alternative, catchment-based approaches could be classified as 'Nature Based Solutions' (NBS) for flood mitigation. Without NBS interventions, rock-lining of stopbanks will likely therefore be required to preserve their integrity during large flood events. If there is excess energy for erosion (as occurs during floods), the river will potentially erode bed and/or banks. If the bank edges are lined with non-erodible rock, the bed becomes the only source of sediment for the river, which means bed scour is likely to occur adjacent to rock armoured banks interfacing with flows (as opposed to the banks being set back).

Widening under the Colombo Road bridge will improve flood capacity but potentially require structural intervention to preserve the integrity of bridge piers should the bed of the river degrade further. Widening does not appear to have a significant impact on velocities, which remain high or slightly higher following the increased channel capacity at these cross-sections (Figure 1.1).

A high-flow path upstream of Mawley Park (Figure 1.5) is proposed to be activated during large floods (only), with a view to developing a wetland in this area. Reactivating floodplain in this way would contribute to some energy dissipation, although the area is small and realistically unlikely to have a significant influence on conditions in the channel. There may be benefits in allowing re-engagement during smaller floods and from a habitat diversity perspective.

Geomorphic responses during smaller flows

Widening of the channel in XS 1-3 (Colombo Road bridge) does provide the potential for some development of bar forms in the channel. Widening provides accommodation space for bars to form, and deposition of gravel may be encouraged. Similar effects have been observed in the Waikanae River in the vicinity of Jim Cooke Memorial Park, where channel widening has been permitted, contributing to bar-form development and an increased diversity in geomorphic units (riffles, lateral bars, medial bars) at low flow (Figure 1.6). Should widening of the Waipoua bed be extended beyond

[1] Waipoua River Geomorphic Assessment Report prepared for Greater Wellington Regional Council, May 2024 contract 1091089.1000 v2.

(upstream) of Colombo Road bridge, similar effects would be anticipated. However, lowering of the berms alone does not increase accommodation space in the channel at low flows, because the bed is not being widened in what is proposed. This means that the changes proposed in XS 4-8 would not facilitate in-channel deposition of bedload, which might be expected in a widened bed. Berm lowering itself will be not improve geomorphic diversity in the channel.

There is a risk that lowered berms simply fill up with fine sediment draped over the top of them during small to medium floods (large floods are likely to scour sediment from these surfaces for reasons articulated above). This risk of re-filling is likely to be exacerbated by any vegetation planted on the lowered berms. Infilling of berms within stopbanks is a common problem in New Zealand's rivers because of the high sediment loads they transport during overbank flood flows and because vegetation stems are particularly efficient at trapping this sediment. Precisely how quickly this re-filling occurs is dependent on flood magnitude and frequency, which is impossible to predict. To prevent or limit re-sedimentation of these berms, the features could be lowered to bed level to foster in-channel deposition of bed sediment as described above at the Colombo Road bridge. If/where the bed is widened (essentially reducing or removing the berm), further protection of the toe of stopbanks will likely be required, given the propensity of the Waipoua to rework its bed and banks (Figure 1.4). Although a widened channel may foster in-channel deposition (and potentially offset bed scour prevalent in the reach), flow may nevertheless be directed at different points and times into or adjacent to the stopbanks where they coincide with the channel margin, which means they will require protection.

A planned high-flow channel upstream of Mawley Park could be subject to re-sedimentation in the same way as lowered berms. In essence this is a natural process: abandoned channels and wetlands on the floodplain will fill up over time.

Summary

I have summarised the likely geomorphic effects of the four options under consideration, differentiated between large and small floods, in Table 1.

Table 1 High level summary of geomorphic effects in response to proposed interventions in the Waipoua River through Masterton for large and small-moderate floods

	Likely geomorphic effects	
Intervention	**Large floods**	**Small-moderate floods**
Proposed berm lowering	Bed and bank scour	Re-sedimentation of berms
Proposed channel widening under the Colombo Road bridge	Bed and bank scour	In-channel deposition of bedload to form bars
Potentially extensive rock lining of riverside stopbanks	Bed scour along rock linings	Bed scour along rock linings
A proposed high flow secondary flow path/back channel upstream of Mawley Park	Possible scour, impacts not modelled	Re-sedimentation

In summary, berm lowering is likely to have significant geomorphic effects in the Waipoua, both in response to large floods (Q_{100} modelled) and smaller (unquantified) flows. A catchment-wide approach to ‘slow the flow’ before floodwaters reach this section of the Waipoua, combined with a widened river corridor as a whole (room for the river) through Masterton would provide the most sustainable, long-term option for flood mitigation in this river. As well as the geomorphic effects, the proposed changes are likely to increase the depth or scale of rock armouring required for structures such as bridge abutments, and stopbanks located near the river edge.

Figure 1.1: Extent of berm lowering in lower Waipoua through Masterton (yellow lines on aerial photo) in conjunction with cross-sections (red lines on aerial photo). Modelled velocities in orange (existing cross-sections) and red dashed (modified cross-sections) lines shown alongside image. In all sections except XS 8 lowering of the berm increases velocities. All velocities exceed critical velocities for entrainment and transport of gravel (cf. Figure 1.3)

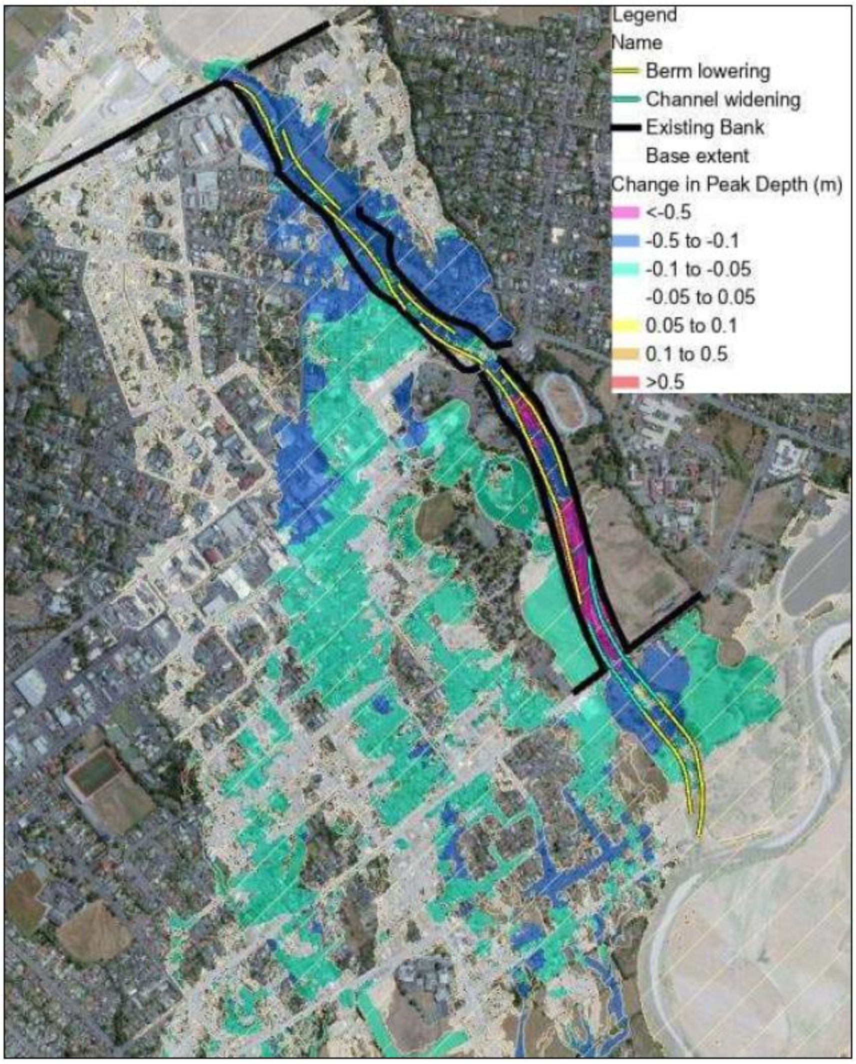

Figure 1.2: Depth difference layer for a 1% AEP flow (Q_{100}) between the base scenario and LRS combined option 13 (channel widened and berms lowered), source: Land River Sea Consulting Limited Memorandum to Greater Wellington Regional Council, 13 September 2024, Figure 2-22

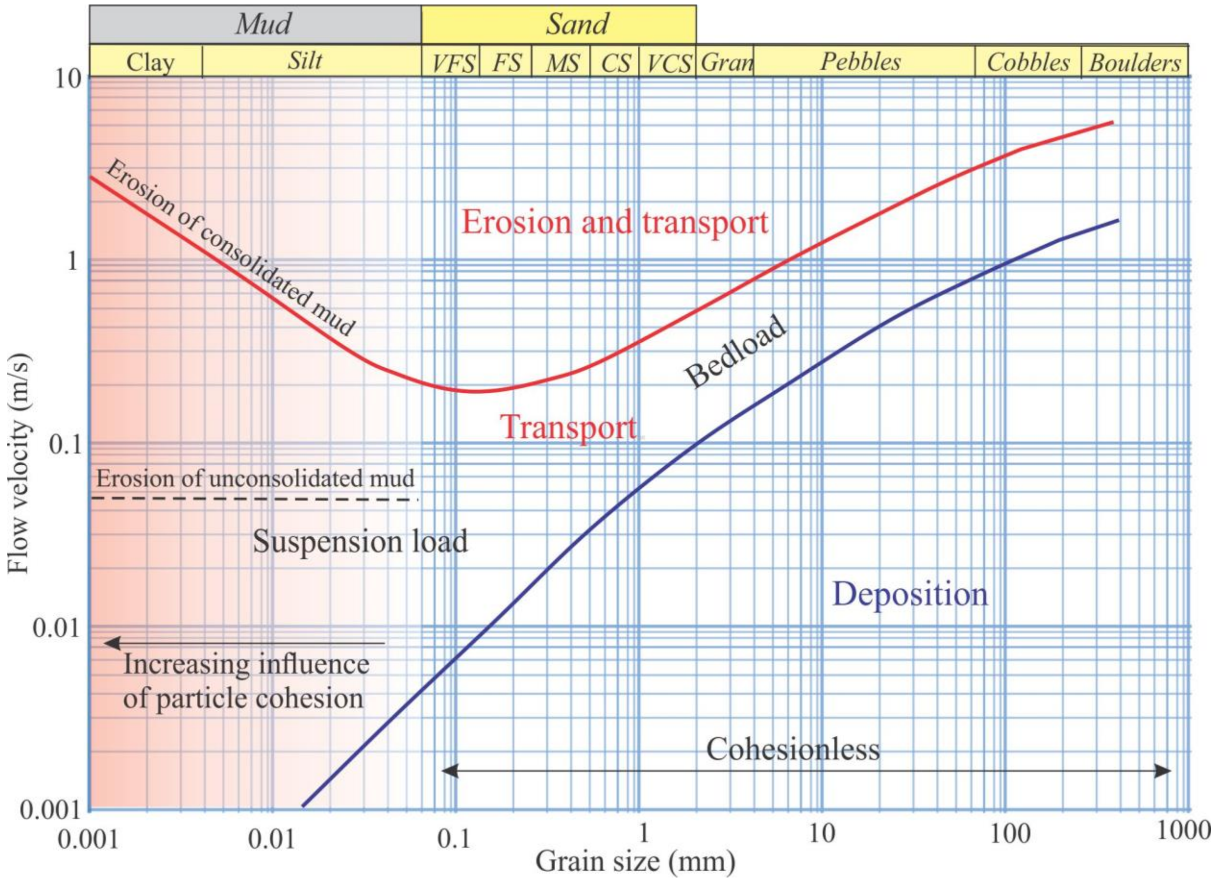

Figure 1.3: Hjulström Curve, plotting the relationship between flow velocity and entrainment/transport/deposition of gain sizes ranging from clay to boulder. The critical velocity for entrainment of particles of a given size is delineated by the red line. Entrainment velocities are higher than transport velocities. Note: the critical velocity for entrainment of gravel is around 1 m/s

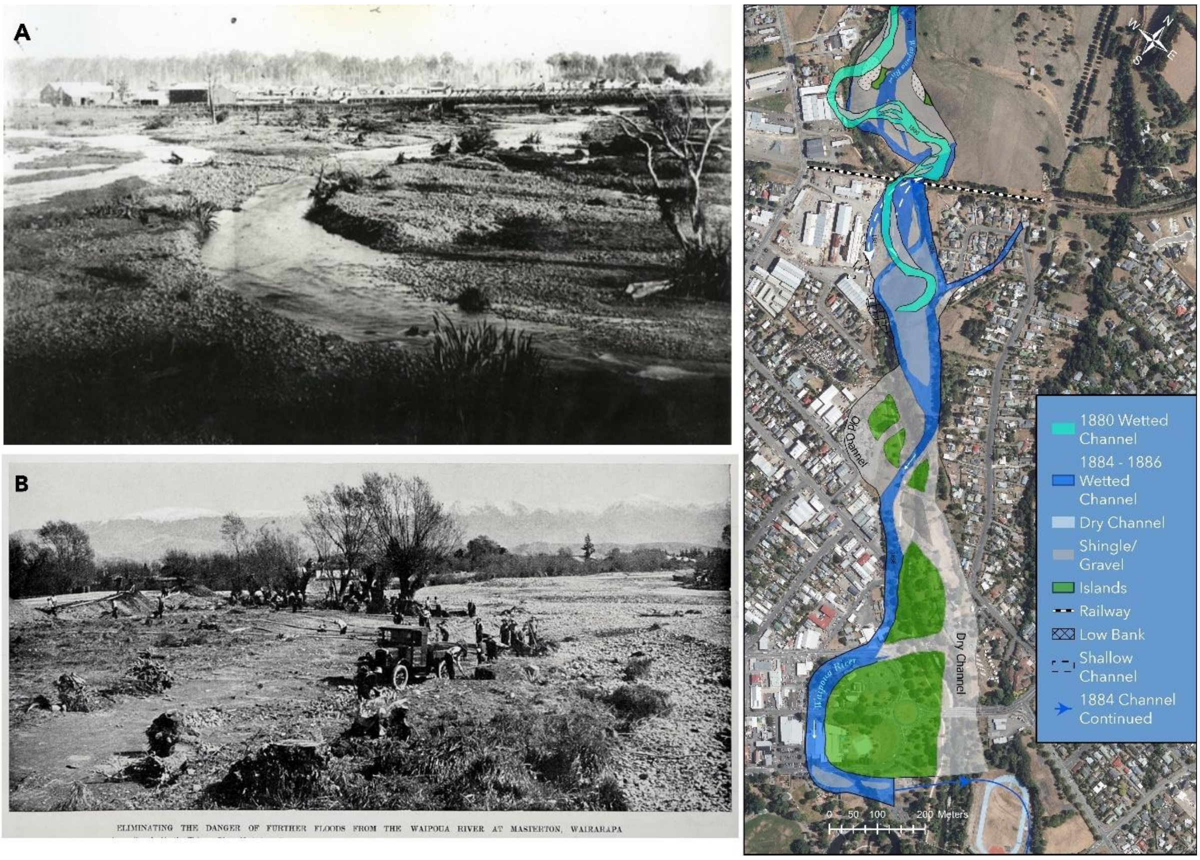

Figure 1.4: A) circa 1880s, Waipoua River in vicinity of Masterton railway bridge (visible); (B) September 1936 'eliminating the danger of further floods from the Waipoua River at Masterton', early stopbank construction. Source: Auckland Libraries Heritage Collections AWNS-19360930-51-03. Both photos show the Waipoua as a wide, laterally active gravelly river. Archive maps from the 1800s overlaid on the 2021 aerial photograph of Masterton (right) show the more sinuous, laterally active nature of the 1880s river compared with the present day

Figure 1.5: Proposed high-flow channel (pink outline) upstream of Mawley Park, to connect with small true left bank tributary (blue line)

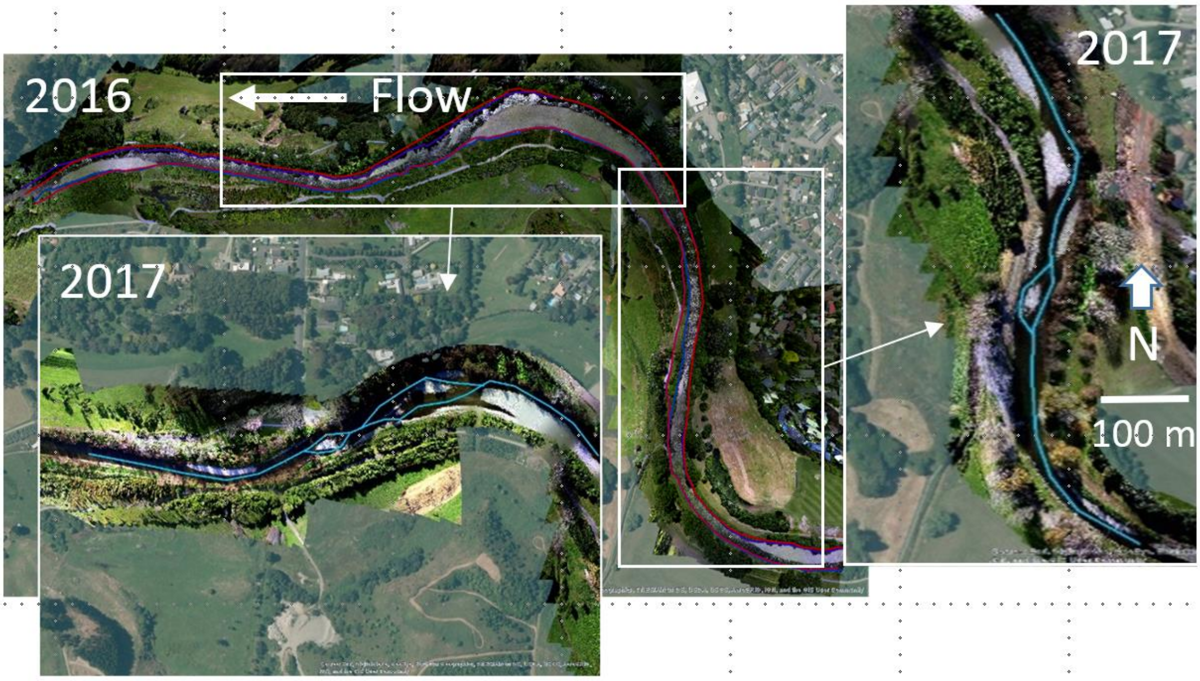

Figure 1.6: Changes in the Waikanae River at Jim Cooke Memorial Park following widening in 2017 (from Fuller et al., 2021[2])

Applicability

This report has been prepared for the exclusive use of our client GWRC, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

7-Mar-25
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[2] Fuller, I.C. et al. (2021) An index to assess the extent and success of river and floodplain restoration: recognising dynamic response trajectories and applying a process-based approach to managing river recovery. *River Research and Restoration*, 37, 163-175.