REPORT

Tonkin+Taylor

Preferred Option Report

Waipoua River Flood Risk Management

Prepared for
Greater Wellington Regional Council

Prepared by
Tonkin & Taylor Ltd

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Executive summary

This report presents the selected approach to flood risk management for the Waipoua River in Masterton. A thorough process, including community, mana whenua and stakeholder involvement, has led to the selection of a preferred option. That option aims to reduce flood risk to the Masterton urban area, balancing the more urgent need for physical works with also realising longer term environmental and flood resilience opportunities.

Background

The Waipoua River has been significantly modified over time through activities such as confinement, channelisation and straightening. These modifications (constraining the river through Masterton), have concentrated the flood risk to the urban area. The modelled and agreed flood hazard to Masterton is considered to be unacceptable. A large part of the Masterton urban area is shown to be subject to flooding, which is reported to be already affecting the availability of insurance and people's investment decisions. The flood risk to properties on the north bank (Oxford Street and Mawley Park) is considered to pose a risk to life. In line with Greater Wellington policy, a level of service of a 1% Annual Exceedence Probability (AEP)[1] flood, with an allowance for climate change out to 2100, has been agreed as the standard for flood risk management.

Process

The process to arrive at a preferred option followed a by-and-large linear process, which consisted of:

1 Agreeing the flood hazard;
2 Developing a longlist of options;
3 Refining this to a shortlist of options;
4 Forming combinations of shortlisted options;
5 Engaging on four concepts with the community; and
6 Recommendation of a preferred combination.

This process was delivered by the Waipoua Project Team, which consists of community, Greater Wellington and mana whenua members, with participation from Masterton District Council officers. The Waipoua Project Team was supported by consultants and other experts as needed.

Preferred option for flood risk management

The preferred option is described in Section 10 of this report, and consists of the following elements:

- Structural measures (new/upgraded stopbanks, flood walls, and bunds) in the urban reach of the river, including in places on retreated alignments, to provide an immediate reduction in the flood risk (once implemented) and provide continuous defences to the urban area. This also includes targeted lowering of the river berms and widening of the channel to increase flood conveyance;
- Nature-based solutions in the catchment upstream of Masterton, to help in managing the flood risk in the long-term and provide wider benefits for the environment and the community;
- Planning controls, to prevent inappropriate development in risky areas (which would lead to the flood risk continuing to increase over time); and

[1] Sometimes referred to as a '100-year' flood

- Emergency management and flood warning improvements. These will both improve safety in areas that are not protected by new/upgraded defences, and help to manage the residual risk, i.e. what happens if the defences fail, or when a larger flood comes than the one that was designed for.

The structural measures are shown on the plan in Figure 10.1.

The following two areas are not proposed to be protected to a 1% AEP + climate change standard:

1 Mawley Park. The Waipoua Project Team sees the flood risk to Oxford St as being particularly high, and urgent to address. They have recommended retreating the stopbank, wherever possible, to an alignment within or behind (landside) of Mawley Park, in order to provide more room for this critical stopbank rather than having it directly on the edge of the river. However, it is understood that this will affect the future use of the land at Mawley Park, and further work would need to be done by MDC and Greater Wellington to agree an alignment here; and

2 The true left bank downstream of the sports bowl. The existing stopbank here will not be upgraded to the higher standard. The possibility of lowering sections of stopbank or otherwise engineering spill locations will be further investigated, to ensure that water will preferentially spill across the rugby fields and Colombo Road, rather than putting pressure on the true right bank defences that protect residential areas.

Masterton District Council is considered to be a key stakeholder in this work, and it is anticipated that it will actively contribute to the future detailed design phase and inform the desired level of service for key assets.

This preferred option largely reflects the community's preferences, as expressed through the engagement carried out in February and March 2025.

1 Scope and purpose of report

The purpose of this report is to document the preferred option recommendation for managing the flood risk to Masterton, and the process followed by the Waipoua Project Team in arriving at its recommendation. The aim is not only to demonstrate a sound recommendation and robust process, but also to capture some of the “why” as to why this particular option was chosen and its key features.

Tonkin & Taylor Ltd (T+T) has prepared this report on behalf of the Waipoua Project Team members, who have had the opportunity to provide feedback on its contents. T+T’s involvement in the optioneering process began in June 2024, late in the longlisting stage. The decisions made prior to this were captured based on documents, photographs of team meeting flip charts and inputs from the Waipoua Project Team.

This report does not seek to cover in detail the pre-optioneering flood modelling, peer review or the wider process that led to an agreement on the flood hazard prior to T+T’s involvement. T+T has, however, summarised the key themes and milestones relating to the flood hazard assessment in Section 2.4 below.

The Waipoua Project Team has been working to address the flood hazard to Masterton from the Waipoua River. It has not addressed flood hazard from other sources, such as local streams/stormwater or the Waingawa River.

2 Background

2.1 The Waipoua River

This section draws heavily on a description prepared by Ian Gunn, a member of the Waipoua Project Team.

The Waipoua River is one of the smaller rivers draining the foothills of the Tararua Range, with a catchment area of approximately 17,000 ha. Historically and pre-historically, the course of the Waipoua River has been forced either way across its alluvial plain by the larger Waingawa and Ruamāhanga rivers to the south and north respectively. It crosses a series of earthquake faults.

It is highly modified, having been:

1 Straightened;
2 Shortened;
3 Channelised;
4 Crossed by five bridges in its urban reach;
5 Stopbanked within the urban reach and with isolated stopbanks further upstream, until just upstream of Paerau Road;
6 Denuded of trees in much of its catchment, with the conversion to pasture of most areas outside of the Tararua Forest Park; and
7 Drained of wetlands.

Figure 2.1 below shows the 1884 river alignment (taken from Carter & Fuller, 2024) and demonstrates the degree of constrainment that has occurred over the intervening years. Figure 2.2, a photograph provided by Greater Wellington, shows the winding path taken by the Waipoua River downstream of SH2 in the early part of the 20th century. This photograph also clearly shows the straightening works (mid- to late-1930s) well underway.

Figure 2.1: Historical river channel (1884) overlaid on recent aerial photography

Figure 2.2: View upstream from previous Colombo Road bridge (additional spans under construction, ca. 1935)

The riverbed, which is naturally degrading (lowering) anyway, has degraded considerably since the straightening and channelisation through the urban reach. Three rock grade control weirs have been constructed across the channel through this reach and have successfully resisted this trend and protected infrastructure (the State Highway 2 bridge and the water intake to the Queen Elizabeth Park Lake of Remembrance). These weirs have been damaged in past flood events and are likely to be seriously damaged in a large flood.

A note on terminology: where "true left" and "true right" are used in this report, these refer to the left and right side of the river while looking downstream.

2.2 Te Kāuru Upper Ruamāhanga FMP

Greater Wellington's Te Kāuru Upper Ruamāhanga Floodplain Management Plan (Te Kāuru FMP) (Greater Wellington, 2019) was adopted in June 2019 following several years of development. This FMP contains agreed approaches to managing the flood and erosion risk of rivers within the Ruamāhanga catchment upstream of the Waiohine River confluence.

At the time of the FMP's adoption, there was disagreement over the extent of the Masterton flood hazard. The Te Kāuru FMP, therefore, included a "major project response" to address the Masterton flood hazard to be developed as a priority for FMP implementation. Its recommendations included:

- Completing geotechnical investigations;
- Updating the flood hazard mapping;
- Developing a preferred option;
- Supporting further work in community preparedness and emergency management improvements; and

- Land use, regulatory and other non-structural approaches. This included aspects which more recently have become known as nature-based solutions, such as wetlands or afforestation.

2.3 The Waipoua Project Team

Concerned residents challenged both the extent/degree of flood hazard from the Waipoua River that had been developed under the Te Kāuru FMP. This led to a public meeting held in Masterton on 11 August 2019 and the subsequent formation of the Waipoua Project Team.

The Waipoua Project Team is made up of members of the Waipoua Catchment Community Group (Andrew Donald, Garry Foster, Ian Gunn, Michael Hewison, Ra Smith and Ken Downing), mana whenua and Greater Wellington, with participation from Masterton District Council officers.

Core aspects of the Waipoua Project Team and its work, summarised from its Terms of Reference, include:

- It is to be composed of five to seven core members plus a facilitator. Community members should represent the Masterton community, include at least one Greater Wellington member, and include other stakeholders or subject matter experts as invited from time to time. It is expected to collaborate with mana whenua and iwi; and
- It is intended to deliver an outcome that is viable, low risk and trusted.

The Waipoua Project Team's vision is: *Waipoua: Mauri-rich, connected and resilient* and its objective was defined as: *Present to the community, using a catchment lens, affordable and environmentally sustainable flood risk management options to minimise impacts to the urban reach*.

The Waipoua Project Team has typically met fortnightly over the duration of the project. It reports to the Upper Ruamāhanga River Management Advisory Committee.

2.4 Investigation and agreement on the flood hazard

The following section draws largely on notes from the Waipoua Project Team meetings and information provided by Greater Wellington, as the investigation and agreement on the flood hazard occurred prior to T+T's involvement in the options development stage of the project.

Greater Wellington's standard process for new flood hazard mapping involves peer review of both the hydrology and the hydraulic (river) modelling, and then an independent audit of the overall mapping, technical approach and process. Community consultation also takes place on the draft maps. The process for the Waipoua mapping was particularly complicated, as community discomfort with the flood hazard information led to significant scrutiny and a process of Greater Wellington working through the modelling work with different groups. Different consultants provided technical input at different stages. The process and timeline are summarised below, based on information provided to T+T by Greater Wellington.

- The process started in 2013 when hydrological investigations were undertaken for the Wairarapa by Pattle Delamore Partners (PDP).
- From approximately 2013 to 2015, a rectangular grid hydraulic model was built for the upper Ruamāhanga River catchment, including the Waipoua River.
- At each stage in the process, peer reviews were undertaken in accordance with council policy at the time.
- In 2014, early draft flood hazard maps were presented to the wider community. There was a lot of discomfort with the maps, which showed a large part of Masterton at risk of flooding, and significant scrutiny was then placed on the hydrological aspects of the modelling. A Waipoua Officers Working Group was formed with officers from Masterton District Council

and Greater Wellington, to agree on hydrology to be used for the flood hazard modelling. Significant discussion occurred regarding the ungauged portion of the catchment (below Mikimiki to the confluence with the Ruamāhanga River).

- A new hydrological assessment was undertaken by MWH and agreed by the working group, with the work being completed in 2016. At this time the hydraulic model was also updated to be a flexible mesh model for the Waipoua River (a newer technology than the previous rectangular grid model).
- Between 2017 and 2019 a new flexible mesh MIKE hydraulic model was built to utilise improvements to the MIKE software, a Danish Hydraulic Institute (DHI) software product.
- In 2019, updated flood hazard maps using the agreed MHW hydrology and flexible mesh model were consulted on with the community. There was again significant discomfort from the community with the results.
- In 2019, an independent audit of the process was undertaken by Land River Sea Consulting (LRS), with the hydrological aspects being done by Barnett & MacMurray (B&M). This was a more hands-on investigation than what would usually be expected from an independent audit. The community also had the ability to ask the auditors questions regarding the modelling during this process.
- The outcome of the 2019 independent audit was a series of major, moderate and minor recommendations for the hydrology and hydraulic modelling.
- It was agreed that these recommendations would be implemented by the independent auditors (Matt Gardner from LRS and Vicki Henderson from B&M).
- Between 2019 and 2023 these recommendations were implemented and updated flood hazard maps have been prepared. **This is the stage at which the Waipoua Project Team became involved.** Full peer review processes were undertaken by new reviewers of these updated models. These peer reviews followed Greater Wellington's Flood Hazard Modelling Standard.
- The updated flood hazard maps were consulted on with the community in late 2022.
- An independent audit was carried out in July/August 2023 by PDP, resulting in a preliminary audit report. This raised concerns which were subsequently addressed by the consultant modellers (LRS, and Barnett & MacMurray), primarily in the hydraulic (river) model.
- These changes were made, with Waipoua Project Team oversight, during late 2023 and early 2024. The independent audit was closed out in June 2024 with the issue of a final audit report following the auditor's review of the changes.
- The flood hazard modelling and mapping are considered final and have been used to determine the preferred flood risk management option for the urban reach of the Waipoua River.

2.5 Overall optioneering process

The Waipoua Project Team's optioneering process for arriving at its recommendation followed a longlist – shortlist – preferred option process. This is consistent with Greater Wellington's Floodplain Management Planning Guidelines and, broadly, with typical approaches taken in making decisions on public infrastructure. The process has analogies with a longlist – shortlist – preferred candidate recruitment process. This process as used by the Waipoua Project Team was as follows:

- Longlist development: this begins with brainstorming and all possibilities are considered. The list is quickly refined on the basis of high-level information, with options discarded that clearly do not meet the project needs (analogy: first pass over the CVs of the job applicants).

- Longlist to shortlist decision: a structured but high-level assessment is made of the most promising options. In this case, a red/amber/green multi-criteria analysis was used as a tool. This may be based on high-level or limited information (analogy: shortlisting the best CVs for an interview).
- Shortlist option development: the shortlist options are developed in more detail. There will likely be a higher level of design and additional technical investigations – for example, in this case costing information and additional hydraulic modelling were obtained (analogy: applicants and interviewers prepare for the interviews).
- Preferred option recommendation: a preferred option is chosen from amongst the shortlist options, explicitly taking into account a wide range of factors. Sometimes, this may be a combination (hybrid) of multiple shortlist options. A greater level of detail is available to support the decision, and usually, the level of stakeholder or community input is greater at this stage. A structured approach is taken to arriving at and documenting the decision. In this case, a scored multi-criteria analysis was used (analogy: job interviews and decision).

2.6 Timeline of options development

Background research, briefings from various experts and high-level canvassing of options began in January 2020. These progressed in parallel with the work on the flood hazard mapping, albeit, that the work on hydrology, hydraulic modelling and flood mapping was the focus of the group over much of the period 2021 to 2023.

Focussed work on developing an initial longlist of options started in late 2022/early 2023, with a final longlist and hydraulic modelling of these options by Land River Sea taking place in early – mid 2024.

The discarding of some longlist items to create a shortlist, followed by combining the shortlist items into different combinations, took place from June to October 2024. These shortlist combinations were then developed further from October 2024 to February 2025 and consulted on with the community in February/March 2025. The preferred option recommendation was made in March 2025.

The timeline in Figure 2.3 gives a high-level overview of the optioneering process. This is described in more detail in Sections 4 to 9.

Figure 2.3: High level optioneering timeline

2.7 Contributions from experts

The following people named in Table 2.1 contributed their expertise at Waipoua Project Team meetings.

Table 2.1: Selected list of presenters to the Waipoua Project Team

Name	Affiliation	Expertise
John Boon	-	Facilitation
Bethanna Jackson Bianca Wulansari Kassun	Victoria University	Ecosystem services Land Use Capability Index (LUCI)
Allan Keene	Wellington Water	Wetlands hydrology
Jim Campbell	Landowner	Wetlands hydrology
Trevor Thompson	QEII National Trust Waipoua Kaitiaki Group	Wetlands hydrology
Vicki Henderson	Barnett & MacMurray	Hydrological modelling for Waipoua catchment
Bruce Geden	Greater Wellington Wairarapa Water	Updates regarding 3D aquifer mapping
Stephanie Tomscha Kiki Morris	Victoria University – Biological Sciences	Wetlands Land Use Capability Index (LUCI)
Ainslee Brown Sam Gundersen	Greater Wellington	Water That Counts project
Ian Fuller	Massey University/Tonkin + Taylor	Fluvial geomorphology
Kyle Christensen	Christensen Consulting	River engineering Design lines for river management
Trevor Carey-Smith	NIWA	Climate change
Aaron Barker	Masterton District Council	Community development Parks and Open Spaces project
Kristin Stokes	Jacobs	Hydrology modelling peer review
Malcolm Birch	Greater Wellington	River management Riparian planting
Matt Gardner Bilu Susan Babu	Land River Sea Consulting	Hydraulic modelling
Ashleigh Hunter (Ward)	WSP	Landscape architecture Indigenous landscape design
Will Conley	WSP	Geomorphology – impacts of earthquake on Waipoua flooding.
Alan Flynn	Masterton District Council	Mapping of fault lines in wider Masterton area
Selene Conn	Tonkin + Taylor	Fluvial geomorphology
Mark Broughton Karen Jones	ENGEO	Geotechnical investigations and assessment of stopbanks
Mark Hooker James Flanagan	Tonkin + Taylor	River engineering and flood management
Karen Baverstock	Tonkin + Taylor	Planning Advice on multi-criteria analysis

3 Flood hazard to Masterton

Masterton, due to being bisected by the Waipoua River, is subject to a significant flood hazard from the river. Flooding to urban parts of Masterton occurred most notably in:

- May 1918;
- August 1932;
- October 1934; and
- June 1947.

Following the 1930s floods, the river was straightened and stopbank defences were raised, which are understood to have been further upgraded following the 1947 flood. The town has not significantly flooded since this time, although the stopbanks came very close to overtopping in places during the 1998 flood.

Due to its smaller/shorter catchment that does not extend very far into the Tararua Ranges, floods on the Waipoua River rise and fall faster than on other Tararua Rivers, and the flood duration overall is typically short in comparison. A 12-hour storm duration was adopted as the critical storm for modelling flood hazard.

3.1 Current flood hazard mapping

The current flood hazard mapping carried out by LRS (LRS, 2023) was accepted by Greater Wellington in June 2024, following conclusion of the independent audit by PDP (as described above in Section 2.4). The flood hazard maps currently in use for providing information for buildings in Masterton are based on the “combined sensitivity scenario” shown on the flood depth map in Figure 3.1 below.

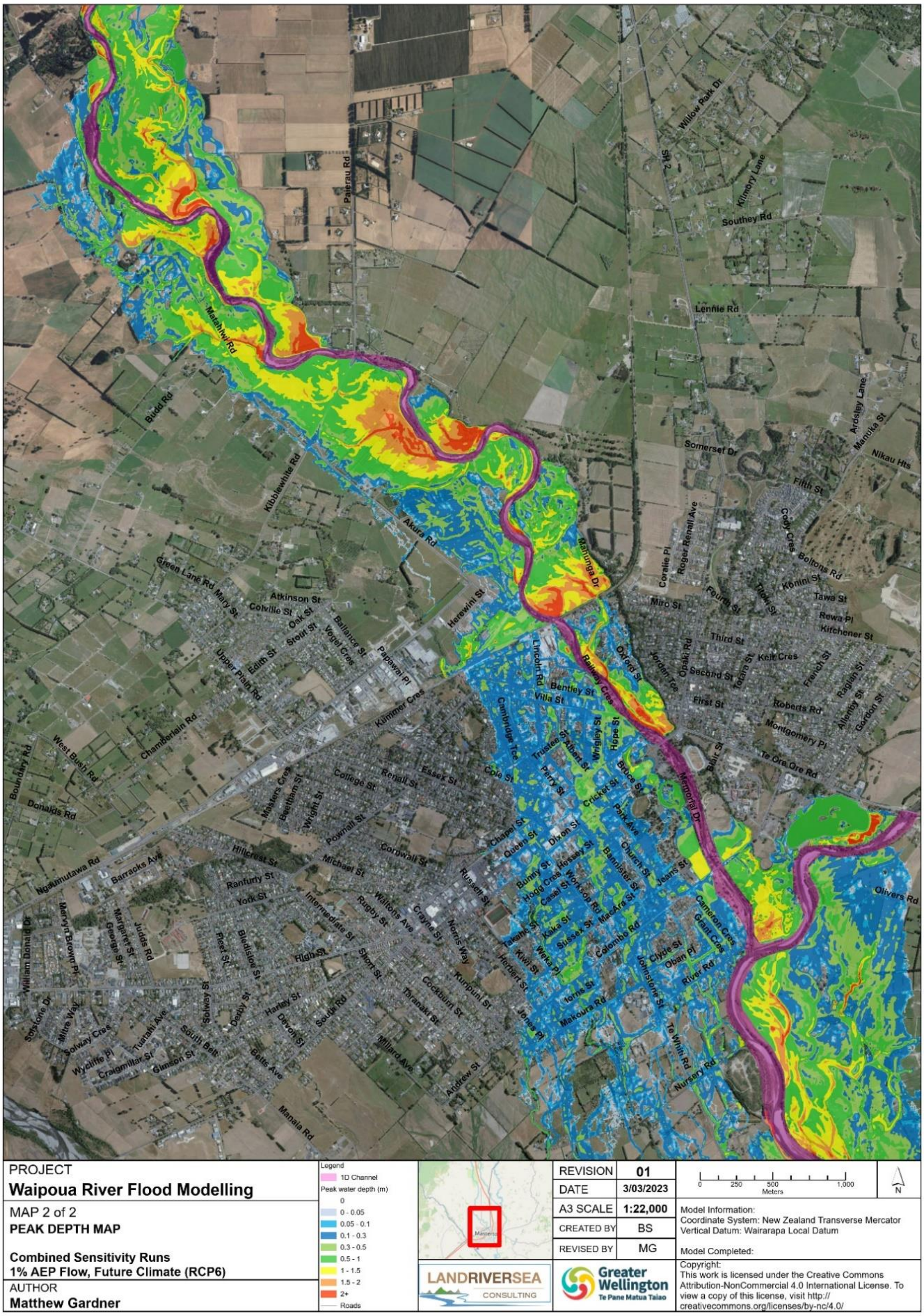

Figure 3.1: Flood risk through the Masterton urban area from a 1% annual exceedance probability flood in the Waipoua River (including an allowance for climate change to 2100 and uncertainties)

Note: whenever the future climate case is mentioned in this report, unless stated otherwise, this refers to climate change scenario RCP6[2] out to the year 2100.

Conclusions from the March 2023 modelling report (LRS, 2023) include:

- The upper/rural reaches of the Waipoua River are exposed to significant flood hazard which is likely to cut off road access/limit access to residential properties even in events as small as a 10% AEP (1 in 10-year event).
- The urban reach of the river poses an inundation threat to Masterton with water spilling into town primarily from the true right bank of the river upstream of the fire station with potential spilling occurring in events upwards of a 5% AEP (1 in 20-year event).
- Whilst the potential areas of inundation cover a significant area, general flood depths and velocities are relatively low, and the general hazard categorisation falls into the lower category which is described as “generally safe for vehicles, people and buildings”.
- The main bridges are shown to have sufficient capacity to pass the 1% AEP future climate event, except for the Colombo Road bridge. This bridge was in the process of being replaced at the time of writing in 2023 and was not raised. Modelling shows that water levels are likely to reach the soffit for events with flows greater than the 5% AEP event, and the bridge is likely to overtop completely in a 1% AEP future climate event (RCP6).
- Whilst water levels do not reach the soffit of the railway bridge, flows from upstream of the bridge still back up behind the railway embankment on the true right bank and begin to overtop the railway line resulting in flooding within the Masterton urban area in the 1% AEP event and 1% AEP future climate scenarios.

3.2 Changing flood hazard

Due to the effects of climate change, reflected in the modelling by LRS, the flood risk to Masterton is changing over time. The following series of maps show the modelled flood hazard for a 1% AEP event:

- With historical climate (Figure 3.2);
- With climate change to 2050 (Figure 3.3); and
- With climate change to 2100 (Figure 3.4).

Note that these maps represent the ‘base’ flood hazard without additional sensitivities, so do not correspond directly to the adopted flood hazard map shown in Figure 3.1.

[2] Representative concentration pathway; a terminology for different climate change scenarios.

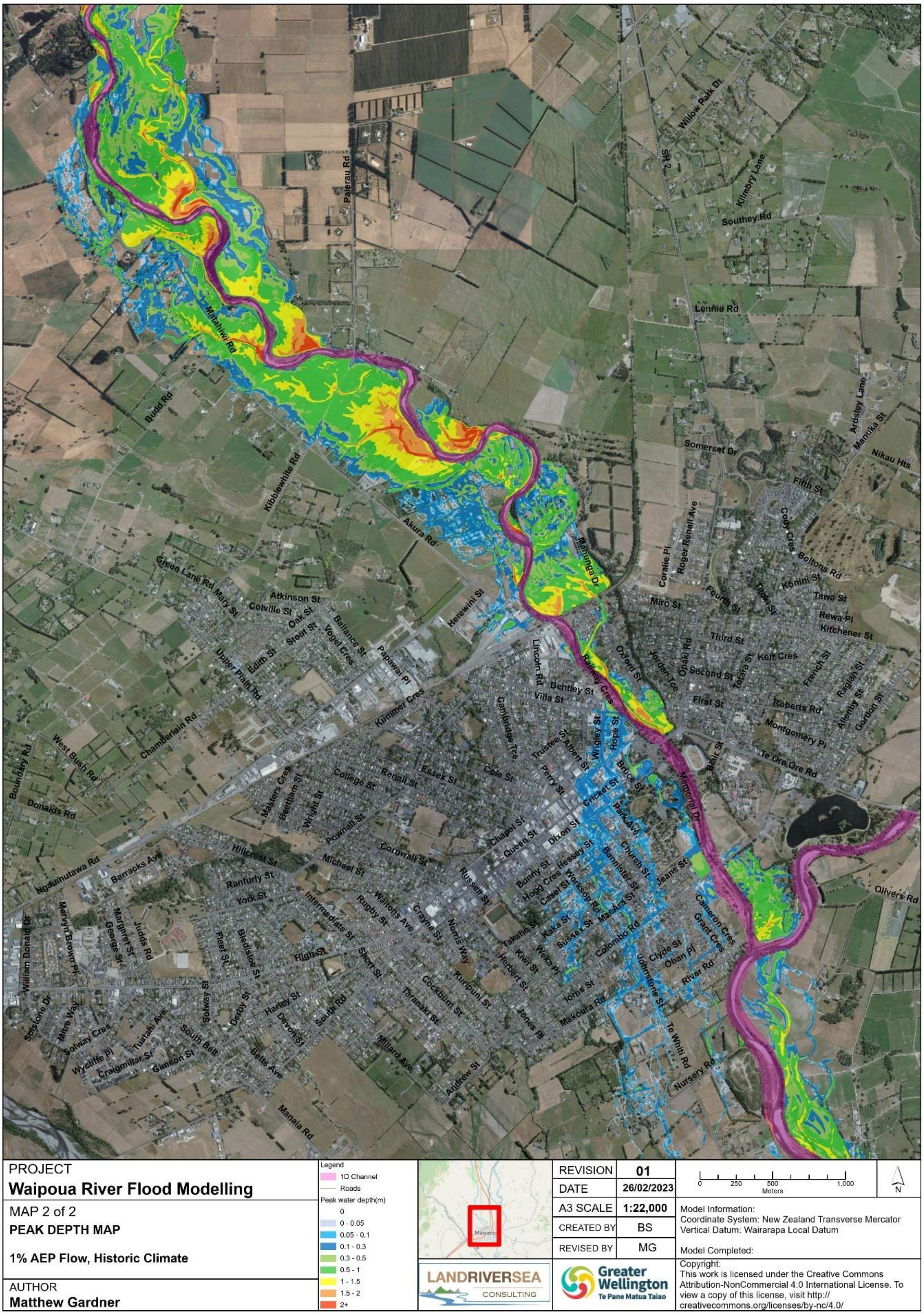

Figure 3.2: 1% AEP flood depth, historic climate, no sensitivity

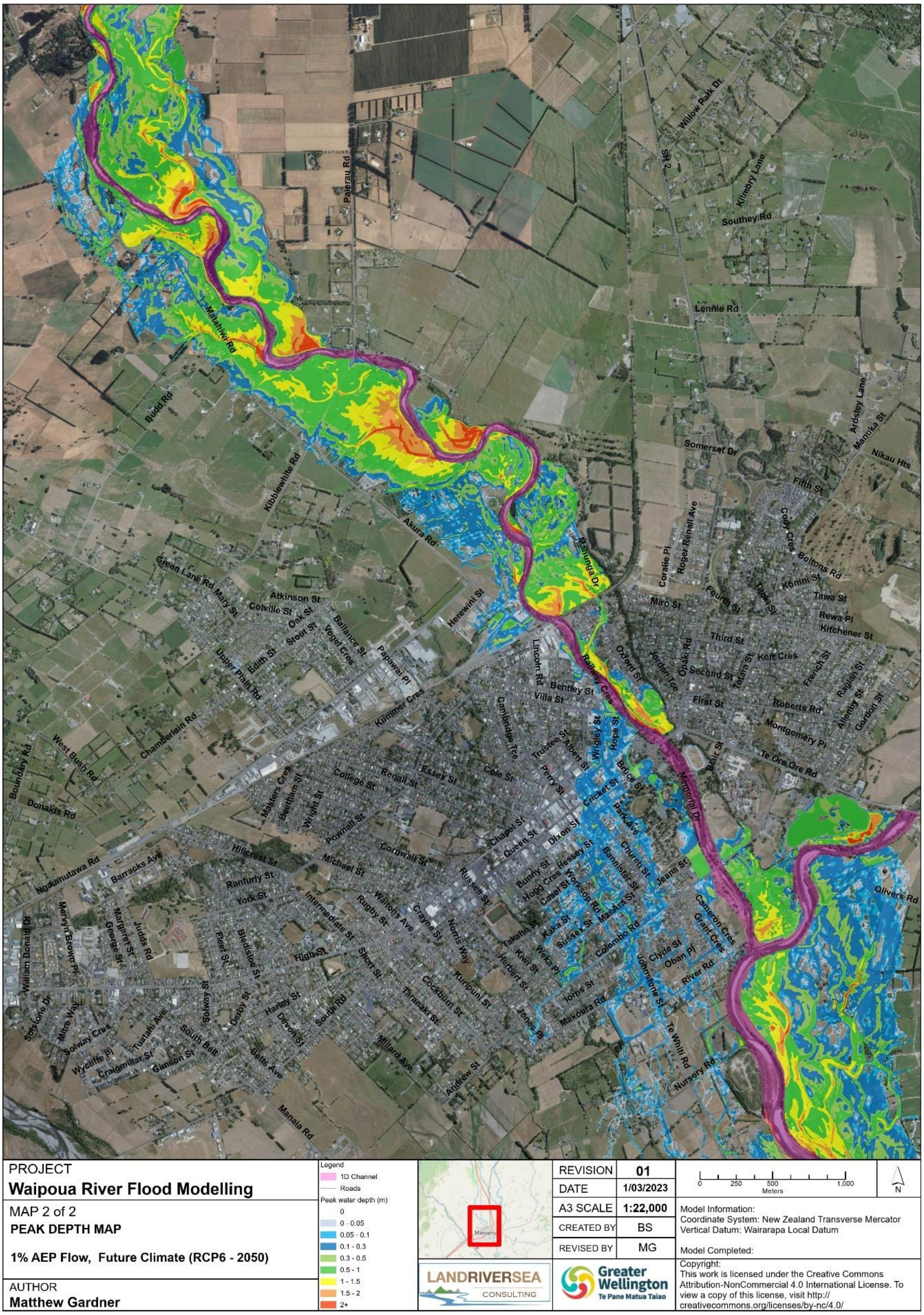

Figure 3.3: 1% AEP flood depth, climate change to 2050, no sensitivity

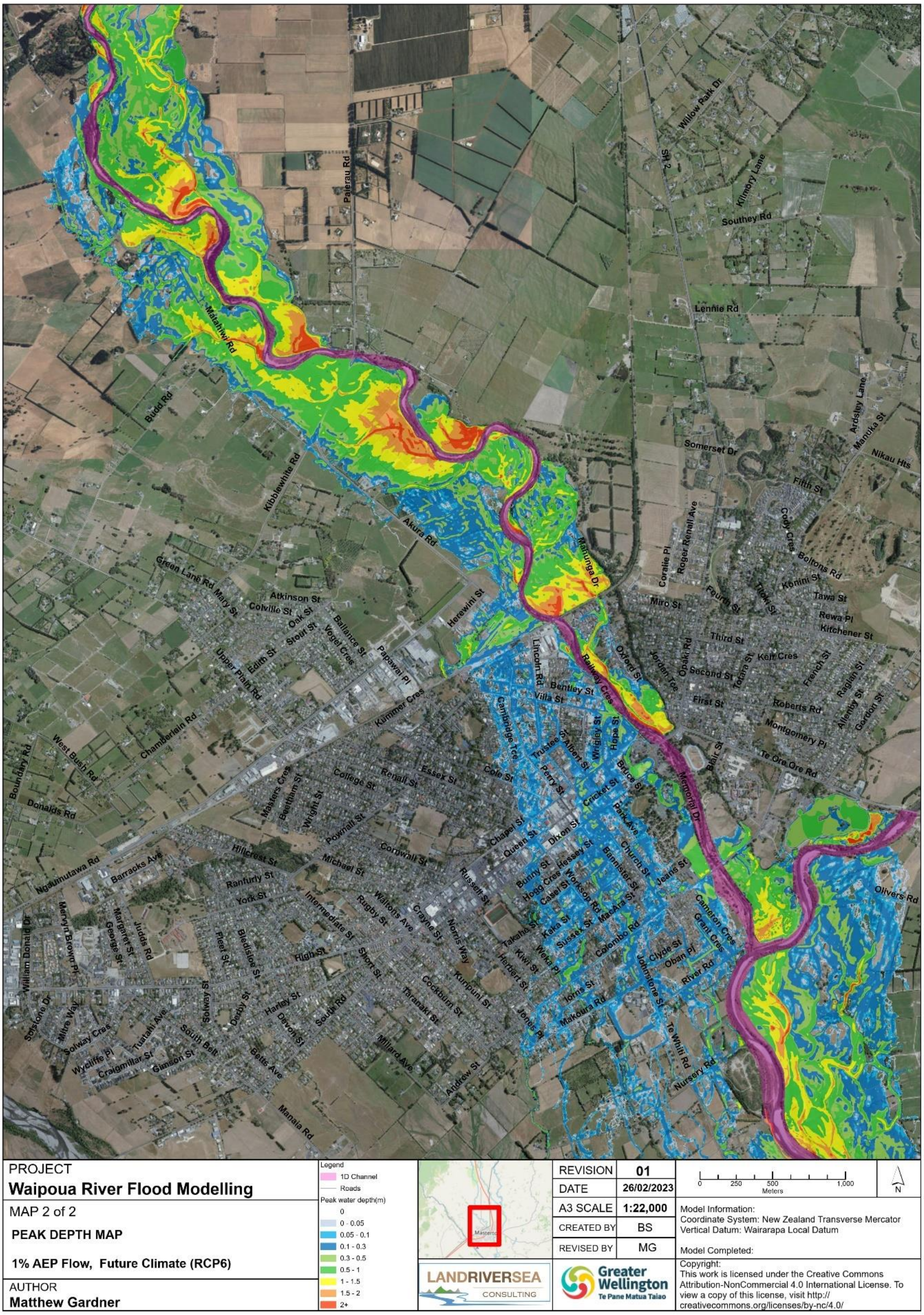

Figure 3.4: 1% AEP flood depth, climate change to 2100, no sensitivity

As can be seen above, the nature of flooding in a 1% AEP event by 2100 is modelled to change considerably, with water spilling over the railway line in addition to flooding that would occur in Oxford Street/Mawley Park and spilling into the town from the vicinity of the fire station. In fact, the flooding at Oxford Street/Mawley Park and at the fire station is modelled to begin in floods greater than around a 5% AEP (20-year) event under the historical climate case. The Waipoua Project Team notes the greater urgency this implies for these locations, in comparison to other locations where a longer-term, phased approach may be appropriate.

3.3 Flood damages assessment 2024

In June 2024, T+T reported on its flood damages assessment (T+T, 2024), based on flood modelling done by LRS. This assessment is included in Appendix B. This included the evaluation of both present-day and future climate conditions, specifically examining scenarios projected for 2050 and 2100. Various flood events were assessed, represented as Annual Exceedance Probabilities (AEP), which included scenarios such as 1%, 2%, and 5% AEP floods, along with some additional scenarios to assess the sensitivity on the analysis in response to varied parameters.

The methodology involved selecting appropriate fragility functions to correlate flood depth and damages across different asset types, including residential, commercial, and industrial properties. The assessment also made an evaluation of flood damages to rural land. Additional dimensions of the assessment looked further into indirect damages, such as relocation costs for residents displaced by flooding, as well as intangible impacts relating to human health and community cohesion, recognising the broader social implications of flood events.

The results were presented in terms of both total damages (for a given flood event) and average annualised damages (average damages expected each year across the whole range of flood events that were modelled). Results were presented as lower and upper bounds.

The urban damages within the study area constituted around 93% of the average annual damages. The expected average annual damages currently range from $370,000 to $740,000 and could roughly triple to between $1.1 million and $2.2 million by 2100 due to anticipated climate change effects.

The estimated damages in a single 1% AEP flood with climate change allowed for out to 2100 range from $21M to $42M, or $49M to $94M when an agreed sensitivity scenario was tested.

Aside from physical and financial damages, flooding poses serious intangible costs, particularly relating to human health and community cohesion. Displacement due to damaged properties can lead to significant psychological impacts, including grief over lost personal belongings and homes, financial anxiety, and potential post-traumatic stress disorders. These emotional and social burdens can erode community ties, disrupt local events, and challenge the social fabric as businesses suffer closures and income losses. The assessment highlights that such intangible impacts are crucial for understanding the overall risk and implementing effective flood management strategies to not only protect economic assets but also to support community resilience and well-being.

4 Overview of process to determine preferred flood management option

Option development and selection followed a mostly linear process, consisting of the following phases:

1 Longlist development;
2 Longlist to shortlist decision;
3 Shortlist of options;
4 Combination of shortlisted options;
5 Concepts for community engagement; and
6 Recommendation of a preferred combination of options.

These phases are described in the following sections.

4.1 Mana whenua involvement

Ra Smith was involved in the Waipoua Project Team from the beginning, in a dual role as a member of the community and also representing Ngāti Kahungunu ki Wairarapa.

Rangitāne o Wairarapa mana whenua were involved in various stages along the way, although most recently with significant input from Daphne Te Whare and Jim Haeata at recent Waipoua Project Team meetings during the shortlist to preferred option process.

4.2 Masterton District Council involvement

MDC officers were invited to all of the Waipoua Project Team meetings. Initially David Hopman was involved with the group and later Phil Evans became MDC's designated contact. Both attended Waipoua Project Team meetings regularly, as other work commitments allowed. The following specific meetings were held with MDC officers and councillors to brief them on the shortlist:

- Greater Wellington presentation to MDC officers on 27 November 2024;
- Greater Wellington presentation to MDC Executive Leadership Team on 11 February 2025; and
- MDC presentation to Council on 26 February 2025.

5 Longlist development and agreement

The design level of service for flood protection has been agreed as a 1% AEP flood, with an allowance for climate change to 2100 in line with Greater Wellington's current Council-endorsed principle.

5.1 Initial longlist

The longlist options were developed by drawing on multiple sources, including:

- Existing knowledge within the Waipoua Project Team;
- Previous material begun as part of the Te Kāuru FMP and then picked up later in an optioneering process led by WSP in 2018-2019 (prior to the existence of the Waipoua Project Team);
- Knowledge provided by the community, and options that have existed in some form for a long time (for example, the idea of a diversion to the Ruamāhanga River is referred to in a Wairarapa Age article from 1935); and
- Feedback and suggestions from consultant advisors to the Waipoua Project Team (T+T, LRS) and other presenters during Waipoua Project Team optioneering meetings.

The initial, extensive longlist (from brainstorming carried out in late 2022/early 2023) is included as Appendix A and contains 76 items/concepts. This is referred to in this report as the 'initial longlist'.

5.2 Final longlist

The items from the initial longlist that the Waipoua Project Team considered the most promising were given to LRS to model for the 1% AEP + climate change design scenario (see Section 5.3.1). This included the following items:

1. A wetland on land adjacent to Mahunga Drive, upstream of the railway line, with the ground level lowered to increase flood storage capacity.
2. A swale (both with and without an accompanying bund) at Akura Road to divert water on the floodplain back into the river.
3. Berm lowering at various locations along the urban reach, especially to improve capacity at the SH2 and Colombo Road bridges.
4. Minor improvements and "topping up" of stopbanks.
5. More significant stopbank upgrades and/or extensions.
6. Retreat of some stopbanks to allow more room for flood flows (at Mawley Park and the true left bank between the SH2 and Colombo Road bridges).
7. Culverts under the road near the two road bridges to take pressure off the bridges.
8. A secondary flow path near Oxford St to relieve flows in the main channel.
9. Alternative stopbank alignments to partially protect Mawley Park but also provide more room for flood flows in the channel.
10. Lowering the level of protection on the true left bank upstream of Colombo Road, to allow water to spill at this location in large floods.
11. Flood walls in locations where available space for stopbanks may be limited, for example around the industrial area at Akura Road/Railway Crescent
12. Upper catchment measures/nature-based solutions to deliver a 5% reduction in flood flows in Masterton.
13. Direct water under SH2 into the sports bowl to utilise this area as flood storage.

14 Allow Queen Elizabeth Park and adjacent areas to flood.

Each of these elements is shown, and its flood impacts described, in Appendix B.

5.2.1 Options discounted from the final longlist

Other options from the initial longlist were discussed in detail at this point within the Waipoua Project Team and were discounted from the longlist. These included:

Table 5.1: Discounted longlist options

Longlist option	Details	Reasoning
Major overflows diversion to the Ruamāhanga River upstream of Masterton	• Diversion was considered where the two rivers are relatively close together and have previously shared a floodplain.	• The Waipoua Project Team looked at the levels and did not consider that this was technically or economically feasible.
		• Both rivers are actively degrading (incising) which makes this progressively more difficult
		• Cost which would include property purchase/compensation would be large.
		• Would need to take a large proportion of the 1% AEP flood flow at this point to have a big impact on flood flows in Masterton as it would only capture approximately half the catchment at this location.
		• Would have a significant impact on Ruamāhanga flood levels downstream of the diversion.
Drainage or stream clearance to increase capacity	• Would include Ngaumutawa Road drain.	• Not considered to be significant regarding managing flooding from the Waipoua River.
Further river straightening	• Noting that the river was extensively straightened in the 1930s.	• No scope seen for further straightening.
		• Not considered desirable given the trend towards bed degrade which is managed through rock grade control weirs.
Gravel extraction	• Targeted extraction to reduce berm levels or to widen the river channel.	• Gravel extraction within the catchment is not considered to be a major driver of flooding within the urban reach.
Construction of a concrete-lined channel through town for the Waipoua River		• Not considered to meet community needs and values.
		• Would likely be unconsentable.
		• A very expensive option.
Temporary flood defences to be raised as necessary		• Considered to be very high-risk given the lengths and heights involved (may be needed in small sections to 'plug-a-gap' – can be revisited during further preferred option design).

Longlist option	Details	Reasoning
Raising all vulnerable houses/buildings		• Not feasible to raise all buildings. • Leaves a safety/access problem outside of the buildings. • Cost is likely to far exceed stopbanking options. • Raises concerns around people directly receiving a private benefit with public money (this would need to be managed).
Lengthening or raising road bridges	• Not considered necessary to be included at this time.	• Should be considered in more detailed modelling of the preferred option in consideration of staging/climate change and the risk associated with reduced freeboard to the bridge in the long term.
Floating buildings		• Considered to raise too many risk and feasibility concerns.
Diversion along railway line	• To be diverted south along the railway line and through existing streams through town.	• Considered too risky. • Unlikely to be sufficient capacity in these streams/stormwater system.
Stopbank removal and managed retreat (potentially moving the town)		• Not seen to align with community expectations.
'Do nothing'/maintenance of the status quo		

5.3 Further investigations that informed the longlist stage

The following technical input (described in the following sections) was sought during the longlist development:

- Hydraulic modelling of the options;
- Stage 1 Geomorphology report;
- Natural Character Index assessment;
- A further geomorphic opinion on bed widening and berm lowering; and
- A geotechnical assessment of the existing stopbanks.

5.3.1 Longlist options hydraulic modelling

As described in LRS's memo describing the options modelling, appended in Appendix B, the options modelling was carried out on a version of the model where the 1-dimensional channel aspect of the model had been replaced by a 2-dimensional mesh (full 2D model) in order to speed up the modelling of options and the model run times. Bridge decks and piers were not represented in this model, which is a limitation to this modelling. It is recommended by T+T that the preferred option be modelled in the original model during the next design stage to understand the impacts of the bridges under different AEP and climate change scenarios.

The hydraulic modelling was an iterative process. This involved LRS carrying out modelling of options/scenarios/combinations requested by the Waipoua Project Team, then reporting back to the group at the next meeting. Modelling of options was a focus of the group for several months, and Matt Gardner and Bilu Susan Babu of LRS were regular meeting attendees during this time.

All of the hydraulic modelling carried out during the optioneering (longlist, shortlist and preferred option) used the technique of "glass walling". This approach simplifies the representation of physical protection works such as stopbanks or flood walls, as thin vertical lines with a great height (higher than any feasible water level in the river). This allows the necessary height of the protection to be determined by looking at the water level on the "wall" and adding an appropriate freeboard. While approximate, this approach is widely used for rapid modelling of options and is considered appropriate for this stage of options development, when alignments are still being tested.

In total, 22 different scenarios were modelled during the refinement of the longlist. These were followed by another 15 combinations of options when considering the shortlist options.

5.3.2 Geomorphological context – Stage 1 report

T+T produced a Stage 1 Geomorphic Assessment for the Waipoua River (T+T, 2024b) which is included as Appendix D to this report. The geomorphic assessment is summarised below.

A modified River Styles assessment was carried out in conjunction with a review of previous reports to determine previous river condition and current river character. High magnitude/low frequency events, such as floods and tectonic activity were identified to cause shifts in river type, with subsequent lower magnitude/higher frequency events (such as smaller flooding) mobilising the large quantities of displaced material in the upper catchment. Five stream types were identified during the high-level desktop assessment:

- Confined, low sinuosity cobble/boulder bed;
- Artificially confined, low sinuosity gravel bed;
- Partly confined, low sinuosity gravel bed;
- Partly confined, moderate/high sinuosity gravel bed; and
- Unconfined, artificially straightened gravel bed.

High level analyses of sensitivity and stream typing have been used to provide an overview of the main geomorphic trends and processes occurring in the catchment.

This project has utilised many data sets, and produced analyses and relationships of stream types, stream power, and connectivity within the Waipoua River (Figure 5.1). Further details, including explanations of stream power and connectivity, can be found in Appendix D.

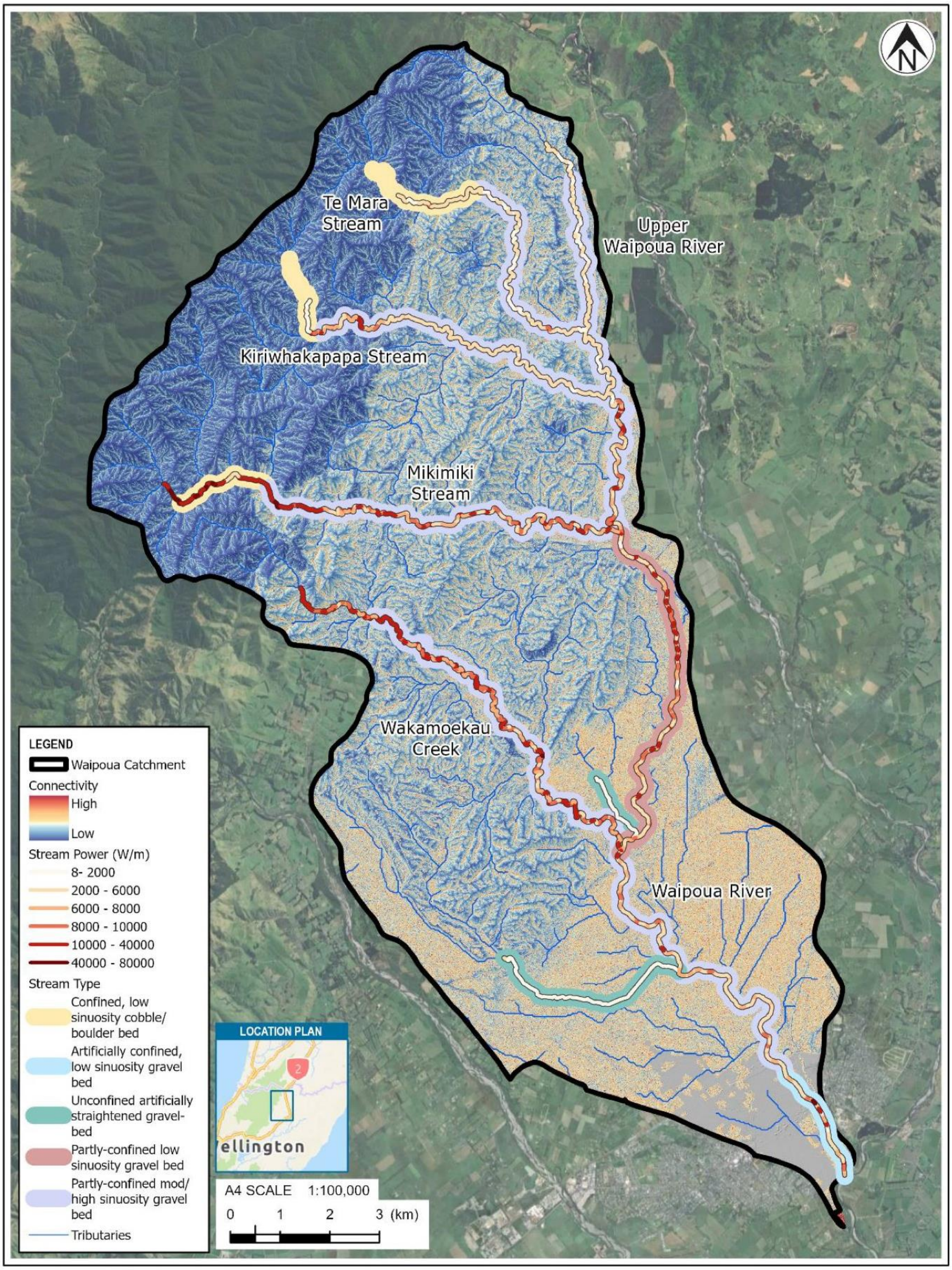

Figure 5.1: The relationship between stream types, stream power, and connectivity within the Waipoua River catchment

The main outcomes of the geomorphic assessment, from the perspective of the Waipoua Project Team, were:

1. Understanding the existing geomorphology of the Waipoua River and catchment;
2. Understanding the geomorphic history of the Waipoua River and catchment;
3. Understanding local fault lines within the catchment and how they may impact on the geomorphology/groundwater/surface water interactions. (see Figure 5.2 below);
4. An understanding of what the river wants to do;
5. Guidance on what can be done through the river plan to support the natural processes of the river system;
6. Understanding how the geomorphology of the river and the catchment affects flooding; and
7. Understanding where catchment/river processes can be protected/enhanced/restored to reduce flood risk and increase river health.

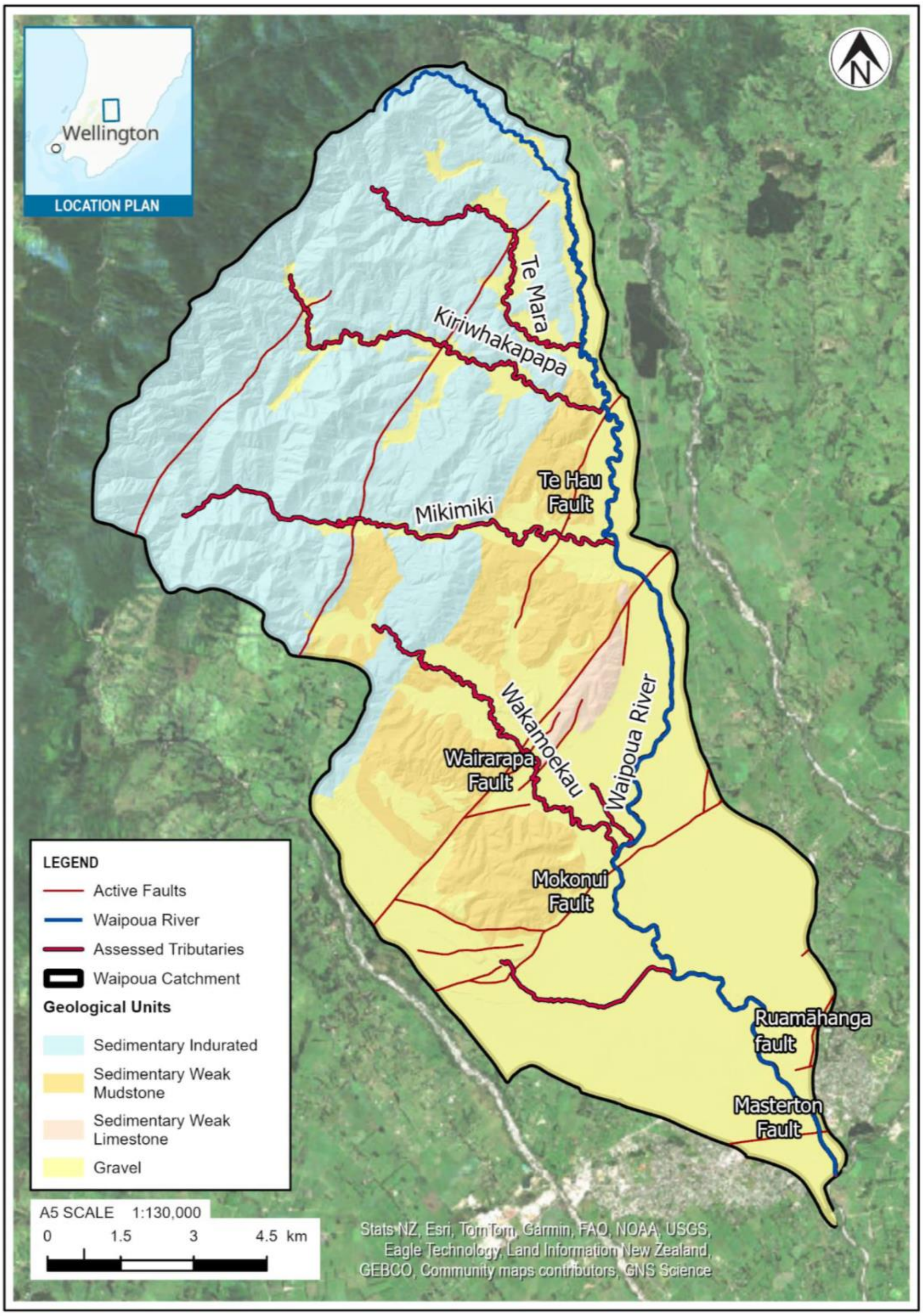

Figure 5.2: Fault lines within the Waipoua River catchment

5.3.3 Natural character index assessment

A natural character index assessment was undertaken by Massey University for the Waipoua River. This provides a way of assessing the ratio between the natural character present in historic imagery (1940s) and 2013 imagery. A summary of the assessment is provided below, with the full report provided in Appendix E.

The outcomes out of this report identified that the Waipoua River corridor, within the 'managed reach' from the Kiriwhakapapa Stream confluence downstream, showed:

- A 49% reduction in active channel area;
- A 58% reduction in lightly vegetated bars;
- A 46% reduction in densely vegetated bars;
- A 44% drop in unvegetated bars;
- A 35% drop in wetted channel area; and
- A 34% drop in wetted channel length.

These changes indicate channel rationalisation and homogenisation within a narrowed active channel. The 2013 river no longer displayed the alternating meandering-wandering reaches of the 1940s and is largely straight and incised throughout.

This information is used to help consider how nature-based solutions can be utilised for flood risk management within the Waipoua Catchment.

Visual results of the comparison between the 1940s and 2013 imagery are provided in the full report in Appendix E.

5.3.4 Further geomorphology memo

This memo by Prof. Ian Fuller of T+T, included as Appendix F to this report, 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 and
- A proposed high flow secondary flow path/back channel upstream of Mawley Park.

These were all features of combinations being considered at the longlist stage and became part of the shortlist of options.

Prof. Fuller's key findings included:

1. 1% AEP + climate change in-channel velocities increased in all cases, due to the proposed stopbank raising along the river confining flood flows to the channel (rather than spilling into Masterton).
2. This, combined with berm lowering and/or channel widening, will mean that the water in the river has more energy to cause bed scour/bank erosion.
3. These changes may further accelerate the trend to bed degrade.
4. Structural intervention (such as rock-lining the riverbank) will likely be increasingly needed as a result, unless nature-based solutions or other upstream measures are also implemented to reduce the flows arriving at the urban reach.
5. Widening at the bridges will potentially require specific structural intervention against bed and/or bank erosion.

6 The proposed high-flow secondary flow path upstream of Mawley Park (one of the longlisted options) is unlikely to have a significant effect on conditions in the channel during large floods but may have benefits in terms of smaller floods and habitat diversity.
7 Berm lowering itself will not lead to an increase in geomorphic/habitat diversity. However, channel widening has the potential to lead to an increase in in-channel deposition of bedload to form bars.
8 Lowered berms and a secondary flow path face the risk of sedimentation during small- to moderate floods. This risk of re-filling is likely to be exacerbated by any vegetation.
9 Berm lowering and channel widening may have quite significant geomorphic effects, and lead to long-term management issues that must be considered.

5.3.5 Stopbank geotechnical assessment

ENGEO Ltd carried out an assessment of the stopbanks through the Masterton urban reach. The purpose of the assessment was to highlight areas of the stopbank that would pose the greatest risk of failure during a flood event. Two reports were completed, which covered both a desktop assessment and site investigations. These are included as Appendix G.

ENGEO concluded that the majority of the stopbanks consist of reasonably strong/stiff material and are in a stable condition under normal (static) loading. There are numerous locations where the existing stopbanks are too low (to contain a 1% AEP flood) and ENGEO focussed on overtopping as a key failure mode.

The geotechnical assessment was based on ground conditions inferred between intrusive investigation locations and acknowledges that the actual conditions between test locations could vary from that assumed. While the assessment identified that portions of the stopbanks are in adequate condition, there are also other zones of stopbank which have visibly deteriorated and are unlikely to meet current standards. The integrity of the full length of the stopbank network should be evaluated against the assumptions used in this assessment as part of detailed design works.

The Waipoua Project Team also noted the presence of trees on the stopbank, which is undesirable in terms of stopbank stability. Trees are a problem because:

- They can topple, pulling large amounts of soil out of the stopbank and compromising its integrity (as well as causing a blockage risk in the channel).
- When they die and the roots rot away, this can leave voids in the stopbank that become potential flow paths.

The trees will need to be addressed, either through complete removal as part of stopbank upgrades or longer-term through operational management (e.g. removing dead trees, digging out the roots and reinstating the stopbank). Commenting on the trees was not within the scope of the ENGEO report and was not covered therein.

6 Shortlist of options

On 2 July 2024, based on a high-level multi-criteria analysis (MCA) using a green-amber-red methodology, the Waipoua Project Team decided to remove the modelled options of directing water under SH2 into the sports bowl, and allowing Queen Elizabeth Park and the adjacent sports fields to flood, from further consideration. This decision was made on the basis that these options showed far more 'red' (drawbacks or concerns) than 'green' (benefits). In particular, the Queen Elizabeth Park area is needed for storage of local stormwater during heavy rain, when the river is high. The Waipoua Project Team drew on this high-level MCA experience later, in deciding the criteria and scoring approach used in the more detailed shortlist to preferred option MCA. These high-level MCA results are included in Appendix H.

Flood modelling results showed very little benefit from including a lowered flood storage/wetland area on Mahunga Farm, so this was removed from the shortlist. Likewise, modelling results showed little incremental benefit from a stopbank part-way through Mawley Park, so options were only included on the shortlist for stopbanks in front of or retreated behind Mawley Park (on the basis that the exact alignment could be confirmed in a later stage). The group also reaffirmed its scope being focussed on the urban reach, as:

- It was clear from the scale of the problem that structural protection measures are needed through this reach, even if measures upstream can deliver improvements (e.g. the 5% reduction in flow that had been discussed as being potentially feasible).
- Nature-based solutions and other measures to slow/retain flows in the catchment will require longer timeframes to implement, so cannot fully meet the immediate needs.
- Considerably more work is needed on catchment-based measures to determine which are most feasible, costs, timeframes, and how much flood benefit they will deliver.

The final shortlist of options following this process was:

1. A swale (both with and without an accompanying bund) at Akura Road to divert water on the floodplain back into the river.
2. A bund/stopbank at top end of Mahunga Drive (upstream of the rail line) to block the flow of water under the rail line.
3. Berm lowering at various locations along the urban reach, especially to improve capacity at the SH2 and Colombo Road bridges.
4. Minor improvements and "topping up" of stopbanks.
5. More significant stopbank upgrades and/or extensions.
6. Retreat of some stopbanks to allow more room for flood flows (at Mawley Park and the true left bank between the SH2 and Colombo Road bridges).
7. A secondary flow path near Oxford St to relieve flows in the main channel.
8. Lowering the level of protection on the true left bank upstream of Colombo Road, to allow water to spill at this location in large floods.
9. Flood walls in locations where available space for stopbanks may be limited, for example around the industrial area at Akura Road/Railway Crescent.
10. Upper catchment measures/nature-based solutions to deliver a 5% reduction in flood flows in Masterton.
11. A bund on the true right, downstream of Colombo Road, blocking floodwaters from entering the Cameron Crescent area.

7 Combination of shortlisted options

The process of combining and rationalising shortlist elements into sensible combinations took place from approximately June to September 2024 and gave rise to the following realisations:

- Continuous or near-continuous protection would be needed along the whole urban reach.
- Some elements would be common to all combinations, as alternatives to these had already been discarded and/or no better alternatives were apparent.

The Waipoua Project Team felt by the end of September that enough work had been done to confidently make a decision on a shortlist for the urban reach, focussing on flood defences, and reflecting three key themes:

1. Options with defences close-in and further out;
2. Options that emphasised the lowering of river berms and widening of the river channel to increase capacity; and
3. An option that considered what reduction in works would be required in tandem with a 5% peak flow reduction due to upstream measures.

A shortlist of four option combinations was agreed at the 8 October 2024 Waipoua Project Team meeting. These shortlist options were each then further developed and refined, including further hydraulic modelling by LRS, from October 2024 to January 2025, to the shortlist concepts that were introduced to the community in February 2025. The details for the four shortlist options are provided in the sections below, while details of community engagement are presented in Section 8.

7.1 Option design approach

The shortlist options were based on high-level optioneering-stage designs. Flood defences (stopbanks, bunds and flood walls) were represented by lines in a Geographic Information System (GIS) overlaid on aerial photography. The alignments first agreed at longlist stage were further refined through a number of iterations, at the direction of the Waipoua Project Team with supporting technical input from T+T and LRS. These iterations were primarily aimed at avoiding private property/community assets and making use of existing high ground as far as practicable. Areas for berm lowering/channel widening, likewise, went through a number of iterations focussed on maximising their hydraulic impact in reducing flood levels.

The 3D modelling approach used in estimating stopbank heights, widths and fill volumes was high-level, although appropriate to this stage of design and cost estimation, where multiple options were still under consideration. Stopbank levels were assessed by determining the nearest modelled water level from the LRS “glass wall” flood modelling. The agreed freeboard (Section 7.2.2) was then added to these levels. The ground level from a Digital Elevation Model (DEM), from which the existing stopbanks had already been removed, was subtracted from the stopbank top level to give an overall height. This height was used in combination with the agreed stopbank geometry (Section 7.2.1) to estimate the stopbank footprint and earthworks volume. Stopbanks have not been modelled in civil engineering modelling/design software and T+T recommends that this takes place in the next stage of design. Because the new/upgraded stopbanks have considerable width, detailed considerations of footprint should be a priority (given that the stopbank representation as a line is only an approximation).

Land purchase costs have not been included in any cost estimates. With possible small exceptions at the upstream ends where space is tight, the stopbanks/bunds/walls from the rail bridge downstream will be built on publicly owned land. Initial engagement with landowners at the Akura industrial area and upstream occurred during the community consultation in February/March 2025 and land requirements have not yet been discussed.

The designs to date have not been focussed on cost reduction, i.e. there has been no explicit optimisation of the alignments to minimise fill or achieve cut-fill balancing.

7.1.1 Key design/costing assumptions

Stopbanks

Stopbanks and bunds were assumed to be built with 25% of fine sized material (silt or clay) to form an impermeable facing on the stopbank. It was assumed that this will be sourced from offsite to address issues of highly variable materials available on site. It was assumed that all the materials sourced from channel widening and berm lowering are suitable to be used as mass fill behind the impermeable facing.

For the purposes of estimation, it was assumed that the stopbanks will be continuous between the rail bridge and the State Highway 2 bridge. In reality there are likely to be short sections of flood wall in locations where space is particularly tight.

Floodwalls

It was assumed that, as the flood wall heights are typically above 0.5 m, these would need flexural strength (i.e. not just mass structures). The flood walls varied in height (including an allowance for freeboard). Maximum wall heights were up to 1.5 m. It was assumed there would be enough room for the walls to be built on the river side of the structures/properties being protected, but this will need to be revisited in the next stage of design.

Rock

A high-level assessment was made on possible locations where rock revetment (“rock lines”) might be required to protect flood defences and community assets. This was done primarily to allow a comparison between the scale of rock protection required between different options, rather than necessarily a design of specifically where this would be built. Flood velocity maps from LRS were used for each option, with particular attention given to areas over 4-5 m/s velocity.

Based on engineering judgement and recent experience of other designs completed for Greater Wellington on the Waipoua River, it was assumed at this point that all rock revetments would have:

- A mass of 15 tonnes/m;
- A total height of 4 m from the toe; and
- A D_{50} (median rock size) of 700 mm.

Channel widening and berm lowering

Berm lowering was assumed to consist of the berms in the identified areas being reduced in height to 1 m above the bed level.

Channel widening was assumed to remove the bank/berm material down to bed level, as far as the identified extent.

7.2 Stopbank design

The following standards were adopted for the optioneering-level designs. These are subject to confirmation/refinement in the next stage of design but provided an appropriately conservative approach in the absence of more detailed modelling and design. These were applied to all stopbanks, including those that are expected to be relatively small and have been noted as “bunds”.

7.2.1 Stopbank geometry

A standard Greater Wellington stopbank geometry was adopted for the shortlist concepts and cost estimation. Its key features (as shown in Figure 7.1) are:

- A 4 m crest width (to allow access and mowing);
- 3.5 horizontal to 1 vertical batter slopes (for stability and mowing); and
- An impermeable facing and apron.

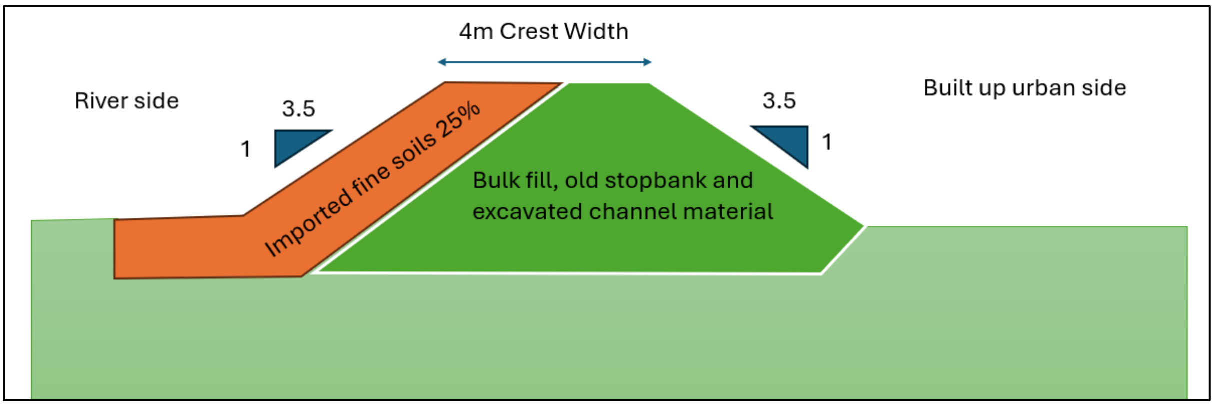

Figure 7.1: Adopted stopbank geometry (not to scale)

7.2.2 Freeboard

Stopbank freeboard is an allowance on top of the modelled water level to allow for:

- A general factor of safety;
- Physical parameters that are not represented by the model, for example superelevation on the outside of curves, standing waves; and
- Modelling uncertainties, if these are not otherwise accounted for.

Freeboard was discussed at the 10 September 2024 meeting, where Greater Wellington noted that its standard practice is to add 600 mm freeboard to the water levels, where these water levels are derived from flood model results including sensitivity scenarios. As the hydraulic model being used for rapid options development was simply the base scenario (1% AEP plus climate change) with no additional sensitivities included, the Waipoua Project Team adopted a blanket freeboard of 900 mm at optioneering stage.

7.3 Common elements

There were several elements that were common to all options. These have been separated out onto their own "common elements" plan in Appendix I, from which it is clear that the four options for the most part had more in common than they had differences.

Additionally, planning controls within the flood hazard areas and emergency management/flood warning improvements were considered by the Waipoua Project Team to apply across all options, regardless of which combination was chosen. The common elements are described below:

- **Akura swale and bund**

  This is intended to protect the houses on the east side of Akura Road and prevent floodwaters flooding the industrial sites on Akura Road before crossing a low point in the railway line and continuing into Masterton. It consists of an enlargement of the existing drain running from the end of Ngaumutawa Road to the river, and construction of a bund to the south side of the drain. The bund is expected to be constructed at least partly from the excavated material from widening the drain.

- **Akura flood wall**

  This is a continuation downstream of the protection that is provided by the Akura bund, around the industrial properties at Akura Road. At some point the space between the properties and the river will become too constrained for an earthen bund and this is expected to transition to a length of floodwall running downstream as far as the railway bridge. The exact location of this transition has not been defined. There may also be the possibility of lowering the river berm on the opposite site (Mahunga Farm) to ease pressure on this location, but this has not yet been looked at in detail. For costing purposes this has been assumed to be a reinforced concrete wall, but other possibilities have not been excluded.

- **Mahunga Drive bund**

  This prevents flood flows from reaching the Mahunga Drive rail underpass and flooding into Oxford Street. It ties into existing high ground at its upstream end, before cutting diagonally across a landowner-preferred alignment to direct flows under the railway bridge (the downstream tie-in).

- **Stopbank upgrades on the true right (south) bank**

  It is proposed to upgrade the existing stopbank/raised berm on its existing alignment between the rail and SH2 bridges, past Railway Crescent/Villa Street. At constrained locations, such as the end of Railway Crescent, it may be necessary to transition to a length of flood wall or half-embankment (where the embankment is supported on the land side by a short retaining wall). Downstream of the SH2 bridge to Colombo Road, stopbank upgrades on the true right bank will be less significant and mostly consist of small amounts of raising or topping up low points. These upgrades prevent spilling that would cause major flooding in Masterton, particularly the stopbanks between the rail and SH2 bridges.

- **Cameron Crescent bund**

  This bund/low stopbank is set back from the river along most of its length to follow higher ground and allow more room for the river to accommodate flood flows. Its purpose is to protect properties in Cameron Crescent and River Road.

- **Berm lowering and channel widening**

  The river berms are the relatively flat areas that sit adjacent to but above the river channel, generally on both sides of the river through the urban reach. These areas are above the river level during normal flows but get flooded in significant flood events. Lowering these berms increases the flood capacity of the river.
  Channel widening refers to digging the active channel of the river (the gravel bed) wider, also to provide additional capacity. This would also provide more capacity in smaller floods and provide more room for river processes.
  Areas of proposed berm lowering and channel widening are shown on the plans in Appendix I. The berm lowering and channel widening that is common to all options is focussed on improving capacity at the two road bridges. Option 2 would involve more berm lowering and channel widening; this is discussed in Section 7.5 below.

- **Additional rock edge protection**

  The inclusion of rock protection in the four options is (as discussed in Section 7.1 above) indicative of the extent and locations where hard-edge protection may be needed to protect stopbanks located close to the river. The options differ in terms of the extent and location of rock protection that is included. It has been assumed at this stage that this protection will be in the form of rock revetments running along the river edge, due to space constraints. While extensive rock edge protection is common to all options, the location and extent varies significantly so this has not been included on the "common elements" map in Appendix I.

The following sections include graphics (Figure 7.2, Figure 7.3, and Figure 7.4) from the Greater Wellington engagement material.

All four options targeted the agreed 1% AEP level of service, including an allowance for climate change to 2100. Plans for the four options are provided in Appendix I. Flood maps for the four options are included in Appendix A of the LRS modelling report (itself included as Appendix C of this report).

7.4 Option 1: Improving and extending existing stopbanks

The approach of Option 1 was to provide the target level of service by raising the existing stopbanks in place.

In addition to the common elements described in Section 7.3 above, Option 1 included a major upgrade of the true left (north) bank stopbank between the rail and SH2 bridges, on its existing alignment. This stopbank was intended to protect Oxford Street and Mawley Park.

The true left bank stopbank between the SH2 and Colombo Road bridges (protecting the sports bowl, deer park and rugby field) would also be upgraded, although this upgrade would not be as extensive.

This option resulted in the highest stopbanks, and water levels of the options considered, as the flood flows are constrained the most tightly between the defences on both banks of the river. The flood capacity at the two road bridges (and/or the degree of freeboard) emerged as a key consideration for all options, but especially Option 1 due to its higher water levels. The bridges have not been explicitly modelled in the hydraulic model used for options development, as noted in Section 5.3.1.

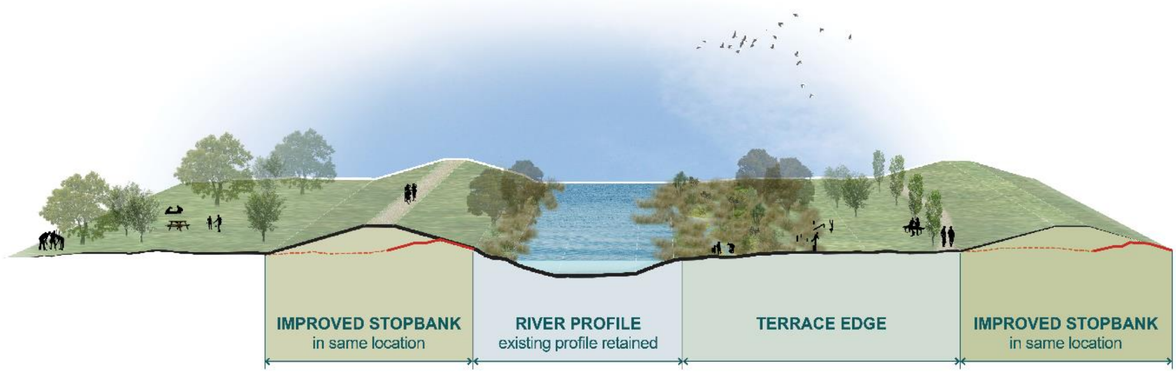

Figure 7.2: Option 1 concept (source: Greater Wellington)

7.5 Option 2: Undertaking extensive work in the river channel

The approach of Option 2 was to provide the target level of service by relying on a greater level of in-channel works to improve flood capacity so that the stopbanks do not need to be raised and extended so much. This option included upgrading the existing flood defences in place, as with Option 1.

This option, as shown on the plan in Appendix I, included a greater degree of berm lowering and channel widening than the other options. It also had a secondary flow path (described on the plan as an “overflow swale”) to take advantage of the extra space available to convey flood flows on the true left bank upstream of Mawley Park. The secondary flow path concept had not been fully developed at this stage, but the concept that was modelled included a bund/small area of higher ground between the main channel and a broad swale that would carry flows during a flood greater than about a 5% AEP (20-year) event. This area was expected to provide opportunities for environmental enhancement such as establishing a wetland and/or back channel that incorporates the confluence with the small stream that enters the Waipoua River at this location. A swimming hole may be suitable at this location.

When this option was modelled, the effects were not consistent along the urban reach (i.e. no consistent lowering in water levels compared to Option 1). The effect of the increased conveyance, especially in the secondary flow path, was to transfer water more quickly downstream. This resulted in higher water levels than might have been expected at downstream bottlenecks, such as the SH2 bridge.

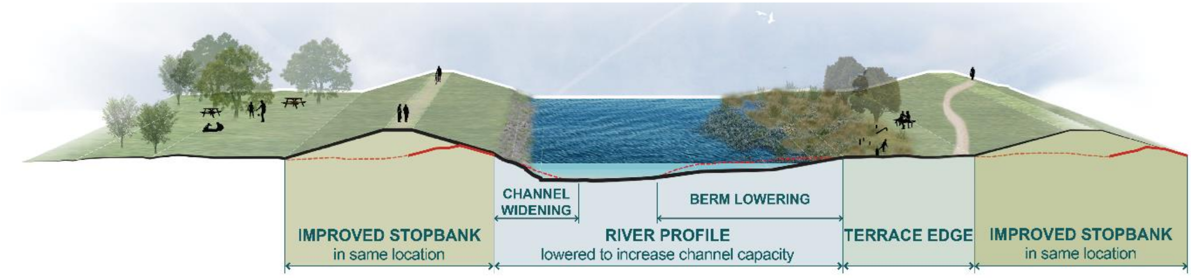

Figure 7.3: Option 2 concept (source: Greater Wellington)[3]

7.6 Option 3: Retreat some stopbanks

The approach of Option 3 was to provide the target level of service by retreating the protection on the true left bank. This meant building new stopbanks on an alignment further back than the existing stopbanks. Elsewhere, protection would be upgraded in-place as with Option 1. This resulted in lower heights for the stopbanks in places (due to the water being spread over a wider area) and reduced the risk of failure (e.g. through river erosion during a flood).

Exactly what would be done with the existing stopbanks close to the river on the true left bank was not confirmed at shortlist optioneering stage, i.e. whether they would be removed, kept but no longer maintained, or maintained at a lower level of service. For modelling and costing purposes, it was assumed that the stopbanks would no longer exist long-term. The removal of these stopbanks in the hydraulic modelling resulted in flooding that begins to affect Mawley Park and the sports bowl/deer park/rugby field areas, in flood events greater than a 10% - 5% AEP (10- to 20- year).

[3] This graphic shows the water level above the lowered berm. Please note this represents an elevated water level. During ‘normal’ conditions, the water level would be below the lowered berm level.

The flood depth map for this option shows the degree of spilling upstream of Colombo Road, which would serve to take the pressure off the protection on the true right/south bank in the case that the bridge becomes blocked or surcharged.

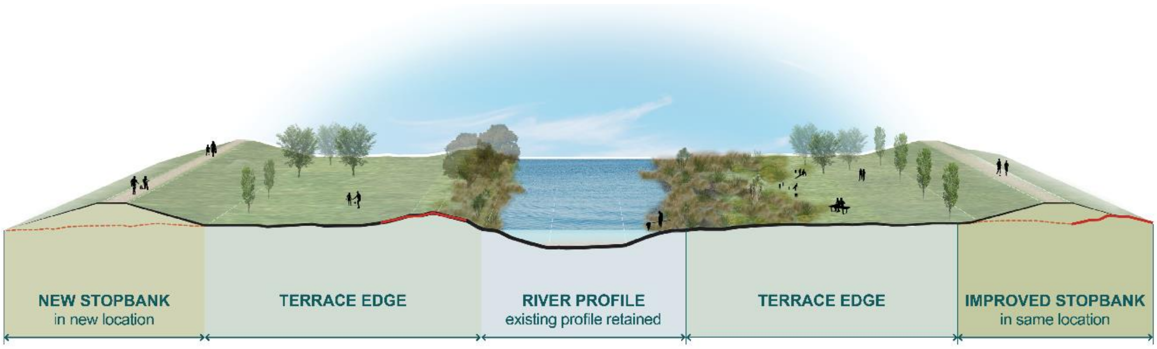

Figure 7.4: Option 3 concept (source: Greater Wellington)

7.7 Option 4: Implement nature-based solutions in the upper catchment

The approach of Option 4 was to provide the target level of service by implementing nature-based solutions in the upstream catchment, in combination with structural works along the urban reach. This was expected to result in:

- Not having to channel as much water down the river, between stopbanks, which is inherently risky;
- Not having to build flood defences as high; and
- The possibility of being able to take a more staged approach to managing climate change through long-term implementation of nature-based solutions.

Additionally, the Waipoua Project Team appreciated the wider benefits that nature-based solutions could potentially bring beyond flood protection.

Option 4 could be complementary to any of the other shortlist options. For modelling and costing purposes, it was assumed to be combined with Option 1. Option 4 was modelled as a 5% reduction in the 1% AEP + climate change design flow, an assumption that was agreed amongst the Waipoua Project Team.

There is considerable uncertainty in exactly which nature-based solutions elements might be implemented in the Waipoua catchment, their feasibility, their effectiveness, their cost and timeframes for implementation. This is the subject of a separate study being carried out by Greater Wellington, which is funded by Ministry for the Environment.

7.8 Stopbank height comparison

Table 7.1 below provides the estimated minimum, average and maximum height for the new or significantly upgraded stopbanks. This enables a comparison of the stopbank heights across the different options. These numbers are only approximate, as they are subject to compounding uncertainties from the reliance on the existing DEM rather than surveyed alignments, the high-level design approach used, and the modelling results used to set the crest levels. To note, is:

- Option 1 typically had the highest stopbanks and Option 3 the lowest.
- The results for Option 2 and Option 3 were more longitudinally variable than the other options, although this summary table is not able to convey that. The exact locations and

dimensions of channel widening/berm lowering (Option 2) and stopbank retreat (Option 3) had a localised impact relative to the other options.

- Upstream of the rail bridge, the stopbank/berm heights were consistent across all options.
- The adopted freeboard of 0.9m allowance played a significant role in the overall heights. The average height of the Cameron Crescent and Akura bunds was not much more than this.
- The true left bank stopbank heights for Option 3 were reduced due to the alignment being on slightly higher ground.

Table 7.1: Stopbank height comparison across the shortlist options

Stopbank element	Average stopbank height (m)				Minimum stopbank height (m)				Maximum stopbank height (m)			
	Option 1	Option 2	Option 3	Option 4	Option 1	Option 2	Option 3	Option 4	Option 1	Option 2	Option 3	Option 4
Akura bund	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	1.5	1.5	1.5	1.4
Cameron Crescent bund	1.2	1.1	1.1	1.1	0.9	0.9	0.9	0.9	1.6[4]	1.6	1.6	1.6
Mahunga stopbank	1.5	1.5	1.5	1.4	0.9	0.9	0.9	0.9	2.1	2.1	2.1	2.1
True left bank between rail and SH2 bridges	1.8	1.9	1.3	1.8	0.8	0.8	0.9	0.8	3.8	3.8	3.0	3.7
True right bank between rail and SH2 bridges	1.6	1.4	1.4	1.4	0.8	0.8	0.8	0.8	3.0	2.8	2.5	2.8

Note: the maximum heights do not necessarily refer to the same locations, as the water levels vary along the river under different scenarios

[4] The original value here (2.1m) was an outlier, and is considered an error, probably due to compounding uncertainties in the calculation. It has been replaced by the 99th percentile value, which gives results consistent with the other options (to be expected at this location).

7.9 Pros and cons

The Waipoua Project Team developed the following table of key pros and cons of each shortlist option (Table 7.2), towards the end of the shortlist development process and prior to engagement beginning in February 2025. In some cases, the information was not yet complete and was developed more fully using these topics in the shortlist to preferred option multi-criteria scoring.

Table 7.2: Pros (normal text) and cons (italics) noted by the Waipoua Project Team prior to engagement on the shortlist (January 2025)

Criteria	Shortlist options				
	Do nothing	Option 1 Stopbanks upgraded in their current locations	Option 2 Channel widening and berm lowering and stopbanks upgraded in their current locations	Option 3 Stopbanks on TLB retreated back from their current locations	Option 4 Stopbanks upgraded in their current locations with a 5% reduction in the peak flows in the channel
Flood Impact	*Significant areas of Masterton are flooded*	Provides protection to the community. *Greatest increase in river channel flood levels.* *Greatest length of stopbank close to river, which raises risk.*	Provides protection to the community with moderate increase in river channel flood levels.	Provides the most secure protection to the community in terms of risk of stopbank failure. Produces the lowest increase overall in river channel flood level.	Provides protection to the community. Moderate increase in river channel flood levels.
Implementation/footprint	No effort to complete No increased footprints	*Increased stopbank footprints, increased need for rock protection.* *This option has the greatest height of stopbanks and largest extent of rock protection.*	*Extensive width and footprint of widening works.* *Largest amount of rock protection required of all the options.*	Stopbank height and footprints near the river are much lower. Lowest amount of rock protection required of the options. *New stopbank footprints on retreated alignments will need to be agreed.*	*The ability to reduce the peak flows by 5% is the main question (can it actually be achieved?).* *The footprint in the upper catchment to achieve the 5% reduction has the potential to be very significant.*
		All options have areas upstream of SH2 where space is tight for stopbanks and realignments and/or alternatives such as flood walls or half embankments will need to be considered to reduce impacts on infrastructure/private property. Option 1 has the greatest stopbank widths and Option 3 the smallest.			
Feasibility	*Feasible – although noting that this would not address the flood risk and therefore not address the main problem.*	*Stopbank footprint, see above.* *The stopbanks are very close to the river channel in several locations, this will drive the need for hard edge protection.*	*Will be very intrusive on the main channel;* *Short- and long-term geomorphic concerns.* *The ongoing maintenance work in the channel will be the highest of the options.* *Most amount of rock required.* *Secondary flow path vs pedestrian footbridge unclear.*	Less rock revetments required so possibly easier to consent. *Removal and/or retreat of existing stopbanks and managing of Colombo Road flooding may be complicated.*	Between the rail and Colombo Road bridges would be easiest to implement. *The effect of the reduction is 100% reliant on the ability to reduce the flows by 5%, there are not many examples of this type of reduction in this type of river.* *Does require increased rock protection*
Economic	*Significant flood damages for Masterton* *Significant disruption to the functioning of the town for extended period of time*	*Provides the protection at increased cost related to increased stopbank costs.* *Increased rock protection costs, risk from erosion.*	Providing protection with reduced stopbank heights. *Ongoing issues with widened channels have not been evaluated.* *Requirement for the most amount of rock protection.*	Provides the most robust protection to the community. *Impacts on the community assets (Mawley Park and sports bowl).*	Good result all round for the community: 5% reduction in peak flow is a real positive. *Loss of productive land in the catchment, economic impact on rural landowners.*
Social	No change to access and interface with the river. *The main problem or risk has not been mitigated.*	*Close in stopbanks can separate community from river.* *Problems accessing the river across the rock revetments.*	Assume better access for community. *Increased need for in channel works on an ongoing basis.*	Banks further back allows easier interface between community and the river. *Change of land use and presumed loss of permanent homes at Mawley Park.* *Flood risk to sports bowl may require changes in management or use.*	The less flow the lower any banks need to be, and the reduced number of complications with flows in the channel.
Cultural	No change to the current status. No increased risk to the river environment above the current.	*Restricts ability to adapt the river channel due to stopbanks in places very close to the channel.*	*Restricts ability to adapt the river channel- provides increased width and lowered berms but does not allow for wider meanders and channel form.* *River more heavily modified.*	Allows for the possibility of changing the way the channel is currently managed in some locations. Having a lighter touch in river channel management.	Reduces the pressure from floods, reduced structure heights etc. *Restricts ability to adapt the river channel.*

Environmental	No change to the current environment. *Low potential for channel change in the future.*	*Restricts ability to adapt the river channel.* *Possible need to increase river channel works.*	*Significant concerns about problems with bed level fluctuations and increased need for ongoing in-channel works.* *No ability to adapt to change in the river dynamics.* *Issues relating to environmental impacts of working within the river corridor (i.e. disruption to habitat).*	In places there is a lot more physical room to allow for changing the channel meanders and alignments, increasing possible back channels etc. and having a lighter touch in river channel management.	*Restricts ability to adapt the river channel, possible need to increase river channel works.*
Te Mana o te Wai	Not yet assessed.	Not yet assessed.	Not yet assessed.	Not yet assessed.	Not yet assessed.

7.10 Cost estimates

T+T prepared high-level cost estimates for the four shortlisted options. These were initially presented to the Waipoua Project Team in December 2024. Refinements and additional scenarios were then assessed and presented in March 2025. The cost estimates have been prepared in line with industry standard approaches, including:

- Design, site investigations and consenting allowances;
- Allowances for public and private utilities within the footprint;
- Construction costs, including contractor's overhead, profit and risk margins; and
- Risk allowances (i.e. "contingency").

The costs are presented in terms of a P_{50} estimate (the "expected value") and a P_{95} estimate[5]. The costs relate to the construction of the structural works, and do not include maintenance/whole of life costs.

The disposal of surplus material excavated from the river channel and berms emerged as a key driver of the costs, especially since the optioneering stage designs were not cost-focused, e.g. there was no work done to optimise for a cut-fill balance. Additionally, Option 2, by its very nature relying on greater excavation to increase flood conveyance, generates far more surplus material than the other options. The assumption in the base estimate was that surplus material could be disposed of for free, but at distances of up to 100 km. This drove the result that it was cheaper to dispose of the material as bulk fill in the upgraded/new stopbanks on site, than to dispose of it elsewhere.

Following initial feedback from the Waipoua Project Team, T+T costed three more scenarios that included:

- Reduced professional fees in all scenarios;
- A scenario where surplus material is disposed of within 40 km;
- A scenario where surplus material is disposed of within 2 km; and
- A scenario where a third party will pick up the stockpiled material from site and pay a small sum per m^3.

The high-level cost estimates were intended primarily for use in comparing between options in deciding on the preferred option. They are only indicative of the expected project costs, because the degree of design at this stage is limited and itself based on broad assumptions, as well as having not yet been through a value engineering exercise of focussing on cost reduction elements (such as cut-fill balancing). The quantities used for cost estimation were based on approximate calculations based on the adopted stopbank geometry, stopbank heights from the hydraulic model results plus 900 mm freeboard, and a publicly available digital elevation model. No detailed survey information was obtained, and broad assumptions were made about what proportion of the new/upgraded stopbank would be constructed from imported impermeable material, and what proportion of the river berm/existing stopbank material would be suitable for use/reuse.

Costings for Option 4 are for the works in the urban reach only. There is considerable uncertainty about what form nature-based solutions in the upstream catchment would take, what they would cost and indeed whether it is feasible to reduce the design flood flow by 5%. It would be reasonable to assume that this would be a considerable additional cost on top of the structural works.

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[5] These are probabilistic concepts – if you did the same project 100 times, 95 of those projects would be delivered with a cost less than the P_{95} estimate. The P_{50} estimate could be considered the median value; 50 of the projects would cost less and 50 of the projects would cost more. There is obviously more risk of cost overruns in adopting the P_{50} value. Most organisations, unless they have a large portfolio of projects to spread their risk across, would be advised to adopt P_{95} costs in their planning.

Summary costs are presented in Table 7.3 below. A memo presenting the cost estimates in full is included as Appendix J.

Table 7.3: Summary of Estimate Baseline and Scenarios

Scope	Option 1	Option 2	Option 3	Option 4
Estimate Baseline - Standard fees and disposal within 100 km				
P50	27,235,000	44,965,000	26,655,000	28,385,000
P95	38,135,000	62,965,000	37,355,000	39,785,000
Scenario 1 - Reduced fees and disposal within 2 km of site				
P50	23,035,000	30,895,000	21,055,000	23,305,000
P95	32,285,000	43,295,000	29,505,000	32,655,000
Scenario 2 - Reduced fees and disposal within 40 km of site				
P50	24,845,000	36,805,000	23,475,000	25,385,000
P95	34,795,000	51,555,000	32,875,000	35,585,000
Scenario 3 - Reduced fees and allowance for loading truck only				
P50	22,145,000	27,555,000	19,955,000	22,275,000
P95	31,045,000	38,605,000	27,955,000	31,225,000
Scenario 3 - Opportunity for sale of excavated material (saving on P50 and P95 estimates)	(38,471)	(131,601)	(50,259)	(44,825)

8 Shortlist engagement summary

This section provides a summary of the engagement undertaken on the shortlist concepts which took place between 17 February and 16 March 2025 and is based on information provided by Greater Wellington. A more detailed description of the community engagement, as well as ongoing engagement with Masterton District Council (officers, executive leadership team and elected members) and the Upper Ruamāhanga River Management Advisory Committee (URRMAC), is provided in the appended engagement summary report (Appendix K).

It is acknowledged that further engagement and discussion with the community, and particularly affected landowners, will need to be undertaken in future phases of the project.

The shortlist options were renamed with the more flexible language “concepts” for the purposes of community engagement, as described further below.

8.1 Community engagement overview

Engagement with the community is recognised as an important part of Greater Wellington’s flood management process. The engagement for this project was aimed to gauge public opinion on the proposed flood risk management concepts and understand community aspirations for the Waipoua River through Masterton.

To aid in the engagement, material was produced to describe the purpose and context of the project and provide information about the flood risk management concepts. The engagement was based on four flood risk management concepts:

- Concept 1 - Upgrade the existing stopbanks;
- Concept 2 – Undertake additional mechanical work in the channel, with stopbank upgrades;
- Concept 3 – Retreat some stopbanks; and
- Concept 4 – Implement nature-based solutions in the upper catchment (in conjunction with another concept).

Within the Waipoua Project Team, up to this point in the project shortlist options had each been considered as feasible stand-alone options. Of particular importance is that nature-based solutions in the upper catchment were assumed to be able to provide a 5% reduction in flow and this was modelled and considered in combination with stopbank upgrades in the urban reach (i.e., Concept 4 included Concept 1). However, for the community engagement it was determined that instead of presenting four designed and complete options, more valuable information could be gathered from the community by describing concepts which are more flexible and could be combined. It was hoped that this change in language would enable the Waipoua Project Team to gather more detailed information from the community and ultimately recommend a preferred option which could incorporate multiple concepts if necessary. As part of the engagement, it was promoted that the final design for managing the flood risk would likely involve a combination of aspects from each of the four proposed concepts. The word “option” was changed for the purposes of engagement to “concept”, to better reflect level of design detail and the ability to mix and combine them.

8.2 Community engagement period

Community engagement was undertaken during a four-week period between 17 February and 16 March 2025. During this period, the following was undertaken:

- Flyers advertising the engagement and asking for feedback were delivered to over 7,300 Masterton homes.
- A social media campaign was run.

- The Greater Wellington website was updated with information on the project and a ‘Have Your Say’ page was established for online feedback.
- Advertising was carried in the Wairarapa Times Age newspaper.
- Targeted engagement with potentially affected areas such as Mawley Park and the Akura Industrial area was conducted.
- Project brochures were handed out at the Masterton train station during peak hours.
- In-person events at the Masterton Library, Lakeview School, Charlie’s Lane, Wairarapa Farmers Market, and at Queen Elizabeth Park were held. Hard copy feedback forms were handed out at these events as an alternative to the online form.

8.3 Community engagement findings

Based on the questions asking the community to rate each concept using ‘love it, like it, neutral, dislike it or hate it’, the use of nature-based solutions was the most favoured by a considerable margin. Upgrading the existing stopbanks was the next most favoured, followed by retreating some stopbanks and finally more extensive in channel works (with stopbank upgrades). The concepts of retreating some stopbanks and in channel works were closely rated but were more polarising. The in-person conversations were largely consistent with these results, with nature-based solutions being most favoured and the other concepts being largely consistent with the ratings.

Where more directed questions were asked regarding people’s values and rating different aspects of the Waipoua River, the highest scores related to giving the river as much room as possible, ensuring access to the river and ensuring changes have a positive effect on the environment. The lower scores were more or less even between protecting Mawley Park, the sports bowl and the Akura industrial area, enhancing the ability for mahinga kai practices and upholding the mana of the river. Protection of the sports fields scored the lowest across all questions.

Comments provided in the written responses were centred on environmental effects as well as the ‘natural’ state of the river (both flow and character). These were followed by comments on existing assets (e.g., Mawley Park or sports bowl) and the cost of upgrading the existing flood protection scheme.

More detail regarding the community feedback on the concepts is provided in the engagement summary report provided in Appendix K.

8.4 Masterton District Council Submission

Masterton District Council prepared a written submission regarding the Waipoua River flood risk management concepts. The draft submission was presented to the Masterton District Council elected members at an extraordinary Council meeting on 19 March 2025, and was subsequently approved.

Key points raised in the submission were:

- Key priorities: risk to life, the potential impacts to assets, the environment and possible impacts on insurability;
- Recognition of the need to protect the town, community assets and private property as well as the importance of the community being able to identify and connect with the river. Encouraging an outcome that results in a fair balance between these benefits; and
- It was preferred that the final preferred option should consist of a combination of elements from the shortlisted options.

Masterton District Council is considered to be a key stakeholder in this work, and it is anticipated that it will actively contribute to the future detailed design phase and inform the desired level of service for these key assets.

9 Shortlist MCA and preferred option decision

9.1 MCA process

A multi-criteria analysis (MCA) was used as a tool to guide the preferred option selection, in line with a process recommended by T+T and adopted by the Waipoua Project Team. MCA is a widely used tool used to assess multiple criteria, both quantitative and qualitative, to compare different alternatives and options. Decision-makers do not necessarily have to choose the highest-scoring option but would be expected to have regard to the results and document the reasons for their decisions.

The process as envisaged was:

1. Small groups composed of Waipoua Project Team and T+T participants would carry out initial scoring of the options against each criterion and would circulate a "scoring memo" prior to the MCA workshop.
2. Additional experts provided by Greater Wellington would provide input to the scoring of ecological and consenting aspects.
3. The Waipoua Project Team would come together at the MCA workshop, discuss and agree the scoring.
4. The scores would be summed across all of the criteria, giving a total score for each option (with even weightings on all criteria).
5. Different weighting scenarios would be considered as a form of sensitivity analysis, to reflect the emphasis that different people or groups might put on certain outcomes or values.
6. The Waipoua Project Team would be guided by these results in choosing a preferred option to recommend.

As it happened, some Waipoua Project Team members were uncomfortable with the summing of scores for a direct numerical comparison, so steps 4 and 5 above did not take place. This was driven primarily by a concern that a sum would not be valid unless some sort of base weighting was agreed (due to the potential for some criteria or groups of criteria to pull the score in a particular direction). Instead, the results were visualised and compared in the form of spider plots (also known as radar plots or radar charts) as described below.

Pre-scoring took place between 25 February and 18 March 2025, in line with the following criteria and guidance (Table 9.1), as agreed at the 25 February 2025 Waipoua Project Team meeting. More detail regarding what was included in each criterion was provided in the scoring memos (Appendix L).

Table 9.1: MCA criteria and guidance for scorers

Category	Criteria	Suggested guidance
Overall	Te Mana o te Wai	Does the option meet the requirements of Te Mana o te Wai?
Construction	Feasibility/Practicality	How easy is the option to build/implement?
	Implementation/consentability	How easy would it be to gain consent to complete the works in the option?
Environment	Cultural	How does the option improve or degrade cultural values?
	Environmental	How does the option affect the environment (ecology and landscape)?
	Social	How does this option improve or degrade the social fabric or values of the community?
Effects/Impacts	Flooding behaviour/Impacts	How does the proposed option affect the flood hazard? Who, if any, might be impacted?
	Economic	What are the benefits of the proposed works, damages and disruption avoided by proposed concepts?

The following scorers scored each category:

- **Te Mana o te Wai** Garry Foster, Daphne Te Whare, Jim Haeata, and Ella Boam (Greater Wellington).
- **Construction** Michael Hewison, Andrew Donald, and James Flanagan (T+T). Additional input on consenting from Sarah Bevin (T+T consultant seconded to Greater Wellington).
- **Environment** Garry Foster, Ian Gunn, and Des Peterson (Greater Wellington). Additional input from Bram Mulling (Greater Wellington).
- **Impacts** Andrew Donald, Mark Hooker (T+T), and Matthew Gardner (LRS – Flooding only).

Scorers had some flexibility in how they scored the options against the criteria. They were provided with guidance and were required to score the options on a scale of -5 (very negative) to +5 (very positive). They were also asked to record their approach, their rationale, any assumptions made, any source information and additional comments in their scoring memo. The initial scoring memos are appended in Appendix L.

The MCA workshop was planned for 18 March 2025, with scorers to present their initial scores at a Waipoua Project Team meeting on 11 March 2025. A decision was not reached by the end of the 18 March 2025 workshop, and the process carried over to the 25 March 2025 Waipoua Project Team meeting.

It was agreed that MDC officers and T+T staff would not participate in the scoring discussions and preferred option recommendation beyond presenting their initial scoring and supporting the group with technical input. Cliff Bouton (as the Waipoua Urban River Management Group representative on the Upper Ruamāhanga River Management Advisory Committee) also did not participate in the decision, although he attended both meetings. Andrew Stewart's role was as facilitator only. This left the following Waipoua Project Team members involved in the decisions on final scoring and a preferred option recommendation:

- Ella Boam;
- Andrew Donald;

- Garry Foster;
- Ian Gunn;
- Michael Hewison;
- Francie Morrow; and
- Daphne Te Whare.

Decisions on revising/accepting the MCA scores, and on the elements that made up the preferred option, were made via a consensus approach. Each decision/resolution needed to be discussed and/or modified until it passed with no objections.

Greater Wellington wanted a “do nothing” option to be scored, to provide a point of comparison for Council in making its final decision on the preferred option, although the Waipoua Project Team had previously discarded this as a shortlist option. This was not opposed in principle, but time constraints meant it was not possible to score it during the meeting slots available. It was agreed that it could be included at a later date, as it would play no role in the recommendation of the Waipoua Project Team.

Costs were discussed in the meeting of 18 March 2025, but only after the MCA scoring had been agreed. Costs were deliberately discussed separately from the scoring of options, and scorers were instructed not to take costs into account when scoring their individual criteria.

9.2 Role of Masterton District Council officers

MDC officers noted in the 11 March 2025 meeting that their input (both in the pre-scoring and related discussions) was limited to commentary on the technical aspects of the four options. Separate to their input, they were supporting their councillors in making an MDC submission on the proposed concepts, which would represent MDC’s official position. MDC officers did not participate in any decision-making. Details of the MDC submission are provided in the engagement summary report provided in Appendix K and summarised in Section 8.4.

Although MDC officers also pre-scored the options from their perspective (in particular, from MDC’s perspective as asset owner) prior to the 11 March 2025 meeting, it was agreed that their scoring would be considered alongside the Waipoua Project Team’s scoring, rather than trying to merge the two.

9.3 MCA scoring

Discussion on the initial scores took place at the 11 March 2025 meeting, and these scores were discussed and agreed amongst the group at the beginning of the 18 March 2025 meeting. This resulted in the following scores (Table 9.2).

As noted above, these were not summed, but rather a spider plot was produced (Figure 9.1).

Table 9.2: Final agreed MCA scores

Category	Criteria	Option 1	Option 2	Option 3	Option 4
Overall	Te Mana o te Wai	-3	-4	3	4
Construction	Feasibility	2	1	2	2
	Implementation	-2	-4	-2	-3
Environment	Cultural	0	-3	3	4
	Environmental	1	-1.5	2	3
	Social	0	-3	3	4
Effects/impacts	Flooding behaviour impacts	3	4	4	5
	Economic	4	4	2.5	4

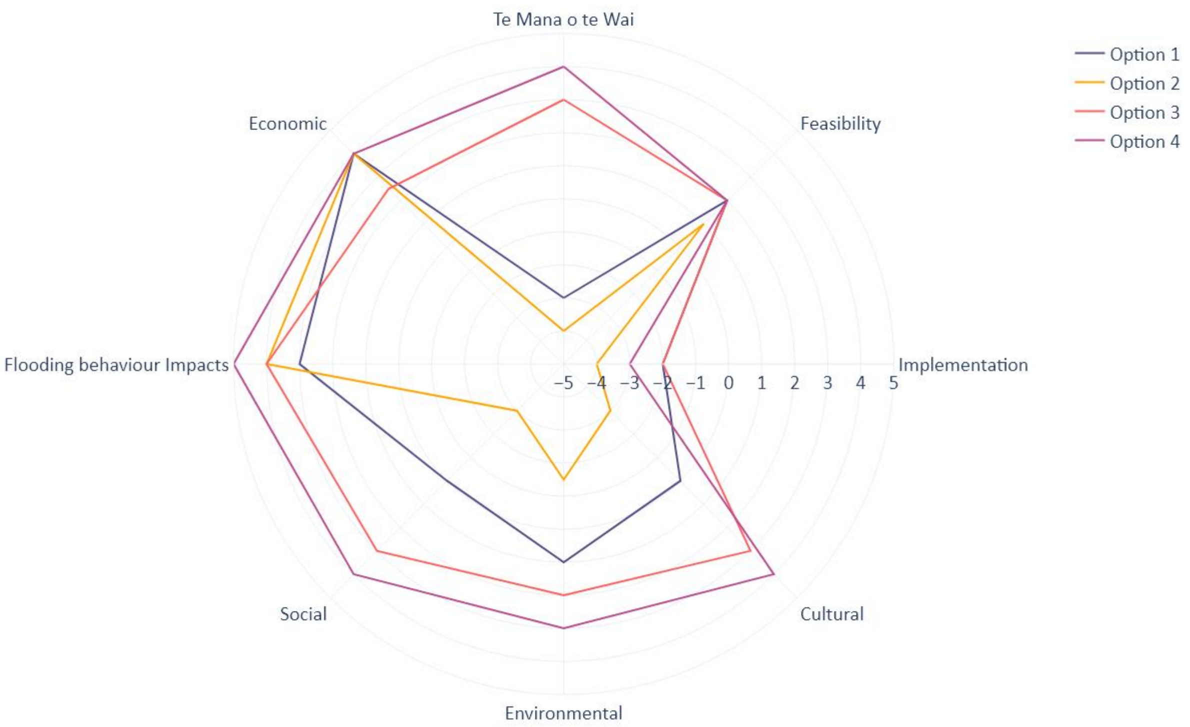

Figure 9.1: Spider plot of the four options scored against the eight criteria

This plot depicts how each option scored against all criteria and also compared to other options. Options lying closer to the middle scored more negatively, while those lying closer to the outside had more positive scores. This plot shows that overall, Concept 2 scored the most negatively/least positively and Concepts 3 and 4 scored the most positively/least negatively.

9.4 Key themes

Key themes that emerged during the MCA scoring and subsequent discussions are noted below (in no particular order):

- **Costs.** The costs shown in Table 7.3 were discussed at the meeting on 18 March. Some members of the Waipoua Project Team expressed continuing reservations about the quantum of the costs, and felt the work would ultimately be delivered at lower cost. It was noted that the optioneering-stage designs are very high level and have not been cost-focussed (e.g. optimising cut-fill balance), which should be a priority in the next stage. The costs were ultimately accepted as being useful for comparing between the four options and helping with a recommendation. They show that Options 1, 3 and 4 all have very similar costs, with Option 2 generally costing more under all scenarios. The costs for Option 2, given that it would generate much more surplus material, are very sensitive to assumptions made about the disposal costs of that material. It was, however, noted that the costs for Option 4 did not include the implementation of nature-based solutions in the catchment above Masterton, the costs for which are very uncertain at the moment and are likely to be significant.

MDC officers had concerns that the $500,000 amount nominally included for MDC water services assets would not be enough, particularly for Options 2 and 3 which they considered to have more impact on wastewater pipelines (not to mention Mawley Park).

- **Risk to life.** Due to the particular hazard (depth and speed of inundation) in Oxford St and Mawley Park, the Waipoua Project Team saw a need to focus on addressing these areas as a priority.
- **The impacts on Mawley Park, the sports bowl, and other community assets.** Retreated stopbanks under Option 3 (or a variation of it) would not protect Mawley Park or the sports bowl/deer park/rugby fields to a 1% AEP + climate change level of service. Also, Option 3 would take up land within Mawley Park for a retreated stopbank. This would have implications for potential flood damages/insurance of Council assets, as well as likely driving a change in use of the land at Mawley Park due to what would likely be considered an unacceptable flood risk (noting that the flood risk there is already significant).
- **Option 4 – nature-based solutions** and in particular, uncertainties around its effectiveness, the additional costs on top of the physical stopbank works, implementation timeframes and land requirements/landowner impacts. Despite these, there was broad support for implementing it in some form as part of the preferred option. There was discussion around whether this should be seen as being an “add-on” to the structural (stopbank) – based options, or whether nature-based solutions should be the primary goal of Option 4 with structural flood defences covering any shortfall for the 1% AEP + climate change event.
- **Residual risk**, that is, the occurrence of a larger flood than the design standard or the risk of flood defences failing. There was some discussion of the fact that all the shortlist options rely on being able to force the entire flow of the river through the middle of town (albeit that Option 4 reduces this flow by an assumed 5%).
- **Scoring differences** between the agreed Waipoua Project Team scoring and that done by MDC officers. This was examined using spider diagrams, similar to Figure 9.1 above, to identify the main areas and reasons for the differences. These differences generally came down to the MDC officers having scored similarly but across a different range of values (i.e. the scores were different, but the overall “shape” of the spider plot was fairly consistent in terms of how the options were ranked) and also MDC’s emphasis on the value of and impacts on community/MDC-managed assets.
- **How Option 2 should be scored for its environmental impacts**, and in particular how much weight should be given to long-term and (perhaps less certain) positive opportunities vs the degree of disturbance during construction.

10 Preferred option

The preferred option consists of recommendations for:

- The following structural flood defence upgrades in the urban reach:
  - New stopbanks and bunds, including in places on a retreated alignment;
  - Upgrades to existing stopbanks;
  - Flood wall(s); and
  - Targeted lowering of river berms and/or channel widening.
- Nature-based solutions upstream of Masterton; and
- The following non-structural responses within the wider catchment:
  - Planning controls; and
  - Education, emergency management/flood warning improvements.

The structural elements of the preferred option are shown in Figure 10.1 below.

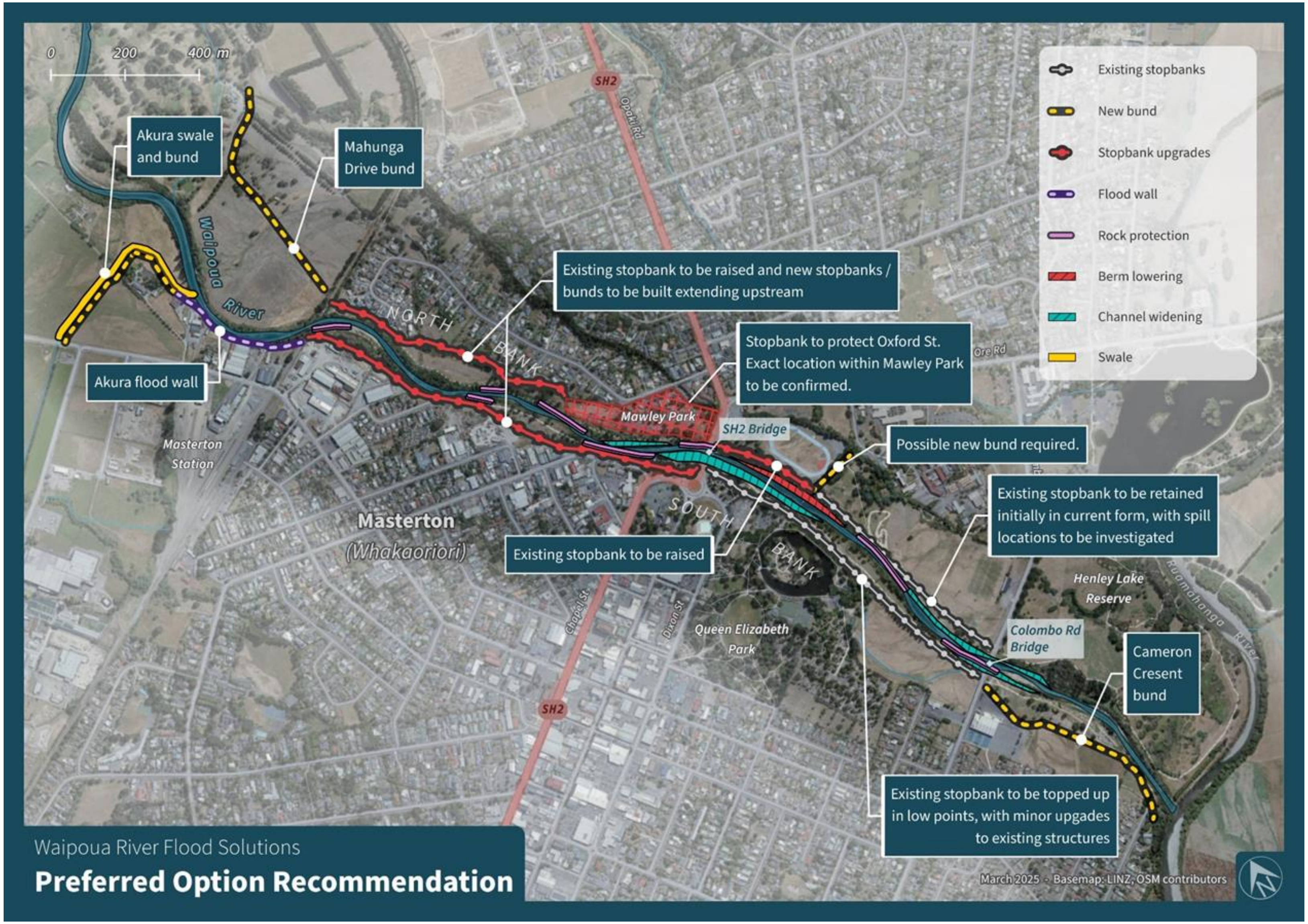

Figure 10.1:Preferred option (urban reach elements)

10.1 Preferred option reasoning

The Waipoua Project Team's preferred option recommendation was made at the 25 March 2025 meeting and considered community feedback, the MCA scores, the information about costs and the submission from MDC. These topics were all discussed at the meetings of 18 and 25 March.

The preferred option is a combination of elements from all the shortlisted options. The team agreed by consensus the following six key elements, which are reflected in the preferred option:

1 It was concluded that continuous flood defences are needed to manage flood risk to the urban parts of Masterton.

2 Nature-based solutions have strong support within the Waipoua Project Team and the broader community. The group also noted Prof. Ian Fuller's support for nature-based solutions (see Section 5.3.4). Nature-based solutions should play a role in the longer-term management of flood risk but will not immediately provide for the 1% AEP + climate change level of service. There is a window of opportunity to start implementing nature-based solutions as a means of addressing future climate change and increasing resilience. Nature-based solutions would fit well into a staged approach, providing additional resilience long-term for the structural measures recommended in the preferred option. Many nature-based solutions have the potential to deliver wider benefits beyond just flood risk reduction, which the Waipoua Project Team supports. Seeking ways to include nature-based solutions must be a priority in the next stage of work.

3 The need to strike a balance between sensible removal of berm material to improve capacity, against the long-term sustainability of the river channel and the berm levels themselves. If you lower the berms too much, they may become built up again anyway. The areas to be excavated should be those that provide the most hydraulic benefit. The amount of excavation will need to be balanced against the amount of bulk fill needed in the construction of the stopbanks.

4 The Waipoua Project Team sees the greatest flood risk (including risk to life) as being around Oxford Street and Mawley Park, especially taking the condition and form of the existing stopbanks into account. These works should have a high priority. However, the Waipoua Project Team also notes that this land is a community asset managed by MDC, bequeathed to the people of Masterton. A number of people live there long-term and there may be a high social cost with changing the level of service and/or land use. It is recommended that a stopbank to protect Oxford Street, built on a retreated alignment through or behind Mawley Park, should be investigated further. However given the social complexities, the exact location should be determined in collaboration between MDC and Greater Wellington. The future use of the land at Mawley Park will need to be considered in line with the flood risk, and how this can be reduced through structural elements, emergency management or other means.

5 The sports bowl should be protected to a 1% AEP + climate change standard. However, downstream of the sports bowl, flood flows should spill preferentially on the true left bank rather than on the right bank (where houses are present). This will be achieved initially by not upgrading the left bank stopbank and leaving it in its current form, whereas the defences on the true right will be built to a 1% AEP + climate change standard. Longer-term, consideration should be given to lowering the level of service of the left bank stopbank.

6 Although not limited to the Masterton urban area or the Waipoua River urban reach, planning controls, emergency management planning and flood warning are very important. These will add additional resilience to what is provided by upgrading flood defences, as well as providing benefits to people outside the defended area. They will also help to manage the risk of the flood problem increasing over time through inappropriate development on the floodplain.

10.2 Structural measures in the urban reach

The preferred option plan is shown in Figure 10.1. The preferred option includes all the common elements of the shortlist options listed in Section 7.3, namely:

- The Akura swale and bund;
- The Akura flood wall;
- The Mahunga Drive bund;
- Stopbank upgrades on the true right (south) bank from the rail bridge to Colombo Road;
- The Cameron Crescent bund;
- Berm lowering and channel widening; and
- Additional rock edge protection.

In developing the preferred option, the Waipoua Project Team considered a hybrid approach of the shortlist options along the true left (north) side of the river. The agreed approach here is:

- A stopbank from the rail bridge to the SH2 bridge, on a retreated alignment, to protect Oxford Street. It is recommended that an investigation be undertaken to determine the exact alignment of this stopbank, but that options to retreat the stopbank should be considered wherever possible, including behind, through or in front of Mawley Park. The exact alignment is to be determined by Greater Wellington and MDC.
- An upgraded stopbank downstream of the SH2 bridge to protect the sports bowl to a 1% AEP + climate change standard. A bund may also be required here, running perpendicular from the stopbank to tie into higher ground.

  Downstream of the sports bowl, the stopbank will remain on its present alignment next to the river but will not be upgraded. This means that it will provide less than a 1% AEP + climate change level of service – noting that the stopbanks here are in better condition than those upstream of the SH2 bridge. When the stopbank on the true right side of the river is upgraded, this will mean that water will need to preferentially spill on the left bank onto the playing fields and across Colombo Road when the flood capacity is exceeded (rather than into the residential area on the right/south side). In the medium term, the level of service on the true left bank will need to be investigated and defined, and in the future may be actively reduced through lowering the stopbank. This may involve one or more engineered spill locations upstream of the Colombo Road Bridge. The present modelling of the preferred option shows no spilling at this location in a 1% AEP + climate change flood.

The alignment of the Cameron Crescent bund should be determined during detailed design, considering aspects such as the area available for sports fields, the existing sewer pipe network, local high ground, height of stopbanks, proximity to houses, room for the river, flood levels and existing river works at confluence.

Between the rail and SH2 bridges, the next design stage should explore ways of allowing the river more room to move/meander and express natural processes to make use of the opportunity provided by a stopbank located away from the river edge.

All new and upgraded structural flood defences are to be designed to a 1% AEP + climate change allowance level of service. The rock protection locations and lengths from Option 1 have been carried over into the preferred option because the stopbank locations are largely reflective of that option, and the stopbank location at Mawley Park is yet to be confirmed. As with the shortlist options, these rock locations and lengths are indicative only, and subject to refinement in the next stage of design.

The Waipoua Project Team noted that it sees the upgrade works between the rail and SH2 bridges as being the highest priority, and in particular the stopbank protecting Oxford Street as well as a decision about the future of Mawley Park.

The preferred option has been modelled by LRS. Flood maps (depth, depth difference, velocity and velocity difference) are included in its report in Appendix C.

10.2.1 Berm lowering/channel widening

The preferred option will include targeted berm lowering and channel widening to improve the river's flood conveyance. This is broadly consistent with the concept shown in Options 1, 3 and 4, and also potentially the secondary flow path of Option 2.

Locations and volumes will be subject to further investigations during the next stage of design and must include consideration of:

- Targeting the locations to the areas that provide the biggest hydraulic benefit (expected to include the two road bridges);
- Balancing cut/fill volumes to optimise costs and derive as much suitable material for stopbank construction as possible;
- Environmental/long term geomorphic impacts, which may also impact the long-term maintenance of the system (e.g. if over-lowered berms fill up again); and
- An envelope that berm levels should be maintained between, to inform operational management.

10.3 Nature-based solutions

The Waipoua Project Team looks forward to seeing the results of Greater Wellington's Feasibility Study of Nature-Based Solutions for the Waipoua catchment, expected in July 2025. It sees nature-based solutions, located upstream of Masterton, playing a role in a staged approach to managing flood risk, being implemented long-term and providing an extra layer of resilience on top of the structural measures to be implemented in the short term. Funding and costs for nature-based solutions are yet to be determined and may depend in part on the outcomes of the feasibility study, including to what degree the nature-based solutions will provide wider benefits.

The Waipoua Project Team recommends that, following receipt of the Feasibility Study, the potential for nature-based solutions be further investigated during the next stage of design. Any staging decisions being made around the structural works should also consider the potential for nature-based solutions.

The Waipoua Project Team believes that any nature-based solutions that "slow the flow" should be considered, and sees particular promise in combinations of:

- Providing more room for the river/reestablishing meanders;
- Reestablishing former channels and overflow paths;
- Distributed storage/bunds/swales/wetlands/leaky dams within the catchment;
- Pest control (to improve forest health);
- Floodplain lowering;
- Afforestation; and
- Increasing soil organic matter content (for example, through changes in farming practices).

10.4 Non-structural recommendations

10.4.1 Planning controls

The Waipoua Project Team expects the adopted flood hazard to be adopted within the Wairarapa Combined District Plan and used to avoid risky development in areas that will still be subject to high flood risk. Once the structural works are complete, MDC should update the hazard information in the District Plan. This information should also be circulated to the insurance industry as an update.

The Waipoua Project Team notes that stormwater flood hazard within Masterton has not been mapped by MDC. This hazard will continue to exist following the stopbank upgrades.

The Building Code will continue to be important in setting minimum floor levels in Masterton, due to the generally shallow nature of Waipoua River flooding should an overdesign event occur, and the pre-existing stormwater flood hazard.

10.4.2 Emergency management

The Waipoua Project Team sees community preparedness playing an important role in managing flood risk – both in terms of flood response and community resilience. It is important that the community understands that stopbanks can fail, and that an overdesign flood will occur one day. Education about the flood hazard is part of this, but the responsible agencies (WREMO, Greater Wellington, MDC) should also have specific emergency procedures in place for such situations.

The Waipoua Project Team is of the view that flood warning and forecasting can and should be improved, and doing so is part of its preferred option. This would involve improved rainfall and flow forecasting, timely notifications and appropriate redundancy in these systems. The Waipoua Project Team supports investment in these. Improved flood warnings, combined with emergency management planning and education, will:

- Reduce risk in areas outside of the urban reach, where no new stopbanks or upgrades are planned;
- Help with the safe use of the land between the stopbanks in the urban reach, as well as on the rugby field upstream of Colombo Road; and
- Improve community safety when an overdesign event occurs.

Emergency management planning will also need to take account of the bridges within the urban reach. In particular, two bridges have been built (Whitipoua Bridge) or rebuilt (Colombo Road) during the time of the Waipoua Project Team's work without any input from it. The Waipoua Project Team is concerned that these bridges will be at risk during a large flood and may have safety implications that need to be managed.

10.5 Reduction in flood damages

The base flood damages assessment (T+T, 2024) has not yet been updated to reflect the preferred option. However, the reduction in flood damages can be estimated, based on the preferred option almost completely eliminating flood damages in the urban area in a 1% AEP + climate change event. The previously calculated flood damages (based on the existing levels of protection) are shown in Table 10.1 below. The sensitivity scenario was an agreed 'what if' scenario to reflect that there are uncertainties in the adopted 'best estimate' water levels.

Table 10.1: Flood damages potentially saved

Flood scenario	Lower bound	Upper bound
1% AEP + climate change to 2100	$21,000,000	$42,000,000
Sensitivity Scenario 1: increase in Manning's 'n' by 20%	$49,000,000	$94,000,000

Urban damages represent approximately 93% of the above costs, within the Masterton-focussed study area of the flood damages assessment.

11 Priorities in the next phase

The next stages of work will involve more detailed design and costing of the preferred option, consenting and planning for implementation (including staging). This will also include further investigations to inform the above. The Waipoua Project Team sees particular priorities in the following areas, as outlined in the sections below.

11.1 Investigations

11.1.1 Key uncertainties

The Waipoua Project Team has made recommendations on analysis and understanding of the current and future flood hazard, and a preferred response to it, based on the best available information. However, it is acknowledged that this information is imperfect. The current understanding of Masterton's flood hazard and the proposed response is affected by significant uncertainties. Further work is required to better understand:

- The hydrology of the catchment, especially of the ungauged portion thereof, and its limited period of record;
- The particular role of the bridges in the urban reach, with respect to the preferred option; and
- The impact that various uncertainties could have on the safety and effectiveness of the proposed works.

The following investigations are proposed to address these uncertainties.

11.1.2 Priority investigations

- Further hydraulic modelling. This should include modelling the preferred option in the original 1D-2D coupled hydraulic model, as to date it has only been modelled in a 2D version of the model with the bridges not modelled. This will be critical for modelling the next iterations of the design, and understanding how much freeboard is available at all of the bridges;
- Sensitivity modelling, to inform freeboard requirements/confirm stopbank levels; and
- Efforts should be made to better understand the hydrology of the river and catchment, which will in the long-term lead to a better understanding of the flood hazard. The Waipoua Project Team supports the continuation of the gauge at the Colombo Road bridge and recommends effort be put into installing gauges (rainfall and, if possible, flow gauging) within the currently ungauged part of the catchment downstream from Mikimiki.

11.2 Nature-based solutions

- Assimilate the results of the feasibility study of nature-based solutions for this catchment, which is currently underway (expected completion in July 2025);
- Test the efficacy of nature-based solutions through pilot projects; and
- Investigate possibilities for alignment and staging of nature-based solutions along with the proposed structural works. For example, the construction of the more urgent structural works between the rail and SH2 bridges, combined with longer-term implementation of NBS to address or partially address less urgent areas, as the risk changes over time.

11.3 Design

- Confirm at which level the true left stopbank upstream of Colombo Road should spill, and whether an engineered spill location(s) is needed;

- In combination with the above item; discussions with MDC about whether Colombo Road should remain open when the stopbank spills, and how this will be achieved (potential road raising and relief culverts will be necessary);
- Further alignment with work being carried out under the Tranche 2 "Before the Deluge" central government funding for flood resilience improvements;
- Agreement between MDC and Greater Wellington on the location of the retreated stopbank at Mawley Park, and agreement on funding of any mitigation needed;
- Collaborate with MDC to develop a full understanding of MDC assets that may be impacted by the preferred option (e.g. the two wastewater pipelines running parallel to the river) and seeking to minimise or design-out these impacts;
- Assessing the current functions being performed by the three grade control weirs, their condition, and whether they should be removed, retained or upgraded. This will include consideration of:
  - The role of Waka Kotahi/NZTA (in relation to the SH2 bridge);
  - The Queen Elizabeth Park water supply intake;
  - Whether the weirs impede fish passage, and what should be done if they do;
  - Do they provide a useful source of rock that could help reduce costs? and
  - Would removing them result in a drop in bed level that would improve flood conveyance?
- The possible influence of overland flows upstream of Masterton at key locations (e.g. the existing cutoff drain at Akura), that are not currently reflected in the model. This would include the sizing of the proposed Akura swale, and consideration of whether it should be combined with the existing Ngaumutawa Road cutoff drain;
- Opportunities to "slow the flow" and give the river room, where space is available, through the design of the preferred option;
- Deciding how existing trees in the stopbank will be managed;
- Value engineering of the preferred option (i.e. a design focus on cost reduction) including seeking to achieve a cut-fill balance. This process will be somewhat iterative, as design changes will need to be modelled to estimate new stopbank heights, which then drive the volume of material required for the stopbanks;
- Refinement of rock revetment locations, lengths and sizing; and
- Confirmation of geometry and freeboard requirements for all stopbanks/bunds, after the model has been updated, and whether any departure from the standard Greater Wellington stopbank profile or freeboard allowances are warranted. This might include consideration of:
  - Height;
  - Distance from the river;
  - Consequences of failure;
  - Additional factors, e.g. water superelevation on a bend, or proximity to a bridge that has too little freeboard and may be subject to blockage/overtopping;
  - Crest width; and
  - Side slope angle.

11.4 Costing

- Updated cost estimates for the preferred option once value engineering (cost optimisation) has taken place; and

- A cost-benefit analysis using the updated costs and an updated flood damages assessment (to reflect the damages saved).

11.5 Implementation planning

- Early implementation of NBS to allow time for it to reach its potential, and early learnings/monitoring to refine the approach and understand its benefits;
- Careful planning and maintenance of any plantings occurring on the berms, so that they do not become an impediment to flood flows;
- Engagement with property owners, particularly in areas such as Akura Road, where the floodwall will need to be built on private property, or with sites where a 1% AEP + climate change standard of protection will not be provided;
- Staging of the physical works; and
- A strategy for consenting the works.

12 Applicability

This report has been prepared for the exclusive use of our client Greater Wellington Regional Council, 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.

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