HCC Water Infrastructure for Growth Feasibility Studies Report

Prepared for

Hutt City Council

Date

July 2024

Tonkin+Taylor | Wellington Water | HUTT CITY TE AWA KAIRANGI

Document Control

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Rev. Number	**Date**	**Description**
1	13/06/2024	Initial draft for feedback from HCC and Wellington Water
2	14/06/2024	Revised draft reflecting feedback from HCC and Wellington Water on initial draft
3	26/06/2024	Final Report following Pricing peer review and revision of housing memo
4	11/07/2024	Final version with requested amendments

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Executive Summary

The Infrastructure Acceleration Fund-funded (IAF) projects will deliver stormwater and wastewater infrastructure to enable the construction of 3,520 new homes in Lower Hutt. Tonkin & Taylor Ltd (T+T) was engaged by Hutt City Council (HCC) in July 2023 to carry out Stage 1 – Feasibility of the IAF project. This report presents the work to investigate the feasibility of the stormwater project. The purpose of Stage 1 was twofold:

1 To investigate the engineering feasibility of the stormwater upgrade and arrive at a feasible preferred option that is within budget, buildable and consentable and has the capacity to deliver on the 3,520 additional dwellings requirement of the funding agreement.

2 To provide a robust, defensible record of the process of selection of the preferred option, that is suitable for use in a Resource Management Act or Public Works Act process.

The Opahu Stream poses a significant flood risk and development impediment. The existing stormwater infrastructure is at capacity. Even accounting for the on-site detention required under HCC's District Plan, the frequency and intensity of stormwater flooding is projected to worsen with future growth, particularly as the effects of climate change and sea level rise continue to be realised. The scale of predicted future flooding is too great a problem to overcome through reliance on stormwater detention and minor network upgrades alone. The preferred option aims to enable housing intensification within the catchment through improvements to the trunk stormwater capacity.

The preferred option consists of:

- A gravity interceptor pipe, collecting flows from the head of the Opahu Stream near High Street and picking up overflows from stormwater pipes along Kings Crescent heading southwards.
- A pump station located on the Opahu Stream near Eastern Hutt School, with a capacity of 2 m^3/s.
- A rising main along Pretoria Street, High Street and Queens Drive.
- An outlet through the new stopbank approximately 50 m downstream of the proposed new Melling Bridge.

The preferred option was arrived at via a longlisting (seven options) and shortlisting (four options) process involving two multicriteria analysis (MCA) workshops. These MCA workshops were based on scoring of a range of criteria by specialists and considered the sensitivity of the results by testing different weightings of criteria. The scoring also included noting any "fatal flaws". A range of different options were considered at the longlist stage. Only pump station/rising main options were included on the shortlist due to the capacity of these options to accommodate the volumes/flows of water that are required to enable housing intensification on this scale.

The stormwater project doesn't target its housing enablement objective via the reduction of existing flooding (which would encourage development in these still higher risk areas, and doesn't deliver enough development potential). Instead, it will be achieved by providing additional trunk capacity in the Opahu Stream – the spine of the stormwater network – to allow intensified development to be able to drain to the stream without worsening flooding elsewhere. Mitigation of existing areas of flood hazard would require works beyond the scope of this project, although the provision of additional trunk capacity may help to enable this.

The area of potential developable residential land (excluding road and road reserve) that would benefit from the improved trunk capacity in the Opahu Stream has been estimated at 38.9 ha.

The delivery of the housing enablement objective via a single upgrade project differs from the approach adopted at the time of the IAF funding application and reflected in the funding agreement,

which envisaged two upgrade projects. However, the preferred option alone still has the ability to provide for the number of dwellings required.

The total budget for the IAF project is [redacted] which must include both the stormwater and wastewater upgrades. Kāinga Ora is contributing [redacted] towards the stormwater portion, with HCC contributing the remaining funding. The latest estimate of wastewater costs (March 2024 - P95 estimate including property purchase) is [redacted] The P95 estimate (Level 1.5, April 2024) for the Stormwater preferred option is [redacted]

The key technical risks facing the design are:

- Contamination or other damage to the Waiwhetū aquifer, from which up to 70% of Wellington's water supply is sourced.
- Lack of agreement with Greater Wellington Regional Council and Riverlink on the nature and design of the outlet to Te Awa Kairangi.
- Only high-level hydraulic modelling has been carried out to date, and no modelling of specific growth scenarios relating to the intensification to be enabled by this project has been undertaken.

The next stage of design should prioritise actions to address these, including:

- Site investigations to inform a better understanding of the risks to the aquifer, and to inform foundation design.
- Further engagement with Greater Wellington Regional Council and Riverlink on the design of the outlet.
- More detailed hydraulic modelling focussed in the area of the preferred option, likely also including survey of critical sections of the Opahu Stream and of the connected stormwater network.

Other non-technical risks include consenting and property acquisition (which both primarily pose risks to the project timeframe). Stage 2 of the project must prioritise the property acquisition and consenting, also to provide certainty to the design parameters and project timeframe.

During this process, several broader network and development guidance improvements were identified that sit outside the design scope of the preferred option. These consist of infrastructure improvements that could be progressed if funding becomes available, and of non-infrastructural recommendations that could have a significant further impact on reducing flood risk, over and above the objectives of this project.

1 Scope Summary

Hutt City Council (HCC) and Kāinga Ora – Homes and Communities, through the Infrastructure Acceleration Fund (IAF) have jointly committed to fund the stormwater upgrades required to facilitate building of up to 3,520 new houses in the lower Hutt Valley. HCC has also committed to fund the wastewater pipeline upgrade required to support this additional growth. Both the wastewater and stormwater scopes of work include elements that are within the Riverlink Project Designation. This report discusses the preferred option for the stormwater upgrade project and the process used to arrive at that preferred option.

T+T carried out Stage 0: Discovery of this project and delivered its gap analysis/recommended approach memo in July 2023. This is appended as Appendix BB. T+T was further engaged by HCC on 24 July 2023 to carry out Stage 1 - Feasibility of the IAF project. This report presents the work to investigate the feasibility of the stormwater project. Refer to 1091097.MM.2200.PRW.ME.DM.66.Wastewater Value Engineering Memorandum for the wastewater project.

The purpose of this stage is twofold:

a To investigate the engineering feasibility of the stormwater upgrade and arrive at a feasible preferred option that is within budget, buildable and consentable and has the capacity to deliver on the 3,520 additional dwellings requirement of the funding agreement.

b To provide a robust defensible record of the process of selection of the preferred option that is suitable for use in an RMA process.

The completion of the first part of the purpose above (confirming feasibility) enables Kāinga Ora and HCC to sign off on Stage 1 of the project. The successful completion of Stage 1 will allow HCC to progress to Stage 2, the consenting and detailed design. Specifically, once stage 1 is complete, HCC will be able to go to market to procure a contractor for Early Contractor Involvement (ECI) during the preliminary design and consenting phases of the project. In parallel, HCC will need to begin the process of identifying and acquiring the required property.

The key deliverables of Stage 1 – Feasibility are:

- This Feasibility Studies Report.
- Drawings.
- Cost estimate.
- Consenting Strategy.
- Property Acquisition Strategy.
- Confirmation of Stage 2 programme milestones.

The total budget for the IAF project is [redacted], including both the stormwater and wastewater upgrades. Kāinga Ora is contributing [redacted] towards the stormwater portion with HCC contributing the remaining funding. The latest estimate of wastewater costs (March 2024 - P95 estimate including property purchase) is [redacted] The P95 estimate (April 2024, level 1.5) for the Stormwater preferred option is [redacted]

The project process follows the requirements of the funding milestone stages outlined in the funding agreement between HCC and Kāinga Ora, administrators of the IAF funding.

1.1 Stakeholders

1.1.1 Partnership with mana whenua

Iwi representatives were consulted during the feasibility stage to identify issues of concern. The process of iwi engagement evolved through the course of the feasibility study. The preferred process settled upon was for [redacted] of the Port Nicholson Block Settlement Trust to be our iwi project representative. [redacted] was given project briefings on both the stormwater and wastewater projects, reported back to mana whenua and brought mana whenua feedback to the project. Mana whenua representation was sought throughout the Multi-Criteria Analysis (MCA) processes and feedback incorporated into the results. A representative from HCC provided indicative scoring for cultural impact for the long list MCA workshop and [redacted] of Hikoikoi Management provided scoring for the shortlist MCA workshop based on iwi knowledge. Hikoikoi Management has been agreed as the point of contact for mana whenua engagement, and has provided a letter on behalf of Wellington Tenths Trust, Palmerston North Māori Reserve Trust and Port Nicholson Block Settlement Trust, indicating that:

- They do not oppose the project.
- They understand the importance of the project to ensure there is capacity in the stormwater trunk network to reduce the possibility of flooding in the Central Hutt area.

1.1.2 Key stakeholders

Table 1.1 details identified stakeholders during the feasibility design process, and the level of engagement conducted to date.

Table 1.1: Key stakeholders

Organisation	State of Engagement	Comments
Hutt City Council	Engaged throughout	• Engagement with transportation, housing, consenting, and parks and recreation teams.
Wellington Water Limited	Engaged throughout	• Long list-stage meeting with Operations staff. • Engagement through the MCA process (resilience, operations). • Involvement in Project Management Board (PMB) and Technical Advisory Group (TAG). • Review of this report and drawings. • Input to Safety in Design (SID) workshop. • Review of draft Principal's Requirements for ECI contract.
Urban Plus (HCC-Led Developer)	Engaged as required	• Engagement through Hutt City Council.
Greater Wellington Regional Council	Engaged as required	• Engagement on stopbank penetrations and consenting approach.
Kāinga Ora	Funder	• Engagement through Hutt City Council.
Wellington Electricity	Early	• Initial engagement for the additional power infrastructure and costs required for the pumpstation.
Eastern Hutt School	Early	• Early conversations were conducted with Eastern Hutt School around potential options.
Ministry of Education	Early	• Early conversations were conducted with the Ministry of Education to discuss property around potential options.

Organisation	State of Engagement	Comments
Chilton St James School	Early	• Early conversations around a potential option were conducted with the Chilton St James to discuss property and discussions of history with the Opahu Stream.
Utilities providers	Not investigated	• Request for before you dig information. • Engagement has not taken place regarding betterment. This will occur in the next stage of design.
Community Groups	Not investigated	• Public groups have not been investigated yet, this will take place in the next stage of the project.

1.2 Project background

The Hutt City Three Waters Growth Study Report (Wellington Water Limited, 2022) identified the Opahu Stream as a key constraint to the stormwater network as much of the Boulcott, Melling, Woburn and Waterloo West networks discharges into it. As a result of these findings, an application was made for 2023 IAF funding to address the constraint to enabling growth in the catchment. Funding was approved in October 2022 leading to the initiation of the Enabling Infrastructure Stormwater and Wastewater projects (the projects covered by this report).

The stormwater infrastructure improvements proposed as part of the IAF project are aimed at removing impediments to housing development, intended to accommodate the predicted population growth in Lower Hutt in the late 2020s and 2030s. This intensification will be entirely brownfield redevelopment. The IAF project is critical to enabling the local stormwater network to provide an acceptable level of service.

Stopbanks provide the wider area with fluvial flood protection from Te Awa Kairangi – the Hutt River, but the low-lying area behind the stopbanks is prone to stormwater flooding. Moreover, the existing stormwater infrastructure in the Opahu Stream catchment, behind the stopbanks, is already at capacity. Even accounting for the on-site storage required under HCC's District Plan, the frequency and intensity of stormwater flooding is projected to worsen with future growth, and particularly as the effects of climate change and sea level rise continue to be realised. The scale of predicted future flooding is too great a problem to overcome through reliance on hydraulic neutrality and minor network upgrades alone.

The project area for the upgrade is the Opahu Stream catchment, shown in Figure 1.1, below.

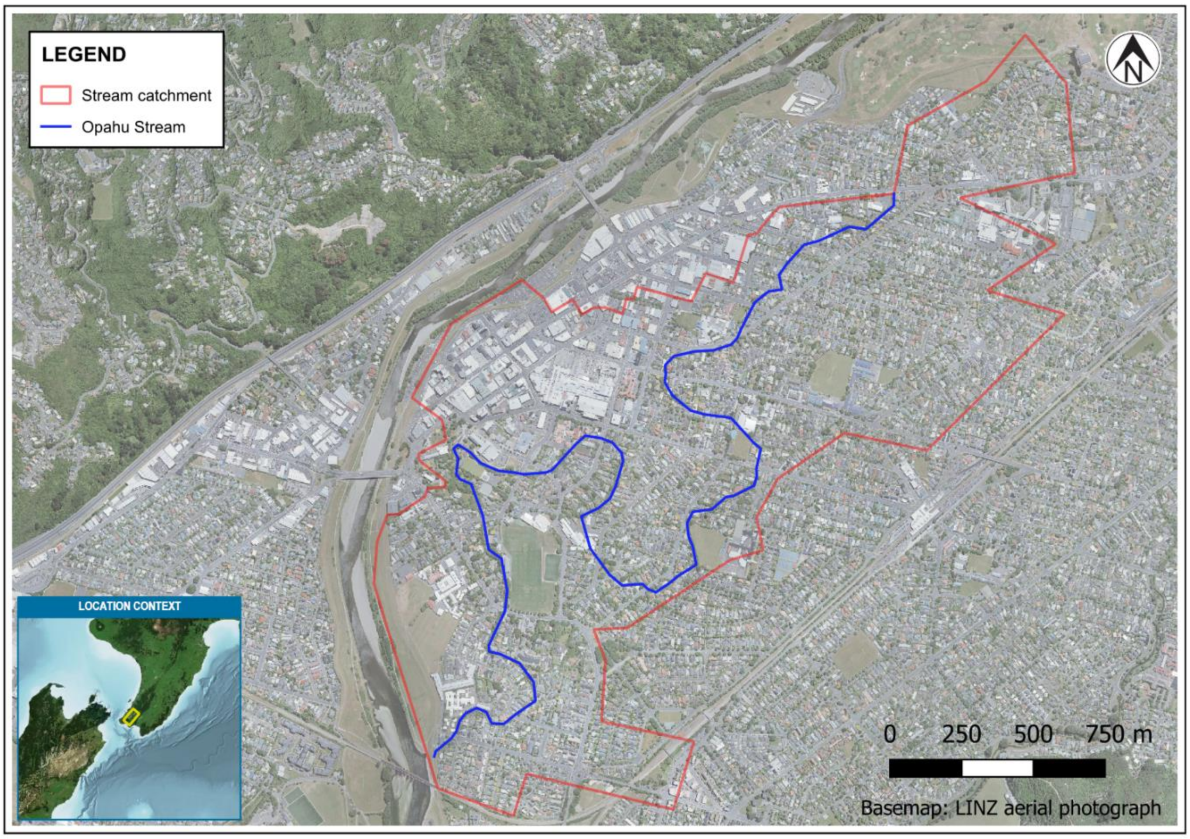

Figure 1.1: Project area

The catchment includes most of the Lower Hutt CBD and is heavily urbanised. The stream itself is very constrained and has little green space along its length. It is very flat, with a fall of approximately 7.1 m along its 5.3 km length (0.13% or 1 in 750). A considerable length of the stream is culverted. There are only pockets of green space along the stream. These consist mostly of school playing fields, with no public green space except the Hutt Recreation Ground and Riddiford Gardens area.

The Stage 0 "discovery stage" of the project (carried out by T+T and Mott MacDonald) investigated the status of the wastewater and stormwater pipeline concept designs (which were previously undertaken by Holmes Consulting and Stantec respectively as part of an earlier project stage), identified gaps and confirmed high level project milestones for delivery. The results from the discovery stage investigations were provided to HCC in the memo *1091097.1-RPT-PD-000 Memo gap analysis and approach_20230706* in July 2023, included as Appendix BB to this report.

1.3 Report purpose and structure

This report discusses the feasibility design. The purpose of the report is to describe the preferred option and the process undertaken to arrive at it, including design approach, design description, costings, risk assessment, MCA process, and constraints.

1.4 Associated documents

Property acquisition and consenting have been identified as significant risks to the project, particularly due to their potential impact on programme. Specialist advice has been sought on these two topics and both a property acquisition strategy and consenting strategy have been developed to guide the approach in the next phase.

1.4.1 Property acquisition strategy

A stormwater property acquisition strategy has been developed based on the preferred option that has been selected. The strategy discusses the processes and framework for the evaluation, selection, approval, and purchase of the property required for the project.

1.4.2 Consenting strategy

The consenting strategy for stormwater was completed in June 2024, to reflect the planning requirements, discuss consenting pathways and provide recommendations for the consent process.

Key recommendations, opportunities and risks identified in the consenting strategy are summarised as follows:

- A standard consenting process under the Resource Management Act 1991 (RMA) is recommended at this point in time. This can be revisited if the process appears likely to be particularly challenging.
- The Riverlink consent decision and conditions set a clear direction for outlets that involve stopbank penetrations through the Hutt Riverbank to be rationalised. However on 20 May 2024, GWRC engineers confirmed in a discussion with the project team and GWRC regulatory officers that the outlets should be separate rather than combined. Resource consent will therefore be required for a new outlet through the stop bank, which would form part of the HCC IAF consent package.
- We consider the discharge of stormwater is likely to be provided for through the existing Stage 1 global stormwater discharge consent (and subsequently the ‘replacement’ Stage 2 global consent application) for stormwater (and wastewater) discharges across Wellington, Porirua, Lower Hutt and Upper Hutt held by Wellington Water.
- There are range of consent triggers within the Greater Wellington Regional Council’s Natural Resources Plan (NRP) and Proposed Plan Change 1 (PC1). This includes earthworks and the diversion of water from the Opahu stream and associated intake structure within the stream.
- Resource consent is also likely to be required for the potential interception of groundwater and dewatering due to the depth of the proposed pump station and pipelines. Actual or potential effects on the underlying aquifer and source drinking water protection will require a robust assessment through the consent process and consideration of opportunities to avoid or mitigate effects.

2 Applicability

This report has been prepared for the exclusive use of our client Hutt City 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.

We understand and agree that our client may submit this report as part of an application for resource consent and that Greater Wellington Regional Council as the consenting authority will use this report for the purpose of assessing that application.

The construction rates utilised for this high-level cost estimate are based on assumed design concepts, estimated quantities and a combination of recently submitted tender rates for similar projects within the regional area, supplemented with current labour, plant and material rates achieving realistic, but nominal productivities (i.e. lineal metres of trenching per day). The property acquisition / compensation costs are based upon current publicly available property estimates. Additional property related fee and disbursement estimates are based on similar property work for other current infrastructure projects. These rates and costs do not include allowance for any cost escalation since the date of the cost estimate other than where/as specifically stated. In addition, this high-level cost estimate assumes a NZS3910 standard form of contract with typical market risk allocation.

Consequently, a significant margin of uncertainty exists on the cost estimate and the contingency we have allowed should be considered as part of the cost rather than a potential add on.

Given this approach, no assessment has been made to forecast market conditions in this estimate. These including any current or potential effects to the economy following the change in government, or recovery following the Auckland anniversary flood, or Cyclone Gabrielle including any supply chain disruption or constraints within the market. We recommend you seek up-to-date specialist economic advice on what budgetary allowances you should make for escalation, including for any potential changes in construction and property costs and timing based on the above. This service can be offered by T+T should this provide additional value.

3 Design process

3.1 Overall approach

The optioneering, options design and preferred option selection followed the approach of:

1. Discovery phase, reviewing existing available information and reporting on flooding in the Lower Hutt valley and stormwater network performance.
2. Agreeing a design philosophy with HCC and Wellington Water.
3. Site walkover and workshop to develop initial longlist ideas.
4. Development of the longlist options, culminating in the selection of the shortlist via a multicriteria analysis (MCA) workshop.
5. Shortlist options development, culminating in the selection of the preferred option via an MCA workshop.
6. Preferred option development and reporting.

3.2 Design philosophy

A workshop was held on 30 June 2023 with T+T, Mott Macdonald, HCC and Wellington Water representatives. The purpose of the workshop was to agree the design approach for the feasibility study. The minutes of this workshop are appended in Appendix C.

A typical approach to design for stormwater infrastructure involves addressing a specific flooding problem (targeting a reduced and defined degree of hazard) or designing infrastructure upgrades to a defined level of service (LOS) - for example, conveyance of the 10% AEP[1] storm.

It was recognised at the workshop that this project's design approach would not be to a particular LOS. Rather, we would develop stormwater upgrade options that provide for the greatest number of potential new homes within the available funding cap. An initial design philosophy (Appendix A) was agreed, with its main focus on:

1. Reducing flooding within the identified growth area.
2. Reducing incidence of flooding / flood damage to surrounding assets.
3. Protecting existing floor levels to 1% AEP where possible.
4. Reduce frequency of flooding to arterial roads identified by HCC.

This philosophy presumed an approach of providing for new homes by reducing the area subject to flood hazard. Reducing the flooding would allow new dwellings to be built in locations currently restricted from being built on because they are subject to flooding. However, the focus changed during the project towards providing for intensified development by improving trunk capacity rather than deliberately reducing the area of land flooded. The revised focus indirectly achieves points 1 to 3 above to a degree (reducing flooding), because in the absence of the IAF project, intensification would still be expected to occur (potentially in a less coordinated, piecemeal way) resulting in an increase in runoff and worsened flooding in areas already at risk. The focus on improving trunk capacity seeks to achieve the following: that the proposed intensification can take place on flood-free land in a way that doesn't worsen flooding elsewhere.

As described above, the budget available for the stormwater upgrades is currently [redacted].

[1] Annual Exceedence Probability

3.3 Basis of design

The design was completed with reference to the following design and guidance documents (also refer to the references, Section 10).

1 Wellington Water Regional Standard for Water Services December 2021 Ver 3.0.
2 New Zealand Building Code, E2.
3 Reference Guide for Design Storm Hydrology Standardised Parameters for Hydrological Modelling (Cardno for Wellington Water).
4 HIRDS Version 4.
5 NZS 4404 Land Development and Subdivision Infrastructure.

Additional guidance was also provided regarding climate change allowances, detailed in Section 3.4.

3.4 Climate change allowances

The allowances for climate change adopted by Wellington Water changed early in the course of this project. The new climate change allowances were advised by Wellington Water in September 2023 and were adopted for the hydraulic modelling carried out by Stantec on the shortlist and preferred options. The new guidelines differ from those that were in place for previous modelling (for example, that underlying the current District Plan maps). These new guidelines include the following allowances set out in Table 3.1 (as outlined in the Design Philosophy in Appendix A):

Table 3.1: Climate change allowances

Category	Sea level rise allowance	Rainfall
Base case scenario for modelling and project work	RSLR out to 2130 for SSP5 – 8.5M scenario	Rainfall figures based on HIRDs V4 RCP8.5 scenario for year 2100.
• Dynamic freeboard modelling for district plan flood extents and minimum floor levels. • Stress testing for critical projects.	RSLR out to 2130 for SSP5-8.5H+ scenario	Rainfall figures based on HIRDs V4 RCP 8.5 scenario for year 2100, scaled up to suit current dynamic freeboard testing method.

4 Multi-criteria analysis

A multi-criteria analysis (MCA) was completed through the long listing and shortlisting phases, with criteria scored by specialists. MCA assists in assessing the relative merits and constraints of an option and making the trade-offs between competing matters more transparent. The purpose of the MCA is to rank options in a robust and transparent manner, in order that the process of finding a preferred option can be clearly demonstrated later, including during the resource consent process.

The scoring scale provides for a "fatal flaw" negative score. This score was used where the expert considered that there were unacceptable adverse effects associated with the option – and that there was no reasonable way to appropriately avoid, remedy or mitigate those effects.

In order to further analyse and test the ranking of the options and inform the overall decision making, sensitivity analysis was undertaken to test the sensitivity of the scoring. A number of weighting systems could be applied (e.g. environmental effects; technical and engineering considerations i.e. constructability, operations, risk and resilience; provision of flooding reduction; property and planning risk etc). Weighting systems were developed for each workshop and are explained further, along with the outcomes of the longlist and shortlist MCA, in Sections 5 and 6.

5 Longlist Development Process and Outcomes

5.1 Information sources

The following sources of information, in addition to the guidance outlined in Section 3.3, were used to inform the longlisting process:

- Site walkover observations.
- Aerial photography and Digital Elevation Model (DEM) publicly available from LINZ.
- Flood modelling results for the 10% AEP and 1% AEP events (flood mapping and stream hydrographs provided at selected locations), Wellington Water[2].
- Hutt City Council 3 Waters Underground Services, Wellington Water.
- Waiwhetu Growth – Stormwater Servicing Options Report (Stantec, 2021).

The *Waiwhetu Growth – Stormwater Servicing Options Report* captured previously considered and discarded options, including a broader catchment options list and suburb-scale options. The project team reviewed this report and considered the conclusions in the report to be valid.

The high-level analysis and options assessment undertaken by Stantec in 2021 (Stantec, 2021) proposed three locations where water could be removed from the stream and pumped to two locations on Te Awa Kairangi. The basic premise of this study was that by removing the tailwater constraint in the trunk network, connected parts of the network would have more capacity. This study used a flooding reduction metric of estimated residential floors flooded (for existing properties). These options assumed that the water would likely be pumped to the pump stations located at these two outlets, which at the time were proposed to be constructed by the Riverlink Alliance.

5.2 Process

A site visit was undertaken in July 2023 to look at areas of interest in the Opahu Stream catchment and the locations of the three earlier remedial options proposed by Stantec (MEL_Option_2, WOB_Option_1, and WOB_Option_2) during the preceding stage of the project. This included a visit to the existing Opahu pump station. Attendees included representatives from the design team, Wellington Water, and Hutt City Council.

The consideration of options in this stage was opened up wider again, as the design philosophy was different compared to the previous study and the amount of available funding was known. It was also important to ensure that other alternatives had been given sufficient consideration and that this process to choose the best option was robust (and well documented). A robust options assessment process was considered critical to support subsequent Resource Management Act and Public Works Act processes.

The site visit informed the long list workshop (project team internal) and the development phase, where 11 options were initially discussed. This list was reduced to seven for development after high-level analyses and through removal and combining of options. These seven options were sufficiently developed and subsequently taken through to the MCA process (described in Section 5.8). Options not proceeded with are discussed in Section 5.7.

[2] These previous modelling results from Wellington Water were used at the Longlist stage, as project-specific modelling of the options was not carried out until the Shortlist stage. Flood maps were not produced for the options in the previous options assessment (Stantec, 2021).

High level analysis included:

- Connection levels required for detention storage (taking into account the flat gradient).
- Cut and fill requirements for storage.
- Operational regime and capacity of the existing Opahu pump station.
- Assessment of the existing modelling results.
- Pipe sizing and locations.

Longlist options development included:

- Additional site visits to potential pump station sites.
- Assessment of gravity and pressure pipe dimensions, slopes, material, location and levels/connection to stream and/or existing infrastructure. This was informed by hydrographs provided by Wellington Water. This included calculating the capacity of existing culverts and required upgrade sizing.
- Consideration of stream improvement options (channel and culvert sizing).
- Calculating detention storage volume, inlet and outlet connections.
- Preparing concept level pump station specifications and sizing.

Seven options were considered as part of the longlist options development. These are illustrated in Figure 5.1, with descriptions in Table 5.1. Option 1b was similar to the earlier Stantec MEL_Option_2 (with a slightly different pump station location and the addition of the gravity interceptor). Option 4 was very similar to the earlier Stantec WOB_Option_1 with WOB_Option_2.

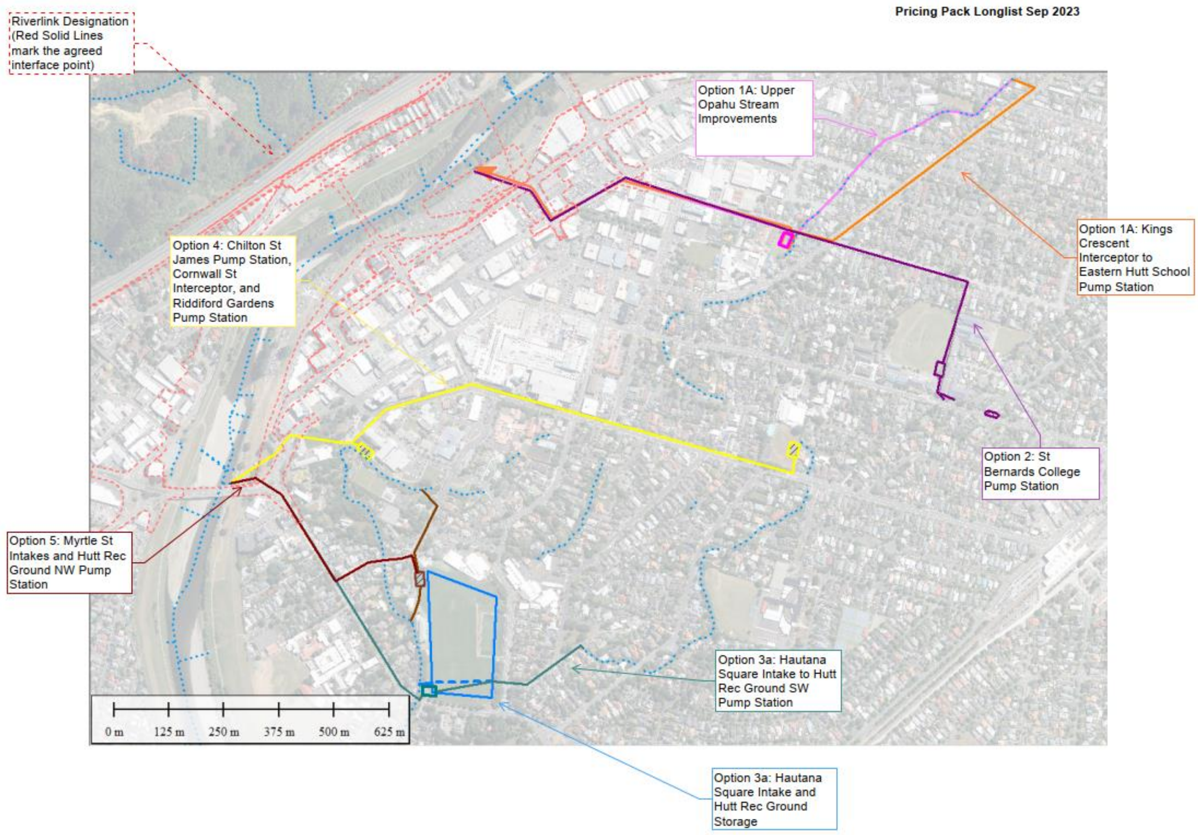

Figure 5.1: Map of longlist options.

Table 5.1: Longlist options descriptions

Option Name	Description
Option 1a: Eastern Hutt School Pump Station with Stream Conveyance Improvements	• Increase the conveyance capacity of the Opahu Stream along Kings Crescent from High Street to Pretoria Street (channel improvements and culvert upgrades). • A stream intake structure and pump station with 2 m^3/s discharge capacity located at Eastern Hutt School. • Rising main from pump station to outfall to Te Awa Kairangi (via Riverlink outlet 35), pipe to be laid within the road reserve.
Option 1b: Eastern Hutt School Pump Station with Kings Crescent Interceptor	• Intercept piped stormwater flows upstream of Opahu Stream via a new weir chamber and divert along Kings Crescent in a new gravity interceptor pipe, collecting flows from selected stormwater pipes crossing Kings Crescent. • A stream intake structure and pump station with 2 m^3/s discharge capacity located at Eastern Hutt School. • Rising main from pump station to outfall to Te Awa Kairangi (via Riverlink outlet 35), pipe to be laid within the road reserve.
Option 2: St Bernard's College Pump Station and Rising Main to Outlet 35	• An intake from the existing stormwater pipelines (primary network) in Waterloo Road. • An intake to capture surface water on the northern side of Waterloo Road (secondary flows). • A pump station on the grounds of St Bernards School. • A rising main along Pretoria St to Outlet 35.
Option 3a: Hautana Square Intake to Hutt Rec Ground Storage	• Intercept flows on a culverted section of Opahu Stream at Hautana Square and divert to a new open channel through Hutt Recreation Ground. • New open channel in Hutt Recreation Ground to fall east to west and discharges into a downstream section of Opahu Stream. • Ground levels within Hutt Recreation Ground lowered to provide temporary detention in flood events, with flows spilling out of bank from the new open channel. • Flood detention to drain by gravity when water levels in Opahu Stream reduce.
Option 3b: Hautana Square intake to Hutt Rec Ground SW Pump Station	• Intercept flows on a culverted section of Opahu Stream at Hautana Square and divert to a new buried gravity pipe through Hutt Recreation Ground. • New gravity pipe discharging to a new pump station in the Hutt Rec Ground (South Western corner). • The pump station will then discharge through Woburn Road to Outlet 24 (in Riverlink designation).
Option 4: Chilton St James Pump Station and Riddiford Gardens Pump Station	• A stream intake and pump station with a capacity of max. 3 m^3/s at Chilton St James School. • A stream intake and pump station with a capacity of max. 3 m^3/s at Riddiford Gardens. • A rising main from Chilton St James PS along Knights Rd to Riddiford Gardens PS, and then a combined rising main along Queens Dr to Outlet 24.
Option 5: Hutt Rec Ground North West Pump Station with two stream intakes	• A stream intake (Intake 1) with a capacity of max. 1.5 m^3/s at Riddiford Gardens (Myrtle St). • A stream intake (Intake 2) with a capacity of max. 1.5 m^3/s at Hutt Rec Ground. • Gravity pipelines from each intake to the pump station.

Option Name	Description
	• A pump station with a capacity of 3 m^3/s at the northwest corner of the Hutt Rec Ground. • A rising main along Myrtle St and Woburn Rd to Outlet 24.

5.2.1 Key constraints

Constraint assessments were completed to understand hydrogeology, contamination, planning, ecology, dry services, and geotechnical constraints in the proposed option areas. These assessments provided additional information to better understand environmental constraints to guide the feasibility assessment of the options, including the identification of fatal flaws, major cost elements, or design challenges. The constraints assessments are included in Appendix D to Appendix I.

These assessments were completed using available data such as beforeUdig data, environmental, hazard and asset maps, and the HCC district plan.

Key constraints that were identified included:

- High groundwater table and high groundwater inflows (dewatering).
- Potential interference with the Waterloo well field.
- Potential aquifer contamination or intrusion risk.
- High density of existing underground utilities.
- Increasing seismic/liquefaction risk closer to Te Awa Kairangi.
- Contamination throughout catchment due to lead-based paint and asbestos materials used in construction of buildings and structures within possible project area. However, there were no specific, serious concerns with any of the longlist options.
- All options will have some degree of ecological impact that must be mitigated, but none of the options has particularly significant impacts in comparison with the others.

A summary of constraints identified in the constraints report is outlined in Table 5.2.

Table 5.2: Summary of constraints

Constraint	Summary
Hydrogeology	PIPELINE ALIGNMENTS • Radial effects (drawdown) extending to sensitive locations: – Source water affected by potential well interference effects (shallow groundwater users and the Waterloo Wellfield bores). – Localised stream depletion effects in high permeability sediments adjacent to the Opahu Stream. • Potentially large groundwater inflows (especially close to Te Awa Kairangi / Hutt River and potentially Opahu Stream) resulting in large groundwater volumes to be removed, treated, and discharged (there may be practical limits on pumps/sizes, treatment and disposal options, etc.). • Ground settlement potential. PUMP STATION EXCAVATIONS • Potentially significant groundwater inflows could result in issues including the challenge of removing large volumes of water due to pump limitations, ground settlement, risks of heave and piping at excavation bases, and concerns about compromising the confining

Constraint	Summary
	layers over the Waiwhetū aquifer, specifically for deep excavations in the Boulcott area and within SPZ1 of the Waterloo Wellfield. Other potential risks include disruption of the Waiwhetū Aquifer caused by deep driven sheet piles, encounters with unforeseen buried structures such as bores and CPTs leading to increased inflows, and heightened groundwater levels close to Te Awa Kairangi / the Hutt River and possibly adjacent to the Opahu Stream. • Radial effects (drawdown) extending to sensitive locations: – Potential well interference effects on groundwater users e.g. greatest risk is to users in the Taita Alluvium and the Waterloo Wellfield bores. – Stream depletion effects from removal of large groundwater volumes for a long duration. – Potential for saline intrusion to occur as a result of drawdown effects over longer durations of dewatering at locations close to the Hutt River.
Contamination	• Historic and current HAIL activities across the project area may result in soil and groundwater contamination. Further investigation, i.e. Detailed Site Investigations (DSIs), of some HAIL sites may be required, particularly where soil disturbance is proposed. • It is likely that lead-based paint and asbestos have also been used in construction within the Project Area. Wear and maintenance of the buildings may have resulted in nearby soil contamination. It is likely that building materials from historic buildings and structures have been buried in areas along the stopbanks and berms. The Asbestos Regulations are likely to apply if works that will disturb asbestos structures are proposed. • The National Environmental Compliance Standards (NECS) will apply to the proposed work and a resource consent will be required to undertake development activities, including; soil disturbance and changes to land uses.
Dry Services	• The dry utilities that were investigated for the IAF HCC stormwater and wastewater improvements are Electricity, Natural Gas, Fibre optic network, Communications, and Geodetic Markers. A summary sheet of the utility owners' requirements is attached in Appendix A of the dry services report. • Many of the dry services can be relocated through a clash resolution process. • "Critical" services were examined specifically, being: 33 kV power, strategic gas mains and core fibre cables. All are present within the study area. – 33 kV cables are present in parts of Kings Crescent, Potomaru Street, Epuni Street and between Rutherford St and the stopbank. – Fibre cables are present in a number of streets, and One NZ's Metro Fibre Ring runs through a number of streets in the CBD. Any options running through the CBD are likely to need to cross this at some point. – Power Co's strategic gas pipes are located around High St, Brunswick St and Kings Crescent.

Constraint	Summary
	• These critical services will need to be taken account of in the design of any pipelines in these areas, but are unlikely to pose a fatal flaw to any options. • More detailed clash assessments were completed in the longlist and shortlist development stage. Refer to Section 5.4 and Section 6.6. • Wellington Electricity is likely able to supply all pump station locations with the expected power demand, without the need for major upgrades. The exception is that its current network is unable to supply power concurrently to pump stations in Myrtle St and Laings Rd. No longlist option proposes this combination of pump stations, so this is not a problem.
Ecology	• The longlist options each encounter at least one of the four ecological constraints: interception of base flows, works in open green space, direct freshwater works within Opahu Stream, and vegetation clearance. The ecological risks associated with each option can be addressed through good design and undertaking best practice fauna management during construction.
Planning	• The District Plan and Neighbourhood Revitalisation Plan frameworks are generally supportive of infrastructure upgrade and development. Resource consent would likely be required, but the preliminary view is that there are no particular constraints or fatal flaws to construction or upgrade of infrastructure for this project. Robust alternatives assessments that demonstrate the appropriateness of the selected options would be required to support the consenting process.
Geotechnical	• All alignment options may have similar geotechnical constraints (liquefaction and geotechnical issues associated with construction) with the exception of lateral spreading, which varies depending on the location and distance from the Hutt River. Project options which are located closer to Te Awa Kairangi have a higher risk of liquefaction and lateral spreading.

5.3 Options not proceeded with

Three additional options were considered at the initial stages of the longlisting process. These included:

- Lower Opahu stream conveyance improvements: increasing capacity to the existing Opahu Pump Station by widening the stream where possible.
- Lower Opahu Stream bypass: increasing capacity to the existing Opahu Pump Station through constructing a separate bypass pipeline from Hutt Recreation Ground to Opahu Pump Station.
- Detention storage at multiple schools adjacent to Opahu Stream: creating detention storage at adjacent school sites.

These were not proceeded with during the longlisting process after high level analysis indicated fatal flaws and marginal flood reduction benefits. In particular, the Lower Opahu Stream options were predicated on them being relatively inexpensive ways[3] to utilise unused capacity at the existing pump station. Once it was found that this pump station would be running at capacity in a 1% AEP event, these options would have required the construction of a new pump station or major add-on

[3] compared with constructing a new pump station

to the existing pump station and they became less attractive compared to alternatives. Refer to Appendix K for further information on these discounted options.

5.4 Design approach

5.4.1 Pump stations

A full description of the approach taken to pump station design is provided in Appendix B. In summary:

- A number of national and international guidelines were considered in the sizing and hydraulic design of the pump station structures, including guidelines produced by Xylem pumps.
- Pump manufacturer guidelines have not been relied upon entirely at this stage, as there is still considerable uncertainty in the selection.
- Only high-level foundation design has been carried out, in the absence of geotechnical investigations. There has been no specific consideration of seismic design. The high-level foundation concept can be found in Appendix J.
- Provision for buildings and ancillary systems has been based largely on the existing Opahu pump station at this stage.

5.4.2 Pipelines

Pipeline sizing and depth was initially based on the following assumptions:

- Rising main sizes selected to give velocities in the range of 2.5 – 3 m^3/s.
- Rising main material PE100 PN16 SDR11.
- Average rising main depth 1.5 m cover to top of pipe.
- Gravity pipelines sized and depths estimated at 0.5% grade.
- Gravity pipeline material RCRRJ.
- All pipelines constructed using an open trenching methodology.

Clash investigations at the longlist stage focussed on potential clashes giving rise to fatal flaws for the gravity pipelines, as these were seen to be more critical. These investigations were done on the basis of Wellington Water GIS information and beforeUdig requests.

No specific consideration has been made at any point in the feasibility design of pressure transients, air management or other detailed hydraulic considerations.

5.5 Riverlink scope

At the longlist stage, all elements of the options within the Riverlink Project designations (the rising mains and the outlets) were included for design and delivery within the Riverlink scope of work. In line with Greater Wellington Regional Council's requirement to not create any additional stopbank penetrations, and to rationalise existing penetrations wherever possible, the design of the longlist options included outlets aligned with the Riverlink outlets 24 and 35. As the design of the outlets lay with Riverlink, only high-level allowances were made in the outlet costing carried out at longlist stage.

Riverlink removed its proposed stormwater pump stations at Outlet 24 and Outlet 35 from its scope during the longlist stage. This removed the option of pumping stormwater from the Opahu Stream to these pump stations and then pumping the combined flows through a single outlet (a 'daisy chain' configuration). The longlist pump station options (and subsequent stages) relied on their own, separate pipelines to the Hutt River.

5.6 Cost estimation

Level 1 cost estimates were prepared by a Quantity Surveyor for each of the long list options. [redacted]

[redacted]

[redacted]							
[redacted]	[redacted]						
[redacted]	[redacted]						
[redacted]	[redacted]						

5.7 Estimation of flood reduction benefits

In line with the design philosophy and the focus on flooding reduction at the longlist stage, the degree of benefit and likely benefit area were estimated for each option. No hydraulic modelling was carried out at the longlist stage, so this assessment relied on interpretation of existing modelling results. The estimates of flooding reduction for each option were based on:

- Hydrographs at selected locations.
- Volumes of flooding in different locations calculated from the 2-D model results.
- Comparison of the above with the expected storage volumes, conveyance improvements and/or pump station flows for each option, combined with engineering judgement.

These potential reductions in areas of flooding were used as a proxy for housing enablement, including in the form of cost/hectare comparisons between options.

From the point of the longlist workshop onwards, it was clear that the available budget of [redacted] would likely only cover a single upgrade project (option) rather than the two projects envisaged in the IAF funding application and agreement. Each option would therefore need to be viable alone in delivering the housing enablement benefit.

5.8 Longlist Multi Criteria Analysis (MCA) Workshop

MCA analysis was undertaken to assess the relative merits, benefits, and disadvantages of each option. The outcomes of the analysis were then used as a decision support tool.

The assessment criteria for the longlist MCA included:

a Flood reduction.

b Constructability.

c Operations.

d Risk and resilience.

e Community effects.

f Cultural values.

g Property.

h Planning and consenting complexity.

Specialist assessors assigned scores for each longlist option and provided reasons for the scores.

On 11th October 2023, the longlist MCA workshop was held, where the specialist assessors, project team, and an MCA specialist gathered and reviewed assessment scores. The weighting for each criterion was also developed and tested during the MCA workshop.

Level 1 cost estimates for each option were also reviewed as part of the process. As not all scores were finalised at the workshop, an additional workshop was held the following day, to finalise MCA outcomes.

Refer to Appendix L for detailed notes on the MCA process and Appendix O for the MCA minutes.

5.8.1 Mana Whenua values

Consultation with mana whenua and iwi representatives was imperative to the decision-making process of this project to gauge issues of concern for iwi.

Mana whenua noted that there were no pā sites located in the option locations and reflected that the improvement to the well-being of Te Awa Kairangi is a high priority for iwi. There are sites of significance in Te Awa Kairangi upstream and downstream of where the project impacts.

5.8.2 Selected options

From the longlist MCA, the options selected for the shortlist were Options 1B, 4, and 5. This was on the basis that:

- Option 1A scored poorly across several criteria, particularly for consenting, constructability, and property. Option 1B addresses flooding in the same area but had fewer constraints identified.
- Option 2 is similar to Option 4 but addresses a smaller area of flooding.
- Option 3A and Option 3B scored favourably overall in the MCA, however both options have a very high cost per property and were therefore considered to provide a lower value outcome.
- Option 5 scored favourably in both the MCA and the cost per property.

These options all consisted of pump stations with rising mains to Te Awa Kairangi at either Outlet 24 or Outlet 35.

This reasoning and decision making is described more fully in the Project Management Board (PMB) report summarising the outcomes of the shortlist selection (Appendix N).

6 Shortlist development process and outcomes

Options 1B, 4 and 5 were selected for the shortlist following the MCA workshop. Further development of these options was carried out to refine the costing and inform the selection of the preferred option at a further MCA workshop. A key aspect of this option development was high-level hydraulic modelling of each option carried out by Stantec in October 2023. This was used to understand the relevant impact/benefit of each option and to understand the design capacity requirement of the pump stations. A summary of the modelling carried out by Stantec to support the shortlist and preferred option stages of the design is provided in Appendix Y. This modelling was done on the basis of the 1% AEP with the previously described climate change allowances.

In order to reduce model run times, the modelling was based on a cut-down version of Wellington Water's Eastern Hutt Model (Stantec, 2022).

The results of the modelling indicated that network constraints also have a strong influence on the flooding. This led us to a change in the design approach away from trying to enable housing through reducing flooding (based on the modelled flooding in the previous study which concluded that the downstream water level in the Opahu Stream was driving the modelled flooding catchment), to achieving this via improving the trunk capacity of the network, focussed on the stream.

6.1 The Pivot

Modelling carried out by Stantec on the shortlist options showed that the impact of the options on flood reduction did not generally extend very far from the stream itself. An example of this finding, showing Option 4, is shown in Figure 6.1.

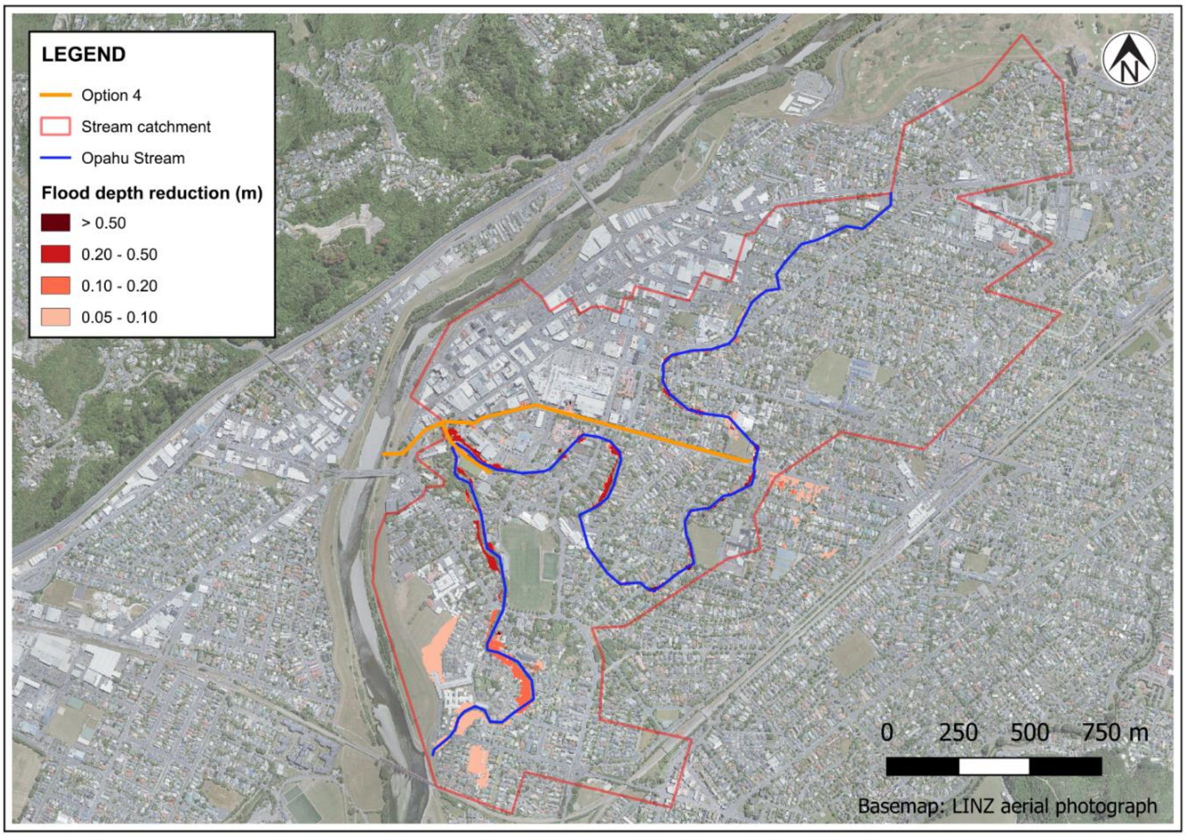

Figure 6.1: Difference in 1% AEP + CC flood depths for shortlist Option 4

This was largely due to:

- Ponding due to various primary network constraints (often at some distance from the stream).
- The lack of functioning secondary flow paths able to convey water to the stream when the pipe network is overloaded (these are often obstructed by roads).

An agreed pivot (agreed with Hutt City Council and the PMB) in approach at this stage (see Appendix P) resulted in an investigation into specific areas of flooding. We focussed on areas that could be connected, via relatively inexpensive and low-technology methods, with reaches of the stream/trunk network where its capacity would be improved by one or another shortlist option. Six areas (the 'clusters') were identified where this seemed feasible and high-level solutions were modelled by Stantec for these. Each cluster was modelled in conjunction with its associated shortlist option, (as the cluster solutions were dependent on the trunk capacity of the stream being increased). The proposed conveyance improvements in these clusters generally consisted of:

- Roadside swales.
- Piped crossings of roads with scruffy dome inlets/outlets.
- Lowered driveways to create or enhance overland flow paths.
- Detention storage in existing car parking areas.

A flood depth of 200 mm was adopted as a threshold for assessing the impact of the different options and clusters (see Appendix S for the justification of this). Several of the clusters provided good drainage to the stream and represented good incremental value in terms of the area of land with reduced flooding. This finding is described in detail in Appendix Q. However, including these additional works would have pushed the overall costs beyond the project budget (see Table 6.1 for updated estimates dating from 1 March 2024, and Appendix R for more detail on the rationale to this finding). Additionally, the area of land where flooding was reduced was nowhere near what would be required to enable all the new development to occur on previously flooded land. The most significant of the cluster solutions, Cluster 4, provided only an additional 2.7 ha of residential land (either non-flooded or to a depth of less than 200 mm). It was decided to not take the clusters further. If in the next stage there is head room in the project budget, HCC could seek to add in one or more of the clusters to achieve further flood reduction and additional housing enablement benefits.

[redacted]

[redacted]	[redacted]	[redacted]		
[redacted]				
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6.2 Shift in focus towards trunk capacity

Following the realisation that targeting flood reduction to enable new housing would neither deliver the number of dwellings needed nor fit within the project budget, the focus shifted towards enabling development on non-flooded land **by improving the trunk capacity of the network**. The Opahu Stream forms the "trunk" of the stormwater network and, by providing additional capacity, future intensified development will have somewhere to drain to. Given the flooding situation that exists within this catchment, improved trunk capacity is a prerequisite for any development that seeks to not make existing flooding worse.

The analysis required to better quantify this approach consisted of:

- Looking into the expected rates of additional runoff from the planned intensification, taking detention storage into account, and
- Estimating the 'benefit area' of each option, in terms of the area of land that could benefit from increased trunk capacity.

These two assessments proceeded in tandem and are described in the sections below.

6.2.1 Increased flows from new development

HCC's District Plan contains permitted activity standards relating to the requirement for detention storage of roof runoff from new developments. Although it is possible that actual consented and constructed developments may achieve a different standard than this (higher or lower), the permitted activity standards were used as the basis for a high-level assessment of increases in runoff from new development. This was done to test whether new developments might even be hydraulically neutral under some conditions, and what range of additional flows we might need to plan for.

The assessment considered various densities of new development in the Opahu Stream catchment. This included a sensitivity analysis of the hydraulic neutrality of potential future developments based on requirements in the Hutt City Council District Plan Chapter 4, with the permitted activity standard requiring rainwater tanks of 5,000 L capacity for roof areas larger than 200 m^2.

Assumptions made in the analysis included:

- There are three townhouses per roof or 12 apartments per roof.
- There is 50 ha of developable land (as an average value of what the shortlisted options might deliver).
- There will be scenarios where the impervious area in the development will exceed the district plan guidelines (minimum 30% permeable).
- The development follows the requirement of 5 m^3 tank for each roof larger than 200 m^2.
- In the scenario where we assumed apartments covering 30% of the developable area, housing will exceed 3500 (to 4000 dwellings) – e.g. the number of dwellings were not reduced to cap at 3500.
- The existing scenario includes an assumed pervious area of 65%.
- Rainfall intensity included allowances for climate change, for all scenarios including the base.

The three (+ base) scenarios investigated included:

Table 6.2: Runoff scenarios

Scenario	Pervious Area	Impervious Area
Existing (runoff coefficient, C=0.48)	65%	35%
Scenario 1 (C=0.76 - Area split 50/50 townhouses and apartments)	20%	80%
Scenario 2 (C=0.695 - Area split 76/24 townhouses and apartments)	30%	70%
Scenario 3 (C=0.695 - Area split 70/30 townhouses and apartments)	30%	70%

Figure 6.2 shows the results for the worst-case scenario investigated, Scenario 1, in terms of water volume.

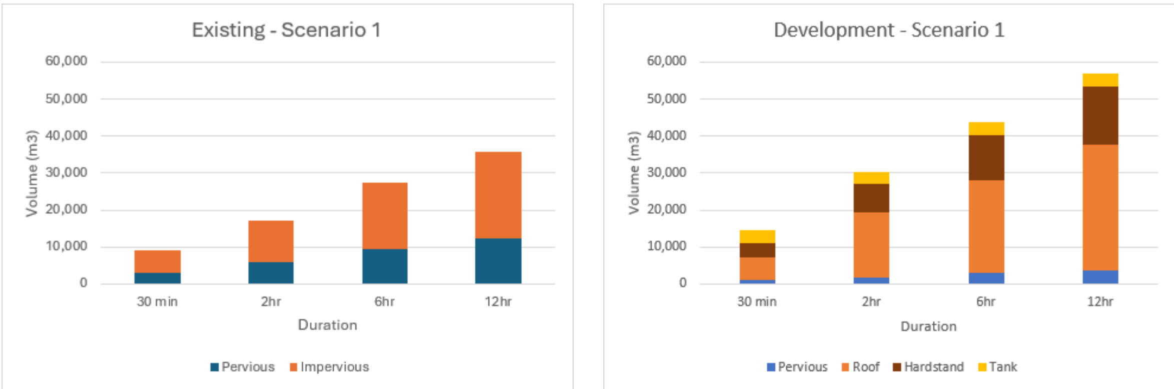

Figure 6.2: Volume comparison between existing and potential development for scenario 1 (C = 0.76)

The difference in flow between the existing and new development is presented in Table 6.3 (no detention tanks) and Table 6.4 below (with detention tanks as described above).

Table 6.3: Pre and post development flow differences (no detention tanks)

	Rainfall duration		
Overview	**30 min (m^3/s)**	**2hr (m^3/s)**	**6hr (m^3/s)**
Max increase (m^3/s)	2.97	1.39	0.75
Min increase (m^3/s)	2.30	1.08	0.58

Table 6.4: Pre and post development flow (with detention tanks) differences

	Rainfall duration		
Overview	**30 min (m^3/s)**	**2hr (m^3/s)**	**6hr (m^3/s)**
Max increase (m^3/s)	1.10	0.92	0.59
Min increase (m^3/s)	0.62	0.66	0.44

Comparing these tables shows that detention tanks will particularly have an impact on shorter, more intense storms. For the 30-minute duration, the detention tanks (as modelled) will reduce the additional runoff to approximately a third or less of what it might have been without detention storage. For longer-duration storms the impact of the detention storage is somewhat less.

A 30-minute duration/time of concentration is, however, too short to reflect the pump station locations, which lie further down the network and (by engineering judgement) are probably best represented by a time of concentration in the 1-3 hour range. However, the shorter time of concentration will be important for sizing the contributing network and overland flow paths locally.

The proposed pump stations in the shortlist options had sizes ranging from 2 to 3 m^3/s. These would be able to manage the increased flows indicated by these high-level estimates, especially at the 2-hour duration which is more appropriate for their location within the catchment.

The decisions made at the longlisting workshop were re-examined by the project team following this shift in approach away from flooding reduction to focussing on trunk capacity. The reasons for the selection of the shortlist options were largely unaffected by the change and the selected shortlist was considered robust.

6.2.2 Trunk capacity as housing enabler

The outcomes of the shortlist option/cluster modelling and the high-level assessment of pre- and post- development flows led to the conclusion that development would be best enabled by developing on flood-free land. A combination of detention storage and increased trunk capacity will be necessary to avoid intensification that worsens flooding elsewhere.

This is also a more resilient and sustainable approach, as it avoids the hazard of encouraging development in areas that are likely to flood.

The benefit area of each option was assessed at a high level by considering the reach of stream experiencing a reduction in water level of greater than 100 mm. This was a proxy for reaches having increased trunk capacity. The connected stormwater network for each option was then used to draw a benefit area associated with this reach.

The exact area that could benefit from a trunk capacity increase depends on:

- The actual hydraulic performance of the stream (this has only been modelled at a high level).
- The location and intensity of the new development, and capacity of the primary and secondary network at that location.
- The degree of detention storage or other stormwater management measures provided within the development.

It may be that, depending on the above, local stormwater upgrades or establishment of overland flow paths are still required in places to connect areas of new development to the increased trunk capacity.

These gross benefit areas were then reduced to reflect the net residential land available, by only taking land zoned Residential into account, and subtracting schools, parks, roads and other non-developable land.

The net residential benefit area for each option, minus the areas with modelled flooding greater than 50 mm depth, was used at the MCA workshop as a metric to represent housing enablement. Avoiding development within areas subject to flooding was considered important, both in terms of managing flood risk and also ensuring that any stormwater detention measures on-site are able to function as intended.

An example of the benefit area for Option 1b is shown on Figure 6.3, below. The gross area of benefit is approximately 75 ha. The net area of benefit excluding areas of flooding greater than 50 mm depth is approximately 40 ha.

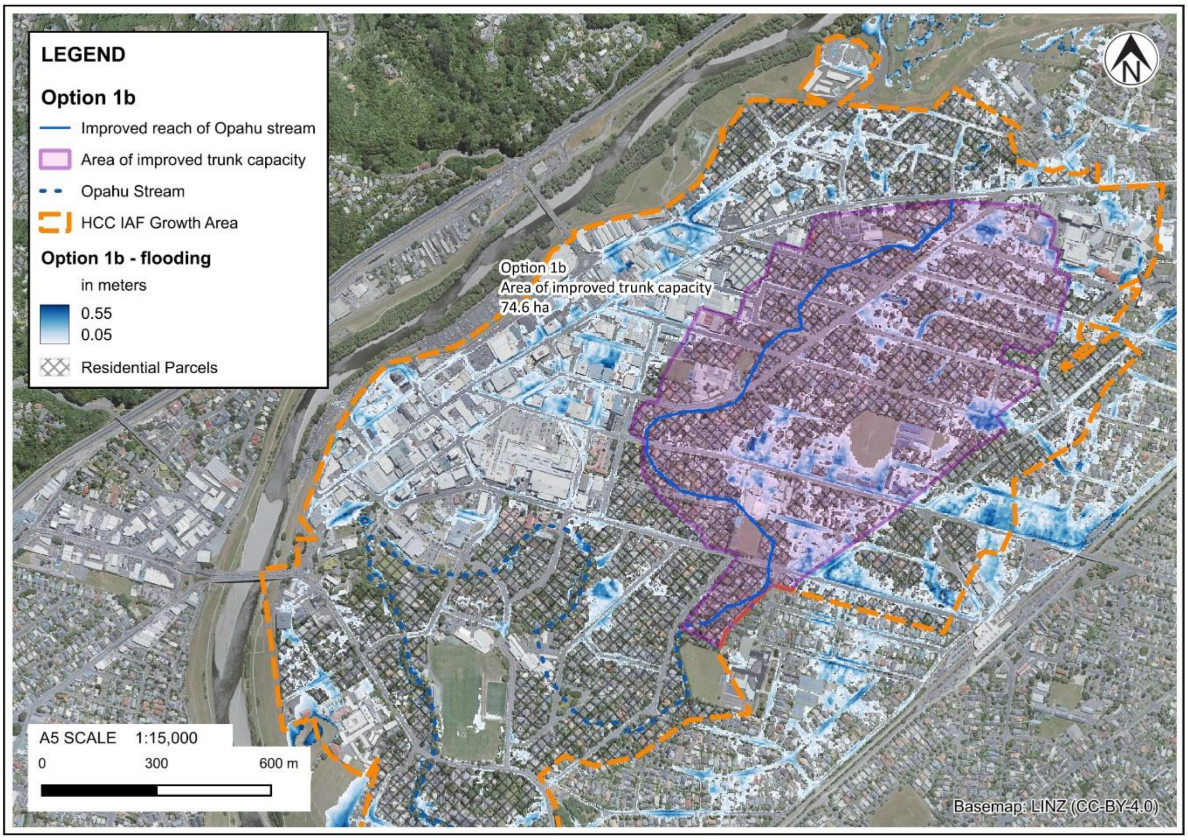

Figure 6.3: Benefit Area for Option 1b

6.3 Option 1b pump station location

During the longlisting process, it was suggested by our property consultant that there would be potential risks with acquiring school land and difficulty in providing appropriate compensation to Eastern Hutt School. The pump station, originally proposed at Eastern Hutt School, was moved to private property at [redacted] altering the interceptor path to extend past the Pretoria Street intersection to the pump station at approximately [redacted] This did not have significant impact on the interceptor length. Refer to Section 6.7 for shortlist configuration of Option 1B.

6.4 Option 4 Chilton St James and Riddiford pump station

Through the development of options, Option 4 (Chilton St James Pump Station and Riddiford Gardens Pump Station) was split into two variants. This was due to the high cost of the original Option 4, and the possibility that Option 4B would provide a proportionally higher benefit, i.e. better value for money. The shortlisted alternatives were:

- Option 4 (Retaining both pump stations).
- Option 4B (only the Chilton St James Pump Station).
- Refer to Section 6.7 for shortlist configuration of Option 4 and Option 4B.

6.5 Stopbank outfalls

At the longlist stage, all elements within the Riverlink project designations (the rising mains and the outlets) were included for design and delivery within the Riverlink scope of work. During the shortlist stage, these items were returned back to HCC to deliver as part of the IAF project.

The shortlist options involved two different locations for the outfalls, one adjacent to the existing Outlet 24, and the other adjacent to the existing Outlet 35.

6.5.1 Outlet 24

The stopbank at Outlet 24 is no longer part of the Riverlink stopbank upgrades as originally intended. Upgrades to the stopbank at this location will occur after the Riverlink project is scheduled to be completed.

Option 4, Option 4b and Option 5 of the shortlist options will require discharge into Te Awa Kairangi at or adjacent to Outlet 24.

A temporary solution to minimise work required on the existing stopbank was considered. This would involve connecting to the existing outlet on the land side of the stop bank and constructing a confluence chamber with the stormwater outlet to transition from pressure to gravity flows. This solution could only be temporary as the arrangement (and interactions with the gravity stormwater network) would be a major constraint on pumped flows. The flows would not cater for climate change impacts on rainfall intensity. The advantage of this option is that works on the stopbank and construction of a permanent outlet could be delayed until the proposed stopbank upgrades occur.

However, in a conversation with Greater Wellington Regional Council on 18 April 2024, following the shortlist workshop, it was noted that the stopbank upgrades at this location would only be to increase the size and footprint of the existing stopbank (and the works would not involve touching the core of the stopbank). This removes the incentive for a temporary arrangement.

6.5.2 Outlet 35

The stopbank at Outlet 35 remains part of the Riverlink stopbank upgrades. Option 1B discharges into Te Awa Kairangi in the vicinity of Outlet 35.

Originally there were two options for consideration (Section 6.5.2.1 and Section 6.5.2.2) for the new penetration to replace the existing Outlet 35. For this stage of design, the cost estimation was completed assuming a combined outlet with a precast concrete box culvert.

6.5.2.1 One combined outlet

This option, which was priced, was developed in order to satisfy GWRC's requirement – as it was understood at the time – to combine the IAF and Riverlink outlets into a single stopbank penetration. This involved placing the outlet from Option 1B and the Riverlink 900 mm diameter outlet into one large precast concrete box culvert (3000 mm x 1500 mm). This would include installing chambers at the landside of the stopbank and on the river side of the stopbank, with bentonite/concrete plugs or equivalent to prevent unplanned flow paths between the pipes.

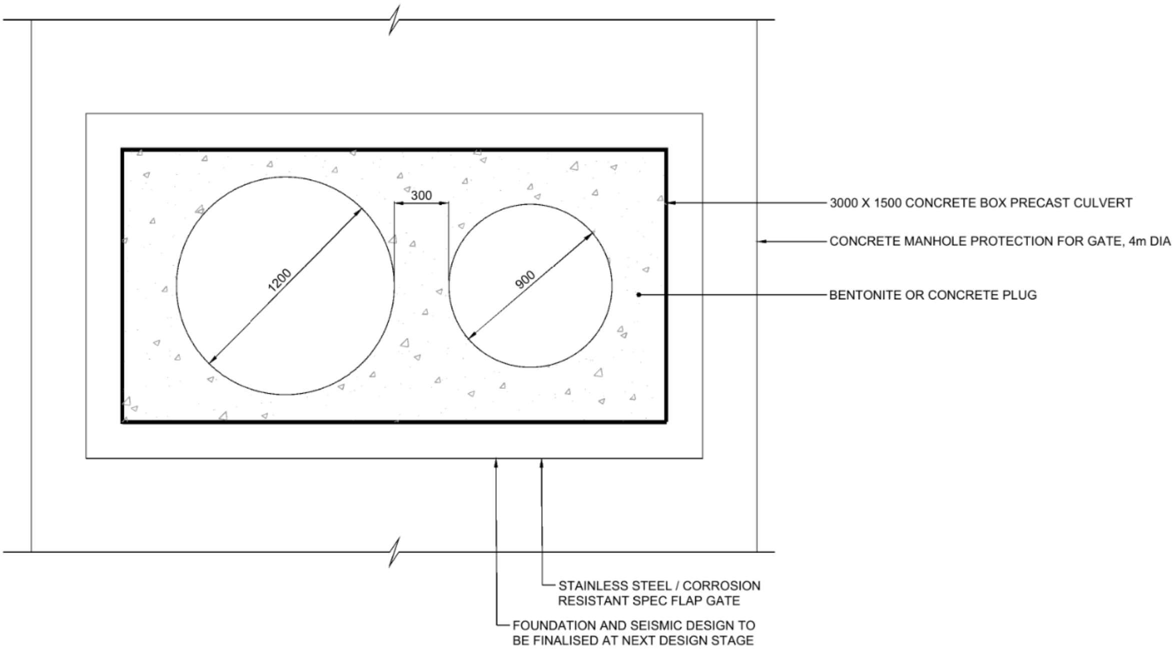

Figure 6.4: Proposed combined outlet at existing Outlet 35 location

6.5.2.2 Two individual outlets

The 18 April conversation with GWRC engineers indicated that two individual outlets may be preferred. This would include having two individual outlets penetrating the stopbank, with allowance for a suitable separation distance between them. The decision between a combined outlet or two individual outlets was not resolved at the shortlist design stage.

6.5.2.3 Planning considerations

The current Riverlink consent provides for activities 'in general accordance' with the application documents. The Riverlink decision and consents specify that rationalisation (where possible) of culverts in the new stopbanks is preferred. Consent condition 112 states that:

"The design for stormwater pipes and culverts under the newly constructed section of stopbank must:

a Combine pipes and culverts where practicable to minimise the number of projections through the stopbank;

b Be designed to allow for future flow increases associated with climate change; and

c Provide for automated gates (penstocks) where back flow prevention is required on culverts replaced under the stopbanks."

However, the original consent application did not anticipate these additional works, so it is possible that GWRC would require a change to consent conditions or a new consent. This is discussed in more detail in the Consenting Strategy.

The outlet configuration is to be confirmed in the next stages of design.

6.6 Refinements to the design approach

In addition to the changes above, the shortlist options were further developed during this phase. This was carried out with a focus on refining feasibility, costings, understanding of benefits and engineering detail to a level sufficient to be able to differentiate options and select a preferred option through the MCA process.

6.6.1 Pump stations

The following refinements were carried out in further developing the pump station designs for the shortlist options:

- Site layouts were produced for each pump station and high-level hydraulic sizing of its structures.
- Setting of weir levels based on the DEM terrain and on hydraulic modelling results (nominally set at a 10% AEP water level).
- Adjustment of pump station design flows in response to hydraulic modelling carried out by Stantec for the 1%AEP + climate change scenario, using updated climate change allowances.
- More detailed consideration of pump selection and wet well sizing, including allowing for the number of pump starts per hour in the Wellington Water Regional Specification for Water Services. System curves were developed for each option to aid pump selection.
- Pump manufacturer guidelines have not been relied upon fully at this stage, but have been considered in conjunction with other guidelines in a more conservative approach, as there is still uncertainty in the pump duty and selection.

6.6.2 Pipelines

The following changes and refinements were made during this stage of the options development:

- Additional beforeUdig information was obtained in areas where it hadn't previously been collected (due to changes to the options).
- It was assumed that excavated material would be suitable for backfill (between the pipe zone and road formation).
- Manhole and ground penetrating radar (GPR) surveys were carried out by Reveal at targeted locations.
- This information, combined with plan information from beforeUdig and Wellington Water, was used to confirm an available corridor and check for fatal flaws, as well as to inform pricing considerations around service location and possible significant service relocations. No 3D modelling of pipelines was carried out at shortlist stage and therefore no detailed consideration of vertical alignments.

6.7 Final shortlisted options

The final four options taken to the MCA workshop after refinement are shown in Figure 6.5, Figure 6.6, Figure 6.7, and Figure 6.8. Refer to Table 6.5 for a brief description of the options. Appendix T explains the preferred option MCA process, including detailed options descriptions.

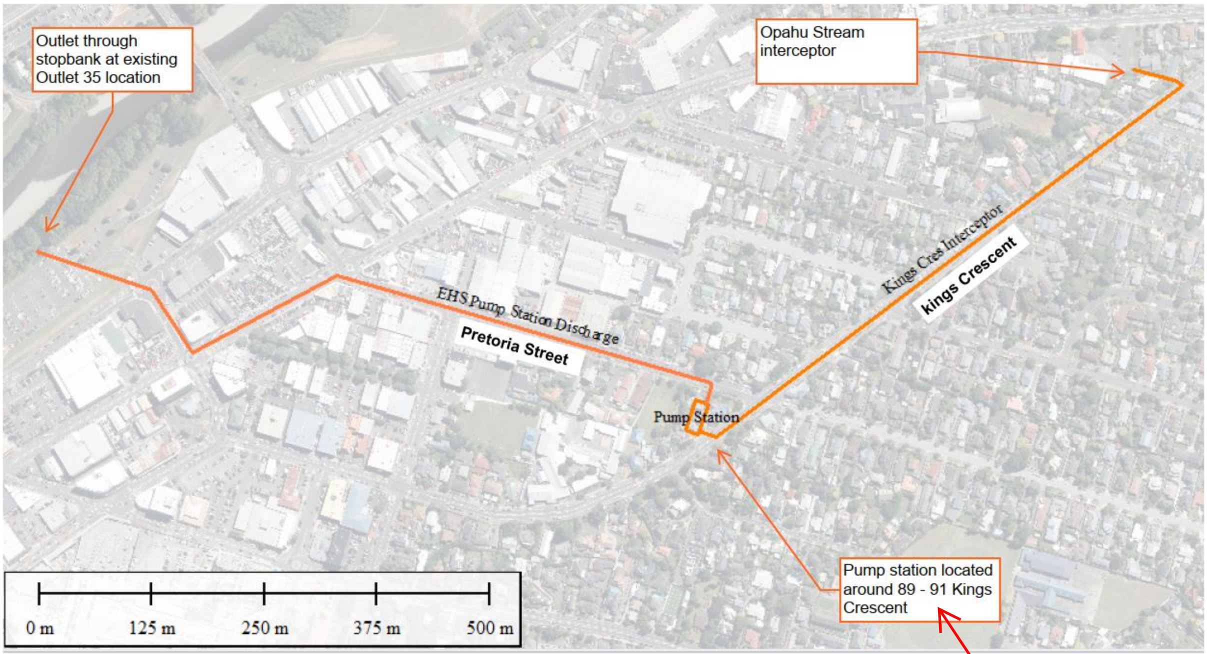

Figure 6.5: Revised option 1b for shortlist MCA

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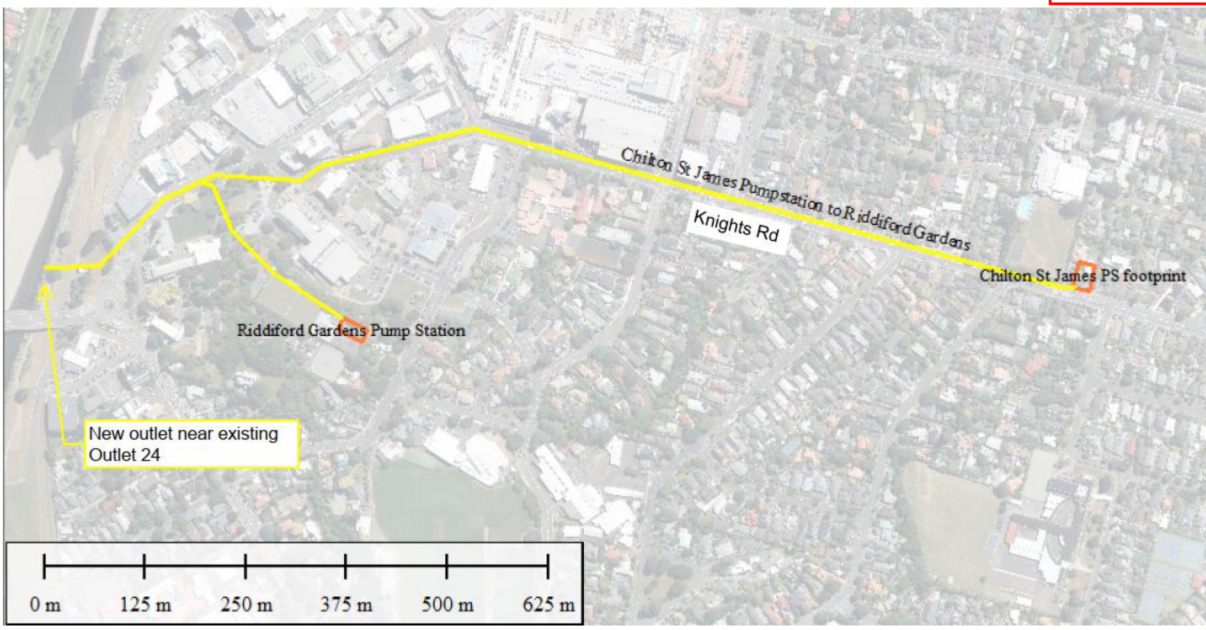

Figure 6.6: Revised option 4 for shortlist MCA

Figure 6.7: Revised option 4b for shortlist MCA

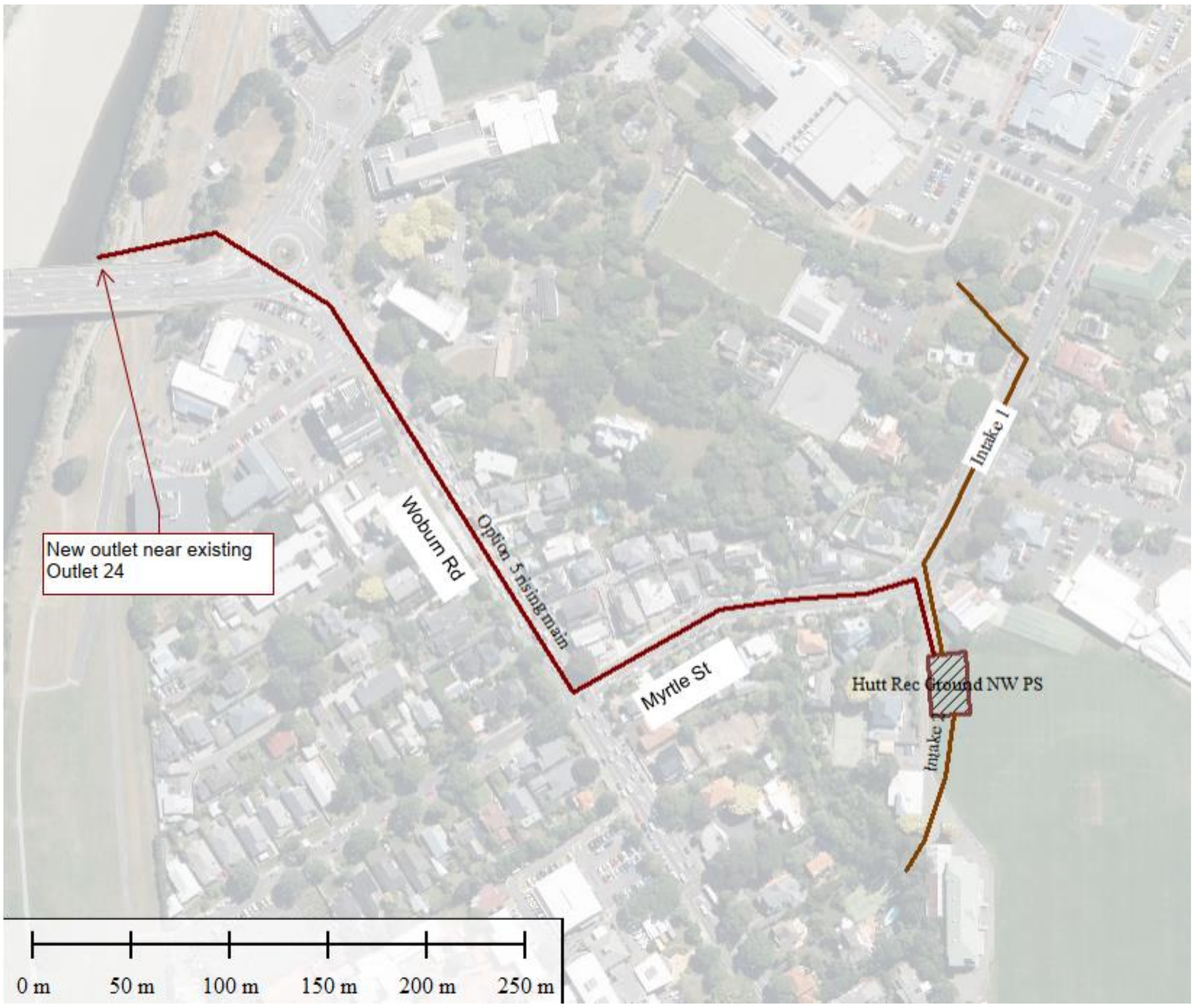

Figure 6.8: Option 5 for shortlist MCA (no changes to longlist option)

Table 6.5: Brief descriptions of shortlist options

Option Name	Description
Option 1b: Kings Crescent Pump Station with Kings Crescent Interceptor	• Intercept piped stormwater flows at upstream end of Opahu Stream via a new weir chamber and divert along Kings Crescent in a new gravity interceptor pipe, collecting flows from selected stormwater pipes crossing Kings Crescent. • A stream intake structure and pump station with 2 m^3/s discharge capacity located at Eastern Hutt School. • Rising main from pump station to outfall to Te Awa Kairangi (via Riverlink outlet 35), pipe to be laid within the road reserve.
Option 4: Chilton St James Pump Station and Riddiford Gardens Pump Station	• A stream intake and pump station with a capacity of max. 3 m^3/s at Chilton St James School. • A stream intake and pump station with a capacity of max. 3 m^3/s at Riddiford Gardens. • A rising main from Chilton St James PS along Knights Rd to Riddiford Gardens PS, and then a combined rising main along Queens Dr to a location near Outlet 24.
Option 4b: Chilton St James Pump Station	• Same as Option 4 without the Riddiford Gardens Pump Station.
Option 5: Hutt Rec Ground North West Pump Station with two stream intakes	• A stream intake (Intake 1) with a capacity of max. 1.5 m^3/s at Riddiford Gardens (Myrtle St). • A stream intake (Intake 2) with a capacity of max. 1.5 m^3/s at Hutt Rec Ground. • Gravity pipelines from each intake to the pump station. • A pump station with a capacity of 3 m^3/s at the northwest corner of the Hutt Rec Ground. • A rising main along Myrtle St and Woburn Rd to a location near Outlet 24.

6.8 Shortlist MCA workshop

The shortlist MCA process, to select a preferred option, is described in detail in the following three documents:

1 Briefing to workshop participants (Appendix T).

2 Workshop minutes (Appendix V).

3 Summary of preferred option outcome (Appendix W).

The previously shortlisted Options 1b, 4 and 5 were assessed prior to MCA workshop. In addition to this, Option 4b as described above was also included on the shortlist.

All options were assessed against the following criteria:

a Ecology.

b Hydrogeology.

c Sustainability.

d Cultural.

e Planning & consenting complexity.

f Property.

g Effects on community.

h Constructability.

i Operation of infrastructure.

j Risk and resilience.

k Enablement of housing development.

l Cost.

6.8.1 Mana Whenua feedback

During the shortlist MCA workshop on 11 April 2024, mana whenua noted that no sites of significance were impacted by any of the shortlisted options and that the main concerns were with the impact on the environment more generally and Te Awa Kairangi specifically. For example, there were concerns expressed for water quality and ecological health. The mana whenua representative noted that any concerns would likely be closely aligned with the ecological assessment. Anecdotally, it was noted that people fish for eels through accessing manholes on the Opahu Stream in their backyards.

6.9 Cost estimation

Cost estimates were produced by a Quantity Surveyor. A summary of the cost estimates for each option is displayed in Table 6.6. For full estimate details, please refer to Appendix U.

There are four confidence levels of cost estimation in the Wellington Water guidelines, intended to correspond to the level of detail and certainty available for each project over its life cycle. Wellington Water guidelines recommend different risk percentages are to be applied to a cost estimate depending on the cost estimate level. Level 1 and 2 requirements are shown in the table below.

Table 6.6: Level 1 and Level 2 cost estimation requirements

Level of cost estimate	Level 1	Level 2
Status of Information	• Risk register outputs. • No site investigations. • Estimate land requirements. • Estimated consent conditions. • Possibility of scope change. • A range of options that may be developed and delivered.	• Risk register outputs. • Limited site investigations. • Estimate land requirements. • Estimated consent conditions. • Possibility of scope change. • Outline design drawings with schedule of quantities.
Recommended Risk Allowance	Known/Unknown Risk – 40% Funding Risk – 60%	Known/Unknown Risk – 20% Funding Risk – 30%

There is a large difference between the recommended risk allocations for a Level 1 and a Level 2 cost estimate. At the long list stage, the level of information available was most closely aligned with the level 1 estimate.

During development of shortlist options, GPR investigations were completed in December 2023 providing location information on the underground utilities. This additional information, along with the beforeUdig information, contributed to the assessment of available space in the road corridor and service relocation. This information could be considered as meeting some of the requirements for limited site investigations under a level 2 cost estimate.

In addition, the land take requirements for pump stations have been assessed and have a reasonably fixed footprint with limited opportunity for movement to other parcels of land or opportunity for reduction in pump station footprint size. This could be considered to be more definitive information than is required for a Level 1 cost estimate.

Furthermore, two iterations of pump station concept design have been undertaken during the longlisting and shortlisting process.

Given the above information, an argument could be made that the level of information known about the options is somewhere between what is assumed for a Level 1 and a Level 2 estimate. This could be used to make a case for reducing the risk allocation for our options to somewhere between a Level 1 and Level 2. A possible reduction in applied risk percentage is shown in the table below as “Level 1.5” cost estimate. This table reduces the percentage of risk for both categories by 10% from the Level 1 recommendations.

[redacted]

[redacted]

[redacted]	
[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	

7 Preferred option

Option 1B was selected as the preferred option following the second MCA Workshop on 11 April. The basis for this decision is described in Appendix W. While Option 5 had a marginally better overall ranking in the MCA raw scoring, the differences in scoring were minor, and Option 1B was considered to better meet the project's primary objective of enabling residential development.

Small adjustments were made to the shortlist design, as documented below. Refer to the drawings in Appendix X.

7.1 Design changes during preferred option development

No changes were made to the design of the Option 1B pump station during the preferred option development phase.

The rising main was retained at 1200 mm diameter, although the pump station design flow had been reduced slightly at the shortlisting stage, due to the long length of pipe and its corresponding head loss. More detailed system performance and pump selection calculations have not been carried out at this stage of design. This diameter corresponds to a velocity of only 2.7 m/s at a flow of 2 m^3/s, so there may be scope at a later stage of design to reduce the diameter further and/or adopt a lower pressure class than SDR 11.

A further site visit was conducted on 27 April 2024, as a sense check at specific locations along the preferred option alignment. It was found that the accessway between Knox Presbyterian Church and Kings Crescent may not have adequate width for the interceptor due to the presence of multiple power cables in the path, including a high voltage cable. The footprint of the neighbouring properties was found to be closer than the property boundaries indicated in GIS and the overall width of the path was narrower than apparent on the aerial photos. New construction has taken place in this area, including a new fence with a concrete footing. An alternative stream intake location was identified at the shared driveway between [redacted]. A decision on the stream intake location is to be made at the next stage of design following further service investigations and property considerations. Property-related costs have been allowed for at [redacted]

The proposed option development also included 3D modelling of the pipelines, giving a better indication of major service clashes and longitudinal profile. Longitudinal concept design has been carried out and high-level long sections produced.

Other key design changes included:

- Rising main:
  - Depth has increased due to 3D modelling of services information received from Reveal investigation, beforeUdig and Wellington Water. The average cover depth of the pipeline has increased from the previously assumed 1.5 m to 2.2 m.
  - Scour/drain chambers included at low points and indicated these on the drawings.
  - Minimum fall of rising main set at 0.33% to ensure it is constructable in continuous falls, for complete emptying and air removal (e.g. for pressure testing). Should this project be an Early Contractor Involvement (ECI) contract, it is recommended that discussions with the contractor are had at next stage of design to confirm whether the minimum fall can be flattened further to reduce pipeline depths.
- Outlet:
  - Allowance in the design for additional waterstops, filter material/drains, or similar measures to prevent piping (internal flow of water within the stopbank). This has not

been designed or costed in detail and is included in the overall allowance in the cost estimate for the outlet.

– Greater Wellington Regional Council, at a meeting on 20 May 2024, confirmed its preference for a separate outlet for the IAF stormwater outlet, i.e. no longer a combined penetration with Outlet 35 (local stormwater). A separate sleeve for the rising main is also not preferred. This late-stage design change has resulted in the removal of the box culvert (performing the role of sleeve) and also the landward of the two chambers associated with the culvert. The downstream chamber will still be required in order to house a flap gate but will no longer need to be so large. The changed arrangements result in an additional approximately 40 m of pipeline length. These changes have been reflected in the drawings for the preferred option. The above-described changes will result in a mix of cost overs and unders, and the overall change is unlikely to be significant at the scale of the project. Therefore the decision was made not to update the cost estimate at this time.

7.2 Delivery of project objectives

The high-level estimate of the area benefitting from an increase in trunk capacity for Option 1b, as described in Section 6.2.2 and Figure 6.3, yielded a net residential area of 40.2 ha. During the preferred option development phase, HCC looked in more detail into housing enablement. This work is described in the memo “Housing Enablement – Comparison of Option 1B and 5” included as Appendix CC. The estimated area of residential housing enabled was slightly reduced to 38.9 ha taking high-level developer economics (improvement ratio) into account.

The delivery of the housing enablement objective via a single upgrade project differs from the approach adopted at the time of the IAF funding application and reflected in the Funding Agreement, which envisaged two upgrade projects. However, the preferred option enables housing intensification over a large area of central Lower Hutt. It also goes further in providing for network capacity than either of the original proposed Melling and Woburn projects, in that it combines a large gravity interceptor with a stream intake/pump station and rising main.

7.3 Sensitivity modelling

Stantec carried out high-level sensitivity modelling on two scenarios:

1 A pump station failure, with the potential to worsen downstream flooding. This was modelled by assuming that the water collected in the gravity interceptor from the head of the Opahu Stream and from the intercepted stormwater pipes was delivered to the stream at the pump station location. This was modelled conservatively as the interceptor itself was not explicitly represented; rather, the water is transferred directly (and instantaneously) to this location.

2 An extreme climate change scenario, consisting of a 50% increase in rainfall intensity on top of the base climate change already allowed for in Section 3.4.

The pump failure scenario indicates the potential for increased water levels along a reach of the stream due to flows from the gravity interceptor exiting the PS at this location. This effect does not extend far from the stream. This should be looked at more closely in the next stage of design, with consideration of the pump station intake weir level in relation to the hydraulics of the gravity interceptor, to decide whether this risk is in fact significant and whether steps need to be taken to mitigate it.

The main impact of the extreme climate change scenario is that water (trapped behind the railway embankment and the Te Awa Kairangi stopbanks) would pond much deeper and more extensively at the bottom end of the catchment. Within the estimated area of effect of the preferred option, flooding would in particular be worse along the stream upstream of Bristol Square and in the Epuni

St/Kings Crescent area. Consideration could be given to oversizing certain critical elements (pump station structure to allow for additional pump, downstream reach of the gravity interceptor) to allow for "no regrets" allowances for this uncertainty. Such an approach would allow the remaining infrastructure to be upsized in the future to deal with greater flows without prohibitive costs.

Stantec also modelled the 10% AEP + climate change and a 1% AEP without climate change events. This information was not used in selection or further development of the preferred option but will be of interest in the next stage of design.

7.4 Considerations for next stage of design

Major considerations for the next stage of design include:

- Trenchless construction: open trenching has been priced but during initial constructability feedback from one contractor we noted their preference for trenchless methods, especially for the gravity interceptor. This would require further investigations to confirm feasibility but could result in cost and time savings.
- Further agreement of outlet details with Greater Wellington Regional Council, including required separation from the Riverlink outlet, measures to be taken against internal erosion and full integration of the outlet into the stopbank geotechnical design (e.g. use of geogrid) need to continue as a priority.
- Consideration of rising main materials. HDPE is not preferred as a rising main material by Wellington Water due to the effects of cyclical loading. More detailed hydraulic analysis will be required, including consideration of the frequency of operation. A departure may need to be requested.
- Location of the Opahu Stream intake. Further service investigations on private property will be required to understand service locations at the proposed intake location. More detailed hydraulic modelling will be required to understand the best location for an intake and its level/sizing. Consideration could be given to whether the interceptor provides enough additional capacity without an intake on the stream at all – i.e. with connections only to stormwater pipes crossing Kings Crescent. Gravity interceptor diameter. For the preferred option design, both branches at the upstream end of the gravity interceptor have been designed as 900 mm diameter, as the proportion of flow in each branch is not yet known. Refinement of these design flows should allow a reduction in the diameter of one or both branches, with a corresponding reduction in pipe depth. More detailed consideration of the overflow chambers located at the stream intake and the stormwater intakes along the gravity interceptor. These will be overflow weir chambers, ideally adjustable via stoplogs or similar, collecting water into the interceptor only when a certain degree of surcharge is occurring so that the pump station doesn't operate every time it rains. The target frequency of operation for the pump station will also need to be defined. Rising main diameter and pipe class. More detailed design may allow a reduction in both wall thickness and pipe diameter, but this will need to be considered in conjunction with system performance, pressure transient analysis and pump selection.
- Pump station sizing with focus on reducing depth. Given the risk associated with pump station depth and the underlying aquifer, this will need to be an early focus in the next stage of design. This could include:
  - Obtaining a departure from Wellington Water for the maximum number of pump starts per hour.
  - Consideration of the role of variable frequency drives in reducing the required storage.
  - Pump selection followed by use of the manufacturer's design guidelines to optimise the pump station depth and volume.

- Maximising the role of the gravity interceptor in providing pump station storage.

- Consideration of the impacts of pump station failure in transferring additional flows to the reach immediately downstream, and whether any measures are required to mitigate this.
- Water quality issues and effects will need to be considered in the next stage, including any opportunities to integrate water quality mitigation as part of the project, as retrofitting later would be far more expensive and intrusive.

A number of additional considerations are noted in the SiD register (Appendix Z).

Other considerations and investigations in the next stage of design should include:

- Confirming objectives of ground investigations at the proposed pump station location and carry these out. These will at least need to confirm foundation conditions and hydrogeology.
- Agreeing a scope for and carrying out more detailed hydraulic modelling.
- Topographic survey of the pump station locations, and of the Opahu Stream (cross-sections, culverts/bridges etc), as informed by the stormwater hydraulic modelling scope.
- Monitoring of water levels in key manholes along the gravity interceptor and in the Opahu Stream downstream of Pretoria St to assist in setting overflow levels and/or frequency of operation for the pump station.
- Further underground services investigations along the confirmed alignments. Potholing to confirm service locations and depths along gravity and rising main alignments.
- Consideration/approval of any departures being sought by the design teams, and revision of the Feasibility stage designs in light of these.
- Consenting-driven investigations:
  - Hydrogeological assessments to consider construction and dewatering effects on aquifer.
  - Preliminary Site Investigations (PSI) to identify any potentially contaminated land that might be disturbed across the footprint of the works.
  - More detailed ecological assessment to consider construction and operational impacts on the Opahu Stream.
  - Use of hydraulic modelling to describe flooding impacts (if any) caused by the pump station inlet and hydraulic control structure.
- Visual effects and noise assessments for the pump station.
- Early approaches to other utility providers around existing work programmes/asset upgrade opportunities (betterment).
- Further engagement with Wellington Electricity on electrical upgrade requirements.
- Obtaining the latest Riverlink designs at the proposed SW outlet location.

8 Wider recommendations

Although only pump station options made the shortlist, a wide range of solutions was considered. During this process, several broader observations have been identified as future actions for HCC, that sit outside the design scope of the preferred option. These consist of infrastructure improvements that could be progressed if funding becomes available, and of non-infrastructural recommendations that could have a significant impact on reducing flood risk:

1. Future planning should as far as possible avoid encouraging development in areas exposed to significant flooding, including flooding within the benefit area identified for the Preferred Option.
2. There are opportunities to improve the existing flooding situation, if desired in the future, by leveraging off the improved trunk capacity that will be delivered by this project. Smaller add-on projects can provide good incremental value in reducing flood depths and extents. The solutions identified in Clusters 1 to 4 would be a good place to start. There may also be opportunities for improving conveyance in particular reaches of the stream where specific constraints are identified.
3. There may be additional opportunities to improve the existing flooding situation through reviewing planning rules to encourage more permeable surfacing such as porous paving, green roofs etc. However, in this location, council would need to work closely with technical experts to assess the return on investment of different options. These opportunities would likely be realised over long term urban renewal timeframes rather than short to medium term urban growth timeframes.
4. Masterplanning of new development (with developer involvement into which areas are most cost-effective) to ensure that these measures can be adequately planned for and programmed. This should proceed in tandem with network planning to determine if any localised stormwater network upgrades are required in order to connect areas of new development with the improved trunk capacity.
5. Identifying, protecting and, where possible, enhancing overland flow paths (the secondary network) as masterplanning and redevelopment progress.
6. Working with large sites within the catchment (some schools, and especially Hutt Hospital) on opportunities for increased on-site management and detention of stormwater when redevelopment is being undertaken.
7. Focussing as much housing intensification as possible into the CBD. This area is already close to 100% impervious, so any residential intensification in this area will not lead to increased runoff. Inclusion of detention storage in any redevelopment may in fact lead to reduced runoff rates.

9 Risk and opportunity

A Safety in Design (SiD) workshop was held on 1 May 2024. The purposes of the SiD process were to:

- Identify opportunities to design safety risk out of the project, at an early stage where the impacts of design changes are relatively minor.
- Provide a record of design improvements to be picked up in the next stage of design.
- Along with the project risk register, to help to inform designers and contractors on risks to help them to prepare bids for the next stage of the project.

Key risks throughout the entire lifecycle of the project were discussed and documented in a live register that will be carried through the next stage of design. This is included in Appendix Z.

A Project Risk Register, output from Project Orbit and reflecting the current risks recorded on the stormwater project, is also provided in Appendix AA.

10 References

Cardno. (2019) *Reference Guide for Design Storm Hydrology: Standardised Parameters for Hydrological Modelling.* Version 7. Wellington Water Limited.

Ministry of Business, Innovation and Employment. (2023) *Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water.* Amendment 12. Ministry of business, Innovation and Employment New Zealand.

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Stantec. (2021) *Waiwhetu Growth – Stormwater Servicing Options*. Rev 2. Stantec.

Stantec. (2022) *Eastern Lower Hutt Stormwater Model Build*. Rev 5.

Wellington Water Limited. (2021) *Regional Standard for Water Services*. Version 3.0. Wellington Water Limited.

Wellington Water Limited. (2022) *Hutt City Three Waters Growth Study 2022*. Version 0. Wellington Water Limited.

Appendix A- Stormwater technical design philosophy

Appendix B- Stormwater pump station design

Appendix C- Stormwater planning meeting minutes

Appendix D- Constraints assessment – Hydrogeology

Appendix E- Constraints assessment – Contamination

Appendix F- Constraints assessment – Planning

Appendix G- Constraints assessment – Ecology

Appendix H- Constraints assessment – Dry Services

Appendix I- Constraints assessment – Geotechnical

Appendix J- Pump station foundation concept

Appendix K- Longlist discontinued options

Appendix L- Longlist MCA briefing notes

Appendix M- Longlist costs summary

Appendix N- Outcomes of shortlisting workshop

Appendix O- MCA workshop meeting notes

Appendix P- Stormwater pivot paper

Appendix Q- Update on stormwater pivot

Appendix R- Interim costs update

Appendix S- Proposal for use of 200 mm flood depth threshold

Appendix T- Briefing notes for shortlist MCA workshop

Appendix U- Shortlist option costings

Appendix V- Shortlist MCA workshop minutes

Appendix W- Outcome of shortlist MCA workshop memorandum

Appendix X- Drawings

Appendix Y- Stantec modelling summary memo

Appendix Z- SiD hazard register

Appendix AA- Risk register

Appendix BB- Stage 0 Gap Analysis Memo

Appendix CC- Memorandum: Housing Enablement