RiverLink

Greater Wellington Te Pane Matua Taiao

HUTT CITY TE AWA KAIRANGI

WAKA KOTAHI NZ TRANSPORT AGENCY

PROUDLY DELIVERING New Zealand Upgrade Programme

RiverLink

Notices of Requirement for Designations and Applications for Resource Consent

Volume Four: Supporting Technical Reports

Technical Report #6

Freshwater Ecology

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Resource consent applications under section 88, and Notices of Requirement under section 168, of the Act in relation to the RiverLink project
BY	Waka Kotahi NZ Transport Agency Requiring Authority Greater Wellington Regional Council Requiring Authority Hutt City Council Requiring Authority

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RIVERLINK
TECHNICAL ASSESSMENT #6
Freshwater Ecology

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1. INTRODUCTION

1. My name is Dean Craig Miller. I hold the position of Principal Freshwater Ecologist at Tonkin & Taylor Limited (T+T) Environmental and Engineering Consultants, and I am a co-author and technical reviewer of this report.
2. I have been providing advice on freshwater ecology matters related to the proposed RiverLink Project (the Project) to Isthmus and GHD, and ultimately Greater Wellington Regional Council, Hutt City Council and Waka Kotahi since December 2020.
3. My contributions include:
    i. Overseeing the preparation of the assessment of the Project's effects on freshwater ecology based on the proposed river and stopbank design and proposed Melling Interchange alignment, and
    ii. Providing recommendations to the project designers to avoid, remedy, and mitigate potential ecological effects.
4. This report also relies on the results of site investigations undertaken by my colleague Mr Patrick Lees.
5. Freshwater field surveys for this Project were undertaken by ecologists from Boffa Miskell Ltd.
6. With my oversight, Mr Patrick Lees of T+T has also contributed to the preparation of this assessment.

1.1 Qualifications and experience

7. I have the following qualifications and experience relevant to this assessment:
    i. I hold the qualifications of Bachelor of Science and Master of Science and Technology with First Class Honours in Biological Sciences, from the University of Waikato.
    ii. I am a member of the New Zealand Freshwater Sciences Society.
    iii. I am employed as a Principal Freshwater Ecologist at T+T and have been with this company for 19 years. I specialise in resource evaluation and management work in freshwater environments with specific areas of expertise in water quality, freshwater ecology and assessment of ecological effects.
    iv. I have been involved in freshwater ecology-related aspects of projects in New Zealand since 2002. This work has included preparation and implementation of ecological monitoring and management plans, specialist water quality and ecology advice, coordination of small and large-scale ecological evaluations, assessment of ecological effects for projects within and affecting freshwater environments, and technical review of resource consent applications. I have been involved in several large infrastructure projects that are similar in technical nature and scale to this Project, including:
        a. I am the lead Freshwater Ecologist for the Peka Peka to Ōtaki Expressway Project, Wellington. I developed the Ecological Management Plan for the project and am responsible for its ongoing implementation. This includes oversight of the ongoing ecological monitoring and effects management work.
        b. I was the lead Freshwater Ecologist for the Waikato Expressway Huntly Section alteration to designation and consenting project. I designed and led

comprehensive field investigations, prepared freshwater ecology inputs into the assessment of ecological effects report for the project, including site values assessment, mitigation, and ecological compensation planning.

8. Patrick Lees of T+T has the following qualifications and experience relevant to this assessment:

   i. He holds the qualification of a Bachelor of Science in Biological Sciences from the University of Canterbury.

   ii. Mr Lees is a Freshwater Ecologist with Tonkin & Taylor Limited ("T+T") having previously been employed by Pattle Delamore Partners Ltd. Mr Lees has been a consultant ecologist for six years. Prior to consulting he was employed by Environment Canterbury for four years as an Aquatic Ecology Officer. Mr Lees has10 years' experience in the field of freshwater science and has worked at T+T since February 2019.

   iii. He is a member of the New Zealand Fish Passage Advisory Group and a member of the New Zealand Freshwater Science Society.

   iv. Mr Lees has worked throughout the South Island undertaking surface water and ecological monitoring and investigation projects, and preparing Assessment of Ecological Effects reports, aquatic ecology restoration and management plans. Mr Less has assisted both private and public sector clients including Waka Kotahi the NZ Transport Agency, KiwiRail, Environment Canterbury, Nelson City Council, Christchurch City Council, and Auckland Council.

9. Mr Lees' experience includes advising on the following projects:

   i. The lead ecologist on a multifaceted ecological investigation into the removal of a closed landfill located on Banks Peninsula. In this project Mr Lees led freshwater, terrestrial, wetland and coastal assessments for the Christchurch City Council to assess effects from removing this landfill to avoid ongoing erosion into the surrounding environment.

   ii. Providing specialist ecological input relating to the impact on fish passage from culvert design for the Te Ahu a Turanga Manawatū Tararua Highway for Waka Kotahi. Where Mr Lees provided input into the design, implementation, and technical specification of culvert impacts on indigenous fish communities within specific catchments of the project area.

1.2 Code of Conduct

10. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

1.3 Purpose and scope of assessment

11. My assessment addresses the following matters:

   i. Describes the existing freshwater environment and ecology. For the purposes of this assessment freshwater ecology covers aquatic fauna including fish and macroinvertebrates, and freshwater habitat within the Project area and downstream to Seaview Bridge,

ii. Describes and assesses the actual and potential effects on freshwater ecology expected to result from the construction and operation of the Project. The main components of the project relevant to this assessment being: river realignment, creation of new stop banks, constructing a new Melling Bridge and upgrading the current Melling interchange,

iii. Recommends measures to avoid, remedy, mitigate, or offset potential effects on freshwater ecology, as appropriate, and

iv. Presents an overall conclusion on the level of actual and potential ecological effects of the Project after the recommended effects management measures are implemented.

1.4 Assumptions and exclusions in this assessment

12. In the preparation of this assessment, I have relied upon the Project description, RiverLink Urban and Landscape Design Framework (UDLF) along with various Project plans and drawings, and the construction methodology provided Chapter 5 in the AEE (Volume 2 of the Application).

13. Additionally, I have relied input from other disciplines to inform my assessment of effects on freshwater ecology. In the preparation of my report, I have reviewed the following assessments of the Project:

i. Mr Josh Markham technical assessment addresses ecological effects of the Project on terrestrial and wetland vegetation and ecology (Technical Assessment #7 – Volume 4 of the Application),

ii. Mr Edryn Breese's technical assessment provides recommendations to manage erosion and sediment during construction, and effects to water quality during construction (Technical Assessment #3 – Volume 4 of the Application),

iii. Mr Allen Ingles' technical assessment covers the assessment of stormwater design for the project (Technical Assessment #2 – Volume 4 of the Application),

iv. Dr Jacqui Bell's technical assessment addresses the Marine Ecology and Coastal Avifauna effects of the Project (Technical Assessment #8 – Volume 4 of the Application),

v. Mr Gary Williams's technical assessment covers the assessment of river geomorphology and instream channel design (Technical Assessment #5 – Volume 4 of the Application),

vi. Mr Mark Pennington's technical assessment covers the impacts changes in hydraulic performance of the receiving Te Awa Kairangi, including the effects of piers and bridge abutments, and any subsequent river channel training associated with the Project (Technical Assessment #1 – Volume 4 of the Application), and

14. Additional to the above I have relied on a range of literature to inform my desktop review of the Project area. The literature relied on is summarised in paragraph 54 and cited throughout the report as appropriate.

15. The following supporting information is attached to this evidence:

i. Appendix A – Site maps;

ii. Appendix B – Aquatic rapid habitat assessment results and macroinvertebrate species list; and

iii. Appendix C –. Hydraulic 2D model outputs.

2. EXECUTIVE SUMMARY

16. The project is to construct, operate and maintain RiverLink. The proposed works include:

    i. A revised river channel and stopbank design to accommodate a greater flood flow;

    ii. Flood resilience, amenity design works within Te Awa Kairangi to provide enhanced amenity outcomes and pedestrian/cycling connections;

    iii. A pedestrian bridge over Te Awa Kairangi;

    iv. An interchange on SH2 at Melling and a new Melling Bridge;

    v. New local road connections and layouts;

    vi. A new Melling Train Station; and

    vii. Enablement of future urban development of Lower Hutt centre along the river.

17. This evidence provides an assessment of effects on freshwater ecology to accompany the resource consent applications for the RiverLink Project.

18. In particular this assessment:

    i. Describes the existing freshwater environment and ecology;

    ii. Describes and assesses the actual and potential effects on freshwater ecology (freshwater fauna and habitats) expected to result from the construction and operation of the Project;

    iii. Recommends measures to avoid, remedy, mitigate or offset potential effects on freshwater ecology, as appropriate; and

    iv. Presents an overall conclusion on the level of actual and potential ecological effects of the Project after the recommended effects management measures are implemented.

19. The proposed RiverLink Project is located in the Wellington Ecological District (ED). The Wellington ED covers the strongly faulted ranges surrounding Wellington, and Lower and Upper Hutt, this area was historically dominated by indigenous podocarp-broadleaved forest ecosystems. The Tararua ED is located to the east and north of the Project area. The Tararua ED is also characterised by steep, strongly faulted ranges which are still largely in indigenous forest.

20. The current land use within and adjacent to the RiverLink Project area is dominated by recreational, urban, residential and industrial uses. Indigenous forest and scrubland persist on the northern hillsides on the western side of the Te Awa Kairangi/Hutt River (Te Awa Kairangi).

21. Multiple areas of ecological significance have been identified in the landscape surrounding the Project area, both in the Proposed Natural Resources Regional Plan (PNRP) and the District Plan but only one significant natural resources site (SNR14) has any overlap with the proposed designation boundary.

22. My assessment was informed by literature review and site investigations to determine the freshwater ecological values including:

    i. An assessment of freshwater habitat value;

    ii. Notable freshwater fauna that are recorded in the Project area or may otherwise occur; and

iii. Fish and macroinvertebrate community assemblage and key habitats within the Project area and downstream habitats that could also be impacted.

23. My assessment of effects followed the Ecological Impact Assessment Guidelines (EcIA Guidelines), with some adaptation for different fauna and ecosystem types (Roper-Lindsay et al., 2018). Using a standard framework and matrix approach such as this provides a consistent and transparent assessment of effects and is considered to be good industry practice.

24. Three freshwater habitat types were identified as relevant to the Project, these are listed in the Table 2-1 below along with their ecological value assessed using the EcIA Guidelines (2018).

Table 2-1 Freshwater habitat types and assigned ecological value using the Ecological Impact Assessment Guidelines (Roper-Lindsay et al., 2018)

Freshwater habitat type	Ecological Value
Te Awa Kairangi	
Downstream of the Project area	High
Within the Project area	High
Tributary sites	
Harbour View Stream	Moderate
Tirohanga Intersection Stream	Moderate
Tirohanga Stream	Moderate

25. Within the Project area, Te Awa Kairangi is a highly confined and heavily managed river, and significantly changed from its natural form. The width of the main channel is constrained in the lower reaches as the river passes the existing Melling Bridge and into the tightly confined lower Te Awa Kairangi reach. The constrained type of river channel affects the shape of the river, with limited space for the movement of river meanders. The existing meander pattern is quite different from what would have been the case in the past.

26. Despite the heavily managed nature of Te Awa Kairangi macroinvertebrate indices within the Project area were indicative of 'good' to 'excellent' water and habitat quality and with high taxa diversity, species richness and abundance. Fish communities were typically diverse and abundant and the importance of the river as habitat and/or a migratory pathway for several At-Risk fish species including longfin eel, īnanga, bluegill and giant bully, and one Nationally Vulnerable species lamprey was evident.

27. The tributary sites had fish communities that were less diverse than that of the main Te Awa Kairangi, and predominantly provided habitat and/or a migratory pathway for non-threatened native migratory fish. Additionally, the tributary sites had moderate habitat quality and complete and partial fish passage barriers were present within two of the tributaries (Harbour View Stream and Tirohanga Intersection Stream, respectively).

28. Potential adverse effects on freshwater values during and after construction of the Project include:

i. the temporary modification of approximately 28 ha of freshwater habitats assessed as ‘High’ ecological value through gravel extraction and associated construction activities within Te Awa Kairangi;

ii. Direct mortality or injury, and temporary disruption to migration and spawning for freshwater fauna (e.g. fish) that may be harmed or displaced during earthworks and river works activities;

iii. Degradation of freshwater habitat quality downstream of river and earthworks activities due to sediment and cement wash discharges. Key potential habitats affected are Te Awa Kairangi downstream of and within the Project area. Both areas are identified as significant under the PNRP;

iv. reduced fish passage within the tributary sites;

v. changes to hydrology that may result in changes in growth rates of cyanobacteria and periphyton species; and

vi. loss of stream habitat within Harbour View Stream.

29. These construction effects can be avoided and minimised through the implementation of fish salvage protocols, good practice sediment and erosion control measures, and construction methodologies (i.e. stand down timings to match fish life cycle stages). Loss of stream habitat and fish passage at Harbour View Stream is unavoidable, and measures to avoid, minimise and remedy are not possible, therefore the loss of habitat at this location must be offset.

30. Various measures are recommended to avoid, minimise and remedy the aforementioned effects. These measures include appropriate construction and erosion sediment control methodologies, monitoring of impacted habitats and fauna to feed into an adaptive management plan(s), pre-works fauna removal, retraining the river channel so there is not a loss in natural character, and designing culverts to accommodate fish passage where practicable. Offsetting is proposed to address the loss of tributary stream habitat. The detailed methodology required to implement the recommendations to an appropriate standard will likely require the preparation and certification of management plans.

31. Without mitigation, the level of effects of the Project on the various freshwater ecology values ranged from High to Low. As per the EcIA Guidelines (2018), effects management measures have been developed and recommended following the mitigation hierarchy to address potential effects assessed as Moderate or above, with the objective to reduce the level of effects to Low.

32. I consider the actual and potential effects of the Project on freshwater ecology will be appropriately addressed if the recommended avoidance, minimisation, mitigation and offset measures outlined in this assessment are implemented.

3. PROJECT DESCRIPTION

3.1 Introduction

33. A full project description is available in the Assessment of Environmental Effects Report ("AEE"). The following section relies on excerpts of the AEE relevant to my assessment of effects.

34. The Project is the design, construction, operation and maintenance of RiverLink. Key components of the project are as follows:

i. Upgrade and raising of existing and construction of new stopbanks on both sides of Te Awa Kairangi/Hutt River between Ewen Bridge and Mills Street;

ii. Instream works between the Kennedy Good and Ewen Bridges to re-align, deepen and widen the active river channel;

iii. The replacement of the two signalised at-grade intersections of SH2/Harbour View Road/Melling Link and SH2/Tirohanga Road with a new grade separated interchange;

iv. Construction of an approximately 215 m long and up to 7 span road bridge with a direct connection across the River from the new interchange to Queens Drive;

v. Removal of the existing Melling Bridge;

vi. Changes to local roads;

vii. Changes to the Melling Line rail network and supporting infrastructure;

viii. Construction of an approximately 177 m long and 4 span pedestrian/cycle bridge over the River;

ix. Construction of a promenade located along the stopbank connecting with future development, running between Margaret Street and High Street. This includes new steps and ramps to facilitate access between the city centre and the promenade;

x. Integration of infrastructure works with existing or future mixed-use development; and

xi. Associated works including construction and installation of culverts, stormwater management systems, signage, lighting, network utility relocations, landscape and street furniture, pedestrian/cycle connections and landscaping within the project area.

3.2 River works

35. The project requires full reshaping of the riverbed to set the channel shape to establish a new natural meander pattern suitable for a widened channel. The re-shaping requires the removal of gravel and vegetation across the full extent of the river channel (between the two existing stopbanks) between Kennedy Good and Ewen Bridges. As described in more detail in the Technical Assessment No.2 Geomorphology Report, the overall purpose of the river works is to:

a. Increase the standard of flood protection along the Project length between Kennedy-Good and Ewen Bridges; and

b. Achieve a better balance between the natural behaviour of the river and the measures used to manage the river which will reduce the degree of maintenance interventions required. In particular, the Project aims to contain the amount of sediment deposition (which requires regular maintenance and removal) to the upper reach of the Project and minimise the sediment maintenance requirements in the lower reach. The Project reach locations are shown below in Figure 3-1.

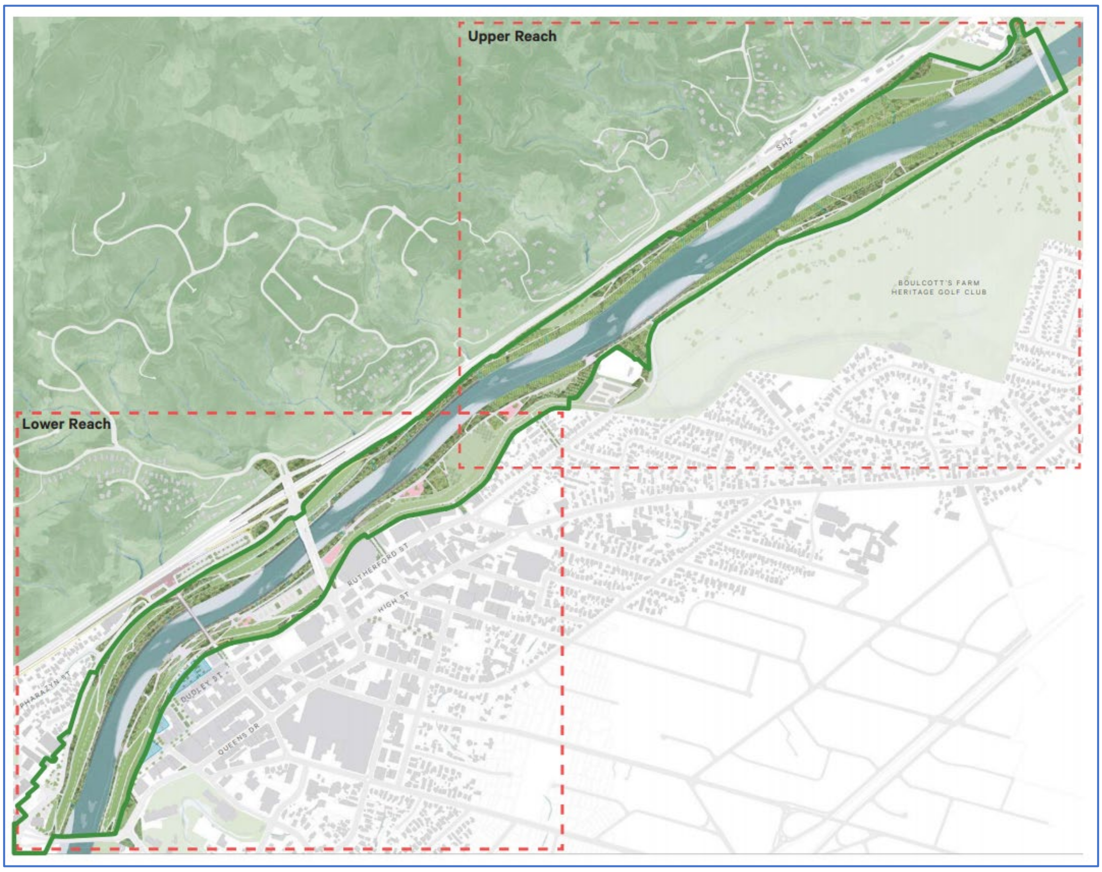

Figure 3-1 Upper and lower reaches of the Project

3.3 Earthworks

36. Earthworks including excavation and filling, reuse of onsite material, removal of waste material and importing material is proposed across the project.

37. Earthworks are associated with removing the existing stopbanks, widening of the river corridor, establishment of berms and stopbanks, raising the land on the western side of the river to achieve design levels for the new interchange and supporting infrastructure and the realigned rail line, and for ground improvement works across the project. Excess or surplus cut material will be stockpiled within the river corridor for re-use across the project as required, it is estimated stockpiles will have a maximum height of 2.5 m.

3.4 Gravel extraction and stockpiling

38. Current design information suggests that approximately 3,000 linear metres of riverbed will be disturbed within Te Awa Kairangi Project area through gravel extraction and stockpiling during the flood protection and river training works. This covers the river corridor between the stopbanks, including the alterations in the active channel (low flow and gravel bar areas where floodwaters move the gravel bed material of the river), berm land alongside this channel and vegetation changes throughout the corridor.

39. Indicatively, approximately 668,000 m^3 of bed and berm material will be disturbed and 152,800 m^3 of gravel bed material will be extracted from the current channel (**Mr Breese's** technical assessment and Construction Methodology in Chapter 5 of the AEE in Volume 2 of the Application).

40. **Mr Williams** outlines that the new river corridor between the stopbanks in the lower reach will typically consist of a 70 m wide active channel with a 10 m wide lower bench on each side, giving a channel width of 90 m, plus an upper berm of at least 25 m on each side.

The total minimum width of the river corridor will be approximately 140 m in total. Rock linings will be placed along the outer (deep pool) side of the bends of the meandering active channel, from below bed levels to the level of the lower bench. These will alternate with vegetated lower berms consistently throughout the lower reach to deliver increased flood protection. There will be five new areas of rock lining installed, ranging in length from approximately 180 m to 600 m.

41. **Mr Williams** details that the overall area of the riverbed will increase from 100,000 m^2 to 138,000 m^2 in the lower reach as the river will be widened a small amount in some locations (typically by 5 – 10 m) to achieve a consistent 70 m wide river channel. Additional area will also be created through lateral shifting of the overall river channel location by up to 30 m. This is to achieve adequate berm size on both sides of river channel to provide security from erosion for the new stopbanks. Five in-river pools will be retained but will be relocated to suit the new river meander pattern as shown on the Stopbank Plans and River Works drawing A16-4831 -SB151-158.

42. **Mr Williams** details that in the upper reach, the overall area of the riverbed will be increased from 123,000 m^2 to 163,000 m^2 as the channel will be widened by up to 25 m to allow a more natural channel movement. The number of in-river pools will reduce from six to five, but the depth and area of the pools will increase. Of importance to the future maintenance requirements of the river is the likely increase in sediment deposition that will occur in this upper reach because of the changes to the configuration of the river. With regular extraction undertaken, the changes to the upper reach will reduce the amount of sediment being transported into the lower reach and further downstream.

3.5 Planning and policy context

43. The following national statutory documents apply to this Project and are relevant to my assessment:

    i. Resource Management Act 1991 (RMA);

    ii. The National Policy Statement for Freshwater Management (NPS FM) introduces several new ‘attributes’ and ‘bottom lines’ for water quality and ecological health in streams as well as new policies around the avoidance of loss of streams and natural wetlands. The NPS FM requires that the management of water gives effect to Te Mana o Te Wai with the aim to improve degraded water bodies to a condition above the ‘National Bottom Line’ and maintain or improve all others;

    iii. The Project works may affect the key attributes included in the National Objectives Framework (NOF) of NPS FM. However, it is unlikely that such effect will last beyond the construction period. I have addressed effects on suspended sediment and deposited fine sediments, the fish and aquatic macroinvertebrate community in relation to the relevant NOF attributes; and

    iv. National Environment Standards for Freshwater (NES F) has introduced several new regulations that identify that any reclamation of riverbed is a discretionary activity and that effects from the placement of culverts on fish passage are specifically addressed.

44. The following regional level statutory documents apply to this Project:

    i. Proposed Natural Resources Plan for the Wellington Region (Appeals version) (PNRP):

        (a) The PNRP contains policies and methods to manage the natural and physical resources of the Wellington region;

(b) Te Awa Kairangi (and its immediate tributaries) within the Project area is subject to a number of planning controls to ensure that adverse effects on the environment are appropriately managed. Key controls are covered in the following paragraphs;

(c) Te Awa Kairangi (and its immediate tributaries) within the Project area is shown in the PNRP as having the following Water Management Classes and Schedules:

(i) River Class 4[1] (Te Awa Kairangi) and River Class 2[2] (tributaries streams)

(ii) Category 2 Surface Water Body[3]

(iii) Schedule C4 – Sites of Significance to Taranaki Whānui ki to Upoko o te Ika a Maui specifically in relation to Mahinga Kai

(iv) Schedule F - Te Awa Kairangi has been identified as having ecosystems and habitats with significant indigenous biodiversity values are

(v) Threatened or at- risk fish habitat: Te Awa Kairangi has been identified as a waterbody with habitat for threatened and at-risk indigenous fish species, and

(vi) Migratory fish habitat: Te Awa Kairangi has been identified as a waterbody that provides habitat for six or more indigenous migratory fish species within the Greater Wellington Region

(vii) Schedule F1b – Inanga Spawning Habitat: Lower Te Awa Kairangi has been identified as having īnanga spawning habitat downstream of the Project area.

(viii) Schedule H1 – Te Awa Kairangi has been identified as having regionally significant primary contact recreation, and

(ix) Schedule I – Te Awa Kairangi has been identified as being an important trout fishery river and spawning rivers

(d) In addition, Chapter 3.5 (Water Quality) and 3.6 (Biodiversity, aquatic ecosystem health and mahinga kai) of the PNRP outline that the:

(i) "Quality of surface water is maintained or improved, and significant contact recreation freshwater bodies (Schedule H1 water bodies) and sites with significant mana whenua values (Schedule C4) are to meet, at a minimum, the objectives in Table 3.1 of the PNRP" (reproduced in Table 3-1 below).

(ii) Water quality and aquatic habitats are managed to maintain biodiversity aquatic ecosystem health and mahinga kai. PNRP objectives for the Te Awa Kairangi and its tributaries in the RiverLink

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[1] River Class 4 = Lowland, large rivers that drain the hill ranges within the wider catchment
[2] River Class 2 = Mid gradient, coastal streams with a hard sedimentary catchment
[3] Category 2 surface water body includes, and is limited to:
(a) estuaries other than those identified in Schedule F4 (coastal sites), and
(b) within the mapped lowland areas shown on Map 29, rivers that have an active bed width of 1m or wider, and drains greater than 1m wide, and water races, and
(c) rivers and streams important to trout spawning habitat identified in Schedule I (trout habitat), and
(d) natural lakes, but excludes any surface water body that meets the definition of a Category 1 surface water body.

project footprint and the lower Te Awa Kairangi are reproduced in Table 3-1 below.

Table 3-1 Primary contact recreation and Māori customary use objectives in freshwater bodies (Table 3.1 of the PNRP)

Water body type	E.coli (cfu/100mL 95th percentile[1])	Cyanobacteria - benthic	Māori customary use	Toxicants and irritants	Water clarity	Sediment cover	Heterotrophic growth
i R ivers	ii 540 at all flows below 3 x median flow, September to April inclusive.	iii ow risk of health effects from exposure	iv Fresh water is safe and supports Māori customary use by the achievement of the huanga v id entified by mana whenua.	vi Conce ntrations of toxicants or irritants do not pose a threat to water users	vii .6 m	viii 5 %	ix o bacterial or fungal slime growths visible to the naked eye as plumose growths or mats

[1] Derived using the Hazen method from a minimum of 30 data points collected over three years

Table 3-2 Aquatic ecosystem health and mahinga kai objectives (Table 3.4 in the PNRP)

River class	Macrophytes	Periphyton biomass (mg/m^2)		Periphyton cover[1] (%)		Invertebrates		Fish	Mahinga kai species
		All rivers	Significant rivers[2]	All rivers	Significant rivers[2]	All rivers	Significant rivers[2]		
1. River class 2 – Te Awa Kairangi tributaries	2. Indigenous macrophyte communities are resilient and their structure, composition and diversity balanced	3. ≤ 120	4. ≤ 50	5. < 20	6. < 20	7. ≥ 105	8. ≥ 130	x Indigenous fish communities are resilient and their structure 9. composition and diversity are balanced	xi Mahinga kai species, including taonga species, are present in quantities, size and of a quality that is appropriate for the area. Huanga of mahinga kai as identified by mana whenua are achieved.
10. River class 4 – Te Awa Kairangi		11. ≤ 120	12. ≤ 50	13. < 40	14. < 20	15. ≥ 110	16. ≥ 130		

a [1] Periphyton cover only applies when periphyton biomass data is not available

[2] Rivers or streams with high macroinvertebrate community health as per Schedule F1

3.6 Mitigation hierarchy under the PNRP

45. The order of priority for ecological impact management we have applied to this assessment is outlined in Table 3-3 . This process has followed the effects management hierarchy as described in Roper-Lindsay et al. (2018) and the PNRP.

Table 3-3 Effects management hierarchy and terminology (Roper-Lindsay et al. (2018))

Effects Management Hierarchy	Definition
Avoidance	To modify a project proposal to prevent any environmental damage or loss of an ecological or environmental feature or function.
Remediation	To reverse or stop any environmental damage.
Mitigation	To alleviate, or to abate, or to moderate the severity of something (environmental damage), and typically occurs at the point of impact.
Biodiversity offset	A measurable conservation outcome resulting from actions designed to compensate for residual, adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss, and preferably a net-gain, of indigenous biodiversity values. Biodiversity offsetting includes: **Like-for-like offset -** The residual effect is offset to a no-net-loss or net-gain level by exchanging the same type of biodiversity in accordance with all of the offset principles. **Trading-up offset -** An out-of-kind exchange of biodiversity that demonstrably exchanges biodiversity of a lesser conservation value for biodiversity of greater conservation value. Meets key offset principles except equivalence of type but is considered to overall deliver an equivalent or improved outcome, because the biodiversity gained is considered to be of greater conservation importance to the biodiversity lost. No standard metrics are currently available to evaluate the exchange so trading up involves an element of subjectivity and societal preference.
Environmental compensation	Non-quantified biodiversity benefits are offered to compensate for biodiversity losses. The compensation actions may benefit different biodiversity to that lost (out-of-kind compensation), including biodiversity of lesser conservation concern than that lost. Compensation is not quantified or balanced with losses and may involve subjective decision-making subject to socio-political influences.

46. Schedule G1 of the PNRP identifies that offsetting can balance residual significant adverse effects and provides specific direction in relation to the loss of biodiversity. Schedule G2 details the principles that should be used to guide the development of biodiversity offsets where it is needed due to instances where significant/more than minor adverse effects from the Project cannot be avoided, remedied or mitigated.

4. ASSESSMENT METHODOLOGY

47. I have used the following methodology to assess the freshwater ecology values and subsequent potential effects of the Project.

4.1 Desktop review

48. Information used to inform my EcAIG assessment outlined above was gathered through a combination of literature review and site investigations.

49. There is a large body of water quality and freshwater ecology information available for the wider Te Awa Kairangi catchment. This information is generally associated with:

   i. Ongoing State of Environment[4] and ecological investigation monitoring[5] undertaken by GWRC;

   ii. The development of Whaitua Implementation Programme (WIP) for the Whaitua Te Whanganui-a-Tara Committee[6];

   iii. Flood Protection Work monitoring completed by GWRC [7,8]; and

   iv. Consent compliance monitoring[9].

50. I also undertook a review of relevant databases with key information sources including:

   i. New Zealand Freshwater Fish Database ("NZFFD") administered by the National Institute of Water and Atmospheric Research ("NIWA"). The NZFFD provides fish capture records within Te Awa Kairangi catchment (accessed November 2020); and

   ii. Land, Air, Water Aotearoa ("LAWA") providing current state and trend analysis for water quality and aquatic macroinvertebrate monitoring sites within the Te Awa Kairangi catchment.

4.2 GWRC Monitoring sites

51. Three GWRC long term monitoring sites are established on Te Awa Kairangi within the vicinity of the Project area. Two are within the RiverLink project area, and one has been established upstream. Aquatic macroinvertebrates, surface water quality, and periphyton (including cyanobacteria) are sampled either monthly, quarterly or over the summer recreational bathing season as per Table 4-1.

52. All relevant data from the sites outlined in Table 4-1 has been obtained from GWRC and is used in the assessments presented in the following sections.

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[4] Martin E, Morar S and Heath MW. 2017. Rivers Water Quality and Ecology monitoring programme: Annual data report, 2016/17. Greater Wellington Regional Council, Publication No. GW/ESCI-T-17/95, Wellington.
[5] Heath MW and Greenfield S (2016) Benthic cyanobacteria blooms in rivers in the Wellington Region: Findings from a decade of monitoring and research. Greater Wellington Regional Council, Publication No. GW/ESCI-T-16/32, Wellington.
[6] Aquanet Consulting Ltd. (2018). Whaitua Te Whanganui-a-Tara River and stream water quality and ecology. Report Prepared for Greater Wellington Regional Council
[7] MWH (2016). Effects of Flood Protection Activities on Aquatic and Riparian Ecology in the Hutt River. Prepared for Greater Wellington Regional Council (Flood Protection)
[8] MWH/Stantec (2019). Baseline Monitoring of Aquatic Habitat Quality and Fish Communities: 2017/2018. Prepared for Greater Wellington Regional Council (Flood Protection)
[9] T+T. 2015. Hutt River Ecological Monitoring: Summer 2014/2015. Prepared for Greater Wellington Regional Council.

Table 4-1 Long-term Te Awa Kairangi monitoring sites

Monitoring sites	River	Agency	Downstream co-ordinates (NZTM)	Location to Riverlink	Type of monitoring
Manor Park	Te Awa Kairangi	GWRC	1766679; 5442285	Upstream	RWQ SOE[1] and macroinvertebrates
Boulcott	Te Awa Kairangi	GWRC	1761038; 5437628	Within	RWQ SOE macroinvertebrates, periphyton
Melling Bridge	Te Awa Kairangi	GWRC	1759906; 5436831	Within	Recreational[2], cyanobacteria

[1] Routine Water Quality – State of the Environment

[2] Recreational water quality monitoring undertaken during the swimming season (November/ December – February/March)

4.3 Field survey methods

53. The following section outlines the additional assessments undertaken to inform this assessment of ecological effects. The purpose of the field investigation (conducted by Boffa Miskell Ltd May 2020) was to fill any gaps and to provide an up to date assessment of the freshwater ecology values of the Project area and includes:

    i. Stream classification and extent under the proposed Project area;

    ii. Rapid Habitat Assessments [10] at three tributary sites;

    iii. Macroinvertebrate and fish surveys at two sites within the Project area; and

    iv. Fish surveys within each of the tributary sites.

54. Survey methods were replicated as closely as practicable to historical freshwater ecology assessments within Te Awa Kairangi (e.g. MWH, 2016[7]; MWH/Stantec, 2019[8]).

4.4 Aquatic survey locations

55. A total of five assessment reaches were established within the Project area. Two were located on the Te Awa Kairangi and three were located on the hill fed tributaries that flow parallel to Tirohanga Road and Harbour View Road (from here on known as Harbour View Stream and Tirohanga Stream tributaries, respectively), and one on the Tirohanga Road intersection (Table 4-2)

56. The Harbour View Stream, Tirohanga Stream, and Tirohanga Road intersection stream tributaries were chosen as they are potentially impacted by the realignment of State Highway 2 undertaken in during the Melling Interchange works. These locations were surveyed by Boffa Miskell Limited in May 2020.

57. Survey locations within Te Awa Kairangi were surveyed along a total length of 150 m at each site and the tributary sites were surveyed along a total length of between 15 – 30 m at each site which was dependent on-site access.

[10] Clapcott J 2015. National rapid habitat assessment protocol development for streams and rivers. Prepared for Northland Regional Council. Cawthron Report No. 2649. 29 p. plus appendices.

Table 4-2 Locations and methods for the 2020 surveys

Survey reach	RHA	Macroinvertebrates	Fish survey
Melling Bridge – Te Awa Kairangi	N	Y	Y
Ewen Bridge - Te Awa Kairangi	N	Y	Y
Tirohanga Stream - tributary	Y	N	Y
Harborview Stream – middle reach	Y	N	Y
Harborview Stream – upper reach	Y	N	Y

4.5 River flow and antecedent rainfall

58. Timing for the aquatic survey and sampling followed industry guidance. Specifically, for macroinvertebrate and fish sampling within Te Awa Kairangi, a stand down period of at least 10 days was adhered to following heavy rainfall events that were likely to result in a bed moving river flows and/or likely to have caused disruption to macroinvertebrate communities[11].

59. River flow and rainfall data were retrieved from Te Awa Kairangi at Birch Lane and Mabey weather stations and Te Awa Kairangi at Taita Gorge flow recorder[12]. The weather stations are located approximately 1.5 km to the east and 3.7 km to the north of the RiverLink project area, respectively. The flow station at Taita Gorge is located approximately 8 km upstream of the RiverLink project area.

60. The rainfall data indicated that the weather conditions were generally settled during the two weeks prior to field assessments being undertaken. However, two days before surveys were undertaken a moderate rainfall event occurred within Te Awa Kairangi catchment (36 mm cumulative over the preceding 24 hours). Surveys within the Harbour View Stream and Tirohanga Stream tributaries were undertaken as this rain event did not appear to increase flows to a level that would disrupt fish and instream habitat within these systems. Sampling of fish and macroinvertebrates within Te Awa Kairangi was completed on 22 May 2020 following 13 days without a fresh/flood event.

4.6 Stream classification and extent

61. Using the catchments identified during the initial desktop assessment as a starting point, all stream length under the proposed Project area was walked by field staff (under my supervision). I have reviewed the findings and results of these surveys which include detailed photographic records.

62. The PNRP adopts a classification of the region's rivers based on size, nature of the catchment and substrate. Te Awa Kairangi and the tributary sites are classified as River Classes 4 and 2, respectively, and are shown on PNRP Maps 21a – 21e. I have used this classification to inform my assessment, particularly where the PNRP has specific attributes to be assessed against river class.

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[11] Stark, J.D.; Boothroyd, I.K.G.; Harding, J.S.; Maxted, J.S.; & Sarsbrook, M.R. (2001). Protocols for Sampling Macroinvertebrates in Wadeable Streams. Technical report prepared for Ministry for the Environment.
[12] Daily rainfall and measured flow data was retrieved from the GWRC Live Data Viewer -http://graphs.gw.govt.nz/ .

63. In addition, the PNRP currently[13] defines an ephemeral flow path[14] as a river that:

i. has a bed that is predominantly vegetated;

ii. only conveys or temporarily retains water during or immediately following heavy rainfall events; and

iii. does not convey or retain water at other times.

4.7 Aquatic habitat

64. Aquatic habitat value was assessed utilising the national Rapid Habitat Assessment (RHA) protocols developed by the Cawthron Institute[10]. The RHA is a commonly used assessment protocol that provides a set of standardised protocols that assess physical instream habitat at the reach scale. The protocols provide an overall habitat score to indicate the condition of ecological habitat within each assessed stream reach with a maximum possible score of 100 (pristine habitat).

65. The RHA was completed at the tributary sites only and a summary of the assessment findings is provided in Section 5.4. RHA habitat scores for each site are provided in full in Appendix B.

4.7.1 Macroinvertebrates

66. Macroinvertebrate community samples were collected via a modified protocol C1 (PC1 hard bottom, semi quantitative) approach to that described in Stark et al. (2001)[11].

67. To assess the macroinvertebrate community, modifications to PC1 included collecting pooled replicate kick net samples from four locations (0.4 m x 0.4 m area totalling over 0.6m^2) across each of three transects per survey reach (i.e., 3 pooled transect samples per survey location). All samples were preserved immediately following collection in approximately 80 % ethanol solution for subsequent submission, sorting and identification. A 200 individual fix count with scan for rare taxa was carried out following Protocol P2 (Stark et al. 2001), with animals identified to species level where possible.

68. Results are presented as follows:

i. **Taxonomic richness.** This is a measure of the number of different types of macroinvertebrate present in each sample and is a reflection of the diversity of the sample;

ii. **Ephemeroptera, Plecoptera and Trichoptera ("EPT") richness**. This index measures the number of pollution-sensitive macroinvertebrates (mayfly, stonefly and caddisfly (excluding Oxyethira and Paroxyethira taxa because these are tolerant of degraded conditions)) within a sample. Percent EPT richness represents the number of EPT taxa as a proportion of the total number of taxa within the sample;

iii. **Macroinvertebrate Community Index ("MCI").** The MCI is an index for assessing the quality class of a stream using presence or absence of macroinvertebrates; and

iv. **Quantitative Macroinvertebrate Community Index (QMCI)**. QMCI is another index-based tool, based on the relative abundance of taxa within a community, rather than just presence or absence (MCI).

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[13] The definition of ephemeral flow path is under appeal
[14] An ephemeral flow path is not a surface waterbody within the PNRP

69. The MCI and QMCI reflect the sensitivity of the macroinvertebrate community to changes in water quality and habitat, where higher scores indicate better stream condition. Macroinvertebrate index values are then translated to quality classes, which describe the ecological health of the stream (Table 4-3).

Table 4-3 Interpretation of macroinvertebrate biotic indices15,16

Quality Class	MCI	QMCI
Excellent	> 119	> 5.99
Good	100 – 119	5.00 – 5.90
Fair	80 – 99	4.00 – 4.99
Poor	< 80	< 4.00

70. To specifically assess ecological health for rivers within the Greater Wellington Region, Clapcott and Goodwin[15] developed an MCI quality class for each river class as described in the PNRP. A predictive model was developed specifically for the Wellington region and provides greater accuracy than the national model (i.e. Stark et al. (2001))) as additional data not used in the development of the national model was used. Table 4-4 shows the MCI quality class for River Class 4 which is applicable to lowland, large rivers that drain the hill ranges within the wider catchment such as Te Awa Kairangi at RiverLink.

Table 4-4 Te Awa Kairangi MCI quality classes developed by Clapcott and Goodwin16

17. River class	18. Excellent	19. Good	20. Fair	21. Poor
22. 4	23. ≥130	24. ≥110	25. ≥90	26. <90

b *Note: only river class 4 is shown as this represents the river type class of the Te Awa Kairangi in the vicinity of the RiverLink project*

4.7.2 Freshwater fish

71. Freshwater fish communities within Te Awa Kairangi were assessed via electric fishing machine (EFM) surveys at two sites within the Project area in accordance with the New Zealand freshwater fish sampling protocols for wadeable rivers and streams (Joy *et al.* 2013)[17] and replicated (in part) the surveys undertaken by GWRC and MWH/Stantec in 2019[8].

72. EFM surveys within the Tirohanga Intersection Stream and the Harbour View Stream were undertaken to understand what fish species may inhabit these smaller tributaries. Changes to the fish survey methodologies undertaken in Te Awa Kairangi were implemented and included a reduction in sample reach length and habitat surveyed. These were undertaken to provide some flexibility around sample reach/effort, so sampling of specific habitat types could be incorporated into the sampling. This was undertaken to detect specific fish species and/or life stages with specific habitat requirements and/or patchy distributions within a stream or river.

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[15] Stark, J D, and Maxted, J R (2007). A user guide for the macroinvertebrate community index. Prepared for the Ministry of the Environment. Cawthron Report No. 1166. 58p
[16] Clapcott, J.E., Goodwin, E., 2014. Technical report of Macroinvertebrate Community Index predictions for the Wellington Region (Cawthron Report No. 2503). Cawthron Institute, Nelson, New Zealand
[17] Joy, M.; David, B.; & Lake, M. (2013). New Zealand Freshwater Fish Sampling Protocols. Part 1 Wadeable Rivers and Streams. Technical Publication National Institute of Water and Atmospheric Research (NIWA).

73. Fish surveys were undertaken using a NIWA EFM300 EFM. All fish captured were identified, measured and counted before being released back to the stream.

4.8 Hydraulic modelling

74. A 2D hydraulic model has been developed for the River Hydraulics Technical Assessment (prepared by **Mr Pennington**). The model build and calibration are described in his report. I provide a summary here for context. In brief, the 2D model provides an indication of channel hydrology and water depth pre and post the development of the Project area. Where pre-development channel geomorphology is based on 2014 river channel cross sections and the post-development channel geomorphology is based on the 2021 channel design cross sections developed for RiverLink.

75. I used the outputs of **Mr Pennington's** 2D hydraulic model in order to determine the potential of the proposed works within the Project area to influence cyanobacteria and periphyton growth through changes to river hydrology and habitat types.

76. For the purpose of this assessment, a low flow scenario (7-day mean annual low flow (7DMALF)), median flow, and a high flow (flows three times the median flow) have been modelled by **Mr Pennington** to provide information on how the river hydrology and water depth will change post-RiverLink. I requested modelling of these flow regimes as they are understood to be the main drivers in flow derived changes to cyanobacteria and periphyton growths within river systems like the Te Awa Kairangi[18] [19] [20] [21].

4.9 Assessment of effects methodology

77. My assessment of ecological effects for the Project broadly follows the Ecological Impact Assessment Guidelines (EcIA Guidelines), with some adaptation for different fauna and ecosystem types (Roper-Lindsay et al., 2018). Using a standard framework and matrix approach such as this provides a consistent and transparent assessment of effects and is considered to be good industry practice.

78. The framework for assessment provides structure but needs to incorporate sound ecological judgement to be meaningful. Deviations or adaptions from the methodology are identified within each of the following sections as appropriate.

79. The EcIA Guidelines have been used to ascertain the following:

    i. The level of ecological value of the environment;

    ii. The magnitude of ecological effect from the proposed activity on the environment; and

    iii. The overall level of effect to determine whether an effects management response is (i.e. mitigation) is required.

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[18] Biggs, B.J.F. 2000. New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Prepared for Ministry for the Environment. NIWA.
[19]Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C. (1997) The natural flow regime. BioScience, 47:769-784.
[20] Richter, B.D., Baumgartner, J.V., Wigington, R., Braun, D.P. (1997) How much water does a river need? Freshwater Biology, 37: 231–249.
21 Heath, M.W., Greenfield, S. 2015. Benthic cyanobacteria blooms in rivers in the Wellington Region. Findings from a decade of monitoring and research. Environmental Science Department. Greater Wellington Regional Council

4.9.1 Assigning ecological value

80. The EcIAG do not provide a unifying set of attributes to assign value to freshwater systems. However, there are numerous widely accepted metrics and measures that are used in the assessment of freshwater systems.

81. For the purpose of this assessment, I have used an adapted freshwater values criteria which is based on the EcIAG[22] (Table 4-5). Freshwater ecological values are assigned on a scale of 'Low' to 'Very High' based on biodiversity and habitats present in the Project area and immediate surrounds.

82. Matters that may be considered when assigning ecological value to freshwater systems include representativeness, rarity/distinctiveness, diversity and ecological context. The relative importance of these matters is often driven by availability of empirical information (measured attributes such as Macroinvertebrate community index (MCI) or water quality data). For individual freshwater species, the national threat status was also used to determine potential ecological values of the site.

83. When assigning ecological value, professional judgment is applied throughout this assessment in relation to assigning value to species, habitats, and environments, with reference to the specific empirical measures described above.

[22] Freshwater ecological values have been assigned using ecological characteristics described in Table 4-5. This approach has been used and accepted in previous consenting processes including for Te Ahu a Turanga: Manawatū Tararua Highway and Auckland Regional Landfill.

Table 4-5 Factors considered in scoring sites freshwater values in relation to species representativeness, rarity, diversity and pattern, and ecological context (adapted from EIANZ, 2018)

Value	Habitat values	Species values
Very high	A reference quality watercourse in condition close to its pre-human condition with the expected assemblages of flora and fauna and no contributions of contaminants from human induced activities including agriculture. Negligible degradation e.g. stream within a native forest catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 120 or greater. EPT richness and proportion of overall benthic invertebrate community typically high. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat natural and unmodified.
High	A watercourse with high ecological or conservation value but which has been modified through loss of riparian vegetation, fish barriers, and stock access or similar, to the extent it is no longer reference quality. Slight to moderate degradation e.g. exotic forest or mixed forest/agriculture catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 80-100 or greater. EPT richness and proportion of overall benthic invertebrate community typically moderate to high. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. No pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat largely unmodified.
Moderate	A watercourse which contains fragments of its former values but has a high proportion of tolerant fauna, obvious water quality issues and/or sedimentation issues. Moderate to high degradation e.g. high-intensity agriculture catchment.	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 40-80. EPT richness and proportion of overall benthic invertebrate community typically low. Fish communities typically moderate diversity of only 3-4 species. Pest or invasive fish species (excluding trout and salmon) may be present. Stream channel and morphology typically modified (e.g., channelised) Stream banks may be modified or managed and may be highly engineered and/or evidence of significant erosion. Riparian vegetation may have a well-established closed canopy. Habitat modified.
Low	A highly modified watercourse with poor diversity and abundance of aquatic fauna and significant water quality issues. Very high degradation e.g. modified urban stream.	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 60 or lower. EPT richness and proportion of overall benthic invertebrate community typically low or zero. Fish communities typically low diversity of only 1-2 species. Pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology typically modified (e.g., channelised). Stream banks often highly modified or managed and maybe highly engineered and/or evidence of significant erosion. Riparian vegetation typically without a well-established closed canopy. Habitat highly modified.

4.9.2 Assess magnitude of effect

84. Magnitude of effect is a measure of the extent or scale of the effect of an activity and the degree of change that it will cause. The magnitude of an effect is scored on a scale of 'Negligible' to 'Very High' (Table 4-6) and is assessed in terms of:

i. Level of confidence in understanding the expected effect;

ii. Spatial scale of the effect;

iii. Duration and timescale of the effect (Table 4-7);

iv. The relative permanence of the effect; and

v. Timing of the effect in respect of key ecological factors.

For avoidance of doubt, I have considered the nature and magnitude of the ecological effect at the physical point of impact with recognition of the effect at a local and landscape spatial scale context as appropriate.

Table 4-6 Criteria for describing magnitude of effect (Roper-Lindsay et al., 20181)

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline[1] conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature.
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature.

[1] Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (Roper-Lindsay et al., 2018).

Table 4-7 Timescale for duration of effects (Roper-Lindsay et al., 2018)

Timescale	Description
Permanent	Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long-term	Where there is likely to be substantial improvement after a 25 year period (e.g. the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary	Long term (15-25 years or longer – see above) Medium term (5-15 years) Short term (up to 5 years) Construction phase (days or months).

4.9.3 Assessment of the level of effects (Step 3)

85. I have identified an overall level of effects for each activity or habitat/fauna type affected by the application using a matrix approach (Table 4-8) that combines the ecological values with the magnitude of effects resulting from the activity.

86. The matrix describes an overall level of effect on a scale of 'Very Low' to 'Very High'. Positive effects are also accounted for within the matrix to capture any positive effects on ecological values proposed as part of a project.

87. The level of effect is then used to guide the extent and nature of the ecological management response required, which may include avoidance, remediation, mitigation, offsetting or compensation. Generally, where there are low and very low levels of effects no management response is required.

Table 4-8 Criteria for determining overall levels of ecological effects (Roper-Lindsay et al., 2018)

Ecological value / Magnitude	Very high	High	Moderate	Low	Negligible
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low

4.9.4 Assigning an RMA interpretation to level of effect

89. The EcIAG process provides for the overall level of ecological effects to be translated to an 'RMA effect' (Table 4-9). The level of 'RMA effect' is determined by planners in consultation with ecologists and set out in the AEE report, rather than in an ecology report. This approach provides for consistency between the descriptions of ecological effects and other types of effects that may arise from a proposed activity, which may be considered elsewhere in the application documents.

Table 4-9 Criteria for describing overall levels of ecological effects (Roper-Lindsay et al., 2018)

Level of ecological effect	RMA interpretation	Description
Very high	Unacceptable adverse effects	Extensive adverse effects that cannot be avoided, remedied or mitigated.
High	Significant adverse effects that could be remedied or mitigated	Adverse effects that are noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.
Moderate	More than minor adverse effects	Adverse effects that are noticeable and may cause an adverse impact on the environment but could be potentially mitigated or remedied.
Low	Minor adverse effects	Adverse effects that are noticeable but that will not cause any significant adverse impacts.
Very low	Less than minor adverse effects	Adverse effects that are discernible from day to day effects, but which are too small to adversely affect the environment
Nil	Nil effects	No effects at all.

5. FRESHWATER ECOLOGICAL VALUES

5.1 Site location and description

90. Te Awa Kairangi is approximately 56 km long and is predominantly shallow, sometimes braided, river which drains in a south-west direction from the headwaters in the Tararua Ranges. Te Awa Kairangi flows through the Hutt Valley before discharging into the Wellington Harbour.

91. The Project area covers an approximately 3-kilometre section of Te Awa Kairangi between Kennedy Good Bridge and Ewen Bridge and includes the immediate urban environs on either side.

92. For clarity the assessment detailed in the following sections includes the Project area and the Te Awa Kairangi habitat downstream of the Project area to Seaview Bridge. The area downstream of Seaview Bridge is addressed separately in Dr Bell's technical assessment.

93. Te Awa Kairangi catchment is approximately 57,491 Ha, the majority of which is covered in hardwood and indigenous forest (Table 5-1). Only in the middle and lower sections of the catchment does increased urbanisation occur when the river flows through Lower and Upper Hutt. Due to being close to these major urban centres Te Awa Kairangi is popular for a range of recreational activities.

Table 5-1 Land cover in Te Awa Kairangi catchment

Land-cover class	Area (Ha)	% of catchment[1]
Urban	3,426.3	6.0 %
Forestry	7,259.7	12.6 %
Gorse/broom	2,235.2	3.9 %
Pasture	6,406.9	11.2 %
Hardwood/Indigenous forest	38,090.9	66.3%
Total	57,491.0	

[1] Proportional landcover taken form Aquanet (2018)[4].

5.2 Ecological context

94. The proposed Project is located in the Whaitua te Whanganui-a-Tara and the Wellington Ecological District (ED). The Whaitua Te Whanganui-a-Tara encompasses the sub-catchments of the Wainuiomata, Orongorongo, Te Awa Kairangi, Wellington Harbour streams, and the southern and western coastal streams. The Wellington ED covers the strongly faulted ranges surrounding Wellington, and Lower and Upper Hutt, this area was historically dominated by indigenous podocarp-broadleaf ecosystems.

95. The land use within and adjacent to the Project area is dominated by urban, residential and industrial uses. There are some areas of regenerating and remnant indigenous forest/scrub and exotic forest/scrub and weeds on the northern and western hillsides on the true right-hand side of Te Awa Kairangi. The land within the Project area is expected to have historically been part of Te Awa Kairangi flood plain.

96. Prior to the clearance of the mixed podocarp-broadleaf forest and the construction of the flood control works Te Awa Kairangi would have comprised of a morphologically and ecologically complex channel. The river would have meandered freely with greater channel sinuosity and branching across the flats through what is now Lower Hutt and Petone[23]. Additionally, the historic river channel would have had a greater volume of woody debris derived from the densely forested upper catchment and the immediate riparian zone. Historically it is likely that the diversity of fish, riverine birds and macroinvertebrate habitats would have been greater compared to the current river channel in the study area[23].

97. Within the Project area, Te Awa Kairangi is a highly confined and heavily managed river, and significantly changed from its natural form. The width of the main channel is constrained in the lower reaches as the river passes the existing Melling Bridge and into the tightly confined lower Te Awa Kairangi reach. The constrained type of river channel affects the shape of the river, with limited space for the movement of river meanders. The meander pattern is quite different from what would have been the case in the past

98. Currently Te Awa Kairangi is managed in accordance with the Hutt River Floodplain Management Plan (HRFMP, 2001). Periodic extraction of the gravel material, and re-shaping of the river channel, has been undertaken since the beginning of river management, with extensive interventions from the 1930s. Over the last 100 years the river has been extensively managed with the channel confined and stopbanks built to manage the flood risk to the adjacent Hutt City Central Business District (CBD).

[23] EOS Ecology. 2017. RiverLink Preliminary Design Report – In-river Ecological Enhancements – Draft. Prepared for Greater Wellington Regional Council.

5.3 Te Awa Kairangi freshwater ecology description and values

99. This section presents the results of the initial stream walkover I undertook in November 2019 and the field surveys undertaken on May 4 2020 and May 15 2020. Additionally, in this section I provide a review of the water quality and freshwater ecology of Te Awa Kairangi in the vicinity of the Project area and lower Te Awa Kairangi.

Existing environment

100. The existing river channel environment has been described in Mr Williams's technical assessment. I provide a summary in the following sections.

101. The gradient of Te Awa Kairangi within the Project area reduces as this is where the river approaches the sea and becomes a depositional zone for gravel bed material being transported from upstream.

102. Although highly constrained and modified, the existing channel reach has an alternating bar form, with a low flow channel around large gravel beaches, and hence a sequence of riffles, runs and pools. Mr Williams's concludes that at present there are 11 significant pools along the Project reach, although 5 of these are relatively shallow.

General freshwater habitat description

103. An initial site walkover to understand the general habitat characteristics encountered within the Project area was completed by Mr Lees in November 2019. The following paragraphs summarise my site walkover findings.

104. Te Awa Kairangi in the vicinity of the Project area is a homogenous river channel that consists of long deep run habitat through to shallow riffle habitat where there is a change in gradient. Only a single, large, wide steep riffle area that supported a diverse range of flow velocities and depths was observed around the Kennedy Good Bridge at the upstream extent of the Project area.

105. Deeper pools and runs were evident along the true right hand side, especially around existing flood protection works and structures.

106. Substrates over the whole reach generally comprised of gravels, cobbles and occasional boulders. Minimal deposits of sediment were observed, these were generally in pools/backwaters and slower flowing runs.

107. The observed periphyton community (assessed via bankside observation) consisted of films species (< 0.5 mm). No mat (> 0.5 mm - > 3.0 mm) or filamentous periphyton was observed. At the time of the site walkover in November 2019 (e.g. mid-spring) no mat forming benthic cyanobacteria (e.g. *phormidium sp*) were observed, however, this does not mean it was not present as the entire width and reach was not assessed.

108. Banks were generally well vegetated with established overhanging vegetation consisting of mature willow species, and a dense layer of exotic herbaceous weedy species (mature rank grasses, Nasturtium, Convolvulus, bramble etc) provided ground cover and runoff filtering.

109. Open gravel beaches and islands were evident within the Project area. Minimal encroachment of exotic weedy species to the gravel beaches was observed at the time of the site walkover.

5.3.1 Te Awa Kairangi water quality

110. GWRC has established two relevant long term water quality monitoring sites on Te Awa Kairangi in the vicinity of Project area. The Manor Park site is located approximately 6

kilometres upstream of the Project area and the Boulcott site is located within Project area (see Site overview Figure in Appendix A).

111. GWRC[4] and Aquanet[6] have recently undertaken a comprehensive review of the current state and trends of water quality in Te Awa Kairangi sub catchment[24]. I have updated a subset of relevant water quality data from these reports to incorporate further available data[25] through to October 2020. This is presented in Table 5-2 below.

112. Where available I have provided a relevant reference to the PNRP Table 3.1 and 3.4 objectives, the NPS-FM 2020[26] Attribute State B (which equates to approximately the 95 % species protection level) and ANZECC default guideline values (DGV)[27] for context.

113. The data indicate that water quality upstream of and within the Project area was generally good with data showing low to moderate nutrient concentrations and low contaminant levels with many parameters analysed being below the level of detection. GWRC[4] concluded that both the Boulcott and Manor park sites had excellent water quality which is also true of the updated dataset.

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[24] Te Awa Kairangi is one of five sub catchments within the Whaitua Te Whanganui-a-Tara
[25] Sourced form GWRC on 24 March 2021
[26] Ministry for the Environment. 2020. National Policy Statement for Freshwater Management.
[27] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default

Table 5-2 Summary of water quality data for the period June 2009 to October 2020 for two sites on Te Awa Kairangi

Water quality	Unit	Manor Park		Boulcott		Relevant attribute state / guideline			
		Median	Maximum, 95^{th} %, or minimum	Median	Maximum, 95^{th} %, or minimum	PNRP[1]	NPS FM (2020) +		ANZG (2018) DGV[2]
							Median	Maximum, 95^{th} %, or minimum	
Ammoniacal-nitrogen++	g/m^3	0.004	0.231	0.004	0.263		>0.03 - ≤0.24	> 0.05 – ≤0.40	0.009
Nitrate-nitrogen	g/m3	0.193	0.330 (95th %)	0.188	0.320 (95th %)		>1.0 - ≤2.4	>1.5 and ≤3.5 (95th %)	0.170
Dissolved Inorganic nitrogen	g/m3	0.199	0.89	0.193	0.56		> 0.021 - ≤0.030		0.011
Total -nitrogen	g/m3	0.3	1.96	0.29	1.75				0.272
Dissolved Reactive Phosphorous	g/m3	0.005	0.01 (95th %)	0.005	0.008 (95th %)		> 0.006 and ≤0.010	> 0.021 and ≤0.030 (95th %)	0.011
Total - phosphorous	g/m3	0.01	0.38	0.009	0.39				0.018
Black Disc	m	2.16	0.03 (min)	1.98	0.03 (min)	1.6	<0.93 and ≥0.76		1.4
Total suspended solids	g/m3	1	440	6	470				1.8
Turbidity	NTU	1.56	240	1.6	260				2.3
Escherichia coliforms	cfu/100ml	80	6000	80	6000	540	≤130		
Dissolved oxygen	% Sat	103.1	71.3 (min)	101.6	71.7 (min)				80 - 105
Dissolved oxygen	mg/L	10.8	8.01 (min)	10.6	8.14 (min)			≥5.0 and <7.5	
Temperature	°C	13.4	24	13.7	24.6				
Conductivity	µS/cm	95	136	92	115.8				145
pH		7.2	8.5	7.2	8.4				7.23 – 7.8
Cyanobacteria	% cover	0	27.5	0	27.5	20			
Periphyton - mats	% cover	0	88	0	88	20			
Periphyton - filamentous	% cover	0	25.25	0	25.25	< 40	>10 and ≤19		
Fine sediment	% cover	8.4	40	8.4	40				

c + Attribute State B (~95% species protection level)

d ++To compare measured data against the NPS FM ammonia attributes requires the data to be adjusted to a standardized pH of 8. Adjusting the ammonia concentration for pH does not mean that the amount of total ammonia present changes. Instead, pH adjustment means calculating the amount of ammoniacal nitrogen at pH 8 that would have the equivalent toxicity to the amount of ammoniacal nitrogen measured in the sample at the pH of that sample.

e 1: PNRP outcome

f 2: Default Guideline Value = 80th percentile for physical and chemical (PC) stressors (indicators) that are harmful at high values (e.g. nitrate). See ANZG Cool Wet Low elevation DGV

114. Water quality conditions at Manor Park and Boulcott are generally similar. With observed median nutrient values below relevant attribute and guidelines levels; dissolved oxygen (DO), temperature, and clarity (black disc) were at a level that would not affect the ecological health of Te Awa Kairangi. This is in general alignment with the conclusion set out by GWRC that the Manor Park and Boulcott sites had excellent water quality[4].

5.3.2 Cyanobacteria

115. Aquanet's[6] review of cyanobacterial growth outlined that the generally low nutrient concentrations of the Te Awa Kairangi may be limiting the growth of periphyton and cyanobacteria. However, on occasion, even slightly elevated nutrient concentrations may be contributing to benthic cyanobacterial blooms in the river. Specifically, when nitrogen concentrations were high and phosphorus concentrations where low blooms of cyanobacteria may occur.

116. High ratios of total nitrogen to total phosphorus have been shown in New Zealand to be associated with cyanobacteria bloom formation[28,29,30]. The nutrient conditions that are favourable for bloom formations are consistent with those observed at the Boulcott and Manor Park sites. Although, nutrients play an important role in cyanobacteria growth, the influence of nutrients on growth/biomass development is not always predictable and may vary spatially and temporally. Other factors that impact the growth and establishment of nuisance cyanobacteria biomass at a site include temperature and hydrology, in particular the time between flushing (fresh and flood) events.

117. Both the Boulcott (within the Project area) and Manor Park (upstream of the Project area) sites exceed the PNRP outcome of 20 % stream bed cover for benthic cyanobacteria. In addition, over the summer period of 2011/12 and 2017/2018 nuisance cyanobacteria blooms (> 50% stream bed cover) were observed at popular swimming spots located within the wider Te Awa Kairangi catchment[6].

5.3.3 Periphyton

118. Periphyton cover at the Boulcott and Manor Park sites was generally low, with an apparent lack of nuisance algae observed at these monitoring sites between January 2009 and May 2019 (GWRC and Aquanet (see Table 5-2)). Both sites are generally expected to have < 40% periphyton cover of the stream bed and therefore meet the objective set in the PNRP. This is reflected in the median percent cover of the river bed by being 0 % cover, while the maximum percent cover for is 55 % for Manor and 66 % for Boulcott (Table 5-2).

5.3.4 Macroinvertebrates

119. Aquatic invertebrate samples are collected yearly during the summer by GWRC from the Boulcott and Manor Park sites (following Protocol C1 in Stark *et al* (2001)[11]). Additional sampling was completed for this assessment at the Melling Bridge and Ewen Bridge during May 2020 by RiverLink. To enable comparison between the long-term monitoring sites and the sampling sites surveyed for this assessment, data analysis in this section has been restricted to that available for the 2019/2020 sampling year.

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[28] Quiblier, C., Wood, S.A., Echenique-Subiabre, I., Heath, M., Villeneuve, A., Humbert, J., 2013. A review of current knowledge on toxic benthic freshwater cyanobacteria – Ecology, toxin production and risk management. Water Research 47, 5464–5479.
[29] Heath, M.W., 2015. Environmental drivers of Phormidium blooms in New Zealand rivers (PhD Thesis). Victoria University of Wellington, Wellington, New Zealand.
[30] Heath, M.W., Greenfield, S., 2016. Benthic cyanobacteria blooms in rivers in the Wellington Region: Findings from a decade of monitoring and research (Greater Wellington Publication No. GW/ESCI-T-16/32). Greater Wellington Regional Council, Wellington, New Zealand.

120. Results showed that all reaches were characterised by an invertebrate community with a moderate number of sensitive species that are intolerant of reduced water quality and instream habitat quality conditions. Summary statistics are available in Table 5-3 and full taxa list is provided in Appendix B. The 2019/20 macroinvertebrate data are summarised as follows:

i. MCI scores ranged between 111 and 118. The MCI scores at each site fell within the "good" quality class (both as described by Stark and Maxted (2007) and Clapcott and Goodwin (2014)). However, the MCI scores for 2019/2020 did not meet the PNRP Objective of ≥ 130 for the Te Awa Kairangi (Table 3-2);

ii. The QMCI scores indicated an "excellent" and "good" quality class at Manor Park, Melling and Ewen Bridge, while at Boulcott the QMCI score indicated a "fair" quality class;

iii. Sensitive EPT taxa were found at all monitoring locations and ranged from 42 % at Boulcott through to 69 % at Ewen Bridge; and

iv. No invertebrate taxa of particular conservation interest were recorded in the samples.

Table 5-3 Summary macroinvertebrate metric scores for survey conducted over 2019/2020

Macroinvertebrate metric	Sites				PNRP outcome
	Manor Park (GWRC))	Boulcott (GWRC)	Melling (this assessment)	Ewen Bridge (this assessment)	
Total number of taxa	27	22	18	13	
% EPT taxa	55	42	61	69	
MCI score	111	111	118	114	≥ 130
MCI quality class: Stark et al[15])	Good	Good	Good	Good	
MCI quality class: Clapcott and Goodwin et al[16])	Good	Good	Good	Good	
QMCI score	6.69	4.11	7.5	5.0	
QMCI quality class	Excellent	Fair	Excellent	Good	

5.4 Tributary freshwater ecology description and values

121. Three tributary streams, which have natural outlets to Te Awa Kairangi, are located on the true right bank of the River, within the Project Area; the Harbour View Stream, Tirohanga Intersection Stream and the Tirohanga Stream. Three additional tributaries are located within the Project Area. The Jubilee Park Outlet will require replacement / construction across the highway. The remaining two tributaries do not provide natural stream outlets to Te Awa Kairangi.

122. All three tributaries are small urban hillside streams which drain a catchment with residential dwellings and mixed exotic and native broadleaf forest scrub vegetation. Each of the three tributary streams cross under SH2 before the eventual confluence with Te Awa Kairangi. Overall, the catchments of each of the tributaries are modified, but do retain some aspects of natural stream characteristics, predominantly in the upper valley reaches.

5.4.1 Tributary rapid habitat assessment

123. Rapid Habitat Assessment (RHA) surveys were completed for this assessment at Harbour View Stream (upper and middle reaches) and Tirohanga Intersection Stream only. No aquatic habitat

surveys were conducted at Tirohanga Stream due to access being on private property. A summary of the assessment findings is provided in the following sections.

5.4.2 Harbour View Stream

124. The Harbour View Stream is a small urban hillside stream with a catchment area of approximately 50 Ha. The Stream drains from residential dwellings and roads in the suburb of Harbour View, down through a vegetated valley before crossing under Harbour View Road and SH2 to the outlet in the Te Awa Kairangi.

Middle reach

125. The middle reach of Harbour View Stream is a permanently flowing stream of approximately 25 m in length and is located upstream of an approximate 120 m piped section. The reach is characterised by steep incised banks along the majority of its length with low sediment bed cover, high invertebrate and moderate fish habitat diversity and abundance respectively. Overhanging vegetation consisted of native trees and an established ground cover of exotic and native herbaceous plants. Bed substrate was comprised of cobbles, gravels and occasional boulders with some areas of green and brown thin film periphyton in shallow sections of the stream reach surveyed. No macrophytes were observed. A representative site photo of this reach is provided in Figure 5-1 below.

126. The overall RHA score for this site was 64 (out of 100), which is moderate and indicative of aquatic habitat that provides some opportunity for freshwater fauna (Table 5-4). However, there appeared to be a lack of abundance in fish cover, with bank vegetation also contributing to a reduced habitat value.

127. The culvert and piped section located at the downstream extent of this reach are likely to restrict fish passage to climbing species (e.g. banded kōkopu, shortfin eel). Primarily, due to the length of the piped section (approximately 120 m) and the change in gradient within the pipe (from flat at the outlet to steeper gradient partway up the culvert) which appeared to increase water velocities.

Figure 5-1 Middle reach of Harbour View Stream

Upper reach

128. The upper reach of Harbour View Stream (upstream of Harbour View Road) is a permanently flowing stream, comprising an open, flat channel with a 10 m high natural waterfall, separating the surveyed reach from the upper Western Hills section of the catchment. This reach is located upstream of a piped section of stream (approximately 90 m long) that connects the upper reach to the middle reach of Harbour View Stream. The reach had high invertebrate habitat diversity and abundance and low fish habitat diversity and abundance respectively. Overhanging vegetation consisted of native trees and an established ground cover of exotic and native herbaceous plants. Substrate was comprised of cobbles, gravels and occasional boulders with high sediment bed cover especially in slower flowing areas. Sporadic areas of green and brown thin film periphyton in shallow sections of the stream reach were observed during the survey. No macrophytes were observed. A representative site photo of this reach is provided in Figure 5-2 below.

129. The overall RHA score for this site was 65 (out of 100), which is moderate and indicative of aquatic habitat that provides some opportunity for freshwater fauna (Table 5-4). However, there appeared to be a lack of abundance and diversity in fish cover, with deposited sediment also contributing to a reduced habitat value.

130. The culvert located at the downstream extent of this reach is unlikely to provide fish passage to upstream habitats. Primarily, due the culvert outlet being perched (52 cm in height), high velocities over the associated concrete apron, and the length and gradient of the piped section connecting the middle and upper reaches of the Harbour View Stream.

Figure 5-2 Upper reach of Harbour View Stream

5.4.3 Tirohanga Intersection Stream

131. The Tirohanga Intersection Stream is a small urban hillside stream with a catchment area of approximately 20 Ha. The Stream drains stormwater from residential dwellings and roads in the suburb of Tirohanga, down through a vegetated valley before crossing under Tirohanga Road and SH2 to the outlet in the Te Awa Kairangi.

132. The Tirohanga Intersection Stream was flowing at the time of the site visit and was characterised by riffle/run habitat sequences. Banks were well vegetated with an established canopy but there was variable presence and density of groundcover vegetation adjacent to the stream. However, a dense layer of leaf litter was observed throughout the area providing for ground cover and runoff filtering. No macrophytes were observed during the site visit. A small water fall is located approximately 100 m upstream of the upper most culvert, it is probable that this waterfall is not a barrier to native climbing species. A representative site photo of this reach is provided in Figure 5-3 below.

133. The overall RHA score for this site was 71 (out of 100), which is moderate and indicative of aquatic habitat that provides some opportunity for freshwater fauna (Table 5-4). However, there appeared to be a lack of abundance in fish cover, with bank erosion and deposited sediment also contributing to a reduced habitat value.

134. The culvert at the Tirohanga Street intersection is perched at the outlet (by approximately 3.5 cm) and has a high flow rate. Although, migratory fish were identified upstream of the culvert it is likely that the culvert is limiting fish passage due to flow and perching at the culvert.

Figure 5-3 Tirohanga Intersection Stream, showing downstream of SH2 (left photo) and upstream of SH2 (right photo)

Table 5-4 RHA scores for each tributary site

RHA protocol	Harbour View Stream - middle	Harbour View Stream – upper	Tirohanga Intersection Stream
1. Deposited Sediment	8	2	5
2. Invertebrate habitat diversity	10	8	10
3. Invertebrate habitat abundance	10	5	10
4. Fish cover diversity	5	1	6
5. Fish cover abundance	3	2	3

RHA protocol	Harbour View Stream - middle	Harbour View Stream – upper	Tirohanga Intersection Stream
6. Hydraulic heterogeneity	6	8	7
7. Bank Erosion	6	10	4
8. Bank vegetation	3	8	7
9. Riparian width	5	10	9
10. Riparian shade	8	10	10
Total habitat score (x/100)	64	64	71
Aquatic ecological value	Moderate - high	Moderate – high	Moderate - high

5.5 Freshwater fish within the Project area

135. In total, 12 indigenous and one introduced freshwater fish species have been recorded within the wider Te Awa Kairangi catchment based on records available on the NZFFD and survey results conducted in May 2020 (this assessment). NZFFD records date from 2000 to 2020. Results are provided in Table 5-5 below.

136. Of the species identified several are 'At risk - declining'[31] species. This means that while the species is not currently threatened and may appear to be common, the population nationally is declining. Some of the documented threats to 'At risk - declining' species include habitat modification and loss, fish passage barriers and commercial fishing[32]. The 'At risk - declining' species identified within the Project area include longfin eel (*Anguilla dieffenbachii*), giant bully (*Gobiomorphus gobioides*), bluegill bully (*Gobiomorphus hubbsi*), kōaro (*Galaxias brevipinnis*).

137. Additionally, one 'nationally vulnerable'[23] species the Lamprey (*Geotria australis*) has been historically identified within the Project area. Nationally vulnerable species face the risk of extinction in the medium term. This species was historically identified within Te Awa Kairangi, and no subsequent identification of this species has been made since. However, this does not mean that the species is not present. It is probable that lamprey are utilising Te Awa Kairangi to access appropriate spawning habitat further upstream. I have therefore been conservative in including lamprey in this assessment of ecological values.

138. Bluegill bully were identified as the most numerically dominant species observed within the Project area. Primarily due to the presence of favourable habitat within the Project area, namely, substrates dominated by cobbles and gravels. Only shortfin eel and banded kokopu were identified within the tributary sites. This is likely due to the limitations on fish passage for swimming species which included changes in gradient which increased velocity, high velocity areas within the culverts, and perching at culvert outlets.

Table 5-5 Identified freshwater fish species

Species	Common name	Threat class	Diadromous	Data source	Within Project designation
Anguilla australis	Shortfin eel	Not Threatened	Y	NZFFD and May 2020 survey	Y (plus tributary)
Anguilla dieffenbachii	Longfin eel	At risk - Declining	Y	NZFFD and May 2020 survey	Y

[31] Dunn, N.R.; Allibone, R.M.; Closs, G.P.; Crow, S.K.; David, B.O.; Goodman, J.M.; Griffiths, M.; Jack, D.C.; Ling, N.; Waters, J.M.; Rolfe, J.R. 2018: Conservation status of New Zealand freshwater fishes, 2017. New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 p
[32] https://www.doc.govt.nz/nature/conservation-status/

Species	Common name	Threat class	Diadromous	Data source	Within Project designation
Retropinna	Common smelt	Not Threatened		NZFFD	
Galaxias maculatus	Inanga	At risk - Declining	Y	NZFFD and May 2020 survey	
Galaxias divergens	Dwarf galaxias	At risk - Declining	Y	NZFFD	
Galaxias fasciatus	Banded kōkopu	Not Threatened	Y	NZFFD May 2020 survey	Y (plus tributary)
Galaxias argenteus	Giant kōkopu	At risk - Declining	Y	NZFFD	
Galaxias brevipinnis	Koaro	At risk - Declining	Y	NZFFD	Y
Geotria australis	Lamprey	Nationally Vulnerable	Y	NZFFD	Y
Gobiomorphus cotidianus	Common bully	Not Threatened	Y – coastal populations	NZFFD and May 2020 survey	Y
Gobiomorphus basalis	Crans bully	Not Threatened		NZFFD and May 2020 survey	Y
Gobiomorphus gobioides	Giant bully	At Risk - Naturally uncommon	Y – coastal populations	NZFFD	Y
Gobiomorphus huttoni	Redfin bully	Not Threatened	Y	NZFFD	Y
Gobiomorphus hubbsi	Blue gill bully	At risk - Declining	Y		Y
Salmo trutta	Brown trout	Introduced		NZFFD	Y

139. Of the native freshwater fish species identified within the wider Te Awa Kairangi catchment, 11 are diadromous (to an extent[33]) and must migrate to the sea as part of their lifecycle. Therefore, catchment access to downstream and upstream habitats is important for these species so that regional populations can be maintained.

5.5.1 Trout fishery

140. Te Awa Kairangi has been identified as a waterbody with trout fishery values and spawning water identified by Wellington Fish and Game (and later adopted into Schedule I of the PNRP). As such annual monitoring by Fish and Game NZ has been undertaken since 1999 to assess the trout abundance within Te Awa Kairangi upstream of Melling Bridge.

141. Below is a summary of the trout fishery within the Project area:

i. Trout numbers were most abundant in the Melling, Taita and Whakatikei sampled reaches of Te Awa Kairangi, however results do vary from year on year;

ii. There is a long-term positive trend in fish counts, which indicates good recruitment and survival;

[33] Common bully generally only undertake diadromous migration when populations are close to the coast.

iii. River bed recontouring and gravel extraction associated with flood protection works is influencing trout numbers at impacted sites in the short term, however, the results indicated that the gravel extraction had no lasting impact on trout numbers or distribution (see MWH (2016)7); and

iv. Broader scale climatic factors (e.g. spring time floods and flood severity) are likely impacting the trout populations in the longer term.

5.5.2 Īnanga spawning habitat

142. Īnanga spawning habitat is commonly located at or around the upstream extent of the spring tide saltwater wedge where eggs are laid at the base of long dense bankside grasses and other thick vegetation. Potential īnanga spawning habitat has been identified downstream of the Ewen Bridge34. Likewise, īnanga spawning habitat has been identified within Schedule F1b of the PNRP within the lower Te Awa Kairangi outside of the Project area.

143. Suitable īnanga spawning habitat has been found in the Te Awa Kairangi, and spawning has been confirmed in the lower reaches around the Sladden Park Boat Ramp35.

144. Aquanet (2018) describe that the upper extent of the salt wedge has been modelled to extend to approximately 200 m upstream of the Ewen Bridge. A 2017 Hutt Estuary monitoring report35 detailed that saltwater extends up to 3 km upstream of the mouth (approximately 230 m downstream of Ewen Bridge) and the water column is often stratified with freshwater overlaying denser saltwater. Overall, inanga spawning could potentially occur in suitable bankside vegetation between these two points. The furthest upstream extent noted within the Aquanet report is within the Project area and therefore spawning could occur if adequate spawning habitat is available. A map showing extent of habitat suitable for īnanga spawning is provided in Figure 5-4 below.

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[34] Taylor, M., Marshall, W. 2016. Inanga spawning habitat quality, remediation and management in the Wellington Region. Report prepared by AEL for Greater Wellington Regional Council, Wairarapa Moana Wetland Group, Porirua City Council, and Wellington City Council.

[35] Robertson, B.M. and Stevens, L.M. 2017. Hutt Estuary: Fine Scale Monitoring 2016/17. Report prepared by Wriggle Coastal Management for Greater Wellington Regional Council. 34p

Figure 5-4 Potential īnanga spawning habitat. Red line indicates where potential suitable habitat may be present (adapted from Taylor and Marshel, 201634)

6. ASSESSMENT OF FRESHWATER ECOLOGICAL EFFECTS

145. This section identifies and assesses the magnitude and overall level of freshwater ecological effects that may arise from the Project. My assessment is based on the information on freshwater ecology values and condition as described in Section 5 of this report (and summarised below), the project description information presented in Section 3, and is guided by the EIANZ EcIAG[2] framework as described in Section 4. I note that while the EcIAG can be applied to determine ecological effects within the river, the guidelines are not necessarily designed to determine effects on water quality.

146. The potential effects on freshwater ecology resulting from the Project have been assessed in terms of short-term during Project works (construction) and long-term effects (operational).

147. Temporary effects relate to the effects within the Project works phase which is expected to last up to four years. While potential long-term effects are those that occur on a permanent basis once the Project works phase has been completed (e.g. loss of stream habitat).

Efforts to address potential adverse effects are considered necessary for all habitats and species that are expected to incur 'Moderate' or higher level of effects as a result of the Project. Additionally, by following the effects management measures outlined in the following sections effects that have a lower level of effect may also be addressed.

6.1 Assessment of construction effects without mitigation

148. This section provides an assessment of freshwater ecology effects without mitigation from a whole of Project area point of view. I have assessed Project works effects within and downstream of the Project area for Te Awa Kairangi and the Project area for the tributary sites.

6.2 Assigning ecological value

149. This section provides an overview of the results of the literature review and subsequent field surveys undertaken in Section 5. The ecological value of Te Awa Kairangi and the tributary sites and affected habitat/fauna is assigned with reference to the values descriptions in Table 4-5.

6.2.1 Te Awa Kairangi

150. Water quality within Te Awa Kairangi is excellent with little indication of pollution outside of occasional elevated concentrations of phosphorus and nitrogen, and elevated faecal coliforms and suspended solids during high flow events.

151. Freshwater habitats within the Project area of Te Awa Kairangi are generally of high-quality with macroinvertebrate community's indicative of fair to excellent quality. Similarly, the section of lower Te Awa Kairangi (downstream of the Project area) has moderate to high quality habitat although slightly reduced compared to the upstream sections which is likely attributed to the further homogenisation of the river habitat and tidal influence.

152. Four 'At risk – Declining' species (i.e. longfin eel, bluegill bully, giant bully, and kōaro) were identified as was lamprey, a 'Nationally – Critical' species, within Te Awa Kairangi Project area. Further 'At Risk' and 'Threatened' species have been identified within the wider catchment. Of these species, some are expected to utilise the Te Awa Kairangi Project area as a migratory pathway to upstream habitats.

153. I have considered recent fish survey data (both historical via the NZFFD and through the field work undertaken for this project), macroinvertebrate data, water quality data and habitat quality data to reach an ecological values conclusion for Te Awa Kairangi (within the Project area and immediately downstream of RiverLink). My assessment is summarised in Table 6-1.

154. With respect to the values identified in the PNRP, the Project area (and the wider Te Awa Kairangi catchment) provides significant indigenous ecosystems for threatened and At risk fish species, of which six or more are migratory indigenous fish. The lower Te Awa Kairangi (to the reach of tidal influence) provides suitable potential habitat for īnanga spawning. Additionally, Te Awa Kairangi Project Area (and the upstream Te Awa Kairangi outside of the Project area) has been identified as a waterbody with trout fishery values and spawning water.

155. Overall, and with reference to the EcIAG (see Table 4-5) and the schedules and classes outlined within the PNRP, I consider the freshwater habitat and fauna present within Te Awa Kairangi to be of **High** ecological value both within the Project area and the lower Te Awa Kairangi for the reasons set out in Table 6-1.

6.2.2 Tributary sites

Harbour View Stream

156. Harbour View Stream is a small hill fed tributary joining Te Awa Kairangi on the true right bank (approximate catchment size is 50 ha). The stream drains a predominantly mixed secondary broadleaved forested catchment with residential dwellings and roads associated with the adjacent suburb in the immediate catchment. Harbour View Stream currently has two piped sections (120 m and 90 m long) that are limiting the connectivity of aquatic habitats within the stream and to the Te Awa Kairangi. Where non piped stream sections are present, these were small open channels approximately 25 m and < 20 m in length. Substrates comprised of cobbles, gravels and occasional boulders, and an overhanging vegetated riparian zone which consisted of native trees with an established ground cover of exotic and native herbaceous plants. Both open reaches would provide aquatic habitat opportunity for freshwater fauna.

157. No fish were observed during the field surveys and no records are available within the NZFFD. Fish passage surveys showed that a combination of the piped sections and perched outlet at the upper culvert are likely to be impacting fish movements into the upper Harbour View Stream catchment.

158. Overall, I assessed freshwater values in Harbour View Stream as **Moderate** for the reasons set out in Table 6-1.

Tirohanga Intersection Stream

159. Tirohanga Intersection Stream is a small hill fed tributary on the true right-hand side of the Te Awa Kairangi (approximate catchment size is 20 ha). The stream drains a predominantly mixed secondary broadleaved forested catchment with residential dwellings and roads associated with the adjacent suburb in the immediate catchment. The stream appears to be an intermittent stream characterised by riffle/run habitat sequences with an established canopy and variable presence and density of groundcover vegetation.

160. During the field surveys one adult shortfin eel and one banded kokopu were identified within the stream. No further historical fish records are available within the NZFFD. Fish passage surveys showed that the outlet of the culvert at Tirohanga Street is likely to be impacting fish passage at times.

161. Two ‘not-threatened’ indigenous fish (shortfin eel and banded Kōkopu) were identified within the stream, however, no historical records are available within the NZFFD. High flows coupled with the perched culvert outlet are likely restricting access for freshwater fauna in and out of the Tirohanga Intersection Stream catchment.

162. Overall, I assessed freshwater values in Tirohanga Intersection Stream as **Moderate** for the reasons set out in Table 6-1.

Tirohanga Stream

163. Tirohanga Stream is a small hill fed tributary on the true right-hand side of the Te Awa Kairangi (approximate catchment size is 20 ha). The stream drains a predominantly mixed secondary broadleaved forested catchment with residential dwellings and roads associated with the adjacent suburb in the immediate catchment. No field surveys were undertaken at this site.

164. However, a review of available data shows that the Tirohanga Stream is similar to the tributaries on the true right-hand side of the Te Awa Kairangi. Overall, I assessed freshwater values in Tirohanga Stream as Moderate for the reasons set out in Table 6-1.

Table 6-1 Summary of freshwater ecological values within the Project area and with reference to the EcIAG criteria in Table 4-5

Reach	Value	Justification
Te Awa Kairangi		
Downstream of the Project area	High	The reach had high ecological or conservation value but has been modified through loss of riparian vegetation and flood management works (e.g. stopbank construction) and is no longer reference quality. There is slight to moderate degradation present. Habitat quality was variable with reducing habitat quality and increased modification further downstream of the Project area. The fish community was diverse and includes ‘At-risk’ species such as longfin eel, īnanga, bluegill and giant bully. No pest or invasive fish were recorded
Within the Project area	High	Benthic invertebrate community generally had high taxa diversity, species richness and abundance. MCI scores typically 80-100 or greater, and the proportion of EPT taxa of overall benthic invertebrate community was moderate. The fish communities were typically diverse and abundant, with the Project area providing habitat and/or a migratory pathway for ‘At-risk’ and ‘Nationally critical’ fish species including longfin eel, īnanga, bluegill and giant bully, and lamprey. No pest or invasive fish were recorded
Tributary sites		
Harbour View Stream	Moderate	Provides potential habitat and/or a migratory pathway for indigenous fish species. Moderate habitat quality but with reducing habitat quality conditions and increased modification further downstream of SH2. Overall, moderate to high degradation has occurred. Stream channel and morphology typically modified (e.g., channelised)
Tirohanga Intersection Stream	Moderate	‘Non threatened’ native migratory fish present. Complete and partial fish passage barriers evident Moderate habitat quality but with reducing habitat quality conditions and increased modification further downstream of SH2. Overall, moderate to high degradation has occurred. Stream channel and morphology typically modified (e.g. channelised)
Tirohanga Stream	Moderate	Provides potential habitat and/or a migratory pathway for indigenous fish species. Moderate habitat quality but with reducing habitat quality conditions and increased modification further downstream of SH2. Overall, moderate to high degradation has occurred. Stream channel and morphology typically modified (e.g. channelised)

6.3 Assessment of Project works - construction effects

165. The RiverLink project is a combination of a number of different infrastructural elements. The construction activities required to create these infrastructural elements vary with regard to the nature of the activity, location, extent and duration. An outline of indicative activities and construction methodologies is provided in the Project Construction Methodology in Section 5 of

the AEE. The methodology adopts a staged approach, with six separate stages and concurrent staging of River works and Bridge Construction.

166. The actual and potential temporary effects during construction of the Project works on freshwater ecology values that are assessed in this section include:

i. Effects on freshwater habitat diversity and condition through temporary modification as a result of gravel extraction/disturbance activities and associated construction activities;

ii. Direct effects on resident freshwater fauna due to injury/mortality through gravel extraction and stream bed disturbance activities, within Te Awa Kairangi and its tributaries within the Project area;

iii. Potential effects from sediment and cement wash discharges during project works within the Project Area and the downstream receiving environment of Te Awa Kairangi; and

iv. Effects on fish migration and spawning within the Project area and any potential effects that Project works may have on fish species known to inhabit Te Awa Kairangi catchment.

6.3.1 Temporary effects from Project works construction on freshwater habitat

167. The construction effects of the Project on freshwater habitats considered for this assessment are impacts of gravel extraction works and temporary structures associated with the construction of bridge piling within Te Awa Kairangi (hereafter broadly grouped as temporary construction activities), and any stream disturbance activities during construction works within the tributary streams.

168. The estimated total footprint of works within Te Awa Kairangi is 72 ha, of which approximately 28 ha is within the river channel. Works will be undertaken progressively over an indicative Project duration of four years. On a yearly basis the total footprint within the river channel will be approximately 7 ha.

169. It is anticipated temporary construction activities associated with the bridges will include the formation of temporary causeways (effectively an armoured section of the bed) within the river. Some channel control work will be undertaken associated with the staged gravel extraction activities in order to effectively undertake piling works out of the flowing river. Temporary causeways will be formed from mounded river gravels and will later be removed as part of bed reprofiling. Temporary causeways will follow the proposed bridge alignments (i.e. generally perpendicular to river flow) and will be trapezoid in form, with a base up to approximately 16-20 m wide (dependent on river depth at the location), with a flat top of approximately 10 m width. Any structures associated with the construction of the bridge piles are anticipated to be in place for construction of those structures. Following the removal of any temporary structures it is anticipated the riverbed will reform and any habitat is expected to return (over a period of months) to its pre-works condition (See construction effects on freshwater habitats).

170. The disturbance of the freshwater habitat through gravel extraction and the associated riverbed disturbance is expected to occur on a large scale and will have an unavoidable impact on freshwater habitats within the Project area. The proposed works could cause a major change to freshwater habitat types. Specifically, such works often result in a reduction of pool and riffle habitat and an increase in run habitat, and nearly always a loss of hydraulic complexity and associated substrate diversity (Perrie 2013a[36]). These effects are only of relevance during the Project works phase of the Project because once construction activities have ceased it is anticipated that freshwater habitats within the Project area will revert to or re-establish to conditions similar to that prior to construction activities. The current flow types present in Te Awa Kairangi within the Project area have been described in full in **Mr Williams'** technical assessment, and generally consist of a low flow channel that flows around large gravel

beaches, with a sequence of riffles, runs and pools. Some deeper pool habitat located on the outside of bends.

171. There is also potential for the proposed Project works to impact the freshwater habitat of Te Awa Kairangi through a combination of lowering the riverbed and widening the channel. This will temporarily change the type of habitat that is available within the impacted reach (e.g. during works and for a period of time after works have ended within the impacted reach). The channel reprofiling, detailed in the example cross-section below (Figure 6-3), shows the typical profile proposed (red line), which incorporates lowering the riverbed, and widening the channel as well as the creation of berms above each riverbank before returning to existing ground levels prior to the stop banks. Bank protection is also proposed either using riprap or planting.

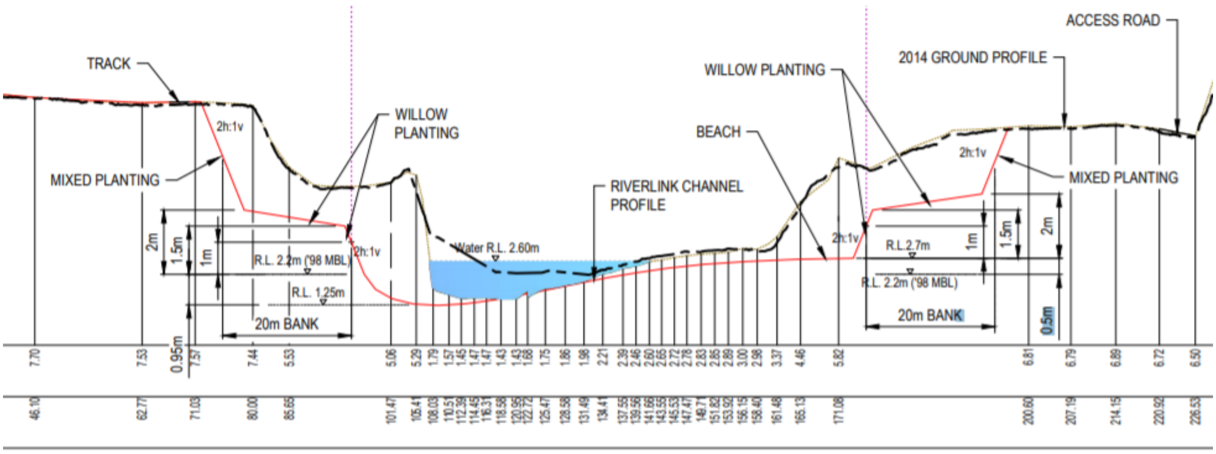

Figure 6-1 Example cross-section showing associated river works

172. Substrate size and distribution are likely to be affected within the impacted reaches. Advice from the Projects geomorphology and sediment water quality experts (**Mr Williams** and **Mr Breese**, respectively) and historical assessments have described the sediment grain size composition (MWH (20167 and Perrie 2013a[36] and Perrie 2013b[37]) within Te Awa Kairangi. This showed that substrate is predominantly a mix of small through to large gravels and small and large cobbles, with minimal deposits of fine sediment (i.e. < 2.0 mm size fraction). The results of Wolman Pebble Count[38] surveys undertaken by Cameron (2018) suggests that bed sediments typically contain 0% silt and clay (<63µm) a median diameter of 22 mm (which corresponds to a small cobble), and 10% sands (> 0.06 – 2.0 mm) (Figure 6-4). **Mr Breese** (sediment water quality) and **Mr Williams** (geomorphology) have indicated that the results from Cameron (2018) are representative of the river bed material within the Project footprint that would be disturbed.

173. The substrate composition described above provides habitat for a relatively high-quality macroinvertebrate community generally comprising of a high proportion of sensitive EPT and provides good habitat for several fish species (including bluegill bully, redfin bully, and long and shortfin eel).

[36] Perrie, A. 2013a. The effects of gravel extraction from the wetted channel on the aquatic ecosystem of the Hutt River: a summary of macroinvertebrate data collected before and after gravel extraction. Memo prepared for the Greater Wellington Regional Council.
[37] Perrie, A. 2013b. The effects of gravel extraction from the wetted channel on the aquatic ecosystem of the Hutt River: a summary of two Environmental Science Department investigations undertaken in 2012/13. Memo prepared for the Greater Wellington Regional Council.
[38] The Wolman Pebble Count is a field technique for quantifying surface bed material size in instream flow studies

Table 3-16: Substrate grain size %-cover in 10 size classes at reach H10

Particle size class		Site 1	Site 2	Site 3	Mean
Clay/silt	<0.06 mm	0	0	0	0
Sand	>0.06- 2.0 mm	12	9	10	10
Small gravel	>2 – 8.0 mm	7	7	7	7
Small-med gravel	>8 – 16 mm	12	12	12	12
Med-large gravel	>16 – 32 mm	26	22	24	24
Large gravel	>32 – 64 mm	30	30	30	30
Small cobble	>64 – 128 mm	13	19	16	16
Large cobble	>128 – 256 mm	0	1	1	7
Boulders	> 256 mm	0	0	0	0
Bedrock	Bedrock	0	0	0	0
%fine sediment		12	9	10	10
d50		20	24	22	22

Figure 6-2 Sediment grain size composition of samples taken upstream and downstream of Melling Bridge (from Cameron, 2018).

174. Results from habitat mapping studies undertaken in Te Awa Kairangi for other gravel extraction and channel re-alignment works (MWH (2016[7]), and Perrie (2013a[36])) showed that these types of works can cause a major (but temporary) change to freshwater habitats within Te Awa Kairangi. For example, Perrie (2013a[36]) details that prior to gravel extraction the riverbed of Te Awa Kairangi upstream of Kennedy Good Bridge comprised a substrate dominated by small and large cobbles (60 %) and immediately after gravel extraction the proportion of the riverbed comprising cobbles was reduced to 23 %. Both studies detailed that any altered river habitat types (riffles, runs and pools and substrate size distribution) were observed to re-establish after a series of high flow events over a period of several months. Therefore, the degree that freshwater habitat is affected by the Project works will be dependent on the frequency and magnitude of high flow events that occur within Te Awa Kairangi and its catchment. It is important to note that even though re-establishment of habitats was observed, the riffle habitats were not completely comparable to the pre-gravel extraction condition. In terms of substrate diversity, this was observed to have re-established to a similar proportion to those recorded prior to extraction works occurred after seven weeks.

175. The proposed construction methodology details that gravel extraction works will take place over the indicative four-year construction period, and will be staged from downstream to upstream during seasonally allowed periods (i.e. approximately 120 days/year has been proposed to have no in-river works conducted). Each stage will only be worked on once with all aspects of in-river Project works being completed before moving to the next stage. This will minimise the extent of habitat being disturbed and effected at any one time and minimise the potential effects on the freshwater habitats that are present.

176. Overall, the Project works will affect a significant length of Te Awa Kairangi and the quality of freshwater habitat diversity and quality within each of the proposed staged reaches is likely to be reduced temporarily for a period of months (i.e. at least 7 weeks as detailed by Perrie 2013a[36]) after that stage of works is completed (depending on river flows post construction).

177.

178. With respect to the EcIAG, changes to freshwater habitats within Te Awa Kairangi could result in the temporary loss or alteration to one or more key habitat features of the existing baseline condition, such that the post-development habitat features will be partially changed. Specifically, such works often resulted in a reduction of pool and riffle habitat and an increase in run habitat, and nearly always a loss of hydraulic complexity and associated substrate diversity. This is

consistent with a Moderate magnitude of effects without any measures to avoid, remedy and mitigate effects (Table 4-6). The High ecological value of Te Awa Kairangi along with a Moderate magnitude of effect will result in an overall 'High' level of effects (Table 4-8). Due to a high level of effect on the freshwater habitat within the impacted reaches further measures are proposed to reduce and monitoring the level of effect in Section 7.

179. During Project works there will be additional areas of temporary bed disturbance within tributary streams during the construction of new or replacement culverts and pipe structures. The duration of works within the tributary streams is likely to be on a shorter time scale than that observed within Te Awa Kairangi due to the nature of works (e.g. culvert upgrade and replacement). Following the completion of these temporary works it is anticipated that disturbed riverbed (and as such freshwater habitats) within the impacted tributary streams will recover and any habitat is expected to quickly return to its pre-works condition (outside of the culverted reaches). The effects on the tributary streams will be on a smaller scale and will likely be localised and temporary with no lasting adverse effects on freshwater habitat quality anticipated.

180. As discussed above the adverse impacts within the tributary streams will be localised and temporary with no lasting effects on freshwater habitat anticipated. With respect to the EcIAG, the potential magnitude of effects without measures to avoid, remedy or mitigate from Project works on freshwater habitats within the tributary sites are 'Low' (Table 4-6) due to the temporary nature of the construction activity and only a minor shift away from existing baseline conditions resulting in an overall 'Low' level of effect (Table 4-8). Note that the effects of permanent habitat loss due to culvert works are addressed in a separate section below.

6.3.2 Temporary effects from Project works construction on freshwater fauna

181. The construction effects of the Project on freshwater fauna considered for this assessment are impacts of gravel extraction and temporary construction activities within Te Awa Kairangi and the tributary sites. During construction, disturbance of the riverbed as described in the previous section could directly impact on the freshwater fauna within each staged area. Project works activities such as gravel extraction disturbance, culverting, piping and temporary diversions can cause the stranding, injury, displacement, or mortality to freshwater fauna.

182. The magnitude of potential effect on freshwater fauna is driven by the nature of the activity, the area of disturbance, density of freshwater fauna in each area, the ability of fauna to escape direct impacts and the controls applied. The magnitude of effects on freshwater fauna for this project will be dependent on the amount of construction-undertaken within the wet river channel at each stage of the Project works.

183. In the following paragraphs I provide an assessment of Project works on aquatic macroinvertebrates and fish in Te Awa Kairangi and the tributaries separately

Te Awa Kairangi

184. Gravel extraction and temporary construction activities will have direct and immediate impacts on aquatic macroinvertebrate and fish communities within Te Awa Kairangi. However, once Project works are completed at the impacted site, it is anticipated that the macroinvertebrate and fish community will start to recover to pre-development state.

185. Results from macroinvertebrate surveys within Te Awa Kairangi indicate that a high-quality macroinvertebrate community generally comprising of a high proportion of sensitive EPT was recorded within the Project area. The diversity and abundance of sensitive macroinvertebrates within the assessed community contributes to the assessment of Te Awa Kairangi having high ecological value despite being a highly managed river.

186. As described in the previous section the Project works will affect a significant length of Te Awa Kairangi. As such within each of the proposed staged reaches there is likely to be temporary

reduction in macroinvertebrate community diversity and abundance after that stage of works is completed and while recovery occurs.

187. Work completed by Perrie (2013a[36] and 2013b[37]) on the effects on aquatic macroinvertebrates from localised gravel extraction activities within a 400 m riffle habitat of Te Awa Kairangi, showed that the macroinvertebrate fauna can recover to pre-extraction state within seven weeks. The type of gravel extraction activities assessed are similar to those proposed as part of the Project works and were over an impact reach of 400 m. The recovery timeframe outlined by Perrie (2013a[36] and 2013b[37]) also aligns with the recovery of the macroinvertebrate community to pre-works condition that is outlined in MWH (2016[7]). The results presented in the Perrie review (2013a[36] and 2013b[37]) and the MWH (2016[7]**Error! Bookmark not defined.**) report are not surprising as macroinvertebrate communities that inhabit gravel bed rivers that undergo natural periodic bed movements during flood flows are generally resilient to periodic disturbance.

188. A diverse fish community is present within Te Awa Kairangi Project area, of which several 'At risk' and one 'nationally vulnerable' species where identified. Of these, bluegill bully were the dominant species identified. It is likely that overall, this species is most at risk from direct impacts due to gravel extraction. Primarily, as bluegill bully were the numerically dominant species, and are expected to spawn and live within the swift water clean cobble areas within riffle habitats of Te Awa Kairangi. I consider that bluegill bully is a good indicator species to inform an assessment of effects from gravel extraction works on fish species within Te Awa Kairangi.

189. Perrie (2013b[37]) compared the effect of gravel extraction on the densities of bluegill bully before and after gravel extraction works (between late November and early February) and at sites upstream, within and downstream of the works. The study focused on the effect of gravel extraction from an approximate 400 m reach of Te Awa Kairangi upstream of the Kennedy Good Bridge and provides an indication of potential impacts on resident fish species after gravel extraction has occurred.

190. The study showed that there was a significant reduction in observed bluegill bully densities at and upstream of the gravel extraction site, and a steady increase in bluegill bully density was observed at the downstream site. The decrease in observed fish density at the upstream site, which is effectively a control/unimpacted site, and the increase at the downstream site shows that the effect on the fish community is not as straight forward as initially anticipated. Therefore, it is not conclusive whether effects on Bluegill bully upstream of impacted reaches can be attributed to gravel extraction, there is the potential for restrictions to upstream movements or movements associated with spawning behaviours to occur. The results discussed in Perrie (2013b[37]) detail that the bluegill bully population is potentially affected by multiple interconnected impacts that included:

i. The change from preferable habitat (riffle) to non-preferable habitat (run) at the impact site;

ii. Displacement of bullies at the impact site to downstream habitats during gravel extraction;

iii. The restriction of upstream movement of bluegill bully; and

iv. Potential changes to fish movement associated with spawning behaviour.

191. With respect to this project, the above monitoring data suggests that impacts on freshwater fauna from gravel extraction within Te Awa Kairangi generally observed a recovery to pre-extraction state after seven weeks.

192. Overall, it is anticipated that effects of gravel extraction and other temporary construction activities on fish and macroinvertebrate communities will occur at the impact sites within Te Awa Kairangi. The proposed construction methodology details that work will take place over the indicative four-year construction period and will be staged from downstream to upstream during seasonally allowed periods (i.e. approximately 120 days/year has been proposed to have no in-river works conducted). Each stage will only be worked on once with all aspects of in-river Project works being completed before moving to the next stage. Similarly, any structures associated with temporary construction activities will later be removed as part of bed reprofiling works that are to take place at the culmination of the staged works. Although Project works are short term and temporary in nature, it is considered likely that gravel extraction works will contribute to a temporary decline of fish and macroinvertebrate abundance and diversity within impacted areas during site works and after works have been completed for several months.

193. The proposed duration of the separate gravel extraction stages and the temporary construction activities are consistent with the EcIAG 'Temporary – construction phase' scale (Table 4-7) which is relevant to determining magnitude of effect. It is probable that any effects could last in the order of seven weeks (based on previous studies) post the completion of each stage until the macroinvertebrate and fish community can recover to pre-impact state through downstream drift (for macroinvertebrates) and recolonisation of habitat (for fish). In terms of the downstream drift of macroinvertebrates to impacted gravel extraction areas, there are sources of healthy and diverse macroinvertebrate communities located upstream of the Project area (i.e. at Manor Park (Table 5-3)), and these could resource the recolonisation of impacted areas. While there may be a partial change from the baseline condition, overtime the underlying character of the environment will be similar to predevelopment. This will primarily occur through the downstream drift from upstream habitats providing a source for the recolonisation of the macroinvertebrates to impacted areas and fish species moving back into the habitat once Project works have been completed.

194. I consider that any decrease in the abundance and diversity of the fish and macroinvertebrate community within Te Awa Kairangi during Project works (e.g. gravel extraction and temporary construction activities) could result in the baseline conditions being ‘partially changed’ temporarily. This is consistent with a ‘Moderate’ magnitude of effects <u>without measures to avoid, remedy or mitigate</u> (Table 4-6). The High ecological value of Te Awa Kairangi along with a Moderate magnitude of effect will result in an overall ‘High’ level of effects (Table 4-8) <u>without any measures to avoid, remedy and mitigate</u>. Due to a high level of effect on the freshwater fish community within the impacted reaches further measures are proposed to reduce and monitor the level of effect in Section 7

Tributary sites

195. The main potential for adverse effects during Project works to the macroinvertebrate and fish community within the tributaries relates to stream bed disturbance during culverting and piping. As discussed in previous sections, negative impacts within the tributary streams will be localised and temporary with no lasting effects on freshwater habitat. Due to the small scale (area of ground disturbance) and temporary nature of the proposed works I do not anticipate that any changes to macroinvertebrate and fish communities would occur beyond the area of immediate bed disturbance.

196. Within the tributaries any Project works that will potentially effect macroinvertebrate communities are likely to impact considerably less stream bed than what is anticipated within Te Awa Kairangi. Therefore, there is likely to be less overall impact on the macroinvertebrate community present within the effected reaches. Any effects are expected to be short term and temporary (as per the EcIAG definition in Table 4-7).

197. The fish population present in the tributary streams was sparse and appeared to be restricted to shortfin eel and banded kōkopu (both are non-threatened native species). No other records of fish were available for any of the tributary sites.

198. Although fish diversity and abundance within the tributary sites was low, Project works still have the potential to impact directly on any fish species that may be present. Any effects are expected to be short term and during the construction phase of the Project (as per the EcIAG definition in Table 4-7) and are expected to potentially have only a discernible change to the baseline condition. This is consistent with a potentially low magnitude of effects. Following completion of Project works the underlying character of the environment will be similar to predevelopment where there hasn't been a loss in open stream length.

199. As discussed above the impacts within the tributary streams will be localised and temporary with no lasting effects on freshwater fauna. Overall, the potential magnitude of effects <u>without any measures to avoid, remedy and mitigate</u> from Project works on freshwater fauna within the tributary sites are 'Low' (Table 4-6). Due to the temporary nature of the construction activity and only a minor shift away from existing baseline conditions. This results in an overall 'Low' level of effect (Table 4-8).

6.3.3 Temporary effects from sediment and cement wash discharges on water quality and freshwater ecology

200. Construction activities will involve land-based earthworks and the disturbance of riverbed material from dry areas of the bed and within flowing water. These activities can cause the mobilisation of fine sediments into the water column. In the absence of controls, there is potential for uncontrolled discharges of disturbed sediment into the receiving environment during Project works.

201. Sediment discharges during Project works have the potential to elevate suspended sediment, reduce water clarity and result in excess deposited sediment on the riverbed with subsequent effects on in-stream ecology. Adverse effects to freshwater fauna include affects to feeding and food supply, disrupting freshwater fish migration and spawning and smothering and clogging benthic habitats.

202. The magnitude of the effects of suspended and deposited sediment on freshwater habitat and fauna will be dependent on the amount of sediment (in terms of the concentration of suspended sediment), the spatial extent of any plume or deposition and the duration of exposure. Information on the characteristics of Te Awa Kairangi bed sediments, the likely duration of suspended sediment events following disturbance and likely deposition areas is provided in the following paragraphs.

203. **Mr Breese** (sediment water quality) and **Mr Williams** (geomorphology) have indicated that the results from Cameron (2018) (see Figure 6-4) are representative of the bed material within the Project footprint that would be disturbed. Based on these results and the advice from the Project experts I have assumed that there will be limited disturbance and subsequent transport of very fine material (i.e. clays and silts <63 µm) to the downstream freshwater receiving environment throughout the Project works phase.

204. However, the mobilisation of fine sand particles (i.e. particles between 0.06 - 2mm) into the water column and subsequent deposition on the river bed downstream of Project works (including downstream of the Project area) will likely occur. Sand sized particles are important also as these can adversely impact the benthic habitat quality when deposited on the riverbed and subsequently freshwater fauna. Figure 6.1 suggests that the Te Awa Kairangi in the project area has approximately 10 % sands.

205. **Mr Breese** outlines that elevated turbidity levels due to suspended sediment are likely to clear within an hour of works finishing or the conclusion of a flood event when high flows can wash out recently disturbed sediment. During low to normal flows, sediment transport is typically limited, and ambient water quality is clear with a turbidity ranging from 0.3-19 NTU (GWRC turbidity data at Boulcott 2003-2020; the upper limit represents 90th percentile from 236 turbidity grab samples between 2003-2020, GWRC environmental data portal). While median turbidity levels at Boulcott are 1.6 NTU. Additionally, any elevated levels of suspended sediments due to Project works will occur for no longer than 12 hours at a time (in any 24-hour period). **Mr Williams** notes that the larger particles will drop out of suspension around 500 m downstream of the impact site.

206. Furthermore, **Mr Breese** has detailed that fine sediment particles being transported down Te Awa Kairangi will settle out of the water column and can accumulate in the lower reaches (i.e. between Ewen Bridge and Seaview Bridge at Waione Street). There are a number of factors which drive sediment accumulation within this reach:

   i. The gradient of the river becomes gentle as it approaches the harbour, slowing flow velocity and reducing the turbulent forces which kept particles in suspension. The result is sediment particles are allowed to settle under gravity.

   ii. The salt water from Wellington Harbour influences the fate of suspended sediment in the fresh water because the saline water causes suspended sediment particles to flocculate (join together) and settle to the riverbed. The influence can range from the Mouth to upstream at Ewen Bridge.

207. There is potential for an increase in deposited sediment within the lower Te Awa Kairangi (immediately downstream of the Project area) during the earthworks phase of stages located at the downstream extent of the Project area. For clarity, it is anticipated that potential impacts from coarser sized fine sediment particles (e.g. 0.06 – 2 mm sized) will occur immediately downstream of the Ewen Bridge within around 500 m downstream from the source of impact. As coarser sized particles will most likely fall out of suspension within this lower reach (between Ewen Bridge and Seaview Bridge at Waione Street), this may result in a cumulative effect of sedimentation (of 0.06 – 2 mm sized particles only) in this reach, as there is likely to be resuspension of this sediment associated with the works.

208. In the following paragraphs I provide an assessment of ecological effects of suspended and deposited sediments, and cement wash on Te Awa Kairangi and the tributaries within the Project area.

Suspended sediment effects

209. On the basis of the above, the main potential for river ecology effects from suspended sediment immediately downstream of the impact sites relates to the temporary reduction in water clarity and the impact of this on the feeding ability of fish, and disruption to fish passage and upstream migrating fish species.

210. NIWA has established turbidity limits to protect fish in New Zealand rivers for base-flow conditions when long-term exposure to sub-lethal turbidity’s may affect fish behaviour and reduce their populations[39]. Banded kōkopu migrants were the most sensitive fish species tested and NIWA suggested that limits should be applied during their migration periods (August to December, inclusive) of 20 NTU. Banded kōkopu have been recorded within the Project area, both within Te Awa Kairangi and the tributary sites, and there are multiple records within the

[39] https://niwa.co.nz/our-science/freshwater/tools/turbidity/base.

wider Te Awa Kairangi catchment. It is therefore reasonable to base an assessment for this project on limits for banded kokopu.

211. With reference to Paragraphs 199 and 201, it is not anticipated that there will be a significant amount of sediment (within <63 μm size fraction) released during Project works and subsequently any adverse effects (from the <63 μm size fraction) on water clarity are expected to be temporary in nature. Likewise, disturbance and temporary sediment discharges within the 0.06 – 2.00 mm size fraction will be limited to the period of the works and shortly after (hours) and may result in a slight reduction in clarity within the mixing zone to conditions similar to or less than what would occur during flood flows, which can reach up to 470 mg/L for total suspended solids and 260 NTU for turbidity (refer to total suspended solids and turbidity data for Boulcott presented in Table 5-2).

212. Within the tributary sites fine sediment (recorded as the proportion of the stream bed covered by sediment < 2 mm in size) was typically recorded to cover between 10 – 60 % at Harbour View Stream and 30 % at Tirohanga Intersection Stream of the stream bed. Any in-stream works undertaken within these tributary sites is likely to remobilise this sediment. However, similarly to the above, this will be limited to the period of works and shortly after and may result in a slight reduction in clarity within the mixing zone. Due to the nature of construction activities within the tributaries (e.g. culvert replacement) any adverse impacts within the tributary streams will be localised and temporary with no lasting effects on freshwater habitat.

Deposited sediment effects

213. The main potential for river ecology effects from deposited sediment immediately downstream of the impact sites relates to the temporary potential effect to fish spawning habitat, food supply, and habitat by smothering and clogging benthic habitats.

214. The mobilisation of fine sand particles (i.e. particles between 0.06 - 2mm) into the water column and subsequent deposition on the river bed downstream of Project works within Te Awa Kairangi will likely occur. The deposition of sediments within the lower Te Awa Kairangi (downstream of the Project area) may also be compounded by reduction of river gradient and the flocculant effect that salt water has on fine sediments. During Project works the find sand particles may have a cumulative effect on this lower Te Awa Kairangi reach. Any mobilisation of fine sand particles and the subsequent deposition on the riverbed will be temporary and only occur during Project works and will only impact the immediate environment downstream of the impact site.

215. As discussed above, the tributary sites are already impacted by moderate deposition of fine sediment and due to the nature of construction activities within the tributaries (e.g. culvert replacement) the negative impacts within the tributary streams will be localised and temporary with no lasting effects on freshwater habitat.

Cement wash effects

216. There is the potential for cement wash to be released during Project works during the construction of bridge pile structures. The release of cement wash can cause temporary changes to water quality (specifically pH) that has the potential to affect the freshwater fauna present within the Project area and downstream in the lower Te Awa Kairangi.

217. Cement wash water and runoff from recently placed cement are of particular concern within aquatic habitats due to its detrimental effect on in stream fauna. Cement wash water and runoff has a high lime content which is water soluble (dissolves easily in water) and can drastically increase the pH of a waterway. The alkalinity can kill or severely burn aquatic life. For fish, the alkalinity is exceptionally damaging to sensitive gill structures. Following the completion of the specific construction activities that require the use of cement the potential effect is likely to be negligeable.

Magnitude of effects from sediment and cement wash discharges during Project works

218. The uncontrolled discharges of disturbed sediment and cement wash into the receiving environment during Project works could result in a short-term temporary change from the baseline conditions during Project works. I consider the effects of sediment and cement wash on Te Awa Kairangi (both within and downstream of the Project area) during Project works could result in the baseline conditions being 'partially changed' temporarily. This is consistent with a moderate magnitude of effects (Table 4-6) without any measures to avoid, remedy and mitigate these effects. The High ecological value of Te Awa Kairangi along with a Moderate magnitude of effect will result in an overall 'High' level of effects (Table 4-8). Due to a high level of effect on water quality and freshwater ecology within and downstream of the impacted reaches further measures are proposed to manage this effect and monitoring the level of effect is proposed in Section 7.

219. Project works specifically undertaken within the tributaries is likely to occur over a period of several years (e.g. works within the tributaries is expected to be completed within Stage 4 and Stage 5, see Project Construction Methodology in Section 5 of the AEE). However, the actual construction works within the streams are anticipated to only last several weeks and effects are expected to be short term and temporary (Table 4-7) and following completion of Project works, the magnitude of effect relating to sediment will reduce to low (Table 4-6) without any measures to avoid, remedy and mitigate these effects. That is, while there may be a discernible change from the baseline condition, the underlying character of the environment will be similar to predevelopment. Moderate ecological value along with a 'Low' magnitude of effect will result in a 'Low' overall level of effects without mitigation (Table 4-8).

6.3.4 Temporary effects of Project works construction on fish spawning and migration

220. This section considers the potential effects of temporary construction generated sediment and modifications to habitat on fish spawning and migration within and downstream of the Project area.

Spawning

221. The main potential effect on spawning activities is the discharge of sediment during construction and the removal, disturbance or modification to spawning habitat.

222. Multiple fish species present in Te Awa Kairangi catchment utilise available habitat in the catchment for spawning. Of particular note is the identification of potential inanga spawning habitat within the lower Te Awa Kairangi nearer the section of tidal influence (see Figure 5-4). In addition to inanga, bluegill bully are also known to spawn in the clean gravel/cobble reaches of the Project area and the kōkopu species may spawn in the immediate riparian vegetation of the tributaries if appropriate habitat is available.

223. Based on the regional fish spawning calendar[40] peak spawning periods for species known to be present within and downstream of the Project area are as follows:

i. Giant and banded kōkopu, the spawning period is April through to August;

ii. For bluegill and common bully the spawning period spans September through to February; and,

iii. For inanga the spawning period spans March through to June.

224. The gravel extraction construction phases outlined in Project Construction Methodology in Section 5 of the AEE details that Project works are likely to occur during the above spawning periods. Therefore, there is potential for the proposed works to effect one or more key elements of the existing spawning habitat for fish species likely to spawn within the Project area.

Additionally, without a robust management and monitoring plan the loss of a moderate proportion of the known population or range of the key identified species could occur. This could result in a partial change in the existing baseline compositions of fish populations that spawn within the Project area, this is consistent with a moderate magnitude of effect (Table 4-6).

225. The High ecological value within and downstream of the Project area within Te Awa Kairangi along with a moderate magnitude of effect will result in an overall level of effects of high (Table 4-8) without any measures to avoid, remedy and mitigate. While the Moderate ecological value within the Project area tributaries along with a moderate magnitude of effect will result in an overall level of effects of 'Moderate' (Table 4-8) without any measures to avoid, remedy and mitigate. Due to a moderate level of effect on the fish spawning within and downstream of the impacted reaches further effects management measures and monitoring the level of effect are proposed as set out in in Section 7

Migration

226. Multiple fish species present in the wider Te Awa Kairangi catchment migrate both upstream and downstream within the main Te Awa Kairangi and to the many of the tributary streams during different stages of their lifecycle.

227. A range of native fish (and trout) will likely be present within or migrate through the river past the site, several of which are classified as At Risk and on is classed as Threatened. Of the species known to undertake migration within the Project area the following migration periods[40] are relevant:

i. Lamprey upstream adult migration occurs between June to December;

ii. Longfin and short fin eel upstream juvenile migration peak occurs from December to April;

iii. Kōaro, banded kōkopu, and giant kōkopu have an upstream juvenile migration occurring from August to November in general;

iv. Common bully upstream juvenile migration occurs from October to February;

v. Bluegill and redfin bully upstream juvenile migration occurs from November to December; and

vi. Inanga upstream juvenile migration occurs from May to November.

228. When all of these species are considered together, the peak migration seasons cover most of the year and can therefore not be avoided. However, the Project works area within the riverbed will be undertaken in a staged approach from downstream to upstream. This proposed duration of the separate gravel extraction stages is consistent with the EcIAG 'Temporary – construction phase' scale (Table 4-7) which is relevant to determining magnitude. In addition, **Mr Breese** outlines that elevated turbidity levels are likely to clear within an hour of works finishing or the conclusion of a flood event when high flows can wash out recently disturbed sediment, and elevated levels of suspended sediments will occur for no longer than 12 hours at a time (in any 24-hour period). As a result, fish passage will be maintained within the river during Project works for an approximate 11-hour period, during this time fish will be able to make their way past while avoiding the construction area.

229. The gravel extraction construction phases and stages which include works in the tributarily sites outlined in Figure 6 3 shows that Project works are likely to occur during the above migration periods. Therefore, there is potential for the proposed works to effect one or more key elements of the existing population or range for migrating fish species within the Project area. This could

[40] Schedule F1a of the proposed Natural Resources Plan

result in a temporary partial change in the existing baseline composition of the fish community, this is consistent with a moderate magnitude of effect (Table 4-6).

230. The High ecological value within and downstream of the Project area within Te Awa Kairangi along with a moderate magnitude of effect will result in an overall level of effects of high (Table 4-8) without any measures to avoid, remedy and mitigate. While the Moderate ecological value within the Project area tributaries along with a moderate magnitude of effect will result in an overall level of effects of 'Moderate' (Table 4-8) without any measures to avoid, remedy and mitigate. Due to a high level of effect on the fish migration within the Project area further effects management measures and monitoring the level of effect are proposed as set out in in Section 7.

6.4 Assessment of operational effects

231. This section provides an assessment of the actual and potential operational effects of the Project on freshwater ecology values. These include:

i. Permanent modification of freshwater habitat as a result of piling, stream piping, and river channel retraining activities; and

ii. Potential changes to background levels of cyanobacteria and nuisance periphyton growths due to changes to hydrological characteristics and local channel morphology of Te Awa Kairangi at RiverLink.

6.4.1 Effects on freshwater habitat from bridge piling and rock lining of the river bank

232. The replacement Melling Bridge, the pedestrian bridge, and rock lining on the river bank will result in permanent features being constructed both on the riverbanks and within Te Awa Kairangi river channel. Current design indicates that three piles will be constructed within or immediately adjacent to the active river channel for the replacement Melling Bridge, and one pier will be constructed immediately adjacent to the active river channel for the pedestrian bridge, while rock lining work will be limited to downstream areas of the Project area and restricted to river banks only

233. Details on the piling construction methodology are provided in the construction methodology of the AEE. In brief the preliminary design shows that a 4 m diameter pier structure will be constructed at each of the bridge piles. The construction methodology within the AEE details that the design of the two bridges has been optimised to minimise the number of piers within the main river channel. Mr Williams notes that the rock lining work will be undertaken to provide stronger bank edge protection, by lining the banks with a blanket of graded rock material.

234. The permanent riverbed disturbance due to occupation by permanent structures as part of the proposal would be relatively small and localised in extent (approximately 53 m^2 will be permanent loss of surface riverbed habitat due to bridge pilling).

235. I consider that any permanent riverbed disturbance from the occupation of the river bed by bridge piles and rock lining of the banks will result in only a minor change from the baseline condition due to the minor loss of riverbed habitat. The loss of habitat is not anticipated to change the known freshwater fauna community present in the impacted reach. The removal of the old Melling bridge will at least partially mitigate for the lost habitat at the new Melling bridge. As Mr Williams notes there will also be a gain in riverbed area within the lower reach of the Project area, this will also provide a mitigation for any effect on riverbed from the rock lining. Once Project works have been completed the underlying character of the Te Awa Kairangi will revert to a condition similar to that observed pre-development. This is consistent with a potentially Low magnitude of effects (Table 4-6).

236. The magnitude of effect, without any measures to avoid, remedy and mitigate, of the Project related to effect on freshwater habitat from bridge construction, is low due to a minor change in the baseline condition, however, this is not anticipated to change the known freshwater fauna community present in the impacted site.

237. High ecological value within Te Awa Kairangi along with a low magnitude of effect will result in an overall level of effects of 'Low' (Table 4-8). No further effects management is considered necessary.

6.4.2 Stream habitat loss at Harbour View Stream

238. The current design shows that the middle reach of Harbour View Stream is to be realigned and piped to the south of its current position. The affected reach will be where the additional SH2 lanes are required for the new interchange. This will result in the loss of approximately 25 linear metres of stream habitat to infilling (hardfill and structural fill). As outlined above, the section of stream that is to be infilled has been assessed as having Moderate value.

239. Mr Ingles' technical assessment (Stormwater and Water Quality Technical Assessment #2 – Volume 4 of the Application) details that the loss of this open channel has been identified within the Project design as being unavoidable. Mr Ingles outlines that this is due to the relocation of the Melling bridge (i.e. location of Melling bridge abutment) and widening of SH2. Post the construction of the Melling bridge and SH2 realignment the stream reach will not be able to be reinstated due to topographical and spatial constraints. Additionally, the new piped section will not provide fish passage as it is being connected to the very steep existing pipe which conveys water under Harbour View Road. The replacement pipe will therefore have a grade and size required to tie into this existing upstream network which will prevent fish passage from occurring. The loss of this section of stream will alter the existing baseline features of the reach. Additionally, the proposed loss of stream length will fundamentally change the post-development composition of the affected reach. This aligns with a 'High' level of effect (Table 4 2)

240. The loss of the Harbour View Stream reach cannot be avoided, remedied or mitigated so should be offset. A suitable method needs to be followed to provide mitigation for the loss of stream habitat through an offset. The PNRP details that offsetting may be undertaken following a suitable biodiversity offsetting accountancy method. The Stream Ecological Valuation (SEV)[41] method represents a good practice method for determine the actual/ potential stream value at the impacted site and any proposed offset site. The SEV method provides an assessment of the quantum of offset that will be required to mitigate the loss of the affected reach (see Section 7 for more details on the proposed offset approach).

6.4.3 Effects on fish passage through the replacement of culverts

241. Many of New Zealand's native fish are diadromous, meaning they migrate to and from the sea as part of their lifecycle. Artificial structures and poor culvert design can restrict fish migration. Often this occurs as a result of culverts being perched, too steep or long, subsequent increases in water flow or a resultant laminar flow with insufficient roughness to allow effective fish movement[42]. The resultant decrease in fish mobility can result in fragmented populations, a reduction in population size, and limiting overall available habitat for freshwater fauna.

242. Consideration of fish passage is relevant to the tributary sites of the Project area. Each of the tributaries have specific design considerations that are assessed individually in respect of effect

[41] Neale M W, Storey R G, Rowe D K, Collier K J, Hatton C, Joy M K, Parkyn S M, Maxted J R, Moore S, Phillips N and Quinn J M (2011). Stream Ecological Valuation (SEV): A User's Guide. Auckland Council Guideline Document 2011/001.
[42] Franklin, P., Gee, E., Baker, C. and Bowie, S. (2018). New Zealand Fish Passage Guidelines for Structures up to 4 metres. NIWA CLIENT REPORT No: 2018019HN.

on fish passage. As much as practicable, the NZ Fish Passage Guidelines[46] and the relevant clauses in the NES for freshwater have been considered in the design of the Project culverts.

Tirohanga Stream

243. Project works that are occurring within this area are not expected to have an effect on the current culvert placement or alignment. Therefore, there is no expected effects to fish passage from the intended Project works.

Tirohanga Intersection Stream (Outlet 38)

244. Currently the SH2 culvert that interacts with the Tirohanga Intersection Stream is not providing full fish passage due to the outlet of the culvert being perched. Migratory fish (e.g. shortfin eel and banded kōkopu) were identified upstream of the culvert, this indicates that fish passage is occurring at times. However, passage is likely limited by high water velocity, culvert gradient, length of culvert, and the outlet perch which is probably restricting fish passage to climbing species only.

245. The Project works will see the Tirohanga Intersection culvert replaced with a culvert that is in accordance with the NZ Fish Passage Guidelines Stream Simulation design principals[46]. By following these best practice outcomes within the Guidelines there is likely to be an improvement in fish passage at this culvert. Additionally, by meeting the Stream Simulation design principals the permitted activity standards in the NES for Freshwater will be met. Therefore, if all Stream Simulation design principles within the Guidelines are followed and the culvert is constructed to these designs then there is potential to see a positive effect on fish passage within the Tirohanga Intersection Stream.

246. A positive magnitude of effects on fish passage within this stream catchment will result in a net gain in freshwater ecological values (Table 4-8).

Harbour View Stream (Outlet 36b)

247. Fish passage is currently restricted in the Harbour View Stream by the perched upstream culvert outlet and extensive piped sections under SH2 and Harbour View Road (approximately 120 m and 90 m, respectively). Of which the Harbour View Road piped section is of high gradient with associated high flows. No fish or koura (freshwater crayfish) were observed during the survey of the open channel reach.

248. The new piped section will have pipe gradient and size that it ties into the existing upstream network, which will prevent fish passage from occurring.

249. Due to the loss of existing open channel, these works may result in a change to the baseline condition. Currently, fish passage to the open channel of Harbour View Stream (from Te Awa Kairangi) is potentially restricted to climbing species (e.g. banded kōkopu, shortfin eel) that can utilise the wetted edge to pass through piped sections, especially when velocities within the pipe are low.

250. Mr Ingles details in his Stormwater and Water Quality technical assessment that due to the design not replacing the upstream pipe (under Harbour View Road), any flows in the new piped section will be extremely high velocity which will prevent fish passage. Similarly, Mr Ingles further details that the required grade and size of the new piped section will not allow fish passage.

251. The piping of the open channel will result in further restrictions to any potential or future fish passage. Fish passage effects already exist due to the length of stream currently piped and its gradient under State Highway 2 and the gradient and high velocities within the upper Harbour View Road piped section. However, through piping the remaining section fish passage will be further limited which may result in the potential loss of the range of species known from the

area. I conclude that the magnitude of effect, without any measures to avoid, remedy and mitigate, is 'High' (Table 4-6).

252. Moderate ecological value along with a high magnitude of effect will result in an overall level of effects of 'High' (Table 4 2). As detailed in Paragraphs 234 and 236, the loss of stream habitat to infilling and diversion of flow through replacement piping is unavoidable and cannot be remedied nor mitigated. This is similarly aligned with the effects on fish passage. Therefore, effects should be offset, following a suitable biodiversity offsetting accountancy method.

Jubilee Park (Outlet 31)

253. The design includes the upgrade and replacement of the culvert outlet (Outlet 31) at Jubilee Park. It is my understanding that that there are no works that will incur the loss or disturbance of stream habitat (outside of that which is expected during culvert upgrading). Outlet 31 discharges flows from three catchments, namely the Jubilee Park Stream catchment and two small stormwater catchments immediately to the east. Outlet 31 will not be designed in accordance with NESFW culvert requirements; however, the use of automated back flow prevention structures will be in accordance with NESFW requirements for flap gates, which means works to this culvert will not preclude fish passage should passage become possible in future.

254. Cyanobacteria and periphyton growth

255. As outlined in Section 3 the Project works will result in the permanent modification of approximately 3 km of Te Awa Kairangi. This will result in changes to the morphology of the river channel, and in turn could result in changes in local river hydrology (including water velocity and water depth). When these changes occur naturally, they have been shown to impact on growth rates, composition, distribution, and abundance of cyanobacteria and periphyton species at a site[29 30 43].

256. Habitat conditions that are most likely to favour periphyton and cyanobacteria growth include**Error! Bookmark not defined.Error! Bookmark not defined.**[44]:

   i. A low frequency of flood events;

   ii. Long duration stable low flows and the subsequent increases in water temperature associated with low water velocity and depth;

   iii. High availability of plant nutrients (soluble nitrogen and phosphorus); and

   iv. High proportions of favourable substrate for biomass development (e.g. cobbles).

257. Of the above conditions, the completed Project works may have an effect on the type and pattern of river hydraulics that can influence the water velocity and depth such by creating an increase in run habitat, and nearly always a loss of hydraulic complexity and associated substrate diversity. This can subsequently impact water temperature. These changes may result in favourable conditions for periphyton and cyanobacteria to grow, when combined with available plant nutrients and a favourable substrate type.

258. For the purpose of this assessment, I have considered the effects the Project will have on water velocity and water depth that has been modelled by **Mr Pennington**. The outputs from **Mr Pennington's** model will provide an indication of potential effects to cyanobacteria and periphyton growth during a low flow scenario (7DMALF), median flow, and a high flow (flows three times the median flow as an indicator of flushing frequency).

Low flow scenario

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[43] Heath, M.W., Greenfield, S. 2015. Benthic cyanobacteria blooms in rivers in the Wellington Region. Findings from a decade of monitoring and research. Environmental Science Department. Greater Wellington Regional Council

259. The 7DMALF model (flows = 3.6 m^3/s) has been used to predict changes to low flow water depth and velocity within Te Awa Kairangi Project area. Results of the model output for water depth are shown in Appendix C. This shows the modelled changes to velocity and water depth within Te Awa Kairangi during 7DMALF conditions.

260. Results show that the extent and distribution of deeper sections in Te Awa Kairangi during 7DMALF flow conditions would incur minor changes to the existing baseline conditions. Overall, the only apparent change in depth that may influence cyanobacteria and periphyton is the reduction in water depth observed downstream of the Kennedy Good Bridge.

261. Other observed changes include an increase in depth at the downstream extent of Te Awa Kairangi at RiverLink. An increase in depth is unlikely to result in more favourable habitat conditions or an increase in water temperature that would favour increased growth in either benthic cyanobacteria and/or periphyton.

262. Similarly to water depth, the modelled results for velocity showed small changes to the extent and distribution of higher velocity areas. These are mainly tied to where Te Awa Kairangi will be widened or constricted. Where constrictions are to take place higher velocity sections are observed during these low flow conditions compared to the existing situation. Lower flow sections post-development occur at the downstream extent where water depth has increased.

263. Overall, the modelled variations in low flows (i.e. 7DMALF) pre and post development do not predict a large impact on the distribution and extent of water depths and velocities. Any observed changes are not likely to change the extent of cyanobacteria and periphyton growths through changes to channel morphology.

Median flow scenario

264. The median flow model (flows = 15 m3/s) has been used to predict changes to what would be considered an approximately normal condition. The model shows water depth and velocity within Te Awa Kairangi Project area.

265. Results show that the extent and distribution of deeper sections in Te Awa Kairangi during median flow conditions would result in minor changes to the existing baseline conditions. Overall, the most apparent change in depth that may have an effect on cyanobacteria and periphyton is the reduction in water depth observed downstream of the Kennedy Good Bridge (similar to that observed during 7DMALF conditions). Other observed changes include an increase in depth and extent of deeper sections at the downstream extent of Te Awa Kairangi. An increase in depth is unlikely to result in an increase in favourable habitat or water temperature that would favour increased growth in either cyanobacteria and/or periphyton relative to the existing situation.

266. Similarly, to water depth, the modelled results for velocity showed minor changes to the existing baseline conditions. These are mainly tied to where Te Awa Kairangi will be widened or constricted. Were constrictions are to take place, higher velocity sections are observed during these median flow conditions. Lower flows sections post-development occur at the downstream extent where water depth has increased.

267. Overall, the modelled variations in median flows pre and post development do not appear to have a large impact on the distribution and extent of water depths and velocities. Any observed changes are not likely to change the extent of cyanobacteria and periphyton growths through changes to channel morphology. Composition will be similar to pre-development circumstances.

High flows scenario

268. The 3 x the median flow (flows = 45m^3/s) has been used to predict changes to high flow water depth and velocity within Te Awa Kairangi Project area. The model shows water depth and

velocity within Te Awa Kairangi. Results of the model output for water depth are shown Appendix C.

269. High flows are relevant as they allow the flushing and scouring of periphyton and cyanobacteria from the habitat. The Project won't change the extent and frequency of flushing flows (e.g. FRE3 flow events), however there is potential for the works to affect how the riverbed scours and moves during these flow conditions.

270. The modelled results for velocity showed minor changes to the existing baseline conditions. These are mainly tied to where the Te Awa Kairangi will be widened or constricted post-development. Where constrictions are to take place, higher velocity sections are observed during these high flow conditions. Higher flow sections post- development occur within the middle to upper RiverLink extent where water depth has generally increased.

271. Overall, the modelled variations in high flows pre and post development do not appear to have a large impact on the distribution and extent of velocities that will scour and flush periphyton and cyanobacteria. Any observed changes are not likely to change the extent of cyanobacteria and periphyton growths. Composition will likely be similar to the pre-development scenario.

Summary - effects on cyanobacteria and periphyton communities within Te Awa Kairangi Project area

272. Modelling undertaken by **Mr Pennington** indicates the change in river channel morphology on river hydraulics and water depth will result in minor changes to the existing baseline conditions. These changes to river hydraulics and water depth are likely to have a minor effect on the known range of cyanobacteria and periphyton within the Te Awa Kairangi at RiverLink relative to the current situation.

273. The magnitude of effect of the Project related to the effect on cyanobacteria and periphyton is 'Low' due any anticipated change to not affect the baseline range of cyanobacteria and periphyton within the Te Awa Kairangi.

274. 'High' ecological value along with a 'Low' magnitude of effect will result in an overall level of effects of 'Low' (Table 4). No further effects management is therefore considered necessary.

• Summary of overall effects without <u>measures to avoid, remedy or mitigate</u>

275. Table 6-2 provides a summary of the effects addressed in this freshwater ecological assessment. Overall, the effects on river ecological values associated with the Project works within and downstream of the Project area, and the tributary sites ranged between Low and High without <u>measures to avoid, remedy or mitigate</u>. Therefore, the overall level of effect on river ecological values is High <u>measures to avoid, remedy or mitigate</u>.

276. Given the Project works and design, and overall level of effect on ecological values as determined through this assessment has identified effects as being greater than 'moderate', further effects management measures will need to be identified and included as part of the proposal.

Table 6-2 Summary of all ecological values, magnitude of effect, and the overall level of effects without measures to avoid, remedy or mitigate

Effect	Ecological value	Magnitude of effect without measures to avoid, remedy or mitigate	Overall level of effect without measures to avoid, remedy or mitigate
Temporary effects from Project works construction on freshwater habitat			
Project Area – Te Awa Kairangi and the Lower Te Awa Kairangi	High	Moderate	High
Project area – Tributary sites	Moderate	Low	Low
Temporary effects from Project works construction on freshwater fauna			
Project Area – Te Awa Kairangi and the Lower Te Awa Kairangi	High	Moderate	High
Project area – Tributary sites	Moderate	Low	Low
Temporary effects from sediment and cement wash discharges on water quality and freshwater ecology			
Project Area – Te Awa Kairangi and the Lower Te Awa Kairangi	High	Moderate	High
Project area – Tributary sites	Moderate	Low	Low
Temporary effects from Project works construction on fish spawning and migration			
Fish spawning – Te Awa Kairangi	High	Moderate	High
Fish spawning – Tributaries	Moderate	Moderate	Moderate
Fish migration – Te Awa Kairangi	High	Moderate	High
Fish migration – Tributaries	Moderate	Moderate	Moderate
Operational effects from the Project			
Effects on freshwater habitat from bridge piling and rock lining of the river bank – Te Awa Kairangi	High	Low	Low
Stream habitat loss at Harbour View Stream	Moderate	High	High
Fish passage: Tirohanga Intersection Stream (Outlet 38)	Moderate	Positive	Net Gain
Fish passage: Harbour View Stream (Outlet 36b)	Moderate	High	Moderate
Permanent effects on cyanobacteria and periphyton due to changes to stream hydrology	High	Low	Low

7. MEASURES TO AVOID, REMEDY OR MITIGATE ACTUAL OR POTENTIAL ADVERSE FRESHWATER ECOLOGICAL EFFECTS

277. Efforts to address potential adverse effects are considered necessary for all habitats and species that are expected to incur ‘moderate’ or higher level of effects as a result of the Project. Additionally, by following the effects management measures outlined in the following sections effects that have a lower level of effect may also be addressed. As such, effects management measures are required to address adverse effects on:

   i. Temporary effects from Project works construction on freshwater habitats;

   ii. Temporary effects from Project works construction on Freshwater fauna: particularly aquatic macroinvertebrates and freshwater fish (including fish passage and spawning) within the Te Awa Kairangi;

   iii. Temporary effects from sediment and cement wash discharges on water quality and freshwater ecology; and

   iv. Loss of stream habitat and fish passage at Harbour View Stream.

278. The overall approach to managing adverse effects of the project on freshwater ecology recommended here follows the effects management hierarchy, in accordance with principles outlined in the PNRP.

279. The hierarchy requires that:

   i. Adverse effects are **avoided** where possible;

   ii. Adverse effects that cannot be demonstrably avoided are **minimised/remedied** where possible;

   iii. Adverse effects that cannot be demonstrably minimised/remedied are **mitigated**; and

   iv. In relation to adverse effects that cannot be avoided, remedied or mitigated (residual effects), biodiversity **offsetting** is considered.

280. The following sections I provide a strategy to avoid, minimise/remedy or mitigate actual or potential adverse effects from Project works on Te Awa Kairangi. This section also provides an outline of the effects management measures to be further developed in an Ecological Management Plan (“**EMP**”) and Erosion and Sediment Control Plan ("**ESCP**") for the project.

7.1 Measures to avoid, remedy and mitigate effects on freshwater ecology

281. An EMP is recommended prior to construction works commencing to avoid, minimise and mitigate effects on freshwater ecology, including offsetting measures to address residual effects. These measures are summarised below.

282. This EMP will be reviewed at key points in the project timeline to ensure the programme is adequate to achieve the objectives and as more information become available. Appropriate review points will include but not be limited to:

   i. Following completion of detailed design and the erosion and sediment control plan to ensure the monitoring of the EMP and erosion and sediment control plan are aligned;

ii. Trigger levels will be reviewed as part of the quarterly reports; and

iii. A wider review of the construction phase monitoring programme will occur as part of the annual report.

283. During the construction process efforts will be made to refine the design to further reduce effects on the freshwater ecology values identified within the Project area. Accordingly, the final amount of stream offset required will be calibrated to reflect the effects of the Project and the ecological gains that are achieved.

Freshwater habitat

284. The potential overall magnitude of effects without measures to avoid, remedy or mitigate on freshwater habitats within Te Awa Kairangi could be High.

285. The strategy for addressing the potential adverse effects freshwater habitat is to:

i. Minimise the potential area impacted at any one time;

ii. Minimise the duration that works will occur in an impacted area (on a daily, weekly, and seasonal timeframe); and

iii. Remediate and improve freshwater habitat once the impact area is completed.

286. I recommend limiting the river length that can be affected by gravel extraction at any one time. As set out in **Mr Breese's** technical assessment the works in flowing water will be restricted to a maximum worked reach of 500 m at any one time. I agree with this limitation in river length, as this will provide sufficient habitat recovery times between gravel extraction activities in different reaches.

287. **Mr Williams** describes in his technical assessment that the design of the river works is based on an improvement to the natural character of the river reach and that once works within the impacted reach are completed there will be a positive net effect on natural character. This is due to enabling the river to move more freely within the vegetated buffers of the upper reach and the widened and more natural planform achieved through the realignment of the lower reach.

288. Further to the above **Mr Williams** notes that the natural character of a river reach "*arises from the holistic interactions and connections of the river system*". Project works construction activities will affect the freshwater habitat at each impacted reach, there are no specific measures that can mitigate short-term variations in the overall responsiveness and trends of Te Awa Kairangi. The mitigation is the longer term improvements to freshwater habitat that arise from the Project.

289. I recommend undertaking an analysis of sediment particle size distribution within the impacted reach to determine how the effected freshwater habitat recovers post Project works being completed.

290. Monitoring of sediment particle size distribution will occur on four occasions: once 'before' impact, once 'immediately after' impact, and once four and seven weeks after the 'immediately after' sampling event. Post all river construction works, Project area monitoring shall be carried out annually for the first 2 years following completion of the channel reshaping works. Results from the completed sediment particle size distribution monitoring (i.e. once completed the seven weeks post the 'immediately after' sampling event) will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly. The substrate composition within Te Awa Kairangi provides habitat for a relatively high-quality macroinvertebrate community and provides good habitat for several fish species. Therefore, the reporting should use an interim

target that no change in median particle size (i.e. d50) should exceed 30 % as a trigger for possible effect and adaptive management. The reporting should recommend any necessary adjustments for future monitoring and adjustments to the 30 % level as the trigger for the adaptive management process. Any adaptive management process will be undertaken to manage the effect on sediment particle size distribution and subsequently habitat at the impact site.

291. The results from monitoring will be interpreted in quarterly reports to assess the effectiveness of the ESCP and SSESCPs. Any improvements erosion and sediment control practises will be proposed and ESCP/SSESCP will be amended accordingly.

292. Table 7-1 summarises the ecological value of the Project area, the magnitude of effect after the proposed mitigation, reason for change in magnitude of effect and overall level of effect after mitigation.

Table 7-1 Overall effect of Project works on freshwater habitat within Te Awa Kairangi

Project area	Ecological value	Reason for value	Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Overall level of effect with mitigation
Te Awa Kairangi	High.	High diversity in fish species present, including several at risk declining species and one nationally critical. Te Awa Kairangi recognised as a significant trout spawning and fishery (non – ecological value) river	Low. (reduced from moderate)	Minimise the potential area impacted at any one time. The gravel extraction works in flowing water will be restricted to a maximum worked reach of 500 m at any one time; Minimise the duration that works will occur in an impacted area (on a daily, weekly, and seasonal timeframe); and Remediate and improve freshwater habitat once the impact area is completed Monitoring of sediment particle size distribution 'before' impact, once 'immediately after' impact, and once four and seven weeks after the 'immediately after' sampling event. Post all river construction works, Project area monitoring shall be carried out annually for the first 2 years following completion of the channel reshaping works. Monitoring of sediment particle size distribution will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly.	Low.

Freshwater fauna

Aquatic macroinvertebrates

293. As detailed in Paragraph 287 I recommend limiting the river length that can be affected by gravel extraction to a maximum worked reach of 500 m at any one time.

294. To understand how the Project works are affecting the macroinvertebrate community within the impacted river lengths, I recommend that macroinvertebrate monitoring be undertaken at each of the impacted reaches to understanding how the aquatic macroinvertebrate community recovers from the Project works.

295. Sampling macroinvertebrates from sites within the directly impacted reaches of the river will occur on four occasions: once ‘before’ impact, once ‘immediately after’ impact, and once four and seven weeks after the immediately after’ sampling event. Post all river construction works, Project area monitoring shall be carried out annually for the first 2 years following completion of the channel reshaping works.

296. This will provide information on what macroinvertebrate taxa or groups are recovering quicker and which are more sensitive to gravel removal. Sampling will occur before and after Project works within each of the impacted sites and must be conducted during a period of stable normal flow conditions.

297. Macroinvertebrate sampling will entail:

    i. Collecting quantitative samples from sites within the impacted sites within the Project area;

    ii. Monitoring should occur before and after Project works at the impacted sites; and

    iii. Targets should include that monitoring should show that the macroinvertebrate community (in terms of taxonomic richness and EPT richness) before and after Project works has not changed.

298. Results from macroinvertebrate monitoring will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly. The macroinvertebrate community composition within Te Awa Kairangi is of good-quality with a moderate proportion of sensitive EPT taxa. Therefore, the reporting should use an interim target that no change (in terms of taxonomic richness, EPT richness, and MCI/QMCI) should exceed 20 % as a trigger for possible effect and adaptive management. The reporting should recommend any necessary adjustments for future monitoring and adjustments to the 20 % level as the trigger for the adaptive management process. An adaptive management process will be undertaken to manage the effect on macroinvertebrates at the impact site

Freshwater fish (including spawning, passage, and migration)

299. The direct effects of in-stream works on freshwater fish cannot be avoided during Project works that are being undertaken at the impact site. Primarily due to construction activities occurring within the active river channel. Therefore, measures need to be taken to minimise and mitigate the effects on freshwater fauna by implementing Fish Recovery Protocols ("**FRP**") as part of the EMP. Fish numbers are expected to be highest in Te Awa Kairangi, while most of the tributaries have barriers to fish passage and as such are likely to have lower numbers of fish present.

300. Mr Breese’s details in his Construction Water Quality technical assessment (Technical Assessment #3 – Volume 4 of the Application) that the gravel extraction works in flowing water will be restricted to a maximum worked reach of 500 m at any one time, and that any works

undertaken within the river channel do not exceed 12 hours per day and take place on no more than 5 consecutive days. I agree with these recommendations.

301. The FRP for the Project should include measures to minimise and mitigate for impacts on freshwater fish. These measures should include:

i. Details of the methodology to be followed for fish salvage and relocation. All suitable habitats need to be fished prior to works in flowing water commence, using a combination of fish recovery methods (e.g. electric fishing, nets/traps, slow dewatering and sorting through dewatered materials) in different habitats as appropriate. Each of these methods has inherent risks and site-specific recovery protocols will need to be developed to minimise potential additional effects on fish during recovery and to provide for the most effective recovery approach. In general, fish will be relocated to an area outside of the current impact area (e.g. upstream reaches), however, all relocated fish must remain within the source catchment (i.e. captured fish are not to be relocated from one tributary to another).

ii. Details of how fish passage will be provided to remaining habitats through the construction period within the tributaries.

302. Furthermore, I recommend that there should be a stand down period between September and November (inclusive) of each year where no works in flowing water should be undertaken. This standdown period will broadly align with important life cycle stages (i.e. fish migration and spawning) for fish species known to inhabit the Project area. A stand-down from works in flowing water will provide some protection against impacting multiple migration periods over several years, which would potentially affect the regional population of specific species.

303. The disruption to native fish spawning and migration through the discharge of sediments will be minimised through construction stages and methodologies and the development and implementation of the ESCP and SSESCPs.

304. Inanga spawning habitat has been identified downstream of the Project area and on the true left bank upstream of Ewen Bridge. I recommend that if Project works are to occur during īnanga spawning season (March to July, inclusive), then prior to construction activities occurring in these areas, a survey to assess actual īnanga spawning is undertaken. If īnanga spawning is identified, then that habitat should be avoided between March to June. Any removal of identified īnanga spawning habitat should be replaced once Project works within the potential spawning locality are completed. This should occur before the next spawning season.

305. To understand how the Project works are affecting the fish community within each of the impacted river lengths I recommend that fish monitoring be undertaken at each of the impacted reaches to understand how the fish community recovers from the Project works. This will provide information on what fish species are recovering quicker and which are more sensitive to gravel removal.

306. Fish sampling from sites within the directly impacted reaches of the river will occur on four occasions: once ‘before’ impact, once ‘immediately after’ impact, and once four and seven weeks after the immediately after’ sampling event. Post all river construction works, Project area monitoring shall be carried out annually for the first 2 years following completion of the channel reshaping works.

307. Similarly, to the results from macroinvertebrate monitoring described above, the results from fish monitoring will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly. The freshwater fish community within Te Awa Kairangi is diverse and includes several ‘At-risk’ and one ‘Nationally vulnerable’ native species, of these native species all are

migratory. Therefore, the reporting should use an interim target of 30 % change in native species (and trout) diversity (number of taxa) and 30 % lower abundance of any native species at the downstream monitoring site compared to the upstream site as a trigger for possible effect and adaptive management. The reporting should recommend any necessary adjustments for future monitoring and adjustments to the 30% level as the trigger for the adaptive management process. An adaptive management process will be undertaken to manage the effect on fish species at the impact site

308. Within any tributaries that have outlets into Te Awa Kairangi flow control structures, such as flap gates, are included in the design. Typically, these can act as barriers to fish migration. Ideally these structures should be avoided. However, as this infrastructure is necessary at these locations, I recommend that the design includes the installation of automated/active flap gates. This design is considered more effective in reducing the impact to fish passage as the design of the flap is to only operate when water levels reach a critical height. This reduces the impact on fish movements and upstream physical habitat. Additionally, automated/active flap gates are considered to be best practice design by the NIWA guidelines[42].

309. Table 7-2 summarises the ecological value of the Project area, the magnitude of effect after the proposed mitigation, reason for change in magnitude of effect and overall level of effect after mitigation.

Table 7-2 Overall effect of Project works on freshwater fauna (including injury and mortality, and effects to fish spawning and migration)

Project area	Ecological value	Reason for value	Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Overall level of effect with mitigation
Te Awa Kairangi	High.	High diversity in fish species present, including several at risk declining species and one nationally critical. Te Awa Kairangi recognised as a significant trout spawning and fishery (non – ecological value) river	Low effect to freshwater fauna (reduced from Moderate)	The implementation of a maximum flowing water worked reach of 500 m will minimise the temporary effects resulting from gravel extraction construction works within the river. This will be adaptive and responsive to fish and macroinvertebrate monitoring results. Any works undertaken within the river channel do not exceed 12 hours per day and take place on no more than 5 consecutive days. Works will be undertaken in dry conditions (behind a bund) where possible. Fish will be salvaged prior to Project works commencing within the bund. Fish salvage undertaken via the protocols outlined in the Fish Relocation Plan (FRP) will be completed and there is available habitat for relocation. Monitoring of the macroinvertebrate and fish community 'before' impact, once 'immediately after' impact, and once four and seven weeks after the 'immediately after' sampling event. Post all river construction works, Project area monitoring shall be carried out annually for the first 2 years following completion of the channel reshaping works. Monitoring of the macroinvertebrate and fish community will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and	Low.

Project area	Ecological value	Reason for value	Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Overall level of effect with mitigation
			Low effect on fish passage and spawning (reduced from Moderate)	construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly To accommodate fish migration a standdown period of September to November (inclusive) will be implemented where no works in flowing waters will be undertaken. Avoidance of īnanga spawning habitat and timings (if found to be present). Fish passage during construction is unlikely to be restricted as a flowing channel will be present at all times. Temporary and partial effects resulting from discharge of sediment during construction works within the river will be avoided and minimised through the development and implementation of the ESCP.	
Tributary sites	Moderate.	Low diversity of fish present, only two native species identified. However, adequate habitat is present.	Negligible effect to freshwater fauna (reduced from Low) Low effect on fish passage and	Fish salvage undertaken via the protocols outlined in the Fish Relocation Plan (FRP) prior to works being undertaken will be completed and there is available habitat for relocation. The FRP will detail how fish diversions will be maintained during construction Temporary and partial effects resulting from discharge of sediment during construction	Very Low (for freshwater fauna). Low (for fish passage and spawning)

Project area	Ecological value	Reason for value	Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Overall level of effect with mitigation
			spawning (reduced from Moderate)	works within the river will be avoided and minimised through the development and implementation of the ESCP. The inclusion of automated/active flap gates on any outlet structures that require flood control infrastructure.	

Sediment and cement wash discharges during Project works

310. The potential overall magnitude of sedimentation effects without measures to avoid, remedy or mitigate could be High. Therefore, I recommend that erosion and sediment controls are implemented for all works areas and these should be designed, constructed, and maintained in accordance with best practice measures. All areas need to be managed to the same high standard of industry best-practice, with recognition of the sensitivity of the receiving environment, the available space for controls, the duration of works and the local topography. The implementation of an ESCP, with Site Specific Erosion and Sediment Control Plans ("SSESCP") will reduce the potential magnitude of effect of construction sedimentation effects. The SSESCP should be prepared for particular construction activities to ensure measures are tailored to the location, unique constraints and different teams of people involved.

311. The proposed approach to erosion and sediment control is described in more detail in **Mr Breese's** Technical Assessment which provides recommendations to manage erosion and sediment, and subsequent effects to water quality, during construction.

312. The strategy for addressing the potential adverse effects of sediment discharges described by **Mr Breese** is to:

i. avoid the circumstances that generate sediment;

ii. minimise the potential to generate sediment; and

iii. mitigate sediment discharges through treatment processes.

313. **Mr Breese's** technical assessment outlines that both the ESCP and SSESCP are to be prepared in accordance with the following erosion and sediment control guidance documents:

i. GWRC Erosion and Sediment Control Guide for Land Disturbing Activities (2021);

ii. NZTA Erosion and Sediment Control Guidelines for State Highway Infrastructure (2014); and

iii. GWRC Code of Best Practice for River Management Activities (2019).

314. Notwithstanding the best practice erosion and sediment controls outlined by **Mr Breese**, the scale of the earthworks, the length of time that the construction works will take place, and natural variability in the climate and rainfall events mean that the predicted sediment from contributing events and levels of effect may not be the exactly the same as those which occur in reality. This is why the assessment undertaken for the Project and the erosion and sediment control measures have adopted a conservative approach (assumptions related to the amount of sediment generated from the Project and resultant downstream freshwater ecology effects). This conservative approach suggests that the actual effects from the Project will be no worse than predicted.

315. While the indicative construction period will last four years, the works are to be staged from downstream to upstream and in conjunction with adjacent river work activities where possible. Overall disturbance will be reduced as any resulting sediment generation will be from a small footprint due to the staged approach adopted. Completed downstream sections are protected from any upstream works which may discharge sediment downstream.

316. Minimisation of the deposition of fine sediment in the freshwater environment should be the aim of any proposed mitigation. **Mr Breese** details that a key element to minimising the potential for sediment generation is to undertake river reprofiling and widening works behind constructed temporary bunds and diversions to separate active earthworks from the flow of the River (i.e. work in the dry).

317. A key aspect of the ESCP will include monitoring of turbidity and suspended solids within Te Awa Kairangi. Monitoring will be undertaken during construction using continuous telemetered

turbidity sensors installed on the piers of the Kennedy-Good, existing Melling and Ewen Bridges and via site specific water quality grab samples.

318. The three turbidity bridge sites will provide:

i. An upstream reference point (Kennedy-Good Bridge) which indicates the quality of the water entering the site;

ii. A mid-site measurement point (Existing Melling) which indicates water quality within the site; and

iii. A downstream site (Ewen Bridge) which indicates the water quality following any sediment discharges from construction activities.

319. **Mr Breese** has outlined proposed “Proactive” and “Management” turbidity triggers within his technical assessment for the Ewen Bridge and Melling continuous monitoring sites. These have been set to act as the threshold to prompt investigation of the probable cause of exceedance and implementation of actions to improve avoidance and/or mitigation measures deployed in the active channel. I have reproduced the proposed turbidity monitoring management triggers and required actions from **Mr Breese’s** technical assessment in Table 7-3 below. I note that these triggers are more conservative than those detailed for sensitive native species known to be present within Te Awa Kairangi catchment (i.e. banded kōkopu are impacted by turbidity levels exceeding 20 NTU).

Table 7-3 Proposed Turbidity monitoring management triggers

Trigger type	Change in Turbidity	Action
Proactive trigger	10 % Difference between the control and downstream of work area outside construction period above a baseline 15 NTUs	Investigate probable cause of exceedance. Implement improvement to measures. Undertake field monitoring.
Management trigger	15 % Difference between the control and downstream of work area outside construction period above a baseline of 15 NTUs	Under actions for the proactive trigger AND undertake an ecological assessment of the effect of the exceedances in a report to GWRC

320. I agree with the recommend water quality monitoring and monitoring management triggers detailed in **Mr Breese’s** technical assessment. Namely that continuous turbidity monitoring will be undertaken in Te Awa Kairangi, and the site-specific sampling of water quality grab-samples will be collected. The outcomes of this sampling will be interpreted in quarterly reports to assess the effectiveness of the ESCP and SSESCPs. Any improvements to erosion and sediment control practises will be proposed and the ESCP and any relevant SSESCPs will be amended accordingly.

321. Further to the specific water quality monitoring that is set out in the ESCP and the SSESCPs, I consider monitoring the proportion of fine sediment (i.e. substrates < 2 mm in size) cover downstream of any current impact site be included in the ESCP. Due to the low baseline nature of fine sediment within and downstream of the Project area (e.g. ≤10 %), it will be possible to detect any freshly deposited sediment that may have been deposited via construction activities during normal flow conditions. Sampling will occur before, during and after Project works downstream of each of the staged sites and must be conducted during a period of stable normal flow conditions.

322. Similar to the results from water quality monitoring, the results from fine sediment monitoring will be interpreted in quarterly reports to assess the effectiveness of the ESCP and SSESCPs. Any improvements erosion and sediment control practises will be proposed and the ESCP and relevant SSESCPs will be amended accordingly.

323. Further to the above, I recommend sediment sampling at additional sample sites throughout the construction footprint prior to the commencement of works.

324. Table 7-4 summarises the ecological value of the Project area, the magnitude of effect after the proposed mitigation, reason for change in magnitude of effect (i.e. Paragraphs in this section) and overall level of effect after mitigation.

Table 7-4 Overall temporary effect from sediment and cement wash discharges on water quality and freshwater ecology

Project area	Ecological value	Reason for value	Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Overall level of effect with mitigation
Te Awa Kairangi	High.	High diversity in fish species present, including several at risk declining species and one nationally critical. Te Awa Kairangi recognised as a significant trout spawning and fishery (non – ecological value) river	Low (reduced from Moderate).	Erosion and sediment controls implemented in accordance with best practice, including: Avoid the circumstances that generate sediment; Minimise the potential to generate sediment; and Mitigate sediment discharges through treatment processes Staging of works, to limit disturbances; Setting target levels that will in turn direct an adaptive construction methodology. Monitoring of fine sediment cover 'before' impact, once 'immediately after' impact, and once four and seven weeks after the 'immediately after' sampling event. Monitoring of fine sediment cover will be interpreted in quarterly reports to assess the effectiveness of the ESCP, SSESCPs, and construction methodology. Any improvements to construction methodology and erosion and sediment control practises will be proposed and methodologies will be amended accordingly.	Low.
Tributary sites	Moderate.	Low diversity of fish present, only two native species identified. However, adequate habitat is present.	Negligible (reduced from Low).	Erosion and sediment controls implemented in accordance with best practice, including: Avoid the circumstances that generate sediment; Minimise the potential to generate sediment; and Mitigate sediment discharges through treatment processes Staging of works, to limit disturbances;	Very Low.

8. RESIDUAL EFFECTS

8.1 Loss of stream habitat and fish passage at Harbour View Stream

325. The loss of stream habitat and fish passage associated with the piping of approximately 25 linear meters of current open channel stream at the Harbour View Road Stream has been identified as having a 'High' level of effect.

326. **Mr Ingles'** technical assessment details that the loss of Harbour View Road Stream habitat cannot be avoided, remedied or mitigated. The section of waterway cannot be retained (avoided) as part of the new works due to the relocation of the Melling bridge (i.e. location of Melling bridge abutment) and widening of SH2. Nor can the stream habitat be reinstated (remedied) within the original vicinity, due to the topographical and spatial constraints. Furthermore, the designed piped section will have a grade and size that will tie into the existing upstream network which will prevent fish passage from occurring. Therefore, fish passage through the new piped section cannot be mitigated. Due to the residual effects of the proposed loss of stream habitat I recommend that biodiversity offsetting should be undertaken. Any offset should achieve in the first instance daylighting stream reaches, stream habitat enhancements, and the removal of fish passage barriers.

327. The loss of the Harbour View Stream reach should be offset. A suitable method needs to be followed to provide mitigation for the loss of stream habitat through an offset. The PNRP details that offsetting may be undertaken following a suitable biodiversity offsetting accountancy method. The Stream Ecological Valuation (SEV)[44] method represents a good practice method for determine the actual/ potential stream value at the impacted site and any proposed offset site. The SEV method provides an assessment of the quantum of offset that will be required to mitigate the loss of the affected reach.

328. I recommend that the SEV method be used to determine the actual/ potential stream value at the impacted Harbour View Stream site and any proposed offset site. The SEV method provides an assessment of the quantum of offset that will be required to mitigate the loss of the affected reach to achieve no net loss of stream habitat.

9. POSITIVE EFFECTS FROM THE PROJECT

329. The Project is proposing to improve in-river ecological values through the installation of features that will increase habitat diversity especially for fish to use as refugia during the day and during flood flows, and to maintain spawning habitat for key fish species (e.g. blue gill bully and īnanga). These should include the following:

   i. Developing habitat appropriate riffle sections;
   ii. Boulders/boulder clusters or rock spurs and vanes;
   iii. Increased indigenous vegetation within the immediate riparian zone;
   iv. Incorporate īnanga spawning habitat within the lower Project area; and
   v. Improve fish passage where practical.

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[44] Neale M W, Storey R G, Rowe D K, Collier K J, Hatton C, Joy M K, Parkyn S M, Maxted J R, Moore S, Phillips N and Quinn J M (2011). Stream Ecological Valuation (SEV): A User's Guide. Auckland Council Guideline Document 2011/001.

330. The Project works will see the Tirohanga Intersection culvert replaced with a culvert that is in accordance with the NZ Fish Passage Guidelines Stream Simulation design principals[46]. By following these best practice outcomes within the Guidelines there is likely to be an improvement in fish passage at this culvert. Therefore, by following these design principles there is potential to see a positive effect on fish passage within the Tirohanga Intersection Stream

331. With the implementation of the above measures, I consider the Project will provide a positive effect to the habitat available for fish within the Project area.

332. Furthermore, as detailed in Mr Williams's technical assessment there will be "*an improvement to the natural character of the river reach while increasing the standard of flood protection. The net effect on natural character is, therefore, positive*." This is primarily as the Project will increase the width and improve the meander form of the active channel of Te Awa Kairangi and the channel sinuosity will be more defined along the lower reach of the project. Along the upper reach, the wider active channel will allow a more natural channel sinuosity and meander mobility.

10. CONCLUSION

333. The potential effects on freshwater ecology resulting from the Project have been assessed in terms of Project works (construction) and operational effects.

334. Project works effects relate to effects during the Project works phase which could include the temporary modification of freshwater habitats, fish injury and/or mortality, temporary fish migration and spawning restrictions, and water quality effects resulting from sedimentation and cement wash. These Project works effects can be minimised through the implementation of fish salvage protocols, good practice sediment and erosion control measures, and construction methodologies.

335. Potential operational effects anticipated to occur from the Project include reduced fish passage within the Harbour View Stream and loss of stream ecological function and habitat area within Harbour View Stream. A variety of measures to avoid, minimise and mitigate effects are proposed to be implemented to minimise these long-term effects.

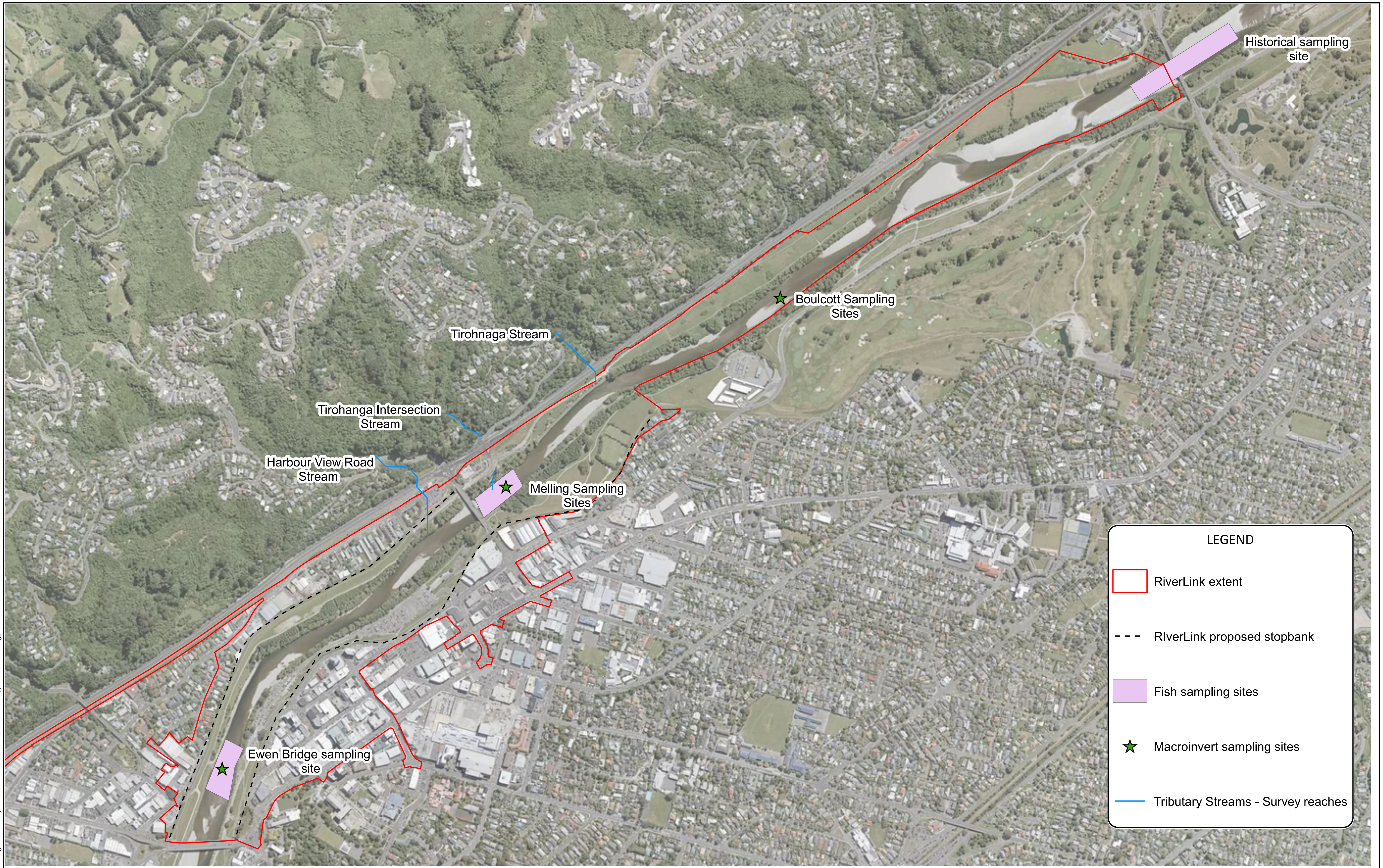
336. While many of the potential effects have been avoided, or remedied and mitigated to the extent possible, there are residual adverse effects resulting from the loss and modification of stream habitat and fish passage within Harbour View Stream. These residual effects are proposed to be addressed by additional measures in the form of an offset aimed at achieving no net loss of ecological function.

337. Overall, I consider that the effects of the Project on freshwater ecology can be avoided, remedied or mitigated and residual effects should be offset to achieve a no net loss of ecological function. I consider that the measures proposed are sufficient to address the effects associated with this Project and will result in a positive overall outcome for freshwater ecology within the immediate Te Awa Kairangi catchment.

23 July 2021

Dean Miller

Appendix A - Site map



Notes: Service Layer Credits: Sourced from LINZ Data service and licensed for re-use under the Creativ Commons Attribution 4.0 New Zealand Licence

A3 SCALE 1:10,000

0 0.2 0.4 0.6 0.8 1 (km)

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SCALE (AT A3 SIZE) 1:10,000		
PROJECT No. 1009095.1000		

RiverLink
FRESHWATER ECOLOGICAL SAMPLING SITES
LOCATION AND EXTENT OF ASSESSMENT SITES AND HABITATS

FIGURE No. Appendix A: Figure 1.

Rev. 1

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Appendix B Aquatic rapid habitat assessment results and macroinvertebrate species list

Appendix B– Aquatic habitat assessment results and macroinvertebrate species list

Rapid habitat assessment scores for Harbour View Stream

Harbour View Stream - upper

Habitat Parameter	Condition category										Score
1	*The percentage of the stream bed covered by fine sediment*										
Deposited sediment	0	5	10	15	20	30	40	50	60	>75	
Score	10	9	8	7	6	5	4	3	2	1	2
2	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*										
Invertebrate habitat diversity	>5	5	5	4	4	3	3	2	2	1	
Score	10	9	8	7	6	5	4	3	2	1	8
3	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles, clear of filamentous algae/macrophytes.*										
Invertebrate habitat abundance	95	75	70	60	50	40	30	25	15	5	
Score	10	9	8	7	6	5	4	3	2	1	5
4	*The numnber of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher*										
Fish cover diversity	>5	5	5	4	4	3	3	2	2	1	
Score	10	9	8	7	6	5	4	3	2	1	2
5	*The percentage of fish cover available*										
Fish cover abundance	95	75	60	50	40	30	20	10	5	0	
Score	10	9	8	7	6	5	4	3	2	1	2
6	*The number of hydraluic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*										
Hydraluic heterogeneity	>5	5	5	4	4	3	3	2	2	1	
Score	10	9	8	7	6	5	4	3	2	1	8
7											
Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank, or stock pugging*										
Right bank	0	<5	5	15	25	35	50	65	75	>75	
Left bank	0	<5	5	15	25	35	50	65	75	>75	
Score	10	9	8	7	6	5	4	3	2	1	10
8											
Bank vegetation	*The maturity, diversity, and naturalness of bank vegetation*										
Left AND right bank	*Mature native trees with diverse and intact understory*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground*		
Score	10	9	8	7	6	5	4	3	2	1	8
9											
Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence, or other structure(s)*										
Left bank	≥30	15	10	7	5	4	3	2	1	0	
Right bank	≥30	15	10	7	5	4	3	2	1	0	
Score	10	9	8	7	6	5	4	3	2	1	10
10	*The percentage of shading of the stream bed throughout the day due to vegetation, banks, or other structure(s)*										
Riparian shade	≥90	80	70	60	50	40	25	15	10	≤5	
Score	10	9	8	7	6	5	4	3	2	1	10
Total	Sum of parameters 1 - 10)										**65**

Harbour View Stream - middle

Habitat Parameter	Condition category										Score
1	*The percentage of the stream bed covered by fine sediment*										
Deposited sediment	0	5	10	15	20	30	40	50	60	>75	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	8
2	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*										
Invertebrate habitat diversity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	10
3	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles, clear of filamentous algae/macrophytes.*										
Invertebrate habitat abundance	95	75	70	60	50	40	30	25	15	5	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	10
4	*The numnber of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher*										
Fish cover diversity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	5
5	*The percentage of fish cover available*										
Fish cover abundance	95	75	60	50	40	30	20	10	5	0	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	3
6	*The number of hydraluic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*										
Hydraluic heterogeneity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	6
7	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank, or stock pugging*										
Bank erosion											
Right bank	0	<5	5	15	25	35	50	65	75	>75	
Left bank	0	<5	5	15	25	35	50	65	75	>75	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	6
8	*The maturity, diversity, and naturalness of bank vegetation*										
Bank vegetation											
Left AND right bank	*Mature native trees with diverse and intact understory*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground*		
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	3
9	*The width (m) of the riparian buffer constrained by vegetation, fence, or other structure(s)*										
Riparian width											
Left bank	≥30	15	10	7	5	4	3	2	1	0	
Right bank	≥30	15	10	7	5	4	3	2	1	0	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	5
10	*The percentage of shading of the stream bed throughout the day due to vegetation, banks, or other structure(s)*										
Riparian shade	>90	80	70	60	50	40	25	15	10	≤5	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	8
Total	Sum of parameters 1 - 10)										**64**

Rapid habitat assessment scores for Tirohanga Intersection Stream

Tironhanga Intersection Trib Upper

Habitat Parameter	Condition category										Score
1	*The percentage of the stream bed covered by fine sediment*										
Deposited sediment	0	5	10	15	20	30	40	50	60	>75	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	5
2	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*										
Invertebrate habitat diversity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	10
3	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles, clear of filamentous algae/macrophytes.*										
Invertebrate habitat abundance	95	75	70	60	50	40	30	25	15	5	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	10
4	*The numnber of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher*										
Fish cover diversity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	6
5	*The percentage of fish cover available*										
Fish cover abundance	95	75	60	50	40	30	20	10	5	0	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	3
6	*The number of hydraluic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*										
Hydraluic heterogeneity	>5	5	5	4	4	3	3	2	2	1	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	7
7 Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank, or stock pugging*										
Right bank	0	<5	5	15	25	35	50	65	75	>75	
Left bank	0	<5	5	15	25	35	50	65	75	>75	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	4
8 Bank vegetation	*The maturity, diversity, and naturalness of bank vegetation*										
Left AND right bank	*Mature native trees with diverse and intact understory*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground*		
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	7
9 Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence, or other structure(s)*										
Left bank	≥30	15	10	7	5	4	3	2	1	0	
Right bank	≥30	15	10	7	5	4	3	2	1	0	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	9
10	*The percentage of shading of the stream bed throughout the day due to vegetation, banks, or other structure(s)*										
Riparian shade	>90	80	70	60	50	40	25	15	10	≤5	
Score	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	10
Total	Sum of parameters 1 - 10)										**71**

Macroinvertebrate species list (sampled May 2020)

	Species	Ewen Bridge	Melling Bridge
Mayfly	Acanthophlebia		1
	Ameletopsis		1
	Coloburiscus		3
	Deleatidium		494
	Neozephlebia		1
Stonefly	Zelandiobius	1	
	Zelandoperla	2	
Caddisfly	Hydrobiosella	1	
	Hydrobiosis	8	6
	Hydropsyche-Aoteapsyche	5	7
	Hydropsyche-Orthopsyche		1
	Olinga	4	8
	Oxyethira		1
	Costachorema		1
	Psilochorema	6	7
	Pycnocentria	5	2
	Pycnocentrodes	5	10
Beetles	Elmidae	56	23
Diptera + other flies	Eriopterini, excl. Molophilus		1
	Tanypodinae		1
	Orthocladiinae, excl. Corynoneura	3	
	Tanytarsini		6
	Potamopyrgus		2
	COLLEMBOLA	1	
	Paracalliope	1	1
	OLIGOCHAETA	24	23

Appendix C - 2D hydrological model outputs

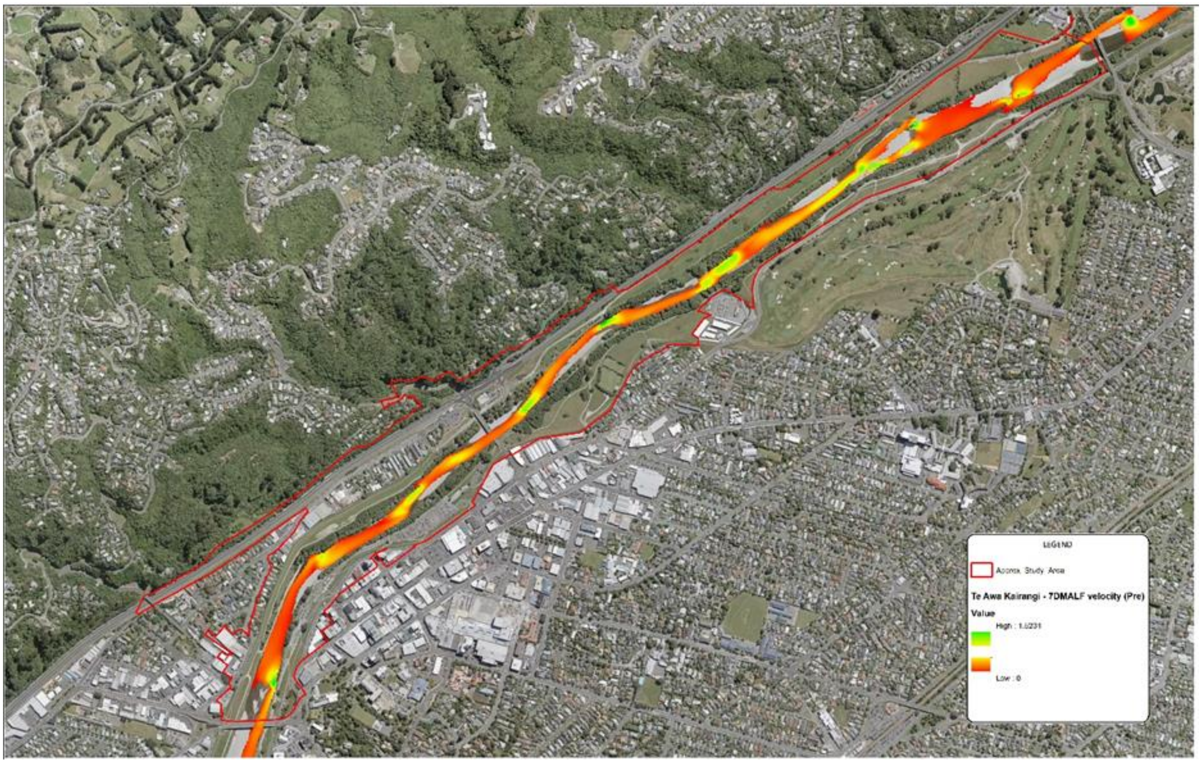

Figure C-1 Median water velocity at low flow scenario (7DMALF) pre-RiverLink

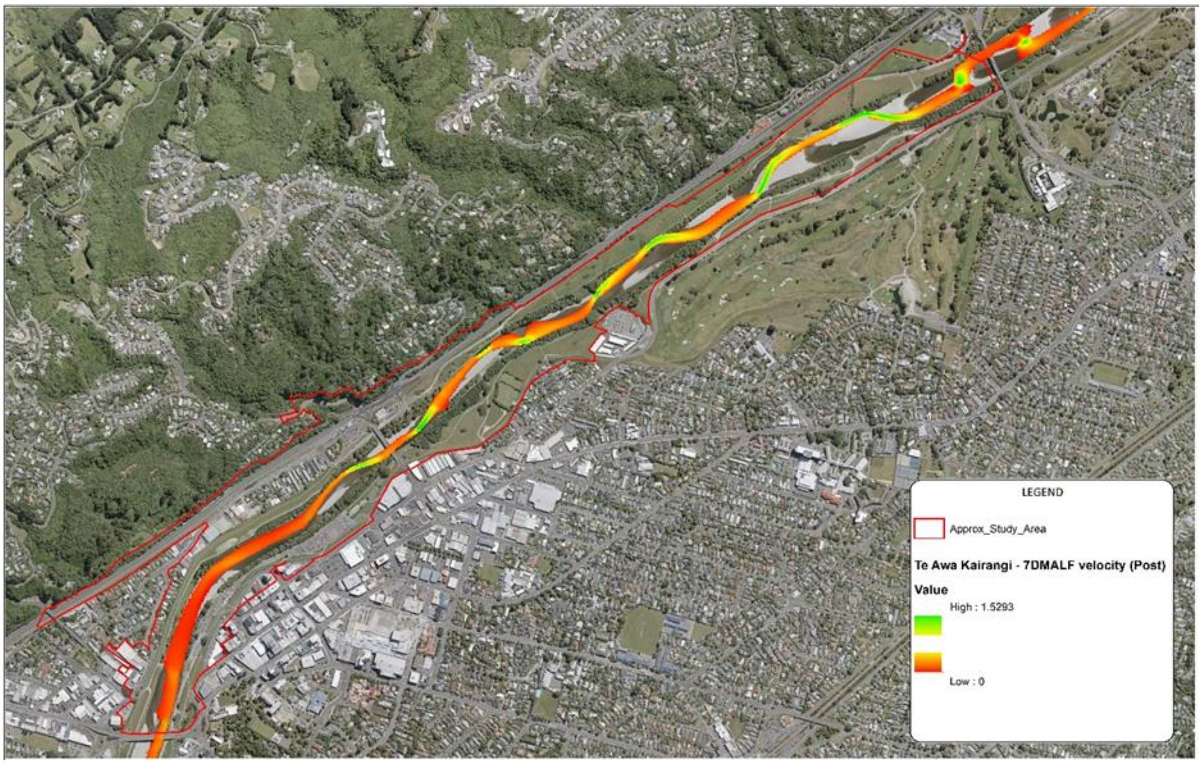

Figure C-2 Median water velocity at low flow scenario (7DMALF) post-RiverLink

Figure C-3 Medium water depth at low flow scenario (7DMALF) pre-RiverLink

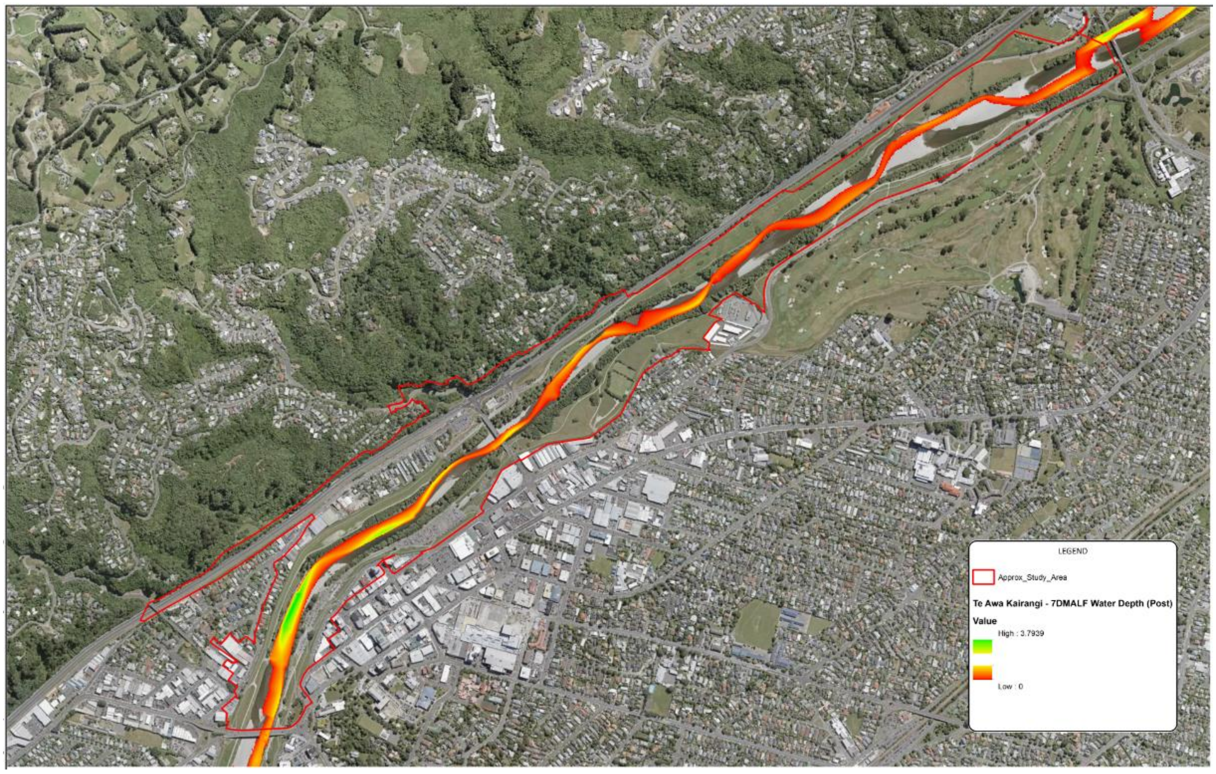

Figure C-4 Medium water depth at low flow scenario (7DMALF) post-RiverLink

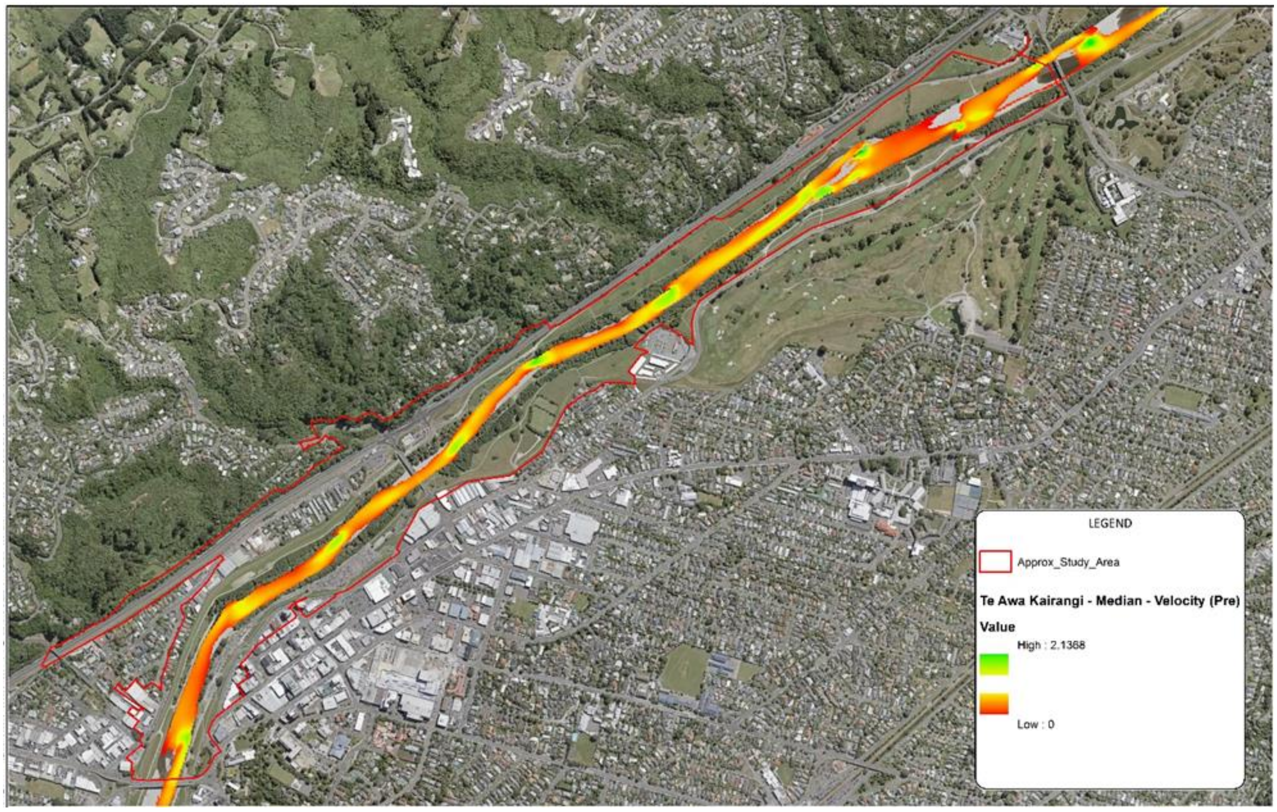

Figure C-5 Median water velocity at median flow pre-RiverLink

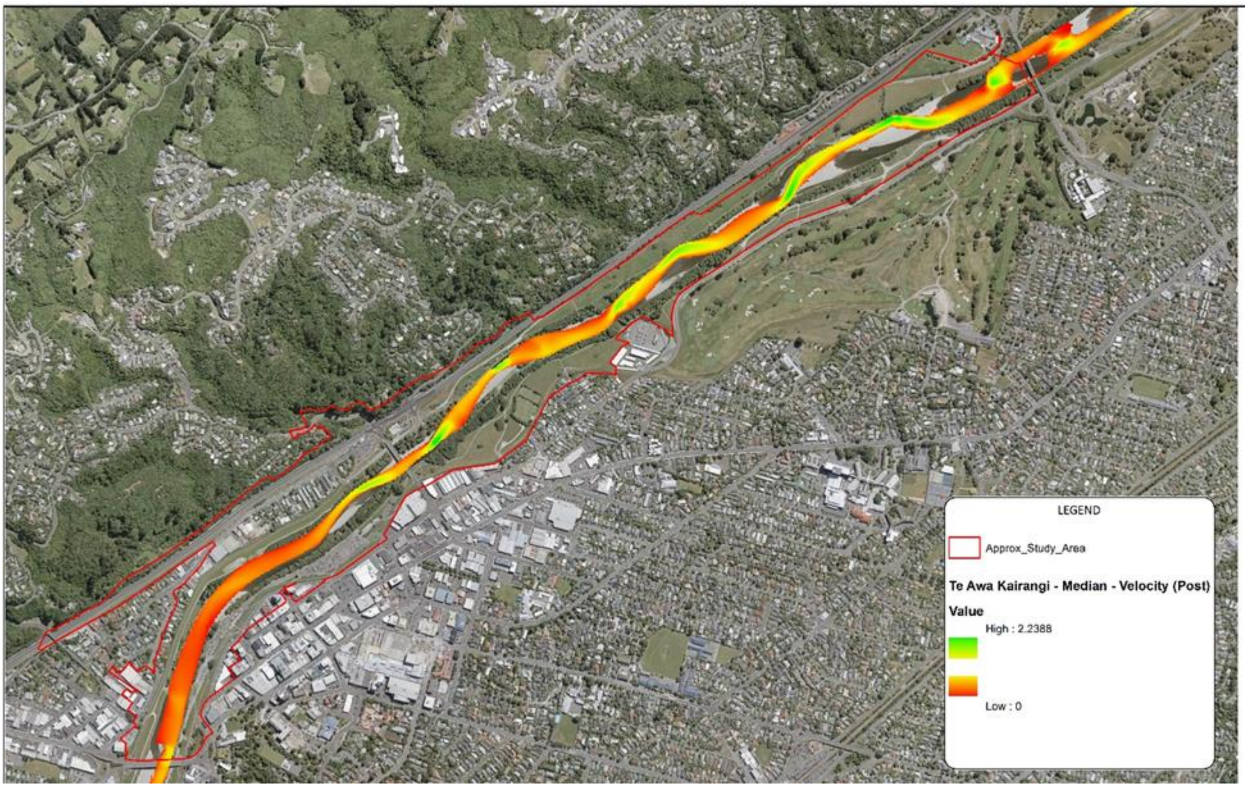

Figure C-6 Median water velocity at median flow post RiverLink

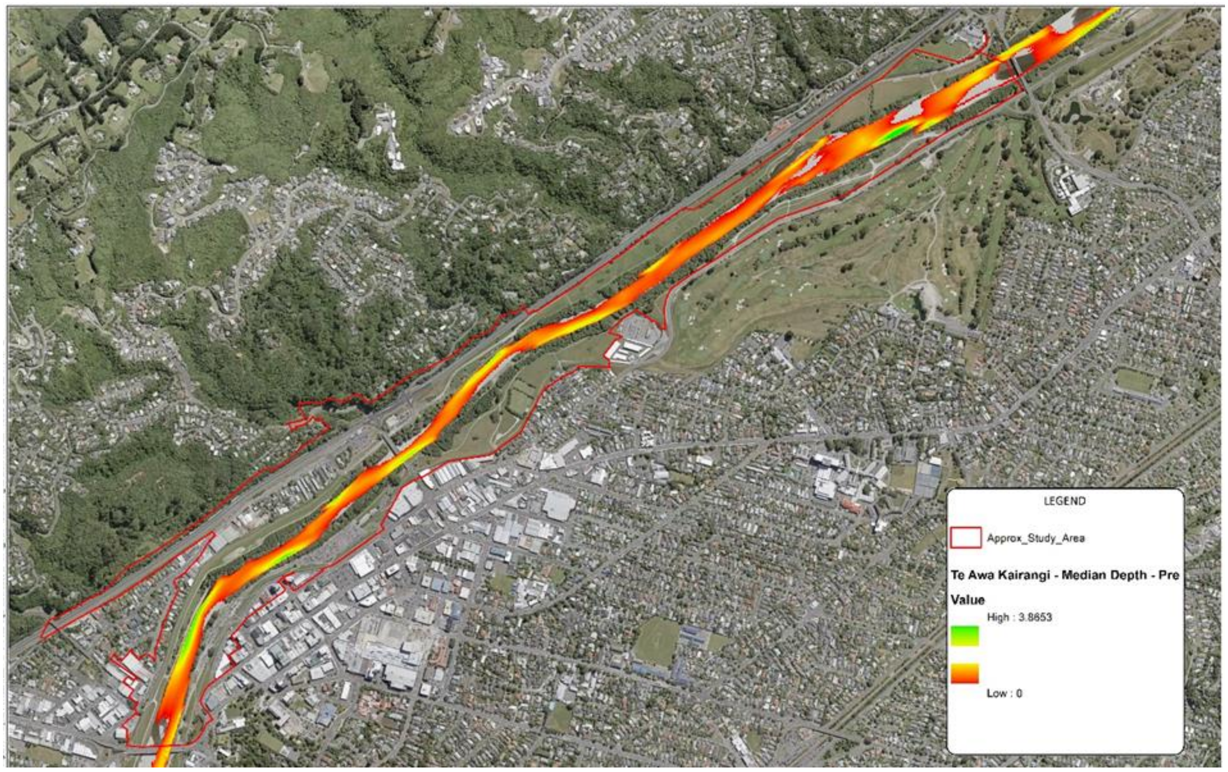

Figure C-7 Medium water depth at median flow scenario pre-RiverLink

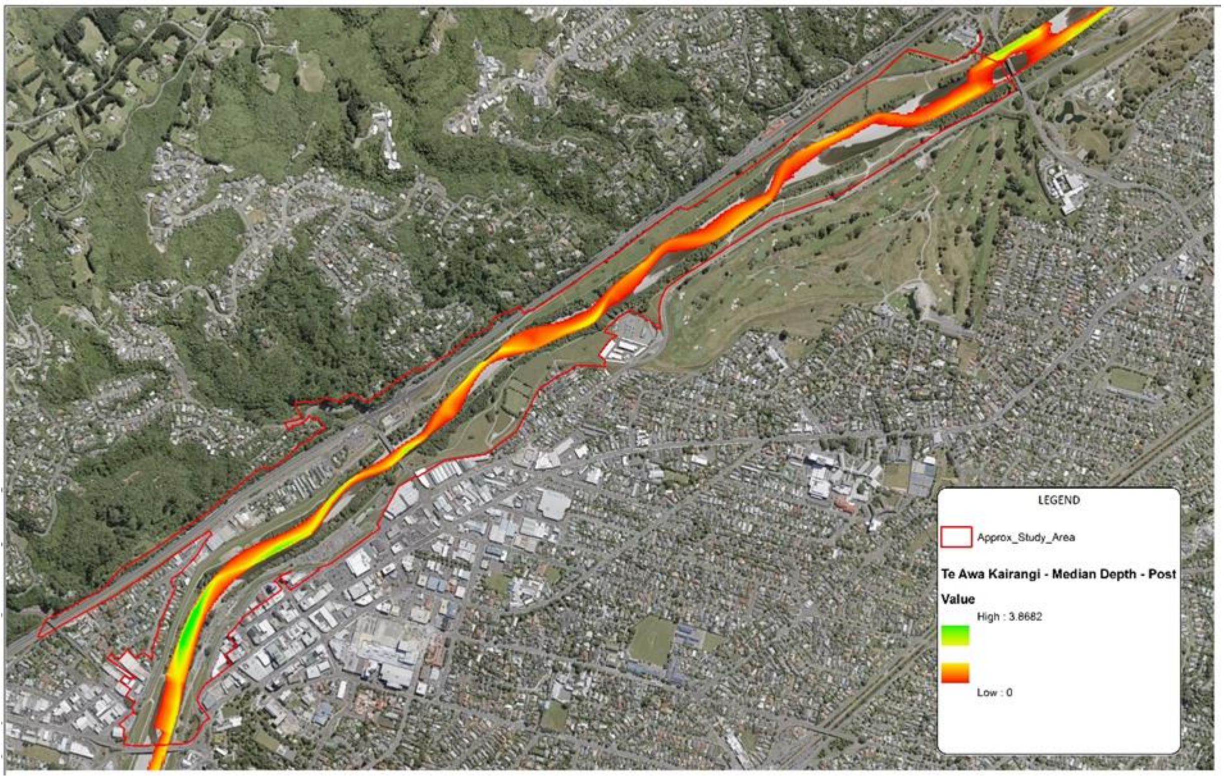

Figure C-8 Medium water depth at median flow scenario post-RiverLink

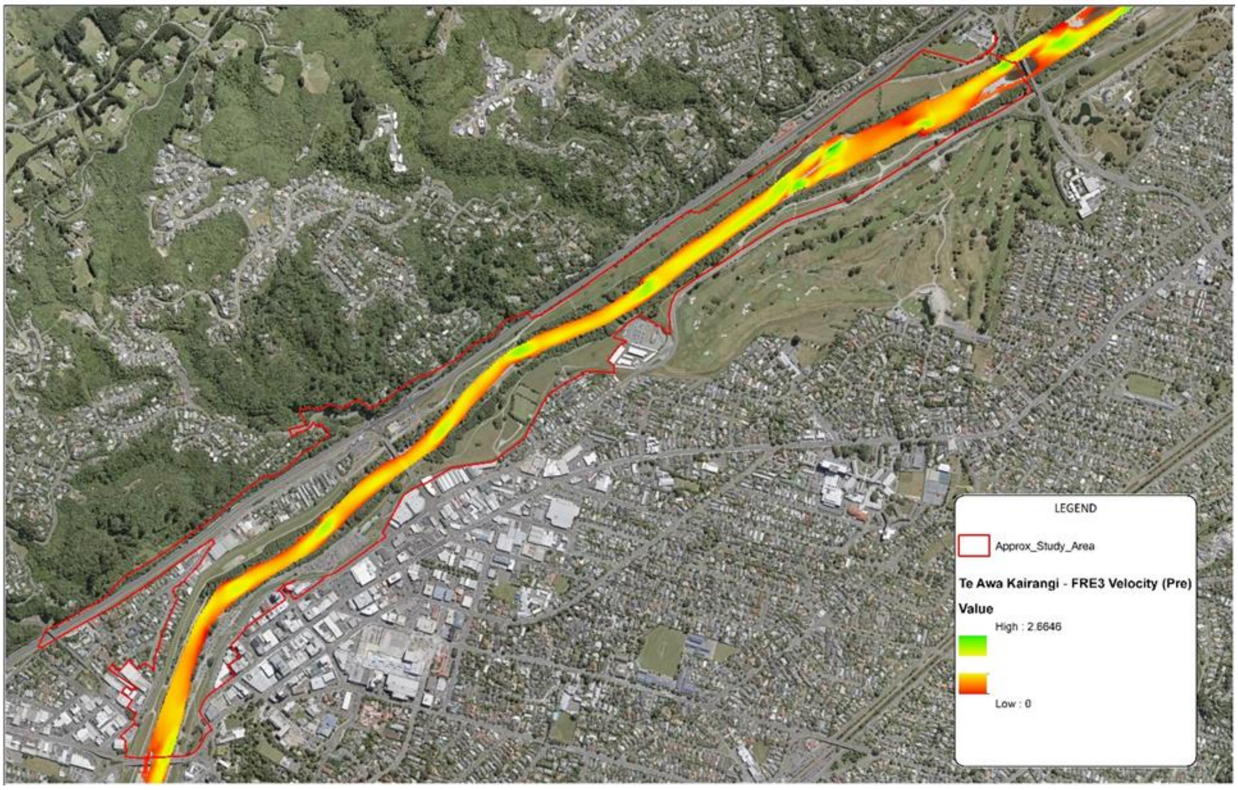

Figure C-9 Medium water velocity at high flow scenario (3 x median) pre-RiverLink

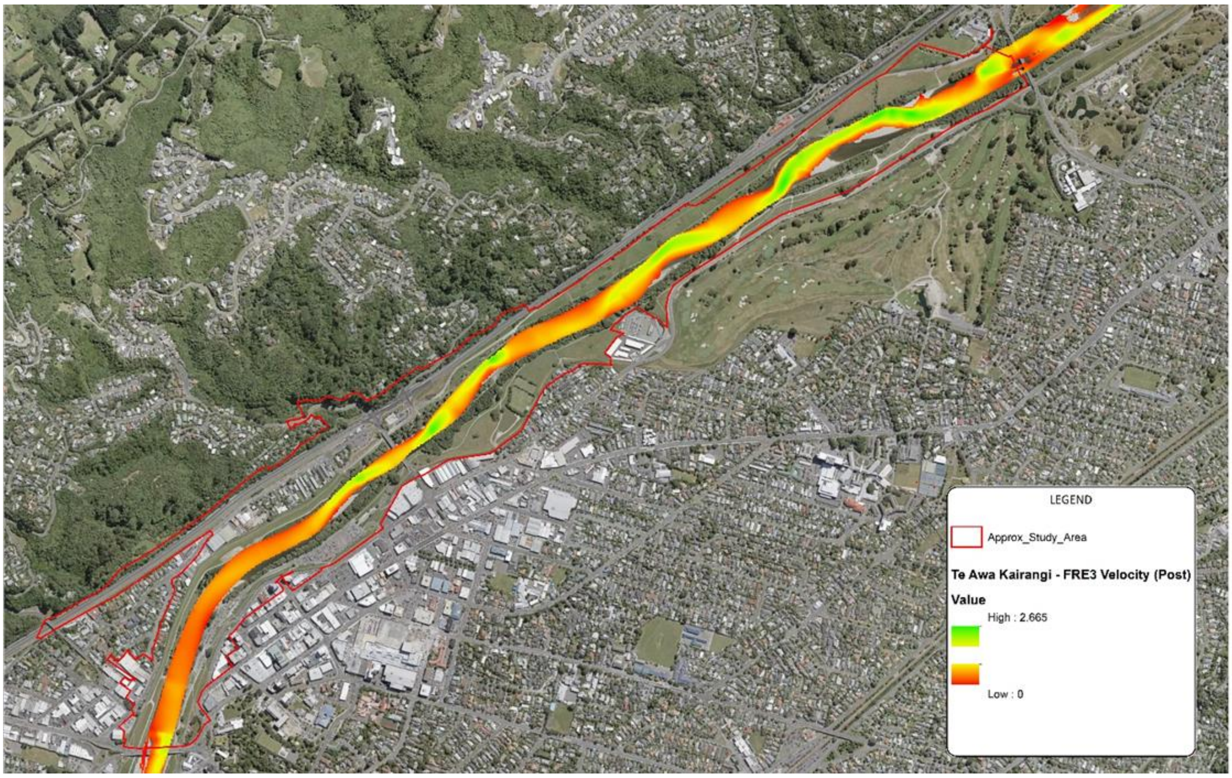

Figure C-10 Medium water velocity at high flow scenario (3 x median) post-RiverLink

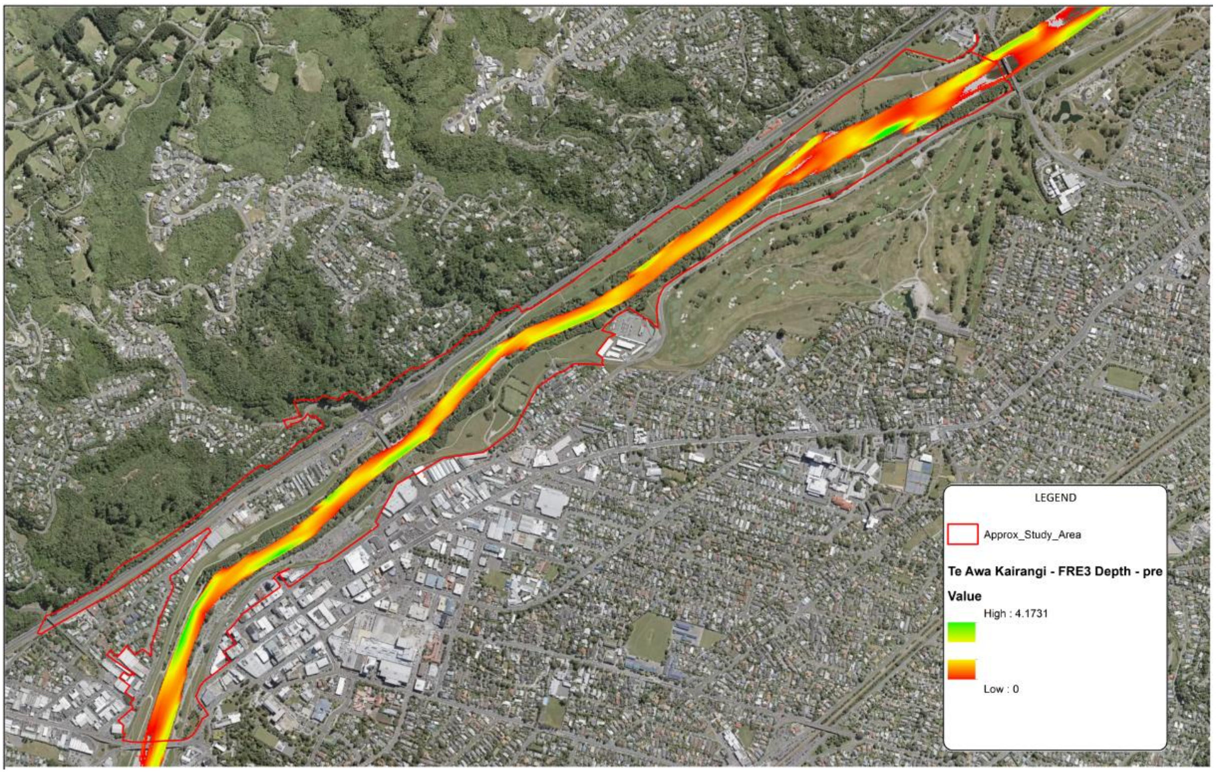

Figure C-11 Medium water depth at high flow scenario (3 x median) post-RiverLink

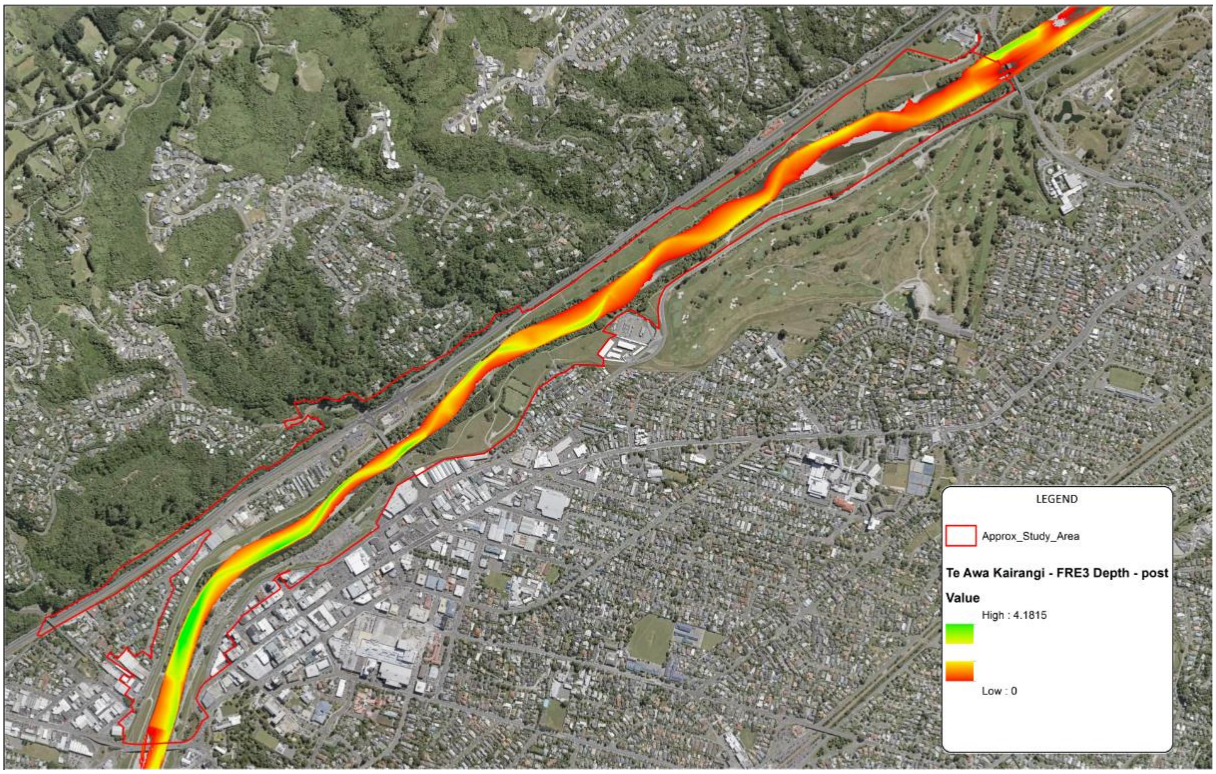

Figure C-12 Medium water depth at high flow scenario (3 x median) post-RiverLink