Westpower Ltd Proposed Waitaha Hydro Scheme Assessment of Environmental Effects: Freshwater Ecology

EOS Ecology Report No. WES05-24011-02 | August 2025

Prepared for Westpower

Prepared by EOS Ecology – Shelley McMurtrie, Catherine Grima

Reviewed by Alex James

www.eosecology.co.nz
info@eosecology.co.nz

PO Box 4262, Christchurch 8140
P 03 389 0538

SCIENCE + ENGAGEMENT

Statement confirming compliance with the Environment Court's Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023

As an expert witness or peer reviewer, I have read, and I am familiar with the Environment Court's Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023.

I have prepared my, or provided input into, an assessment of effects for the Waitaha Hydro Scheme in compliance with the Code of Conduct and will continue to comply with it in this Fast-track Approvals Act process. In particular:

- my overriding duty is to assist the decision-maker impartially on matters within my expertise;
- unless I state otherwise, my 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; and
- I have not, and will not behave as, an advocate for the Applicants.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Westpower proposes a run-of-the-river hydro-electric power scheme (the **Scheme**) for the Waitaha River, approximately 60 km south of Hokitika[1] on the West Coast of the South Island, New Zealand.

1.2 The Scheme is a run-of-river design with no instream storage. The proposed Headworks include a low weir and intake structure situated at the top of Morgan Gorge that will divert water into a pressurised tunnel and desander. The pressurised tunnel will convey the diverted water down to a Power Station below Morgan Gorge. Having passed through the turbines the diverted water will be returned via a tailrace discharging to the Waitaha mainstem in the vicinity of the confluence of Alpha Creek. The Scheme will divert up to a proposed maximum of 23 m3/s (cumecs), while maintaining a minimum residual flow of 3.5 m^3/s immediately downstream of the intake. The hydro design includes a 10 cumec bypass valve to maintain water flow following Power Station outages. The abstraction reach concerns approximately 2.5 km of the Waitaha River, including Morgan Gorge. Construction access to the Headworks above Morgan Gorge would initially be via helicopter and / or on foot and then via the access tunnel (once it is completed), while an access road and transmission line corridor (average 15 m in width) would be required from the Waitaha Valley Road to the Power Station to enable a connection to the existing network. There will be no above ground road access to the Headworks. A short access road will provide temporary access between the access tunnel portal and Construction Staging Area 1 (Headworks) during the construction phase. There will also be a short access road from the access tunnel portal to the riverbed to facilitate safe maintenance at the intake. Further detail on the Scheme as it relates to freshwater ecology is set out in **Appendix B.** A description of the Scheme and Project Site is set out in the '**Project Overview**' Report and the **Project Description**.

1.3 Westpower Ltd (**Westpower**) commissioned EOS Ecology to assess the potential effects of the Scheme on freshwater ecology (fish, invertebrates, freshwater plants and habitat) (this **Freshwater Ecology Report**). Wetlands are not included in this assessment, as they have been covered in the **Vegetation Report (**TACCRA, 2025). The qualifications and experience of the report author relevant to the Scheme are set out in **Appendix A**.

1.4 This report considers and assesses:

(a) the values and the significance of the Project Site and the potential effects of the Scheme in relation to freshwater ecology (water quality, habitat, freshwater plants (periphyton/algae, bryophytes and macrophytes), macroinvertebrates, and fish)); and

(b) how actual and potential effects are proposed to be managed.

1.5 We are advised that with respect to the Department of Conservation concessions required for this project, this assessment of effects of the Scheme on freshwater ecology are applicable to the application for concessions under the Conservation Act 1987.

1.6 This freshwater ecology assessment focuses on technical/science-related material and whilst it may be used to inform a cultural assessment, it is not intended to take the place of one or be used to speak for iwi on their behalf. We understand that Te Rūnanga o Ngāti Waewae and Te Rūnanga o Makaawhio (together, Poutini Ngāi Tahu) are the rūnanga that exercise tino rangatiratanga within, and are the kaitiaki of, the natural and physical resources within the West Coast including the

[1] Measured using local roads and tracks to the Power Station.

Waitaha River. We have been advised that Poutini Ngāi Tahu are project partners and support the Scheme and have chosen not to prepare a cultural impact assessment but have contributed to the preparation of the broader assessment of environmental effects and have provided a letter of support for the Scheme.

2. EXISTING ENVIRONMENT

CATCHMENT OVERVIEW

2.1 At 315 km^2 the Waitaha River catchment is the third largest catchment within the Harihari/Wilberg ecological district. The Scheme is situated in the middle of the catchment (**Figure 1**), near the border of the Wilberg/Harihari ecological district; which is where the catchment changes to more of a farmed landscape. The Waitaha River at the location of the Scheme is dominated by a glacial mountain fed topography/source of flow; defining it as a system with strong seasonal flow patterns (low winter flows and high summer flows) and high turbidity due to the presence of fine glacial sediment. The upper catchment receives significant annual rainfall of around 12-14 m, with some of the world's highest annual rainfall having been recorded in nearby catchments (**Hydrology Report**: Doyle, 2025). The dominant geology is a mixture of poor to well-foliated fissile schist and glacial outwash gravels in the valley floors and terraces, and landslips are a characteristic feature of the area.

2.2 The Waitaha River exhibits a high natural disturbance regime with frequent large floods, high fluxes of bed-material, and transient deposition and re-working of sediment (**Sediment Report:** Hicks, 2025). The annual frequency of floods greater than three times the 20 cumec median flow (FRE_3) at Kiwi Flat (downstream of the Whirling Water confluence) is approximately 26 (**Hydrology Report**); meaning that approximately 26 times a year there are flood flows that are greater than three times the median flow of 20 cumecs. This type of flood frequency is in the upper range for New Zealand rivers, and is a significant factor affecting/limiting the biological community inhabiting the river. Climate change predictions indicate an increase in the frequency and size of flood flows (**Hydrology Report**).

2.3 Further catchment overview is provided in **D** (Section 10). Further information on the hydrology of the river is provided in the **Hydrology Report**; sediment and channel bed characteristic in the **Sediment Report**; vegetation in the **Vegetation Report**; and riverine birds in the **Terrestrial Fauna Report** (Buckingham, 2025) and **Whio Report** (Overmars, 2025).

INVESTIGATIONS

2.4 There has been a considerable amount of freshwater ecology investigations undertaken, spanning multiple years, that provide a comprehensive understanding of the ecological state and values of the Waitaha catchment's waterways. This includes investigations undertaken as part of earlier project work in 2007, 2008 and 2013 (Drinan & McMurtrie, 2014; McMurtrie & Suren, 2014), as well as supplementary eDNA sampling in 2024 (McMurtrie & Grima, 2024). The earlier surveys were detailed, quantitative, and comprehensive; covering a wide range of aquatic habitats throughout the catchment. Even though that data is 11-17 years old, there has been no land use change in the catchment since that time, and according to the **Hydrology Report** the river flow has not significantly changed over that time either. As such there is nothing that would have caused the freshwater communities to change, and so those survey findings remain valid today. The more recent sampling in 2024 consisted of eDNA sampling, which is new technology that did not exist at the time of the original surveys and so was used to supplement the past investigations in relation to detecting species presence.

2.5 All investigations relate the ecological data back to where they are found within the catchment, as shown in Figure 1:

(a) Downstream Reach (downstream of Douglas Creek and thus downstream of the Scheme).

(b) Douglas Creek Reach (from Douglas Creek to Morgan Gorge, including the proposed abstraction reach).

(c) Kiwi Flat Reach (from the top of Morgan Gorge to the bottom of Waitaha Gorge, including the intake structure site).

(d) Upstream Reach (upstream of Kiwi Flat and thus upstream of the Scheme).

2.6 All investigations also relate ecological data back to waterway types; being the mainstem of the Waitaha River, stable tributaries or 'other' tributaries.

2.7 Investigations undertaken in the Waitaha River catchment include:

(a) Sampling of macroinvertebrates at 31 sites by McMurtrie & Suren (2014). This entailed the collection of 308 invertebrate samples collected via recognised conventional quantitative sampling methods (Surber sampling, rock rolling, boulder rubbing). Samples were then processed in the laboratory, with invertebrates counted and identified to the lowest (i.e., most detailed) practicable level.

(b) Sampling of periphyton (algae) at 31 sites McMurtrie & Suren (2014). This entailed the collection of 31 samples collected via recognised conventional quantitative sampling methods (Biggs & Kilroy (2000) 'method 1b'). Samples were then processed in the laboratory to identify and count algae taxa.

(c) Collection of water quality samples and habitat assessments by McMurtrie & Suren (2014), at the 31 sites where invertebrates and periphyton were collected from. Water samples were collected once from all 31 sites, and further samples were collected from six of these sites on an additional three occasions. Water samples were tested in the laboratory for nutrients.

(d) Sampling of fish at 48 sites by Drinan & McMurtrie (2014). Sampling used all recognised conventional fish sampling methods; electrofishing, fyke netting, Gee's minnow trapping, spotlighting.

(e) Further sampling to specifically look for the presence of the introduced alga. This used recognised conventional sampling methods of drift sampling and rock scrapings (in 2007/2008 by McMurtrie & Suren (2014)), as well as the collection of water samples for eDNA analysis (in 2024 by McMurtrie & Grima (2024)).

(f) Collection of environmental DNA (eDNA) samples at 20 sites by McMurtrie & Grima (2024). This entailed the collection of 120 water samples for laboratory eDNA analysis to look for the presence of freshwater species (fish, invertebrates, periphyton). This was to provide supplementary species presence data to add to the comprehensive conventional quantitative sampling described above.

2.8 Further detail of the investigations is provided in **Appendix E**.

2.9 In addition to the ecological surveys described above, the Allen & Hay (2013) **IFIM Report**[2] undertook Instream Flow Incremental Methodology (**IFIM**[3]) work to determine how the available habitat used by different biota within the river changes would change in response to different residual flows, which aids in ascertaining the ecological effects of removing different quantities of water from the river.

ECOLOGICAL VALUES

2.10 Water quality

(a) The Waitaha River catchment from Douglas Creek upstream (i.e., within the Upstream Reach, Kiwi Flat Reach and Douglas Creek Reach) is a naturally low nutrient system. The results of most nutrient tests from samples collected in the catchment were either below the laboratory detection limits or were at very low levels that were well below the national average for rivers across the country (based on data from the National River Water Quality Network (**NRWQN**)). The low-nutrient water of the Waitaha catchment is typical of other West Coast rivers where catchment modification is minimal. The low nutrient water of the Waitaha River mainstem, combined with a high flood frequency, means that the risk of excessive algal growth in the river is minimal.

(b) Further detail is set out in **Appendix D** (Section 11).

2.11 Periphyton and bryophyte communities

(a) Periphyton communities within the Waitaha catchment were similar throughout the Catchment, with the exception of two stable tributaries that supported distinct communities (as indicated by the Detrended Correspondence Analysis (**DCA**)[4] analysis). All taxa are typical of low nutrient South Island rivers. Periphyton biomass was lower in mainstem sites due to the low nutrient conditions and frequent flooding. Diatoms dominated the assemblages, underscoring the low nutrient and flood-prone nature of most of the waterways.

(b) The introduced didymo (*Didymosphenia geminata*) is an invasive freshwater algae that has spread throughout South Island rivers since its discovery in 2004. It is now known to be present in the Waitaha River catchment, with eDNA sampling detecting it in the mainstem and tributary streams in the Douglas Creek and Kiwi Flat reaches. Whilst it thrives in low-nutrient waters the glacial flour and unstable flood-prone nature of the Waitaha River mainstem will ensure that it is unable to reach nuisance levels.

(c) The mainstem river and 'other tributaries' supported few bryophytes. Bryophyte diversity and coverage were significantly higher in stable tributaries, and in particular in a stable spring-fed tributary in the Douglas Creek Reach ('Stable Trib' on the true-right of the river opposite Douglas Creek) where there was over 60% bryophyte coverage and 15 species. The scarcity

[2] The **Hydrology Report** by Doyle (2025) noted that as a result of no significant difference in the hydrology statistics calculated in Doyle (2013) compared to Doyle (2025), that the origional assessments informed by these data would not need to be redone. As such the assessment of Allen & Hay (2013) (**IFIM Report**) remains as it is.

[3] IFIM stands for Instream Flow Incremental Methodology, and is a modelling approach used to predict the effect of changing flows in a waterway, based on the assumption that biota (such as fish) are constrained by their environment, that limiting factors are flow related, and that it is possible to produce a single index incorporating the relationship between biomass and all important physical factors (Maughan & Barrett, 1992).

[4] Detrended Correspondence Analysis (DCA) is a statistical technique that graphically represents the similarity of biological communities by plotting them on an x-y graph; such that samples with similar species assemblages appear close together on the graph, and samples with very different communities appear far apart from each other. Samples are plotted in two dimensions (x and y, or Axis 1 and Axis 2). The calculation of a separate *gradient length* along both Axis 1 and 2 provides a measure of the degree to which species composition changes along the ordination axis. A large gradient length (>4) indicates almost complete species turnover along the ordination axis, so that samples at opposite ends of an axis share no taxa in common.

of bryophytes in the mainstem reflects an unsuitable habitat; with unstable substrate, abrasive glacial flour and a flood-prone nature.

(d) The mainstem river in the Waitaha catchment is a low nutrient, high disturbance system unsuitable for periphyton and bryophytes. In contrast, the stable tributaries (unaffected by the Scheme) serve as biodiversity hotspots for bryophytes, which are vital for supporting freshwater invertebrate habitats. Such stable environments are less common in the catchment, underscoring the importance of these tributaries for maintaining freshwater biodiversity within the catchment.

(e) Further detail is set out in **Appendix D** (Section 12 and 13).

2.12 Benthic invertebrates

(a) A total of 100 freshwater invertebrate taxa were recorded in the Waitaha catchment, with the community dominated by insect groups such as mayflies, chironomid midges, caddisflies, and stoneflies. There were four taxa recorded that have a conservation status of ‘At Risk – Naturally Uncommon – these were one stonefly (*Megaleptoperla grandis*), one mayfly (*Deleatidium magnum*), and two caddisflies (*Costachorema brachypterum* and *Philorheithrus latentis*). The community was comparable to those of other neutral pH, fast-flowing West Coast rivers from unmodified catchments in high rainfall areas; where water quality is high and nutrient levels and algal biomass low. Invertebrate biotic metrics (such as taxa richness, MCI[5] and QMCI[6], and the number of EPT[7]) were all typical of other rivers flowing through unmodified catchments and did not greatly differ from that of other large river catchments throughout the West Coast.

(b) There was a distinct difference in the invertebrate communities found in the stable tributaries compared to the more unstable mainstem and other tributaries of the Waitaha catchment. Stable tributaries supported distinct communities (as indicated by the DCA analysis) and had a significantly higher invertebrate diversity and density than the mainstem and other tributaries. These differences can be attributed to the particularly stable nature, high water clarity, and abundant bryophyte community in the stable tributaries. These stable tributaries, particularly the stable spring-fed tributary in the Douglas Creek Reach (‘Stable Trib’ site on the true-right of the river opposite Douglas Creek) supported almost three times as many taxa as the mainstem and had a high species evenness and high numbers of EPT taxa. The ‘Stable Trib’ site was also the only location where waikoura/freshwater crayfish were found. The stable tributaries are considered to be biodiversity ‘hotspots’, are locally important for maintaining biodiversity values and ecosystem functioning within the wider catchment, and will be unaffected by the Scheme.

(c) In contrast, the mainstem and other tributaries had low densities, low species diversity, and low species evenness, with the mayfly *Deleatidium* and orthoclad midges dominating the community of these sites (80% and 70% of total abundance, respectively). The limited invertebrate community is attributed to the naturally unstable nature of these sites, with a high disturbance regime, low nutrients and presence of glacial flour (fed from the glaciers in the upper catchment) also limiting basal food supply. Such naturally flood-prone systems are most

[5] MCI stands for Macroinvertebrate Community Index, which is an aquatic invertebrate health score based on the presence of taxa with different tolerance ratings.
[6] QMCI is the quantitative variant of the MCI score, and as such takes into account the abundance of taxa.
[7] EPT stands for Ephemeroptera, Plecoptera, Trichoptera, which are insect orders that are considered to represent taxa that are most sensitive to habitat and water quality degradation. As such EPT are referred to as the ‘clean water taxa’.

influenced by the intensity and frequency of disturbances, which far outweigh biotic interactions such as predation, competition, and resource supply (Peckarsky, 1984; Lancaster, 1996). The invertebrate community is therefore naturally limited to those taxa that can rapidly colonise or persist in disturbed environments, such as some chironomids and mayflies, with their non-synchronous life cycle and use of side braids, river margins and tributaries allowing for continual recolonisation of disturbed environments.

(d) Further detail is set out in **Appendix D** (Section 14).

2.13 Fish

(a) A total of eight fish species were recorded in the Waitaha catchment; these were (in order of occurrence from most recorded to least recorded) kōaro (*Galaxias brevipinnis*), longfin eel (*Anguilla dieffenbachii*), brown trout (*Salmo trutta*), torrentfish (*Cheimarrichthys fosteri*), lamprey (*Geotria australis*), redfin bully (*Gobiomorphus huttoni*), common bully (*Gobiomorphus cotidianus*) and giant kōkopu (*Galaxias argenteus*). There was one fish species with a conservation status of ‘Threatened – Nationally Vulnerable’ (lamprey) and four with a conservation status of ‘At Risk – Declining’ (kōaro, longfin eel, torrentfish, giant kōkopu). The fish community is comparable to other fast-flowing West Coast rivers from unmodified catchments in close proximity (<23.2 km distance) and generally typical of West Coast rivers.

(b) Kōaro was the only fish species found upstream of Morgan Gorge; meaning that Morgan Gorge represents a fish passage barrier to all species other than kōaro, which have evolved key physiological and behavioural traits that allow them to negotiate barriers impassable to other species. However, even the distribution of kōaro diminished with distance further up the catchment, indicating the natural attrition caused by multiple natural barriers in this mountainous catchment. For kōaro, the tributaries represented a preferable habitat than the river mainstem; which reflects the unstable environment and limited food supply available in the mainstem.

(c) Within the Douglas Creek Reach, there was also a large difference in fish distribution between the tributaries and the mainstem. Only four fish species (kōaro, brown trout, torrentfish, longfin eel) were found in the mainstem, compared to seven species in the tributary sites. However, many tributaries were inaccessible to fish due to natural barriers at the confluence with the mainstem or due to lack of permanent flow. As such most fish in the tributaries were recorded from the spring-fed tributary in the Douglas Creek Reach (‘Stable Trib’ site on the true-right of the river opposite Douglas Creek) and from Douglas Creek; both of which are downstream of the Scheme Power Station, and which will be unaffected by the Scheme.

(d) Fish densities in the mainstem were also much lower compared to the tributaries. The low density and diversity of fish in the mainstem channel reflects the unstable environment and limited food supply available in the mainstem.

(e) The ‘Stable Trib’ (the spring-fed stable tributary on the true right opposite Douglas Creek) is considered a ‘hotspot’ for fish. It is also a significant lamprey rearing habitat, with 25 juvenile lamprey (ammocoetes) caught in a small area, and could also be a trout rearing habitat. Concomitantly the Kiwi Flat Reach is important to the kōaro fishery, as salmonids are unable to access this area. The historical records of brown trout co-occurrence with kōaro from waterways in nearby catchments shows that, of the total 88 sites with survey data, kōaro exist in isolation from brown trout in 20 waterways (in comparison with 43 where they co-occur); representing 30% of waterways where kōaro have been recorded.

(f) In terms of the value to the salmonid fishery, the river mainstem in the Douglas Creek reach is of little value to the brown trout fishery, with most recreationally fished sections downstream of SH6 or in downstream tributaries such as Ellis Creek. We were unable to find any fish survey records for salmon in the catchment, but Douglas Creek is still regarded as a salmon spawning waterway by Fish and Game.

(g) Further detail is set out in **Appendix D** (Section 15).

2.14 **Table 1** below provides a summary of the significance of the values assessed in accordance with the relevant planning provisions. These documents are the Regional Policy Statement (**RPS**) (WCRC, 2020), the proposed Te Tai o Poutini Plan (**TTPP**) (TTPPC, 2022), the Westland District Plan (**WDP**) (WDC, 2002), and the West Coast Conservation Management Strategy 2010-2020 (**CMS**) (DOC, 2010). The provisions of each of the above planning documents relevant for assessing significance are set out in **Table 5** of **Appendix F**. Further detail of the significance of the values relating to freshwater ecology is also provided in **Appendix F.**

Table 1 ***Significance of freshwater ecology values in the Waitaha River, assessed in accordance with the relevant planning provisions.***

Criteria	Significance of freshwater ecology values in the Waitaha River
Representativeness (RPS [Policy 7.1(a); Appendix 1: Criteria 1(a)(b)], TTPP [Policy ECO-P1(2)(i)], WDP [Policy 4.9D (ii)], and CMS [Policy 3.3.2.3 (1)])	**High significance value**: see Appendix F (Section 18) for the value rationale.
Rarity/Distinctiveness (RPS [Policy 7.1(a); Appendix 1: Criteria 2(a)(b)(c)(d)], TTPP [Policy ECO-P1(2)(i)], WDP [Policy 4.9D (iii)], and CMS [Policy 3.3.2.3 (1)])	**Medium significance value overall / High significance value for the 'Stable Trib' in Douglas Creek Reach**: see Appendix F (Section 18) for the value rationale.
Diversity and Pattern (RPS [Policy 7.1(a); Appendix 1: Criteria 3(a)], TTPP [Policy ECO-P1(2)(i)], and CMS [Policy 3.3.2.3 (1)])	**High significance value**: see Appendix F (Section 18) for the value rationale.
Ecological Context (RPS [Policy 7.1(a); Appendix 1: Criteria 4(a)(b)], TTPP [Policy ECO-P1(2)(i)])	**High significance value**: see Appendix F (Section 18) for the value rationale.
Intactness (WDP [Policy 4.9D (i)], and CMS [Policy 3.3.2.3 (1)])	**Very High significance value**: see Appendix F (Section 18) for the value rationale.
Protected Status (WDP [Policy 4.9D (iv)])	**Low significance value**: see Appendix F (Section 18) for the value rationale.
Connectivity (WDP [Policy 4.9D (v)])	**High significance value**: see Appendix F (Section 18) for the value rationale.
Threat (WDP [Policy 4.9D (vi)])	**Medium significance value overall / High significance value for 'Stable Trib' in Douglas Creek Reach**: see Appendix F (Section 18) for the value rationale.
Migratory Species (WDP [Policy 4.9D (vii)])	**Medium significance value**: see Appendix F (Section 18) for the value rationale.
Viability (CMS [Policy 3.3.2.3 (1)])	**High significance value**: see Appendix F (Section 18) for the value rationale.

Regional Policy Statement (RPS), proposed Te Tai o Poutini Plan (TTPP), Westland District Plan (WDP), West Coast Conservation Management Strategy 2010-2020 (CMS).

3. ENVIRONMENTAL EFFECTS ASSESSMENT

3.1 This assessment is based on the proposed construction programme provided in the **Project Description** and in the General Arrangement Maps. Further detail regarding the potential effects and proposed management is provided in **Appendix G.**

CONSTRUCTION EFFECTS

3.2 Sediment release

(a) There is the potential for the release of sediment from the construction footprint (relating to vegetation clearance and construction of infrastructure), from temporary tracking across some waterways (Macgregor Creek, as well as the Waitaha River between Macgregor Creek and Granite Creek, and up the side of Granite Creek to the site of the temporary Granite Creek bridge location), and from gravel screening and sediment stockpile and distribution areas before they are able to be stabilised. The Erosion and Sediment Control Plan (ESCP) provides details around the measures that will be undertaken to control and reduce the release of sediment during the construction phase.

(b) The sensitivity of a receiving environment is moderated by the natural sediment regime experienced by that system. The Waitaha River and ‘other’ tributaries have high natural sediment loads and frequent floods and the biota in these systems are adapted to such conditions. The potential for construction-derived sediment runoff is highest during rainfall events. Any residual construction-derived sediment entering these systems following implementation of good erosion and sediment control measures will be dispersed quickly and will be indistinguishable from naturally occurring sediment entrained in flood flows. This means construction-related sediment effect will be ‘**less than minor**’. That said, we recommend that construction of the crossing structure (i.e., a Hynds ‘drift deck’ or similar) for Macgregor Creek should be prioritised to limit the amount of vehicle crossing via the temporary access track across the braid plain.

(c) Small stable tributaries such as the ‘Stable Trib’ (in the Douglas Creek Reach on the true-right opposite Douglas Creek), which do not naturally experience elevated flows or sediment loads during rainfall, are more sensitive to sediment inputs. Any sediment runoff is highly unlikely to reach the Stable Trib due to the distance of any works from the stream (at least 50 m based on the current access road alignment). Vigilance remains necessary, however, to prevent sediment from entering standing or slow-moving waters that the access road may intersect. With good erosion and sediment control measures the effects will be kept to a ‘**less than minor’** level.

3.3 Release of cementitious contaminants

(a) Concrete work (mainly *in situ* pouring of concrete) will occur near or within the Waitaha River for construction of the intake infrastructure (weir, sluice channel, kōaro passage structure etc) and Power Station, whilst shotcreting will be used in tunnels and around the Power Station. The *in situ* pouring of concrete will also be used in the Granite Creek bridge construction (pouring of abutments), and some cementitious products will be used for the Macgregor Creek crossing that involves the use of a crossing structure (i.e., a Hynds ‘drift deck’ or similar). In addition, cleaning of concrete tools or formwork will occur within the work site areas, and a concrete batching plant will be located in farmland to the north of Macgregor Creek.

(b) Water contaminated with concrete or cementitious products (mortar, grout, plaster, stucco, cement, slurry) is highly alkaline and can harm aquatic life by causing pH shifts and increasing ammonia levels, which can be toxic to fish.

(c) Strict measures are needed to prevent release of contaminated water into freshwater environments, but if effectively managed and implemented will keep the effects to a '**less than minor'** level.

3.4 Release of other construction-derived contaminants

(a) The use of machinery during the construction phase brings with it the risk of spills and leaks from fuel and lubricants where machinery is working within or close to waterways. This can be easily avoided through good machinery maintenance and implementing storage and refuelling well away from waterways.

3.5 Spread of freshwater pest species (didymo)

(a) The invasive algae didymo has been recorded from within the catchment as well as in nearby catchments. Sensible check-clean-dry protocols to limit the spread of didymo are well documented. Whilst the Scheme has no control of the behaviour of other users in the catchment, implementation of such protocols is standard operational procedure for site works of the types proposed and should limit the spread during the construction phase.

3.6 Fish passage during in-channel works

(a) It is usually necessary to maintain fish passage when undertaking in-river works. However, in the case of in-channel works at the Headworks, instead of maintaining fish passage for all species it will be critical to ensure that during weir construction only upstream passage of kōaro is maintained (i.e., all other fish passage is to be excluded, as is currently the case).

(b) Maintaining fish passage during construction of the access road at ephemeral or intermittent waterways (Macgregor Creek and Alpha Creek) will not be necessary given that year-round fish passage access is not available under natural conditions and the system upstream of the crossing would be unlikely to support permanent fish populations.

(c) Granite Creek appears to have perennial flow and so maintenance of fish passage is necessary. However, as a bridge is proposed for this site which will span the wetted channel, the construction works should not result in any impacts to fish passage during that time. This also applies to the temporary bridge that will be installed ahead of the permanent bridge (so as to facilitate the construction of the permanent bridge).

(d) There are a number of ponded water areas or small waterway channels that appear to soak to ground along the access road alignment proximal to the 'Stable Trib'. No surface water connection between these areas of surface water and the 'Stable Trib' or the mainstem river were able to be found. As such it is unlikely that these areas support migratory fish species. The **Project Description** indicates the existing hydrology of such areas will be maintained by culverts. However, given the isolation of these smaller areas from the river, it will not be necessary to ensure fish passage during the construction phase, especially considering the construction time will be relatively short for each water body.

3.7 Mortality of biota at the site of in-channel works

(a) Some mortality of freshwater biota (fish, invertebrates) and periphyton will be unavoidable at the site of in-channel works; as well as during the initial vehicle tracking within the wider braid plain of Macgregor Creek, the Waitaha River between Macgregor Creek and Granite Creek, and up the side of Granite Creek to the site of the temporary Granite Creek bridge location.

(b) This is unlikely to have any lasting impact on the ecology of Macgregor Creek or the mainstem river given the small size of the works in comparison to the size of the river, and due to the intermittent nature of flow in Macgregor Creek and the very low density and diversity of invertebrates and fish inhabiting the mainstem river. However, there is the potential for fish to be present in the margin of the river where the tail race will be constructed, and as such we recommend implementing a fish relocation at that work site prior to its dewatering.

(c) Macgregor and Alpha Creeks have intermittent or ephemeral flows, so if they are dry at the time of temporary crossings or the construction of vehicle crossings, no freshwater taxa will be affected. Even if they are flowing (and thus dewatering will be required), the ecological impact of any localised mortalities will be ‘**less than minor’** given the small size of the area affected and the high disturbance regime of these waterways which are naturally inhabited by resilient taxa that will recolonize the site.

(d) For Granite Creek if a pier is required in the channel for the bridge span, then if it could be placed outside flowing areas that would result in no effect at all. Yet even if an in-channel pier was constructed in an area of flowing water this would have minimal impact given the small size of the area and the presence of freshwater communities that will readily recolonize following completion of any in-channel works.

(e) There is the potential for the temporary access route from Macgregor Creek to Granite Creek to impact on a small unnamed tributary just upstream of the confluence of Macgregor Creek with the Waitaha River. To mitigate this, we recommend that the access route is moved into the bed of the wider Waitaha River braid plain to avoid the tributary waterway confluence point altogether. This will have little impact on the biota of the larger river, with the permanent flow being located away from this location and with the river already naturally experiencing a high disturbance regime.

(f) There are a number of ponded water areas or small waterway channels that appear to soak to ground along the road alignment proximal to the ‘Stable Trib’, and the **Project Description** indicates an intent to install culverts at these locations. Given the unknown nature of these areas, it would be worthwhile to either sample these for non-migratory fish before construction starts (to inform which areas may need fish removal at the time of the works) or implement a fish rescue at the time of each culvert installation.

3.8 Gravel extraction from the Waitaha River

(a) Approximately 23,000 m^3 of gravel is needed from the Waitaha River to build the access road, with this to be taken from dry gravel beds within the wider braid plain of the Waitaha River. The impact of the gravel extraction on the local channel morphology and gravel transport is assessed to be ‘**minor’**, with further downstream effects ‘**less than minor**’, according to the **Sediment Report**. Thus, provided that gravel extraction and machinery stays out of the active wetted channels, the water table is not intercepted, sediment release is controlled, and standard measures as described in Rule 29 (b-j) (relating to gravel extraction) of the West Coast Regional Land and Water Plan (**RLWP**) (including setback distances) are followed, there should not be any interaction with, or impact on, the aquatic ecology of the river. It is noted in the **Sediment Report** that it is not practicable to specify the exact location of extraction in advance of the works being undertaken, as the area of extraction will need to reflect the current conditions of the river and locations of wet braids and bar locations, which will move over time. Thus, there needs to be allowance made for the ability of the extraction area to move in relation to the conditions at the time of extraction.

3.9 Further detail of the construction effects of the Scheme is provided in **Appendix G** (Section 19). Table 2 provides a further summation of those construction effects and management measures.

OPERATIONAL EFFECTS

3.10 Residual flow

(a) The Scheme will divert up to 23 cumecs of water while maintaining a proposed residual flow of 3.5 cumecs within the Waitaha River mainstem channel, running from the weir structure at the top of Morgan Gorge to the downstream end of the tail race that redirects the flow back into the river, just upstream of Alpha Creek. The residual flow/abstraction reach is approximately 2.5 km, which represents roughly 6% of the Waitaha mainstem length between the coast and Ivory Lake. The setting of the residual flow of 3.5 cumecs was informed by an assessment of effects to freshwater ecology and the results of the IFIM modelling (see **the IFIM Report**), which is discussed further in **Appendix B** (Section 8).

(i) The Scheme will change the low to median flow statistics[8] through the abstraction reach, reducing the median flow from 19.7 (or 19.9 based on the extended flow modelling in the **Hydrology Report** cumecs to that of the residual flow (3.5 cumecs) at the Headworks. The residual flow within the residual flow/abstraction reach will be supplemented by perennial flow from two waterways entering Morgan Gorge that will help raise the residual flow to around 4.2 cumecs downstream of Glamour Glen for 50% of the time.

(ii) Residual flow immediately downstream of the Headworks will occur for approximately 57% of the time for a take of 19 cumecs, and 66% of the time at take of 23 cumecs, noting that the residual flow will only persist for a few days before being increased by a fresh or flood. The assessment of the residual flow duration is a conservative one, as it is likely that the time that the river is in residual flow will be somewhat less than what has been calculated, due to the practical considerations that operational station shut down could also occur when the river is at lower flows.

(iii) The frequency of floods exceeding the FRE_3 value at the bottom of Kiwi Flat will remain all but unchanged at a take of 23 cumecs (**Table 5**). Therefore, the Scheme will have little effect on the frequency of even smaller floods through the abstraction reach.

(b) In regard to periphyton, IFIM modelling predicted a large increase (174%) in short filamentous algae, an increase in long filamentous algae (127%) and a decrease (28% useable habitat) in diatoms within the abstraction reach. However, these are unlikely to occur given the low nutrient status and high disturbance regime of the river. Thus given (i) the comparatively short distance of the abstraction reach (totalling approximately 2.5 km or roughly 6% of the Waitaha mainstem between the coast and headwaters at Ivory Lake), (ii) the low nutrient status of the river that would limit growth, (iii) the existing low periphyton biomass and low diversity and

[8] This residual flow and maximum take was informed by the results of the IFIM modelling (see **the IFIM Report** by Allen & Hay, 2013). A detailed description of hydrology is provided in Doyle (2013) and the **Hydrology Report** (Doyle, 2025). We note that the **Hydrology Report** advises against reassessing past related studies, such as the **IFIM Report**, on the basis of the updated hydrological information, as the underlying flow statistics are considered virtually unchanged. As such the information presented here is that provided in the **IFIM Report** which was informed by the Doyle (2013) report.

density within the abstraction reach, (iv) all species within the abstraction reach also being found throughout the rest of the Waitaha mainstem and tributaries unaffected by the Scheme, and (v) the overarching dominance of the disturbance regime and sediment dynamics on the periphyton community remaining unchanged, the overall impact of the residual flow on the periphyton community of the Waitaha River is assessed as being low (or **'minor'**).

(c) In regard to macroinvertebrates, IFM modelling predicted variable effects ranging from decreases to increases in habitat availability depending on the particular Habitat Suitability Curve used. The IFIM modelling is limited to predicting changes in habitat suitably in relation to water depth, velocity and substrate. However, any predicted changes based on this modelling will most likely be overridden by the low nutrient and high disturbance regime of the river, which are the overarching factors affecting the benthic aquatic community of this river; and that will not change under the Scheme's operation. Thus given (i) the comparatively short distance of the abstraction reach (totalling approximately 2.5 km), (ii) the low periphyton biomass and low diversity and density of aquatic invertebrates within the abstraction reach, (iii) the presence of all species throughout the rest of the Waitaha mainstem and in tributaries unaffected by the Scheme, and (iv) the overarching dominance of the disturbance regime and sediment dynamics on the benthic fauna remaining unchanged, the overall impact of residual flow on the benthic aquatic macroinvertebrate community of the Waitaha River is assessed as being low (or **'minor'/'less than minor'**).

(d) In regard to fish, IFIM modelling predicted that habitat availability for adult brown trout would be greatly reduced during dry and typical flow months and habitat for native fish found in the abstraction reach would generally increase, apart from longfin eel, which is predicted to decrease slightly. However, when put into context with the fact that the mainstem of the Waitaha River in the abstraction reach is already sub-optimal for trout, longfin eels, and kōaro; due to the low food supply and high disturbance regime, it is unlikely that these predicted changes would eventuate under the Scheme's operation. Thus given (i) the comparatively short distance of the residual flow (totalling approximately 2.5 km), (ii) the low diversity and densities of fish species within the abstraction reach (brown trout, kōaro, longfin eel, torrentfish), (iii) the overall sub-optimal fish habitat in the mainstem within the abstraction reach, (iv) the ability of kōaro to still migrate upstream into tributary waterways within the abstraction reach and upstream into Kiwi Flat, and (v) the protection of flow and surface water connections for the 'Stable Trib' and Douglas Creek (which are located approximately 800 m downstream of the end of the abstraction reach), the overall effect of residual flow on the fish communities is assessed as being low (or '**minor**'/'**less than minor**') – provided that fish passage is prevented at the intake weir structure for all fish other than for the upstream movement of kōaro into Kiwi Flat (this is covered in Section 3.16).

(e) It would be possible to monitor the buildup of filamentous algae during prolonged periods of residual flow (i.e., greater than four weeks) in the abstraction reach, and if this reaches problem levels then any excessive accumulations could be flushed out by temporarily reducing the take to the Power Station. This is a similar approach to what is recommended in the **Sediment Report** for managing 'transient fine sediment drapes' (see 3.12 (c)). This monitoring can be included in an adaptive management plan that allows for the monitoring duration to be modified based on findings from initial monitoring. Whilst excessive periphyton growth is not expected to be an issue due to the low nutrient status of the river and regularity of large bed-moving floods that will continue even with the Scheme, this type of monitoring and adaptive management regime would certainly ensure any potential effects of residual flow on periphyton growth (and from that invertebrate communities) could be reduced from a **'minor**' to '**less than minor'** level.

3.11 Rapid flow changes as part of planned maintenance or emergency shutdowns

(a) Run-of-the-river schemes can cause rapid flow changes during planned maintenance (expected to occur 1-2 times a year) and emergency shutdowns (may occur around four times a year, half of which will be the result of storms and the majority occurring outside low flow periods). Flow redirection under emergency shutdowns will occur within a very short timeframe (i.e., within a few minutes), and will cause a rapid increase in flow at the intake point, and a concomitantly rapid decrease in flow going into the river at the point of the Power Station tail race. The opposite will occur when the Scheme starts up again following a shutdown. The **Flow Modelling Report (**AusHydro, 2025 produced a 2D model to look at the effect of emergency shutdowns and planned shutdowns under three different flow scenarios. The effect of rapid flow changes are influenced by channel morphology and distance downstream of the tail race.

(i) **Single confined channel immediately downstream of the Power Station:** Under the three flow scenarios there will be an approximate 40 minute lag between the leading edge of the water diverted at the intake reaching the part of the river at the point of the Power Station tail race. For that period of time there will be a sharp decrease in flow and water depth in the river downstream of the Power Station tail race.

(ii) **Braided channel further downstream of the Power Station:** The temporary flow reduction as a result of an emergency shutdown will not be felt at the start of the braided section until around 25 minutes after shutdown[9]. It appears that the period of reduced flow depth will occur for approximately 45 minutes – which is the time it takes for flow diverted from the intake into the channel to reach this section of the river. The magnitude of the flow reduction is less than in this reach, in part a result of the flow inputs from other sources, but the flow depth reduction will also be affected by the number of braids in the channel (i.e., smaller shallower braids will experience more water loss than larger deeper braids). The flow reduction will propagate downstream, with the **Flow Modelling Report** indicating that flow changes will reduce with increasing distance downstream, and likely barely perceptible at the coast.

(b) Rapid reductions in flow could result in fish being trapped in isolated pools (entrapment) or stranded on exposed substrate (beach stranding). The chance and rate of fish stranding depends on factors such as down-ramping speed, ramping range (magnitude of change), habitat cover, and temperature-dependent fish behaviour.

(i) Fish entrapment could occur where the water levels drop enough to create isolated pools of water within the channel, from which fish are not able to escape. The constrained single channel within the Douglas Creek Reach, combined with the limited fish found in this section reduces the risk of fish entrapment. The Downstream Reach, with its wider braided channel, is more vulnerable to flow reductions and thus presents a greater potential entrapment risk. Whilst the modelling provided in the **Flow Modelling Report** in an eight-braid section of channel indicates that some water would remain in all braids, the

[9] This is the time that it takes for the full flow in the single channel from the point of the tail race to move downstream to the start of the braid section.

naturally variable nature of braided rivers coupled with the granularity and uncertainty of the model means that it would be difficult to be certain whether such quick flow reductions would create pockets of isolated bodies of water and trap fish. However, since these flow reductions are for a short time (i.e., 40-45 minutes) and there is good water quality, the risk of fish mortality from entrapment remains limited, although there may be an increased chance of predation (from birds or other fish trapped in the same area) should they be present and able to capitalise on such a random event. With increasing distance downstream, additional flow inputs (both surficial and subsurface) will further lessen the magnitude of flow reduction with increasing distance downstream, and in turn lessen the chance of there being fish entrapment further downstream.

(ii) Beach stranding could occur where the water levels drop low enough and fast enough to cause fish to become stranded on exposed areas of substrate, with the greatest potential in marginal habitats that would be exposed. Smaller benthic fish (e.g., juvenile kōaro and torrentfish) would potentially be able to find refuge in interstitial spaces, whereas larger, water-column dwelling fish like trout and salmon may be more at risk. The **IFIM Report** estimates an 85% habitat retention in the Douglas Creek Reach under a 3-cumec residual flow. Combined with the short reach and lower fish diversity in this section, strandings would be a low probability or unlikely to significantly impact fish populations. The braided area of the Downstream Reach has a higher proportion of marginal habitat and so has a comparatively higher risk of beach stranding. Whilst the **Flow Modelling Report** modelling within an eight braid section indicates that water will remain in all braids in the modelled scenario, there is uncertainty in the model and insufficient detail to ascertain the portion of marginal habitat that would be reduced. The ability of fish to survive fish beach strandings for the 40-45 minutes of flow loss will again depend on size and behaviour, with the more common smaller native fish and eels/tuna better able to seek refuge under rocks and within the interstitial spaces where water may remain.

(c) Rapid flow reductions from emergency shutdowns may impact fish spawning if redds or eggs in the channel are exposed and dry out. However, most native fish in the mainstem would be unaffected, as they lay eggs in areas that naturally become exposed (e.g., kōaro) or spawn at sea (e.g., longfin eel). Salmonids, which build in-channel redds, are unlikely to be significantly impacted, as the Waitaha mainstem in the Douglas Creek reach and nearby downstream habitat lacks suitable spawning habitat. Some effect may occur for torrentfish if shutdowns coincide with their spawning, particularly in the Downstream Reach, where braided sections are more favourable habitat.

(d) The effect of rapid reductions in flow from emergency shutdowns on macroinvertebrates is considered to be low or **'less than minor'**. This is due to the already significantly naturally disturbed system of the Waitaha mainstem and braided river channel downstream of the tail race with braids subsequently drying and moving on a regular basis. Indeed, benthic invertebrate communities have been found to recolonise river braids within 30 days after drying (**IFIM Report**).

(e) Fish displacement or washout can occur during up-ramping, when there is a sudden increase in river discharge. This sudden increase in flow would be evident at and immediately downstream of the Headworks during an emergency shutdown, as well as at the tail race when the system starts up again. Water column-dwelling fish like trout and salmon are most vulnerable, as unlike most of our more benthic-dwelling native fish species, they are less able to seek refuge in the riverbed. Juvenile native fish that are migrating upstream could similarly be affected if up-ramping occurred during their migration period. Displacement risk is offset by the existing highly variable flow, where records show sharp increases in flows over a short time (24 cumec increase in 15 minutes; Martin Doyle, unpublished data – albeit not as quickly as in an emergency shutdown, but comparable to a ramped maintenance shutdown). The Waitaha River's natural flood-prone nature and the low fish population in the Douglas Creek Reach, will help to naturally mitigate the effects of up-ramping to some degree.

(f) Further details regarding these effects are covered in **Appendix G** (Section 20.2).

(g) The **Project Description** includes ramping procedures to prevent a sudden change in flow during planned shutdowns/startups, that will help further reduce the risk of fish stranding and displacement during planned maintenance. The longer this ramp up and ramp down can take, the better; as it provides an opportunity for the leading edge from the Headworks to reach the tailrace at the Power Station (i.e., the two ends of the abstraction reach). We also recommend that planned shutdowns extend over a longer duration than startups, on the basis that the area at greater risk to fish stranding is the downstream reach (which would experience a short term loss of flow during Scheme shutdowns).

(h) The ability to provide mitigation during an emergency shutdown is more limited, due to its unplanned nature. However, the following are some ameliorating factors or mitigations options that are available:

   (i) The fact that emergency shutdowns most often occur during storm events when the river would have a higher flow (**Project Description**), naturally ameliorates the risk of fish stranding or washout, as a higher flow in the river at the time of an emergency shutdown reduces the magnitude of the temporary flow change.

   (ii) The flow change caused by an emergency shutdown, whilst rapid, is temporary, lasting somewhere between 30-45 minutes according to the **Flow** M**odelling Report**. Thus, the survival of biota is influenced by their ability to survive entrapment or stranding for that length of time, with most of the fish inhabiting the mainstem having behavioural attributes that will improve their chances of survival.

   (iii) The number of likely emergency shutdowns is expected to be around four a year, so the frequency the river will experience a rapid flow change is low.

   (iv) The scheme includes infrastructure that will allow a bypass flow of 10 cumecs to still be diverted down the tunnel during an emergency (and planned) shutdown, that will discharge as an aerated plume of water to the river immediately downstream of the Power Station. This will reduce the magnitude of flow change during emergency (and planned) shutdowns at both the intake and within the Downstream Reach, meaning reduced effects. As a secondary flow change will occur when the bypass value is shut off, it is recommended that the bypass valve is not closed until the flow redirected into the channel from the Headworks has reached the tail race, and that it is closed over at least a 30 minute period to minimise the flow deficit.

(i) Given the uncertainties around the modelling set out in the **Flow Modelling Report**, we also recommend monitoring to assess effects of planned shutdowns/startup flow changes on fish stranding. This would be done by monitoring/observing fish stranding in the river downstream of the tail race (including within the braided section) under test conditions during the commissioning of the Scheme. We recommend an adaptive management plan be put in place that would allow management approaches relating to planned shutdowns/startups to be informed by findings made during these test conditions (i.e., increasing or decreasing the ramp rate). At a minimum, conditions need to provide for adapting to data obtained through robust test conditions.

3.12 Altered sediment dynamics within the residual flow section and downstream of the tail race

(a) According to the **Sediment Report:**

(i) Bedload sediment will continue moving downstream via the sluice channel with minimal changes, although during operation of the residual flow it will be transported via smaller flows.

(ii) Finer sediments will be captured in the tunnel desander and periodically flushed downstream via the tailrace, potentially affecting local ecology near the tail race.

(iii) Bank erosion could increase near the Power Station during large floods due to loss of floodplain area, or via the aerial plume of water from the emergency bypass valve (depending on where it is directed).

(b) The **Sediment Report** predicts that in general the Scheme will have '**less than minor**' effects on sediment transport and channel characteristics along the Waitaha River, both within the residual flow reach and downstream of the tail race, as well as in regard to potential bank erosion opposite the Power Station Site and as a result of the aerial plume from the emergency bypass valve. This would similarly mean there would be '**less than minor'** effects to freshwater ecology.

(c) The **Sediment Report** does identify the potential for some additional fine sediment accumulation (referred to as 'transient fine sediment drapes') within the abstraction reach during prolonged periods of minimum residual low flow. This could have some impact on freshwater invertebrates within the abstraction reach if it were to smother otherwise course substrate habitat, but the mitigation proposed in the **Sediment Report** ensures that this can be managed to a '**less than minor'** level, by monitoring fine sediment accumulation in the lower part of the abstraction reach and flushing any excessive accumulations by temporarily reducing the take to the Power Station. This monitoring can be included in an adaptive management plan that allows for the monitoring duration to be modified based on findings from initial monitoring.

(d) In terms of limiting the effects of suspended sediment from the flushing of the desander sediment, we recommend that this is undertaken during natural runoff events when it will mimic natural turbid flood conditions, thereby keeping the effects to a '**less than minor'** level.

3.13 Backwater effects and sediment aggradation upstream of the Headworks at Kiwi Flat

(a) The **Sediment Report** concludes that the proposed weir would cause no long term backwater effects and that the sediment aggradation resulting from the weir would be little different to what would otherwise occur due to the much larger and existing constricting effect of the narrow entrance to Morgan Gorge, which currently sets the hydraulic control for flood flows along the lower section of Kiwi Flat. Photos of the effect of the Morgan Gorge constriction on flood flows in Kiwi Flat can be seen in the **Hydrology Report**. As such the weir's only impact would be a short-lived backwater effect that would extend a few hundred meters upstream during initial flood events, and which would naturally aggrade with riverbed material to match the level of the weir in a relatively short timeframe (i.e., after the first few floods).

(b) Following the **Sediment Report** conclusion that such effects of the weir will be '**less than minor**', since they will be limited spatially and masked by the natural variability experienced at Kiwi Flat during its frequent floods and erratic sediment supplies, it is similarly concluded there will be a '**less than minor'** effect on the freshwater ecology in this area.

3.14 Fish entrainment and mortality through the tunnel and Power Station turbines

(a) Kōaro are the only fish species upstream of Morgan Gorge and thus the only species potentially affected by the intake structure at Kiwi Flat. The small size and poor swimming ability of kōaro larvae make it inevitable that some will be entrained and pass through the tunnel to the turbines. Although studies on larger fish indicate possible injury or death during turbine passage, a New Zealand study on small fish (trout fry) suggests mortality rates could be low (3-6%), and postulated that larvae of our diadromous indigenous species like kōaro are therefore likely to survive passage through low-head turbines. The whitewater nature of the Morgan Gorge also represents an existing particularly high energy environment that may already affect kōaro fry survival.

(b) Preventing kōaro larvae from entering the tunnel via screens is difficult due to their small size. Their small size means that the screens on the intake, normally designed to deflect bedload material and debris, will be too large to prevent the passage of the small fish fry. However, the intake design will also include hydraulic features to manage the approach and sweeping velocities in order to keep fish and debris out of the tunnel. However, some kōaro larvae will inevitably enter the tunnel. There is limited knowledge around the spawning and larval drift period for kōaro, with the best estimates being that larval drift primarily occurs during elevated flows in autumn. This increases the chance of additional flow being available to go over the weir and not through the intake tunnel, meaning a greater chance of those flows also transferring kōaro through the residual reach.

(c) Given the low density of kōaro upstream of Morgan Gorge and potential survival during turbine passage, and assuming that the proportion of larvae entrained would be proportional to the flow diverted into the tunnel compared to the flow remaining in the river, the overall impact on the kōaro population may be minimal.

(d) Involvement of a suitably qualified and experienced freshwater ecologist during the detailed design phase of the intake may help with reducing potential kōaro larvae entrainment into the tunnel.

3.15 Fish attraction to the tailrace

(a) Fish species such as kōaro, torrentfish, brown trout, and longfin eel are likely to be attracted to the tailrace discharging into the Waitaha River. Overall fish densities in the mainstem are low, with higher density and diversity found in tributaries. As the tailrace offers a stable flow and clearer water, this will make it attractive to fish in the mainstem. Specifically, juvenile kōaro migrating upstream along the river's edges may be drawn into the tailrace, potentially reducing their numbers moving further upstream.

(b) The design will need to incorporate features or measures that will help to discourage or limit fish access into the tail race and/or facilitate the upstream movement of fish that may be otherwise attracted to the tail race; with this being facilitated by the inclusion of a suitably qualified and experienced freshwater ecologist during the detailed design phase. Checking the structure after any significant bed-moving flood event will also be useful as it can identify if any remediation works are needed to maintain such fish passage features.

3.16 Fish passage at weir intake structure

(a) Morgan Gorge currently acts as a natural fish passage barrier for all species except kōaro, which are specially adapted to navigate obstacles. The preservation of this passage for kōaro, whilst continuing to exclude all other fish species, is crucial since they contribute to the local ecosystem while being negatively impacted by introduced salmonids such as brown trout. The proposed design of the Scheme includes a weir at the top of Morgan Gorge that will serve as an effective barrier to other fish species; while the climbing ability of kōaro will allow the design of a kōaro passage structure that will give them ongoing access to Kiwi Flat.

(b) The **Project Description** includes allowance for a kōaro passage structure that will be located to the true-left of the weir Headworks structure. Because the details of a kōaro fish passage structure is such a key component of the detailed design, and will need to incorporate key design criteria as outlined in Section 20.7(b), it will need to be guided by a suitably qualified and experienced freshwater ecologist who should be involved during the detailed design phase and provide oversight during construction.

(c) The environmental flow gate ensures a continuous residual flow of 3.5 m^3/s, while the sluice gate manages sediment release. Detailed design of the kōaro passage structure will need to consider the positioning of these other discharges to ensure kōaro are attracted to the kōaro passage structure rather than the residual flow or sluice gate, further highlighting the need for input from a qualified freshwater ecologist during the design phase.

(d) Monitoring kōaro population dynamics in tributaries in the Kiwi Flat area compared to tributaries downstream of the Scheme could be used to determine if recruitment is still occurring into the Kiwi Flat area with the Scheme in place. Following a BACI (before-after-control-impact) design will allow for wider population stochasticity (i.e., factors affecting recruitment that are not related to the Scheme) to be factored out. Should the BACI monitoring show that over time there is a reduction of kōaro recruitment into Kiwi Flat compared to downstream sites, then as part of the adaptive management plan there could be allowance made for modifying the kōaro passage structure.

3.17 Fish passage at tributary waterway crossings

(a) The Project Description outlines that small watercourses will be crossed with culverts, while larger tributaries with intermittent or ephemeral flow will use culverts (Alpha Creek) or a ford crossing formed by *in situ* materials or a crossing structure (i.e., a Hynds 'drift deck' or similar) (Macgregor Creek), and larger perennial tributaries (Granite Creek) will be spanned by a bridge. Careful design and maintenance of these structures to account for fish passage will ensure minimal ('**less than minor'**) impacts. Specifically:

(i) Bridges are the preferred option for crossing large perennial flowing tributaries due to their neutral impact on channel morphology and flow, ensuring no hindrance to fish passage.

(ii) For tributaries with intermittent or ephemeral flow, culverted fords or culverts are sufficient for fish passage, and should provide for fish movement during times of flow. However, installation should be informed by the most recent version of the New Zealand fish passage guidelines (but reflecting local waterway conditions and fish species present/expected to be present), with structures inspected after significant floods to address potential scouring that may impede fish access.

(iii) There are areas of ponded water or small waterway channels that appear to soak to ground along the road alignment proximal to the 'Stable Trib'. They have no identified surface water connection and thus are unlikely to be habitat for migratory fish species. The **Project Description** indicates the existing hydrology of such areas will be maintained by the use of culverts where the access road crosses them. As these areas were not assessed to confirm the absence of fish, it would prudent to install culverts in a way that allows for fish passage, meaning that if there are any fish inhabiting these isolated areas, they will at least be able to move freely upstream and downstream of the access road.

3.18 Surface water runoff (for infrastructure hard surfaces and access tunnel discharge)

(a) There will be hard surfaces created by the Scheme, such as a metalled access road and buildings/structures associated with the Power Station, all of which will result in stormwater runoff during rain events. The largest of these is the access road from Macgregor Creek to the Power Station. This will be metalled (with limited sealing around significant waterway crossings) and will have minimal vehicle traffic (1-2 vehicles per week), reducing the risk of vehicle-related contaminants. The design of the access road is also specified to avoid impacting the hydrology of nearby waterways, ponded areas, and wetlands.

(b) Overall, the impact to freshwater systems from contaminated stormwater runoff can be minimised through effective stormwater management. The design allows for water table and sediment management along the access road. Runoff should ideally discharge to the ground, and should at least avoid any chance of discharge into sensitive tributary waterways such as the 'Stable Trib'. Infrastructure surfaces exposed to rainfall or transporting water should avoid materials that are a source of freshwater contaminants (i.e., unpainted zinc roofs or use of copper).

(c) After the tunnel's construction, there will be a permanent discharge of clean water from the tunnel, sourced from natural flow through the rocks. The **Project Description** indicates this will be directed into the tailrace or directly into the river. Whilst there should be no impacts to freshwater ecology as a consequence of discharging this clean water into the river, we recommend that this discharge is directed into the tail race rather than into the main river channel.

3.19 In-channel maintenance works at the Headworks

(a) Planned maintenance at the intake will involve using machinery to clear boulders, gravel, and debris to ensure the river continues to flow towards the intake and sluice gate after significant flow events. Potential effects are expected to be similar to those of other in-channel construction activities, with work limited to a small area near the intake and lasting no more than a day. Given the river's natural high bed sediment movement, the impacts of this small-scale activity on the freshwater environment should be minimal. However, strict contaminant controls and equipment safety measures are essential to prevent spills and avoid equipment washing downstream into Morgan Gorge.

3.20 Loss of shading of waterways from removal of riparian vegetation

(a) The **Vegetation Report** assesses the impact of permanent loss of vegetation, and so the freshwater assessment here is limited to the effect of riparian vegetation removal of stream shading, which is limited to tributary waterways in the path of the access road to the Power Station. The main tributaries (Macgregor, Alpha, Granite Creeks) are large enough that existing riparian vegetation does not provide any shading and so the removal of trees within the 15 m road corridor at crossings will not alter channel shading. The heavily shaded 'Stable Trib' is most sensitive to loss of shading, but as the proposed road alignment is far removed (at least 50 m away) there will be no effect. The potential effect of loss of shading from permanent removal of riparian vegetation is mainly limited to smaller ponded and seepage areas along the access road. However, given the alignment of the road crossing these at roughly perpendicular orientation, and the road alignment chosen to miss larger tree specimens, the overall effect is assessed as '**less than minor'** in relation to the provision of shading.

3.21 Lighting around built infrastructure

(a) Nighttime artificial lighting can confuse various animals that are used to naturally dark nighttime environments. For the adult phase of night-flying freshwater insects, such as mayflies and caddisflies, these lights can be particularly distracting and confusing, with lighting of wet surfaces creating the illusion of a water's surface, leading to egg-laying on asphalt. This can decrease reproductive success and impact population viability. The river mainstem and tributary waterways all support freshwater insect communities that are free from artificial light, could be negatively impacted by lighting associated with the Scheme.

(b) The Scheme's design includes features to minimise these potential lighting effects, including no lighting along the road corridor; minimal lighting at the Power Station and Headworks that will only be activated when necessary; use of remote controlled infrared cameras (that do not require lights to see) at the Power Station and Headworks for remote monitoring of the areas; and consideration of lighting types that limit the emission of blue light and reduce light scatter. Such measures, combined with planting of screening vegetation, should ensure that lighting effects have a '**less than minor**' effect.

3.22 Further detail of the operational effects of the Scheme is provided in **Appendix G**. **Table 2** provides a further summation of those construction effects and management measures.

4. RECOMMENDED EFFECTS MANAGEMENT MEASURES

CONSTRUCTION EFFECTS MANAGEMENT

4.1 The following is a summary of the management measures already proposed or that we recommend to minimise the environmental effects of the Scheme on freshwater ecology. Further detail can be found in **Appendix G.**

4.2 Sediment release

(a) Keep the area of exposed ground to a minimum and have route planning that minimises effects on waterways – this has been a feature of the design to date.

(b) Locate the power poles for the power supply lines along existing and proposed new access roads or tracks where possible.

(c) Keep the location of power poles away from any existing waterways where possible.

(d) Follow good erosion and sediment control practices, as per the Scheme's Erosion and Sediment Control Plan (ESCP). This includes having suitable bunding around temporary spoil piles to prevent suspended sediment runoff from escaping the area; and staging and hydroseeding of spread construction spoil on farmland.

(e) Ensure construction related discharges from any sediment retention pond meet no less than 100 mm visual clarity for the discharge.

(f) Any settled sediment in the sediment retention ponds should be removed from the pond and disposed of off-site. If there is the possibility that sediment has been contaminated then it should be disposed of to landfill rather than to the construction site spoil, or the sediment should be tested prior to disposal to confirm where it is suitable to dispose of it.

(g) Keep the access road corridor well away from the 'Stable Trib' on the true-right opposite Douglas Creek. The **Project Description** specifies that it must not be closer than 20 m, but it would preferrable to have the road located further away than that if possible. Based on the current proposed alignment the road corridor is approximately 50 m away at its closest point. It is recommended that the location of the 'Stable Trib' is accurately marked via a ground survey, prior to finalising the road alignment.

(h) During construction of the access road to the Power Station Site, do not allow any sediment-laden water to enter the 'Stable Trib' on the true-right opposite Douglas Creek, or into any smaller seepage that could potentially discharge into the 'Stable Trib'.

4.3 Release of cementitious contaminants

(a) Ensure any concrete waste does not enter surface waters and all mortars, grouts, and other cement-based products used are fully cured prior to contact with water.

(b) Having strict measures in place for maintaining dry work areas when dealing with wet cement-based products in-channel or in areas where it is not possible to store and treat site runoff will be important to minimise such potential effects, particularly in areas where there is less water dilution (i.e., flowing tributary waterways).

(c) Washing of concreting tools, machinery, or formwork should be done well away from any waterways and in a contained area. It may be most practicable to do this at the concrete batching plant located in farmland north of Macgregor Creek.

(d) Treatment of any construction runoff that has come into contact with wet cement or cement-based products to be stored in a secure storage area, where the water can be tested for pH and pH treated to a level suitable for the receiving environment, if required, before release.

(e) The installation of any in-channel structures for the access road should use precast concrete units where possible if the channel they are being installed in has water.

4.4 Release of other construction-derived contaminants

(a) Ensure refuelling and storage of machinery/equipment/fuels/chemicals occurs where it cannot enter the waterway if there is a spillage, and that fuels and chemicals are stored well away from waterways.

(b) Properly maintaining all machinery on a preventative schedule will reduce the risk of breakdown.

(c) Spill kits should also remain on site at all times to contain any accidental spills and ensure no contaminants enter the waterways, and staff should be trained in its use.

4.5 Spread of freshwater pest species (didymo)

(a) Check-clean-dry protocols for the limiting the spread of didymo are well documented.

4.6 Fish passage during in-channel works

(a) Ensure that conditions at the site of the weir during construction maintain the current flow and physical barriers that prevent all but kōaro from accessing Kiwi Flat. As the river flow will be diverted through a narrower section of channel during construction of the intake channel and weir infrastructure to allow for works to be undertaken ‘in the dry’, such conditions should be ensured. If needed, seek guidance from a suitably qualified and experienced freshwater ecologist.

4.7 Mortality of biota at the site of in-channel works

(a) For the main river dewatering sites, if possible time the works to take advantage of low river flows, which will also help to reduce the area of wetted channel that is dewatered.

(b) For the Granite Creek bridge construction, if a pier is required in the channel, then if possible locate it outside of the portion of channel that is flowing at the time of construction, should bridge design specifications allow.

(c) For the temporary access route just upstream of the Macgregor Creek and Waitaha River confluence, it will be necessary to move the route into the bed of the wider Waitaha River braid plain to avoid the tributary waterway confluence point.

(d) For the ponded areas and small waterway channels along the road alignment implement a fish transfer at the time of each culvert installation. Alternatively, implement a fish survey of these waterbodies prior to road construction, and for any site where no fish are found then a fish transfer programme at the time of construction would not be required for that crossing.

4.8 Gravel extraction from the Waitaha River

(a) Follow the measures as described in Rule 29 (b-j) (relating to gravel extraction) of the West Coast Regional Land and Water Plan.

(b) Given the mobile nature of the river bed, in order to achieve (a) it will be necessary to allow for flexibility in the specific location for the extraction area.

4.9 Further detail of the proposed management for the Scheme's adverse effects during the construction phase is provided in **Appendix G** and is summarised in **Table 2** below.

OPERATIONAL EFFECTS MANAGEMENT

4.10 Residual flow

(a) Monitor for any buildup of periphyton (especially filamentous algae) during prolonged periods (i.e., greater than four weeks) of the minimum residual flow in the abstraction reach, and if this reaches problem levels then flush any excessive accumulations by temporarily reducing the take to the Power Station. This can be included in an adaptive management plan that allows for the monitoring duration to be modified, based on findings from initial monitoring.

4.11 Rapid flow changes as a result of planned maintenance and emergency shutdowns

(a) Planned starting and stopping of the Scheme managed using ramping procedures to prevent a sudden increase or decrease in flow in the main stem of the river. The ramping duration for planned shutdowns should be a longer duration than startups, on the basis that the area at greater risk to fish stranding is the downstream reach (which would experience a short term loss of flow during Scheme shutdowns).

(b) The bypass valve should remain on at least until the flow redirected into the channel from the Headworks has reached the tail race, whilst its shutdown should occur over at least a 30 minute period to minimise the flow deficit.

(c) Observations undertaken during test conditions to assess the effects of changes in river flow during planned shutdowns on fish stranding in the Douglas Creek Reach and braided portion of the Downstream Reach.

(d) An adaptative management plan should be put in place to allow for management approaches to be informed by the findings of observations of fish stranding made during test situations for managed shut downs (up- and down-ramping). This will help to identify the optimal up- and down-ramping rate that minimises fish stranding whilst managing scheme operational considerations.

4.12 Altered sediment dynamics within the residual flow section and downstream of the tail race

(a) As per the **Sediment Report**, monitor fine sediment accumulation in the lower part of the abstraction reach when the river is in minimum residual flow for greater than two weeks, and if monitoring indicates a buildup, then flush any excessive accumulations by temporarily reducing the take to the Power Station. This can be included in an adaptive management plan that allows for the monitoring duration to be modified, based on findings from initial monitoring.

(b) Flushing of the underground desander back into the Waitaha River via the tail race should occur during natural runoff events, when the river naturally has a more turbid flow – this is also recommended in the **Sediment Report**.

4.13 Backwater effects and sediment aggradation upstream of weir intake structure at Kiwi Flat

(a) No mitigation required.

4.14 Fish entrainment and mortality in intake and Power Station turbines

(a) Involvement of a suitably qualified and experienced freshwater ecologist during the detailed design phase to input to the design of the intake to further reduce kōaro larvae entrainment into the tunnel where possible.

4.15 Fish attraction to the tail race

(a) Detailed design of the tail race should incorporate measures to discourage or limit fish access and/or facilitate the upstream movement of fish that may be otherwise attracted to the tail race, and include input from a suitably qualified and experienced freshwater ecologist.

(b) Have a qualified and experienced freshwater ecologist check the tail race after any significant bed-moving flood event along the confluence with the Waitaha River, to see it if any remediation works are needed to retain the ability of the race design to achieve point 4.15 (a) above.

(c) If the tail race needs to be dewatered, then undertake a fish rescue beforehand. Any fish caught should be transferred into the river mainstem upstream of the tail race.

4.16 Fish passage at weir intake structure

(a) Detailed design of the kōaro passage structure and relevant Headworks infrastructure (i.e., weir, sluice gate, intake) should involve input from a suitably qualified and experienced freshwater ecologist, as well as oversight during construction of the kōaro fish passage structure, to ensure that 3.16 is able to be met.

(b) Develop and implement a BACI (before-after-control-impact) monitoring programme for kōaro populations within tributaries of the Kiwi Flat area compared to sites downstream of the Scheme to check that recruitment is still occurring into Kiwi Flat with the Scheme in place. If monitoring shows that recruitment is declining as a result of the Scheme then designing alterations to the kōaro passage structure may be possible.

4.17 Fish passage at tributary waterway crossings

(a) A culvert or other crossing structure that allows river water to pass through/under the structure, such as a Hynds ‘drift deck’ or similar for crossing Macgregor Creek.

(b) Design for all culvert or culverted ford structures to be informed by the most recent version of the New Zealand fish passage guidelines (but reflecting local waterway conditions and fish species present/expected to be present), with structures inspected after significant floods to address potential scouring that may impede fish access.

4.18 In-channel maintenance works at the Headworks

(a) Strict contaminant controls and equipment safety measures to prevent spills and avoid equipment washing downstream into Morgan Gorge.

4.19 Loss of shading of waterways from removal of riparian vegetation

(a) Supplementary planting of indigenous vegetation as recommended in the **Vegetation Report**.

4.20 Lighting around built infrastructure

(a) The design features and management approaches already proposed in the Project Design will be sufficient to keep the impacts of lighting to a ‘**less than minor’** level. This includes no lighting along the road corridor; minimal lighting at the Power Station and Headworks that that will only be activated when necessary, use of remote controlled infrared cameras (that do not require lights to see) at the Power Station and Headworks for remote monitoring, and the use of lighting that limits the emission of blue light and is designed to reduce light scatter.

4.21 Further detail of the proposed management for the Scheme's adverse effects during the Scheme's operation is provided in **Appendix G** and is summarised in Table 2 below.

Table 2 Environmental effects on freshwater ecology associated with each phase of the Scheme (construction and operational), the suggested approaches to manage these effects, and effects after management measures have been applied.

Scheme phase	Environmental effects (positive and adverse effects)	Assessment of effects	Recommended effects management	Residual effects post mitigation
Construction effects	Sediment release	• Mainstem & Other Tributaries: Minor • Stable Tributaries: More than minor	• Minimise exposed ground and plan routes to reduce waterway impact • Place power poles along existing roads/tracks where possible • Avoid placing power poles near or in waterways • Follow good erosion and sediment control practices, as defined in the Scheme's Erosion and Sediment Control Plan. • Prioritise construction of the crossing structure (a Hinds 'drift deck' or similar) for Macgregor Creek to limit the amount of vehicle crossing via the temporary access track across the braid plain • Water discharged from sediment ponds into mainstem river to have a visual clarity of no less than 100 mm • Remove and properly dispose of settled sediment from sediment ponds; test for contamination if needed • Keep the access road corridor well away from the 'Stable Trib'; mark location of 'Stable Trib' accurately via survey • Prevent sediment-laden water from entering the 'Stable Trib' during road construction	• Mainstem & Other Tributaries: Less than minor • Stable Tributaries: Less than minor
	Release of cementitious contaminants	• Small stable tributaries: Significant adverse effects • Mainstem and other waterways: More than minor	• Ensure concrete waste does not enter surface waters; fully cure cement-based products before contact with water • Maintain dry work areas when using wet cement-based products near waterways • Wash concrete tools, machinery, formwork well away from waterways and in a contained area (such as at the concrete batching plant) • Treat water contaminated with cementitious runoff in a secure storage area, testing and treating pH to a suitable pH range for the receiving environment before release	Less than minor

Scheme phase	Environmental effects (positive and adverse effects)	Assessment of effects	Recommended effects management	Residual effects post mitigation
			• Use precast concrete units for in-channel structures along access road when possible	
	Release of other construction-derived contaminants	More than minor	• Refuel and store machinery/equipment/fuel/chemicals away from waterways to prevent contamination in case of spills • Maintain machinery regularly to reduce breakdown risks • Keep a spill kit on site to contain accidental spills and protect waterways	Less than minor
	Spread of freshwater pest species (didymo)	More than minor	• Check-clean-dry protocols for control of the spread of didymo	Less than minor
	Fish passage during in-channel works	• At Kiwi Flat: more than minor • Tributary waterways: less than minor	• Maintain current fish passage conditions in river at the intake site, ensuring only kōaro can access Kiwi Flat	Less than minor
	Mortality of biota at the site of in-channel works	• Mainstem: Minor • Ephemeral/Intermittent tributary waterways: Less than minor • Granite Creek: Less than minor • Unnamed tributary upstream of the confluence of MacGregor Creek and Waitaha River: More than minor • Small seepages along road alignment: More than minor	• Mainstem: fish relocation of the tail race in-channel construction site prior to its dewatering • Unnamed tributary upstream of the confluence of Macgregor Creek and Waitaha River: move the temporary access route out into the main river braid plane and away from the confluence point • Small seepages along road alignment: fish rescue at the time of each culvert installation	• Mainstem: Less than minor • Ephemeral/Intermittent tributary waterways: Less than minor • Granite Creek: Less than minor • Unnamed tributary upstream of the confluence of Macgregor Creek and Waitaha River: Less than minor • Small seepages along road alignment: Less than minor
	Gravel extraction from the Waitaha River	• Minor	• Follow the additional measures recommended in Rule 29 (b-j) of the West Coast Regional Land and Water Plan (RLWP) relating to gravel extraction • Allow for flexibility in the location of gravel extraction in order to meet the extraction measures defined in the RLWP.	• Less than minor
Operational effects	Residual flow	• Minor or Less than minor	• Monitor periphyton in residual reach during prolonged periods of residual flow (> 4 weeks) and flush if excessive; and use findings to inform adaptive management procedures for monitoring periodicity	Less than minor
	Fish stranding during flow changes	• More than minor	• Use ramping procedures for gradual changes in river flow, including for shutdown of the bypass valve	Douglas Creek Reach: Minor to less than minor

Scheme phase	Environmental effects (positive and adverse effects)	Assessment of effects	Recommended effects management	Residual effects post mitigation
			• Monitor fish stranding in residual flow reach and Downstream Reach during test conditions and use findings to inform adaptive management procedures for ramping rates used during startups and planned shutdowns	Downstream Reach: Minor
	Altered sediment dynamics within the residual flow section and downstream of the tail race	• In general: less than minor • Transient fine sediment drapes & desander flushing: more than minor	• Monitor fine sediment buildup in lower residual flow reach and flush if necessary; and use findings to inform adaptive management procedures for monitoring periodicity • Flush out sediment from desander during natural runoff events when river is turbid	• In general: Less than minor • Transient fine sediment drapes & desander flushing: Less than minor
	Backwater effects and sediment aggradation upstream of weir intake structure at Kiwi Flat	• Less than minor	• No mitigation required	• Less than minor
	Fish entrainment and mortality through the tunnel and Power Station turbines	• Minor	• Involvement of a suitably qualified and experienced freshwater ecologist during the detailed design phase of the intake may help with further reducing potential kōaro larvae entrainment into the tunnel.	• Minor
	Fish attraction to the tailrace	• More than minor	• Detailed design of the tailrace to incorporate measures to discourage fish access and/or facilitate the upstream movement of fish that may be otherwise attracted to the tail race, with input from a suitably qualified and experienced freshwater ecologist • Checks and modifications to the tail race if needed following large bed-moving flood events to ensure the structure retains the relevant fish passage features as described above. • Should dewatering of the tail race occur, then undertake a fish rescue beforehand.	• Less than minor
	Fish passage at weir intake structure	• Significant adverse effects	• Detailed design of the kōaro passage structure to enable kōaro fish passage whilst preventing other fish, with input from a suitably qualified and experienced freshwater ecologist, and oversight during construction • Monitor kōaro recruitment into Kiwi Flat (following a BACI design), and adapt design if needed	• Less than minor

Scheme phase	Environmental effects (positive and adverse effects)	Assessment of effects	Recommended effects management	Residual effects post mitigation
	Fish passage at tributary waterway crossings	• Ephemeral/intermittent tributary waterways: Minor • Granite Creek: less than minor • Small seepages along road alignment: less than minor	• Use of a culvert or other crossing structure that allows water to pass through.under the structure (i.e., a Hynds 'drift deck' or similar) for crossing MacGregor Creek • Be informed by the most recent version of the NZ fish passage guidelines for all tributary crossing structures • Inspect structures after floods and remediate scours/fish passage issues	• Ephemeral/Intermittent tributary waterways: Less than minor • Granite Creek: Less than minor • Small seepages along road alignment: Less than minor
	In-channel maintenance works at the headworks	• Minor	• Refuel and store machinery/equipment/fuel/chemicals away from waterways to prevent contamination in case of spills • Strict controls to limit chance of machinery-related contaminant spills and to avoid equipment being washed into Morgan Gorge	• Less than minor
	Lighting around built infrastructure	• Less than minor	• The design features and management approaches already proposed in the Project Design will be sufficient to keep the impacts to a less than minor level	• Less than minor

5. CONCLUSION

5.1 A comprehensive sampling programme encompassing multiple methods and years provides a robust understanding of the freshwater ecology of the Waitaha River catchment both within and upstream of the Scheme area.

(a) The aquatic invertebrate fauna of the Waitaha catchment is composed of a diverse assemblage of insect taxa, dominated by mayflies, chironomid midges, caddisflies, and stoneflies. Invertebrate density and diversity are significantly higher in stable tributary sites than the mainstem sites or other tributaries. These stable tributaries are locally important for maintaining biodiversity values and ecosystem functioning. In contrast, invertebrate density in the mainstem of the Waitaha River is low, with a similar assemblage of taxa across the different river reaches. This species-poor mainstem river community was dominated by only a few taxa (e.g., *Deleatidium* and midges) that are capable of persisting in a system subject to frequent floods, with low primary production and unstable substrate.

(b) Investigations confirm that the freshwater invertebrate fauna of the Waitaha catchment is typical to that of other neutral pH, fast-flowing West Coast rivers flowing through unmodified catchments in high rainfall areas, where water quality is high and nutrient levels and algal biomass are low.

(c) There was a distinct longitudinal distribution pattern for fish, with kōaro the only species found upstream of Morgan Gorge; confirming that Morgan Gorge is a fish passage barrier to other species. Within Kiwi Flat some of the more stable tributary waterways supported good numbers of kōaro in contrast to the mainstem where few kōaro were caught.

(d) Downstream of Morgan Gorge there is a moderate diversity of fish, with eight species recorded within the Douglas Creek Reach; kōaro, longfin eel, brown trout, torrentfish, lamprey, redfin bully, common bully, and giant kōkopu (from most to least recorded). Lamprey have a conservation status of Threatened – Nationally Vulnerable, whilst four species have a conservation status of At Risk – Declining (kōaro, longfin eel, torrentfish, giant kōkopu). The mainstem of the river does not support a great diversity or abundance of fish; with only kōaro, brown trout, torrentfish, and longfin eel recorded here, and all in low numbers. The high disturbance regime and lack of food resources are the most likely reason for this. In contrast the ‘Stable Trib’ (on the true right in the Douglas Creek Reach opposite Douglas Creek) is considered a ‘hotspot’ for fish, a significant lamprey rearing habitat, and an important trout rearing habitat. Many other tributaries in the Douglas Creek reach are intermittent or ephemeral or sufficiently steep that not many fish inhabit them. The Douglas Creek Reach is considered suboptimal habitat for brown trout and of little value to the brown trout fishery, and most recreationally fished sections of the Waitaha are well downstream (near SH6 bridge and downstream). We could not find any fish survey records of Chinook salmon in the Waitaha catchment, although Douglas Creek (which is outside of the Scheme area) is still regarded as a salmon spawning waterway by Fish & Game.

(e) The fish community of the Waitaha catchment is a subset of a larger regional species pool, and so is not unique. However, the presence of only kōaro above Morgan Gorge is noteworthy as such trout-free kōaro habitats in rivers as large as the upper Waitaha, although not exclusive, is less common in a New Zealand context. This is a key state that will have to be maintained should the Scheme proceed.

5.2 The construction effects relate to the creation of the access roads and other infrastructure (Headworks including the weir and intake at Kiwi Flat, tunnel, Power Station and tailrace). The most obvious potential effects during the construction phase are sediment mobilisation, release of concrete-wash and other contaminants, the spread of didymo, maintaining fish passage during in-channel works, mortality of freshwater biota at the site of in-channel works, as well as removal of gravels for road construction.

(a) The potential effects of the construction phase are minimised to a '**less than minor**' level via the planned and recommended programme to reduce effects as well as the nature of the environment (e.g., the existing unstable nature and high sediment load of the Waitaha River mainstem and of most of the tributary waterways within the construction footprint, and the intermittent/ephemeral nature of some of the tributary waterways that will be crossed by the access road). Of particular note are the endeavours to keep infrastructure and construction activities well away from the 'Stable Trib' that represents such an important freshwater habitat within the area.

5.3 The run-of-river scheme will mean that operational potential effects largely focus on the 2.5 km residual flow reach (with a residual flow of 3.5 cumecs at the Kiwi Flat intake) and on the weir structure at the top of Morgan Gorge.

(a) IFIM modelling predicted a large increase in short and long filamentous algae and a decrease in diatoms within the abstraction reach as a result of the residual flow, while there were variable predicted effects on the aquatic invertebrate community ranging from decreases to increases in habitat availability depending on the particular Habitat Suitability Curve used. The IFIM modelling is limited to predicting changes in habitat suitably in relation to water depth, velocity and substrate. However, any predicted changes based on this modelling will most likely be overridden by the low nutrient and high disturbance regime of the river, which are the overarching factors affecting the benthic aquatic community of this river; and that will not change under the Scheme's operation.

(b) IFIM modelling revealed that habitat availability for adult brown trout is predicted to be greatly reduced during dry and typical flow months and habitat for native fish found in the abstraction reach will generally increase, apart from longfin eel, which is predicted to decrease slightly. However, when put into context with the fact that the mainstem of the Waitaha River in the abstraction reach already appears to be sub-optimal for trout, longfin eels, and kōaro; due to the low food supply and high disturbance regime, it is unlikely that these predicted changes would eventuate under the Scheme's operation.

(c) This means that overall effect of residual flow on the freshwater ecology of the river would be '**minor'** or **'less than minor'** – provided that fish passage is maintained at the intake weir structure to prevent the upstream movement of all but kōaro into Kiwi Flat. The unique climbing ability of kōaro will be a key focus for the design of the weir and related fish passage structures; so as to maintain the current fish (kōaro) passage into the Kiwi Flat area.

5.4 Rapid flow changes, such as those during maintenance or emergency shutdowns in run-of-the-river schemes, pose risks to fish populations through entrapment, beach stranding, and displacement. During an emergency shutdown, flow redirection can happen within minutes, causing a sudden increase in flow at the intake and a sharp decrease at the Power Station tailrace (and the reverse during startup), with effects likely evident for around 40-45 minutes.

(a) Fish entrapment risks are higher in the Downstream Reach where the river is braided, but the short period of rapid flow reduction and good water quality and high dissolved oxygen levels will lessen the potential for fish mortality from entrapment. Beach stranding could occur in marginal habitats within the braided channel of the Downstream Reach during down-ramping. This is less likely to affect smaller benthic fish that can find refuge in interstitial spaces, but larger fish like trout could be affected, although they are in low abundance in the river mainstem within the Douglas Creek Reach.

(b) Sudden increases in flow can also displace fish, particularly water column-dwelling species like trout and salmon, or juvenile native fish migrating upstream. The existing highly variable flow and natural flood-prone nature of the river and the low fish population in the Douglas Creek Reach reduces the potential fish displacement effects of up-ramping.

(c) Egg drying from sudden flow reductions is likely limited to species like torrentfish that may spawn in the permanently wetted channel, if shutdowns occur during spawning. However, densities of torrentfish are low in the Douglas Creek Reach and relatively low in the braided section of the Downstream Reach.

(d) The ability to provide mitigation during emergency shutdowns is limited but there are some natural ameliorating factors to consider, such as that emergency shutdowns most often occur during storm events when the river would have a higher flow (and so the magnitude of flow change will be less), the flow change is temporary in nature, and the number of estimated emergency shutdowns is low (around four a year).

(e) Implementing a managed ramping regime for startups and planned shutdowns, and visually monitoring changes in the Douglas Creek Reach and Downstream Reach during test conditions to assess impacts on fish stranding is required. We recommend an adaptive management plan that allows approaches to be adjusted based on observed effects in real time (i.e., deciding on the optimal up- and down-ramping rate), providing flexibility over setting fixed conditions from the outset. In general we recommend that planned shutdowns have longer ramping periods than startups.

5.5 Other operational effects (altered sediment dynamics within the residual flow section and downstream of the tail race, backwater effects and sediment aggradation upstream of weir intake structure at Kiwi Flat, fish entrainment and mortality through the tunnel and Power Station turbines, fish attraction to the tailrace, fish passage at tributary waterway crossings, surface water runoff from infrastructure hard surfaces and access tunnel discharge, in-channel works at the intake site, permanent loss or riparian vegetation, and lighting around built infrastructure) are likely to have a ‘**minor**’ or ‘**less than minor**’ effect on freshwater ecology following implementation of the mitigation and adaptive management measures that are planned or recommended in this report (see Section 4 and **Table 2**).

5.6 Periodic monitoring of transient fine sediment drapes and periphyton growth in the abstraction reach and of the kōaro population is also recommended, so as to help with adaptive management of the Scheme.

APPENDIX A – QUALIFICATIONS AND EXPERIENCE

6. QUALIFICATIONS AND EXPERIENCE

6.1 My full name is Shelley Alexandra McMurtrie. I am a co-director and the Principal Scientist at EOS Ecology, where I have worked for 25 years.

6.2 I hold a Master of Science (First Class Honours) in Ecology and a Bachelor of Science (double-majoring in Zoology and Plant & Microbial Sciences) both from University of Canterbury.

6.3 I have 25 years of professional experience studying aquatic (freshwater and estuary/coastal) and riparian ecosystems. I have authored and peer reviewed a large number of consent-related reports (AEEs, SARs, NORs) and associated investigations pertaining to large and small scale infrastructure, hydro schemes, land development projects, and fish passage; audited (or peer reviewed others' audits) consent applications on behalf of Councils; and presented expert evidence at hearings. I have been the technical lead on studies relating to water and sediment quality, the effects of stormwater, wastewater and landfill discharges, restoration/naturalisation initiatives, effects of earthquakes on aquatic biota, as well as shellfish and fish food safety; and have developed and implemented long-term monitoring and management plans for surface water systems and invasive species for braided river systems. I have also published new keys for the identification of Subantarctic aquatic biota and discovered and helped to classify new freshwater invertebrate species. I have also led the development of Catchment Management Plans (CMPs), ascertaining state/pressures and identifying solutions at a catchment- and site-scale to improve the management and function of waterway catchments through a collective approach to implementation. Similarly I have led the mapping of erosion risk factors and areas of greatest potential sediment yield within catchments. In addition to work in aquatic ecology I have been the technical lead for studies assessing the performance of sediment and erosion control measures, and have been an external supervisor and external peer reviewer for Master of Science students/candidates for Aoteroa New Zealand universities.

6.4 I have also been the ecology technical lead on small- and large-scale multidisciplinary design & construction projects for infrastructure (roading, motorways, cycleways, bridges, culverts, and sewers), land development (urban subdivisions, urban revitalisation, integrated catchment management planning), habitat (waterways and wetlands) naturalisation or creation, flood mitigation, stormwater management, and coastal works. This work has entailed designing habitats, interventions and approaches for freshwater and coastal systems (including fish passage structures), reviewing engineering designs, and overseeing construction.

6.5 I am a member of a number of relevant associations including:

(a) the New Zealand Freshwater Sciences Society since 2001,

(b) the Environment Institute of Australia and New Zealand since 2011, and

(c) the International Erosion Control Association, since 2020.

APPENDIX B - FURTHER DETAIL ON THE PROJECT DESIGN AND PROJECT BACKGROUND INFORMATION AS IT RELATES TO FRESHWATER ECOLOGY

7. AREAS OF THE SCHEME THAT RELATE TO FRESHWATER ECOLOGY

7.1 The Scheme structures and access route is proposed to be located primarily on the true right side of the Waitaha River from SH 6 to about half way up Kiwi Flat. There will be a permanent access road built from the true-right of Macgregor Creek to the Power Station; due to lack of public access through the private farmland on the true-right of Macgregor Creek this access road will not be open to the public. The Scheme transmission network will follow this new access road from the Power Station to Macgregor Creek, and from there will mainly follow existing roads on the true right of the Waitaha River. There will be no access road into the Headworks; access will initially be via foot and/or helicopter and then via the tunnel (once completed). However, there will be a short access road from the intake structure to the riverbed (in the same location as the temporary construction access track) that will only be used when access to the weir is required.

7.2 During the construction phase there will be a temporary machinery track across Macgregor Creek (until the permanent crossing structure is completed), as well as along the true-right edge of the wider braid plain of Macgregor Creek, the Waitaha River between Macgregor Creek and Granite Creek, and up Granite Creek, so as to access the site of the temporary bridge crossing for Granite Creek that will enable the construction of the permanent bridge. During construction there will also be a temporary short access road from the access tunnel portal to Construction Staging Area 1 (on a raised area on the true-right upstream of the Headworks).

7.3 The area of abstraction reach is approximately 2.5 km, from the bottom of Kiwi Flat/top of Morgan Gorge to just upstream of Alpha Creek. For freshwater ecology considerations the area is divided into four sections (**Figure 1**):

(a) Downstream Reach (downstream of Douglas Creek and thus downstream of the Scheme).

(b) Douglas Creek Reach (from Douglas Creek to Morgan Gorge, including the proposed abstraction reach).

(c) Kiwi Flat Reach (from the top of Morgan Gorge to the bottom of Waitaha Gorge, including the intake structure site).

(d) Upstream Reach (upstream of Kiwi Flat and thus upstream of the Scheme).

7.4 Within these reaches there are three different waterway types; the mainstem of the Waitaha River, stable tributaries or other tributaries.

7.5 From a freshwater ecology perspective, the main areas of Scheme are as follows:

(a) The abstraction reach (ca. 2.5 km), which will experience a residual flow.

(b) The section of river downstream of the tail race that will experience temporary drops/increases in flow during emergency and planned shutdowns.

(c) Where the access road to the Power Station Site crosses tributary waterways (**Figure 3**).

(d) The temporary machinery track across Macgregor Creek (during construction of the crossing structure like a Hynds 'drift deck' or similar), as well as along the true-right edge of the wider braid plain of Macgregor Creek, the Waitaha River between Macgregor Creek and Granite Creek and Granite Creek to assist with construction of the Granite Creek bridge (**Figure 6**).

(e) The areas of Waitaha River downstream of Douglas Creek where gravel extraction will occur.

(f) The weir structure and associated infrastructure within the mainstem of the Waitaha River at the bottom of Kiwi Flat/top of Morgan Gorge.

(g) The intake structure that diverts flow from the Waitaha River at the bottom of Kiwi Flat/ top of Morgan Gorge.

(h) The Power Station and tail race that returns the taken flow to the river just upstream of Alpha Creek.

(i) The lighting and stormwater infrastructure related to the buildings and access roads.

(j) The construction area that will have exposed soils during construction, including the proposed sediment stockpile areas.

7.6 In our assessment we have referred to the following documents that provide information on the Scheme:

(a) The **Project Description**

(b) Design drawings (including the plan views of the scheme in **Figure 2, Figure 3, Figure 4, Figure 5**)

(c) Access road plots; the latest version referred to was dated 23 June 2025. Specifically plan sheet 3 (**Figure 6**).

(d) The **Hydrology Report** by Doyle (2025).

(e) The **IFIM Report** by Allen & Hay (2013).

(f) The **Sediment Report** by Hicks (2025).

(g) The **Flow Modelling Report** by Culnie (2025).

(h) The **Vegetation Report** by TACCRA (2025).

(i) The **Terrestrial Vertebrate Fauna Report** by Buckinham (2025) and **Whio Report** by Overmars (2025) are also referred to in passing.

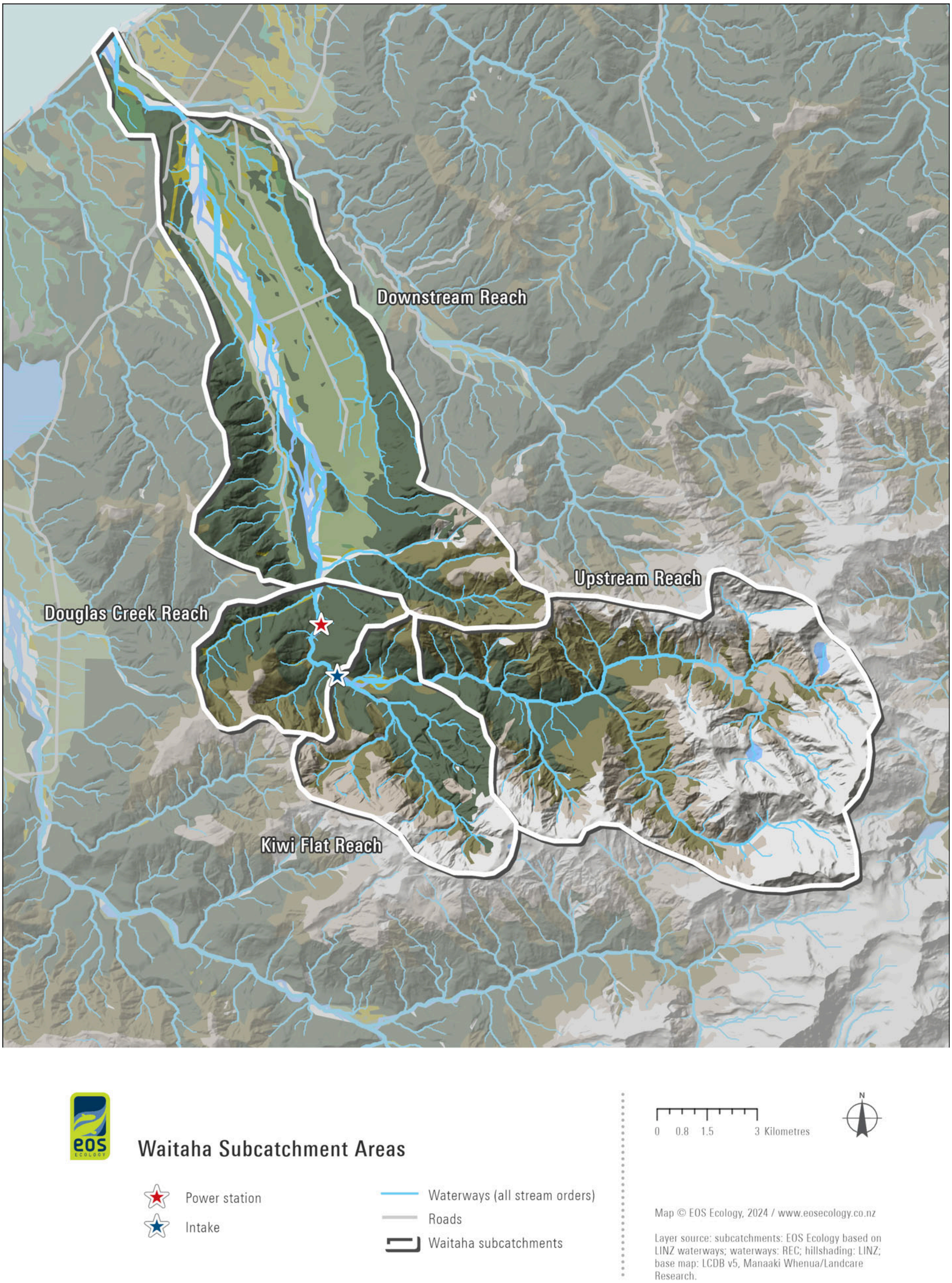

Figure 1 Overview map showing the Waitaha catchment and the four subcatchment areas that were defined for the freshwater ecology assessment. Key locations for the Scheme (intake and Power Station) are also indicated.

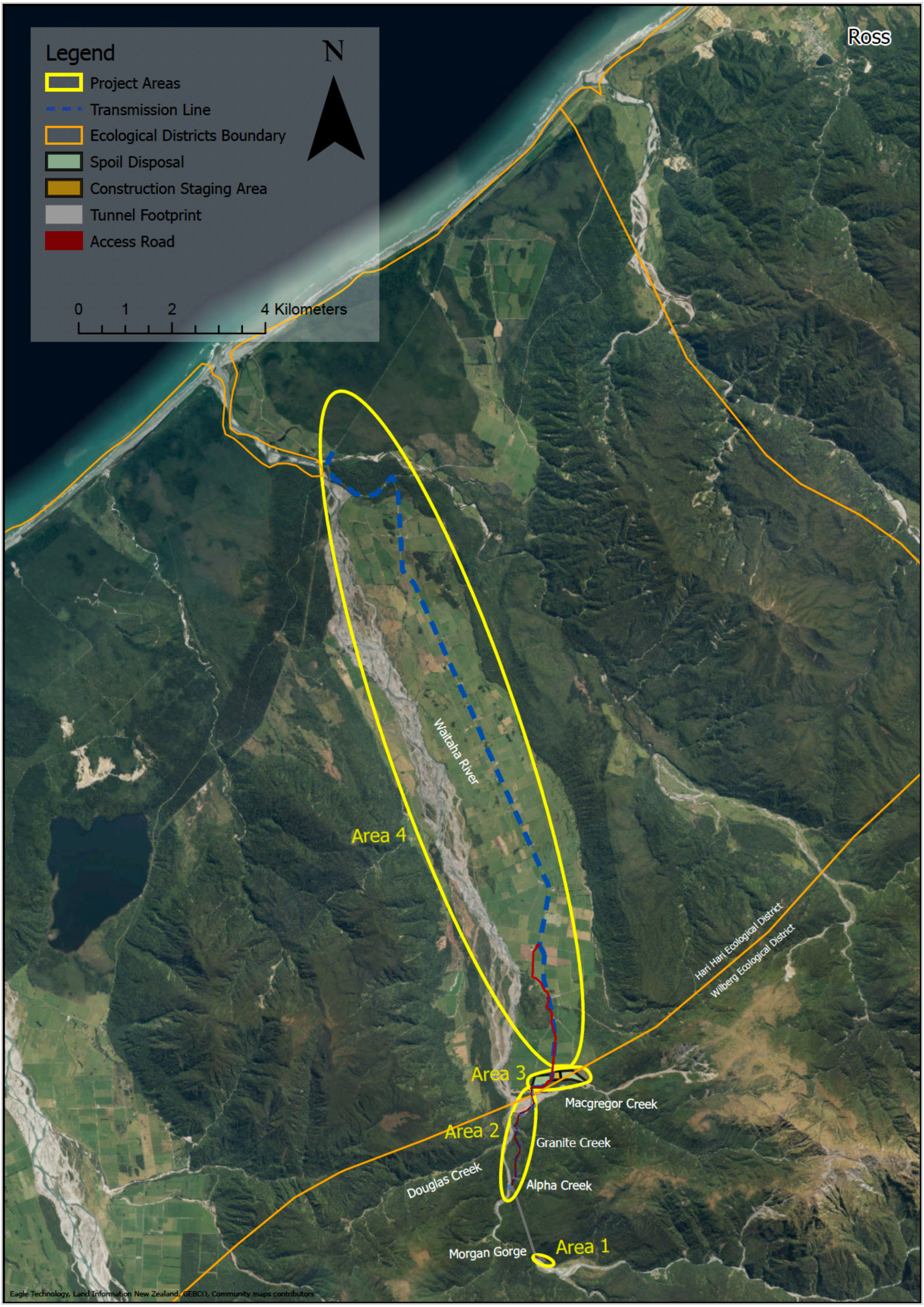

Figure 2 Overview of the project areas and transmission and access road route into the Power Station. Source: Westpower.

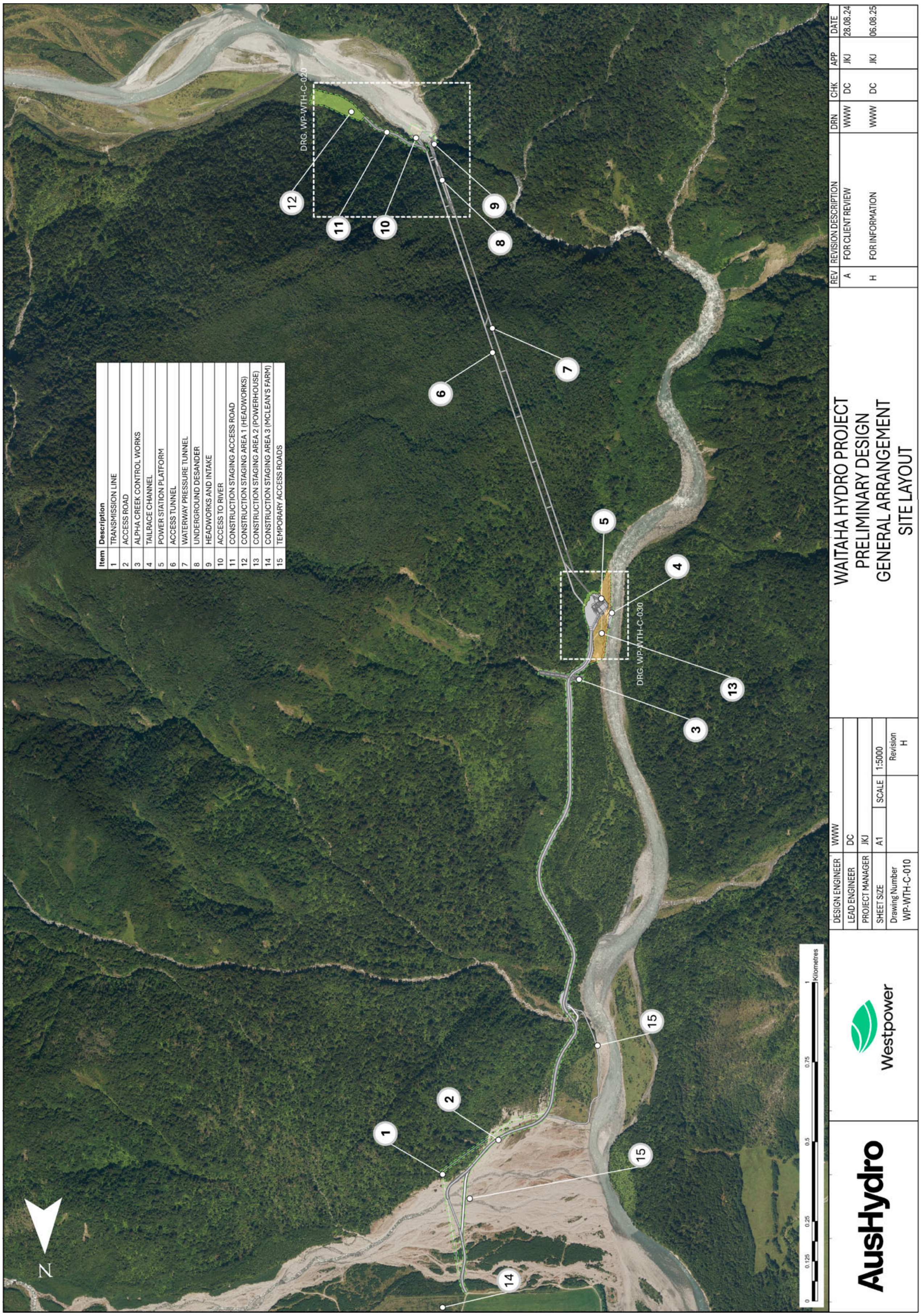

Figure 3 Plan view of the key areas of the scheme (Revision H, dated 6 August 2025).

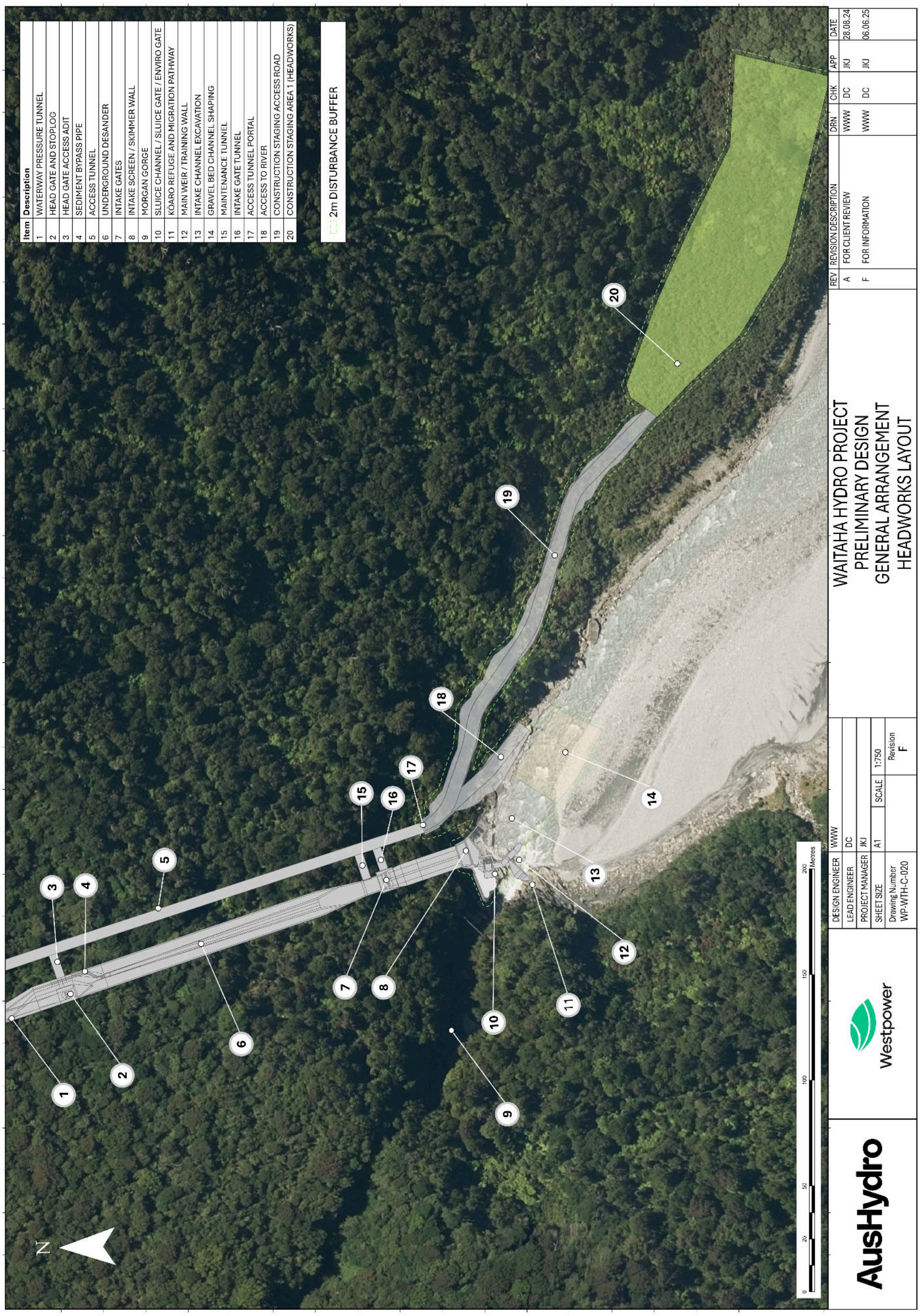

Figure 4 Plan view of the Headworks area of the scheme (Revision F, dated 6 June 2025).

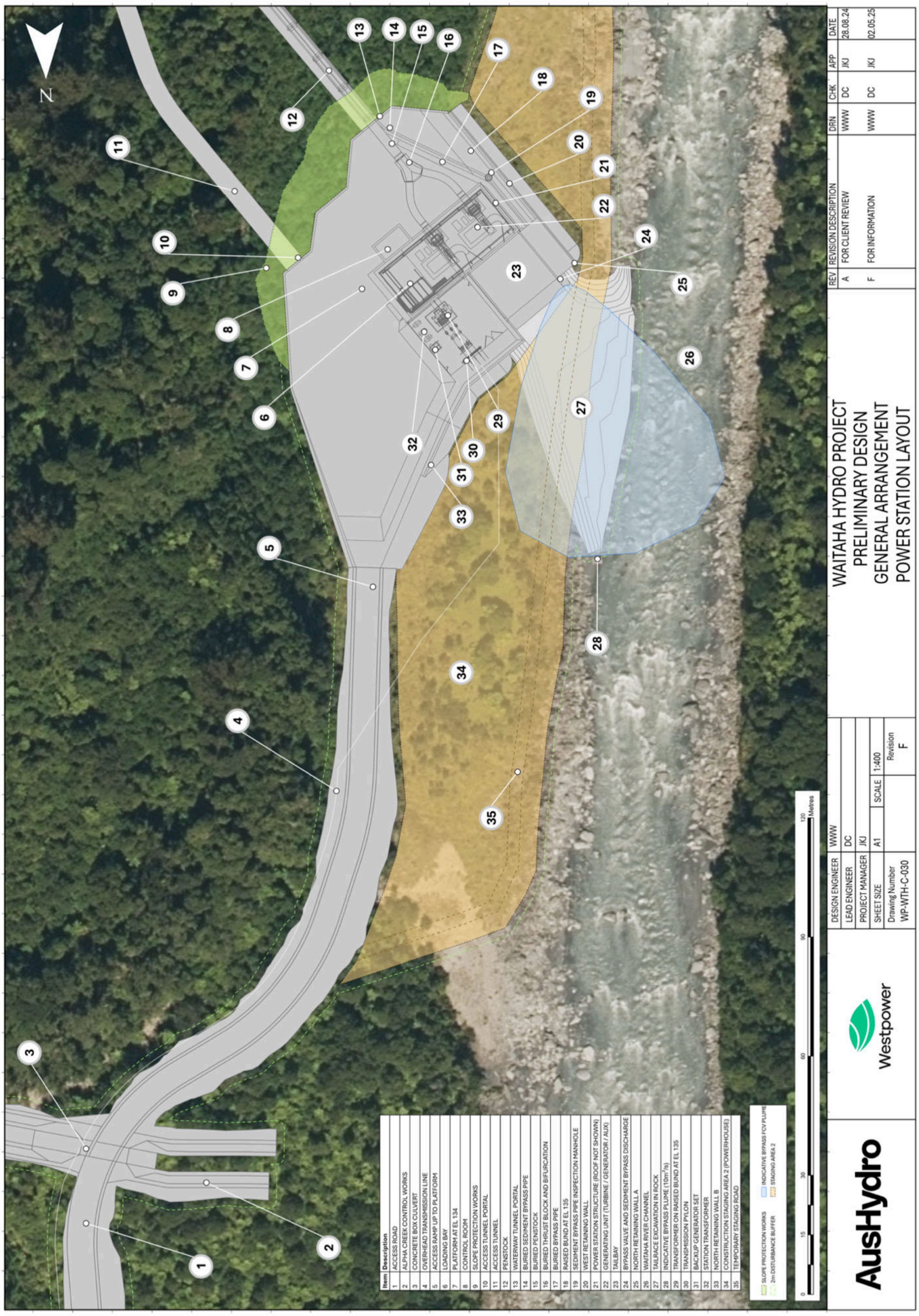

Figure 5 Plan view of the Power Station area of the scheme (Revision F, dated 2 May 2025).

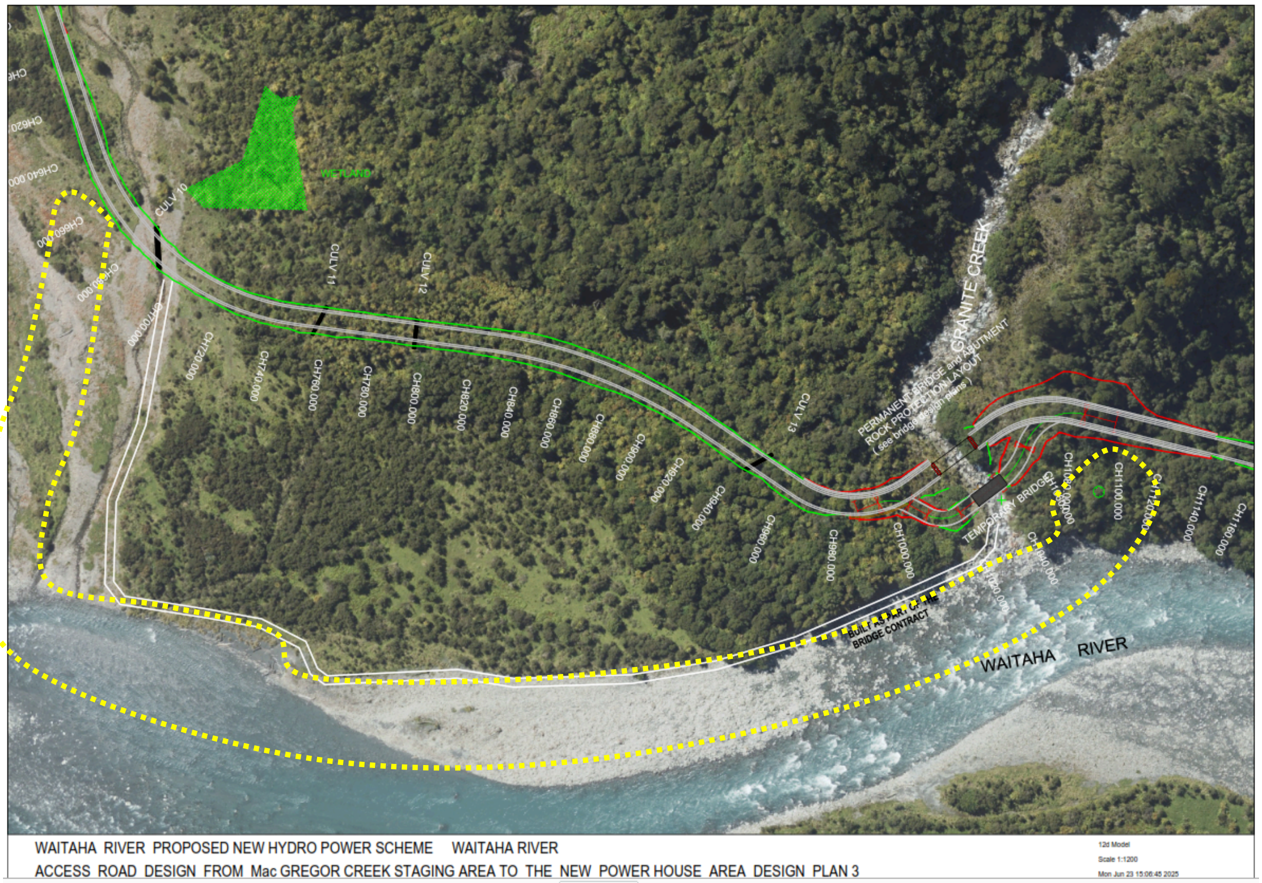

Figure 6 *Plan Sheet 3 from the Access Road Plots file set (dated 23 June 2025), showing the temporary machinery track along the true-right edge of the wider braid plain of the Waitaha River between MacGregor Creek and Granite Creek, and up the true-right side of Granite creek, to assist with construction of the Granite Creek bridge. This route has been identified with a yellow dashed line.*

8. SETTING OF A RESIDUAL FLOW OF 3.5 CUMECS

8.1 Four levels of residual flow (2, 3, 4, and 5 m^3/s (cumecs)) were considered for the Scheme. The setting of a residual flow of 3.5 cumecs was informed by site-specific IFIM modelling (provided in the **IFIM Report** by Allen & Hay (2013)), and consideration of those results against wider freshwater ecology (including hydrology and geomorphological aspects).

Summary of methods

8.2 IFIM stands for Instream Flow Incremental Methodology, and is a modelling approach used to predict the effect of changing flows in a waterway, based on the assumption that biota (such as fish) are constrained by their environment, that limiting factors are flow related, and that it is possible to produce a single index incorporating the relationship between biomass and all important physical factors (Maughan & Barrett, 1992). While IFIM modelling is a useful tool to obtain an appreciation of the potential effects of different residual flow rates, there are some limitations that need to be acknowledged when interpreting the results. In a review of IFIM in New Zealand Hudson *et al.* (2003) stated that

"*there are many interactions between species, life stages, and other variables that influence the state of the ecosystem that are not modelled by PHABSIM [and] … the physical habitat is a necessary but not sufficient condition for a viable population of aquatic animals (Milhous, 1999)".*

8.3 IFIM modelling is therefore an important starting point to assessing potential effects of residual flows, the results of which must then be considered in context with wider biological, hydrological and geomorphological processes of the system in question, so as to obtain a more accurate prediction of potential effects on freshwater biota. As such, the results of the IFIM modelling relating to residual flows of 2, 3, 4 and 5 cumecs were then reviewed and considered in an ecological context to determine at which point the effects of a residual flow were considered to have sufficiently diminished in the context of this system.

8.4 The full methodology undertaken for the IFIM modelling is provided in the **IFIM Report** and is not repeated here. In summary, IFIM modelling was undertaken for the following biota:

(a) Periphyton, including short filamentous algae, long filamentous algae, and diatoms; based on generic Habitat Suitability Curves (**HSC**) for New Zealand that were developed from expert opinion rather than on survey data.

(b) For macroinvertebrates Waitaha-specific HSC were developed for the four most abundant benthic invertebrate taxa found in the Waitaha mainstem (based on the comprehensive sampling undertaken by McMurtrie & Suren (2014)), as well as a combined 'all invertebrates' HSC. These most abundant taxa were also found in blue duck faeces (Fred Overmars, Sustainability Solutions, pers. comm), confirming their relevance for food production for this species. The five Waitaha-specific invertebrate HSC are shown in bold in **Table 3**, and are 'Waitaha *Deleatidium'*, 'Waitaha *Stictocladius'*, 'Waitaha Orthocladiinae', 'Waitaha *Neocurupira',* as well as 'all invertebrates – Waitaha'. The mayfly *Deleatidium* is New Zealand's most common mayfly genus that is widespread in hard-bottomed (stony) waterways throughout the country; Orthocladiinae is a sub-family of the nonbiting midge Chironomidae family, and *Stictocladius* is a common genus from that family; whilst *Neocurupira* belongs to the family Blephariceridae which are flattened larvae of net-winged midges common in very fast water where they are able to persist due to feet that are modified suction pads. In addition, the **IFIM Report** also included some generic HSC that had been developed from other rivers in New Zealand for the mayfly *Deleatidium* and the non-biting midge sub-family Orthocladinae, as well as a generic 'food producing' based on overseas data (Waters, 1976). Given the differences between the Waitaha and these New Zealand and overseas HSC, it is questionable as to how useful they are in this context, but they do provide the opportunity for some comparison.

(c) A total of 11 species of fish were modelled (brown trout (*Salmo trutta*), kōaro (*Galaxias brevipinnis*), longfin eel (*Anguilla dieffenbachii*)*,* shortfin eel (*Anguilla australis*), torrentfish (*Cheimarrichthys fosteri*), lamprey (*Geotria australis*); common bully (*Gobiomorphus cotidianus*); redfin bully (*Gobiomorphus huttoni*); short jaw kokopu (*Galaxias postvectis*); banded kokopu (*Galaxias fasciatus*) and giant kokopu (*Galaxias argenteus*)). Of these, four species are the focus, based on having been recorded in the mainstem or tributaries of the residual reach section and upstream. These were two size classes of brown trout (adult >200-250 mm, and juvenile < 200–250 mm and 150-200 mm), kōaro, two size classes of longfin eel (>300 mm and < 300 mm), and torrentfish. Trout and salmon spawning and fry rearing were not considered because the mainstem river and the tributaries in the abstraction reach (i.e., from Alpha Creek upstream) are unsuitable habitat for such. However, all fish species were considered in regard to fish passage in case some fish not found in the mainstem are accessing tributary waterways.

(d) Whio/blue duck HSC were also modelled but is not covered here. Refer to the **Whio Report** for consideration of residual flow on whio. However, we note that as blue duck feed on invertebrates, the findings here relating to invertebrates would presumably influence the findings relating to whio.

(e) Habitat available at the residual flow options of 2, 3, 4, and 5 cumecs was compared to habitat available at the relevant flow statistic (i.e. median or MALF1) under the natural flow regime. According to the **IFIM Report** the mean annual low flow (MALF1) is ecologically relevant to annual spawning fish because it defines the minimum space available each year on average, and is relevant to native fish species with generation cycles longer than one year, at least in small rivers where the amount of suitable habitat declines at flows less than MALF1. The **IFIM Report** states that due to the relatively fast rate of recolonisation by invertebrates, the median flow (which describes typical flow) is an ecologically relevant flow statistic when assessing the effects of flow regime change on benthic invertebrate habitat.

8.5 The modelling produced both graphs and summary tables expressing the average habitat suitability (Habitat Suitability Index: HSI) under the different residual flow scenarios. The results as presented in the summary tables are provided here in **Table 3**. Consideration and interpretation of the predicted changes took into account that that direction of change is likely to be more accurate than the specific magnitude of change.

Summary of findings

8.6 **Results for periphyton:** The **IFIM Report** states that the hydraulic-habitat modelling predicts that the modelled residual flow scenarios will cause substantial changes to the habitat quality for periphyton (10-204% habitat quality retention) compared to that available at the natural low flow.

(a) When looking at the difference between the four residual flow options (**Table 3**) the changes as a result of the different residual flows modelled drops off between a residual flow of 4 and 5 cumecs. However, when taking into account wider limitations to periphyton growth based on the low nutrient status of the river and high disturbance flow regime of the river – neither of which would change as a result of a residual flow being set – it was felt that there would be less increase in filamentous algae and less decrease in diatoms than what is indicated by the IFIM modelling. The **IFIM Report** also acknowledges this. As such it is expected that the periphyton growth would remain similar except during prolonged periods of residual flow of around six weeks or more; which is not predicted to occur based on the hydraulic information provided in the **Hydrology Report**.

(b) On the basis on the above, it was determined that the residual flow was best informed by the results of the macroinvertebrate and fish IFIM.

8.7 **Results for macroinvertebrates:**

(a) The **IFIM Report** states that the change in habitat availability (quantity and quality) for the dominant invertebrate taxa varies, ranges from a substantial decrease to a moderate increase (32-133% habitat retention), depending on the habitat criteria used and the species being modelled.

(b) With the exception of *Neocurupira*, all of the Waitaha-specific HSC indicate little significant impact of the different residual flows on habitat availability. However, when looking at the difference between the four residual flow options across all modelled macroinvertebrate types (**Table 3**), it is evident that there is a reduction in the level of habitat loss between a residual flow of 3 and 4 cumecs. There is also the acknowledgement that there is a higher level of plasticity in the habitat preferences in all of our freshwater macroinvertebrate taxa, with the modelled taxa (*Deleatidium*, Orthocladiinae, *Stictocladius* and *Neocurupira* all being recorded in smaller, shallower, and slower flowing tributary waterways as well as in the mainstem. As such the changes in water depth and water velocity at residual flow is unlikely to negatively impact on them to the degree indicated from the HSC curves of the **IFIM Report**. Indeed, it is ultimately the overarching low basal food supply (as a result of the low nutrient status and high disturbance regime) and high disturbance regime (with FRE_3 events (i.e., flows greater than three times the median flow) occurring 26 times a year) limiting the habitat suitability of the mainstem. Given the lack of land use in the upstream catchment (which is the only factor that could otherwise increase nutrient inputs) and the run-of-river Scheme that will not alter the flood frequency, these overarching catchment-wide factors will continue to dominate the response of the invertebrate community to a residual flow.

8.8 **Results for fish:**

(a) The **IFIM Report** states that habitat availability for adult brown trout is predicted to be greatly reduced during dry and typical flow months (50-102% habitat retention) and habitat for native fish known to occur in the abstraction reach will generally increase (93-139% habitat retention).

(b) When looking at the difference between the four residual flow options (**Table 3**) it is evident that the level of habitat loss is greatly diminished between a residual flow of 3 and 4 cumecs. Indeed, the only habitat loss predicted to occur for fish is for introduced species (brown trout) whilst all native fish species habitat is predicted to remain similar or increase under all residual flow options according to the IFIM modelling.

(c) The mainstem of the Waitaha River in the Douglas Creek Reach represents suboptimal habitat for fish species, with very few species and very few individuals captured during the extensive fish surveys undertaken by Drinan & McMurtrie (2014). There is a very low density of invertebrates in the mainstem, a high flow disturbance regime, and high turbidity at most times of the year (due to the presence of glacial flour); all factors that diminish the value of the mainstem as permanent fish habitat. The low water temperatures (below 12 degrees for the seven months when temperature was logged daily, and only 11 days when water temperature was higher than 11ºC – see Drinan & McMurtrie (2014)) would also render the mainstem unsuitable for eel species, which tend to become inactive at temperatures below 11-12ºC (Joy *et al*., 2013). As such the mainstem of the river through this section would likely be used more as a passage route to access tributary waterways and (in the case of kōaro) upstream habitat.

8.9 **Results for fish passage:** The **IFIM Report** notes that hydraulic-habitat modelling indicates that depths will be sufficient for the upstream passage of salmonids and native fish under all of the residual flow options.

Conclusion

8.10 Overall, the **IFIM Report** notes that most of the results from the hydraulic-habitat modelling indicate that the most substantial changes in habitat (increases or decreases) occur during dry or typical flow months with the lowest residual flow (2 cumecs). They also note that there is very little (if any) difference between habitat retention values calculated using a 19 cumec abstraction verses a 23 cumec abstraction. However, when we considered the results of the IFIM modelling and taking into the context of the hydraulic and geomorphological conditions of the Waitaha River, it was apparent that there was a reduction in negative effects between a residual flow of 3 and 4 cumecs. As such a residual flow of 3.5 cumecs was considered to provide a balance between minimising the effects of residual flow on the freshwater ecology of the system and providing sufficient water for a viable Power Station.

8.11 Predictions of habitat retention do not account for the inflow of tributaries within the abstraction reach, which will reduce the predicted effects on stream ecology. The **IFIM Report** acknowledges that their predictions are therefore ecologically conservative (i.e. results will overestimate the adverse effects and underestimate the positive effects). When considering the residual flows and the supplementary flow provided by the two main tributaries near the top of Morgan Gorge (Glamour Glen and Anson Creek) the residual flow is predicted to be 4.2 cumecs for at least 50% of the time of residual flow (**Hydrology Report**), and as such the predicted effects of a residual flow of 3.5 m^3/s is likely to be closer to the modelled effects of a 4 cumec residual flow.

8.12 Following this consensus on the residual flow of 3.5 cumecs, a more detailed assessment of effects was undertaken based on that selected residual flow of 3.5 cumecs, which is covered in **Appendix G** (Section 20.1).

Table 3 *Results of the IFIM modelling, showing the percentage habitat retained under residual flow scenarios of 2, 3, 4 and 5 cumecs, taken from the* ***IFIM Report*** *(Allen & Hay, 2013) for periphyton (compared to MALF1), freshwater macroinvertebrates (compared to median flows) and fish (compared to MALF1). The invertebrate types that have had specific Habitat Suitability Criteria (HSC) developed based on invertebrate samples collected by McMurtrie & Suren (2014) in the Waitaha mainstem are in bold; those are the most relevant ones for use here. Similarly the fish found in the Downstream Reach (where residual flow will occur) or Upstream Reach are in bold; those are the most relevant ones for use here. A further breakdown of predictions for dry- and wet-year monthly flows is provided in the* ***IFIM Report****.*

Group	Type	Residual Flow (cumecs)			
		5	**4**	**3**	**2**
Periphyton (algae)	Periphyton-diatoms	62	40	28	10
	Periphyton-long filamentous algae	113	118	127	124
	Periphyton-short filamentous algae	136	155	174	204
	Number attributes with <60% or >130% habitat retention	1	**2**	**2**	**2**
Freshwater macro-invertebrates	**All Invertebrates - Waitaha**	103	102	98	92
	***Deleatidium* -Waitaha**	92	90	88	86
	Orthocladiinae- Waitaha	110	116	121	127
	***Stictocladius* - Waitaha**	127	130	133	130
	***Neocurupira* - Waitaha**	56	49	42	35
	Food producing - USA	91	80	69	54
	Deleatidium (Jowett et al. 1991)	120	119	116	112
	Deleatidium - Waitaki	64	55	43	32
	Orthocladiinae - Waitaki	82	75	67	58
	Number of attributes with <70% habitat retention	2	2	**4**	**4**
Fish	**Brown trout adult (Hayes & Jowett 1994)**	91	83	70	50
	Brown trout adult (Bovee 1995) no substrate	84	73	59	41
	Brown trout juvenile (Bovee 1995) no substrate	102	101	96	84
	Brown trout 15-25 cm (Raleigh *et al.* 1986)	98	95	91	83
	Kōaro	97	93	104	123
	Longfin eel >300 mm	98	96	93	84
	Longfin eel <300 mm	108	102	99	98
	Shortfin eel >300 mm	104	107	110	109
	Shortfin eel <300 mm	119	126	129	137
	Torrentfish	97	99	104	90
	Lamprey	114	126	124	108
	Common bully	117	120	123	133
	Redfin bully	119	120	123	139
	Banded kokopu adult	112	123	135	126
	Shortjaw kokopu	111	113	107	101
	Giant kokopu	103	107	104	103
	Number of attributes with <70% habitat retention	0	0	**1**	**2**

KEY (as per Allen & Hay, 2013)

Habitat loss (lowest to greatest retention)	<50%	50-60%	60-70%	70-80%	80-90%	90-100% (no change)
Habitat gain (greatest to lowest gain)		>140%	130-140%	120-130%	110-120%	100-110% (no change)

APPENDIX C - SCOPE AND APPROACH OF FRESHWATER ECOLOGY REPORT

9. SCOPE OF THE FRESHWATER ECOLOGY SURVEYS

9.1 All investigations relate the ecological data back to where they are found within the catchment, as shown in **Figure 1**. For some surveys there was also sampling undertaken in the nearby Wanganui[10] catchment which served as a catchment comparison for the 2007 invertebrate and periphyton surveys - however these are not included in the summary here.

9.2 All investigations also relate ecological data back to waterway types; being the mainstem of the Waitaha River, stable tributaries or other tributaries. The waterway types were defined based on differences in-channel type and (for tributary waterways) stability, both of which influence invertebrate communities. For the earlier fish ecology assessments (Drinan & McMurtrie, 2014) no distinction was made between 'stable' or 'other' for the tributary waterways, but this has now been undertaken to provide consistency in the reporting of the benthic ecology and fish ecology findings.

[10] The area surveyed within the adjacent Wanganui catchment in 2007 provided a between-catchment comparison that enabled consideration of the uniqueness of the benthic freshwater ecology in the Waitaha catchment to the local area.

APPENDIX D - DETAIL OF THE EXISTING ENVIRONMENT

10. CATCHMENT OVERVIEW

10.1 The Waitaha River catchment is approximately 315 km^2 and is the third largest catchment within the Harihari/Wilberg ecological district. The Scheme is situated in the middle of the catchment (**Figure** 1), near the border of the Wilberg/Harihari ecological district; which is where the catchment changes to more of a farmed landscape. Based on the River Environment Classification (**REC**) data, the Waitaha River at the location of the Scheme is dominated by a glacial mountain fed topography/source of flow; defining it as a system with strong seasonal flow patterns (low winter flows and high summer flows) and high turbidity due to the presence of fine glacial sediment.

10.2 The river flows through V-sided valleys dominated by alpine shrubs and tussocks above the tree line, and mixed hardwood/podocarp forest below the tree line. It has a steep gradient overall, dropping some 2,620 m from the highest peak in its catchment (Mt Evans) to the sea. The upper catchment receives significant annual rainfall, ranging from about 5.5 m at Kiwi Flat to around 12–14 m at the divide (the **Hydrology Report**). This high rainfall, along with snow and ice exert, considerable influence on the flow conditions of the river, with floods occurring approximately every 8.6 days (**Hydrology Report**). The dominant geology of the area is a mixture of poor to well-foliated fissile schist and glacial outwash gravels in the valley floors and terraces. Signs of recent erosion and aggradation in the catchment are common: landslips are a characteristic feature of the area.

10.3 The mainstem of the Waitaha River is dominated by a plane-bed/cascade morphology, with a mixture of sand-gravel–cobble substrate in slower flowing areas of the river, and massive boulders and shifting gravel in faster flowing areas. The river is predominantly a single-thread channel above Kiwi Flat, but as the valley flattens and widens at Kiwi Flat the river takes on a slightly braided nature, with low terraces representing the previous location of the river channel. At the downstream end of Kiwi Flat the river flows through Morgan Gorge as a confined channel, with a substrate dominated by bedrock, massive boulders, and shifting gravels. The river remains confined in a single channel and dominated by extremes of substrate size (e.g., boulders and gravel) until just downstream of the Douglas Creek confluence. Downstream of the Douglas Creek confluence the Waitaha River widens to a braided floodplain channel that flows across agricultural land for 17 km before discharging into the Tasman Sea near the coastal settlement of Kakapotahi.

10.4 The Waitaha River exhibits considerable instability due to frequent large floods, high fluxes of bed-material, and transient deposition and re-working of sediment (**Sediment Report**). The annual frequency of floods greater than three times the median flow (FRE_3) at Kiwi Flat (downstream of the Whirling Water confluence) is approximately 26 (**Hydrology Report**); meaning that approximately 26 times a year there are flood flows that are greater than three times the median flow of 20 cumecs. This type of flood frequency is in the upper range for New Zealand rivers and is a significant factor affecting/limiting the biological community inhabiting the river.

11. WATER QUALITY

11.1 Nitrate levels in the catchment were very low, with Ammoniacal-N, Total Nitrogen (TN) and Total Kjeldahl Nitrogen (**TKN**) being below laboratory detection limits at all sites and sampling rounds. Whilst total organic nitrogen (**TON**) was detected on all sampling rounds, it was still at relatively low levels, ranging from 24 mg/m^3 in a stable tributary of Kiwi Flat (Site 24) in April 2007, to 85 mg/m^3 in the Waitaha River at the upstream end of Kiwi Flat (Site 20) in September 2007. There was no difference in nitrate concentrations in any of the four pre-defined areas within the Waitaha River.

11.2 Dissolved reactive phosphorus (**DRP**) was below the laboratory detection limit (< 4 mg/m^3) at all sites and sampling periods except for two tributaries in Kiwi Flat on the last sampling round in September 2007 (Site 24 and 27) where it reached only 9 mg/m^3. Total phosphorus (**TP**) was detected 43% of the time and had a mean of 3.68 mg/m^3. There was no difference in phosphorus concentrations in any of the four pre-defined areas within the Waitaha River.

11.3 There are no ANZG (2018) default guideline values (DGVs) for glacial fed rivers, so we were unable to compare the Waitaha River water quality data against national guidelines. However, McMurtrie & Suren (2014) did compare their water quality data against river water quality data collected from across New Zealand which is available in National River Water Quality Network (**NRWQN**). This showed that water chemistry of the Waitaha catchment was comparable for pH and conductivity (with these values close to the national median values from the NRWQN), while most nutrient levels were well below the NRWQN values.

11.4 The low-nutrient water of the Waitaha catchment is typical of many other West Coast rivers where catchment modification is minimal. The low nutrient water of the Waitaha catchment, combined with a high flood frequency, suggests that the likelihood of excessive algal growth in the river is minimal.

11.5 Further detail is set out in Section 3.2 of McMurtrie & Suren (2014).

12. PERIPHYTON AND MACROPHYTE/BRYOPHYTE COMMUNITIES

12.1 Periphyton communities were similar throughout the mainstem and most tributary waterways of the Waitaha catchment, although two stable tributary sites supported distinct communities, as indicated by the Detrended Correspondence Analysis (**DCA**)[11] analysis that was undertaken. All taxa recorded are common and widespread in South Island rivers and the communities are typical for the catchment type in terms of their diversity and species composition. Periphyton biomass was low in the mainstem sites and stable tributaries, but was slightly higher in 'other' tributaries. The low biomass in the mainstem sites is due to the low-nutrient waters and flood-prone nature of the Waitaha River. Slightly higher biomass at the most downstream site in the Downstream Reach of the Waitaha River as would be expected due to diffuse nutrient inputs from developed agricultural areas. The low biomass in the stable tributaries is due to the higher abundance of bryophytes in these more stable flow waterways. All sites were dominated by diatom assemblages rather than filamentous algae, also reflecting the low nutrient and flood-prone nature of most of the waterways.

12.2 Both the diversity and coverage of freshwater bryophytes (mosses, liverworts and hornworts) was higher in the stable tributary waterways than in the mainstem river or 'other' tributary waterways. This was reflected in the dramatically higher bryophyte coverage (>60%) recorded in the stable spring-fed tributary in the Douglas Creek Reach (on the true-right of the river opposite Douglas Creek –Site 21 and 22 from McMurtrie & Suren (2014)[12]) during the 2007 surveys, and the detection of 15 bryophyte species in the stable tributaries (compared to 10 species detected in the 'other' tributaries and only four species detected in the mainstem sites) during the eDNA sampling in 2024. Overall, the lack of bryophytes in the mainstem and many of the 'other' tributaries reflects the unstable nature of the system, with slow growing bryophytes mostly limited to the more stable flow habitats, such as that of the stable tributaries in the Douglas Creek Reach and Kiwi Flat Reach.

[11] Detrended Correspondence Analysis (DCA) is a statistical technique that graphically represents the similarity of biological communities by plotting them on an x-y graph; such that samples with similar species assemblages appear close together on the graph, and samples with very different communities appear far apart from each other. Samples are plotted in two dimensions (x and y, or Axis 1 and Axis 2). The calculation of a separate *gradient length* along both Axis 1 and 2 provides a measure of the degree to which species composition changes along the ordination axis. A large gradient length (>4) indicates almost complete species turnover along the ordination axis, so that samples at opposite ends of an axis share no taxa in common.

[12] This waterway is herewith referred to as the 'Stable Trib' in the Douglas Creek Reach.

The most substantial communities were found within the spring-fed stable tributary opposite Douglas Creek, which is downstream of the abstraction reach but close to the Scheme's proposed access road.

12.3 Overall, the findings of the periphyton and bryophyte surveys were that the mainstem river represents a low nutrient, high disturbance system that is not conducive to the growth of periphyton or bryophytes. The stable tributaries within the catchment represent biodiversity 'hotspots' for bryophytes, which in turn provide an important habitat for freshwater invertebrates. These types of stable environments are not common in West Coast catchments that naturally exhibit high instability due to frequent large floods, high fluxes of bed-material, and transient deposition and re-working of sediment – as such it is the stable tributaries that represent the more distinctive freshwater habitat within this catchment.

12.4 Further detail is set out in Section 3.4 of McMurtrie & Suren (2014).

13. PERIPHYTON – NUISANCE DIDYMO

13.1 In the surveys undertaken by McMurtrie & Suren (2014), non-viable (dead) didymo (*Didymosphenia geminata*) cells were detected in periphyton samples collected from five sites in 2007, (including in the mainstem and tributaries within the catchment), although further sampling in 2008 failed to find any cells, viable or otherwise – leading to inconclusive results. The more recent eDNA sampling in 2024 (McMurtrie & Grima, 2024) detected didymo DNA from four sites including within the mainstem in the Douglas Creek reach and tributaries (stable and other) within the Kiwi Flat Reach. The DNA signature for didymo at these sites were all generally low indicating that whilst present this species is not a dominant feature of the environment; and certainly didymo growths were not obvious at any of the sampling sites either during 2007, 2008 or 2024 sampling.

13.2 Although didymo is relatively prevalent in the West Coast region now, the Waitaha River itself is less likely to be conducive to didymo blooms, given the frequent floods and high suspended sediment loads that would keep biomass to a minimum.

13.3 Further detail is set out in Section 3.4.6 of McMurtrie & Suren (2014) and Section 3.4 of McMurtrie & Grima (2024).

14. BENTHIC INVERTEBRATES

14.1 A total of 100 different freshwater invertebrate taxa were found in sites surveyed by McMurtrie & Suren (2014), with the fauna composed of a diverse assemblage of insect taxa, dominated by mayflies, chironomid midges, caddisflies, and stoneflies. In addition, the megainvertebrate waikōura/freshwater crayfish (*Paranephrops planifrons*) was recorded from the stable tributary on the true-right opposite Douglas Creek in both the conventional fish sampling by Drinan & McMurtrie (2014) and eDNA sampling. As waikōura need stable flows it is not surprising that their distribution was limited to this low gradient spring/seepage flow fed system.

14.2 Macroinvertebrate communities in the stable tributary sites were significantly different to those found in the mainstem or other tributary sites. The density (individuals/m^2) and diversity of taxa in the stable tributary sites was also significantly higher than in the mainstem sites or other tributaries. Stable tributaries supported more than double the diversity of invertebrate taxa than the mainstem or other tributary sites, with an average of 32 taxa and 19 EPT[13] taxa for stable tributary sites vs 13-18 invertebrate taxa and 7-11 EPT taxa in mainstem and other tributary sites, respectively. The

[13] EPT stands for Ephemeroptera, Plecoptera and Trichoptera orders, which make up the 'cleanwater taxa'.

mainstem and other tributaries also had lower species evenness – with mainstem sites dominated (80% total abundance) by the mayfly *Deleatidium* and orthoclad midges (Orthocladiinae and *Stictocladius*) and other tributaries dominated by *Deleatidium (*70% of total abundance). In contrast stable tributaries had far greater species evenness, with no one species reaching more than 20% total abundance. Most of these differences in stable tributaries were a result of the stable spring-fed tributary in the Douglas Creek Reach.

14.3 The limited invertebrate community in the mainstem and 'other' tributaries compared to the biodiversity hotspots of the stable tributaries is a function of the high disturbance regime of the Waitaha River and 'other' tributaries. Stream disturbance is recognised as the primary abiotic factor regulating stream invertebrate communities in pristine systems (Winterbourn, 2004b). Such flood-prone systems are most influenced by the intensity and frequency of disturbances, which far outweigh biotic interactions such as predation, competition, and resource supply (Lancaster, 1996). In such flood-prone systems, the invertebrate community is limited to those taxa that can rapidly colonise or persist in disturbed environments, such as some chironomids and mayflies. The mayfly *Deleatidium* is widely distributed throughout New Zealand and is often the dominant taxa in flood-prone systems (Winterbourn, 2004b) such as the Waitaha mainstem and other tributaries. This mayfly is particularly well adapted to disturbed environments, with their non-synchronous life cycle and use of side braids and river margins allowing for continual recolonisation of disturbed environments (Winterbourn, 2004a).

14.4 Systems devoid of regular disturbance (such as the stable tributary streams in the catchment) typically support a much greater diversity and abundance of invertebrates (Death, 1995; Lancaster, 1996), and in such systems biotic factors (e.g., resource supply, predator-prey interactions) have a greater influence on population dynamics (Peckarsky, 1984; Wootton *et al.,* 1996). As biodiversity 'hotspots', the stable tributaries of the Waitaha catchment are also locally important for maintaining biodiversity values and ecosystem functioning within the catchment.

14.5 The freshwater invertebrate fauna of the Waitaha catchment is comparable to those of other neutral pH, fast-flowing West Coast rivers flowing through unmodified catchments in high rainfall areas, where water quality is high and nutrient levels and algal biomass are low. Invertebrate biotic metrics (such as taxa richness, MCI[14] and QMCI[15], and the number of EPT) from the 2007 sampling data were all typical of other rivers flowing through unmodified catchments and did not greatly differ to that of other large river catchments throughout the West Coast.

14.6 There were only four invertebrate taxa found in the Waitaha river that have a conservation status (based on the lists in Grainger *et al.*, 2018), and that was a conservation status of 'At Risk - Naturally Uncommon'. These are:

(a) The stonefly *Megaleptoperla grandis* – found in the mainstem and 'other' tributaries in the Kiwi Flat Reach.

(b) The mayfly *Deleatidium magnum* – found in all waterway types (mainstem, stable tributary, 'other' tributary) and subcatchment areas (Douglas Creek Reach, Kiwi Flat Reach, Upstream Reach.

(c) The caddisfly *Costachorema brachypterum* –found in the mainstem in the Douglas Creek Reach and Upstream Reach

[14] MCI stands for Macroinvertebrate Community Index, which is an aquatic invertebrate health score based on the presence of taxa with different tolerance ratings.
[15] QMCI is the quantitative variant of the MCI score, and as such takes into account the abundance of taxa.

(d) The caddisfly *Philorheithrus latentis* – found in the 'Stable Trib' (on the true-right opposite Douglas Creek) in the Douglas Creek Reach.

14.7 Further detail is set out in Section 3.5 of McMurtrie & Suren (2014) and Section 3.4 of McMurtrie & Grima (2024).

15. FISH

15.1 A total of 424 individuals and eight fish species were captured via conventional sampling methods (by Drinan & McMurtrie (2014)) within the four sub-catchment areas, whilst the more recent eDNA sampling (by McMurtrie & Grima (2024)) recorded nine species (**Table 4**). These were (in order of occurrence from most recorded to least recorded) kōaro (*Galaxias brevipinnis*), longfin eel (*Anguilla dieffenbachii*), brown trout (*Salmo trutta*), torrentfish (*Cheimarrichthys fosteri*), lamprey (*Geotria australis*), redfin bully (*Gobiomorphus huttoni*), common bully (*Gobiomorphus cotidianus*) and giant kōkopu (*Galaxias argenteus*).

15.2 According to the latest conservation status of fish (Dunn *et al.,* 2018), one of these species has a conservation status of 'Threatened – Nationally Vulnerable' (lamprey) and four have a conservation status of 'At Risk – Declining' (kōaro, longfin eel, torrentfish, giant kōkopu). Three species are 'Not Threatened' (redfin bully, common bully, shortfin eel) and one is 'Introduced & Naturalised' (brown trout).

15.3 There was a distinct longitudinal distribution pattern, with kōaro the only fish species found upstream of Morgan Gorge (**Table 4**). Given the comprehensive sampling – covering a range of conventional fishing methods along with more recent eDNA sampling, a large number of sites (48 sites sampled via conventional methods and 20 via eDNA sampling) and waterway types (a mix of mainstem, stable tributaries and other tributaries), and sampling across multiple years (2008, 2013, 2024) – we are confident that kōaro are the only fish species that is able to penetrate upstream of Morgan Gorge. The physiological (such as specially adapted fins) and behavioural (leaving the main flow and using surface water tension of wet rocks out of the flow to move upwards) traits of kōaro make it uniquely capable amongst our fish species to penetrate inland beyond where other fish are able to access, including climbing up vertical surfaces and negotiating velocity barriers (McDowall, 2003). Thus, whilst there is no obvious waterfall within Morgan Gorge, the highly constrained nature of the gorge that produces a high velocity white water rapids environment with a myriad of smaller drops is such that it prevents passage by other fish species. Notably the distribution of kōaro diminished within the catchment upstream of Waitaha Gorge (i.e., upstream of Kiwi Flat); likely a result of natural attrition caused by the presence of additional natural migration barriers and limited food resources.

Table 4 Fish species recorded in the Waitaha subcatchment areas using conventional fishing methods by McMurtrie & Drinan (2014) and eDNA sampling by McMurtrie & Grima (2024). The latest conservation status of fish (Dunn et al., 2018) is also shown. The numbers shown indicate the number of sites within each subcatchment area and waterway type that a species was recorded by the conventional sampling (first number) and eDNA sampling (second number). A '-' indicates no surveys were done in that reach.

Reach & number of sites sampled (conventional/eDNA)		**Downstream Reach** 3 sites (3/-)		**Douglas Creek Reach** 23 sites (18/5)			**Kiwi Flat Reach** 29 sites (21/8)			**Upstream Reach** 13 sites (6/7)		**Total**
Waterway type		Mainstem	Trib-stable	Mainstem	Trib-other	Trib-stable	Mainstem	Trib-other	Trib-stable	Mainstem	Trib-other	
No sites sampled per waterway type: total (conventional/eDNA)		2 (2/-)	1 (1/-)	8 (7/1)	7 (5/2)	8 (6/2)	9 (8/1)	11 (7/4)	9 (6/3)	6 (3/3)	7 (3/4)	68 (48/20)
Fish Species	Conservation Status											
Kōaro *Galaxias brevipinnis*	At Risk – Declining	**1** (1/-)		**5** (4/1)	**6** (4/2)	**6** (4/2)	**5** (4/1)	**10** (6/4)	**7** (4/3)		**1** (0/1)	41
Longfin eel *Anguilla dieffenbachii*	At Risk – Declining		**1** (1/-)	**1** (1/0)	**4** (2/2)	**7** (5/2)						13
Brown trout *Salmo trutta*	Introduced & naturalised	**2** (2/-)		**6** (5/1)	**3** (2/1)	**5** (4/1)						16
Torrentfish *Cheimarrichthys fosteri*	At Risk – Declining			**5** (4/1)	**2** (1/1)	**2** (1/1)						9
Lamprey (ammocete) *Geotria australis*	Threatened – Nationally Vulnerable					**3** (2/1)						3
Redfin bully *Gobiomorphus huttoni*	Not Threatened					**2** (1/1)						2
Common bully *Gobiomorphus cotidianus*	Not Threatened		**2** (2/-)									2
Shortfin eel *Anguilla australis*	Not Threatened		**1** (1/-)									1
Giant kōkopu *Galaxias argenteus*	At Risk – Declining					**1** (0/1)						1
No. fish species recorded per reach & waterway type		2	3	4	4	7	1	1	1		1	
No. fish species recorded per reach		5		7			1			1		

15.4 In the Douglas Creek Reach, there was also a large difference in species diversity between the tributaries and the mainstem. Only four fish species (kōaro, brown trout, torrentfish, longfin eel) were found in the mainstem, compared to seven species in the tributary sites (these four fish species as well as lamprey, redfin bully and giant kōkopu) (**Table 1**). Within the tributaries, most fish species were limited to the Douglas Creek and the 'Stable Trib' (the stable spring-fed tributary opposite Douglas Creek). Upstream of these tributaries, only kōaro and longfin eel were found in any of the surveyed tributary waterways of the Douglas Creek Reach. However, longfin eel distribution and abundance were limited compared to kōaro, with only one specimen caught in a tributary and mainstem site upstream of Douglas Creek. Many of the tributaries in the Douglas Creek reach are intermittent or ephemeral and so are not suitable fish habitat. Others have natural fish passage barriers (steep sections and short waterwalls/drops) near their confluence with the mainstem, that would prevent most fish from being able to access them.

15.5 Fish densities in the mainstem were particularly low, with an average of 2.3 individuals per 100 m^2 in the Douglas Creek Reach, and <0.1 individuals per 100 m^2 in the Kiwi Flat reach (where only kōaro are found). The low densities and diversity of fish in the mainstem indicates that the mainstem channel within the Douglas Creek Reach and upstream is not favourable habitat for fish; likely a consequence of the unstable nature of this glacial-fed river and the poor food resources.

15.6 Across all survey areas total fish densities were considerably higher in tributaries than in the mainstem. The greatest species richness (seven species) and fish densities (46 individuals per 100 m^2) were recorded from the spring-fed stable tributary on the true right opposite Douglas Creek. Tributaries within the Kiwi Flat Reach (particularly Caesar Creek and the Kiwi Flat 'Stable Trib' which support 14.5 kōaro per 100 m^2 and 6.4 kōaro per 100 m^2, respectively) similarly appear to be more important than the mainstem as adult kōaro habitat. Such tributaries in the Kiwi Flat Reach will also likely be important spawning habitat for kōaro.

15.7 The fish fauna of the Waitaha catchment is reasonably similar to those in close proximity (<23.2 km distance) and typical of West Coast rivers. However, the value of the Kiwi Flat Reach to the kōaro fishery is important, as salmonids (such as brown trout) are unable to access this area. The historical records of brown trout co-occurrence with kōaro from waterways in nearby catchments shows that, of the total 88 sites with survey data, kōaro exist in isolation from brown trout in 20 waterways (in comparison with 43 where they co-occur); representing 30% of waterways where kōaro have been recorded.

15.8 The 'Stable Trib' (the spring-fed stable tributary on the true right opposite Douglas Creek), which is downstream of the abstraction reach but close to the Scheme's proposed access road, is a 'hotspot' for fish diversity and density within the Waitaha catchment. It is also a significant lamprey rearing habitat, with 25 juvenile lamprey (ammocoetes) caught in a small (approximately 2 m^2) area. Based on the number of small trout recorded (54 across all conventional sampling sites), this stable tributary could also be a trout rearing habitat in this section of the catchment, given the unsuitability of most tributary waterways in the Douglas Creek Reach as trout habitat, and the lack of trout access into Kiwi Flat.

15.9 Trout Fishery Value: The mainstem of the Waitaha within the Douglas Creek Reach is suboptimal habitat for brown trout and of little value to the brown trout fishery. The lower reaches of the river (i.e., in the Downstream Reach) are likely to be more amenable to trout, where the river plain widens, water velocities are lower, and there is a greater lateral spread of flood flows in comparison with the more confined Douglas Creek Reach. This is supported by the fact that the most recreationally fished sections of the Waitaha are downstream of the SH6 bridge and Ellis Creek (just above SH6 bridge) (Dean Kelly, Fish & Game, pers. comm.).

15.10 Salmon Fishery Value: Based on search of all available online databases as of November 2024 (the New Zealand Freshwater Fish Database (**NZFFD**) and the Wilderlab eDNA sampling database) as well of our own sampling data, there are no fish survey records of Chinook salmon (*Oncorhynchus tshawytscha*) from the Waitaha catchment. Irrespective of this, Douglas Creek is regarded as a salmon spawning waterway (Dean Kelly, Fish & Game, pers. comm.).

15.11 Further detail is set out in Section 3.3-3.7 of Drinan & McMurtrie (2014) and Section 3.1 of McMurtrie & Grima (2024).

APPENDIX E – INVESTIGATIONS

16. FRESHWATER ECOLOGY INVESTIGATIONS UNDERTAKEN

16.1 There has been a considerable amount of freshwater ecology investigations undertaken, spanning multiple years, that provide a comprehensive understanding of the ecological state and values of the Waitaha catchment's waterways. This includes investigations undertaken as part of earlier project work in 2007, 2008 and 2013, as well as supplementary eDNA sampling in 2024. The earlier surveys were both detailed, quantitative, and comprehensive, and covered a wide range of aquatic habitats throughout the catchment. Even though that data is 11-17 years old there has been no land use change in the catchment since that time, and according to the **Hydrology Report** the river flow has not significantly changed over that time either. As such there is nothing that would have caused the freshwater communities to change, and so those findings remain valid today. The more recent sampling in 2024 consisted of eDNA sampling, which is new technology that did not exist at the time of the original surveys and so was used to supplement the past investigations.

16.2 Four separate surveys pertaining to freshwater ecology have been undertaken since 2007. These are:

(a) September 2007: Surveys undertaken using conventional sampling methods for benthic ecology. Included sampling of invertebrate community, freshwater plants (macrophytes, bryophytes, periphyton) and freshwater habitat.

(b) March 2008: Surveys specifically targeted at looking for the presence of the invasive diatom didymo (*D. geminata*).

(c) February/March 2008 and March/June 2013: Fish surveys undertaken using conventional sampling methods. Included electrofishing, spotlighting, and setting/retrieving fyke nets and Gee minnow traps.

(d) July 2024: supplementary eDNA sampling to look for presence of less common freshwater invertebrate species with a conservation status (i.e., threat classification) that may not have been identified via the previously collected samples, and to complement the body of evidence regarding the presence of fish species in different parts of the catchment.

(e) Note that Items (a) and (b) are covered in McMurtrie & Suren (2014); Item (c) is covered in Drinan & McMurtrie (2014); and Item (d) is covered in McMurtrie & Grima (2024).

16.3 Benthic ecology: A total of 38 sites (31 in the Waitaha catchment, seven in the Whanganui catchment) were sampled for invertebrates, habitat, freshwater plants (periphyton, bryophytes, macrophytes), and water quality in September 2007 (**Figure 7**). The sites sampled provide a robust representation of the different freshwater habitat types and areas within the Waitaha catchment. The sampling methodologies employed during these surveys included:

(a) Invertebrate sampling: Quantitative samples collected via Surber sampling, rock rolling or boulder rubbing. A total of 373 samples were collected (308 in Waitaha catchment, 65 in Whanganui catchment), with 4-12 replicate samples collected per site. Samples were preserved in iso-propanol alcohol and processed in the laboratory following a full count methodology identifying invertebrates to the lowest practicable level. The data produced was therefore quantitative (number/m^2) allowing samples collected within the Waitaha River mainstem to be used to generate the Waitaha-specific habitat suitability curves in the IFIM[16] modelling of the **IFIM Report**. Further detail is set out in Section 2.4.1 of McMurtrie & Suren (2014).

(b) Habitat: Water depth, water velocity and substrate size were recorded where each invertebrate sample was collected, to enable catchment-specific habitat use curves for the key invertebrate species found in the Waitaha River to be generated and used in the IFIM modelling of the **IFIM Report**. Site-wide habitat measures were also collected such as Pfankuch stability score, site length and channel width. Further detail is set out in Section 2.4.2 of McMurtrie & Suren (2014).

(c) Freshwater plants: The overall cover of macrophytes and bryophytes (liverworts and mosses) was visually assessed at each site. Key species were identified from each site. A total of 31 periphyton samples were collected (31 in Waitaha catchment, 7 in Whanganui catchment), via quantitative rock scrapings from 3-7 stones per site, defined as Method 1b in Biggs & Kilroy (2000). Periphyton samples were analysed via NIWA for chlorophyll *a* (a measure of the total amount of live algae in a sample) and ash-free dry mass (AFDM, a measure of the total organic matter in a sample). Sub-samples from each sample were examined under microscope to identify algal taxa present. Further detail is set out in Section 2.4.3 of McMurtrie & Suren (2014).

(d) Water quality: Water temperature, pH, and conductivity were measured in situ from all 38 sampling sites. Water samples were also collected from 15 sites (11 in the Waitaha catchment and four in the Whanganui catchment) during the 2007 surveys, and analysed via Hill Laboratories for total suspended solids (**TSS**), ammoniacal-N (NH_3-N), total nitrogen (**TN**), total Kjeldahl nitrogen (**TKN**), total organic nitrogen (TON), dissolved reactive phosphorus (**DRP**), and total phosphorus (**TP**). Repeat water quality sampling at six mainstem sites in the Waitaha catchment, provided water quality data for a further three times in 2007. Further detail is set out in Section 2.4.5 of McMurtrie & Suren (2014).

16.4 Didymo drift and rock sampling: A total of seven sites in the Waitaha catchment were sampled for the presence of the invasive diatom didymo in March 2008 using conventional sampling methods (**Figure 7**). This sampling was undertaken following the identification of didymo in the wider West Coast area, and so it was felt that additional sampling for didymo was warranted. The sampling methodology involved:

(a) Specialised drift netting and collecting algal scrapings from the surface of 25 rocks taken from across five transects downstream of the drift net. The algal samples were submitted to NIWA where they were analysed for the presence of didymo. Further detail is set out in Section 2.4.4 of McMurtrie & Suren (2014).

16.5 Fish: A total of 48 sites in the Waitaha catchment were sampled for fish in 2008 and 2013 using conventional fishing methods. This included 20 mainstem sites and 28 tributary sites (**Figure 8**) in order to provide a robust representation of the different freshwater habitat types and areas within the Waitaha catchment. All fish captured at a site were identified to species and their length recorded. The sampling methodologies employed during these surveys comprised:

[16] IFIM stands for Instream Flow Incremental Methodology, and is a modelling approach used to predict the effect of changing flows in a waterway, based on the assumption that biota (such as fish) are constrained by their environment, that limiting factors are flow related, and that it is possible to produce a single index incorporating the relationship between biomass and all important physical factors (Maughan & Barrett, 1992).

(a) Electrofishing: single-pass electrofishing was undertaken at 37 sites. In flowing water, fish temporarily stunned by the current are washed downstream and caught in a hand-held stop-net located 1–2 m downstream of the electrofishing operator. A hand-net held by the electrofishing operator is also used to capture fishor the tributary waterways. In tributary waterways the entire width of the stream channel was fished over a defined length of channel. For the larger mainstem this was not possible, and so electrofishing involved spot fishing habitats within the survey area, where it was safe to access and fish.

(b) Nets/Traps: Both fyke nets and Gee minnow traps were used in areas where other fish survey techniques were deemed insufficient, such as deeper areas where electric fishing techniques are less effective and/or spotlighting too difficult. Between 3-6 baited (with fish burley pellets) fyke nets (15-mm stretched mesh size) were set overnight at eight sites (six mainstem, two tributaries). Between 2-10 baited (with fish burley pellets) Gee minnow traps (5-mm mesh size) were set overnight at ten sites (seven mainstem, three tributaries).

(c) Spotlighting: Spotlighting was used at three tributary sites. Spotlighting is done at night and involves slowly walking upstream along the bank, shining a suitably powered light source into the water to find and capture (via hand netting) fish. The ability to spotlight is dependent on good water clarity, a smooth water surface, and a channel width less than a few meters (where the full channel can be lit from the bank), and so was not suited to the mainstem river or larger tributaries.

(d) Further detail is set out in Section 2.3 of Drinan & McMurtrie (2014).

16.6 Supplementary eDNA: A total of 20 sites were sampled for environmental DNA (eDNA) in July 2024 (**Figure 9**). This was to supplement data obtained via conventional surveys in the previous surveys. As eDNA samples pick up eDNA from a larger upstream area than conventional sampling, the sites sampled are representative of the different habitat types present within the wider Waitaha catchment. The sampling methodology for the collection of eDNA samples involved:

(a) Collection of six replicate samples per site (total of 120 samples across the 20 sites), which were filtered on site and sent to Wilderlab for eDNA processing.

(b) Greater sampling effort was applied to the tributary waterways (as they provide more suitable habitat for biota and their smaller size improves the chances of eDNA sampling detecting biota) and to the area upstream of Morgan Gorge to confirm whether or not the gorge represents a barrier to the passage of fish species other than kōaro.

(c) As eDNA can pick up DNA from over a large distance, sites within tributary waterways were located near the downstream confluence point with the mainstem, and mainstems sites were located near the downstream end of each sub-catchment reach.

(d) Further detail is set out in Section 1.2 and Section 2 of McMurtrie & Grima (2024).

16.7 The collected ecological data was analysed and summarised as per the methods defined in Section 2.5 of McMurtrie & Suren (2014), Section 2.4 of Drinan & McMurtrie (2014), and Section 2.4 of McMurtrie & Grima (2024).

16.8 Instream Flow Incremental Methodology (**IFIM**): In addition to the ecological surveys described above, the **IFIM Report** undertook IFIM work[17] to determine how the available habitat used by

[17] The **Hydrology Report** by Doyle (2025) noted that as a result of no significant difference in the hydrology statistics calculated in Doyle (2013) compared to Doyle (2025), that the origional assessments informed by these data would not need to be redone. As such the assessment of Allen & Hay (2013) (**IFIM Report**) remains as it is.

different biota within the river changes in response to different residual flows, which aids in ascertaining the ecological effects of removing different quantities of water from the river.

(a) The **IFIM Report** used 1-dimensional (**1-D**), hydraulic-habitat modelling, which involves measuring water depths, velocities, substrate composition, across representative river cross-sections at a given flow. Survey points were also taken along the cross sections up on the banks above water level, to allow model predictions to be made at flows higher than the survey flow. The stage at zero flow was also estimated at each cross section to enable fitting of rating curves and making model predictions at low flows. Following this, modelled depths, velocities and substrate types were compared with habitat suitability criteria (**HSC**) describing the suitability of different depths, velocities and substrate sizes as habitat for species of interest.

(b) The IFIM investigation included nine cross-sections within the Douglas Creek Reach. These were located near the downstream end of that reach (between Alpha Creek and Douglas Creek), which was the only part of the river where it was possible to sample across the entire width of the river channel.

(c) Predictions of habitat retention were modelled by the **IFIM Report** at the one-day mean annual low flow (**MALF [1 day][18]**) and median flows[19], for the following:

(i) Three types of periphyton (short filamentous algae, long filamentous algae, diatoms) were modelled based off commonly used HSC that were developed based off expert opinion of a New Zealand periphyton specialist (Barry Biggs, NIWA).

(ii) Two types of HSC were used for benthic invertebrates – one set from the invertebrate and habitat data collected during this survey, and thus specific to the Waitaha River. These include HSC for all invertebrates generally (Waitaha-all invertebrates) and, individually, for the most abundant invertebrate taxa collected in the Douglas Creek Reach: the mayfly *Deleatidium*, the midges Orthocladiinae and *Stictocladius*, and the net-wing midge *Neocurupira*. For comparison, a range of HSC developed in other parts of New Zealand or overseas were also modelled. This included a 'food producing' (Waters, 1976) HSC based on salmonid food sources in American streams, the generalised *Deleatidium* HSC of Jowett *et al.* (1991), and HSC developed from the Waitaki River for *Deleatidium* (Waitaki *Deleatidium*), and Orthocladiinae (Waitaki Orthocladiinae).

(iii) Eleven species of fish were modelled based on commonly used HSC: two size classes of brown trout (adult >200-250 mm, and juvenile <200–250 mm), kōaro, two size classes of both longfin and shortfin eel (>300 mm and <300 mm), torrentfish, lamprey, common bully, redfin bully, short jaw kōkopu, banded kōkopu and giant kōkopu. Of these, only four species – brown trout, kōaro, longfin eel and torrentfish – were recorded within the portion of Douglas Creek Reach to be affected by residual flow.

(d) A more detailed description of the methods and model used in the IFIM is set out in the **IFIM Report**.

(e) While IFIM modelling is a useful tool to gain an appreciation of the potential effects of different residual flow rates, there are some limitations that need to be acknowledged when interpreting the results. In a review of IFIM in New Zealand by Hudson *et al.* (2003), it is stated that:

[18] It is noted that whilst the MALF [1 day] value has since changed from 7.09 m^3/s in Doyle (2013) to 7.32 m^3/s in the **Hydrology Report** (Dolye, 2025), the **Hydrology Report** advises against reassessing past related studies (which would include the IFIM modelling) on the basis of the updated hydrological information, as the underlying flow statistics are considered virtually unchanged.
[19] Refer to Appendix B (Section 8.4) for the reasoning for the use of MALF [1 day] and median flow.

"there are many interactions between species, life stages, and other variables that influence the state of the ecosystem that are not modelled by PHABSIM [and] … the physical habitat is a necessary but not sufficient condition for a viable population of aquatic animals (Milhous, 1999)". As suggested in the **IFIM Report**, "flow relationships predicted using various HSC may be best interpreted as providing an indication of the range of possible responses of habitat to flow changes".

(f) IFIM modelling is therefore an important starting point to assessing potential effects of residual flows, the results of which must then be considered in context with wider biological, hydrological and geomorphological processes of the system in question, to obtain a more accurate prediction of potential effects on freshwater biota.

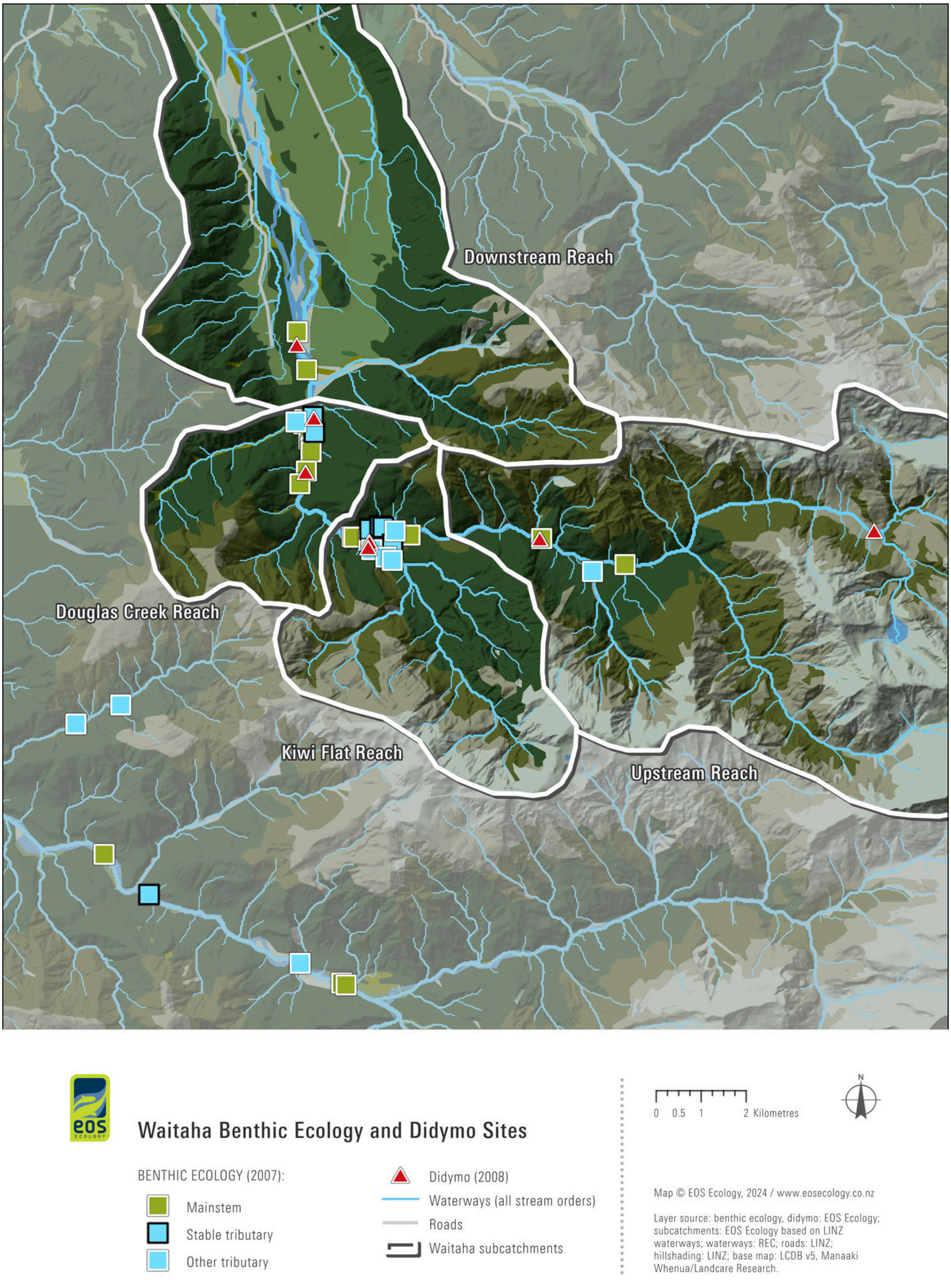

Figure 7 *Map showing the location of sites sampled by McMurtrie & Suren (2014) during the September 2007 benthic ecology surveys (invertebrate/periphyton/habitat) and March 2008 didymo sampling, using conventional sampling methods.*

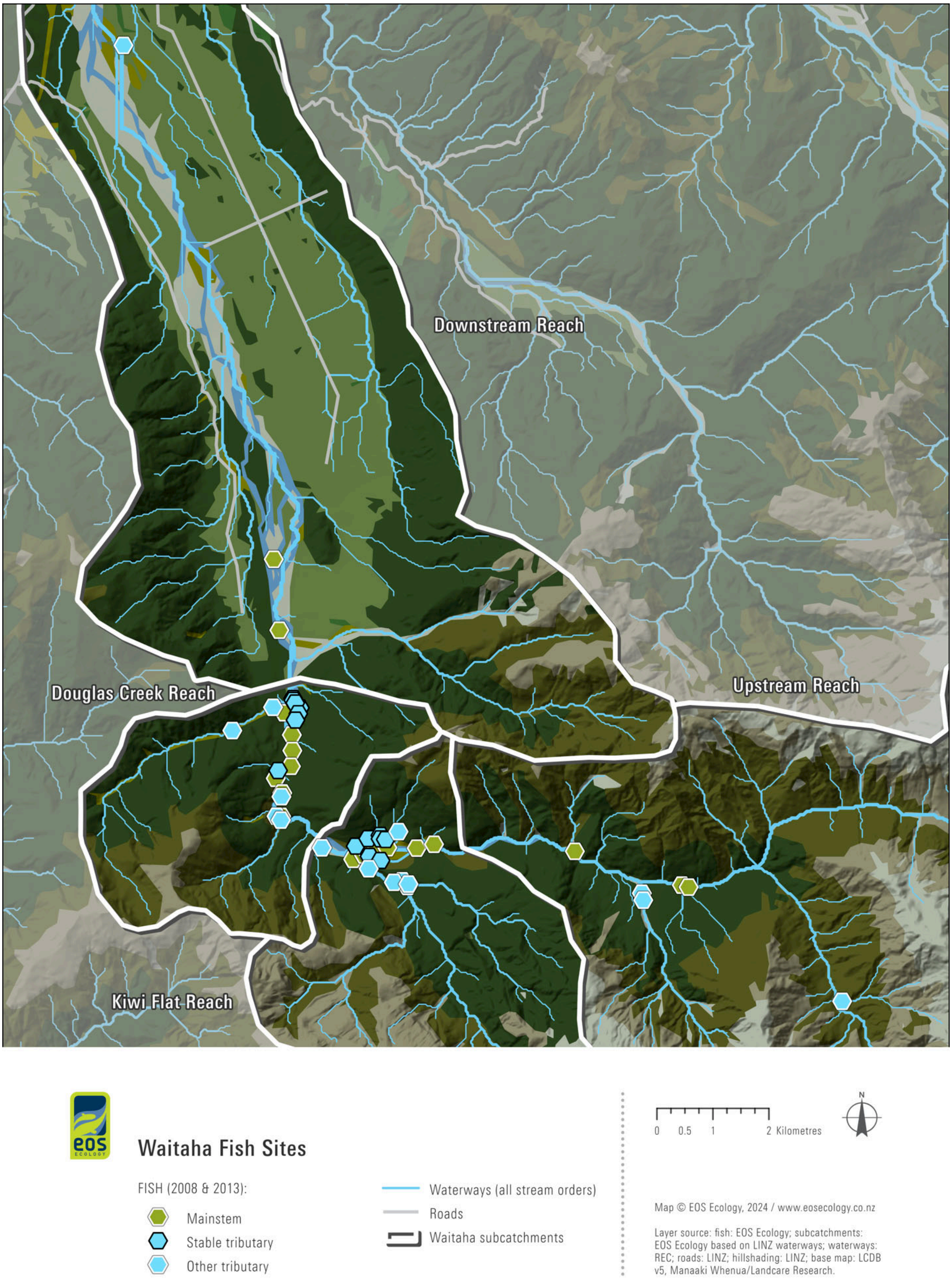

Figure 8 Map showing the location of sites sampled by Drinan & McMurtrie (2014) during the February/March 2008 and March/June 2013 fish surveys using conventional sampling methods.

Figure 9 Map showing the location of sites sampled by McMurtrie & Grima (2024) during July 2024 using eDNA sampling techniques.

APPENDIX F - SIGNIFICANCE OF THE VALUES RELATING TO FRESHWATER ECOLOGY

17. RELEVANT POLICIES

17.1 The following policy documents include provisions for assessing the significance of values related to freshwater ecology:

(a) West Coast Regional Policy Statement (**RPS**) (WCRC, 2020)

(b) Westland District Plan (**WDP**) (WDC, 2002)

(c) Proposed Te Tai o Poutini Plan (**TTPP**) (TTPPC, 2022)

(d) West Coast Conservation Management Strategy 2010-2020 (**CMS**) (DOC, 2010)

17.2 The **RPS – Section 7: Ecosystems and Indigenous Biological Diversity – Policy 7.1(a)** (WCRC, 2020) states that areas of significant habitats of indigenous fauna will be identified using criteria set out in **Appendix 1** of the RPS. Appendix 1: '*Ecological criteria for identifying significant terrestrial and freshwater indigenous biological diversity*' outlines nine criteria for assessing whether an area is considered significant habitat for indigenous fauna (see **Table 5**). If one or more criteria are met, then the area is deemed significant habitat for indigenous fauna for the purposes of Section 6(c) of the *Resource Management Act* (RMA) 1991 (Government of New Zealand, 1991).

17.3 The **WDP – Section 4.9: Natural Habitats and Ecosystems – Policy 4.9D** (WDC, 2002) outlines nine criteria for assessing whether an area is considered significant indigenous habitat. All criteria, except criteria 4.9D (viii) 'Scientific or other Cultural Value'[20], is relevant to freshwater ecology (see **Table 5**). If one or more criteria are met, then the area is deemed significant indigenous habitat for freshwater taxa for the purposes of Section 6(c) of the RMA 1991.

17.4 The proposed **TTPP – Part 2: Natural and Environmental Values, ECO-Ecosystems and Indigenous Biodiversity – Policy ECO-P1(2)(i)** links back to the RPS and states that to: '*Identify areas of significant indigenous vegetation and fauna habitat in the Buller and Westland Districts, the criteria set out in **Appendix 1** of the West Coast Regional Policy Statement will be used to assess significance*' (TTPPC, 2022).

17.5 The **CMS – Part 3 Section 3.3.2.3: Prioritising Natural Heritage Work – Policy 1** (DOC, 2010) outlines seven criteria for identifying and assessing the relative value of natural heritage. All criteria, except 'natural landscape character', is relevant to freshwater ecology (see **Table 1**).

17.6 The provisions of each of the above planning documents relevant for assessing significance of freshwater ecology values are set out in **Table 5**.

[20] Te Rūnanga o Ngāti Waewae and Te Rūnanga o Makaawhio (Poutini Ngāi Tahu) are the rūnanga that exercise tino rangatiratanga within, and are the kaitiaki of, the natural and physical resources within the West Coast including the Waitaha River. It is understood that Poutini Ngāi Tahu are project partners and support the Scheme. It is further understood that Poutini Ngāi Tahu have chosen not to prepare a cultural impact assessment but have contributed to the preparation of the assessment on environmental effects and have provided a letter of support for the Scheme. On this basis it is understood that any potential cultural issues relating to the subject matter of this report have been adequately addressed.

Table 5 ***Policy, information and criteria framework for determining significance and natural heritage values for purposes of Section 6 (c) of the RMA 1991. Note this be should be read in columns and not across rows.***

RPS (Policy 7.1(a); Appendix 1) & TTPP (Policy ECO-P1(2)(i))*	WDP (Policy 4.9D)	CMS (Policy 3.3.2.3 (1))
Criteria 1(a) – Representativeness. Indigenous vegetation or habitat of indigenous fauna that is representative, typical or characteristic of the indigenous biological diversity of the relevant ecological district. This can include degraded examples where they are some of the best remaining examples of their type, or represent all that remains of indigenous biological diversity in some areas.	**Policy 4.9D (i) – Intactness.** The area is unmodified by human activity, comprises a predominantly intact indigenous system and is not affected in a major way by weed or pest species.	**Policy 3.3.2.3 (1) – Representativeness.** Natural heritage should be identified and its relative value assessed using standard criteria such as representativeness. Related policy: **Policy 3.3.3.2 (1)** Management of threats to freshwater species, habitats and ecosystems must take into account the need to: (c) Maintain representative examples of the full range of indigenous ecosystems.
Criteria 1(b) – Representativeness. Indigenous vegetation or habitat of indigenous fauna that is a relatively large example of its type within the relevant ecological district.	**Policy 4.9D (ii) – Representativeness.** The area is one of the best examples of an association of species which is typical of its ecological district.	**Policy 3.3.2.3 (1) – Viability.** Natural heritage should be identified and its relative value assessed using standard criteria such as viability. Viability is defined in CMS as 'The ability of a species or a community to persist over time.' Related policy: **Policy 3.3.3.2 (1)** Management of threats to freshwater species, habitats and ecosystems must take into account the need to: (e) Achieve recovery of threatened indigenous species (including their genetic integrity and diversity) and restore their habitats where necessary.
Criteria 2(a) – Rarity/Distinctiveness. Indigenous vegetation or habitat of indigenous fauna that has been reduced to less than 20% of its former extent in the region, or relevant land environment, ecological district, or freshwater environment.	**Policy 4.9D (iii) – Distinctiveness.** The area has indigenous species or an association of indigenous species which is unusual or rare in the ecological district, or endemic or reaches a distribution limit in the ecological district. The area may be distinctive because of the influences of factors such as altitude, water table, soil type or geothermal activity.	**Policy 3.3.2.3 (1) – Diversity.** Natural heritage should be identified and its relative value assessed using standard criteria such as diversity. Related policy: **Policy 3.3.3.2 (1)** Management of threats to freshwater species, habitats and ecosystems must take into account the need to: (a) Prevent the loss of indigenous species and the full range of their habitats and ecosystems; (d) Maintain populations of indigenous species, habitats and ecosystems with unique or distinctive values.
Criteria 2(b) – Rarity/Distinctiveness. Indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk, or uncommon, nationally or within the relevant ecological district.	**Policy 4.9D (iv) – Protected Status.** The area has been set aside by New Zealand Statue or Covenant for protection and preservation or is a recognised wilderness area.	**Policy 3.3.2.3 (1) – Presence of threatened and/or taonga species and their habitat.** Natural heritage should be identified and its relative value assessed using standard criteria such as the presence of threatened and/or taonga species and their habitat. Related policy: **Policy 3.3.3.2 (1)** Management of threats to freshwater species, habitats and ecosystems must take into account the need to: (a) Prevent the loss of indigenous species and the full range of their habitats and ecosystems; (e) Achieve recovery of threatened indigenous species (including their genetic integrity and diversity) and restore their habitats where necessary; (h) Protect recreational freshwater fisheries and freshwater fish habitats.

RPS (Policy 7.1(a); Appendix 1) & TTPP (Policy ECO-P1(2)(i))*	WDP (Policy 4.9D)	CMS (Policy 3.3.2.3 (1))
Criteria 2(c) – Rarity/Distinctiveness. The site contains indigenous vegetation or an indigenous species at its distribution limit within the West Coast region or nationally.	**Policy 4.9D (v) – Connectivity.** The area is connected to one or more other significant areas in a way, (including through ecological processes) which makes a major contribution to the overall value or natural functioning of those areas.	**Policy 3.3.2.3 (1) – Intactness.** Natural heritage should be identified and its relative value assessed using standard criteria such as intactness. Related policy: **Policy 3.3.3.2 (1)** Management of threats to freshwater species, habitats and ecosystems must take into account the need to: (b) Maintain contiguous sequences of indigenous ecosystems (e.g. from mountains to sea); (f). Restore threatened indigenous ecosystems and connections between ecosystems where necessary.
Criteria 2(d) – Rarity/Distinctiveness. Indigenous vegetation or an association of indigenous species that is distinctive, of restricted occurrence, occurs within an originally rare ecosystem, or has developed as a result of an unusual environmental factor or combinations of factors.	**Policy 4.9D (vi) – Threat.** The area supports an indigenous species or community of species which is threatened within the ecological district or threatened nationally.	
Criteria 3(a) – Diversity and Pattern. Indigenous vegetation or habitat of indigenous fauna that contains a high diversity of indigenous ecosystem or habitat types, indigenous taxa, or has changes in species composition reflecting the existence of diverse biological and physical features or ecological gradients.	**Policy 4.9D (vii) – Migratory Species.** An inter-tidal area or area of forest, wetland, lake, estuary or other natural habitat that is important for migratory species or for breeding, feeding or other vulnerable stages of indigenous species.	
Criteria 4(a) – Ecological Context. Vegetation or habitat of indigenous fauna that provides or contributes to an important ecological linkage or network, or provides an important buffering function.		
Criteria 4(b) – Ecological Context. Indigenous vegetation or habitat of indigenous fauna that provides important habitat (including refuges from predation, or key habitat for feeding, breeding, or resting) for indigenous species, either seasonally or permanently.		

RPS - West Coast Regional Policy Statement (WCRC, 2020); TTPP - proposed Te Tai o Poutini Plan (TTPPC, 2022), WDP - Westland District Plan (WDC, 2002); CMS - West Coast Conservation Management Strategy 2010-2020 (DOC, 2010).

*TTPP uses the same criteria as that set out in Appendix 1 of the RPS to assess significance.

18. SIGNIFICANCE OF FRESHWATER ECOLOGY VALUES IN THE WAITAHA RIVER

18.1 The following paragraphs provide the rationale for the significance value assigned to each freshwater ecology significance criteria.

18.2 ***Representativeness*. High significance value rationale:**

(a) Waitaha River mainstem is representative of glacial-fed or mountain-fed naturally disturbed river systems typical of the West Coast Region. There are three main rivers (Waitaha River, Wanganui River, Whataroa River) within the Harihari ecological district (ecological code 50.03) and Wilberg ecological district (ecological code 50.04) (DOC, 2024)[21] and these are all glacial-fed or mountain-fed systems (based on the River Environment Classification (**REC**) topography/source of flow 'Glacial Mountain (**GM**)' and 'Mountain' classification). It is not possible to say which is most representative of such systems; all we can say is that the Waitaha River is the smallest of these three catchments – although size should not be considered the only basis for consideration of what is most representative.

(b) Waitaha River mainstem and its tributaries support freshwater habitat that is representative of the indigenous freshwater plants (periphyton, algae, bryophytes, macrophytes), freshwater fish, and macroinvertebrate associations in the Harihari and Wilberg ecological districts. The lack of land use change or development in the mid-upper reaches means that the freshwater system remains largely unimpacted by anthropogenic land use changes in those parts.

(c) Based on our analysis of 20 West Coast rivers, the Waitaha River is indistinct from other catchments in the Harihari and Wilberg ecological districts in terms of indigenous freshwater plants, freshwater fish, and macroinvertebrate associations. Freshwater fish species (and the freshwater crayfish/kōura) recorded within the Scheme's footprint, and within the greater Waitaha River catchment, have also been recorded from other nearby catchments, and are typical of West Coast rivers. For example, apart from bluegill bully (which have not been recorded in the Waitaha catchment), the composition of the fish communities of the Waitaha River catchment are the same as that of the Mikonui River catchment, 11.1 km north of the Waitaha River catchment. Invertebrate communities in the Waitaha River catchment are composed of similar species assemblages as found in other West Coast rivers, and (on a more local scale) there is similarity in the aquatic invertebrate and periphyton community of the Waitaha River mainstem and the nearby Wanganui River. However, the Waitaha River is a good representative and characteristic example of an association of species typical of the Harihari and Wilberg ecological districts. It is just not possible to confirm with certainty that the Waitaha River is 'one of the best examples' of an association of species in the two ecological districts per WDP Policy 4.9D(ii) criteria.

18.3 ***Rarity/Distinctiveness.* Medium significance value rationale overall (High significance value for 'Stable Trib' in Douglas Creek Reach):**

(a) The stable spring fed tributary in the Douglas Creek Reach (the 'Stable Trib' on the true-right of the Waitaha River opposite Douglas Creek) is a freshwater system that is considered to be locally unique within the Waitaha catchment. At a community composition and biodiversity level, the 'Stable Trib' could be regarded as being locally important because the community

[21] Based on the digitised ecological district maps layer the very uppermost extremity of the Waitaha catchment in the vicinity of Ivory Lake sits within the Whitecombe ecological district. For the purposes of this significance values assessment, we have chosen to exclude this district due to the fact that the area is especially small (<1% of the Waitaha catchment area) and may be an artifict of the digitisation of the ecological district boundary line (i.e., Lake Ivory itself is bisected by the boundary line for the district).

composition of indigenous invertebrate and bryophyte communities was distinct from other sites surveyed within the Waitaha River and Wanganui River catchments. Our sampling of the adjacent Wanganui River catchment (also within the Wilberg ecological district) did identify a stable tributary, and we would expect there would be other such habitats within the wider Wilberg ecological district. However, we are unable to confirm the extent of other such low gradient stable spring-tributaries in the Wilberg Ecological District and therefore it cannot be definitively stated if this stable tributary could be regarded as being unique (based on habitat and community composition) at a regional scale.

(b) Kōaro was the only fish species recorded upstream of Morgan Gorge at Kiwi Flat. The kōaro population at Kiwi Flat is in isolation of introduced brown trout, as a result of the Morgan Gorge being a natural fish passage barrier for all fish species bar kōaro. Although trout-free kōaro habitats are not rare in a regional context (e.g., of 88 sites with survey data, kōaro exist in isolation from brown trout in 20 waterways), we nevertheless consider the trout-free kōaro habitat within the Kiwi Flat Reach to be important to the kōaro fishery.

(c) Regarding species rarity on a national level - the stable tributary in the Douglas Creek Reach (the 'Stable Trib' on the true-right of the Waitaha River opposite Douglas Creek) supports lamprey (classified as Threatened – Nationally Vulnerable), and giant kokopu (classified as At Risk – Declining according to the conservation status of Dunn *et al.,* 2018). Other tributaries (including the 'Stable Trib') and the Waitaha mainstem within the Douglas Creek Reach also support three other fish species classified as At Risk – Declining: kōaro, longfin eel, torrentfish (according to the conservation status of Dunn *et al*., 2018). The waterways within the Kiwi Flat Reach also support kōaro. Notwithstanding these records, all four At Risk – Declining species are quite common in other West Coast catchments. Therefore, considering these findings, this criterion is not significant or of high natural value for the Waitaha catchment or for the area of the Scheme. We would make the exception however for the 'Stable Trib' on the true-right of the Waitaha River opposite Douglas Creek, which given the high numbers of lamprey found there (classified as Threatened – Nationally Vulnerable), could be considered to be of significant or of high natural value.

(d) Waterways within the Douglas Creek Reach, Kiwi Flat Reach and Upstream Reach of the Waitaha catchment support four freshwater macroinvertebrate species classified as At Risk – Naturally Uncommon (based on the conservation status of Grainger et al., 2018): one mayfly species (*Deleatidium magnum*), one stonefly species (*Megaleptoperla grandis*), and two caddisfly species (*Costachorema brachypterum* and *Philorheithrus latentis*). Of these only *Costachorema brachypterum* was recorded from a part of the mainstem of the Waitaha River that would be affected by the Scheme (i.e., the Douglas Creek Reach). We consider such findings mean that this criterion is not significant or of high natural value for the Waitaha catchment or the area affected by the Scheme.

(e) Based on a comparison of known distribution records there is a new distribution record for the net-winged midge (Blephariceridae) *Peritheates turrifer*, which has previously thought to be restricted to areas north of Arthur's Pass (Winterbourn et al., 2006). Similarly, an adult male caddisfly *Paroxyethira sarae* was identified from the Kiwi Flat area, while this species has only been previously recorded from the Canterbury and Buller regions. However, as both records are from areas outside of the influence of the Scheme (e.g., Moonbeam Torrent upstream of Kiwi Flat for *Peritheates turrifer* and a tributary waterway in Kiwi Flat for *Paroxyethira sarae*), it does not elicit any significance criteria for the Scheme. Six caddisfly species were found that are not in the New Zealand caddisfly database within a 20 km radius of Kiwi Flat, which could mean that they are new records for the area, but all are already well distributed throughout the South Island. We consider such findings mean that this criterion is not significant or of high natural value for the Waitaha catchment or for the area affected by the Scheme.

18.4 ***Diversity and Pattern.*** **High significance value rationale:**

(a) Waitaha River catchment contains a high diversity of indigenous freshwater ecosystems and habitat types for indigenous freshwater taxa, including the mainstem of the Waitaha River which includes a mix of channel morphologies formed through changes in gradient and valley constriction (confined plane-bed, cascade, torrent, chute and waterfall sections, as well as more open braided river sections), stable tributaries (including low gradient spring/seepage fed systems with riffle/run/pool morphologies, and hill fed systems with step-pool, cascade, and riffle morphologies), and unstable ('other') tributaries with step-pool, cascade, riffle, run and plane bed morphologies.

(b) Waitaha River catchment contains a moderate diversity of indigenous freshwater taxa. Seven fish species were recorded in tributary waterways, and four fish species were recorded in the mainstem. The Waitaha River catchment comprised a diverse assemblage of freshwater insect taxa, although this was driven by a high diversity of macroinvertebrate taxa in the stable tributary sites; diversity in the other tributary and mainstem river was relatively low as a result of the high natural disturbance regime of the glacial mountain- and mountain-fed catchment. There was also a high diversity of freshwater bryophytes (mosses, liverworts, and hornworts) in the stable spring-fed tributary in the Douglas Creek Reach (the 'Stable Trib' on the true-right of the river opposite Douglas Creek).

(c) Waitaha River catchment has a freshwater taxa composition that reflects the physical features of the catchment (e.g., the confined channel of Morgan Gorge, plane-bed/cascade morphology of the upper Waitaha River mainstem) and ecological gradients (e.g., single-thread channel, and braided floodplain channel of Waitaha River mainstem), that are dominated by a high natural disturbance regime.

18.5 ***Ecological Context.*** **High significance value rationale:**

(a) Waitaha River catchment provides an important ecological linkage and network. The Waitaha River flows through V-sided valleys dominated by alpine shrubs and tussocks above the tree line, and mixed hardwood/podocarp forest below the tree line, and over half of its catchment (from Macgregor Creek upstream) is within an area unmodified by land use. Downstream of the Douglas Creek/ Macgregor Creek confluence, the Waitaha River widens to a braided floodplain channel that flows across agricultural land for 17 km before discharging into the Tasman Sea. The upper catchment receives some of the world's highest rainfall, ranging from about 5,500 mm at Kiwi Flat to around 12,000–14,000 m at the divide, with a maximum of 18,442 mm. The large portion of the catchment that is unmodified by land use change, which is all in the upper catchment, means that the Waitaha River mainstem and its tributaries provide important freshwater habitat (including refuges from predation, or key habitat for feeding, breeding, or resting) for indigenous freshwater taxa, both seasonally and permanently.

18.6 ***Intactness.*** **Very High significance value rationale:**

(a) Waitaha River catchment (therefore including the mainstem and its tributaries) from Macgregor Creek/Douglas Creek (Douglas Creek Reach) upstream is unmodified by land use activity. This represents well over half the catchment, and all of it is in the upper catchment. Despite the lack of land use change in much of the catchment, there are nevertheless signs of human activity within these freshwater environs of the otherwise seemingly unmodified part of the catchment. For example, the introduced invasive algae didymo (*Didymosphenia geminate*) has been recorded from tributaries and the mainstem of the river within the Douglas Creek Reach and Kiwi Flat Reach. Given the prevalence of didymo in the West Coast region now, it is likely that this has been spread through the catchment by birds and recreational users.

(b) Waitaha River mainstem and its tributaries comprise a predominately intact indigenous freshwater system. When compared with river water quality data from the whole of New Zealand (the National River Water Quality Network; NRWQN) the water chemistry of the Waitaha catchment most nutrient levels were well below the NRWQN values at the time of the water sampling.

(c) Waitaha River mainstem and its tributaries are not affected in a major degree by weed or pest species. Didymo DNA was detected from four sites including the mainstem in the Douglas Creek reach and tributaries (stable and other) within the Kiwi Flat Reach; however, the DNA signatures at all sites were generally low, indicating that this species is not a dominant feature of the environment. The Waitaha River itself is less likely to be conducive to didymo blooms, given the frequent floods and high suspended sediment loads that would keep biomass to a minimum.

18.7 ***Protected Status.*** **Low significance value rationale:**

(a) There are no wilderness areas, as designated under the *Conservation Act*, in the project area.

(b) The closest wilderness area to the project area is Adams Wilderness Area, which is a gazetted wilderness area south of the project area (Evergreen Mapping NZ, 2024).

18.8 ***Connectivity.*** **High significance value rationale:**

(a) Given the high proportion of the catchment that is unmodified by land use activities, and the fact that such unmodified areas cover the entirety of the upper and mid catchment, the Waitaha River catchment makes a major contribution to the overall value and natural functioning of these areas. The Waitaha catchment is bounded on both sides by other catchments that have similarly large portions of their upper catchment that is unmodified by land use activities, and as such creates a much larger area of connected environments. However, in terms of freshwater ecology, there is unlikely to be much movement of freshwater biota between these adjacent catchments, with most movement of freshwater taxa occurring longitudinally along the river network and less lateral dispersal. The exception to that relates to diadromous freshwater fish species that spend part of their life cycle at sea, and which therefore have much larger connected metapopulations (as our diadromous native fish do not home to their catchment of origin). In that regard, kōaro found in the Waitaha catchment could conceivably connect with and contribute to kōaro populations in nearby catchments through kōaro that have hatched within the Waitaha catchment and washed to sea, then migrating back into freshwater as juveniles in the seasonal whitebait run to other nearby catchments, and vice versa.

18.9 *Threat.* Medium significance value rationale overall (High significance value for 'Stable Trib' in Douglas Creek Reach):

(a) The stable tributary within the Douglas Creek Reach (the 'Stable Trib' on the true-right of the Waitaha River opposite Douglas Creek) supports lamprey which is classified as Threatened –

Nationally Vulnerable (Dunn *et al.,* 2018). On this basis of the large numbers of ammocete lamprey that were found, indicating this is a key spawning habitat for lamprey, we would consider the 'Stable Trib' as being of high value. However, when taken in context of the wider Waitaha catchment area of the Scheme, we feel that the value is of medium significance.

(b) Waterways within the Douglas Creek Reach support four fish species classified as At Risk – Declining: kōaro, longfin eel, torrentfish, and giant kōkopu (Dunn *et al.,* 2018). Waterways within the Kiwi Flat Reach also support kōaro. Notwithstanding these records, all four species are also common in other West Coast catchments. Therefore, considering these findings, this criterion is not significant or of high value for the Waitaha catchment or for the area of the Scheme.

(c) Waterways at Douglas Creek Reach, Kiwi Flat Reach and Upstream Reach support four freshwater invertebrate species classified as At Risk – Naturally Uncommon: one mayfly species (*Deleatidium magnum*), one stonefly species (*Megaleptoperla*), and two caddisfly species (*Costachorema brachypterum* and *Philorheithrus latentis*) (Grainger *et al.,* 2018). We consider such findings mean that this criterion is not sufficient to rate it as a high value for the Waitaha catchment or the area affected by the Scheme.

18.10 ***Migratory Species*. Medium significance value rationale:**

(a) The stable spring-fed tributary in the Douglas Creek Reach (the 'Stable Trib' on the true-right of the Waitaha River opposite Douglas Creek) is considered a 'hotspot' for fish diversity and density within the Waitaha River catchment. It supports seven migratory fish species: kōaro, longfin eel, torrentfish, brown trout, redfin bully, lamprey, and giant kōkopu. In particular, this stable tributary is considered significant lamprey rearing habitat, and potentially provides rearing habitat for brown trout. Although the stable tributary provides significant habitat for migratory species at a local scale (i.e. at the catchment level), other catchments within the region (i.e., at the regional level) also contain these fish species. Therefore, although significant and of high natural value at a local level, it is of lesser significance at a regional level as these migratory species are widespread in other West Coast rivers.

(b) Kiwi Flat Reach supports only one fish species, which is kōaro. This is because Morgan Gorge acts as a natural fish passage barrier to all other fish species (e.g., brown trout), except kōaro. As mentioned above, although trout-free kōaro habitats are not rare on a regional level, we nevertheless consider the trout-free kōaro habitat within the Kiwi Flat Reach to be important to the kōaro fishery.

18.11 ***Viability.* High significance value rationale:**

(a) Kōaro, longfin eel, torrentfish, and giant kōkopu are indigenous fish species that have a conservation status of At Risk – Declining', meaning that populations are declining at the national level. Similarly, lamprey is currently assessed as Threatened – Nationally Vulnerable' (Dunn *et al.,* 2018) which means that it is vulnerable at the national level. Whilst at the national level these species have a conservation status that indicates they are either at risk or threatened, the Waitaha catchment provides them with an environment that would allow them to persist in that area over time. For migratory fish species, there are other environmental factors that may occur outside of the catchment that may affect their ability to persist but that has not been considered here.

18.12 **Table 1** contains the criteria from the four relevant policy documents and a summary of the significance of the freshwater ecology values assessed in accordance with these criteria.

APPENDIX G - POTENTIAL EFFECTS OF THE SCHEME ON FRESHWATER ECOLOGY AND RECOMMENDED MITIGATION

Information regarding the construction programme is provided in the **Project Description** and in the General Arrangement Maps (Revision E and F), which is what this assessment has been based on.

19. CONSTRUCTION EFFECTS

19.1 Sediment release

(a) The **Project Description** specifies the construction area as being 46.4 ha (intake area including weir structure 1.3 ha; Power Station area 1.4 ha; access road and transmission line between Macgregor Creek and the main Waitaha substation 22.1 ha). Within this construction footprint there will be vegetation clearance and thus exposure of soils; with the total area of indigenous vegetation clearance defined in the Project Description as 6.8 ha, with 0.7 ha of this within the riparian zone. As these areas undergo vegetation clearance there is the potential for sediment release to the freshwater receiving environment. Access roads and the location of the power lines on land north of Macgregor Creek will follow existing roads and as such excavation will be limited to the installation of the power poles. There is some risk of sediment release from temporary tracking across Macgregor Creek, the construction of crossings for waterways, temporary soil stockpile areas at the Power Station and Construction Staging Area 1 at Kiwi Flat, and the main disposal soil stockpile areas and gravel screening area located on farmland north of Macgregor Creek; as well as from farmed areas where the spoil will be finally distributed, prior to the establishment of pasture grasses. Without sufficient sediment control measures some of this sediment-laden water could make its way into nearby surface water environments.

(i) **Sediment release directly into mainstem:** the greatest risk for sediment release into the mainstem relates to the construction of the intake infrastructure at Kiwi Flat (the weir, intake structure, and Construction Staging Area 1), the Power Station Site (Power Station and tail race), construction of the tunnel (from the Power Station to the Headworks), forming a temporary access route for machinery around the edge of Macgregor Creek, Waitaha River and Granite Creek (to facilitate the construction of the Granite Creek bridge), and gravel extraction from the Waitaha River. The **Project Description** specifies that sediment from works at the Headworks will be returned to the river due to the topography of the area and flows in the river presumably preventing the ability to hold and treat sediment-laden water. In contrast water from within the access tunnel and Power Station Site will be directed to a temporary sediment pond before being discharged to the river.

(ii) **Sediment release into tributaries:** the greatest risk for sediment release into tributaries relates to the construction of the access road and transmission line through to the Power Station. There are 14 possible waterways within the path of the proposed access road from (and including) Macgregor Creek to the Power Station. Three of these crossings are of tributary waterways large enough to be mapped on cartography maps/visible on aerials and include (in a north-south direction) Macgregor Creek, Granite Creek and Alpha Creek (**Figure 3**), with the latter also involving the construction of some flood training bunds upstream and downstream of the Alpha Creek crossing. There are an additional 11 areas identified as smaller watercourses or areas of ponded water as mapped in the **Vegetation**

Report (**Figure 10**). It is likely that water in these channels soak to ground as no surface water connections were identified in previous surveys along the length of the stable tributary on the true-right of the river opposite Douglas Creek (pers. obs.), but it is possible that some overland flow may occur during larger rain events in wetter years.

(b) Suspended sediment can have a range of effects on aquatic ecosystems including alteration of water chemistry, increasing turbidity, increasing invertebrate drift, and altering community structure. Deposition of sediment can change the nature of the substrate by filling the interstitial spaces between the rocks reducing the complexity of benthic habitat. Sediment deposition can also lead to a reduction in biota (invertebrates and algae) that prefer a clean, stony substrate and an increase in those that are tolerant of, or prefer, finer sediment. Suspended sediment is also a significant limiting factor for the establishment of bryophyte communities, as it can cause substantial abrasion.

(c) Effects of sediment release into the Waitaha mainstem and 'other' tributaries:

(i) The sensitivity of a receiving environment is moderated by the natural sediment regime experienced by that system. The Waitaha River naturally contains high suspended sediment loads, with the estimated average annual load of suspended sediment passing through Morgan Gorge exceeding 3 million tonnes/year sourced from very high, steep, bare headwater slopes formed in fissile schist, which has a texture and durability akin to "Weet-bix" that feed sediment to the stream network by slips, slides, gullies, and debris flows (**Hydrology Report**). Extensive deposits of sediment, in the form of sand/silt banks and delta lobes, are evident throughout the catchment. This means that freshwater biota inhabiting the Waitaha mainstem must be tolerant of flows with high levels of suspended sediment for extended periods throughout the year. Considering the potential for construction-derived sediment runoff is highest during rainfall events, its effects on aquatic biota are likely to be indistinguishable from that of naturally occurring sediment entrained in flood flows.

(ii) The Waitaha River has a high flood frequency, with floods or freshes occurring on average every 8.6 days throughout the year (**Hydrology Report**); therefore, any construction-derived sediment entering the river (which will be more likely liberated during rainfall events) will likely be rapidly dispersed and will not cumulatively increase downstream as the Scheme progresses. Similarly, the Waitaha River has high flows in spring and early summer and is naturally discoloured by snowmelt (**Hydrology Report**). During this period, the effects of construction-derived sediment release from the Scheme works will likely have no more effect than what naturally occurs during a fresh/flood.

(iii) Construction-mediated increased turbidity (as a result of sediment mobilisation) will most likely be most obvious in the Waitaha River mainstem during winter, when snowpack and glacial melt provide a small suspended sediment load and residual turbidity at baseflows. Notwithstanding the comparatively lower winter flow, the relatively large volume of flow within the Waitaha River should provide significant dilution to any mobilised sediment that is liberated to the river as a consequence of the proposed works; thereby, minimising its effect on freshwater biota. It is anticipated that with the use of a temporary sediment pond at the Power Station Site will further reduce sediment release to the river. Combined with good sediment control practices this will help to lessen sediment release to the river, except during periods of rainfall when the mainstem river will be elevated and already sediment-laden.

(iv) The three main tributaries that the access road to the Power Station will cross (Macgregor Creek, Granite Creek and Alpha Creek) are all indicative of high gradient systems with high sediment moving events evident by the large gravel outwash channels (in particular for Macgregor Creek). Whilst only Granite Creek appears to hold flow for most of the year, based on their river channel morphology, all three appear to experience substantial sediment movement during periods of heavy rain. As such it is likely that the amount of sediment that would likely enter these waterways during rain events, following the implementation of good erosion and sediment control measures, would be negligible compared to the amounts that would be moving through these waterways naturally. That said, we would recommend that the construction of the final crossing structure for Macgregor Creek be prioritised to limit the amount of vehicle crossing via the temporary access track across the braid plain.

(d) Effects of sediment release into stable tributaries:

(i) The small 'Stable Trib' located on the true-right of the river opposite Douglas Creek is fed from seepages, and based on the bryophyte community that has colonised small, easily moved substrate, it is clear that it does not often experience elevated flows. It represents a locally unique stream that has high biodiversity values, especially for bryophytes and fish, and could be an important trout rearing and juvenile lamprey habitat (Drinan & McMurtrie, 2014). Any sediment or other contaminants mobilised during vegetation clearance, road construction, or other construction works close to this waterway could have a detrimental effect on this small system, due in large part to its small size (so little dilution factor), high water clarity, low gradient (so little capacity to flush the sediment from the channel), and stable flow regime.

(ii) Whilst the impact of even a small amount of suspended sediment release into the 'Stable Trib' would have a large impact, the potential for suspended sediment or other contaminants to enter this small stream is unlikely, given the access road is currently proposed to be located at least 50m[22] away from the channel (based on the current proposed alignment) and there are no obvious surface water connections to the stream. That said, given that there are a number of ponded water areas or small waterway channels (that appear to soak to ground) along the road alignment proximal to the 'Stable Trib' (**Figure 10**), it will be important to be vigilant about ensuring there is no opportunity for construction-derived suspended sediment to enter these other areas of standing or slow flowing surface water seepages.

[22] This distance was measured off a high resolution aerial photo and will likely have an inaccuracy of several meters. The Project Design specifies that the access road corridor will be located at least 20 m from the 'Stable Trib'.

Figure 10 Areal map showing areas identified as smaller watercourses or areas of ponded water (shown as black circular symbols) as mapped during a ***Vegetation Report*** *walkover of the proposed access route between Macgregor Creek and the proposed Power Station location. Note that there is no access route from the Power Station to the intake (access will be via the tunnel). Source: Westpower.*

19.2 Release of cementitious contaminants

(a) The **Project Description** notes that there will be concrete work (mainly *in situ* pouring of concrete) involved for the construction of the Headworks (intake, weir, sluice channel, kōaro passage structure, etc), and at least some of that work will occur within or immediately proximal to the bed of the Waitaha River. The construction of the Power Station will also involve some concrete work. In addition, shotcreting will be used to seal at least 50% of the tunnel walls, as well as the ground surface of, and the rock face/slope around, the Power Station access portal. There will also be pouring of concrete for the Granite Creek bridge abutment construction, cleaning of concrete tools, machinery, or formwork within the work site areas, and a concrete batching plant will be located in farmland to the north of Macgregor Creek, where concrete will be mixed prior to delivery onsite (transported via helicopter or vehicles). Culverts or fords that are used to cross tributary waterways (i.e., Alpha Creek and Macgregor Creek (the latter via a crossing structure like a Hynds ‘drift deck’ or similar) will be using pre-cast units and so the risk of concrete contamination here is minimal, but there may be some use of cementitious products to seal sections of culvert/ford/crossing structures and/or associated footings.

(b) Concrete or cementitious (mortar, grout, plaster, stucco, cement, slurry) washout wastewater is caustic and considered to be corrosive with a pH over 12. Concrete wash water and uncured cement-related products can harm aquatic life, primarily though causing rapid pH shifts and increasing ammonia levels. Ammonia can block oxygen transfer from the gills to the blood and can cause immediate and long-term damage to gills (Ogbonna & Chinomso, 2010). As ammonia also becomes increasingly toxic as the pH rises above 7.0, the careless use of these products can result in significant fish kill events (McMurtrie, 2014), with a small amount of water contaminated by cementitious material having a disproportionately large effect in small waterways (i.e., where there is less dilution potential).

(c) Having strict measures in place for preventing the release of contaminated water into freshwater environments with be critical, especially near small waterways with low dilution factors. This should include maintaining dry work areas when dealing with wet cement-based products in-channel, or in areas where it is not possible to store and treat site runoff then having some treatment of water prior to discharge will be critical, to ensure the pH of any discharged water is at a level suitable for the receiving environment. According to McMurtrie & Suren (2014) the pH of the Waitaha River and tributaries downstream of Morgan Gorge is between pH 7.1-7.8, meaning that a treated discharge limit of pH 6.7-8.2 would be appropriate. Similarly, washing of concreting tools, machinery or formwork should be done well away from any waterways and in a contained area. Indeed, it may be most practicable to undertake such cleaning at the concrete batching plant located in farmland north of Macgregor Creek.

19.3 Release of other construction-derived contaminants

(a) The use of machinery during the construction phase brings with it the risk of spills and leaks from fuel and lubricants where machinery is working within or close to waterways. This can be easily avoided through good machinery maintenance and implementing storage of machinery/fuels/chemicals and refuelling well away from waterways. Spill kits should also remain on site at all times and staff should be trained in its use. Such measures have already been included in the **Project Description**.

19.4 Spread of freshwater pest species (didymo)

(a) Didymo has been recorded within the catchment as well as in nearby catchments. With its presence within the catchment, wildlife and recreational users will likely already be facilitating the movement of didymo around the catchment. The Waitaha River and many of its unstable tributaries are not regarded as being particularly suitable for didymo growth due to the frequent floods and the high year-round sediment load (C. Kilroy, NIWA, pers. comm). The more stable tributary waterways, such as the 'Stable Trib' located on the true-right of the river opposite Douglas Creek, could be more susceptible to didymo infestation as they are less flood prone and less turbid. However, all construction works are located well away from this waterway.

(b) Sensible check-clean-dry protocols for the limiting the spread of didymo are well documented, and these measures have already been included in the **Project Description**. Whilst the project has no control of the behaviour of other users in the catchment, implementation of such protocols is standard operational procedure for site works and should limit the spread as a result of the construction phase.

19.5 Fish passage during in-channel works

(a) Construction of the weir intake structure could potentially impact on fish passage, as the intent is to divert the river flow during construction to allow for a dewatered construction area. Similarly, construction of waterway crossings for tributary waterways could affect fish passage if waterways are flowing and there is a diversion or constriction of flow.

(b) Fish passage in Waitaha River at the site of the weir: The only fish found upstream of Morgan Gorge is kōaro. Thus, instead of maintaining fish passage, it will instead be critical to ensure that at all stages of the project the current fish passage conditions that mean only kōaro are able to penetrate to Kiwi Flat is maintained. In that regard, a diversion of river flow at the site of the weir installation (including the concentration of the river flow through a smaller portion of the channel) will further diminish the already unlikely chance of any other fish from moving upstream into Kiwi Flat at that time. Conversely, such a diversion would be unlikely to materially impact on the upstream movement of kōaro, which are physiologically and behaviourally adapted to negotiate barriers that are insurmountable to other species (McDowall, 2003).

(c) Fish passage during construction of tributary waterway crossings

(i) For waterways such as Macgregor Creek and Alpha Creek, which are only intermittently flowing/have subsurface flow at this point, maintaining fish passage during construction of the access road crossings is not necessarily required, given that year-round fish passage access is not available under natural conditions and the system upstream of the crossing would be unlikely to support permanent fish populations.

(ii) Granite Creek appears to support perennial flow, and as such fish passage during construction would be required. However, as a bridge is proposed for this site, construction works are unlikely to result in any impacts to fish passage during that time. The **Project Description** indicates that this will be a single span bridge (i.e., no bridge pier in the middle of the channel) but if additional bridge piers were required it should be possible to divert water flow around any pier construction area to still maintain fish passage. Any localised increases in water velocity should not have any lasting impact on fish passage given the steep gradient and boulder-strewn nature of the channel this tributary would already be limiting fish access to those species that are agile climbers (i.e., kōaro).

(iii) There are a number of ponded water areas or small waterway channels that appear to soak to ground along the road alignment proximal to the ‘Stable Trib’ (**Figure 10**). No surface water connection between these areas of surface water and the ‘Stable Trib’ or the mainstem river were able to be found. As such it is unlikely that these areas support migratory fish species. The **Project Description** indicates an intent to maintain the existing hydrology of such areas, which would presumably involve the use of culverts. However, given the isolation of these smaller areas from the river, it will not be necessary to ensure fish passage during the construction phase, given the time will be relatively short for each water body.

19.6 Mortality of biota at the site of in-channel works

(a) Construction of the weir intake structure, the end of the Power Station tail race, fords, culverts, or bridges constructed in the bed of tributary waterways, and the temporary access route for machinery across Macgregor Creek (ahead of the crossing structure (i.e., Hynds ‘drift deck’ or similar) construction) as well as around the edge of Macgregor Creek, the Waitaha River and Granite Creek to install a temporary bridge across Granite Creek (**Figure 6**), could potentially result in mortality of freshwater biota at the site of the works (where there is perennial flow). This relates to either crushing of biota with machinery in the wetted channel, or to any area of construction that would need to be dewatered within flowing systems. The **Project Description** does specify that works in the river will be timed to take advantage of low river flows, which will also help to reduce the area of wetted channel that is dewatered.

(b) The impact of such mortality for the in-channel works in the mainstem river at the intake and tail race are unlikely to have an impact on the ecology of the river given the small size of the works in comparison to the size of the river, and due to the very low density and diversity of invertebrates and fish inhabiting the mainstem river. The invertebrate community of the mainstem river is already dictated by a high disturbance regime and dominated by taxa that are able to recolonise following a disturbance. As such the dewatered areas within the mainstem river will be readily recolonised by the river invertebrate community. Given the very high velocities and large proportion of bedrock as the site of the weir and intake structure, the chance of trapping fish within the dewatered construction area is limited given the inhospitable environment. There is a greater potential for fish to be present in the wetted margin of the river where the tail race will be constructed, and as such it would be worthwhile implementing a fish relocation of the work site prior to its dewatering.

(c) As Macgregor Creek and Alpha Creek have intermittent flow at the site of the proposed road crossings, then these systems already undergo seasonal mortality of taxa through channel drying. If these areas are dry at the time of the temporary vehicle crossing and in-channel works then there will be no loss of freshwater taxa. If these waterways are flowing at the time of construction of permanent structures then dewatering of the work site will be required. Like the mainstem river, the freshwater inhabitants of these waterways are dominated by a high disturbance regime and have life histories that will allow them to readily recolonise the area following completion of the works via the larger metapopulation. The construction of the Macgregor Creek crossing structure (i.e., Hynds 'drift deck' or similar) should be prioritised to limit the amount of vehicle crossing via the temporary access track across the braid plain. In relation the installation of power poles for the transmission line that will be located along the access road alignment, the **Project Description** specifies that there will be no power poles within the bed of the creek.

(d) To allow for a more efficient construction programme (i.e., with multiple construction teams working at different locations within the area) and to keep vehicles out Granite Creek, a temporary bridge will be installed at Granite Creek ahead of the construction of the permanent bridge. This will require temporary access route for machinery around the edge of Macgregor Creek, Waitaha River and Granite Creek. Based on the current alignment (**Figure 6**), the proposed track should remain well out of the wetted channel of the Waitaha River and Granite Creek, and is already within a high disturbance area of these systems, and as such it is not considered to have an impact on them. However, just upstream of the confluence of Macgregor Creek and the Waitaha River the track appears to cut across the lower reaches of an unnamed tributary. Whilst not surveyed, the aerial imagery implies that this tributary could be similar to the smaller seepage-fed waterways found along the raised land around the Power Station. These smaller more stable habitats would be more sensitive to habitat damage and as such the tracking of machinery or forming an access track across its confluence could have some impact to the ecology of the waterway. It is advised that the track be moved out into the bed of the wider Waitaha River braid plain to avoid the tributary waterway confluence point altogether.

(e) For the Granite Creek bridge (both permanent and temporary), the only works that may possibly come into contact with the riverbed will be during the construction of the bridge abutments, and if there is the need for a pier to be located within the channel span of the bridge crossing. Such works would result in limited in-channel works, and like the other steep gradient tributaries in this area, it will have freshwater communities that are dictated by the high disturbance regime, and will be able to readily recolonise the area following completion of the works from the wider metapopulation. However, if a pier is required in the channel, then if possible, it would be preferrable to locate it outside of the portion of channel that is flowing at the time of construction – although it is recognised that this may not be possible from a bridge design standard.

(f) There are a number of ponded water areas or small waterway channels that appear to soak to ground along the road alignment proximal to the 'Stable Trib' (**Figure 10**), and the **Project Description** indicates an intent to install culverts at these locations. Given the unknown nature of these areas it would be worthwhile to either sample these for non-migratory fish before construction starts, or implement a fish rescue at the time of each culvert installation.

19.7 Gravel extraction from the Waitaha River

(a) The **Project Description** specifies that gravel will be sourced from the Waitaha River for the construction of the access road, from the general vicinity of the small hill on the true-right of the river just south of Allen Creek. The proposed extraction will be up to 23,000 m^3 material, which will be removed via sculping (where surficial materials are removed without intercepting the water table), and with works staying out of the active wetted channel.

(b) The **Sediment Report** notes that given the nature of the Waitaha River, the impact of the gravel extraction on the local channel morphology and gravel transport will be '**minor**', with further downstream effects considered to be '**less than minor**'. Rule 29 (b-j) of the West Coast Regional Land and Water Plan (RLWP) provides conditions around which gravel extraction can be undertaken, including setback distances, and these should be followed.

(c) Thus provided that gravel extraction and machinery stays out of the active wetted channels, the water table is not intercepted, sediment release is controlled, and the other measures in Rule 29 (b-j)of the RLWP are followed, there should not be any interaction with, or impact on, the aquatic ecology of the river.

(d) As noted in the **Sediment Report**, given the natural migration of the river braids and bars, it is not practicable to strictly define the area of channel where gravel extraction can be undertaken ahead of the extraction works commencing, as the river braids may have moved in the intervening time. Thus in order to ensure that the gravel extraction can meet the requirements set out in (c) above, it will be necessary to provide for flexibility in the exact location of the extraction.

(e) The **Terrestrial Fauna Report** considers any effects on riverine birds that may utilise the dry riverbed areas, and so is not considered here.

20. OPERATIONAL EFFECTS

20.1 Residual flow

(a) The Scheme will divert up to 23 cumecs of water through the Scheme while maintaining a proposed residual flow of 3.5 cumecs within the Waitaha River mainstem channel, running from the weir structure at the top of Morgan Gorge to the downstream end of the tail race that redirects the flow back into the river, just upstream of Alpha Creek (**Figure 1**). The residual flow/abstraction reach is approximately 2.5 km, which represents roughly 6% of the Waitaha mainstem length between the coast and Ivory Lake. The setting of the residual flow of 3.5 cumecs was informed by an assessment of effects to freshwater ecology and the results of the IFIM modelling (see **the IFIM Report** by Allen & Hay, 2013), which is discussed further in **Appendix B** (Section 88). A detailed description of the hydrology is provided in Doyle (2013) and in **the Hydrology Report**. We note that the **Hydrology Report** advises against reassessing past flow-related studies, such as the **IFIM Report**, on the basis of the updated hydrological information contained within the **Hydrology Report,** as the underlying flow statistics are considered virtually unchanged. In summary:

(i) The Scheme will change low to median flow statistics through the abstraction reach, reducing the median flow from 19.7 (or 19.9 based on the extended flow modelling by the **Hydrology Report** cumecs to that of the residual flow — 3.5 cumecs – at the intake .

(ii) Anson Stream (that joins the Waitaha River within Morgan Gorge) and Glamour Glen (that joins the Waitaha immediately downstream of Morgan Gorge) will supplement the residual flow of 3.5 cumecs. These two streams will boost the residual flow below the Scheme intake considerably after rain, and for 50% of the time they will add at least 0.7 cumecs. Therefore, the residual flow downstream of Glamour Glen will be at least 4.2 cumecs for 50% of the time.

(iii) Residual flow at the intake will occur for 57% of the time for a take of 19 cumecs, 62% of the time for a take of 21 cumecs, and 66% of the time at take of 23 cumecs. However, the days of residual flow will not occur as consecutive days but as small intervals of time before the occurrence of a fresh or flood; these occurring every 8.6 days on average.

(iv) Residual flow at the intake will only persist for several days before being disturbed by a fresh or flood. On average, there will be approximately 14 occurrences a year when the residual flow state lasts one day, approximately four occurrences a year when the residual flow state lasts three days, and about one occurrence a year when the residual flow state lasts 10 days (Figure 11).

(v) The assessment of the residual flow duration is a conservative one, as it is likely that the length of time the river is in residual flow will be less than that calculated and summarised in Section 20.1(a)(iii) and Section (20.1(a)(iv), due to the operational station shut down that will occur when the river flow is at low levels.

(vi) The frequency of floods exceeding the FRE_3 value at the bottom of Kiwi Flat will remain all but unchanged at a take of 23 cumecs (**Table 5**). Therefore, the Scheme will have little effect on the frequency of even smaller floods through the abstraction reach.

(vii) The **Project Description** specifies the length of mainstem channel that will experience residual flow will be approximately 2.5 km, running from the weir structure at the top of Morgan Gorge to the downstream end of the Power Station tail race that redirects the flow back into the river, just upstream of Alpha Creek. This represents roughly 6% of the Waitaha mainstem between the coast and Ivory Lake.

*Table 6 Frequency of floods exceeding the FRE_3 value (three times the median flow) for natural flow (at the bottom of Kiwi Flat) versus a 23 cumecs take on an annual basis. Taken from the **Hydrology Report**.*

Flow Scenario	Frequency of floods exceeding the FRE_3 value
	From the Hydrology Report Doyle (2025)
Natural flow at intake	26.2
Take of 23 cumecs	23.6

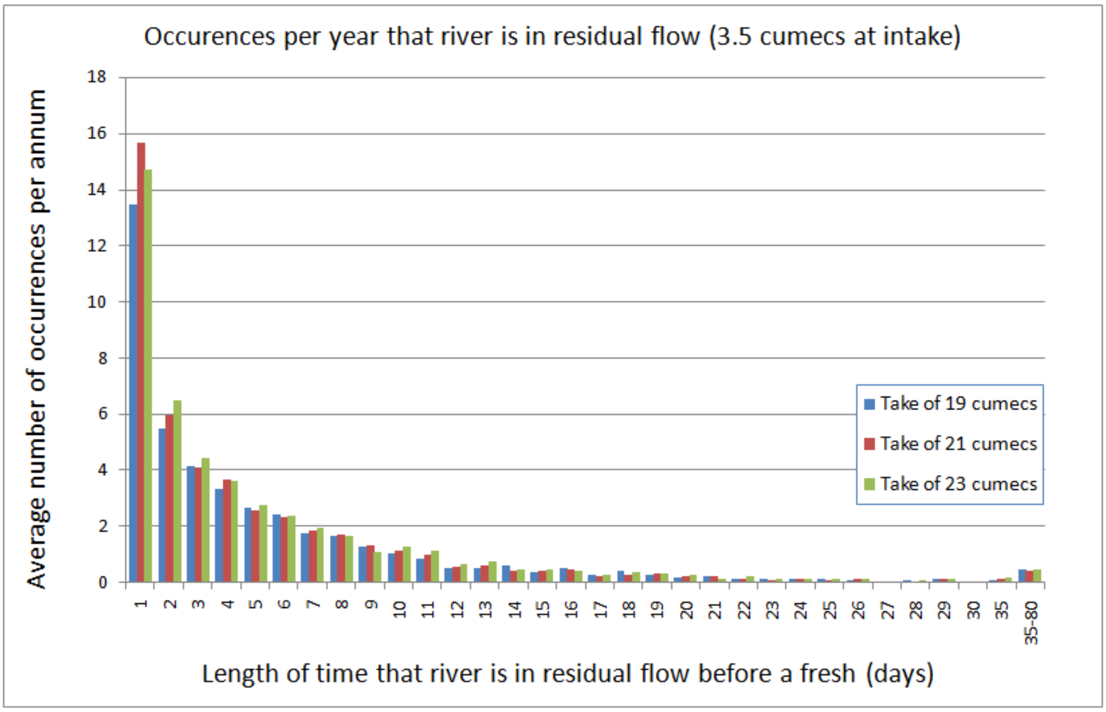

*Figure 11 Histogram from the **Hydrology Report** (Doyle, 2025) showing frequency of 3.5 cumec residual flow periods before a fresh occurs. This does not take into account any shut down of the station when the river is at a low flow (but at flows greater than the residual 3.5 cumecs) that could occur for operational reasons.*

(b) Potential effect of the residual flow on periphyton:

(i) The **IFIM report** predicts a dramatic reduction in suitable retention of diatom habitat and a dramatic increase in filamentous algae (**Table 6**). However, the IFIM predictions are based on habitat changes in terms of water velocity and depth, and thus do not take into account other factors critical to algae growth, such as the nutrient status of the river, antecedent flow conditions, and regularity of fresh events (e.g., short term flow fluctuations). This is a known limitation of IFIM modelling and there is recognition that additional ecological interpretation of the findings is required (Milhous, 1999; Hudson *et al*., 2003).

(ii) The periphyton community of the Waitaha is currently limited by the low nutrients, high glacial flour content, and high disturbance regime of the system. While the IFIM modelling predicts as much as a 127-174% increase in suitable habitat for filamentous algae (short filamentous and long filamentous, respectively at a 3 cumec residual flow, **Table 7**), there was no filamentous alga identified from sites within the abstraction reach (Appendix IV in McMurtrie & Suren, 2014). Studies in New Zealand (Biggs & Close, 1989; Claussen & Biggs, 1997) have shown that it is the magnitude of the flow change (from the flow conditions that the periphyton have been acclimated to) that is critical to controlling periphyton growth, with a minimum change in flow of three times the preceding stable flow being needed to remove significant amounts of filamentous algal biomass. As the size and regularity of fresh events will not change under the Scheme, with fresh events greater than 30 cumecs occurring, on average, every 8.6 days, it is conceivable that there will be little capacity for filamentous algae to become established should the Scheme go ahead. As the sediment dynamics of the river will remain largely unchanged (**Sediment Report**), the physical abrasion by sediment movement, purported to be more important than the effect of velocity alone (Jowett & Biggs, 1997; Biggs *et al.,* 1999), will also continue to aid in preventing excessive algal/plant growth. Experiments regarding periphyton recovery following repeated flood events has also shown that recovery of periphyton after each successive flood is progressively slower (Robinson *et al*., 2004) – given the regularity of flood events in the Waitaha River this would further reduce the ability for filamentous algae to become established. The only time that filamentous algae could become established to any visible extent would be during a particularly prolonged period between fresh events that also coincide with a time when the river was clear of glacial flour. However, the **IFIM Report** notes that given the low nutrient status of the Waitaha that it could take longer than six weeks of residual flow conditions for periphyton to accrue to nuisance levels; a period of time that is unlikely to occur consecutively in a year for this flood-prone system. Thus, when the low nutrient conditions, sediment dynamics, and disturbance flood regime of the system is taken into account it is unlikely that there will be any appreciable increase in filamentous algae growth under the Scheme.

(iii) It is not clear in the **IFIM Report** as to why the IFIM model predicted such a dramatic decrease (28-40% retention under a 3 and 4 cumec residual flow, respectively (**Table 6**)) in diatom habitat quality under residual flow conditions, but based on the Habitat Suitability Criteria (**HSC**) used for diatoms (Appendix 1 in the **IFIM Report**) it would appear to be primarily based on a narrow velocity preference given to diatoms. As the HSC curves used for periphyton were based on generalised models and not those specific to the Waitaha there could be a level of uncertainty in the model. It is also possible that the IFIM model takes into account the relationship between filamentous and diatom algal growth e.g., the theory that as filamentous algal growth increases diatom biomass decreases through competition. However, as we have already noted, the predicted dramatic increase in filamentous algae should not occur in the mainstem, and as such there will not be an interspecific competition causing reduced diatom biomass. The density of periphyton (as measured by chl *a*, dry weight and ash free dry weight (**AFDW**)) was particularly low (below the national mean) for the Waitaha River mainstem, and based on the identification of periphyton taxa was made up entirely of diatom and cyanobacteria communities. Under the operation of the Scheme it is more likely that the flow regime would continue to be more suitable to diatom growth due to the continued limitation of filamentous algal growth caused by the river's disturbance regime. Observations in the main tributaries of the Waitaha River such as Douglas Creek, Ceasar Creek, and Whirling Water – that have smaller discharges (the largest of the three is Whirling Water with a median flow of 2.4 cumecs; M. Doyle, pers. comm.) but are relatively unstable systems (e.g., experience large flood events with some regularity) – had a greater periphyton biomass that consisted of similar diatom species and cyanobacteria to the mainstem (an average of 30.7 mg/m^2 in Whirling Water compared to 5.5 mg/m^2 in the mainstem). It therefore seems unlikely that diatom habitat suitability would reduce to the 28 or 40% habitat retention predicted by the IFIM modelling under a residual flow of 3 and 4 cumecs (respectively).

(iv) While not present in the sampling sites, some small areas of bryophytes (mosses: *Grimmia apocarpa* and *Tridontium tasmanicum*) were observed growing on a few large boulders lining the edge of the river. As aquatic bryophytes are intolerant of desiccation, they will not tolerate being exposed in residual flow conditions. This loss is not something that can be avoided under the Scheme, although we note that the total coverage of aquatic bryophytes on large boulders lining the river was particularly low – reflecting the high sediment loads these rivers carry during floods, and the subsequent high abrasion that these plants are faced with, despite the presence of large stable bedrock substrate in these rivers which would otherwise be good habitats for these plants. It is possible that over time they may colonise larger more stable boulders within the wetted residual flow area, although we note again that the overarching natural high disturbance regime of this river is not conducive to bryophyte growth.

(v) The **IFIM Report** suggests that any reduction in periphyton and invertebrate habitat may be greater than modelled due to the loss of the more stable lateral habitat at the edges (due to the fact that the river morphology will continue to be defined by the flood flows). They estimate that under a residual flow of 3 and 4 cumecs that the wetted width retained for periphyton will be 85% and 92% respectively, and for invertebrates will be 66% and 71% respectively. Based on observations in the field, the lateral habitat of the mainstem that would be lost through the abstraction reach (below Morgan Gorge at least) due to residual flow is, in general, similar to that present in the central portion of the mainstem, with mid-channel habitat structure and complexity comparable to that present at the river's edge (**Figure 13**). It is therefore likely that a comparable amount of refugia (in the form of larger stable substrates) will be present in the abstraction reach during residual flow as there is during the existing flow.

(vi) Thus on balance, given (i) the comparatively short distance of the abstraction reach (totalling approximately 2.5 km or roughly 6% of the Waitaha mainstem between the coast and headwaters at Ivory Lake), (ii) the low nutrient status of the river that would limit growth, (iii) the existing low periphyton biomass and low diversity and density within the abstraction reach, (iv) all species within the abstraction reach also being found throughout the rest of the Waitaha mainstem and tributaries unaffected by the Scheme, and (v) the overarching dominance of the disturbance regime and sediment dynamics on the periphyton community remaining unchanged, the overall impact of the residual flow on the periphyton community of the Waitaha River is likely to be low (or **'minor'**). There is a possibility of some algal blooms if the river stays at residual flow for prolonged periods of time, although given the low nutrient status of the river this could take more than six weeks of residual flow, which is unlikely to occur in reality.

*Table 7 Results of the IFIM modelling, showing the percentage habitat retained under residual flow scenarios of 3, 4 and 5 cumecs, taken from the **IFIM Report** (Allen & Hay, 2013) for different types of periphyton and freshwater macroinvertebrates. The invertebrate types that have had specific Habitat Suitability Criteria (HSC) developed based on invertebrate samples collected by McMurtrie & Suren (2014) in the Waitaha mainstem are in bold. The proposed residual flow of 3.5 cumecs at the intake structure falls between the modelled 3 and 4 cumec residual flow. Tributary inputs within Morgan Gorge will increase the residual flow below Morgan Gorge to at least 4.2 cumecs for 50% of the time the river is in residual flow.*

Group	Type	Residual Flow (cumecs)		
		5	4	3
Periphyton (algae)	Periphyton-diatoms	62	40	28
	Periphyton-long filamentous algae	113	118	127
	Periphyton-short filamentous algae	136	155	174
Freshwater macroinvertebrates	**All Invertebrates - Waitaha**	103	102	98
	Food producing - USA	91	80	69
	***Deleatidium* -Waitaha**	92	90	88
	Deleatidium (Jowett et al. 1991)	120	119	116
	Deleatidium - Waitaki	64	55	43
	Orthocladiinae- Waitaha	110	116	121
	Orthocladiinae - Waitaki	82	75	67
	***Stictocladius* - Waitaha**	127	130	133
	***Neocurupira* - Waitaha**	56	49	42

KEY (as per Allen & Hay, 2013)

Habitat loss	90-100% (no change)	80-90%	70-80%	60-70%	50-60%	<50%
Habitat gain	100-110% (no change)	110-120%	120-130%	130-140%	>140%	

(c) Potential effect of the residual flow on macroinvertebrates:

(i) The **IFIM Report** predicts both increases and decreases in habitat for key invertebrate species. Suitable habitat for all invertebrates from the Waitaha ("All Invertebrates – Waitaha") is predicted to marginally increase or remain similar to the current conditions (**Table 6**). The mayfly *Deleatidium*, which is the numerically dominant species in the abstraction reach, is predicted to marginally increase under the generic *Deleatidium* HSC (Jowett *et al.* 1991), only marginally decrease under the *Deleatidium*-Waitaha HSC, but decrease to around 50% under the *Deleatidium*-Waitaki HSC. A similar pattern occurs for Orthocladiinae where the Waitaha-specific HSC indicates an increase in habitat retention versus a decrease under the Waitaki-derived HSC curve. This is not surprising given the much greater water depth that the Waitaki samples were collected at (via the use of Scuba divers) compared to the sampling in the Waitaha. The wide range of optimal habitat in the different HSC graphs derived for the same species but from different systems indicates the plastic nature of many of our aquatic invertebrate fauna in relation to depth-velocity preferences. *Deleatidium* and Orthoclads are widely spread throughout New Zealand and found in small streams through to large rivers, with their depth-velocity preferences ranging depending on the size of the system they are found in. This is best illustrated from the sampling for this project by McMurtrie & Suren (2014), where *Deleatidium* dominated samples in the deep, fast water of the Waitaha mainstem (46% abundance overall), as well as in the shallower and slower flowing waters of the 'other' tributary waterways where their abundance was even greater (69% overall).

(ii) The **IFIM Report** suggests that the modelled reduction in invertebrate habitat may be greater than modelled due to the loss of the more stable lateral habitat at the edges (due to the fact that the river morphology will continue to be defined by the flood flows). They estimate that under a residual flow of 3 and 4 cumecs that the wetted width retained for invertebrates will be 66% and 71% respectively. Based on observations in the field, the lateral habitat of the mainstem that would be lost through the abstraction reach (below Morgan Gorge at least) due to residual flow is, in general, similar to that present in the central portion of the mainstem, with mid-channel habitat structure and complexity comparable to that present at the river's edge (**Figure 13**). It is therefore likely that a comparable amount of refugia (in the form of larger stable substrates) will be present in the abstraction reach during residual flow as there is during the existing flow.

(iii) The IFIM modelling predicts the most significant impact of the residual flow for the net-wing midge *Neocurupira*. This small midge is morphologically adapted to inhabit fast-flowing habitat with small suctorial discs that allow it to attach to a surface in high flows. *Neocurupira* were more abundant in the mainstem of the Waitaha (3.7% overall) than in the tributary waterways (stable tributaries: 0%, other tributaries: 1.3%) (McMurtrie & Suren, 2014). They were found in fast flowing water in the Waitaha mainstem, and were most abundant in the Douglas Creek reach and Upstream Reach, where they represented 6% of total abundance. It is probable that they will find suitable microhabitats within the channel under residual flow, although there would conceivably be an overall reduction in suitable habitat within the residual flow reach for this specialist species. They will of course remain in other parts of the river mainstem, as well as tributary waterways where there is suitable high velocity habitat.

(iv) As previously stated, the limitations of IFIM modelling is well known and there is recognition that additional ecological interpretation of the findings is required (Milhous, 1999; Hudson *et al*., 2003). Given the wide range in the magnitude and rate of change of flow conditions in the Waitaha River under the existing flow regime (**Figure 12**), it is likely that other factors such as habitat disturbance and food availability already limit aquatic invertebrate communities in the mainstem, independent of physical habitat availability. As previously stated, the invertebrate community of the Waitaha mainstem is depauperate compared to adjacent stable tributary waterways, and dominated by two taxa (*Deleatidium* and Orthocladiinae) that are best able to persist in highly disturbed systems. The abundance of EPT taxa is significantly lower in the mainstem in the Douglas Creek Reach (e.g., the abstraction reach) and algal biomass is below the national average. It is likely that the disturbance regime will continue to limit the invertebrate fauna of the Waitaha mainstem even under the Scheme, with the effects of the residual flow '**minor**' in comparison to these overarching factors.

(v) Thus on balance, given (i) the comparatively short distance of the abstraction reach (totalling approximately 2.5 km or roughly 6% of the Waitaha mainstem between the coast and Ivory Lake), (ii) the low periphyton biomass and low diversity and density of aquatic invertebrates within the abstraction reach, (iii) the presence of all species throughout the rest of the Waitaha mainstem and in tributaries unaffected by the Scheme, and (iv) the overarching dominance of the disturbance regime and sediment dynamics on the benthic fauna remaining unchanged, the overall impact of residual flow on the macroinvertebrate community of the Waitaha River is likely to be **low** (or '**minor**'/'**less than minor**').

Figure 12 Comparison of the Waitaha River (in the Douglas Creek Reach) at different flows (discharge values given are for the top of Kiwi Flat). All photographs provided by Martin Doyle.

Waitaha River upstream of 'Rhys Creek', looking upstream in June 2013.

Waitaha River just upstream of the Alpha Creek confluence, in June 2013. Large boulders mid-channel are visible through the water.

Figure 13 *The Waitaha River within the abstraction reach has large-sized substrate across the full width of the channel. This implies that at residual flow there will still be large stable boulders to provide habitat and refuge for aquatic biota.*

(d) Potential effect of the residual flow on fish:

(i) The **IFIM report** states that habitat availability for adult brown trout is predicted to be reduced and habitat for the native fish known to occur in the abstraction reach (kōaro and torrentfish), will generally increase (93–104% habitat retention for the 3 and 4 cumec residual flows, respectively), apart from longfin eel, which is predicted to decrease slightly (**Table 7** as well as Appendix 6 and 7 of the **IFIM Report** for further breakdown for dry-typical- and wet-year monthly flows). The **IFIM Report** suggests that any reduction in fish habitat may be greater than modelled due to the loss of the more stable lateral habitat at the edges (due to the fact that the river morphology will continue to be defined by the flood flows). However, in the case of the abstraction reach in the Waitaha River, the lateral habitat of the mainstem being lost (below Morgan Gorge at least) due to residual flow is, in general, very similar to that present in the central portion of the mainstem, i.e. mid-channel habitat structure and complexity is comparable to that present at the river's edge (**Figure 12, Figure 13**). It is therefore likely that a comparable amount of refugia (in the form of larger stable substrates) will be present in the abstraction reach during residual flow.

(ii) The predicted reduction in adult brown trout habitat within the abstraction reach is likely due to the reduced flow as this species is recognised as being relatively flow demanding, whilst most native fish species are not (Hay, 2010). Also, Hayes & Jowett (1994) found that optimal adult brown trout feeding habitat was usually in water deeper than 0.5 m; the overall area of habitat up to (and over) this depth is likely to be reduced through the abstraction reach.

(iii) Despite this potential reduction of habitat, other factors, such as flow regime, food availability, and spawning success likely already limit brown trout populations in the mainstem, independent of physical habitat availability. The recording of low trout numbers in the mainstem throughout the abstraction reach – a total of 16 brown trout recorded from seven mainstem sites – is likely a function of the oligotrophic nature of the Waitaha River yielding limited basal prey resources, coupled with its flood-prone nature providing little suitable spawning, nursery or adult habitat. Therefore, overall, a reduction in potential brown trout habitat in this section is likely to have only '**minor**' effects on an already sub-optimal salmonid habitat. Also, far greater numbers of brown trout were recorded from the 'Stable Trib' and Douglas Creek, both of which will largely be unaffected by the Scheme.

(iv) IFIM modelling does not assess any potential changes in invertebrate drift dynamics that may be associated with the residual flow, but such effects could have an impact on fish species that feed on drifting invertebrates, such as trout. The change in flow, including the rate and magnitude of change can influence invertebrate drift patterns. For example, Irvine & Henriques (1984) found that while flows changing on consecutive days failed to produce any measurable effect on benthic invertebrates in the regulated Hawea River, it did result in increased numbers of drifting larvae (chironomids, caddisflies, and oligochaetes) compared to days when flow was stable. However, they found no difference in the drift density under different flow increases, indicating that rapid rates of change of flow may not necessarily cause more benthic invertebrates to enter the drift than slow rates of change. The effect that regulated flow change can have on invertebrate drift dynamics is dependent on the type of scheme and on the existing conditions of the system. In this case, the Waitaha River is already a flood-prone system where flow can increase very quickly under natural conditions (i.e., a 24-cumec increase in flow has been recorded over a 15-minute period (Martin Doyle, unpublished data)), and where invertebrate and fish diversity and density is particularly low within the residual reach section; whilst the Scheme, as a run-of-river design, will not significantly alter flood events or the existing high disturbance regime of this system.

(v) Despite the predictions in the IFIM modelling for a reduction in longfin eel habitat, at least for the abstraction reach below Morgan Gorge, this must be taken in context of the current longfin populations within the Waitaha mainstem. Only two longfin eels were recorded from the nine fished sites within the abstraction reach of the Douglas Creek Reach – one from the mainstem and one from a small tributary. Although the section through Morgan Gorge itself was not able to be surveyed (it was physically not possible to sample in this section due to the highly turbulent and fast flowing water and considerable safety concerns), photographic evidence suggests that this section of river would be largely unsuitable for longfin eel and brown trout habitation due to its extremely turbulent nature (**Figure 14**); however torrentfish could conceivably inhabit the gorge up to the first passage barrier. A further 39 longfin individuals were caught in the Douglas Creek and 'Stable Trib' that are located downstream of the abstraction reach. The water temperature of the mainstem is below 11ºC for most of the year, and is below 9ºC for extended periods; *Anguilla* growth is known to cease below this latter value (Graynoth & Taylor, 2000). Coupled with the very low density of macroinvertebrates in the mainstem (McMurtrie & Suren, 2014), and the high disturbance regime of the river, the Waitaha within the residual flow reach in its current state is largely unsuitable for longfin eels. Thus, the predicted marginal reduction in habitat for longfin eels based on the IFIM modelling, coupled with the fact that the mainstem within the abstraction reach is currently sub-optimal for longfin eels, means the effect of the minimum residual flow on longfin eels would be '**less than minor**'.

(vi) The predicted increase in kōaro habitat is primarily related to the habitat preferences of kōaro defined in the habitat use curves (being optimal at approximately 0.1–0.3 m depth and 0.8–1.4 m/s velocity (based off Jowett & Richardson, 2008), which based on the IFIM modelling would become more prevalent in the abstraction reach. Kōaro are also known to live in lakes where water velocities are even lower. McDowall (2000) acknowledges that kōaro generally prefer small to moderate-sized streams, and this is also evident in the Waitaha catchment where kōaro densities were significantly greater in small tributaries than in the larger mainstem. According to the **IFIM Report,** during typical months, habitat gains occur at greater frequencies throughout the year, while habitat gains are predicted for mid-winter (July and August) during wet months (**IFIM Report**). Despite the IFIM model predicting a considerable increase in kōaro habitat, it is more likely that kōaro densities will remain similar to current levels due to little change in (i) the disturbance regime of the river or (ii) to the already low food resources.

Table 8 *Results of the IFIM modelling, showing the percentage habitat retained under residual flow scenarios of 3, 4 and 5 cumecs, taken from the* ***IFIM Report*** *(Allen & Hay, 2013) for fish. The proposed residual flow of 3.5 cumecs at the intake structure falls between the modelled 3 and 4 cumec residual flow. Tributary inputs within Morgan Gorge will increase the residual flow below Morgan Gorge to at least 4.2 cumecs for 50% of the time the river is in residual flow. Only those fish species that were recorded from the mainstem of the residual reach, from within tributaries in the residual reach, or from any waterways upstream of the residual reach, are shown. A greater array of modelled fish are provided in the* ***IFIM Report****, along with a further breakdown of predictions for dry- and wet-year monthly flows.*

Group	**Type**	**Residual Flow (cumecs)**		
		5	**4**	**3**
Fish	Brown trout adult (Hayes & Jowett 1994)	91	83	70
	Brown trout adult (Bovee 1995) no substrate	84	73	59
	Brown trout juvenile (Bovee 1995) no substrate	102	101	96
	Brown trout 15-25 cm (Raleigh et al 1986)	98	95	91
	Kōaro	97	93	104
	Longfin eel >300 mm	98	96	93
	Longfin eel <300 mm	108	102	99
	Torrentfish	97	99	104

KEY (as per Allen & Hay, 2013)

Habitat loss	90-100% (no change)	80-90%	70-80%	60-70%	50-60%	<50%
Habitat gain	100-110% (no change)	110-120%	120-130%	130-140%	>140%	

(vii) With regards to fish passage issues related to the residual flow, the **IFIM Report**, using a minimum depth criterion of 5 cm for native fish passage and 25 cm for large salmonids (>50 cm in length), suggests that apart from a slight reduction in the minimum passage width for native fish, there is expected to be no adverse effect on fish passage for either native or introduced species. Given the ability of kōaro (the only species found in tributaries upstream of Douglas Creek – with the exception of one eel – and the only species found upstream of Morgan Gorge) to migrate upstream using the wetted splash zone and through interstitial spaces in the substrate, it is highly unlikely that the residual flow will have any negative effect on the upstream migration of kōaro. In some instances, including within Morgan Gorge, it may make upstream passage somewhat easier for their upstream migration due to a reduction in fast-flowing sections, while their climbing ability should ensure their passage over any drops that may appear in the Morgan Gorge section as a result of reduced flow.

(viii) Thus on balance, given (i) the comparatively short distance of the residual flow (totalling approximately 2.5 km), (ii) the low diversity and densities of fish species within the abstraction reach (brown trout, kōaro, longfin eel, torrentfish), (iii) the overall sub-optimal fish habitat in the mainstem within the abstraction reach, (iv) the ability of kōaro to still migrate upstream into tributary waterways within the abstraction reach and upstream into Kiwi Flat, and (v) the protection of flow and surface water connections for the 'Stable Trib' and Douglas Creek (which are located approximately 800 m downstream of the end of the abstraction reach), the overall effect of residual flow on the fish communities appears to be '**minor**' – provided that fish passage is maintained at the intake weir structure to prevent the upstream movement of all but kōaro into Kiwi Flat (this is covered in Section 20.7).

(e) It would be possible to monitor the buildup of periphyton (especially filamentous algae) during prolonged periods of residual flow (i.e., greater than four weeks) in the abstraction reach, and if this reaches problem levels then any excessive accumulations could be flushed out by temporarily reducing the take to the Power Station. This is a similar approach to what is recommended in the **Sediment Report** for managing 'transient fine sediment drapes' (see 20.3 (c)). This monitoring can be included in an adaptive management plan that allows for the monitoring duration to be modified based on findings from initial monitoring. Whilst excessive periphyton growth is not expected to be an issue due to the low nutrient status of the river and the regularity of large bed-moving floods that will continue even with the Scheme, this type of monitoring and adaptive management regime would certainly ensure any potential effects of residual flow on periphyton growth (and from that invertebrate communities) could be reduced from a **'minor' to 'less than minor'** level.

Figure 14 Photographs taken within Morgan Gorge (near the hot pool) showing the turbulent and high-gradient nature of the river through this section. All photographs were taken in February 2013 when flow was approximately 10 cumecs. Photographs © Boffa Miskell, 2013.

20.2 Rapid flow changes as part of planned maintenance and emergency shutdowns

(a) Planned shutdowns for maintenance or recreation are expected to occur 1-2 times a year, whilst emergency shutdowns may occur around four times a year largely as a result of weather (i.e., storm) events causing a fault on the transmission network or internal plant/machinery malfunction. During shutdowns the intake will be shut and the flow previously running through the tunnel will instead be redirected down the main river channel (i.e., over the intake weir and down Morgan Gorge). During a Power Station shutdown the change in flow in the river will occur within a very short timeframe (i.e., within a few minutes for emergency shutdowns). The result of shutdowns will be a rapid increase in flow at the intake point, and a concomitantly rapid decrease in flow at the point of the Power Station tail race (**Table 9**). The opposite would then occur when the scheme starts up again following a shutdown (i.e., a decrease in flow at the intake point and a concomitant increase in flow at the point of the Power Station tail race) (**Table 9**). The **Flow Modelling Report** produced a 2D model to look at the effect of emergency shutdowns and planned shutdowns under three different flow scenarios shown in **Table 10** (scenario 1 = a full 23 cumec take with a 3.5 cumec residual flow in the abstraction reach, scenario 2 = a 13 cumec flow take with 35 cumec residual flow in the abstraction reach, scenario 3 = a full 23 cumec take but with more flow (13.5 cumecs) in the abstraction reach), with or without different bypass flow options (no bypass or a bypass of 10 cumecs) or a 30, 45 or 60 minute ramp down.

Table 9 Table showing the relative increase or decrease in flow in different parts of the Waitaha River during a Scheme shutdown and startup.

Scheme operation	Abstraction Reach (from Headworks intake to the Power Station tail race)	Downstream Reach (from Power Station trail race downstream)
Startup	Reduced flow	Increased flow
Shutdown	Increased flow	Reduced flow

*Table 10 River flow scenarios modelled in the **Flow Modelling Report** (AusHydro, 2025).*

Scenario	Flow in Waitaha River upstream of intake) (m^3/s)	Flow diverted through power station (m^3/s)	Residual flow through abstraction reach (m^3/s)	Notes
1	26.5	23	3.5	Approx. 27% exceedance
2	16.5	13	3.5	Nominal lower flow – approx. 56% exceedance
3	36.5	23	13.5	Nominal higher flow – approx. 17% exceedance

(b) During a (non ramped) shutdown, the flow changes experienced in the channel downstream of the tail race will be a rapid decrease in flow, but the changes are influenced by channel morphology and distance downstream of the tail race, as described below.

(i) **Single confined channel immediately downstream of the power station:** Under the three flow scenarios there will be an approximate 40 minute lag between the leading edge of the water diverted at the Headworks intake reaching the part of the river at the point of the tail race[23]. This means that for that period of time there will be a sharp decrease in flow and water depth in the river from just downstream of the Power Station tail race.

(ii) **Braided channel further downstream of the Power Station:** The temporary flow reduction as a result of the emergency shutdown will not be felt at the start of the braided section until around 25 mins after shutdown, which is the time that it takes for the full flow in the single channel from the point of the tail race to move downstream to the start of the braid section. It appears that the period of reduced flow depth will occur for approximately 45 minutes (in flow scenario 1) – which is the time it takes for flow diverted from the Headworks intake into the channel to reach this section of the river. The magnitude of the flow reduction is less in this reach compared to the single confined channel section upstream, in part a result of the flow inputs from other sources. However, the flow depth reduction will also be affected by the number of braids in the channel (i.e., smaller shallower braids will experience more water loss than larger deeper braids). The flow reduction will propagate downstream, with the **Flow Modelling Report** indicating that flow changes will reduce with increasing distance downstream, and likely barely perceptible at the coast.

(c) During a shutdown, the flow changes experienced within the abstraction reach will be a rapid increase in flow, as the flow previously diverted through the intake will instead flow down the mainstem. The **Flow Modelling Report** plotted the modelled flow increase at the Morgan Gorge hot pool (approximately 0.8 km downstream of the intake weir). In an emergency shutdown the flow increase occurs over just a few minutes and, not surprisingly, the greatest magnitude of flow depth increase occurs when the abstraction reach is at the residual 3.5 cumecs and the water take is at the maximum 23 cumecs.

(d) One effect of planned maintenance or emergency shutdowns on fish communities is fish strandings during a rapid reduction of flow (Irvine *et al.,* 2008; 2015). This could occur in the river downstream of the tail race during shutdowns and in the abstraction reach during a scheme restart following a shutdown. Fish juveniles especially, can strand in pools/sidewater/backwater areas or in interstitial spaces when the water level drops suddenly. Strandings can be classified into two categories: entrapment, where fish become isolated in pockets of water without access to the free-flowing surface water; and beach stranding, where fish flounder out of the water on the substrate (Hunter, 1992). Fish stranding rates are dependent on numerous factors that include, but are not limited to, dewatering speed (down-ramping rates), ramping range (magnitude of change), available cover, response to falling water levels and temperature-dependent behaviour (Halleraker *et al.,* 2003; Irvine *et al*., 2015 and references therein).

[23] Whilst we refer here to 'the point of the tail race' the **Flow Modelling Report** specifies the location in the model as being approximately 100 m downstream of the Power Station.

(e) **Fish entrapment:** Fish entrapment could occur where the water levels drop enough to create isolated pools of water within the channel, from which fish are not able to escape.

(i) The **IFIM Report** predicts that there will be little change in fish passage within the Douglas Creek reach where the IFIM was focused (which includes the section of single channel downstream of the tail race), implying that there will not be a large extent of isolated habitat created during rapid flow reductions in the section of single channel downstream of the tail race (i.e., the Douglas Creek Reach) that was modelled. This would mean that there is less risk of fish entrapment (where fish are caught in isolated pools) in the Douglas Creek reach (the abstraction reach and the section of single channel downstream of the tail race to the Douglas Creek confluence), where the channel is constrained and the flow concentrated in a single channel under shutdown and/or startup scenarios.

(ii) The potential for fish entrapment would be greatest in the Downstream Reach, where the river is less constrained and widens out into a braided river morphology, thereby increasing the chances of isolated bodies of water being created due to shallower water depths in some of the smaller braids. The **Flow Modelling Report** modelled a cross-section of the braided channel downstream of Douglas Creek where there was a maximum of eight braids, and concluded that water would be maintained in all braids, although it was acknowledged that there is significant uncertainty in the results, stating "*given the inherent uncertainty in uncalibrated modelling, conservatism should be applied to the interpretation and use of model outcomes*". The naturally variable nature of braided rivers coupled with the granularity of the modelling means that it is difficult to be sure whether such quick flow reductions would create pockets of isolated bodies of water to trap fish. Yet it is probable that if fish are entrapped in isolated bodies of water, that they would be able to survive for that period of time given the good water quality and high dissolved oxygen levels of the river. There could however, be an increased chance of predation (from birds or other fish trapped in the same area), should they be present and able to capitalise on such a random event. With increasing distance downstream, additional flow inputs (both surficial and subsurface) will further lessen the magnitude of flow reduction with increasing distance downstream, and in turn lessen the chance of there being fish entrapment further downstream.

(f) **Beach stranding:** Beach stranding could occur where the water levels drop low enough and fast enough to cause fish to become stranded on exposed areas of substrate.

(i) The areas where the risk of beach stranding is greatest is in areas of marginal habitat, as these are the areas that will experience flow loss and leave fish exposed. It is possible that stranded, smaller benthic fish, such as juvenile kōaro and torrentfish, would be able to seek cover or make their way to permanent water via their ability to move through larger interstitial spaces; and this may allow them to survive beach stranding during the approximate 40-45 minutes of the temporary flow reduction. Larger and water-column dwelling fish species such as salmonids (trout and salmon) would be less able to find their way to water if they were caught in the margin areas.

(ii) Young *et al*. (2011) noted that the risk of fish stranding is diminished where the channel is relatively constrained and the flow concentrated within a single channel, as it improves the ability for fish to be able to move with the dropping water into the residual habitat. This means that the risk of beach stranding is less through the Douglas Creek Reach (i.e., the abstraction reach and section of single channel downstream of the tail race to the Douglas

Creek confluence) as that is where the river remains in a single confined channel. The **IFIM Report** predicts that 85% of the wetted channel width will be retained for fish habitat within the Douglas Creek Reach during a 3-cumec residual flow). Coupled with the relatively short length of river affected in the Douglas Creek reach (totalling approximately 2.4 km) and comparatively low diversity and number of fish (particularly salmonids) in this part of the river, beach strandings would be a low probability or unlikely to have a significant detrimental impact on the overall fish population.

(iii) As with fish entrapment, the potential for fish beach stranding is greatest in the Downstream Reach, where the river is less constrained and widens out into a braided river morphology, thereby increasing the relative proportion of marginal habitat and thus the chances of fish being stranded out of water. The **Flow Modelling Report** modelled cross-sections in an eight-braid section of the river indicates that water will remain in all braids in the modelled scenario, but there is insufficient detail to ascertain the portion of marginal habitat that would be reduced, and there remains inherent uncertainty in the model. The ability of fish to survive the 40-45 minutes of temporary flow reduction will depend on their size and species, with smaller native fish and native eels/tuna better able to seek refuge under rocks and within the interstitial spaces where water may remain.

(g) Other potential effects of the rapid reductions in flow include impacts to fish spawning, where redds/eggs in the channel are exposed and dry out (Young *et al*., 2011). This will not impact some of the native fish recorded in the mainstem as they either lay their eggs in the riparian/river margins that are inundated during elevated flow and then develop out of the water, hatching several weeks later during another inundation (e.g., kōaro), or spawn out at sea (eel species). Fish most likely to be affected would be salmonid species that lay their eggs in redds, however the mainstem of the Waitaha River near the Power Station is not optimal habitat for adults and will not be suitable spawning habitat –although salmonid spawning habitat may be present in the river mainstem further downstream (where the effects of the rapid flow loss are ameliorated by other inputs). There may be some effect on torrentfish if the emergency shutdowns occur during their spawning period. This is unlikely to have any significant impact in the Douglas Creek Reach due to there being so few fish present in the mainstem there, but may have some impact in the Downstream Reach where the river is more braided and likely more suitable for torrentfish.

(h) The effect of rapid reductions in flow from emergency shutdowns on macroinvertebrates is considered to be **low** or '**less than minor**'. This is due to the already significantly naturally disturbed system of the Waitaha mainstem and braided river channel downstream of the tail race where braids subsequently drying and moving on a regular basis. Indeed, benthic invertebrate communities have been found to recolonise river braids within 30 days after drying — which would be mainly by drift of colonists from permanently flowing braids upstream (**IFIM Report**). As such the fauna inhabiting Waitaha mainstem throughout its reach have evolved to such a disturbance regime and the effect of a temporary drop in flow from an emergency or planned shutdown will not significantly impact on them.

(i) **Fish displacement:** There is also the potential for fish displacement or washout following the operational shut down of the Scheme (i.e. up-ramping), where there is a sudden increase in river discharge. This sudden increase in flow would be evident at the intake site during any shutdown (emergency or planned shutdown), as well as at the tail race when the system starts up again. The potential effect of up-ramping is dependent on the frequency and speed of the up-ramping, the preceding flow conditions (and their duration), and the time of year that it could occur. Water column-dwelling fish, such as trout and salmon, are most susceptible to displacement during up-ramping periods as they are unable to seek refuge within the riverbed substrata during high-flow periods. However, it may also pose a risk for juvenile native fish migrating upstream, should these sudden flow increases occur during their upstream migration period. The Waitaha River is currently a flood-prone system, and flow can increase very quickly under natural conditions (albeit not as quickly as in an emergency shutdown, but comparable to a ramped maintenance shutdown). For example, a 24-cumec increase in flow has been recorded over a 15-minute period (Martin Doyle, unpublished data). Because of the flood-prone nature of the river, and the low diversity and number of fish in the Douglas Creek Reach, it is probable that the effect of up-ramping would be minimal for fish.

(j) The **Project Description** includes a number of management measures and monitoring that will be implemented to inform an adaptive management programme that will help further reduce the risk of fish stranding and displacement during planned maintenance. The proposed measures include:

(i) The **Project Description** specifies the incorporation of infrastructure that will allow a bypass flow of 10 cumecs to still be diverted down the tunnel during a planned (and emergency) shutdown, discharging as an aerated plume of water to the river immediately downstream of the power station. This will reduce the magnitude of flow change during emergency (and planned) shutdowns, as shown in the **Flow Modelling Report**. As a secondary flow change will occur when the bypass value is shut off, it is recommended that the bypass valve is not closed until the flow redirected into the channel from the Headworks has reached the tail race, and that it is closed over at least a 30 minute period to minimise the flow deficit, as described in the **Flow Modelling Report**.

(ii) Planned starting and stopping of the Scheme is managed using ramping procedures to prevent a sudden increase in flow in the main stem of the river or in the case of starting, increased discharge from the tailrace. We note that the longer this ramp up and ramp down can take, the better; as it provides an opportunity for the leading edge from the intake to reach the tailrace at the Power Station (i.e., the two ends of the abstraction reach). This is borne out in the **Flow Modelling Report**, which shows that a 60 minute down-ramp reduces the steepness of the curve (i.e., the flow drops down at a slower rate) and retains three times the flow compared to a 30, 45, and 60 minute ramp down. As such, the longer ramp down rates would give biota more time to respond to the flow change and seek refuge, and ensure that more flow is retained. However, we also note that a 24-cumec increase in flow has been recorded over a 15-minute period (Martin Doyle, unpublished data), and as such a 15 minute ramping rate would be not dissimilar to that. On balance we recommend that planned shutdowns occur over a longer duration than startup, on the basis that the area at greater risk to fish stranding is the downstream reach (which would experience a short term loss of flow during Scheme shutdowns).

(k) The ability to provide mitigation during an emergency shutdown is more limited. However, the following are some ameliorating factors or mitigations options that are available:

(i) The fact that emergency shutdowns most often occur during storm events when the river would have a higher flow (**Project Overview Report**) naturally ameliorates the risk of fish stranding or washout, as a higher flow in the river at the time of an emergency shutdown reduces the magnitude of the temporary flow change.

(ii) The flow change caused by a shutdown, whilst rapid, is temporary. Lasting only as long as it takes for the flow that can no longer pass through the Power Station to flow down the river, which, according to the **Flow Modelling Report**, is somewhere between 30-45 minutes. Thus, the survival of biota is dependent on their ability to survive entrapment or stranding for that length of time, with most of the fish inhabiting the mainstem having behavioural attributes that will improve their chances of survival.

(iii) The number of likely emergency shutdowns is expected to be around four a year (1.1% of the year), so the number of times that the river will experience a rapid flow change annually is not significant.

(iv) The **Project Description** includes the following statement that provides a level of commitment to attempting to mitigate where possible: *Procedures put in place to manage situations which may result in the Scheme shutting down without notice, e.g. automatic emergency shutdowns, including to maintain public safety.* The **Project Description** also specifies a bypass flow of 10 cumecs to still be diverted down the tunnel during an emergency (and planned) shutdown, discharging as an aerated plume of water to the river immediately downstream of the power station. This will reduce the magnitude of flow change during emergency (and planned) shutdowns, as shown in the **Flow Modelling Report**. As noted in Section 20.2 (j) (i), as a secondary flow change will occur when the bypass value is shut off, it is recommended that the bypass valve is not closed until the flow redirected into the channel from the Headworks has reached the tail race, and that it is closed over at least a 30 minute period to minimise the flow deficit, as described in the **Flow Modelling Report**.

(l) Given the uncertainties around the modelling in the **Flow Modelling Report**, we recommend that monitoring and observations of flow changes and fish stranding be undertaken in the river within the abstraction reach (Douglas Creek Reach) and (more importantly) downstream of the tail race (including within the braided section) under test conditions during the commissioning of the scheme.

(m) We would recommend that an adaptive management plan be put in place that would allow for management approaches relating to planned shutdowns and startups (following planned shutdowns or emergency shutdowns) to be informed by the findings of monitoring observations made during these test conditions of up- and down-ramping, so as to find the optimal ramping rate for minimising fish stranding whilst managing scheme operational considerations. At a minimum, conditions need to provide for adapting to data obtained through robust test conditions

20.3 Altered sediment dynamics within the residual flow section and downstream of the tail race

(a) The weir structure and diversion of some of the water flowing through Kiwi Flat into the intake structure at Morgan Gorge has the potential to alter the sediment dynamics within the residual flow reach, as well as downstream of the tail race, which could have flow-on effects for freshwater ecology values.

(i) The Scheme's design allows for bedload sediment to be directed into the sluice channel and into Morgan Gorge, meaning that there will be little change to the larger bedload moving downstream from the weir structure, following the infilling of the area upstream of the weir (see Section 20.4), but bedload will be transported via a smaller flow in the abstraction reach during times of the lowest flow level of 3.5 m^3/s.

(ii) Sand coarser than 300 microns that enters the intake structure will be intercepted by the desander. Sediment that has accumulated in the underground desander will be periodically flushed back into the Waitaha River via the tailrace, downstream of the residual flow reach. If the sand from the desander accumulated in the area around the tail race, that this could alter the local freshwater ecology values in that area.

(iii) There is the potential for increased bank erosion on the true-left of the mainstem channel opposite the Power Station Site; which could occur during large floods as a consequence of the loss of the wider flood plain area where the Power Station will be located, or via the aerial plume of water from the emergency bypass valve (depending on where it is directed).

(b) In the **Sediment Report** it is predicted that in general the Scheme will have '**less than minor**' effects on sediment transport and channel characteristics along the Waitaha River, both within the residual flow reach and downstream of the tail race, as well as in regard to potential bank erosion opposite the Power Station Site or as a result of the aerial plume from the emergency bypass valve. This would similarly mean there would be '**less than minor**' effects to freshwater ecology.

(c) Settled fine sediment effects: However, the **Sediment Report** does note that there is the potential for some additional fine sediment accumulation (referred to as 'transient fine sediment drapes') within the abstraction reach during prolonged periods of flow at the residual 3.5 m^3/s flow. This could have some impact on freshwater invertebrates within the abstraction reach if it were to smother otherwise course substrate habitat. The recommendation in the **Sediment Report** is to monitor fine sediment accumulation in the lower part of the abstraction reach following two weeks of continuous maximum residual flow, and flushing any excessive accumulations by temporarily reducing the take to the Power Station, is something that we would also support from a freshwater ecology perspective to reduce the level of effects to that of a '**less than minor**' level. It will be important to ensure that any flushing flows are increased gradually to avoid any subsequent flow change effects as discussed in Section 20.2. This monitoring can be included in an adaptive management plan that allows for the monitoring duration to be modified based on findings from initial monitoring.

(d) In relation to the effects of suspended sediment from the desander flushing, provided that the desander flushing occurs during natural runoff events (when the river would have naturally higher turbidity), the effect on the freshwater ecology of the river is likely to be minimal, given that it would be analogous to the conditions experienced during natural flood events (high flows with elevated sediment concentrations) and contains only material that was already entrained within the river channel consisting of uncontaminated material originating from the catchment upstream of the intake structure.

20.4 Backwater effects and sediment aggradation upstream of weir intake structure at Kiwi Flat

(a) As noted in the **Sediment Report** , the intake weir at the entrance to Morgan Gorge might, by lifting the hydraulic control for flows along Kiwi Flat, cause permanent aggradation (i.e., rise in bed level) along the whole length of Kiwi Flat. This could also cause the bed of Whirling Waters to rise, and so change the existing landscape.

(b) However, the **Sediment Report** has predicted that the weir at its proposed location and with its proposed profile would have no significant impact on river processes during large floods along Kiwi Flat, largely due to the much larger and existing constricting effect of the narrow entrance to Morgan Gorge, which sets the hydraulic control for flood flows along the lower section of Kiwi Flat.

(c) The **Sediment Report** concludes that the weir's only impact would be developed at lower flows when it would set the hydraulic control at the gorge entrance, where a backwater effect would extend a few 100 m upstream (to a point where the river bed level increased at a boulder-bed riffle). This backwater effect would be short-lived, with the **Sediment Report** predicting that it would fill with cobbly-gravel material quickly, possibly over the first small high-flow event or flood recession.

(d) The conclusion in the **Sediment Report** is that such effects of the weir will be '**less than minor**', since they will be limited spatially and lost in the natural variability experienced at Kiwi Flat during its frequent floods and erratic sediment supplies. As such there will be similarly '**less than minor**' effect on the freshwater ecology in this area.

20.5 Fish entrainment and mortality through the tunnel and Power Station turbines

(a) As kōaro are the only fish species found upstream of Morgan Gorge, it is the only fish that has the potential to enter the tunnel and Power Station via the intake structure at Kiwi Flat. Kōaro are an amphidromous species; upon hatching the tiny larvae are washed out to sea where they mature into juveniles before returning to freshwater as part of the whitebait run. Due to their tiny size, the newly hatched kōaro larvae are poor swimmers that drift passively in the current. It is therefore inevitable that at least some kōaro larvae will become entrained within the intake channel, and subsequently passed through the tunnel to the Power Station and turbines. Although studies have demonstrated that fish can be injured or killed during passage through turbines and other hydro scheme infrastructure (primarily due to high shear stress-mediated abrasion and turbine-related barotrauma), the majority of these studies have focused on larger-sized fish (Brown *et al.,* 2009; and references therein). In contrast, Boubée (2003) estimated mortality for smaller-sized fish during passage through turbines in the lower Waitaki River, based on reasonably low-head (30 m) Kaplan turbines, to be as low as 3–6% for trout fry (30 mm in length) and 5–7% for fingerlings (115 mm in length). Although not quantified, the author of that report also stated that larvae of indigenous species (including kōaro) were expected to survive passage through the low-head turbines for that scheme.

(b) The ability to prevent kōaro larvae from entering the tunnel purely thorough mesh size of a screen at the intake will be difficult due to the very small size of the kōaro larvae. The design of the intake structure will include a screen and associated hydraulic features (approach velocity (**AV**) and sweeping velocity (**SV**)) that will help to keep fish out of the tunnel. This information implies that the SV encourages fish and debris to move past the screen face, keeping them in the river and directing them towards the debris bypass. There is insufficient information for us to make a firm conclusion as to whether this will be sufficient to prevent the tiny kōaro larvae from entering the tunnel, and so we must currently assume that it will be inevitable that a portion of kōaro larvae will enter the intake tunnel during their spawning season. On this basis we have currently had to assume that the proportion of larvae that enter the intake will be proportional to the flow that enters the tunnel vs the flow that remains in the river. Although kōaro hatching has never been observed in New Zealand, McDowall & Suren (1995) recorded kōaro larvae emigrating from the Otira River during late March. They suggested that spawning had occurred 3–4 weeks earlier; meaning that the spawning period for kōaro could be around the March–May. Kōaro spawn amongst the marginal gravels and litter during periods of elevated stream flow (O'Connor & Koehn, 1998), and hatch approximately 3-4 weeks later during elevated flow. This means that the larval drift would most likely occur at times of elevated autumn flow, when there would be additional flow remaining within the mainstem.

(c) Considering the relatively low densities of kōaro that were recorded above Morgan Gorge, coupled with the fact that juvenile kōaro larvae could potentially remain unharmed during passage through the penstock and turbines (Eric Graynoth, NIWA, pers. comm.), and the high energy whitewater nature of the Morgan Gorge may already affect kōaro fry survival, the potential effect of kōaro passage through the penstock and turbines on the overall kōaro population of the Waitaha may not be substantial.

(d) However, it would be beneficial to involve a suitably qualified and experienced freshwater ecologist during the detailed design phase, to input into the design of the intake to reduce kōaro larvae entrainment into the tunnel where possible.

20.6 Fish attraction to the tailrace

(a) Fish will undoubtedly be attracted into the tailrace where it discharges to the Waitaha River. The main species recorded from the mainstem within this area included kōaro, torrentfish, brown trout, and longfin eel. In general fish densities in the mainstem were particularly low, with greater density and diversity of species found in the tributary waterways that were accessible to fish. It is likely the tail race will attract fish due to comparatively stable flow environment and reasonably clear water. As kōaro juveniles would typically migrate upstream along the edges of the mainstem (due to the slower velocities in such areas), many of those individuals migrating upstream along the true-right side of the river could potentially be similarly attracted into the tailrace. This would effectively reduce the number of juveniles migrating further upstream in the system. The preference would therefore be to discourage/limit fish access into the trail race structure or design it to facilitate the upstream movement of fish that may be otherwise attracted to the tail race.

(b) The **Project Description** includes provision for design to incorporate suitable measures to limit or discourage fish entering into the tail race. The design of tail race should also involve a suitably qualified and experienced freshwater ecologist to provide guidance as to what features/approach would help to discourage fish access and what design features could be used to facilitate the upstream movement of fish that may be otherwise attracted to the tail race.

(c) It would also make sense to have a qualified and experienced freshwater ecologist check the tail race after any significant flood event that causes the substrate to move within the tail race or along the confluence with the Waitaha River, to see it if any remediation works are needed to retain the ability of the race design to achieve point 20.6 (a) above.

(d) If the tail race needs to be dewatered for any reason, then it would be important to undertake a fish rescue beforehand as there will likely be fish in the area. Any fish caught should be transferred into the river mainstem upstream of the tail race.

20.7 Fish passage at weir intake structure

(a) Based on the extensive fish sampling programme by Drinan & McMurtrie (2014) and McMurtrie & Grima (2024), Morgan Gorge is considered to be a natural fish passage barrier to all but kōaro, a native migratory galaxiid that is physiologically (specially adapted fins) and behaviourally (leaving the main flow and using surface water tension of wet rocks out of the flow to move upwards) adapted to negotiate barriers that are insurmountable to other species

(McDowall, 2003). Many of our native galaxiid species are impacted by introduced salmonid species such as brown trout (McDowall, 2006), and so the waterways in the Kiwi Flat area, in particular the tributary waterways, could be considered important habitat for the kōaro that make their way into the area. As such, maintaining this fish passage status quo (i.e., with only kōaro accessing the Kiwi Flat area) is a key ecological consideration for this project. The advantage of the Scheme's design is that whilst there is the possibility of residual flow improving fish passage conditions within Morgan Gorge, the 4-7 m high (on the downstream side) weir structure, which spans the width of the channel at the top of Morgan Gorge will be an effective barrier to the upstream movement of fish. The environmental flow (the constant residual flow of 3.5 m^3/s) passes through the intake structure to discharge through a smaller gate adjacent to the sluice gate, (with larger flood event flows passing directly over the weir) where it discharges via a freefall of water. The unique climbing ability of kōaro can then be taken advantage of to create a separate fish passage structure that will allow them access to Kiwi Flat whilst preventing other fish species from gaining access.

(b) The **Project Description** includes allowance for allowance of a kōaro passage structure to facilitate the upstream movement of kōaro whilst preventing access by other fish species, which will be located to the true-left of the weir structure at the Headworks site (the 'kōaro refuge and migration pathway' structure annotated in Figure 15 Figure 4). There was no design detail at the time of writing this report, but a diagrammatic representation has been provided by the project designers (Figure 15Figure 15). Whilst this reflects initial discussions around the criteria for a kōaro passage structure the diagram is conceptual only. Given the special climbing ability of kōaro it should be possible to design a structure that provides for the upstream movement of kōaro but prevents other fish access, but this will require further detailed design to ensure its functionality. The detailed design would be contingent on the specific *in situ* conditions, but would need to incorporate the following key criteria, and have a suitably qualified and experienced freshwater ecologist involved in the detailed design and provide oversight during construction:

- A rough surface that has a micro texture that will facilitate the ability for kōaro to grip the surface. A rough concrete surface could work well in that regard.
- A ramped structure with a varied slope that provides flatter resting areas as well as steeper sections for climbing up. The location of this ramp structure may be best housed between the elbow of the weir structure and the natural rock on the true-left of the river, where the structure could be embedded to angle down/wrap around the side of the existing rock face, therefore providing flexibility in the slopes used.
- Larger material (i.e., rocks) embedded into the surface to provide variations in water velocity and patches of cover.
- A small amount of water running over the surface – the key criteria is more of a wetted surface and splash zone rather than a full flow of water; koaro will climb up the structure not swim up it.
- No sharp edge or sharp angle at the top of the structure; climbing fish are not able to negotiate such structures.
- Located off to the true-left side of the main weir structure where it should be possible to control how much water goes over the surface.

The kōaro passage structure may also be used to facilitate the upstream passage of whio/blue duck chicks, which is considered in the **Whio Report**. Whilst it is likely that the design criteria for kōaro will also suit whio, if there becomes a conflict between the design of a kōaro upstream passage structure (whilst excluding trout) and a whio chick upstream passage structure, then the criteria for the former would need to take precedence.

- The environmental flow gate maintains the continual residual flow of 3.5 m^3/s whilst the sluice gate is used to release larger sediment (gravel etc) trapped in the intake back into Morgan Gorge. The detailed design of the kōaro passage structure will need to take into account the location of these flow discharges in relation to the location of the kōaro passage structure, to help to guide/attract kōaro to the fish passage structure.

(c) It will be important to monitor to confirm that the Scheme is allowing kōaro to access Kiwi Flat but not allowing other fish through. Implementing monitoring at the kōaro passage structure itself will be practically difficult to achieve, given the need for a camera close to the structure and the high flood periodicity of the system (which would damage any camera setup). Monitoring kōaro population dynamics in tributaries in the Kiwi Flat area compared to tributaries downstream of the Scheme could instead be used to determine if recruitment is still occurring into the Kiwi Flat area with the Scheme in place. Following a BACI (before-after-control-impact) design will allow for wider population stochasticity (i.e., factors affecting recruitment that are not related to the Scheme) to factored out[24]. Should the BACI monitoring show that over time there is a reduction of kōaro recruitment into Kiwi Flat compared to downstream sites, then as part the adaptive management plan there could be allowance made for modifying the kōaro passage structure. This is another advantage to having the kōaro passage structure not being directly integrated into the Scheme's weir structure.

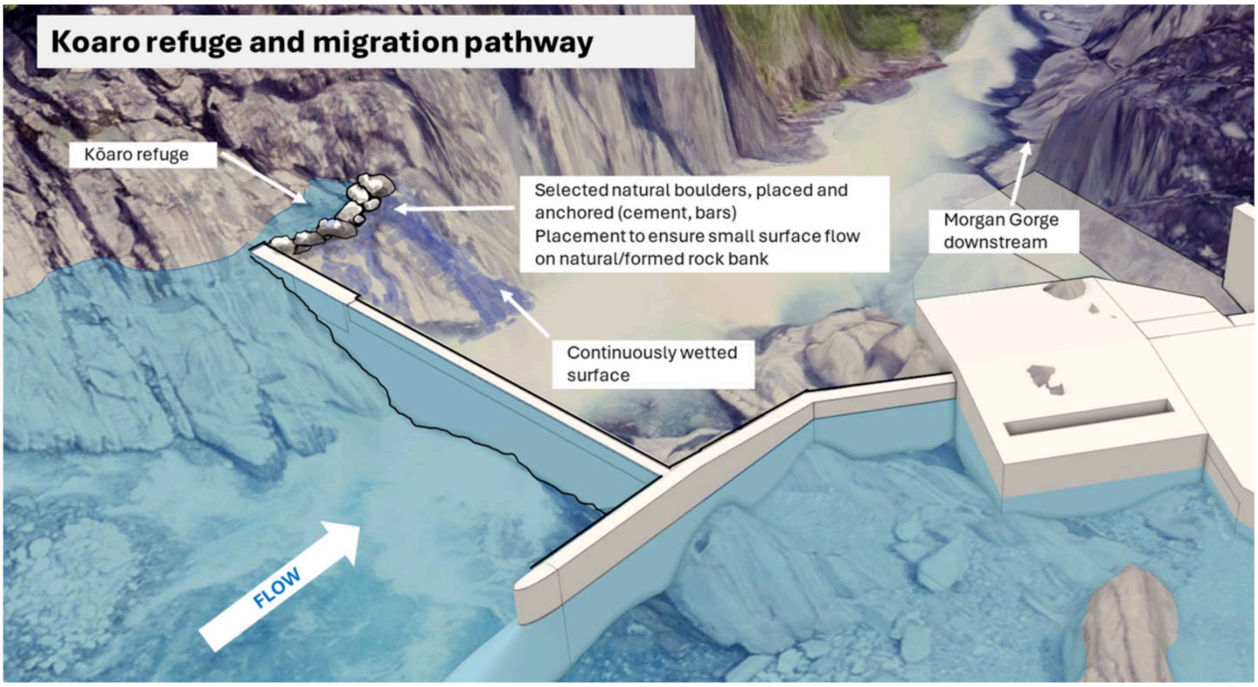

Figure 15 Diagrammatic representation of the weir and Headworks with the kōaro fish passage structure visualised on the true-right of the weir. Source: AusHydro.

[24] The use of BACI monitoring of koaro populations was discussed with Department of Conservation (DOC) during a meeting on the 2 May 2025 (with Graeme Silver and Marine Richardson) and there was general agreement to the approach. However, we note that this does not represent any formal agreement on behalf of DOC.

20.8 Fish passage at tributary waterway crossings

(a) The **Project Description** specifies that small watercourses will be crossed via culverts, whilst larger tributaries that have intermittent or ephemeral flow will have a culvert (Alpha Creek) or a crossing formed by *in situ* materials or crossing structure (i.e., Hynds 'drift deck' or similar; (Macgregor Creek), and larger tributaries with perennial flow (Granite Creek) will have a bridge. With a design and maintenance regime for the structures that takes into account fish passage (within the content of the waterway type) the impacts to fish passage will be '**less than minor**'.

(b) Bridges are the most preferred option in terms of fish passage as they do not in any way alter the channel or flow morphology of a system. Thus, the use of a bridge to cross Granite Creek will not in any way impact on fish passage.

(c) For tributaries that have intermittent or ephemeral flow (Macgregor Creek, Alpha Creek) a ford or culvert-type structure will be adequate for fish passage, given that fish passage and fish habitat is already limited by the lack of perennial flow and the steep and bouldery nature of the waterways. However, installation of the structure should still be informed by the most recent version of the New Zealand fish passage guidelines for such structures (i.e., Franklin *et al.,* 2018), and they will need to be checked following large flood/bed moving events to remediate any scour on the downstream side that may prevent fish access during times of flow. We note that the potential to form a crossing at Macgregor Creek with *in situ* materials may result in some fish passage issues at times when the creek may have surface water flow, and in that situation the use of a culverted ford structure would be preferred. Figure 3 indicates the placement of control works to maintain creek bed level upstream and downstream of the Alpha Creek crossing, which will also help with reducing the potential for channel scour.

(d) There are a number of ponded water areas or small waterway channels that appear to soak to ground along the road alignment proximal to the 'Stable Trib' (**Figure 10**). No surface water connection between these areas of surface water and the 'Stable Trib' or the mainstem river were able to be found. As such it is unlikely that these areas support migratory fish species. The **Project Description** indicates an intent to maintain the existing hydrology of such areas, which would presumably involve the use of culverts. As these areas have not been assessed it would be worthwhile to err on the side of caution and install culverts in such a way that they will not prevent any fish that may inhabit these isolated waterbodies to be able to move upstream and downstream of the access road.

20.9 Surface water runoff (for infrastructure hard surfaces and access tunnel discharge)

(a) Some of the created hard standing areas, such as the access road from Macgregor Creek to the Power Station and the Power Station infrastructure, will generate stormwater runoff during times of rain. This can be managed via effective stormwater design. The **Project Description** specifies that the access road from Macgregor Creek to the Power Station will be a metalled surface with 'limited seal' used either side of significant waterway crossings, that will include water tables and sediment management measures. In addition, the access road will be built so as to not affect the hydrology of any waterways, ponded areas and wetlands upgradient of the road. The access road will be a private road and the amount of vehicles on the access road is expected to be minimal (estimated at 1-2 vehicles per week) and as such it is not anticipated that the road will be a significant source of vehicle-related contaminants, but will be a source of suspended sediment due to its metalled nature.

(b) The proposed use of water tables and sediment management measures, combined with the relatively small area of hard surface will help to keep stormwater runoff to a minimum. Ensuring that all surface runoff from infrastructure is discharged to ground rather than to any surface water body, or if a surface water discharge is required, then avoiding any discharge to any of the stable tributary waterways in the area (including the 'Stable Trib') will further minimise the effects of stormwater runoff on any sensitive receiving environments. In addition, infrastructure surfaces exposed to rainfall or transporting water should avoid materials that are a source of freshwater contaminants (i.e., unpainted zinc roofs or use of copper).

(c) Following construction of the tunnel the **Project Description** indicates that there will a permanent discharge of water from within the tunnel. As this will be clean water (sourced from natural flow through the rocks it is proposed (depending on volumes) that this be directed either into the tailrace or directly into the river. Whilst there should be no impacts to freshwater ecology as a consequence of discharging this clean water into the river, we recommend that this discharge is directed into the tail race rather than into the main river channel.

20.10 In-channel maintenance works at the Headworks

(a) Planned maintenance at the Headworks will involve using machinery to clear boulders, gravel, and debris in the river channel to ensure the river continues to flow towards the intake and sluice gate after significant flow events.

(b) The potential effects of this could be similar to that described in Section 19.1 (sediment release), Section 19.3 (release of other construction-derived contaminants) and Section 19.6 (mortality of biota at the site of in-channel works). The channel in the vicinity structure will be 'trained' with larger boulders/debris moved so that the flow is directed towards the intake structure. This is expected to take less than a day at a time. As such the area of works will be small (the channel proximal to the intake) and will occur within a short period of time (i.e., a day), which would mean that the scale of the effect is relatively small. The **Sediment Report** considers the effects of these works will be '**less than minor**' in terms of effects on sediment release. We agree that given the large bed moving events that this system experiences, such site-specific works are unlikely to have any measurable impact on the freshwater environment.

(c) That said, it will be important to implement strict contaminant control measures to minimise the risk of a spill, and practices to ensure that there is no risk of machinery or equipment being washed down into Morgan Gorge where it will be difficult to access to remove.

20.11 Loss of shading of waterways from removal of riparian vegetation

(a) The **Vegetation Report** has assessed the effects of permanent vegetation loss and as such the consideration of vegetation loss here relates only to the loss of riparian vegetation that may have otherwise provided for shading of waterways, which would relate to tributary waterways in the path of the access road to the Power Station. The main tributary waterways (Macgregor Creek, Alpha Creek, Granite Creek) are sufficiently large that the existing riparian vegetation does not provide significant shading; meaning the removal of large trees within the 15 m wide road corridor at the point of the road crossing would have a '**less than minor**' effect on channel shading. The 'Stable Trib' would be the waterway at most risk from a change in shading, given the large proportion of shade-tolerant bryophytes in the channel, and the alignment of the road corridor roughly parallel to it. However, the road corridor is sufficiently far away (at least 50 m according to the current proposed road alignment) that there would be no change to shading of this waterway. Permanent removal of riparian vegetation that provides significant shading is therefore limited to the smaller ponded and seepage areas along the access road between Macgregor Creek and the Power Station. However, given the alignment of the road crossing these at a roughly perpendicular orientation, and the road alignment chosen to miss larger tree specimens, the overall effect is assessed as '**less than minor**' in relation to the provision of shading.

(b) Supplementary native planting of some of the construction areas that are not permanently occupied as recommended in the **Vegetation Report** will also serve to benefit any proximal freshwater systems, if it reduces areas exposed to direct rainfall (and therefore runoff), or helps to screen any outside lighting (e.g., around the Power Station or Headworks). These should be planted with locally sourced native plants appropriate to the environment and suitable to the conditions.

20.12 Lighting around built infrastructure

(a) Artificial lighting at night can confuse animals including birds, insects, fish, reptiles, and frogs. For night flying insects (including winged adult phase of freshwater insects) such lights can have a synergistic effect with hard surfaces (especially when wet) creating what appears to be a waterway (Longcore & Rich, 2004; Horvath *et al.,* 2009). Mayflies, caddisflies, stoneflies, and other aquatic insects have been observed treating asphalt surfaces as waterways and in some instances actually laying eggs on road surfaces (Horvath *et al.*, 2009). This can have serious implications for some species when such behaviour decreases population viability as reproductive success is diminished. The invertebrate community of the 'Stable Trib' has a relatively diverse assemblage of insect taxa with flighted adults that presently have a surrounding zone free from artificial light. Similarly, the mainstem of the Waitaha River has an invertebrate assemblage dominated by insect taxa that have a surrounding zone currently free from artificial light.

(b) The **Project Description** already describes a number of design features and management approaches that will reduce the impact of lighting to a '**less than minor**' level, especially when also combined with the supplementary planting described in the **Vegetation Report**. These include:

(i) No lighting along the road corridor.

(ii) Whilst the provision of lighting is required at the Power Station and Headworks, it will be normally turned off, and only switched on if needed for personnel to attend the site after dark.

(iii) Use of remote controlled infrared cameras at the Power Station and Headworks for remote monitoring of the areas.

(iv) Using lighting that limits the emission of blue light, is downward-lit, and is designed to reduce upward light scatter.

APPENDIX H – REPORT REFERENCES

21. REFERENCES

Allen, C. & Hay, J. 2013. In-stream habitat flow asessment for the Waitaha River: Morgan Gorge to Douglas Creek. Cawthron Institute, Nelson. Document Number 2306. 138 p.

AusHydro 2025. Waitaha Hydro Project – downstream flow modelling. 7 May 2025.

Biggs, B. & Close, M.E. 1989. Periphyton biomass dynamics in gravel bed rivers: the relative effects of flows and nutrients. *Freshwater Biology* 22(2): 209-232.

Biggs, B.J.F., Smith, R.A. & Duncan, M.J. 1999. Velocity and sediment disturbance of periphyton in headwater streams: biomass and metabolism. National Institute of Water and Atmospheric Research Ltd (NIWA). 222-241 p.

Boubée, J. 2003. Project Aqua – Migrant fish protection measures: Concept report National Institute of Water & Atmospheric Research Ltd, Hamilton. NIWA Client Report: MEE01205. 66 p.

Brown, R.S., Carlson, T.J., Welch, A.E., Stephenson, J.R., Abernethy, C.S., Ebberts, B.D., Langeslay, M.J., Ahmann, M.L., Dan H. Fell, Skalski, J.R. and others 2009. Assessment of Barotrauma from Rapid Decompression of Depth-Acclimated Juvenile Chinook Salmon Bearing Radiotelemetry Transmitters. *Transactions of the American Fisheries Society* 138(6): 1285-1301.

Buckingham, R. 2025. Westpower Ltd proposed Waitaha hydro scheme – Assessment of Effects on terrestrial fauna (bats, avifauna and *Powelliphanta* land snails). T/A Wildlife Surveys.

Clausen, B. & Biggs, B.J.F. 1997. Relationships between benthic biota and hydrological indices in New Zealand streams. *Freshwater Biology* 38(2): 327.

DOC (Department of Conservation). 2010. West Coast Conservation Management Strategy Volume I 2010–2020. West Coast *Tai Poutini* Conservancy Management Planning Series No. 10. Department of Conservation, Hokitika, New Zealand. Available at: https://www.doc.govt.nz/documents/about-doc/role/policies-and-plans/west-coast-cms-2010/westcoast-cms-complete.pdf. Accessed: 8 October 2024.

DOC. 2024. DOC Open Spatial Data. Ecological Districts. Available at: https://doc-deptconservation.opendata.arcgis.com/datasets/4f40397b253646f0a2ac6898ff4012c5_0/explore?location=-40.414725%2C-7.135018%2C5.81. Accessed: 17 October 2024.

Doyle, M. 2013. The hydrology of the Waitaha catchment. 38 p.

Doyle, M. 2025. Westpower Ltd proposed Waitaha hydro scheme: changes to the natural environment – hydrology.

Drinan, T. & McMurtrie, S. 2014. Proposed Waitaha hydro scheme assessment of environmental effects: Fish of the Waitaha Catchment. EOS Ecology, Christchurch. EOS Ecology Report No. 06003-ELE01-03. 111 p.

Dunn, N.R., Allibone, R.M., Closs, G.P., Crow, S.K., David, B.O., Goodman, J.M., Grifiths, M. Jack, D.C., Ling N., Waters, J.M. & Rolfe, J.R. 2018. Conservation status of New Zealand freshwater fishes, 217. New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 pp.

Evergreen Mapping NZ. 2024. Wilderness Areas of New Zealand. Prepared by Evergreen Mapping NZ for the Federated Mountain Clubs of New Zealand. Available at: https://www.arcgis.com/apps/View/index.html?appid=5ddf67795e9443abb933b9e751fb581b. Accessed 17 October 2024.

Franklin, P., Gee, E., Baker, Cindy, & Bowie, S. 20118. New Zealand fish passage guidelines for structures up to four metres. National Institute of Freshwater and Atmospheric Research, Hamilton. 226 p.

Government of New Zealand. 1991. *Resource Management Act*. Public Act 1991 No 69. Date of assent: 22 July 1991. Version: 2 October 2024. Available at: https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html. Accessed: 19 October 2024.

Grainger, N., Harding, J., Drinan, T., Collier, K., Smith, B., Death, R., Makan, T. & Rolfe, J. 2018. Conservation Status of New Zealand Freshwater Invertebrates, 2018. Department of Conservation, Wellington, New Zealand. 25p

Graynoth, E. & Taylor, M.J. 2000. Influence of different rations and water temperatures on the growth rates of shortfinned eels and longfinned eels. *Journal of Fish Biology* 57(3): 681-699.

Hay, J. 2010. Instream flow assessment for the Mataura River. Cawthron Institute. Report Number 1757. 35 p.

Hayes, J.W. & Jowett, I.G. 1994. Microhabitat models of large drift-feeding brown trout in three New Zealand Rivers. *North American Journal of Fisheries Management* 14: 710-725.

Hicks, M. 2025. Westpower Ltd proposed Waitaha hydro scheme – Assessment of Environmental Effects sediment. National Institute of Water & Atmospheric Research Ltd, Christchurch.

Halleraker, J.H., Salveit, S.J., Harby, A., Arnekleiv, J.V., Fjeldstad, H.P. & Kohler, B. 2003. Factors influencing stranding of wild juvenile brown trout (*Salmo trutta*) during rapid and frequent flow decreases in an artificial stream. *River Research and Applications* 19: 589–603.

Horvath, G., Kriska, G., Malik, P., Robertson, B. & G, H. 2009. Polarized light pollution: a new kind of ecological photopollution. *Frontiers in ecology and the environment* 7(6): 317-325.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. Washington Departmentof Fisheries Technical Report 119, Olympia.

Hudson, H.R., Byrom, A.E. & Chadderton, W.L. 2003. A critique of IFIM - instream habitat simulation in the New Zealand context. *Science for Conservation* 231: 69p.

Irvine, J.R. & Henriques, P.R. 1984. A preliminary investigation on effects of fluctuating flows on invertebrates of the Hawea River, a large regulated river in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 18: 10.

Irvine, R.L., Oussoren, T., Baxter, J.S. & Schmidt, D.C. 2008. The effects of flow reduction rates on fish stranding in British Columbia, Canada. *River Research and Applications* 25(4): 405-415.

Irvine, R.L., Thorley, J.L., Westcott, R., Schmidt, D. & Derosa, D. 2015. Why Do Fish Strand? An Analysis Of Ten Years Of Flow Reduction Monitoring From The Columbia And Kootenay Rivers, Canada. *River Research and Applications* 31: 1242 - 1250.

Jowett, I.G. & Biggs, B.J.F. 1997. Flood and velocity effects on periphyton and silt accumulation in two New Zeland rivers. *New Zealand Journal of Marine and Freshwater Research* 31(3): 287-300.

Jowett, I.G. & Richardson, J. 2008. Habitat use by New Zealand fish and habitat suitability models. National Institution of Water & Atmostpheric Research Ltd, Wellington, New Zealand. 148 p.

Jowett, I.G., Richardson, J., Biggs, B.J.F., Hickey, C.W. & Quinn, J.M. 1991. Microhabitat preferences of benthic invertebrates and the development of generalised *Deleatidium* spp. habitat suitability curves, applied to four New Zealand rivers. *New Zealand Journal of Marine and Freshwater Research* 25: 187-199.

Joy, M., David, B. & Lake, M. 2013. New Zealand freshwater fish sampling protocols: Part 1- Wadeable rivers & streams. Palmerston North, New Zealand, Massey University. Pp. 64.

Lancaster, L. 1996. Scaling the effects of predation and disturbance in a patchy environment. *Oecologia* 107(3): 321-331.

Longcore, T. & Rich, C. 2004. Ecological light pollution. *Frontiers in ecology and the environment* 2(4): 191-198.

Maughan, O.E. & Barrett, P.J. 1992. An Evaluation of the Instream Flow Incremental Methodology (IFIM). *Journal of the Arizona-Nevada Academy of Science* 24/25: 75-77.

McDowall, R.M. 2000. *The Reed Field Guide to New Zealand Freshwater Fishes*. Reed Publishers ltd, Auckland. 224 p.

McDowall, B. 2003. Native freshwater fish: The key to climbing in kōaro. *Water & Atmosphere 11*: 16-17.

McDowall, R.M. 2006. Crying wolf, crying foul, or crying shame: alien salmonids and a biodiversity crisis in the southern cool-temperate galaxioid fishes? *Reviews in Fish Biology and Fisheries* 16(3-4): 233-422.

McDowall, R.M. & Suren, A.M. 1995. Emigrating larvae of koaro, *Galaxias brevipinnis* Günther (Teleostei: Galaxiidae), from the Otira River, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 29: 271-275.

McMurtrie, S. 2014. Assessment of the ecological impact of culvert repair work at Rue Noyer culvert on Walnut Creek. EOS Ecology, Christchurch, New Zealand. EOS Ecology Report No. 14027-CHR01-01. 53 p.

McMurtrie, S & Grima, C. 2024. Proposed Waitaha Hydro Scheme: Summary of Freshwater Biota Records from eDNA Sampling. EOS Ecology Report No. WES05-24011-01. EOS Ecology, Christchurch. 29 p.

McMurtrie, S. & Suren, A. 2014. Proposed Waitaha hydro scheme assessment of environmental effects: Benthic ecology of the Waitaha catchment. EOS Ecology, Christchurch. EOS Ecology Report No. 06003-ELE01-02. 148 p.

Milhous, R.T. 1999. History, theory, use, and limitations of the physical habitat simulation system. Proceedings of the Third International Symposium on Ecohydraulics. Pp. 26.

Ogbonna, J.F. & Chinomso, A.A. 2010. Determination of the concentration of ammonia that could have lethal effect on fish pond. *ARPN Journal of Engineering and Applied Sciences* 5(2): 1–5.

O'Connor, W.G. & Koehn, J.D. 1998. Spawning of the broad-finned Galaxias, *Galaxias brevipinnis* Gunther (Pisces: Galaxiidae) in coastal streams of southeastern Australia. *Ecology of Freshwater Fish* 7(2): 95.

Overmars, F. 2025. Westpower Ltd proposed Waitaha hydro scheme – Assessment of Environmental Effects: Whio blue duck (*Hymenolaimus malacorhynchos*). Sustainability Solutions Ltd., Mapua.

Peckarsky, B.L. 1984. Predator-prey interactions among aquatic insects. In: Resh, V.H. & Rosenberg, D.M. (ed). *The Ecology of Aquatic Insects*. Praeger Publishers, New York. Pp. 196-254.

Robinson, C.T., Uehlinger, U. & Monaghan, M.T. 2004. Stream ecosystem response to multiple experimental floods from a reservoir. *River Research and Applications* 20(4): 359-377.

TACCRA, 2025. Westpower Ltd proposed Waitaha hydro scheme – Assessment of Environmental Effects: Vegetation. TACCRA Ltd.

TTPPC (Te Tai o Poutini Plan Committee). 2022. Te Tai o Poutini Plan. A combined district plan for the West Coast. Proposed Plan. Prepared by Te Tai o Poutini Plan Committee in association with West Coast Regional Council, Greymouth, New Zealand. Available at: https://ttpp.nz/wp-content/uploads/2023/02/ProposedTTPP_2023.pdf. Accessed: 8 October 2024.

Waters, B.F. 1976. A methodology for evaluating the effects of different streamflows on salmonid habitat. In: Orsborn, J.F., Allman, C.H. (eds). Proceedings of the symposium and speciality conference on in-stream flow needs II. American Fisheries Society, Bethesda, Maryland. Pp. 224-234.

WCRC (The West Coast Regional Council). 2020. West Coast Regional Policy Statement 24 July 2020. The West Coast Regional Council, Greymouth, New Zealand. Available at: https://www.wcrc.govt.nz/repository/libraries/id:2459ikxj617q9ser65rr/hierarchy/Documents/Publications/Regional%20Plans/Regional%20Policy%20Statement/Operative%20RPS%20final%2014%20July%202020.pdf. Accessed: 8 October 2024.

WDC (Westland District Council). 2002. Westland District Council - District Plan. Operative 1 June 2002. Hokitika, New Zealand. Available at: https://www.westlanddc.govt.nz/sites/default/files/westland-district-plan-current.pdf Accessed: 8 October 2024.

Winterbourn, M.J., Gregson, K.L.D. & Dolphin, C.H. 2006. *Guide to the Aquatic Insects of New Zealand.* 4th (ed). Entomological Society of New Zealand, Auckland.

Young, P.S., Cech, J.J. & Thompson, L.C. 2011. Hydropower-related pulsed-flow impacts on stream fishes: a brief review, conceptual model, knowledge gaps, and research needs. *Reviews in Fish Biology and Fisheries* 21: 713–731.