BEFORE THE NEW PLYMOUTH DISTRICT AND TARANAKI REGIONAL COUNCILS

IN THE MATTER	**of the Resource Management Act 1991 ("the Act")**
AND	
IN THE MATTER	**of applications from NZTA to alter a designation and for resource consents for the Mt Messenger Bypass Project – SH3 between Uriti and Ahititi ("the Project")**

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EVIDENCE ON BEHALF OF THE DIRECTOR-GENERAL OF CONSERVATION

(Freshwater)

24 JULY 2018

Department of Conservation

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INTRODUCTION

1. My full name is Thomas Joseph Drinan. I am employed by the Department of Conservation as a Freshwater Technical Advisor. I have been in this position since March 2017.

2. I hold a Bachelor of Science (Applied Ecology) and Doctor of Philosophy (PhD) degree, both from University College Cork. My PhD thesis investigated the effects of conifer plantation forestry on the hydrochemistry and aquatic biota of peatland lakes.

3. Prior to my current position, I worked in consultancy roles with both EOS Ecology and Golder Associates (NZ) Limited. In those roles, I undertook numerous ecological assessments, compliance monitoring, waterway restoration, and ecological surveys from a wide variety of waterway types.

4. In 2015, I completed Auckland Regional Council's training course on the Stream Ecological Valuation (SEV) method.

5. I am familiar with the Project route, following a site visit on 8 August 2017.

6. I am authorised to give this evidence on behalf of the Director-General of Conservation in relation to the Proposed State Highway 3 Mt Messenger Bypass Project (hereafter referred to as the 'Project').

CODE OF CONDUCT

7. I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014, and I agree to comply with it. My qualifications as an expert are set out above.

8. The data, information, facts, and assumptions I have considered in forming my opinions are set out in my evidence to follow. The reasons for the opinions expressed are also set out in the evidence to follow.

9. Unless I state otherwise, this evidence 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 that I express.

10. In preparing this evidence, I have read and given consideration to the following:

a) The reports and statements of evidence (the evidence-in-chief [EIC] and supplementary statements of evidence, where relevant) of other experts giving evidence on behalf of both the New Zealand Transport Agency (NZTA) and the Director-General of Conservation, relevant to my area of expertise. In particular, the evidence of Mr Keith Hamill, Dr Martin Neale, Mr Alastair McEwan, Mr Graeme Ridley, Mr Roger MacGibbon, and Mr Peter Roan (Annexures A & B).
b) Assessment of Ecological Effects – Freshwater Ecology (River Lake Limited Technical Report 7b – Rev. Number 0, dated December 2017).
c) Ecology supplementary report – Freshwater Ecology (River Lake Limited Technical Report – Rev. Number A, dated February 2018).
d) Memo from Brian Smith (NIWA) to Corinne Watts (Landcare Research) subject *'Adult aquatic insect recorded from Mt Messenger Malaise nets'* (Project No. SCJ182GOV/Landcare.BS, dated 10 April 2018).
e) Assessment of Ecological Effects – Vegetation (NSES Limited Technical Report 7a – Rev. Number 0, dated December 2017).
f) Ecology supplementary report – Vegetation (NSES Limited Technical Report – Rev. Number A, dated February 2018).
g) Ecology supplementary report – Terrestrial Invertebrates (Corinne Watts, Landcare Research Technical Report – Rev. Number A, dated February 2018).
h) Ecology and Landscape Management Plan (and associated appendices) (Mt Messenger Alliance).
i) Construction Water Management Plan (and associated appendices) (Mt Messenger Alliance).
j) Mt Messenger Bypass Project – Proposed Designation Conditions.
k) Section 92 Request for Further Information by New Plymouth District Council (dated 22 March 2018), and the Response by Mt Messenger Alliance (dated 6 April 2018).
l) Review of Ecological Aspects of the Application to Reroute SH3 at Mt Messenger, North Taranaki – May 2018. Report prepared by Wildland Consultants Limited for New Plymouth District Council. Contract Report No. 4402e.

SCOPE

11. My evidence will address the following matters:

    a) The aquatic conservation values of the Project area, including the habitat requirements and life histories of aquatic biota (particularly freshwater fish);

    b) The assessment of ecological effects relating to aquatic ecological values;

    c) The mitigation measures and biodiversity offset proposed for these effects to achieve 'no net loss of ecological values' or a 'net positive gain'; and

    d) The monitoring proposed to assess potential effects and mitigation efficacy.

12. The matters that I address in my evidence are those outstanding from the meeting between Mr Keith Hamill and myself held on 28 March 2018. The outcomes from this meeting can be seen in Appendix 1.

EXECUTIVE SUMMARY

Proposed mitigation/compensation

13. The available data shows that the waterways within the Project area contain aquatic macroinvertebrate and fish communities that are generally in very good to excellent condition. Furthermore, many of the waterways provide habitat for rare and at-risk taxa of notable conservation value. These aquatic biodiversity values are further supported by geospatial analyses of the conservation values and ecological integrity of the Tongaporutu and Mimi (to a lesser extent) rivers (based on the Freshwater Ecosystems of New Zealand [FENZ] database).

14. The Applicant used Auckland Council's Stream Ecological Valuation (SEV) method (Storey et al. 2011a) to assess the ecological values of the affected streams, and to form the basis for effects assessment and development of an ecological compensation package. In my opinion, it not an appropriate or sufficient tool for assessing biodiversity values, nor for quantifying the amount of compensation required for lost biodiversity values.

15. Notwithstanding that Mr Hamill considers that he has adequately acknowledged the aquatic ecological value of these waterways through the use of SEV scores (and associated ECRs), I have the following concerns with his approach:

a) The SEV scores provide only a limited measure for biodiversity, as only three of its 14 functions relate to biodiversity values. The method was designed to assess the health or ecological value of streams from a functional perspective, not from a biodiversity perspective;

b) Furthermore, the SEV scores provide the 'currency' to be used in the Environmental Compensation Ratio (ECR) calculations. However, the SEV guidelines recommend that two of the three biotic functions be excluded from ECR calculations;

c) Mr Hamill did not adhere to the SEV guidelines with regards to instances where when the calculation produces an ECR value of < 1, then that ECR should default to 1;

d) Although Mr Hamill has revised the post-impact SEV score for steep culverts to 0.15, I do not agree that a piped stream will retain an SEV score post-culverting of 0.15 or 0.23. I believe piped sections of waterways should be given a post-impact SEV score (SEVi–I) of 0; and

e) This method does not incorporate measures of biodiversity such as (a) diversity, distribution, and population size of extant aquatic species; (b) their conservation status (rarity and distinctiveness); (c) their habitat requirements for all stages of their life cycle (i.e., spawning, nursery, juvenile and adult habitat); and (d) ecosystem 'representativeness', 'irreplaceability', and 'ecological integrity', as well as 'ecological context'.

16. To address these matters, I have recalculated the ECRs attempting to remediate these discrepancies. My recalculations are based on a greater degree of objectivity to account for biodiversity values. They also align the Project's current average ECR (2.6) with that from other roading projects (e.g. Transmission Gully had an average ECR of 3.3), and the average ECR for Auckland (3). Following these calculations, I have arrived at a length and area of stream channel to restore that is up to 2,185 m/1,893m^2 greater than that proposed by Mr Hamill. This increase is excluding the additional multiplication factors that I recommend should be applied to the final ECRs for the forested, headwater streams, which I have calculated to result in a further 2,720 m/2,581 m^2. Combined, these recalculations suggest that an additional 4,905 m/4,474 m^2 length and area of stream channel will require

restoration (i.e., a total of 13,360 m/12,627 m^2 length and area of stream channel, as opposed to what is currently proposed [8,455 m/8,153 m^2]).

17. Finally, undertaking environmental compensation requires the SEV scores to be known from the compensation sites. The reason being that the proposed compensation site may have high ecological values that cannot be improved upon, or conversely, may have low ecological values that are not amenable to significant improvement in ecological value. However, the use of the proposed compensation sites for the Project (for the proposed riparian offset restoration planting) have yet to be formally agreed with the respective landowners.

Potential fish passage impediments

18. The Applicant initially set a low design target for providing fish passage for this Project, but has since revised down the number of permanent culverts (from 21 to 19), and changed the design standards for 7 of the 19 proposed culverts, including reduced gradients. However, 12 permanent culvert designs are still not in accordance with best practice, and two of these culverts propose the use of iris baffles.

19. The Applicant has proposed wording "*the diversion/culvert shall provide for fish passage in accordance with the ELMP*"[1], opining the objective should be to provide sufficient fish passage that would naturally occur upstream of the culvert or diversion. I consider that the requirements for fish passage should be stated on the face of the resource consent conditions. Furthermore, I consider that TRC's proposed resource consent conditions for diversions and culverts should remain as "…*shall not restrict fish passage*". Otherwise, the Applicant should identify diversions/culverts for which an exemption is sought (and would need to seek approval from DOC under the Freshwater Fisheries Regulations 1983).

Sediment discharge effects

20. As stated in Mr Duirs' evidence, there remains a high potential of significant sediment loss from this Project's activities. These subsequently pose a major risk to the biodiversity values (especially to sensitive life cycle stages [e.g., eggs, juveniles, etc.]) of the receiving aquatic environments.

[1] Mr Hamill's EIC at paragraph 159.

21. Sediment discharges are well known to affect the aquatic biota of receiving environments both (i) when sediment particles are suspended in the water column, and (ii) when sediment falls out of suspension and settles on the stream bed and/or bank. Despite both effect types being well documented, Mr Hamill states "*The primary ecological concern regarding sediment in discharges is not so much the change in clarity of water but instead deposition of sediment on the stream beds*" (Technical Report 7b). I agree with Mr Hamill in that there are potentially significant effects of deposited sediment; however, I do not agree with this statement. Not considering suspended sediment effects yields an incomplete assessment of potential sediment-related effects on aquatic biota.

Stream habitat fragmentation

22. Stream fragmentation effects will have major implications for the aquatic invertebrate communities of the Project area. I consider that additional compensation will be needed (to be informed by targeted monitoring), as I consider these effects cannot be adequately mitigated once the Project has been finalised.

Flow alteration effects

23. I have several concerns with the attempted assessment of effects, as well as the proposed takes as detailed by the Applicant. I consider the assessment of the hydrological effects on stream hydraulic conditions to be an overly simplistic and inaccurate.

Fish recovery/rescue protocols

24. I have major concerns with the proposed approach to fish (and megainvertebrate) recovery and rescue. These direct effects are arguably the easiest freshwater effects to minimise. Insufficient effort is proposed for these direct effects on aquatic biota. I recommend changes to these protocols in my evidence.

Management/monitoring plans (and associated additional mitigation)

25. I am unsure as to the basis for Mr Ridley's statement that "*DOC has received a copy of the CWDMP [footnote: Formal copy sent 4th May 2018] and has confirmed acceptance of the CWDMP for monitoring construction relates activities as fit for purpose. This matter has*

therefore been resolved"[2]. I have not agreed on this matter with neither Mr Ridley nor Mr Hamill.

26. Mr Duirs' evidence raises concerns over the ability of the Applicant to apply best practice erosion and sediment control (ESC) measures at the site. Considering effects may be significant, I propose an increased level of monitoring for both water quality and aquatic biota (invertebrates and fish). I support Mr Duirs' recommendation for *in-situ* turbidity sensors (at both upstream and downstream sites), and provide further detail on the recommended locations of such devices.

27. Overall, many aspects of the proposed mitigation (and monitoring) do not provide much certainty regarding the mitigation of effects. For example, a trigger value (25 mm of rainfall in a 24-hour period) and management thresholds are provided in the CWMP for when additional ecological monitoring (of sediment deposition within the kahikatea swamp maire forest [in the upper Mimi River catchment]) is required, and I comment on these. However, there is no detail provided around the basis upon which additional mitigation may be required if adverse aquatic ecological effects beyond those anticipated occur. The ELMP describes, in relation to additional monitoring in the kahikatea swamp maire forest, that suitably qualified project ecologists will assess the extent of any effects in this area, and prepare a report with recommendations for further monitoring or remedial actions[3]. In addition, the CWMP states "*Liaise with TRC to establish what remediation or rehabilitation is required and whether this is practical to implement*"[4]. For this, and any other potential adverse aquatic ecological effects related to the Project, I recommend that the calculation of additional mitigation required should be undertaken with an explicitly defined method. The resource consent conditions that will be provided at the hearing will recommend this potential task(s) should be undertaken in conjunction with the Ecology Review Panel.

[2] Mr Ridley's EIC at paragraph 144.
[3] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.4.4.
[4] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix E: Construction Water Management Plan, Section 11.1.

AQUATIC CONSERVATION VALUES OF THE PROJECT AREA

Overview

28. The Proposed State Highway 3 Mt Messenger Bypass Project (the 'Project'), between Uruti and Ahititi in North Taranaki, will affect numerous waterways in both the Tongaporutu and Mimi River catchments (Figure 1). Many of these waterways are high-gradient, low-order[5] tributaries to the Mangapepeke Stream (a tributary of the Mangaongaonga Stream, which joins the Tongaporutu River east of Ahititi) and Mimi River, which drain indigenous forest-dominated sub-catchments near the Mt Messenger peak. Further downstream, on the Mangapepeke Stream and Mimi River proper, channel gradients ease considerably, while the land cover on the valley floors gives way to rough pasture and grazed wetlands. The range of aquatic and riparian habitats, and how they vary longitudinally from upstream to downstream, can be seen in Figure 2 (for the Mangapepeke Stream sub-catchment). The underlying geology for the overall Project area is finer grained 'papa'[6] sandstone, mudstone, and limestone[7].

29. There are also six indigenous wetland communities recorded from within the valley floors in the Project area, including the 'kahikatea swamp maire forest' in the upper Mimi River catchment, and the 'exotic rushland' in the Mangapepeke River catchment (Technical Report 7a; Ecology supplementary report – Vegetation).

Aquatic habitat

30. As recorded in the meeting with Mr Hamill on 28 March 2018, I consider that the Mr Hamill has undertaken sufficient data collection to enable an overall assessment of the freshwater habitat and biodiversity values present in the Project area. However, as noted in the meeting outcomes, there remains some uncertainties, particularly regarding the aquatic biota that may inhabit the upper reaches of certain streams (particularly higher gradient systems), for which permanent culverts are proposed.

31. The upper Mangapepeke Stream and its headwater tributaries are higher gradient,

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[5] Stream order is determined by the coalescence pattern. Streams with no upstream tributaries are termed 'first order'. Two first order streams converge to form a second-order stream, two second-order tributaries form a third-order stream, and so on to create the riverine network.
[6] The terms 'papa' or 'papa-rock' are used for the widespread soft, blue-grey mudstone or muddy sandstone.
[7] http://data.gns.cri.nz/geology/, accessed 17 May 2018.

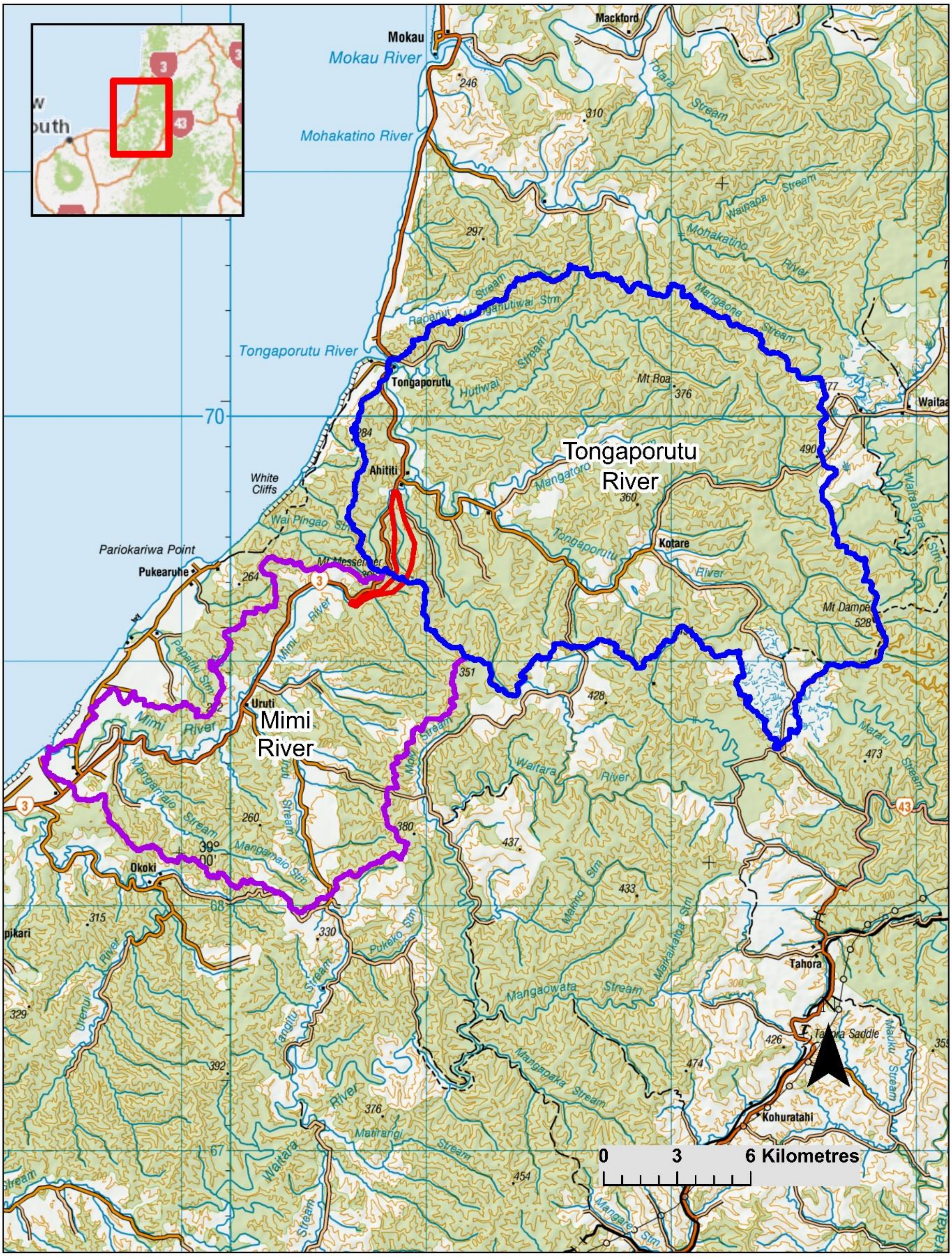

Figure 1. Map of the Project area (delineated in red), showing the Tongaporutu (delineated in blue) and Mimi River (delineated in purple) catchments.

Upper Mangapepeke Stream

Upper Mangapepeke Stream

Benthic substrate of the upper Mangapepeke Stream

Upper Mangapepeke Stream

Mangapepeke Stream

Middles reaches of Mangapepeke Stream

Middles reaches of Mangapepeke Stream

Middles reaches of Mangapepeke Stream

Figure 2. Select photographs of the Mangapepeke Stream sub-catchment (all within the Project area) taken during the August 2017 field visit. Photographs are ordered from upstream (top left) to downstream (bottom right).

with a step-pool/cascade channel morphology, and drain indigenous forest (Figure 2). A number of waterfalls are present in some of the high-gradient tributaries. Further downstream, the land cover changes to rough pasture and grazed wetland (mainly rushland), while the stream channel changes to a pool-riffle channel type, substrate grain size declines (apart from the occasional large woody debris), and floodplain width increases significantly. Mr Edward's evidence discusses the value of these riverine floodplains as habitat for wetland invertebrates, particularly within the Mangapepeke Stream sub-catchment. A remnant kahikatea swamp forest is noted as being present on the true right of the valley (near site Ea10).

32. The habitat of the headwater tributaries of the Mimi River are similar to those described for the Mangapepeke Stream (i.e., steep gradient, step-pool/cascade channel morphology, draining indigenous forest). Similar to the Mangapepeke Stream, the mid-reaches of the Mimi River are dominated by run and pool habitat (with concomitant increases in stream width, depth, and floodplain width, and decreases in substrate grain size). Of note for the upper Mimi River catchment, however, is the kahikatea swamp maire forest, located immediately downstream of a number of tributary waterways directly affected by the Project.

33. In addition to those described above, there are also numerous smaller tributaries present in the both catchments (mainly in the valley floors) that are described as 'drains' (many of which are categorised as either ephemeral or intermittent)[8].

34. I note in Mr Ridley's evidence that he states the streams within the Project area "*…have been subject to, and continue to be subject to, significant feral pig damage*"[9]. Notwithstanding that Mr Ridley provides no evidence to substantiate this claim, I am surprised that such an obvious and apparent adverse effect on aquatic habitat has not been acknowledged or noted by Mr Hamill.

35. Furthermore, I note Mr Ridley's evidence states that the baseline water quality monitoring data (which commenced in November 2017) "*shows the high sediment*

[8] Most larger rivers are **perennial**, meaning they maintain continuous flow throughout the year. However, certain riverine ecosystems experience periodic flow cessation and often loose some or all surface water – these being termed **temporary** streams and rivers. **Temporary** streams can be further classified as **intermittent** and **ephemeral**. **Intermittent** systems are typically conceptualized as having relatively long, seasonal flowing phases, compared with precipitation-driven hydrological unpredictability in **ephemeral** streams (Stubbington et al. 2018, and references therein).

[9] Mr Ridley's EIC at paragraph 47.

loadings that occur naturally in these waterways during rain events which is a reflection of the underlying geology"[10]. I highlight the following issues with that statement:

a) The monitoring data provided in Annexure 2 of the Construction Water Discharges Monitoring Programme (CWDMP), provides concentrations[11] of total suspended solids (TSS), assumed to be collected at either relatively low or high water levels (not sediment loads)[12]. To calculate sediment loads, it is also necessary to have a corresponding measure of stream discharge (Q) when the sample was collected (i.e., they should be discharge-weighted). Furthermore, depth-integrating sampling at multiple 'verticals' across the flow is also needed to properly measure sediment loads (Hicks and Gomez 2003). Finally, multiple samples are required across the period of interest (e.g., event-based, seasonally, etc.), as it is well recognised that single, discrete samples of TSS are of little value in terms of understanding dynamic processes (i.e., sediment load variation through time) in aquatic ecosystems (ANZECC[13] 2000).

b) Notwithstanding that Mr Ridley did not provide estimates of sediment loads, previous research into suspended sediment yields from New Zealand rivers demonstrates that rivers in this region (West coast study region) generally have low to moderate yields of suspended sediment (Hicks et al. 2011) (see Appendix 2). This study further highlights that suspended sediment yields to the New Zealand coast are dominated by rivers in the East Cape area (~69 Mt/y) and South Westland (~62 Mt/y) (Hicks et al. 2011).

Aquatic biota

Aquatic macroinvertebrate communities

36. As I describe below, the aquatic macroinvertebrate data collected by Mr Hamill demonstrates that the macroinvertebrate communities of most of the waterways in the Project area are in very good to excellent condition. Furthermore, the

[10] Mr Ridley's EIC at paragraphs 49 – 52.
[11] Mr Hamill's EIC at paragraph 76.
[12] Sediment loads are defined by Davies-Colley et al. (2015) as "*the dry-weight mass flux (or discharge) of sediment across a channel section averaged over a period of time*".
[13] Australian and New Zealand Environment and Conservation Council.

waterways of the area provide habitat for numerous rare and at-risk taxa of notable conservation value.

37. Benthic macroinvertebrates are organisms without backbones that live on or within the streambed substrata. Examples of aquatic invertebrates found in rivers include insect nymphs/larvae (e.g., mayflies, stoneflies, caddisflies, etc.), aquatic oligochaetes (worms), crustaceans (e.g., shrimps and crayfish), and molluscs (e.g., snails). Macroinvertebrates occupy a niche as primary consumers, feeding mostly on periphyton, detritus (i.e., leaf litter, dead wood, decomposing macrophytes, etc.), or other invertebrates. In turn, they are predated upon by fish and other vertebrates, such as waterfowl. In addition to their intrinsic value, they are important for processing organic matter and primary productivity, and passing it on to higher trophic levels (i.e., organisms higher in the food chain) (Parkyn et al. 2010).

38. The following metrics/indices have been provided by Mr Hamill describing the benthic macroinvertebrate data collected;

a) **Taxa richness**: The total number of macroinvertebrate taxa (families, genera, species) present in a sample. In general, a stream which has a diverse range of habitat and/or high water quality will support a variety of different taxa, and numbers recorded will be higher. However, one issue with taxa richness is that higher taxa richness does not always necessarily infer 'better', and can occur in streams that are slightly enriched (e.g., nutrient runoff from intensive agriculture), rather than in streams that are in 'pristine' condition. Benthic macroinvertebrate taxa richness can also be influenced by flow regime. For example, taxa richness is often reduced immediately following high flow events.

b) **EPT taxa richness**: The total number of pollution-sensitive Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) 'EPT' taxa. Generally, streams that have high quality habitat and/or 'clean' water will support stream benthic macroinvertebrate communities with greater numbers of sensitive EPT taxa.

c) **Percent EPT taxa (% EPT taxa)** – the number of pollution-sensitive Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) 'EPT' taxa. Generally, streams that have high quality habitat and/or 'clean' water will support stream macroinvertebrate communities with greater numbers of sensitive EPT taxa.

d) **MCI and SQMCI scores** – the Macroinvertebrate Community Index (MCI) and the Semi-Quantitative MCI (SQMCI) are biological indices that are based on indicator scores of between 1 to 10 assigned to each taxon, reflecting their sensitivity to organic enrichment. Although developed to assess nutrient enrichment, it is now used to evaluate the general health of New Zealand streams. MCI scores are based on presence/absence data, while the SQMCI incorporates coded abundance data (rare, common, abundant, very abundant, very very abundant). Higher MCI and SQMCI scores generally indicate better habitat quality (and concomitantly better water quality). These scores are interpreted following the thresholds and classes provided in Table 1.

Table 1. Intrepretation of MCI and SQMCI scores (reproduced from Stark & Maxted 2007).

Quality class	MCI	SQMCI
Excellent	>119	>5.99
Good	100 – 119	5.00 – 5.99
Fair	80 – 99	4.00 – 4.99
Poor	<80	<4.00

39. Benthic macroinvertebrate samples were collected by Mr Hamill on three sperate sampling occasions in 2017 (see Appendix 3 for sampling site locations):

i. **7 – 8 June**: four sites in the Mangapepeke Stream (E2, E3 and E4) and two sites in the Mimi River catchment (E6 and E7);

ii. **31 July – 1 August**: two sites in the Mangapepeke Stream (Ea10 and Ea13) and three sites in the Mimi River catchment (Ea26, Ea27 and Ea28); and

iii. **30 October – 1 November**: four sites in the Mangapepeke Stream catchment (ETL5, Ea7, Ea23 and N1TL).

40. Aquatic macroinvertebrate sampling at most sites was undertaken using Protocol C2 (soft-bottomed, semi-quantitative method) of Stark et al. (2001). Protocol C1 (hard-bottomed, semi-quantitative method) was undertaken at a limited number of sites.

41. Pollution-sensitive taxa comprise a majority or abundant component of most of the macroinvertebrate communities sampled.

42. It is worth noting, however, that site Ea28, which recorded the poorest quality macroinvertebrate community was sampled after a large rainfall event (25 mm of rain within the preceding week, and approximately 50 mm of rain within the preceding 10 days). The resulting flood events, which can mobilise bed material, can cause significant mortality and displacement of invertebrates, and several weeks of stable flows may be required for communities to regain characteristics observed prior to the flood. Consequently, this yields a degree of uncertainty to the representativeness of the data collected from this sampling round (i.e., it may under-represent the macroinvertebrate communities usually present during baseflow conditions). Also, site N1 TL is in a separate sub-catchment of the Mangapepeke Stream (to the west of the Project area); therefore, is not directly representative of the macroinvertebrate communities of the Project area.

43. In addition to the data collected by Mr Hamill, ten Malaise net samples (set as part of the terrestrial invertebrate surveys by Dr Corinne Watts) were examined by Mr Brian Smith of NIWA for specimens of the winged adult stage of EPT taxa (to complement Mr Hamill's aquatic benthic survey data). For ease of reference, the main findings from Mr Smith's investigation are reproduced here;

a) Twenty-six EPT specimens representing 11 species were recovered from five Malaise nets;

b) Nine of the 11 species are listed as 'Not Threatened' under the New Zealand Threat Classification System (NZTCS)[14] by Grainger et al. (2014), due to large stable populations;

c) A single specimen of *Alloecentrella incisus*, a small Helicophidae caddisfly with a central North Island distribution (Henderson & Ward 2007), was recorded from Plot 5 (in the Mimi River catchment). This species is classified as 'At Risk – Naturally Uncommon' by Grainger et al. (2014). Although *A. incisus* is considered 'Range Restricted' (Grainger et al. 2014), it was, however, collected within its known distribution; and

d) The Notonemouridae stonefly, *Spaniocercoides watti*, recorded from Plot 1 (in the Mimi River catchment) was previously known from only eight females from two North Island locations; five from Waipoua State Forest and three

[14] The New Zealand Threat Classification System (NZTCS) assesses the conservation status of species according to the risk of extinction they face within New Zealand (Townsend et al. 2007). Please refer to Appendices 4 and 5 for further information.

from the Kiripaka Stream. The additional four specimens recorded are also female and represent the southern-most distribution record for this species. Due to an overall lack of information on the distribution and abundance of *S. watti*, this species is classified as 'Data Deficient' by Grainger et al. (2014).

44. Finally, there is a single record of the Dytiscidae beetle, *Hyphydrus* (*Apriophorus*) *elegans* (Montrouzier, 1860), from the lower Mimi River catchment (see Appendix 6). This species is classified as 'Data Deficient' by Grainger et al. (2014).

45. It is worth noting that targeted sampling of stream habitats for aquatic macroinvertebrate taxa (e.g., dedicated Malaise netting) within the Project area would, in all likelihood, reveal further records of taxa of notable conservation value (Death [2015]). The reason being is that positive species-level identification of many of New Zealand's aquatic invertebrate fauna is not achievable without examining the adult life stage (particularly adult male genitalia) (Mr Hamill's aquatic macroinvertebrate samples were identified mainly to genus[15] level [as most individuals will be in an immature life history phase]). This was similarly noted by Forest & Bird (paragraph 119 of the s92 request).

Megainvertebrate fauna

46. Two megainvertebrates were recorded from several sites within the Project area: kōura/freshwater crayfish (*Paranephrops planifrons*) and kākahi/freshwater mussel (*Echyridella menziesii*)[16]. Kākahi have a conservation status of 'At Risk – Declining', while kōura are 'Not Threatened' (Grainger et al. 2014).

47. I agree with Mr Hamill's comments that both species are likely to be widespread in waterways throughout the Project area, despite Mr Hamill only recording kākahi from the lower reaches of both the Mangapepeke Stream and the Mimi River.

48. In addition to Mr Hamill's surveys, spotlighting surveys undertaken by DOC staff in the summer of 2013 also recorded large populations of kākahi from the upper Mimi River (study site 2) (Figure 3). The authors of that report noting that the

[15] Genus is a taxonomic rank within the biological classification of organisms. In the hierarchy of biological taxonomy, the genus level sits below the family level and above the species level.

[16] Mr Hamill noted *Hyridella* sp. as being present. This genus name was noted as *Echyridella* in Grainger et al. (2014). These kākahi are likely to be *Echyridella menziesii* (Dieffenbach, 1843), based on the recorded distributions of the three freshwater mussel species known from New Zealand (Dr Susan Clearwater, Ecotoxicology Scientist, NIWA, pers. comm.).

Figure 3. Photographs of a freshwater mussel bed (top), a mature indiviual (middle) recorded from the upper Mimi River by DOC staff during the summer of 2013. The sample sites (study sites 1 & 2) are shown in the bottom panel.

"*Mimi River has extensive freshwater mussel beds which are possibly rare in the region and should be protected*". Kōura were also recorded at both sites during these surveys

Fish communities recorded, including their habitat requirements and life histories

49. Mr Hamill undertook fish surveys using a variety of standard methods (electric-fishing, fyke netting, and spotlighting), at 11 sites in the Mangapepeke Stream[17] and five sites in the Mimi River[18] catchments. These surveys were undertaken at the same time of year as the benthic macroinvertebrate surveys; however, some sites were resurveyed in the latter sampling round (late October to early November).

50. As with the aquatic macroinvertebrate sampling, caution is needed when interpreting the winter fish surveys results. As noted by Mr Hamill, this is not recommended, with national guidelines recommending avoiding fish surveys between 1 May and 30 November (Joy et al. 2013). This recommendation is due to fish becoming less active at lower water temperatures, and thereby less susceptible to capture. This seasonal effect was highlighted when sites E4 and E5 in the Mangapepeke Stream were resurveyed in October, following the initial survey in June. Only two species were recorded during the winter surveys – a single longfin eel (*Anguilla dieffenbachii*), and 24 redfin bully (*Gobiomorphus huttoni*). In contrast, five species were recorded during the spring survey – giant kōkopu (*Galaxias argenteus*), banded kōkopu (*Galaxias fasciatus*), and kōura, as well as longfin eel and redfin bully – totalling 99 individuals. Notwithstanding different methods were employed across the two sampling events, this finding suggests that the winter-collected data is likely to have under-represented the extant fish communities.

51. Nevertheless, Mr Hamill recorded a total of seven fish species across the three sampling events. These include shortfin eel (*Anguilla australis*), longfin eel, giant kōkopu, banded kōkopu, īnanga (*Galaxias maculatus*), common bully (*Gobiomorphus cotidianus*), and redfin bully. Four of these species – longfin eel, giant kōkopu, īnanga and redfin bully – have a conservation status of 'At Risk – Declining', under the NZTCS (Goodman et al. 2014). The three remaining fish species have a conservation status of 'Not Threatened'.

52. Mr Hamill also calculated the fish index of biotic integrity (IBI) for all the winter survey sites (E1, E4, E5, E6, E7 and Ea25). The fish IBI is based on six separate

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[17] Mangapepeke Stream sub-catchment sites: E1, Ea7, Ea10a, Ea10b, Ea12, Ea13, E4, Ea14, E5, Ea15 and E TL5.

[18] Mimi River catchment sites: E6, Ea21, Ea23, E7 and Ea25.

metrics, which are combined to derive a single composite value (ranging from 0 to a maximum of 60) that provides a measure of the condition of fish communities at a given site. The interpretation of final scores varies by region (depending on the distribution of site scores and the resulting quantile regression lines); however, IBI scores between 47–60 are generally considered 'Excellent', while scores between 36–46 are considered 'Good' (Joy 2007). All sites surveyed recorded scores in the 'Excellent' to 'Good' range. Mr Hamill did not report fish IBI scores for the remainder of the sites surveyed.

53. In addition to Mr Hamill's fish surveys, the New Zealand Freshwater Fish Database (NZFFD)[19] lists three further fish species recorded from the Tongaporutu and Mimi River catchments. These additional species include shortjaw kōkopu (*Galaxias postvectis*), kōaro (*Galaxias brevipinnis*) and giant bully (*Gobiomorphus gobioides*) (see Appendix 7). Under the NZTCS, shortjaw kōkopu is listed as 'Threatened – Nationally Vulnerable', kōaro as 'At Risk – Declining', while giant bully as 'Not Threatened' (Goodman et al. 2014). Photographs of some the native freshwater fish species recorded are shown in Appendix 8.

54. I consider the apparent lack of non-native fish from both catchments is noteworthy, and further adds to their conservation value.

55. The habitat requirements and general biology of the native freshwater fish taxa recorded from the Project area, as well as the wider Tongaporutu and Mimi River catchments, are wide-ranging and variable. For the sake of brevity, this information is summarised in tabular format in Table 2.

56. In addition to the information provided in Table 2, many native freshwater fish require different habitats for different stages of their life cycle (i.e., spawning, nursery, juvenile and adult habitat) (ontogenetic habitat shifts)[20]. Furthermore, diel and seasonal variation in habitat preferences have been described for many of New Zealand's native freshwater fish, whereby individuals have differing habitat preferences depending on the time of day and season (e.g., David & Closs 2003; Davey et al. 2011). Many fish switch between distinct sheltering or resting habitats

[19] NZFFD retrieved 2 May 2018.

[20] Ontogenetic changes in habitat are driven by shifting life history requirements, whereby different habitats are selected during various life history stages, often to avoid predators and/or improve foraging (and thereby maximise energy gains) (Sutherland 1996, cited in Ong et al. 2015).

Table 2. Conservation status, habitat requirements and general biology of the freshwater fish recorded from within (and nearby) the Project area.

Common name	Taxa	Conservation status[1]	Habitat requirements[2]	Diadromous (Y/N)[2, 3]	Spawning habitat and timing[2, 3]
Shortfin eel	*Anguilla australis*	Not Threatened	Use a wide variety of habitats such as lakes, wetlands and low elevation rivers and streams. Usually secretive and nocturnal, using cover such as aquatic macrophytes, large woody debris, tree roots, undercut banks, deep pools and large boulders. Most abundant in low gradient waterways close to the coast.	Y	Marine – subtropical Pacific Ocean spawning grounds.
Longfin eel	*Anguilla dieffenbachii*	At Risk – Declining	Like shortfin eels, also uses a wide variety of habitats. Juveniles and smaller adults live amongst gravels in riffles; larger adults forage in riffles. Instream cover used by adult eels includes aquatic macrophytes, large woody debris, tree roots, undercut banks, deep pools and large boulders.	Y	Marine – subtropical Pacific Ocean spawning grounds.
Giant kōkopu	*Galaxias argenteus*	At Risk – Declining	Adult fish live in deep, slow-flowing water with plenty of instream cover. Instream cover such as; woody debris, macrophytes, undercut banks, and riparian vegetation are very important for giant kōkopu. Juveniles live in similar habitat to the adults, but use faster-flowing backwaters close to riffles.	Y*	Apr–Aug, on low gradient stream banks amongst vegetation on riparian margins alongside adult habitat.
Kōaro	*Galaxias brevipinnis*	At Risk – Declining	Known as riffle dwellers, living in fast flowing shallow habitats with cobble and boulder substrates, in forested catchments. Can also inhabit lakes (non-diadromous populations).	Y*	Apr–Jun; amongst gravels on river margins alongside adult habitat (partially submerged).
Banded kōkopu	*Galaxias fasciatus*	Not Threatened	Small stable streams with large cobble substrate, and pools. Like giant kōkopu require good instream cover (e.g., undercut banks, large woody debris, marginal vegetation, etc.).	Y*	Apr–Jun; riparian margins alongside adult habitat.
Īnanga	*Galaxias maculatus*	At Risk – Declining	Live in a wide variety of pelagic habitats, but prefer areas where instream cover is available (e.g., macrophytes and marginal vegetation).	Y*	Feb–Jul, with peak Mar–May; riparian vegetation in tidal reaches.
Shortjaw kōkopu	*Galaxias postvectis*	Threatened – Nationally Vulnerable	Densely forested streams with large cobble and boulder substrates, and stable pools.	Y*	Apr–Jul, with peak May–Jun; amongst litter and gravels on river margins alongside adult habitat.
Common bully	*Gobiomorphus cotidianus*	Not Threatened	Amongst gravel/cobble substrates in margins of gravel rivers, usually in areas of slower flow.	Y*	Oct–Feb; eggs laid in nests under rocks or amongst aquatic vegetation or instream debris.
Giant bully	*Gobiomorphus gobioides*	Not Threatened	Habitats containing plenty cover (e.g., overhanging banks, large rocks and large woody debris). Highly solitary and territorial.	Y	Oct–Feb, not well known, but similar to other bullies (i.e., nests under rocks)
Redfin bully	*Gobiomorphus huttoni*	At Risk – Declining	Stable rivers and streams with moderate to swiftly flowing water. Live amongst large cobble and boulder substrates in riffles and rapids.	Y	Aug–Nov; eggs laid in nests on flat surfaces on the underside of rocks in slower-flowing, shallow areas.

Notes: [1] Goodman et al. (2014); [2] McEwan (2015), and references therein; [3] Water Ways Consulting Limited (2017), and references therein; * These taxa can also form non-diadromous populations (i.e., facultative diadromy).

during the day, to more active foraging behaviours at dusk or night (crepuscular activity) (e.g., giant kōkopu) (David & Closs 2003). With respect to seasonal variation in habitat use, David & Closs (2003) found that giant kōkopu occupied areas of low flow velocities, relatively deep water, and silty substrata when active during winter, whereas when active during summer, they occupied areas of higher water velocities, shallower depths, and coarser substrata (i.e., actively selecting different habitats by season). Such temporal shifts in habitat preference means that to protect a particular fish species within a catchment, it is necessary to retain suitable habitat (and unimpeded access to it) for all stages and periods of that taxon's life history, not just daytime adult habitat.

57. All ten of the freshwater fish taxa recorded from the Project area are diadromous – meaning they migrate between freshwater environments and the sea during some part of their life cycle (McDowall 1990).

58. The migratory patterns of these ten diadromous taxa can be divided into two main categories: 'catadromous' and 'amphidromous'. Catadromous species (eels) live in freshwater but migrate to spawn at sea, while amphidromous taxa (large galaxiids, īnanga and bullies [common, giant, and redfin]) spend part of their life at sea, but this marine stage is not directly related to spawning. Larval movement to the sea is facilitated by river flow, which is followed (several months later) by an upstream migration of juveniles back into freshwater, where they develop into adults and spawn (McDowall 1990). Therefore, unimpeded access to and from the sea is required for all these species.

Conservation values of the Tongaporutu and Mimi River catchments

Overview of freshwater conservation tools and spatial frameworks

59. A number of tools have been developed by DOC to aid in assessing ecosystem patterns, ecological integrity[21], and conservation priority of New Zealand's freshwater ecosystems. These tools, which are used for prioritising conservation effort, were initiated within Central Government's Waters of National Importance (WONI) programme, and resulted in the output of a draft framework and candidate list of river catchments for priority management (Chadderton et al. 2004). Following adoption into DOC's wider Natural Heritage Management System

[21] Ecological integrity can be defined as "*The degree to which the physical, chemical and biological components (including composition, structure and process) of an ecosystem and their relationships are present, functioning and maintained close to a reference condition reflecting negligible of minimal anthropogenic impacts*" (Schallenberg et al. 2011).

(NHMS), it was apparent that improvements were required with respect to classifying and prioritising freshwater ecosystems to align WONI products with the NHMS approach. These improvements were subsequently developed into a decision support tool for ranking conservation values of river sub-catchments nationally – Freshwater Ecosystems of New Zealand (FENZ)[22] (Leathwick et al. 2010a). FENZ (and its outputs for riverine values) will be discussed in greater detail in the following sections.

Freshwater Ecosystems of New Zealand (FENZ)

60. As I describe in this section, spatial analyses identify the Tongaporutu River (and to a lesser extent the Mimi River) catchment as having significant conservation values throughout its entire catchment. This evaluation is based on both their contribution to the protection of a representative range of New Zealand's riverine ecosystems, and their high levels of ecological integrity.

61. As stated above, FENZ has been developed to support assessment of the conservation value and ecological integrity of New Zealand's riverine and terrestrial ecosystems, and these are directly relevant to any assessment of the values of the landscapes and associated riverine features that would be affected by the Project. FENZ is a spatially-explicit decision support tool that includes (i) a comprehensive collection of spatial data describing ecosystem patterns, ecological integrity and conservation values of New Zealand's rivers and streams, and (ii) a systematic approach to the prioritization of ecosystem management to ensure the protection of a representative range of New Zealand's ecosystems.

62. To objectively assess the conservation value and ecological integrity of both the Tongaporutu and Mimi River catchments, it was necessary to initially place them both into the broader context of their environmental similarities with other New Zealand rivers, and then separately compare the conservation rankings and ecological integrity scores (contained within the FENZ database) of these selected rivers. Without such an approach, comparing the rankings of the Tongaporutu and Mimi rivers against other rivers of varying environmental characteristics (and associated biological communities) is relatively uninformative. Appendix 9 to my evidence sets of the methods used for this exercise.

[22] https://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/.

63. In addition to maps of catchment ecological integrity, I created three separate maps of the conservation rankings for each of the Tongaporutu and Mimi rivers, with their respective similar catchments:

i. Biogeographic (regional) unit ranks;

ii. National ranks; and

iii. National ranks with protected planning units accounted for (protection mask)[23].

64. Sub-catchment ranks for each of these maps can be interpreted as blue catchments having the highest rank/value, while dark red/orange have the lowest rank/value (apart from national rank with protection mask [which is described above]).

65. For the sake of brevity, I have only included the biogeographic (regional) unit rank maps in the main body of my evidence (Figure 4 & Figure 5); the remaining maps can be seen in Appendix 9. As can be seen from the maps, the classification has identified three comparable catchments for the Tongaporutu (all of which lie north of the Tongaporutu), and 28 comparable catchments for the Mimi River (all of which are coastal, being mainly scattered along the Marlborough, Nelson and Tasman coastlines, in addition to the two neighbouring catchments to the south of the Mimi).

66. The Tongaporutu River ranked second highest (out of four rivers) within the biogeographic (regional) unit rankings (median: 8.9%), national level rankings (median: 7.1%), and the national sub-catchment ranks with protected sub-catchments included (protection mask) (median: 25.5%) (Figure 6). The Mohakatino River had the highest rank for all three rankings (medians: 1.5%, 1.9% and 22.7%, respectively). To put these values into context, FENZ rankings within the top 20% is a criterion regularly used to determine the highest priority sites within a given region, or nationally. Finally, the Tongaporutu River ranked second highest for catchment condition/ecological integrity (median: 0.78). Like the

[23] These set of national rankings were calculated in which planning units having 80% or more of their area protected were held back until all other planning units had been removed – this indicates both the relative value of planning units that are already protected (green colour ramp), and those units that are currently lacking protection that would best complement those already protected (blue to grey colour ramp) (Leathwick et al. 2010a).

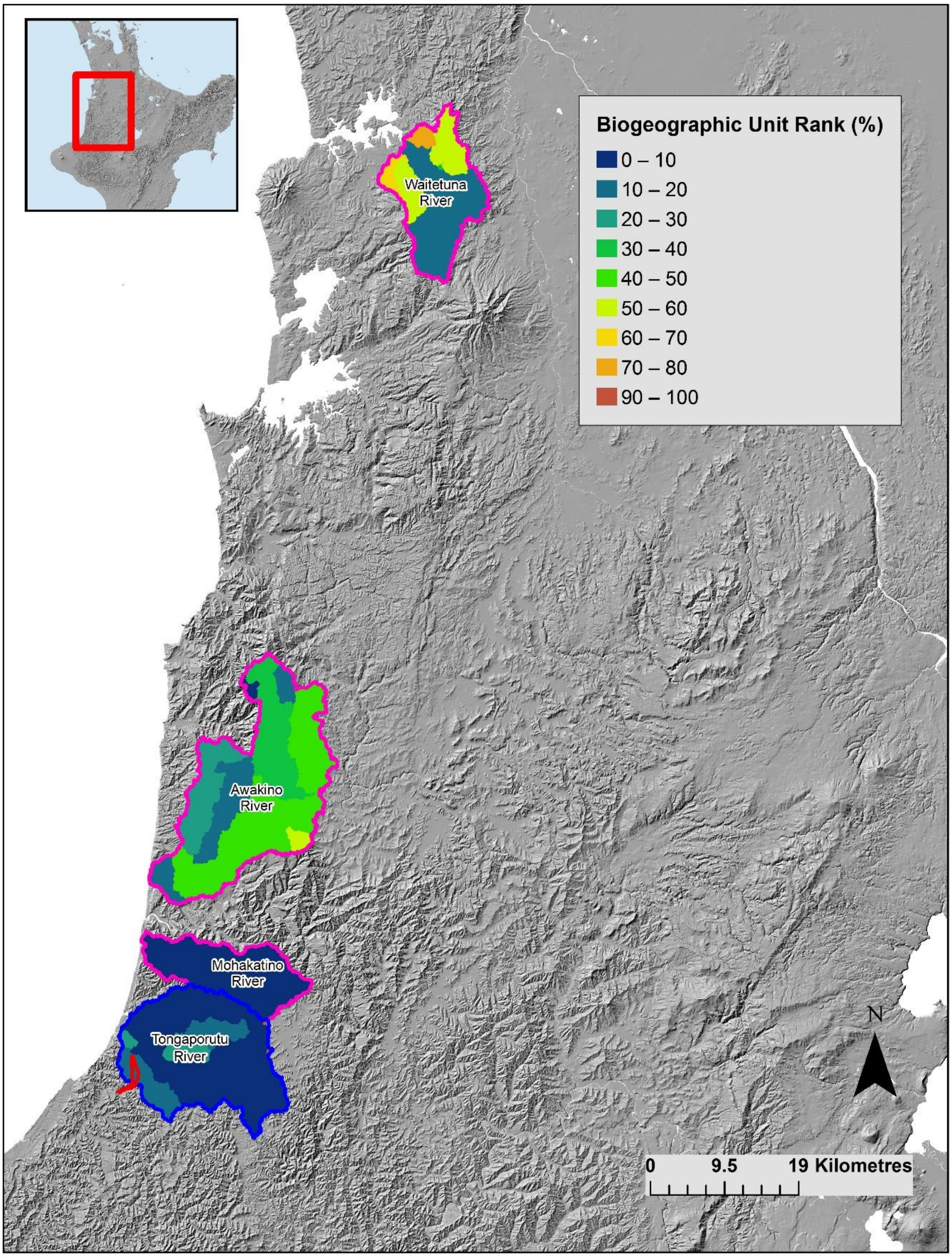

Figure 4. Biogeographic (regional) unit sub-catchment ranks for the Tongaporutu River and similar catchments. The Project area is highlighted in red.

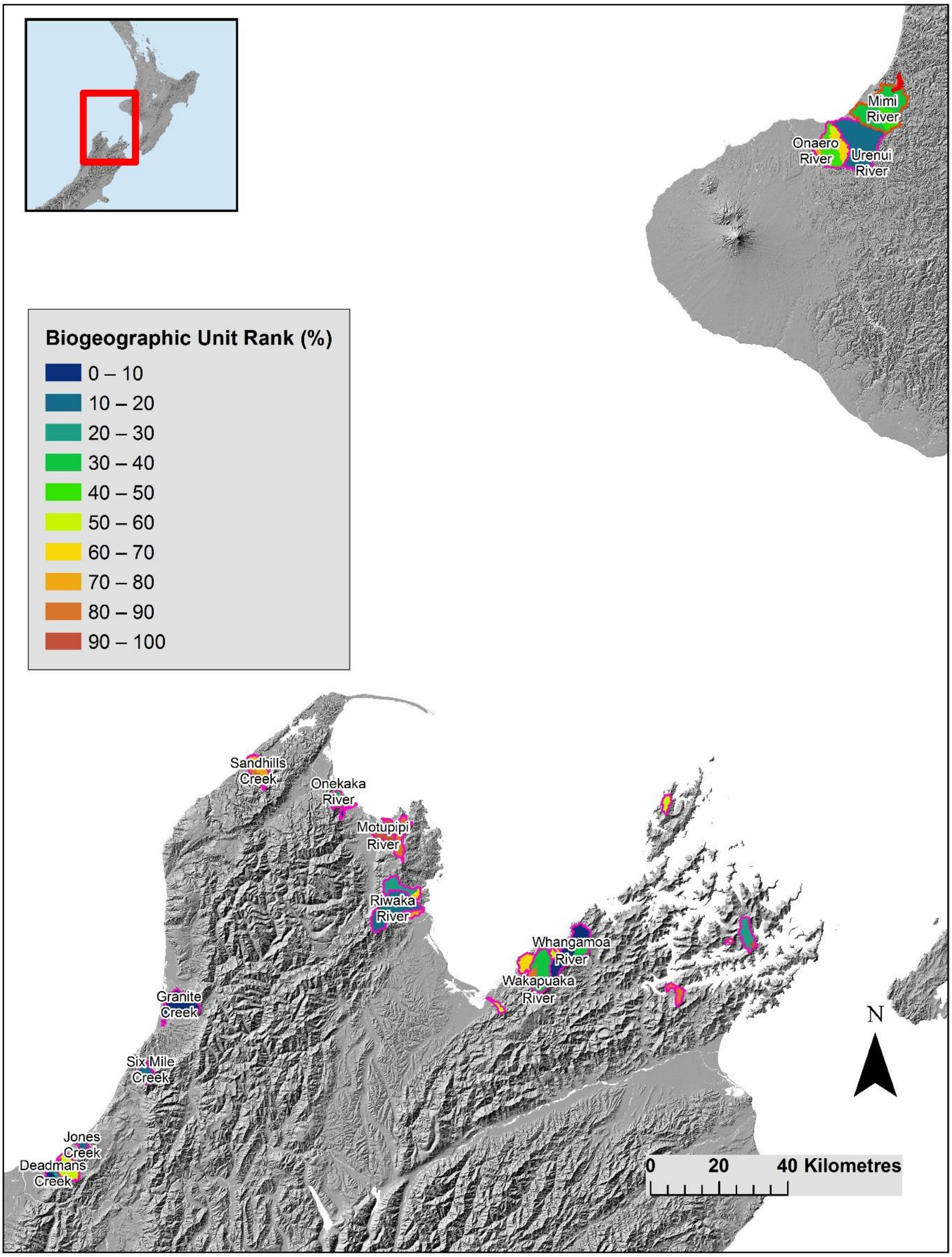

Figure 5. Biogeographic (regional) unit sub-catchment ranks for the Mimi River and similar catchments. The Project area is highlighted in red.

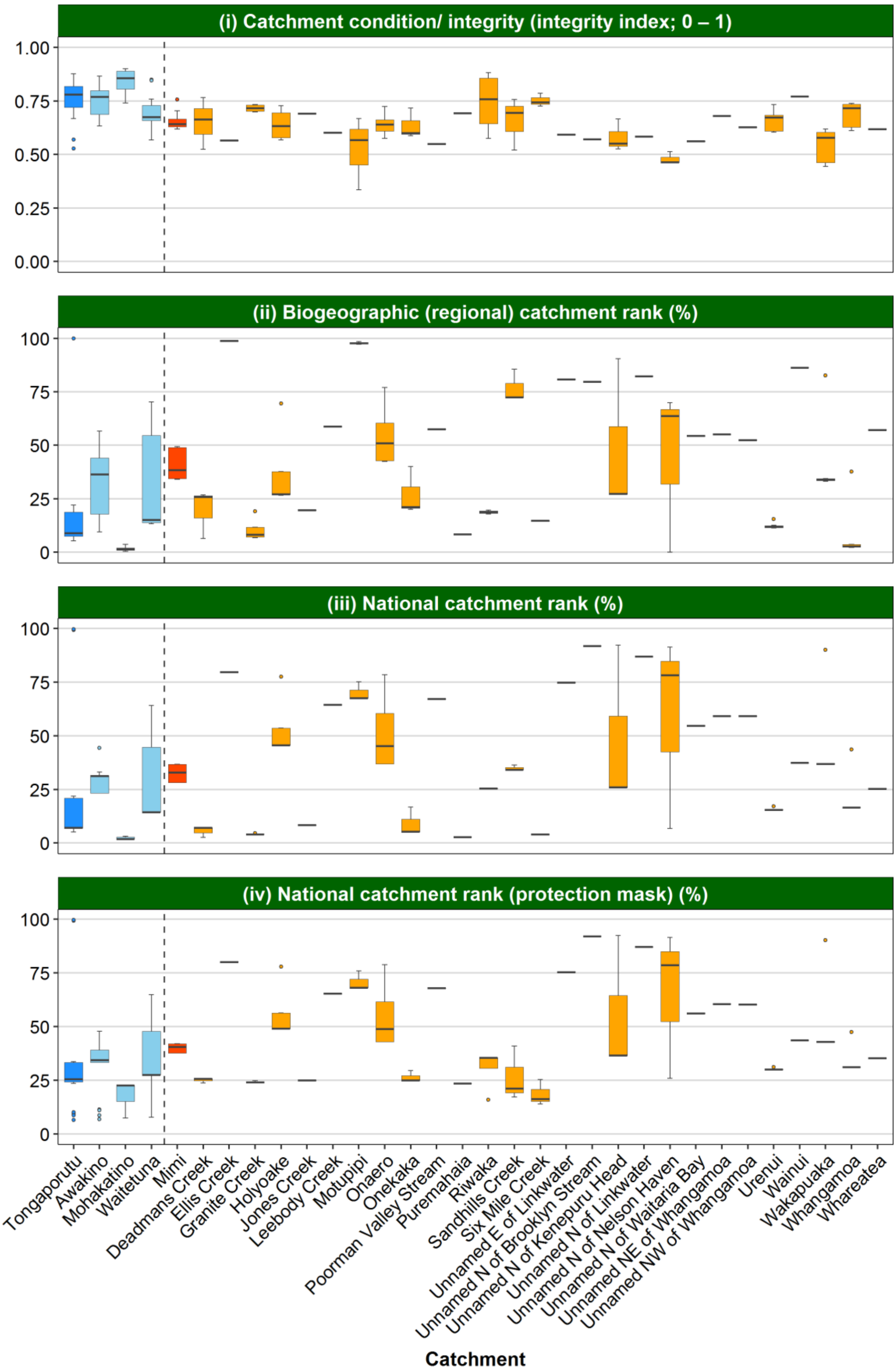

Figure 6. Boxplots[24] of the median catchment (from top to bottom) (i) condition/integrity, (ii) biogeographic (regional) ranks, (iii) national ranks, and (iv) national ranks (protection mask) for both the Tongaporutu (blue) and Mimi River (red/orange) catchments.

[24] These plots show the median sub-catchment value at the centreline of the box, the 25th to 75th percentiles are enclosed within the rectangular box, and the range (based on 1.5 x interquartile range) is shown by the 'whiskers'. The individual points represent outliers.

analyses, the Mohakatino River ranked highest with respect to catchment condition/ecological integrity (median: 0.86).

67. The Mimi River ranked thirteenth (out of 28 rivers) within the biogeographic (regional) unit rankings (median: 38.5%), and ranked twelfth for both the national level rankings (median: 32.9%) and the national sub-catchment ranks with protected sub-catchments included (protection mask) (median: 40.5%) (Figure 6). The Whangamoa River (northeast of Nelson) had the highest regional rank of all catchments (median: 2.8%), the Puremahaia River (northwest of Takaka) had the highest national rank (median: 2.9%), and Six Mile Creek (north of Seddonville) had the highest protection mask ranking (median: 16.3%). The Mimi River ranked twelfth for catchment condition/ecological integrity (median: 0.64). The Wainui River (east of Takaka) ranked highest with respect to catchment condition/ecological integrity (median: 0.77).

Assessment of ecological value using the Stream Ecological Valuation (SEV) method

68. Mr Hamill used Auckland Council's Stream Ecological Valuation (SEV) method (Storey et al. 2011a) to assess the ecological values of the affected streams, and to form the basis for effects assessment and development of an ecological compensation package.

69. I consider the SEV is a useful tool for broadly assessing streams in terms of their ecological function. However, in my opinion, it not an appropriate or sufficient tool for assessing biodiversity values, nor for quantifying the amount of compensation required for lost biodiversity values.

70. The SEV method is based on 14 ecological functions, which are grouped into four main functional categories:

i. **Hydraulic functions (4)** – natural flow regime; floodplain effectiveness; connectivity for natural species migrations; natural connectivity to groundwater;

ii. **Biogeochemical functions (5)** – water temperature control; dissolved oxygen levels; organic matter input; instream particle retention; decontamination of pollutants;

iii. **Habitat provision functions (2)** – fish spawning habitat; habitat for aquatic fauna; and

iv. **Biodiversity provision functions (3)** – fish fauna intact; invertebrate fauna intact; riparian vegetation intact.

71. The SEV score is essentially the 'currency' used to calculate the Environmental Compensation Ratio (ECR) (Figure 7). The ECR is a separate tool, used in conjunction with the SEV, which allows the calculation of mitigation required to offset the impact arising from the proposed activity. The ECR is calculated using a simple and straightforward formula based on the predicted decline in SEV score at the impact site and the predicted increase in SEV score at the mitigation site. The inclusion of the multiplication factor of 1.5 in the ECR calculation accounts for the time lag between performing stream remediation works and realising the ecological benefits of such works (including uncertainty of potential outcomes)[25].

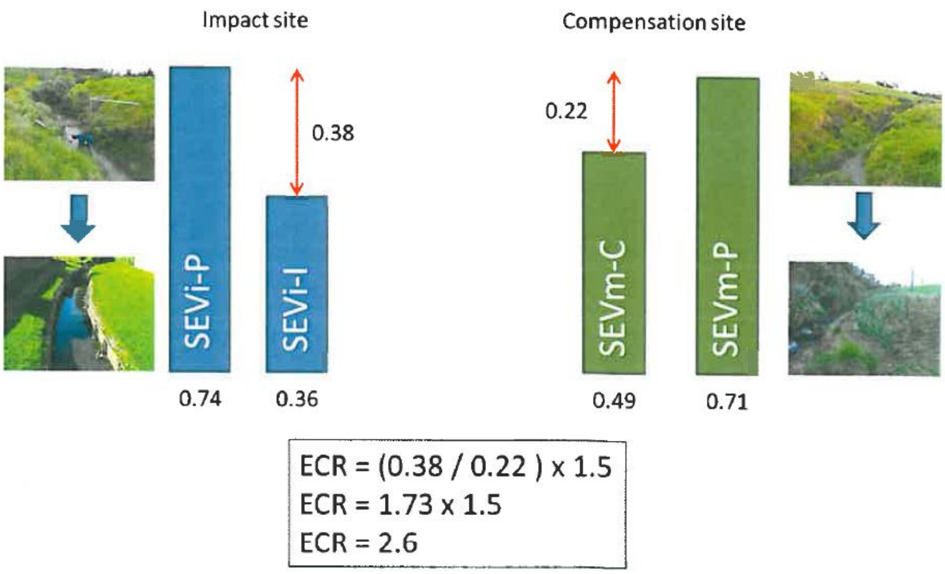

Figure 7. An example of calculating an ECR using the SEV scores. The ECR incorporates the loss of SEV score at the impact site (0.38), with the gain at a mitigation site (0.22), to derive a ratio of 2.6.

72. Despite having a function group for 'biodiversity provisions', thereby implying that biodiversity values are given reasonable regard with this method, overall the SEV provides a limited measure of biodiversity (only three of the 14 functions relate to biodiversity). This was not the intention of the method (Storey et al. 2011a). It was designed to assess the health or ecological value of streams from a <u>functional</u> perspective, not from a biodiversity perspective.

[25] Mr Hamill's EIC at paragraph 42.

73. Furthermore, the SEV method requires the biotic functions 'fish fauna intact' and 'invertebrate fauna intact' to be excluded from the calculation of the ECR due to "*the difficulty of predicting these outcomes*" (Storey et al. 2011a). Therefore, while the SEV provide a means of assessing and predicting several ecological functions, and combining them into a composite value used to calculate a compensation ratio, these scores give limited regard to biodiversity values.

74. I will discuss the limitations of using the SEV method (in isolation) to quantify biodiversity compensation, as well as my concerns about the application of the SEV and ECR methods for this Project, later in my evidence.

High quality/value waterways recognised in the Regional Policy Statement and Regional Freshwater Plan

75. The Regional Policy Statement (RPS) and the Regional Freshwater Plan (RFP) recognise both the Tongaporutu and Mimi rivers as having high natural, ecological and amenity values (Appendix I of the RPS). The specific values recognised for each catchment are listed in Table 3.

Table 3. Specific values recognosed in the RPS and RFP for the Tongaporutu and Mimi River catchments (reproduced from Appendix I of the RPS).

Catchment	Recreational & fishery values	Aesthetic & scenic values	Comments
Tongaporutu	Good diversity of native aquatic fauna including eels, whitebait, bullies and torrent fish and presence of threatened species. Recreational uses (canoeing, whitebaiting).	Highly rated for aesthetic and scenic values. Estuary considered to be an area of outstanding coastal value.	Water quantities and flows contribute significantly to high recreational, scenic and aesthetic values. Native forest in upper reaches
Mimi	Whitebaiting. Good diversity of native aquatic fauna including eels, whitebait, bullies and torrent fish.	Good scenic values, steep cliffs with puketea forest. High ecological values in upper reaches. Estuary considered to be an area of outstanding coastal value.	Retained native vegetation.

76. Protection of these rivers and streams is afforded by many separate policies across different sections within the RPS[26].

[26] Policies 1, 2, 3 and 5 of Section 6.1; Policies 1, 2, 3, 4 and 5 of Section 6.2; Policies 2 and 3 of Section 6.3; Policies 1 and 2 of Section 6.4; Policy 1of Section 6.5; Policies 1 and 2 of Section 6.6; Policy 1 of Section 6.7; Policies 1 and 2 of Section 7.1; Policies 1, 2, 3 and 4 of Section 8.1: Policies 1, 2 and 3 of Section 8.2; Policy 1 of Section 8.3; Policies 1, 2, 3, 4 and 5 of Section 9.1; Policies 1 and 2 of Section 10.1; Policies 1 and 2 of Section 10.2; Policy 1 of Section 10.3; Policies 1, 3 and 4 of Section 11.1; Policy 2 of Section 14.1; Policy 1 of Section 15.1.

77. Regarding the RFP, protection of these catchments is afforded by way of Policy 3.1.4 – "*The high natural, ecological and amenity values of those rivers and streams listed in Appendix IA will be maintained and enhanced as far as practicable. Adverse effects of activities on these values will be avoided as far as practicable, or remedied or mitigated*".

78. Inanga spawning sites are also known from the lower reaches of both the Tongaporutu and Mimi rivers (Taranaki Regional Council [TRC] 2013) (see Map in Appendix 10).

ASSESSMENT OF AQUATIC ECOLOGICAL EFFECTS

79. The Project will have adverse effects on streams, rivers, and wetlands in the Project area in a number of ways. These can be broadly grouped into short-term and long-terms effects[27].

80. The main short-term effects include (i) physical disturbance of the waterway during road construction (including facilitation works), habitat loss, fish passage impediments, sediment-related effects, vegetation clearance, potential contamination from construction-related sources (i.e., hydrocarbons, woodchip leachate, cement, etc.), and flow alteration due to two separate water abstractions (takes).

81. In contrast, the main long-term effects include (i) potential fish passage impediments; (ii) loss of stream habitat; (iii) potential biosecurity risks; and (iv) poor stormwater quality runoff.

82. According to Mr Hamill's calculations[28];

a) **2,882 m** of stream channel (corresponding area: 2,810 m^2) will be affected in the Mangapepeke Stream sub-catchment;

b) **823 m** of stream channel (corresponding area: 567 m^2) will be affected in the Mimi River catchment; and

c) In total, **3,705 m** of stream channel (corresponding area: 3,376 m^2) will be affected across both catchments. With respect to habitat type, Mr Hamill previously noted that 82% by length (94% by channel area) of the 3,822 m

[27] Mr Hamill's EIC at Table 5, page 22.
[28] Mr Hamill's supplementary evidence at paragraph 25 and Table 1, page 9.

stream length affected[29] was perennial habitat, with the 'pristine' value sites being completely perennial (based on my interpretation of Table 2.11 of the Supplementary Report). I assume that these habitat proportion values have not substantially changed with Mr Hamill's updated calculations. There is no mention as to the criteria Mr Hamill used to classify intermittent streams.

83. As recorded at our meeting on 28 March 2018, several of these potential effects have been resolved (in terms of adequate effects mitigation) between Mr Hamill and myself. These resolved issues will not be considered further in my evidence. There are, however, several outstanding issues, which I consider need to be addressed by the Applicant. These predominately relate to the proposed mitigation/compensation, particularly regarding:

a) biodiversity values of headwater systems;

b) potential fish passage impediments;

c) use of SEV to calculate biodiversity compensation;

d) calculations of ECR;

e) sediment discharge effects;

f) stream habitat fragmentation;

g) flow alteration effects;

h) fish recovery/rescue protocols; and

i) riparian offset restoration planting.

Proposed mitigation/compensation

Biodiversity values of headwater systems

84. As noted in DOC's submission[30] to both TRC and New Plymouth District Council (NPDC), I consider that the Applicant has not given sufficient consideration to the

[29] Mr Hamill's EIC at Table 4, page 21.
[30] Both submissions dated 27 February 2018.

biological importance of the affected headwater systems[31], with respect to effects mitigation/compensation.

85. There is an extensive body of literature highlighting the importance of headwaters streams (e.g., Freeman et al. 2007; Meyer et al. 2007a, b; Finn et al. 2011; Wohl 2017), including numerous studies from New Zealand (Parkyn et al. 2006; Smith 2007; Storey & Quinn 2008; Storey et al. 2011b). A recurring theme throughout much of this research is that headwater systems play an important role in actively sustaining biodiversity across many stream sizes, and headwaters probably contribute disproportionately to biodiversity at the river network scale (Finn et al. 2011). Furthermore, these systems are often overlooked, and are subject to greater degradation than higher-order streams as they are widespread, small, and perceived as having low biological value (Storey et al. 2011b). This problem has received particular attention in Taranaki, with a review of the Regional Freshwater Plan for Taranaki recommending amendments to policies, methods, and rules to address the impacts of small stream modifications (TRC 2012).

86. The attributes of headwaters that underpin their biological importance are numerous (e.g., Meyer et al. 2007a, b). Some of the attributes include the following (classified into four attribute groups):

a) Support many habitat-specialist or rare taxa

i. Provide unique and highly diverse physico-chemical habitats; and

ii. Provide a refuge from predators, competitors, and invasive species.

b) Headwaters are essential for species living in larger streams

i. Populations in headwaters are genetically connected to populations living in larger streams;

ii. Provide spawning and nursery habitats for many aquatic biota;

iii. Provide high-quality feeding areas;

iv. Provide thermal refugia (due to cooler groundwater inputs); and

[31] The term 'headwater' is most often used to describe first- and second-order streams, as shown on topographic maps (Meyer & Wallace 2001; Freeman et al. 2007).

v. Provide a source of colonists and a network of movement corridors.

c) Headwater biodiversity affects the character and function of terrestrial and downstream ecosystems

i. Headwaters supply food to neighbouring ecosystems; and

ii. Biological activity in headwaters affects connections to neighbouring ecosystems.

87. Many of these attributes have been similarly highlighted by New Zealand studies. For example, Smith (2007) in a study of the adult aquatic insect fauna of the nearby Mokau River and three of its forested headwaters tributaries, found that the headwater tributaries contributed 95% of all EPT species recorded, with one site containing 81% of all species present. Furthermore, 43% of all species were only collected within tributaries. Storey & Quinn (2008) also found 95 taxa of aquatic invertebrates, including eight mayfly, six stonefly and 16 caddisfly species, in stony-bottomed, intermittent headwaters in Hawke's Bay. In a study of six headwater streams of the Wellington region, Storey (2010) recorded numerous rare invertebrate taxa (of notable conservation value), and numerous habitat-specialist invertebrates (e.g., seepage-specialist caddisflies), with the author noting that "*rare or geographically-restricted taxa appeared to be more common at the intermittent sites than at wet sediment or perennial sites*". Parkyn et al. (2006) also observed that the isolated pool habitat of Waikato forested headwater streams had a significantly different community composition to the headwater flowing and the perennial habitats. Finally, the results of a study investigating the biodiversity values of 12 headwater streams in Auckland led the authors to state that "*protecting headwater habitats from infilling or piping may be important in maintaining landscape-level diversity of aquatic invertebrates*" (Storey et al. 2011b).

88. The surveys undertaken by Mr Hamill confirm that the headwaters of both the Mangapepeke Stream and Mimi River catchments are of significant biodiversity value. However, the ECR calculations do not incorporate these high biodiversity values. In my opinion, this represents a major shortcoming of the Application with respect to mitigating adverse effects on lost freshwater biodiversity values.

89. To address this issue, I have calculated additional multiplication factors to account for the biological importance of these headwater streams.

Potential fish passage impediments

90. As mentioned earlier, all fish species recorded from the Project area are diadromous, meaning that they spend some part of their lives at sea. Consequently, they need free access to, from, and within freshwater habitats to successfully complete their life-cycles (McDowall 1990). Blocking or limiting fish movements within and between waterways is, therefore, a significant and ongoing threat to freshwater fish[32].

91. Instream structures (e.g., culverts) can adversely affect aquatic communities by a variety of mechanisms. This includes disrupting stream processes, altering habitats, and impeding or blocking the movements of aquatic biota. The effects often manifest as reduced fish abundances and changes to species diversity within catchments (Franklin et al. 2018).

92. These effects, in turn, pose a potential high risk of adverse effects on kākahi (freshwater mussel) populations – *E. menziesii* is listed as 'At Risk – Declining' (Grainger et al. 2014). This species has a unique life cycle, which requires host fish for their larvae (termed glochidia). Briefly, males release their sperm into the water in spring and summer where it is taken in by the females to fertilise their eggs. The eggs are held in a special brood pouch in the gill, where they develop into larvae known as glochidia (less than half a mm long). In summer, the glochidia are released into the water column, after which point the glochidia have 2 – 3 days to find a fish host to provide nutrients and dispersal ability to other habitats. Some overseas mussels are host-specific; however, *E. menziesii* appears to be able to use a range of fish species including kōaro, bullies and trout. Following a period of 'hitch-hiking' on their host fish, the larvae detach and settle into the sediments to develop further. Therefore, any adverse effects experienced by the fish communities within the Project area, are likely to be reflected in the extant kākahi populations.

93. The Project involves installing 19 permanent[33] and 17 temporary culverts. The 19 permanent culverts may involve replacing or extending existing culverts, with many culverts being between 25 – 45 m in length, with longer culverts up to 250 – 280 m

[32] These effects (and more) are similarly echoed in TRC's 'Small Stream Modification in Taranaki' assessment report, particularly for headwater streams (TRC 2010).
[33] Mr McEwan's EIC at Table 2, Appendix 1.

(culvert 15) in length proposed near headwater sites. I have calculated the average length of proposed permanent culverts for the Project to be 62 m in length.

94. Mr McEwan notes the following regarding culvert gradients:

a) 13 culverts will have a grade of about 1% or less;

b) three culverts will have a moderately steep grade of about 2 to 3% (culverts 5, 7, and 8);

c) three culverts will have very steep grades of 14 to 17% (culverts 11, 13, and 17).

95. Fish passage will not be provided at culverts 2, 10, 13, and between culverts 5 and 6 (sites Ea2, Ea11, Ea14 and Ea6, respectively)[34]. Mr Hamill notes that culverts 2, 10 and 13 all have very small upstream catchments (≤2 ha), and are ephemeral in nature[35], while site Ea6 has a catchment of 4.4 ha[36].

96. For the remaining 16 culverts, the Applicant[37] states that fish passage will be provided using three sperate approaches;

a) Hydraulic design: culverts 1, 3 – 8, 14 – 16, 20, and 21;

b) Stream simulation: culverts 9 and 18; and

c) Steep culvert with flexible iris baffles (weir-type baffles): culverts 11 and 17.

97. Overall, I commend the Applicant for replacing culvert 12 with a bridge, removing the need for culvert 19, and also for refining the design of seven of the culvert structures based on the recently released New Zealand Fish Passage Guidelines (for structures up to 4 metres) (Franklin et al. 2018)[38]. Furthermore, I accept the explanation given as to the design constraints present at culvert 15 (site Ea10)[39]. I nevertheless highlight that culvert 15 poses a higher risk of yielding fish passage issues over time, as it is being designed to the minimum culvert design standards

[34] It is important to note that under Section 42(1) of the Freshwater Fisheries Regulations 1983, the following applies to the construction of all culverts: "*Notwithstanding regulation 41(2)(d), no person shall construct any culvert or ford in any natural river, stream, or water in such a way that the passage of fish would be impeded, without the written approval of the Director-General incorporating such conditions as the Director-General thinks appropriate*" (i.e., these fish passage impediments need to be either approved or exempted by DOC).
[35] Mr Hamill's supplementary evidence at paragraph 20.
[36] Mr Hamill's EIC at paragraph 107.
[37] Mr McEwan's EIC at Table 2, Appendix 1.
[38] Mr McEwan's EIC at paragraph 18.
[39] Mr McEwan's EIC at paragraphs 17 and 29.

for fish passage (considering it may be up to 280 m in length, and has an upstream catchment of approximately 65 ha [which drains indigenous forest land cover]) (Franklin et al. 2018). Mr McEwan notes that hydraulic design (minimum culvert design standards in Franklin et al. [2018]) may not be achievable for culvert 17 due to its steep grade[40], which is also a concern. I also note that 12 of the 19 culverts (approximately 63%) are not being designed to the standards set in Franklin et al. (2018), but rather in general accordance with the New Zealand Transport Agency's (NZTA) fish passage guidance for state highways (NZTA 2013)[41]. As a final point, I note the following in the Applicant's consent conditions: "*The design of fish passage provisions for culverts shall be informed by the NZ Transport Agency's "Fish passage guidance for state highways" (August 2013) guidelines*" [42], which appears to make no reference to Franklin et al. (2018).

98. I agree with Mr Hamill that these design changes, whilst not changing the overall effect of the Project on fish passage (remaining low), will help to improve the likelihood of success for predicted fish passage outcomes[43]. Notwithstanding this point, I consider further efforts should be made to reduce the uncertainty of effects that the Project may have on fish passage. These include;

a) The flexible iris baffles (weir-type baffles) proposed by Mr McEwan[44] to provide fish passage at a number of culverts are not recommended by the New Zealand Fish Passage Advisory Group (NZFPAG)[45], on which the NZTA has a representative. The following is a direct extract from the recently released New Zealand Fish Passage Guidelines (for structures up to 4 metres), regarding the use of baffles: "*Based on these experimental results, and observations from field trials of spoiler baffles in Australia (MacDonald and Davies 2007) and New Zealand (Franklin and Bartels 2012), spoiler baffle designs (Figure 5-6c; Figure 5-7) are presently recommended as the preferred solution for improving fish passage through culvert barrels. In contrast, weir style baffles are not currently recommended for use where the objective is to optimise fish passage success unless further work is done to establish their performance relative to the preferred spoiler baffle designs*" (Franklin et al. 2018, and references therein).

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[40] Mr McEwan's EIC at paragraph 31[footnote 8].
[41] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.3.4.3.
[42] Mr Roan's supplementary evidence at Annexure A, Condition 25(f)(iv) (Resource Consent Conditions).
[43] Mr Hamill's supplementary evidence at paragraph 9.
[44] Mr McEwan's EIC at paragraph 14(d).
[45] https://www.doc.govt.nz/nature/habitats/freshwater/fish-passage-management/advisory-group/

b) I note that Mr Hamill refers to "*baffles will be used to provide fish passage in most of these culverts* (which I assume refer to those listed in paragraph 18 of his supplementary evidence)"[46], while Mr McEwan refers to iris baffles being used at culverts 11 and 17 (as their gradients are greater than 3% – below this gradient threshold I understand that spoiler baffles are preferred)[47]. However, I note that spoiler baffles (or "*equivalent features*") are only specified for culverts with a grade between 0.5 to 1% in the ELMP[48]. Irrespective of these discrepancies, I recommend that spoiler baffles be used regardless of culvert gradient – as per the New Zealand Fish Passage Guidelines (Franklin et al. 2018).

c) I do not agree with Mr Hamill's opinion that the overall effect of permanently impeding fish passage to a stream (site Ea6) with an approximately 4.4 ha upstream catchment is small[49]. Furthermore, I disagree that the "*magnitude of effect of restricting upstream migration to about 50ha of catchment for a season is likely to be 'low'*" [50] (Technical Report 7b). I consider this effect to be of much greater magnitude.

99. Finally, I do not agree with Mr Hamill's statements that the "*the key outcome is for the culverts and diversions to provide sufficient passage of fish that would naturally occur upstream of the culvert/diversion so as to maintain healthy populations*…and…*The applicant proposes wording the conditions as "<u>the diversion/culvert shall provide for fish passage in accordance with the ELMP</u>*" [51]. I consider that the requirements for fish passage should be stated on the face of the relevant resource consent conditions. I support the TRC Officer's proposed resource consent conditions for diversions and culverts as "…*shall not restrict fish passage*".

Use of SEV to calculate biodiversity compensation

100. As I stated previously, I consider the SEV is not an appropriate or sufficient tool for assessing biodiversity values, nor for quantifying the amount of compensation required for lost biodiversity values. Only three of its 14 functions relate to biodiversity. Furthermore, the use of SEV scores to calculate an Ecological

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46 Mr Hamill's supplementary evidence at paragraph 19.
47 Mr McEwan's EIC at paragraph 14(d), and Table 2, Appendix 1.
48 Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.3.4.3.
49 Mr Hamill's EIC at paragraph 107.
50 Mr Hamill's EIC at paragraph 96.
51 Mr Hamill's EIC at paragraph 159.

Compensation Ratio (ECR) becomes even more limited, as the SEV method requires the biotic functions 'fish fauna intact' and 'invertebrate fauna intact' to be excluded from the calculation of the ECR due to "*the difficulty of predicting these outcomes*" (Storey et al. 2011a). In my opinion, the use of SEV in isolation to quantify compensation for residual freshwater effects, represents a fundamental shortcoming of the Project. Additionally, I believe the current approach used to calculate compensation (including the updated quantum proposed[52] – 8,455 m/8,153 m^2 of stream restoration) falls short of achieving no net loss for the Project, with regards to freshwater biodiversity values.

101. To accurately quantify the compensation required to mitigate for the freshwater biodiversity values lost due to the Project, the approach used would need to incorporate the following measures (by applying appropriate weightings):

a) The diversity, distribution, and population size of extant aquatic biota;

b) Their conservation status (rarity and distinctiveness);

c) Their habitat requirements (and its availability within the Project area) for all stages of their life cycle (i.e., spawning, nursery, juvenile and adult habitat); and

d) Ecosystem 'representativeness'[53], 'irreplaceability'[54], and 'ecological integrity'[55], as well as 'ecological context'[56].

102. Despite Mr Hamill mentioning some of these terms (listed above) in Section 2.8.1 of Technical Report 7b, there is only a sole instance in his proposed compensation package where a site of higher biodiversity value has been afforded any additional compensation (the ECR at site Ea10 was doubled). I agree with Dr Neale where he states that "…*the SEV and ECR are tools that require professional judgement in their application and deviation from this approach may be appropriate in certain circumstances*"[57] (also

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52 Mr Hamill's supplementary evidence at paragraph 25.
53 Representativeness can be defined as "*a long-established goal referring to the need for reserves to represent, or sample, the full variety of biodiversity, ideally at all levels of organization*" (Austin & Margules 1986).
54 Irreplaceability can be defined as "*the likelihood that a given site will need to be protected to achieve a specified set of targets or, conversely, the extent to which options for achieving these targets are reduced if the site is not protected*" (Pressey et al. 1994).
55 Ecological integrity can be defined as "*the degree to which the physical, chemical and biological components (including composition, structure and process) of an ecosystem and their relationships are present, functioning and maintained close to a reference condition reflecting negligible of minimal anthropogenic impacts*" (Schallenberg et al. 2011).
56 Ecological context can be defined as "*the extent to which the size and configuration of an area and its degree of buffering from a surrounding landscape affects its ability to maintain its indigenous biodiversity*" (Davis et al. 2016).
57 Dr Neale's EIC at paragraph 14.

mentioned in the SEV guidelines [Storey et al. 2011a]). However, I do not consider sufficient and accurate judgment has been applied with regards to the proposed compensation. Instead, Mr Hamill has assessed the ecological value of streams in the Project area from a functional perspective, rather than their biodiversity value, and has used this to derive compensation for residual freshwater effects.

103. To summarise, I do not consider the use of SEV in isolation (with respect to calculating the 'currency' for the ECR) to be an adequate tool for calculating the compensation required for the loss of biodiversity values that will manifest as a result of Project activities. As it currently stands, I have little confidence that the Project will achieve its intended no net loss outcome.

Calculations of ECR

104. The practice of undertaking environmental compensation requires SEV scores to be known from the compensation sites (as well as the impact sites). These scores are needed to ensure that the proposed compensation site is suitable for on-site environmental compensation. The reason being that the proposed compensation site may have high ecological values that cannot be improved upon, or conversely, may have low ecological values that are not amenable to significant improvement in ecological value (e.g., highly resilient aquatic communities in degraded habitat). This task was undertaken by Mr Hamill, who undertook SEVs at numerous potential 'restoration' sites[58], on private land, not owned or controlled by NZTA. The average estimated improvement in SEV scores at potential compensation sites was 0.24. Furthermore, the raw SEV/ECR data[59] provided to me by Mr Hamill suggests that 8,999 m/9,904 m^2 of stream channel <u>may</u> be available in these areas for compensation. It is important to note, however, that the use of these proposed compensation sites has yet to be formally agreed with the respective landowners (although informal agreement has been obtained to fence and plant 5.5 km of stream channel outside of the designation)[60]. While I agree with Dr Neale that the use of the proposed compensation sites would afford a greater deal of certainty regarding the benefits of restoration activities (being downstream of native forest-dominated catchments)[61], this statement (and its implications for the proposed offsetting package) need to be interpreted with caution until such time as formal

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[58] Approximately 19 sites in the Mangapepeke Stream (eastern branch) and five sites in the Mimi River catchment.
[59] Data received from Mr Hamill by email on 17 May 2018. File name 'Habitat fish v3 Doc.xlsx'.
[60] Mr Hamill's EIC at paragraph 49, and Mr MacGibbon's EIC at paragraph 177(a).
[61] Dr Neale's EIC at paragraphs 32, 33 and 35.

landowner agreed has been reached between the respective parties. Needless to say, this has major implications for compensating for the freshwater biodiversity values that will be lost as a result of the Project.

105. I have a number of other outstanding issues with regards to the correct application of the SEV scores and ECR calculations. These can be summarised as follows:

a) A number of sites in Table 2.12 (e.g., Ea1, Ea2, Ea3, etc) of the Supplementary Freshwater Ecology report have been assigned individual SEV scores and corresponding ECRs; however, Table 2.1 of the same report, and Table 1 of Mr Hamills' evidence, suggests that these sites were not subject to a SEV survey. Furthermore, Mr Hamill provides no rationale for these individual SEV scores. This information should be provided.

b) It appears that the ECRs have been calculated inclusive of the biotic functions 'fish fauna intact' and 'invertebrate fauna intact'. The SEV guidelines (Storey et al. 2011a) recommend these be excluded from the calculation of the ECR due to "*the difficulty of predicting these outcomes*" (Storey et al. 2011a).

c) Notwithstanding Mr Hamill's updated SEV calculations (based on Dr Neale's review)[62], I do not agree that a piped stream will retain an SEV score post-culverting of 0.15/0.23 (the lower value being applied to higher gradient culverts). In my opinion, this is misleading, and all such areas that are piped should be given a post-impact SEV score (SEVi–I) of 0. I no longer consider that the affected (piped) length of stream will support <u>biodiversity</u> values, as opposed to <u>functional</u> values. Notwithstanding that the physico-chemical habitat of the stream channel within culverts may retain reasonable resemblance to the pre-culvert state (apart from far less ambient light), basal food resources (e.g., algae), and its processing by primary consumers (e.g., invertebrates), would be severely diminished on a permanent basis. Therefore, I do not consider there will be sufficient energy available (carbon) to sustain a healthy and functioning aquatic ecosystem within culvert pipes. Furthermore, I have major reservations that newly created stream channels (stream diversions) will attain an after impact SEV score (SEVi–I) similar (or higher) to the original stream

[62] Dr Neale's EIC at paragraph 19 and 28, and Mr Hamill's supplementary evidence at paragraph 23(a).

channel (not to mention regaining comparable biodiversity values). These comments especially apply for higher value sites draining areas of indigenous forest cover.

d) Mr Hamill provides numerous ECRs of <1[63]. I appreciate Mr Hamill's explanation of the ECR values given for stream diversions[64]. I acknowledge that including or excluding the diversion reach in the ECR can lead to confusion as to the perceived quantity of compensation being offered. However, as per the SEV guidelines, I recommend that if a calculation produces an ECR value of < 1, then that ECR should default to 1. Therefore, for stream diversions, 100% of the stream area affected by the diversion should be included in the offset <u>in addition</u> to the enhancement of the stream diversion reach. Such an approach is warranted (as a minimum measure) as I do not agree with Mr Hamill's opinion regarding the high likelihood of stream diversions yielding their pre-impact (the original stream channel) ecological state[65]. The authors of the guidelines report that ECRs "*greater than 1 (i.e., more compensation is required to match the amount of stream habitat lost/damaged) are valid because of: (i) the ecological risk factors associated with the cumulative loss of streams to development and the steady change in areal distribution of high quality stream reaches; (ii) the long time-lag before full benefits of environmental compensation (e.g., from riparian planting) accrue to the mitigated site, this may exceed 10 years; and (ii) the overall difference between the expected and actual success of stream restoration methods*" (Storey et al. 2011a). This default minimum ECR should be applied irrespective of whether the effect is temporary or permanent, as time lags and risk of restoration failure (i.e., ecological outcomes less than anticipated) are common across all effect types.

e) I have re-calculated the ECRs to incorporate some of these changes (listed above), and have arrived at a length and area of stream channel to restore that is up to 2,185 m/1,893 m^2 greater than that proposed by Mr Hamill. This demonstrates that the required compensation to offset the residual adverse effects of the Project will be at least 23% higher (by stream area) than what is currently proposed (8,153 m^2). This increase is <u>excluding</u> the

[63] Mr Hamill's supplementary evidence at Appendix 1.
[64] Mr Hamill's supplementary evidence at paragraph 23(b).
[65] Mr Hamill's EIC at paragraph 45.

additional multiplication factors that I recommend should be applied to the final ECRs for forested, headwater streams (discussed in the following sections) (which I have calculated to result in a further 2,720 m/2,581 m^2 length and area of stream channel to restore, respectively).

106. Furthermore, the SEV (and ECR) only focuses on the point of impact effects (e.g., X m of stream piped); it does not account for cumulative effects of stream fragmentation. There are numerous additional effects that are likely to occur outside the affected reach, which have not been captured and incorporated into the SEV/ECR (and therefore are not considered in the compensation). These larger-scale effects need to be considered in a more holistic manner, with regards to compensation, if no net loss of biodiversity value is to be a realistic target for the Project.

107. Therefore, I recommend that the Applicant applies a further multiplication factor to the ECRs (once finalised) to account for the loss of higher biodiversity values within the headwater systems, in addition to the standard multiplication factor of 1.5 (which accounts for time lags, and uncertainties regarding restoration success). While I accept that there is no agreed approach (either nationally or internationally) to setting multiplication factors for compensation (Bull et al. 2017), they are nevertheless employed extensively in projects seeking to achieve no net loss of biodiversity values. The main reasons for which multiplication factors are employed include:

a) to achieve broader biodiversity conservation objectives (Brownlie & Botha 2012);

b) to overcome poor information or predictive capability (Moilanen et al. 2009);

c) to manage risks of complete failure for biodiversity offsets (Maron et al. 2012);

d) to account for temporal issues (Overton et al. 2012); and

e) to account for imperfect exchange currencies (McKenney & Kiesecker 2010).

108. While it could be argued that points (c) and (e) relate more to accounting for inappropriate biodiversity offset measures, I recognise there will always be a degree

of uncertainty regarding restoration success. For example, there is growing body of evidence demonstrating that instream and riparian restoration measures (including riparian planting) are not as effective as expected, and that such measures may need to be applied at larger scales (or contiguously within a stream network) to manifest a meaningful biological response in stream communities (e.g., Parkyn et al. 2003, 2010; Wilcock et al. 2009; Greenwood et al. 2012; Wahl et al. 2013; Scrimgeour et al. 2014; Holmes et al. 2016; Wright-Stow & Wilcock 2017).

109. I have derived additional multiplication factors based on the aquatic macroinvertebrate data collected by Mr Hamill. Notwithstanding my concerns with some of the data, I generally agree that it provides a reasonably objective measure of stream biodiversity value. I only considered the qualitative (presence/absence) MCI index, as I agree with Mr Hamill in that quantitative (abundance) data (SQMCI) is more sensitive to flood-mediated effects (Stark & Maxted 2007).

110. As rightly noted by Mr Hamill, MCI and SQMCI scores are highest in the upper, forest-dominated stream reaches, and decline further downstream where the mainstems (and tributaries) run through pasture and grazed wetland (mainly rushland). To account for this increased biodiversity value in these forested headwater systems, I have calculated the proportional increase in MCI scores between the mainstem valley floor sites (that run through pasture) versus the higher gradient, forested stream reaches. For the Mangapepeke Stream sub-catchment, I calculated that the MCI was approximately 40% higher (on average) in the headwater systems, while in the Mimi River catchment it was approximately 10% higher.

111. On that basis, I consider the following multiplication factors should be applied to the final ECRs for forested, headwater streams to account for their higher biodiversity value:

a) Mangapepeke Stream sub-catchment: 40%; and

b) Mimi River catchment: 10%.

112. This approach affords a greater degree of objectivity in comparison with other more subjective measures (such as the expert judgement referred to by Mr Hamill and Dr Neale), and ensures that adverse effects on stream reaches of higher biodiversity value are accounted for in compensation. This addition would also better align the Project's current average ECR (2.6) with that from other roading

projects (e.g., Transmission Gully had an average ECR of 3.3), and the average ECR for Auckland (3). Considering the aquatic biodiversity values present (in terms of pristine [or close to] forested, aquatic habitats, which harbours numerous biota of high conservation value), I am surprised by how low the Project's reported average ECR is.

Sediment discharge effects

113. While monitoring is useful to refine erosion and sediment control (ESC) measures as the Project advances, it is critical that sufficient effort and resources are invested at the planning stage of proposed works, rather than at the reactive stage during construction. Based on Mr Duirs' evidence[66], there remains a high potential of significant sediment loss from this Project's activities, which consequently poses a major risk to the biodiversity values of the receiving aquatic environments.

114. Sediment discharges can have both optical and non-optical effects on the aquatic biota of the receiving environment (Clapcott et al. 2011, and references therein; Davies-Colley et al. 2015, and references therein). When suspended in the water column, sediment particles likely affect aquatic biota most severely through their influence on the optical properties of the water; these include a reduction in light penetration needed for plant growth, as well as a reduction in visual clarity (MfE 1994). Non-optical effects of sediment discharges arise when the suspended sediment falls out of suspension, in areas of decreased water velocity such as pools and deeper reaches, and deposits on the bed of the receiving environment (i.e., sedimentation of the streambed). I consider both effect types need to be considered for appropriate effects management of the Project, and therefore, I do not agree with Mr Hamill's following statement: "*The primary ecological concern regarding sediment in discharges is not so much the change in clarity of water but instead deposition of sediment on the stream beds*" (Section 4.2.2.1 of Technical Report 7b). Only considering depositional effects would knowingly exclude suspended sediment-related effects, which are also of considerable concern. I will explain why in the following sections.

115. As mentioned above, the effects of sediment on receiving freshwater environments can be divided into two main categories:

[66] Mr Duirs' EIC at paragraph 9.3.

a) **optical effects** – due to sediment suspended in the water column; and

b) **non-optical effects** – whereby fine sediment gets deposited on the stream bed and/or bank.

116. Suspended sediments increase turbidity and reduce light penetration, whereas fine sediment deposition modifies the streambed by altering physical habitat. Suspended sediment can have a range of effects on aquatic ecosystems including reducing periphyton and macrophyte growth (i.e., primary production) by attenuating light before it reaches the streambed (Ryan 1991, and references therein). Suspended sediment (increased turbidity) can adversely affect macroinvertebrates through abrading, and clogging of gills and filter-feeding apparati (Jones et al. 2012). Fish, in particular, can be adversely affected by suspended sediment. Direct effects on fish populations include reduced foraging efficiency, reduced growth, and resistance to diseases (via gill damage), whereas indirect effects relate to altered movement and migration patterns, feeding success, and changes to habitat quality and quantity (Cavanagh et al. 2014, and references therein). For example, Richardson et al. (2001) showed that the upstream migration of banded kōkopu was reduced when turbidity exceeded 25 Nephelometric Turbidity Units (NTU), resulting in recruitment limitation. In turbid waters, even with abundant prey items, visual-feeding fish (e.g., drift-feeding native species such as giant kōkopu, īnanga, etc.) can experience reduced feeding efficiency and greater energetic costs; such effects have been linked to lower growth rates in riverine fish (Kemp et al. 2011, and references therein). Frequent or extended periods of high turbidity can also cause changes to fish distributions and community structure (Cavanagh et al. 2014, and references therein). Finally, highly turbid water can also affect the amenity and recreational values of a waterway – for example, turbid water may render a waterway less suitable for whitebaiting.

117. In contrast, sediment deposition can adversely affect aquatic biota by reducing habitat quality and quantity by filling interstitial spaces, covering substrata, and reducing habitat complexity (Jowett & Boustead 2001). Greenwood et al. (2012) found that fine sediment cover of the streambed was one of the most influential determinants of invertebrate communities of lowland streams in Canterbury. Similarly, Burdon et al. (2013) identified a 'tipping point' of 20% fine sediment cover of the streambed, above which marked declines in metrics of aquatic invertebrate community health manifest. Studies have shown that the communities

in fine sediment-affected streams are usually characterised by lower abundances of pollution-sensitive EPT taxa, and increased abundances of pollution-tolerant taxa such as chironomids (Diptera), molluscs and worms (Greenwood et al. 2012; Burdon et al. 2013). With respect to fish communities, this can lead to altered community structure, reduced reproductive success and increased morality, particularly for eggs and larvae (Wood & Armitage 1997; Kemp et al. 2011, and references therein).

118. I disagree with Mr Hamill's opinion that "*After implementing mitigation, the overall level of effect from sedimentation is expected to be 'low' for all stream types/area*" (Section 4.2.2.3 of Technical Report 7b). Both juvenile kākahi (freshwater mussels) (Dr Susan Clearwater, Ecotoxicology Scientist, NIWA, pers. comm.) and giant kōkopu egg survival are particularly sensitive to potential sediment-related effects. As mentioned earlier, both species are thought to be widespread throughout the Project area. Recent discoveries of giant kōkopu spawning sites by NIWA staff have shown that their preferred spawning habitat is vegetated, shelving riparian areas (Franklin et al. 2015); this habitat type is likely to be present throughout the Project area. Franklin et al. (2015) also observed site fidelity between years, with multiple spawning events at individual sites within years. This further highlights the importance of avoiding adverse effects on this critical habitat type for this species, as sedimentation of eggs could lead to mass recruitment failure for this species (as demonstrated for īnanga – e.g., Hickford & Schiel 2011).

Stream habitat fragmentation

119. The effects of stream habitat fragmentation have major implications for the Project, considering the proposed culverting will lead to substantial fragmentation. While monitoring post-construction will help to quantify effects, I fail to see how such effects can be adequately mitigated once the Project has been finalised. If effects are identified following monitoring, I recommend (below) that additional mitigation should be determined in conjunction with the Ecology Review Panel and TRC.

120. There are two primary mechanisms by which stream invertebrates disperse:

a) swimming, crawling, climbing or drift by aquatic insect larvae and aquatic adults; and

b) aerial dispersal by winged adult insects (Parkyn & Smith 2011, and references therein).

121. The same study by Parkyn & Smith (2011) found that most stream invertebrates typically disperse along stream corridors, even those with flying adult stages. This remains the case even when the stream corridor distance is longer than the overland distance between sites (Campbell et al. 2007; Tonkin et al. 2014). Furthermore, lateral dispersal away from streams has been shown to be limited for the majority of aquatic insects (Bilton et al. 2011, and references therein; Parkyn & Smith 2011, and references therein). For example, Collier and Smith (1997) found that for three forested streams in the central North Island, most caddisfly species stayed within a zone of activity 30 m from the stream edge, with some rare captures at 200 m distance. A similar finding was noted in numerous other studies, whereby the vast majority of dispersing individuals (> 90%) were captured within 30 – 50 m of the stream channel or less (Briers et al. 2002; Winterbourn 2005; Winterbourn et al. 2007).

122. Adult insect flight is recognised as the dominant mode of dispersal for many freshwater invertebrates (Bilton et al. 2001), including the sensitive EPT taxa. For example, Graham et al. (2017) found that New Zealand stream invertebrates rarely crawl more than 200 m upstream of their original location. Furthermore, many aquatic insects are known to be positively polarotactic (lured to horizontally polarized light), whereby they find water using horizontally polarized light reflected from the water surface (Horváth & Kriska 2008, and references therein). This is of key importance, as when these adults leave the water they face the task of detecting water while dispersing in order to return to water to avoid dehydration, oviposit, or simply return to the aquatic environment (Horváth & Kriska 2008). The effects of stream fragmentation via culverting on stream invertebrate dispersal has been demonstrated previously. For example, Blakely et al. (2006) found that road culverts (22 m-long culverts, located in a low-gradient, spring-fed system [Avon River]) acted as a hindrance to upstream recolonization by adult aquatic insects in urban stream environments.

123. In addition, following a potential natural, local extinction event (e.g., large flood, or slip), unless the invertebrate community (either downstream or in nearby headwater streams) is dominated by strong dispersers, the recovery trajectory for the invertebrate community at that affected site will diverge from that which existed

pre-disturbance (e.g., culverting). Aerial distance from colonist source streams is known to be an important predictor of local invertebrate diversity in streams recovering from anthropogenic disturbance, especially during the early years of recovery (Patrick and Swan 2011). In summary, invertebrate taxa with poorer dispersal abilities may no longer be able to colonise the 'disconnected' stream reach (i.e., weaker fliers, or those without terrestrial or aerial life cycle stages [i.e., crustaceans, molluscs, and oligochaetes]).

124. Overall, stream fragmentation effects will have major implications for the invertebrate communities of the Project area.

125. Finally, I commend Mr Hamill for undertaking an assessment of effects of the current SH3 road on the community composition of aquatic macroinvertebrates[67]. However, without seeing the details of that study I cannot comment on its relevancy in addressing my outstanding concerns regarding stream fragmentation effects.

Flow alteration effects

126. The Applicant proposes two separate water takes for the purpose of dust suppression throughout the Project. These takes include (details taken from Technical Report 7b and Mr Hamill's evidence):

a) Up to 150 m^3 per day from the Mimi River, near the southern extent of the Project area (catchment area of about 978 ha);

b) Up to 300 m^3 per day from the Mangapepeke Stream. The location will be near the northern extent of the designation, either about 50 m upstream of the confluence with the west branch (catchment area of about 330 ha) or just downstream of this confluence (catchment area to 683 ha); and

c) The instantaneous rate of either take will not exceed 5 L/s; and

d) While Mr Hamill's evidence suggests that neither take has a minimum (cease) flow limit[68], the ELMP goes on to state that "*the critical level for ceasing the water takes is based on maintaining greater than two thirds of instream habitat*

[67] Mr Hamill's EIC at paragraph 148.
[68] Mr Hamill's EIC at paragraph 91.

available at mean annual low flow (MALF)'[69]. This needs to be clarified as to whether a minimum flow is being applied or not.

127. Mr Hamill subsequently attempted to describe the sensitivity of both the Mangapepeke Stream and Mimi River (near the points of take) with regards to flow alteration (Section 2.3.5.3 of the Supplementary Freshwater Ecology report).

a) I have several concerns with the proposed takes in their current format, which I detail below. I am comfortable with TRC's proposed resource consent conditions for the surface water takes (TRC Planning Officer's Report). However, if these conditions are not agreed upon by the Applicant, I consider that both a minimum flow (e.g., 90% of 7-day MALF)[70] and total allocation limit (e.g., 10% of 7-day MALF) are needed for both proposed takes to ensure that a minimum habitat protection level (retention level) is maintained at all times. These limits should be based on measured flow at the point of take, rather than modelled estimates[71].

128. My concerns with the Applicant's proposal as follows:

a) I do not agree with Mr Hamill's approach to deriving minimum flows, nor his attempt at estimating the corresponding reach-scale water level[72]. In order to convert water level (or 'stage height') into a volume of water (or 'discharge'), one must establish a relationship between them (i.e., a rating curve). In the absence of any rating curves for either waterway, I fail to see how Mr Hamill can accurately predict a water level change across varying flows.

b) Mr Hamill goes on to state that "*Furthermore, in these types of streams, water depth is more directly relevant to effects on fish habitat than flow*" (Technical Report 7b), which he subsequently attempts to demonstrate by means of a 500 m longitudinal survey of water depths of both streams (from their respective points of take). Mr Hamill graphically presents this data, with the addition of a secondary plot assuming a 0.1% gradient in both stream reaches (Figures 2.2 & 2.4 of the Supplementary Freshwater Ecology report). Mr

[69] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.3.7.1.
[70] 7-day MALF: 7-day mean annual low flow (m^3/s) – the mean of minimum flow for each water year after having applied a running 7-day mean to the daily flows (Booker 2015).
[71] Mr Hamill's EIC at paragraph 87.
[72] Mr Hamill's EIC at paragraphs 89 and 90.

Hamill graphically presents the same data in his evidence[73], where he estimates water depths in the Mangapepeke Stream (but not the Mimi River) when flow is at MALF[74]. I consider these to be an overly simplistic and inaccurate assessment of the hydrological effects on stream hydraulic conditions. I will explain why in the following sections.

c) A reduction in flow (e.g., of 20% instantaneous flow) will not yield a uniform reduction in water level (and therefore available stream habitat) throughout the affected (abstraction) reach[75] (i.e., the relationship between hydraulic conditions and streamflow will not be linear at the reach scale). Instead, shallower habitats (e.g., riffles) at higher gradient reaches points will experience a relatively greater effect due to reduced flow, in comparison with lower gradient reaches (e.g., deeper pools) (e.g., Magoulick & Kobza 2003; Bradford & Heinonen 2008; Rolls et al. 2012). It follows that this will result in a correspondingly greater effect on aquatic biota that have stronger affinities for these shallower habitats. Mr Hamill provides habitat preferences for both longfin eel and īnanga; however, he does not provide habitat preferences for redfin or common bully, even though they were recorded at higher abundances (eight redfin bully and seven common bully) than longfin eel (five individuals) at site E1 (the closest fish survey site to the proposed abstraction point). Therefore, Mr Hamill's following statement is incorrect and misleading: "*The fish surveys of the downstream sections of the Mangapepeke River have found the fish community dominated by inanga, longfin eel and to a lesser extent redfin bully*" (Section 2.3.5.3 of the Supplementary Freshwater Ecology report). Both of these bully species, the habitat of which Mr Hamill excluded from mentioning, are well known to inhabit shallower habitats (average depth preference: ~0.2 m) (Jowett & Richardson 1995).

d) Mr Hamill fails to adequately consider (i) that most aquatic biota have varying habitat affinities at different stages of their life cycle (i.e., spawning, nursery, juvenile and adult habitat) (ontogenetic habitat shifts), and (ii) the diel and seasonal variation in habitat preferences have been described for

[73] Mr Hamill's EIC at Figure 7.
[74] Mean Annual Low Flow – Mr Hamill does not state what MALF index was used in his EIC. However, the River Environment Classification (REC) database, which I assume he refers to in his EIC, defines MALF as "*an estimate of the flow that a river descends to or below, on average, once every two years*" (Snelder et al. 2010).
[75] Mr Hamill's EIC at paragraph 90.

New Zealand's native freshwater fish. As mentioned earlier, such varying habitat preference means that to protect the aquatic biota within a catchment, it is necessary to retain suitable habitat for all stages and periods of that taxon's life history, not just daytime or adult habitat. I consider that these activities pose a greater potential effect than opined by Mr Hamill – "*only minor effects (or less)*" (Section 2.3.5.3 of the Supplementary Freshwater Ecology report). For example, reducing the available shallow habitat will yield increased trophic interactions both among (competition between bully species) and between species (e.g., eel predation on bullies).

e) I do not agree with Mr Hamill's opinion that "*Compared to the applicant's approach, it would allow more water abstraction when the Mangapepeke Stream is at MALF and only start to become more protective the flow drops below 20 L/s. This is likely to be a rare event, and considering the short-term nature of the consent this approach is likely to be less protective than what is proposed by the applicant*"[76]. Mr Hamill provides no evidence (e.g., a flow duration graph) to substantiate the claim about the frequency of low flow events. Furthermore, in the absence of applying a minimum flow or proportional flow allocation limit (e.g., 25% of instantaneous flow), the Applicant could reduce streamflow to well below the lowest recorded flow (i.e., Qmin[77] minus full allocation), especially during the drier, summer months when water demand for dust suppression would presumably be at its highest.

f) Finally, neither of the freshwater ecology reports referred to the proposed weir structures associated with each of the proposed takes (and associated with the damming resource consents). I am comfortable with TRC's proposed resource consent conditions for these damming activities (TRC Planning Officer's Report); however, I recommend that the requirement for both of these structures to provide for <u>unimpeded</u> fish passage (as per the weir design standards in Franklin et al. [2018]) also be included in the conditions (proposed Consents 10659-1.0 and 10660-1.0).

[76] Mr Hamill's EIC at paragraph 92.
[77] Qmin: annual minimum daily flow.

Fish recovery/rescue protocols

129. Mr Hamill states the fish recovery and rescue protocols will "*minimise and mitigate the direct effect of stream works on fish, kōura and kākahi*"[78], while the ELMP states the intend of these protocols is "*to minimise the direct loss of native freshwater fish as a consequence of works in waterway*"[79]. Notwithstanding this discrepancy of scopes, Mr Hamill briefly describes three separate protocols for fish recovery (prior to instream works):

A. Overnight netting prior to works;

B. Electric fishing and voluntary leaving; and

C. Kākahi recovery.

130. In addition, Mr Hamill describes rescue measures during the in-stream works. Finally, Mr Hamill describes relocation protocols for aquatic biota (fish, kōura and kākahi) captured. It is proposed to undertake fish rescue at all of the 40 sites containing water at the time of earthworks (Table 2.1 of Appendix D of the Ecology and Landscape Management Plan [ELMP]). However, Mr Hamill proposes to not undertake fish recovery at 18 of these 40 sites.

131. Protocol (B) is the dominant fish recovery protocol being proposed for most of the 22 sites where recovery will be undertaken. For 16 of these 22 sites (approximately 73%), this is the only protocol proposed. According to Mr Hamill this protocol "*includes fish recovery measures that can occur on the day that a stream is dewatered. Where practical, and to minimise injury to fish, preference will be given to encouraging fish to voluntary leave the stream section prior to netting and electro-fishing*"[80].

132. I have major concerns with the proposed approach to fish (and megainvertebrate) recovery and rescue:

a) I agree with Mr Hamill's opinion that inappropriate use of electrofishing machines (or nets/traps for that matter) can result in injury or death to the target organism. However, I consider that a qualified and experienced

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[78] Mr Hamill's EIC at paragraph 70.
[79] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Appendix D: Fish Recovery and Rescue Protocols, Section 1.1.
[80] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Appendix D: Fish Recovery and Rescue Protocols, Section 2.

electrofishing machine operator (or a freshwater ecologist experienced in netting and trap) can undertake such tasks with minimal risk to fish and aquatic invertebrates.

b) Further details need to be provided regarding 'excluding juveniles' with regards to protocol (A). As a general statement, I find many of the criteria for applying this protocol (or parts thereof) overly subjective and vague.

c) I do not agree that 'voluntary leaving' should be the preferred method of excluding fish from a stream reach, especially not for kōura[81]. I have personally undertaken fish removal activities in similar circumstances, and found that the majority of fish will simply become stranded during dewatering. This phenomenon has been demonstrated in relation to hydro-schemes effects, whereby down-ramping of flows below dams has caused fish stranding in downstream reaches (e.g., Melcher et al. 2017, and references therein). I consider the channel morphology (step-pool/cascade) of many of the affected reaches is not conducive to fish leaving voluntarily as flows recede. Instead, I believe that most fish will seek refuge in the nearest available (i) deeper water (i.e., fish will aggregate in pools or runs), and/or (ii) instream substrate (e.g., burrow into coarse substrates, enter interstitial spaces and/or root wads), undercut banks, or overhanging riparian cover. While I acknowledge that the efficacy of various fish survey methods varies across different habitat types, I nevertheless recommend that conventional fish survey methods need to be applied in addition to 'voluntary leaving'. I provide detailed recommendations below to reduce this risk.

d) Protocol (C) (kākahi recovery) is only proposed for six sites in total, all of which are located in the Mangapepeke Stream sub-catchment. Considering that kākahi are thought to be widespread throughout the Project area, I recommend active searches (dedicated for kākahi) are needed for all waterways prior to dewatering, not just where they are adjudged to potentially be present. This should occur in addition to searches occurring during dewatering. Recent research in New Zealand has highlighted that mussels can be very cryptic and difficult to detect, and that visual detection

[81] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Appendix D: Fish Recovery and Rescue Protocols, Section 3.

rates can vary markedly throughout the year (Dr Susan Clearwater, Ecotoxicology Scientist, NIWA, pers. comm). This highlights that mussels present could easily not have been detected in previous surveys.

133. Overall, considering the known scale of impacts this Project will have on the aquatic habitat and biodiversity values of the affected waterways, there is a lack of effort being offered for these direct effects on aquatic biota. These potential effects are arguably the easiest freshwater-related effects to minimise for the Project. The risk of employing insufficient fish salvage effort was recently highlighted in the case of the Waikato Expressway (see Appendix 11). In that instance, an area that was undergoing excavation (relating to a culvert) without prior fish rescue (as per the Fish Management Plan) was found to contain two 'At Risk – Declining' fish species (one of which was of notable significance), as well as a number of other native fish – unfortunately a number of fish died. The discovery forced the cessation of works for numerous days while fish removal surveys were being undertaken. This example also serves to demonstrate the risks posed by inadequate fish management plans and protocols (including their implementation), as the reach was initially deemed 'dry' by an Environmental Advisor; therefore, was fish rescue was not considered necessary. If there had been a survey of the waterway prior to these works, it is highly likely that all fish could have been safely transferred, and works would have remained uninterrupted.

Riparian offset restoration planting

134. As mentioned earlier, a major outstanding issue regarding the proposed riparian offset restoration planting is that the use of the proposed compensation sites has yet to be formally agreed with the respective landowners – "*All riparian restoration areas used will require the Transport Agency to acquire the necessary rights to implement the restoration programme*"[82].

135. As described earlier, the practice for undertaking environmental compensation requires the SEV scores to be known from the proposed compensation sites (as well as the impact sites). Considering this fact, coupled with my outstanding concerns regarding the SEV scores and ECR calculations, and the fact that the Project design details are yet to be finalised, I recommend that all references referring to the absolute quantum of proposed compensation (8,455 m/8,153 m^2 of

[82] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 4, Section 4.6.4.1.

stream restoration) be removed from resource consent conditions and management plans. The absolute quantum of proposed compensation cannot be calculated with any degree of certainty until such time as these issues have been resolved.

136. There are numerous statements in the ELMP ('Individual property Riparian Fencing and Planting Plans'[83]), which I consider pose a substantial risk to the realisation of biodiversity gains intended from the riparian planting. These include the following:

a) I consider an appropriately qualified and experienced freshwater ecologist should design and manage the stream restoration works, not a landscape architect.

b) "*Detailed site-specific design of each fence line and planting area needs to be undertaken with each property owner and/or farm manager. This detailed design will include stock crossings (ie. culverts) where these are necessary*". This could enable stream restoration works that yield further adverse effects on waterways in the general area.

c) "*In some sections of stream it will be necessary to reduce riparian widths to less than 10 metres to accommodate farm operational requirements. Where this occurs, the restoration ecologist designing the riparian planting areas and writing the plan will endeavour to create effective riparian habitat (shade and habitat) on the opposite side of the stream to create favourable instream conditions. Where effective stream shading cannot be achieved, and fences need to be close to the stream edge, that section of stream will not be counted as part of the 8.455km offset requirement*". Further details are needed on the term 'effective', to minimise subjectivity and ensure that adequate riparian planting is provided to achieve the compensation target.

137. I recommend that objectives be explicitly stated in the relevant resource consent conditions and the ELMP to address these issues.

[83] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 4, Section 4.6.4.3.

Recommended amendments/additions to resource consent conditions and management/monitoring plans

Overview

138. All monitoring thresholds and limits should be explicitly stated in the relevant resource consent conditions, as opposed to being referred to in the associated monitoring plans (these subsequently being contained within the management plans). This specifically relates to both the Freshwater Ecology Management Plan and the Construction Water Discharges Monitoring Programme.

139. The Freshwater Ecology Management Plan generally lacks sufficient information regarding design details and proposed mitigation measures. For example, the potential use of fish trap and transfer has been proposed near the large area of fill near the tunnel portals; however, no details have been provided for this activity (e.g., location and type of trap(s), inspection or fish relocation frequency, duration of use, etc.)[84].

140. Many aspects of the proposed mitigation (and monitoring) do not provide much certainty regarding the mitigation of effects. For example, it is stated in the ELMP that "*if after 2 years the recruitment of young fish is not occurring then refinements to the culverts fish passage devices will be made, where practicable, to remedy any barriers to upstream fish migration*"[85]. Other subjective statements can be seen in 'Monitoring Action 2' of the event-based monitoring[86]. The inclusion of terms such as 'where practicable', and the omission of explicitly stated management responses, do not afford a great deal of assurance that the intended outcomes of the Project will in fact be achieved.

141. Overall, I consider that these issues need to be addressed, and recommend that the intended design details and mitigation measures be explicitly stated in both the relevant resource consent conditions and the ELMP.

Fish recovery/rescue protocols

142. I recommend the following changes to these protocols, which will ensure that as many fish and megainvertebrates are removed from the affected reach as possible:

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[84] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.3.4.2.
[85] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.4.4.2.
[86] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.4.4 (page 94).

a) All fish recovery/rescue work should be undertaken by an appropriately qualified and experienced freshwater ecologist(s);

b) Fish recovery operations should commence four days prior to the stream diversion or dewatering. At this point, the affected reach should be isolated by stop nets (or other permeable barrier), to prevent further fish movement into the reach;

c) Four nights prior to the dewatering or diversion, Gee's minnow traps (model G40M) and/or fine-mesh fyke nets (with built-in exclusion/separation grids) should be set in the affected reach. Preferably both methods would be used simultaneously; however, the choice of method(s) should be determined by the aquatic habitat present (i.e., water depth and width, and habitat complexity) [87]. With regards to the netting and trapping, if any 'Threatened' or 'At Risk' species (as per Goodman et al. [2014]) are caught then further netting and trapping should be undertaken for a minimum of one additional night, until:

    i. Catch rates of the 'Threatened' and/or 'At Risk' species fall below 0.25 fish per trap or net per night (average value); or

    ii. A maximum of three further nights of trapping prior to the dewatering or diversion (i.e., a maximum of four nights in total, including the initial night's trapping);

d) I agree with the trapping and netting effort stated in the ELMP – "*Gee minnow traps will be set at a density of 12 traps per 100 m and fyke nets will be set at a density of 6 per 100 m of stream if the channel is deep enough*". I also agree that two nights' trapping and/or netting effort is sufficient if ≥3 fish per trap or net per night (average value) of not threatened fish species (as per Goodman et al. [2014]) are recorded on the first night;

e) Electrofishing should be undertaken throughout the entire affected reach on each of the two mornings immediately prior to dewatering/diversion.

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87 I note the following statement in the Fish Recovery and Rescue Protocols: "*Gee minnow traps are not required if the fyke nets are fine-meshed (e.g. mesh size <6.4mm) and incorporate a fish exclusion barrier (see Joy et al. 2013)*". I disagree with this statement, as in my experience, the presence of larger eels within fyke nets generally discourages the entry of smaller fish species. Therefore, Gee's minnow traps should also be used, as larger eels are unable to enter these traps; thereby, maintaining a greater chance of capture (and relocation) from the affected reach for these smaller species.

Finally, on the night prior to the dewatering or diversion, spotlighting should also be undertaken;

f) The count, length, and site location of all fish electrofished, trapped, netted, and spotlighted should be recorded (by species). Their release locations should also be recorded;

g) I recommend active searches for kākahi in all waterways prior to dewatering, not just where they are adjudged to potentially be present. This should occur in addition to searches occurring during dewatering;

h) Partial dewatering should occur in all instances during dewatering or diversions to avoid unnecessary stranding/desiccation of aquatic biota; and

i) I agree that fish rescue should be carried out for all streams during construction work.

General freshwater ecological monitoring

143. In general, I agree with the majority of the proposed monitoring detailed in the ELMP[88]. However, I recommend the following additions/alterations:

a) Aquatic macroinvertebrate and fish population monitoring should be carried out bi-annually (twice yearly) at all of the proposed ecological monitoring sites (except for site EM5) for the entire duration of the Project, not just when construction activities (i.e., earthworks) are occurring within that (sub)catchment.

b) Aquatic macroinvertebrate sampling should be undertaken following Protocols C3 (hard-bottomed, quantitative) or C4 (soft-bottomed, quantitative), as set out in Stark et al. 2001) – '*Protocols for sampling macroinvertebrates in wadeable streams'*. The choice of protocol (C3 or C4) should be determined by the physical character of each individual site. A minimum of three replicate samples should be collected at each site. Samples should be processed using Protocol P3 – Full count with subsampling option. Sampling should be undertaken during spring (October to December) and summer (February and March) each year, with all sites being sampled during the same sampling round (as per TRC's State

[88] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.4.

of Environment Monitoring [SEM] programme – TRC [2017]). Combined, these sampling methods should provide accurate information about the richness and composition of the aquatic macroinvertebrate communities present; thereby, enabling the most reliable means of detecting potential Project-related adverse effects.

c) The following six invertebrate indices should be calculated for each replicate at each site: total abundance, taxa richness, EPT taxa, EPT abundance, MCI, and QMCI.

d) Fish population monitoring should be undertaken following the methods described in the national guidelines of Joy et al. (2013) – '*New Zealand freshwater fish sampling protocols*'. Spotlighting should be undertaken at all sites, and should be complemented by either electrofishing and/or Gee's minnow trapping or fyke netting (whichever is most suited to the habitat of the site in question). Freshwater fish are generally visually cryptic and difficult to detect, and are therefore one of the more difficult taxonomic groupings to obtain measures of distribution and population size. Similarly, no one method is suitable for accurately assessing all fish species present (Joy et al. 2013). For example, large galaxiids (giant and banded kōkopu) tend to be underestimated by electrofishing, whereas eels tend to be underestimated by spotlighting (Joy et al. 2013). All results of all methods should be reported in terms of catch per unit effort (CPUE) – a measure of the number of individuals from each species caught for a given amount of effort. Such relative abundance estimates provide more information that simply species composition data; therefore, are more sensitive to potential changes over time.

e) Baseline monitoring should be collected at all sites (except for site EM5) for both aquatic macroinvertebrate and fish communities prior to construction.

Ecological monitoring in response to observed effects

144. I recommend the following aquatic macroinvertebrate monitoring should occur in response to situations where water quality management thresholds have been exceeded for longer than 48 hours duration.

145. If turbidity values at a given site(s) remain generally elevated above its respective management threshold for more than 48 hours (greater than 90% of that time),

then responsive aquatic macroinvertebrate sampling (as per the methods above) should be undertaken within two working days at the relevant control and the downstream impact site(s). The downstream impact site(s) chosen for sampling, should be the site(s) closest to the discharge point. This, however, should be determined in conjunction with TRC.

146. The assessment should be undertaken by a suitably qualified and experienced freshwater ecologist, and should detail whether the following thresholds have been exceeded:

a) A decline in the QMCI score of 1.5 or more from the corresponding control site or baseline monitoring scores; and

b) A decline of greater than 20% in sensitive invertebrate taxa (in this case taxa with an MCI score of ≥5), compared with the control site or baseline monitoring scores.

147. If these thresholds have been exceeded, the consent holder should undertake mitigation works, which should include sediment removal procedures (e.g., Sand Wand™ [Gray 2013]) and/or additional biodiversity offsets (e.g., further riparian planting). The choice of mitigation measure(s), the quantity of mitigation, and the timeframe within which it will be implemented, should be determined in conjunction with the Ecology Review Panel and TRC.

148. These mitigation responses should similarly apply to the sediment deposition monitoring of the sediment plates (at monitoring site EM5) in the kahikatea swamp maire forest. I notice that the management threshold response associated with this monitoring has increased to 6 mm sediment deposition (from 5 mm) in the two most recent versions of the ELMP, without any justification. Accepting a higher sediment deposition threshold brings with it obvious higher ecological risks to both the receiving wetland (regionally significant) and freshwater environments. This lower level of protection is surprising considering that this habitat is described by Mr Nick Singers as "*ecologically diverse and important*…and…*Wetland plants can be particularly sensitive to changes in hydrology and sedimentation*" (Technical Report 7a).

Mitigation efficacy monitoring

<u>*Fish passage*</u>

149. I agree that fish passage monitoring should be undertaken at culverts 9, 15, and 18 (corresponding to sites Ea10, Ea16, and Ea23, respectively) to ensure that unimpeded fish passage is being maintained. However, I recommend monitoring should also be undertaken at higher gradient culverts (i.e., those posing a higher risk of impeding fish passage[89]), not just those with lower gradients. Therefore, I recommend that monitoring also be undertaken at culverts 11 and 17 (corresponding to sites Ea12 and Ea21, respectively). Furthermore, kōura passage should be monitored at these sites, as this species was found at both of these sites, not just site Ea21[90].

150. Fish passage monitoring should be undertaken following the methods recommended in Franklin et al. (2018). This monitoring should be undertaken annually for at least three years post-construction.

151. All permanent culvert inspections should be repeated four years after installation, to ensure the appropriate functioning of non-barrier permanent culverts. These inspections should be undertaken by a suitably qualified and experienced freshwater ecologist (in the area of fish passage), not solely an engineer[91]. This inspection should specifically address the following (at a minimum);

    a) Whether substrate is being retained within the culvert;

    b) Condition of fish passage devices (e.g., baffles);

    c) Signs of erosion or scour of the streambed and/or banks near the inlet and outlet of the structure;

    d) Streamflow velocities are not increased in any areas within the structures that could compromise fish passage (e.g., baffles and rock weirs are functioning as intended); and

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[89] Mr Hamill's supplementary evidence at paragraph 19.
[90] Mr Hamill's supplementary evidence at paragraph 18, and Table 2.5 of the Supplementary Freshwater Ecology.
[91] Mr Roan's supplementary evidence at Annexure B, Construction Environmental Management Plan, Appendix D: Ecology and Landscape Management Plan, Chapter 8, Section 8.4.4.1.

e) Potential debris posing a risk of blocking fish passage or increasing velocities.

152. If monitoring and/or inspections identify potential fish passage issues, appropriate remedial actions should be undertaken, and further monitoring/inspections carried out annually, until fish passage is being appropriately provided for (as agreed by the Ecology Review Panel and TRC).

Stream diversions

153. The success of (i) newly created stream diversions and (ii) stream reaches subject to riparian planting (i.e., the offset compensation reaches) will require monitoring and potentially additional works to help ensure that they are achieving their predicted aquatic biodiversity value.

154. I recommend that SEV and aquatic biota (aquatic macroinvertebrate and fish) surveys be carried out at a number of stream diversions three years after they have been constructed. This will determine (i) if these diversions have been colonised by aquatic biota, and (ii) if they are tracking toward attaining a comparable ecological function and biodiversity value, compared with the original stream reach. Furthermore, the SEV data can help guide the selection of further mitigation measures for these stream diversions (e.g., resolving lack of organic matter), with respect to the ecological functions that appear to be hindering the achievement of their anticipated biodiversity outcome.

155. I recommend a similar approach for all areas proposed for riparian offset restoration planting, to ensure that the target SEV scores are being realised. This monitoring should occur five years after the riparian planting has occurred (to account for greater time lags). This can similarly be used to determine if there are ongoing issues, which are preventing the anticipated biodiversity outcomes from being achieved.

156. Section 7.2.1 of the Landscape and Environment Design Framework (LEDF) states that "*Where practicable, create at least the same length of stream as what is lost. Where this is not practicable, the reduction in stream habitat has been accounted for in the offset calculations for the Mt Messenger Project (see Freshwater Ecology Technical Report (December 2017) and Supplementary Report (February 2018)*". Every effort should be made to ensure that the length of the diversion channel be as close as possible to the length of the original stream channel.

Additional mitigation

Adult invertebrate passage

157. Malaise netting should be undertaken at the recommended fish passage monitoring sites, to determine if the permanent culverts are impeding the upstream flight of adult aquatic insects along stream channels.

158. Malaise netting (excluding any light attractants) should be undertaken at all sites during December to January, following installation of permanent culverts.

159. Netting methods should follow those described in Blakely et al. (2006).

160. Any additional mitigation required should be determined in conjunction with the Ecology Review Panel and TRC.

Additional adverse effects

161. Any additional adverse freshwater effects that may occur within the Project area (e.g., unanticipated effects due to a hydrocarbon spillage), or outside of the Project footprint (yet related to Project activities) prior to the Project being finalised, will require mitigation. The choice of mitigation measure(s), the quantity of mitigation, and the timeframe within which it will be implemented, should be determined in conjunction with the Ecology Review Panel and TRC.

Water quality monitoring for sediment discharges

162. Considering the scale of earthworks associated with the Project, I agree with Mr Duirs[92] and Mr Stewart (from TRC)[93] that *in-situ* turbidity sensors should be used (at both upstream and downstream sites) in both the Mimi River and the Mangapepeke Stream, such that turbidity can be measured remotely using an associated telemetry system (with synchronous data logging at 15-minute intervals). Continuous (telemetered) turbidity sensors are particularly useful compliance monitoring tools – especially for remote locations, such as the Project area. Continuous monitoring ensures that any potential sediment loss events (e.g., associated with storm events) are accurately captured in monitoring (more so than the event-based sampling proposed with currently installed static samplers).

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92 Mr Duirs' EIC at paragraphs 6.5 to 6.10.
93 Mr Ridley's supplementary evidence at Appendix 2.

163. Continuous turbidity monitoring enables the indirect continuous monitoring of visual clarity. Furthermore, it enables the indirect continuous monitoring of total suspended solids (TSS), which in turn enables the estimation of sediment loads transported by a waterway. To accomplish this, each turbidity sensors needs to be locally calibrated to discharge TSS concentrations. To facilitate the development of a robust turbidity-TSS rating table, the associated TSS sampling should occur across a wide range of turbidites. To determine sediment loads, the accompanying water level logger data is also needed to determine corresponding flow rates (discharge).

164. I recommend the management thresholds (measured in NTU) be set as a relative change threshold between the paired upstream and downstream sites, such that turbidity measured at each downstream ('impact') site can be no greater than 20% higher than that measured at the respective upstream ('control') site.

165. The sensor data should be checked at a minimum of once every hour during rainfall events by staff on site, to facilitate a fast response time by the consent holder (or their representative) to any potential management threshold exceedance. Runoff events, while largely determined by rainfall intensity, duration, and distribution, also depend on other factors such as soil type (and associated porosity and infiltration capacity), and antecedent soil moisture. Surface runoff events (and thereby sediment loss) will occur at lower rainfall amounts than those stated for triggered sampling in the CWDMP (trigger event: 25 mm of rainfall in a 24-hour period).

166. I consider this provides a pragmatic approach that minimises sediment loss to the stream and subsequently the marine reserve (despite the fact that some sediment loss is inevitable during earthworks).

167. This approach in both catchments would enable (i) remedial action to be undertaken in a timely manner on-site before effects become overly and unnecessarily damaging; (ii) an assessment of the actual effects of any discharge from the Project on water clarity and suspended sediment (if locally calibrated to the site); and (iii) help determine what proportion of the catchment sediment load the respective Project area yields.

168. In the case of the exceedance of any of the management thresholds, the recommendations for reactive management measures should be applied. Furthermore, if the exceedance occurs for more than more than 48 hours (greater

than 90% of that time), then the responsive aquatic macroinvertebrate sampling (and potential mitigation measures) should also be instigated (as described above).

Thomas Joseph Drinan

24 July 2018

REFERENCES

ANZECC & ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy Paper No. 4. Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand.

Austin MP, Margules CR 1986. Assessing representativeness. In Wildlife Conservation Evaluation (ed. Usher MB) 45–67. Chapman & Hall, London.

Bilton DT, Freeland JR, Okamura B 2001. Dispersal in freshwater invertebrates. Annual Review of Ecology and Systematics 32: 159–181.

Blakely TJ, Harding JS, McIntosh AR, Winterbourn MJ 2006. Barriers to the recovery of aquatic insect communities in urban streams. Freshwater Biology 51: 1634–1645.

Booker D 2015. Hydrological indices for national environmental reporting. Prepared for the Ministry for the Environment. CHC2015–015. Christchurch, NIWA.

Bradford MJ, Heinonen JS 2008. Low Flows, instream flow needs and fish ecology in small streams. Canadian Water Resources Journal 33: 165–180.

Briers RA, Cariss HM, Gee JHR 2002. Dispersal of adult stoneflies (Plecoptera) from upland streams draining catchments with contrasting land-use. Fundamental and Applied Limnology/Archiv für Hydrobiologie 155: 627–644.

Brownlie S, Botha M 2012. Biodiversity offsets: adding to the conservation estate, or 'no net loss'? Impact Assessment and Project Appraisal 27(3): 227–231.

Bull JW, Lloyd SP, Strange N 2017. Implementation gap between the theory and practice of biodiversity offset multipliers. Conservation Letters 10(6): 656–669.

Burdon F, McIntosh A, Harding J 2013. Habitat loss drives threshold response of benthic invertebrate communities to deposited sediment in agricultural streams. Ecological Applications 23(5): 1036–1047.

Campbell Grant EH, Lowe WH, Fagan WF. 2007. Living in the branches: population dynamics and ecological processes in dendritic networks. Ecology Letters 10: 165–175.

Cavanagh J-AE, Hogsden KL, Harding JS 2014. Effects of suspended sediment on freshwater fish. Landcare Research Contract Report: LC1986.

Chadderton WL, Brown DJ, Stephens RT 2004. Identifying freshwater ecosystems of national importance for biodiversity: Criteria, methods, and candidate list of nationally important rivers. Department of Conservation, Wellington.

Clapcott JE, Young RG, Harding JS, Matthaei CD, Quinn JM, Death RG 2011. Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

Clausen B, Biggs BJF 1997. Relationships between benthic biota and hydrological indices in New Zealand streams. Freshwater Biology 38: 327–342.

Collier KJ, Smith BJ 1997. Dispersal of adult caddisflies (Trichoptera) in forests alongside three New Zealand streams. Hydrobiologia 361: 53–65

Davey AJH, Booker DJ, Kelly DJ 2011. Diel variation in stream fish habitat suitability criteria: implications for instream flow assessment. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 132–145.

David BO, Closs GP 2003. Seasonal variation in diel activity and microhabitat use of an endemic New Zealand stream-dwelling galaxiid fish. Freshwater Biology 48: 1765–1781.

Davies-Colley R, Hicks M, Hughes A, Clapcott J, Kelly D, Wagenhoff A 2015. Fine sediment effects on freshwaters, and the relationship of environmental state to sediment load – a literature review. Prepared for the Ministry for the Environment. NIWA Client Report: HAM2015-104.

Davis M, Head NJ, Myers SC, Moore SH 2016. Department of Conservation guidelines for assessing significant ecological values. Science for Conservation 327. Department of Conservation, Wellington.

Death RG 2015. A recommended design for monitoring state and trends in lotic invertebrate diversity in the Conservation Estate. Innovative River Solutions, Institute of Agriculture and Environment – Ecology, Massey University.

Finn DS, Bonada N, Múrria C, Hughes JM 2011. Small but mighty: headwaters are vital to stream network biodiversity at two levels of organization. Journal of the North American Benthological Society 30: 963–980.

Franklin PA, Gee E, Baker C, Bowie S 2018. New Zealand Fish Passage Guidelines for structures up to 4 metres. NIWA Client Report: 2018019HN.

Franklin PA, Smith J, Baker CF, Bartels B, Reeve K 2015. First observations on the timing and location of giant kokopu (*Galaxias argenteus*) spawning. New Zealand Journal of Marine & Freshwater Research 49(3): 419–426.

Freeman MC, Pringle CM, Jackson CR 2007. Hydrologic connectivity and the contribution of stream headwaters to ecological integrity at regional scales. Journal of the American Water Resources Association 43: 5–14.

Goodman JM, Dunn NR, Ravenscroft PJ, Allibone RM, Boubée JAT, David BO, Griffiths M, Ling N, Hitchmough RA, Rolfe JR 2014. Conservation status of New Zealand freshwater fish, 2013. New Zealand Threat Classification Series 7. Department of Conservation, Wellington.

Graham ES, Storey R, Smith B 2017. Dispersal distances of aquatic insects: upstream crawling by benthic EPT larvae and flight of adult Trichoptera along valley floors. New Zealand Journal of Marine and Freshwater Research 51: 146–164.

Grainger N, Collier K, Hitchmough R, Harding J, Smith B, Sutherland D 2014. Conservation Status of New Zealand freshwater invertebrates, 2013. New Zealand Threat Classification Series 8. Department of Conservation, Wellington.

Gray DP 2013. Fine sediment removal from streams: environmental effects, protocols and a prosed rule. Environment Canterbury Technical Report No. R13/95.

Greenwood MJ, Harding JS, Niyogi DK, McIntosh AR 2012. Improving the effectiveness of riparian management for aquatic invertebrates in a degraded agricultural landscape: stream size and land-use legacies. Journal of Applied Ecology 49: 213–222.

Hickford MJH, Schiel DR 2011. Population sinks resulting from degraded habitats of an obligate life-history pathway. Oecologia 166: 131–140

Hicks DM, Gomez B 2003. Sediment transport. In: Kondolf GM, Piegay H (eds.). Tools in Fluvial Geomorphology. John Wiley and Sons, Ltd., Chichester: 425-461.

Hicks DM, Shankar U, McKerchar AI, Basher L, Lynn I, Page M, Jessen M 2011. Suspended sediment yields from New Zealand Rivers. Journal of Hydrology (NZ) 50(1): 81–142.

Holmes R, Hayes J, Matthaei C, Closs G, Williams M, Goodwin E 2016. Riparian management affects instream habitat condition in a dairy stream catchment. New Zealand Journal of Marine and Freshwater Research 50: 581–599.

Horváth G and Kriska G. 2008. Polarization vision in aquatic insects and ecological traps for polarotactic insects. In: Lancaster J, Briers RA (eds.). Aquatic insects: challenges to populations. Wallingford, UK: CAB International Publishing.

Jones JI, Murphy JF, Collins AL, Sear DA, Naden PS, Armitage PD 2012. The impact of fine sediment on macro-invertebrates. River Research and Applications 28: 1055–1071.

Jowett IG, Boustead NC 2001. Effects of substrate and sedimentation on the abundance of upland bullies (*Gobiomorphus breviceps*). New Zealand Journal of Marine and Freshwater Research 35: 605–613.

Jowett IG, Richardson J 1995. Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. New Zealand Journal of Marine and Freshwater Research 29: 13–23.

Joy MK 2007. A new fish index of biotic integrity using Quantile regressions: the Fish QIBI for the Waikato Region. Environment Waikato technical report 2007/23.

Joy M, David B, Lake M 2013. New Zealand freshwater fish sampling protocols: part 1 – wadeable rivers and streams. Massey University, Palmerston North.

Kemp P, Sear D, Collins A, Naden P, Jones I 2011. The impacts of fine sediment on riverine fish. Hydrological Processes 25: 1800–1821.

Leathwick J, West D, Gerbeaux P, Kelly D, Robertson H, Brown D, Chadderton W, Ausseil A, 2010a. Freshwater ecosystems of New Zealand (FENZ) geodatabase. Users guide. Wellington, Department of Conservation.

Leathwick, J.R., Moilanen, A., Ferrier, S. 2010b. Community-level conservation prioritization and its application to riverine ecosystems. Biological Conservation 143: 984–991.

Leathwick JR, Snelder T, Chadderton WL, Elith J, Julian K, Ferrier S 2011. Use of generalised dissimilarity modelling to improve the biological discrimination of river and stream classifications. Freshwater Biology 56: 21–38.

Magoulick DA, Kobza RM 2003. The role of refugia for fishes during drought: a review and synthesis. Freshwater Biology 48: 1186–1198.

Maron M, Hobbs RJ, Moilanen A, Matthews JW, Christie K, Gardner TA, Keith DA, Lindenmayer DB, McAlpine CA 2012. Faustian bargains? Restoration realities in the context of biodiversity offset policies. Biological Conservation 155: 141−148.

McDowall RM 1990. New Zealand freshwater fishes: a natural history and guide. Auckland: Heinemann Reed.

McEwan A 2015. Native fish habitat requirements. Unpublished report. Department of Conservation, Wellington.

McKenney B, Kiesecker JM 2010. Policy development for biodiversity offsets: a review of offset frameworks. Environmental Management 45: 165–176.

Melcher AS, Bakken TH, Friedrich T, Greimel F, Humer N, Schmutz S, Zeiringer B, Webb JA 2017. Drawing together multiple lines of evidence from assessment studiess of hydropeaking pressures in regulated rivers. Freshwater Science 36(1): 220–230.

Meyer JL, Wallace JB 2001. Lost linkages and lotic ecology: rediscovering small streams. In: Press MC, Huntly NJ, Levin S (eds). Ecology: achievement and challenge. Oxford, Blackwell Science.

Meyer JL, Kaplan LA, Newbold D, Strayer DL, Woltemade CJ, Zedler JB, Beilfuss R, Carpenter Q, Semlitsch R, Watzin MC, Zedler PH 2007a. Where rivers are born: The scientific imperative for defending small streams and wetlands. American Rivers and Sierra Club. 26 p.

Meyer JL, Strayer DL, Wallace JB, Eggert SL, Helfman GS, Leonard NE 2007b. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43(1): 86–103.

MfE 1994. Water Quality Guidelines No. 2: Guidelines for the Management of Water colour and Clarity. Published by the Ministry for the Environment, Wellington, New Zealand.

MfE 2008. Proposed national environmental standard on ecological flows and water levels: discussion document. Wellington, New Zealand. New Zealand Ministry for the Environment. ME 868.

Moilanen A, Teeffelen JA, Ben-Haim Y, Ferrier S 2009. How much compensation is enough? A framework for incorporating uncertainty and time discounting when calculating offset ratios for impacted habitat. Restoration Ecology 17: 470–478.

NZTA 2013. Fish passage guidance for state highways. Prepared by NZTA. Version 1.0, August 2013.

Ong JJL, Rountrey AN, Meeuwig JJ, Newman SJ, Zinke J, Meekan MG 2015. Contrasting environmental drivers of adult and juvenile growth in a marine fish: implications for the effects of climate change. Scientific Reports 5: 10859.

Overton JM, Stephens RTT, Ferrier S 2012. Net present biodiversity value and the design of biodiversity offsets. Ambio 42: 100–110.

Parkyn SM, Davies-Colley RJ, Halliday NJ, Costley KJ, Croker GF. 2003. Planted riparian buffer zones in New Zealand: do they live up to expectations? Restoration Ecology 11(4): 436–447.

Parkyn S, Phillips N, Smith BJ 2006. Aquatic invertebrate biodiversity and spatial characterisation of non-perennial streams in native forest in the Waikato. NIWA Client Report: HAM2006-041.

Parkyn S, Collier K, Clapcott J, David B, Davies-Colley R, Matheson F, Quinn J, Shaw W, Storey R 2010. The restoration indicator toolkit: Indicators for monitoring the ecological success of stream restoration. NIWA, Hamilton.

Parkyn S, Smith B 2011. Dispersal constraints for stream invertebrates: setting realistic timescales for biodiversity restoration. Environmental Management 48: 602–614.

Patrick CJ, Swan CM 2011. Reconstructing the assembly of a stream-insect metacommunity. Journal of the North American Benthological Society 30: 259–272.

Pressey RL, Johnson IR, Wilson PD 1994. Shades of irreplaceability: towards a measure of the contribution of sites to a reservation goal. Biodiversity and Conservation 3: 242–262.

Richardson J, Rowe DK, Smith JP 2001. Effects of turbidity on the migration of juvenile banded kokopu (*Galaxias fasciatus*) in a natural stream. New Zealand Journal of Marine and Freshwater Research 35: 191–196.

Rolls RJ, Leigh C, Sheldon F 2012. Mechanistic effects of low-flow hydrology on riverine ecosystems: Ecological principles and consequences of alteration. Freshwater Science 31(4): 1163–1186.

Ryan PA 1991. Environmental effects of sediment on New Zealand streams: a review. New Zealand Journal of Marine and Freshwater Research 25: 207–221.

Schallenberg M, Death R, Clapcott J, MacNeil C, Young R, Sorrell B, Scarsbrook M, Kelly D 2011. Approaches to assessing ecological integrity in New Zealand freshwaters. Science for Conservation Series 307. Department of Conservation, Wellington.

Scrimgeour GJ, Tonn WM, Jones NE 2014. Quantifying effective restoration: reassessing the productive capacity of a constructed stream 14 years after construction. Canadian Journal of Fisheries and Aquatic Sciences 71(4): 589–601.

Smith BJ 2007. Adult aquatic insect fauna of the Mokau River. Environment Waikato Technical Report 2007/24.

Snelder T, Biggs B, Weatherhead M 2010. New Zealand river environment classification user guide. Ministry for the Environment, Wellington, New Zealand.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR 2001. Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for Ministry for the Environment, Wellington, New Zealand. Sustainable Management Fund Project No. 5103.

Stark JD, Maxted JR 2007. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No.1166.

Storey RG 2010. Aquatic biodiversity values of headwater streams in the Wellington region. Prepared for Greater Wellington Regional Council. NIWA Client Report: HAM2010-095.

Storey RG, Quinn JM 2008. Composition and temporal changes in macroinvertebrate communities of intermittent streams in Hawke's Bay, New Zealand. New Zealand Journal of Marine and Freshwater Research 42: 109–125.

Storey RG, Neale MW, Rowe DK, Collier KJ, Hatton C, Joy MK, Maxted JR, Moore S, Parkyn SM, Phillips N, Quinn JM 2011a. Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

Storey RG, Parkyn S, Neale MW, Wilding T, Croker G 2011b. Biodiversity values of small headwater streams in contrasting land uses in the Auckland region. New Zealand Journal of Marine and Freshwater Research 45:2, 231-248.

Stubbington R, Chadd R, Cid N, Csabai Z, Miliša M, Morais M, Munné A, Pařil P, Pešić V, Tziortzis I, Verdonschot RCM, Datry T 2018. Biomonitoring of intermittent rivers and ephemeral streams in Europe: Current practice and priorities to enhance ecological status. Science of the Total Environment 618: 1096–1113.

Sutherland WJ 1996. From Individual Behaviour to Population Ecology. Oxford University Press.

Tonkin JD, Stoll S, Sundermann A, Haase P 2014. Dispersal distance and the pool of taxa, but not barriers, determine the colonisation of restored river reaches by benthic invertebrates. Freshwater Biology 59: 1843–1855.

Townsend AJ, de Lange PJ, Duffy CAJ, Miskelly CM, Molloy J, Norton DA 2007. New Zealand Threat Classification System manual. Department of Conservation, Wellington.

TRC 2010. Small Stream Modification in Taranaki – An assessment of the ecological and hydrological values of small streams, the cumulative extent and ecological effects of modification, and implications for policy and practice. TRC Technical Report No. 537059.

TRC 2012. Future directions for the management of river and stream bed modification – Review of the Regional Fresh Water Plan for Taranaki. TRC Technical Report No. 1000228.

TRC 2013. Maintaining indigenous freshwater biodiversity in the Taranaki region – Review of the regional fresh water and soil plans for Taranaki. TRC Document No: 1092542.

TRC 2017. Freshwater macroinvertebrate fauna biological monitoring programme Annual SEM Report: 2015-2016. TRC Document No: 1716915.

Wahl CM, Neils A, Hooper D. 2013. Impacts of land use at the catchment scale constrain the habitat benefits of stream riparian buffers. Freshwater Biology 58: 2310–2324.

Water Ways Consulting Limited 2017. National Environmental Standard – Plantation Forestry – Additional Fisheries Advice. Prepared for Ministry of Primary Industries. MPI Technical Paper No: 2017/27.

Wilcock RJ, Betteridge K, Shearman D, Fowles CR, Scarsbrook MR, Thorrold BS, Costall D 2009. Riparian protection and on-farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. New Zealand Journal of Marine and Freshwater Research 43: 803–818.

Winterbourn MJ 2005. Dispersal, feeding and parasitism of adult stoneflies (Plecoptera) at a New Zealand forest stream. Aquatic Insects 27: 155–166.

Winterbourn MJ, Chadderton WL, Entrekin SA, Tank JL, Harding JS 2007. Distribution and dispersal of adult stream insects in a heterogeneous montane environment. Fundamental and Applied Limnology/Archiv für Hydrobiologie 168: 127–135.

Wohl E 2017. The significance of small streams. Frontiers of Earth Science 11(3): 447–456.

Wood PJ, Armitage PD 1997. Biological effects of fine sediment in the lotic environment. Environmental Management 21: 203–217.

Wright-Stow AE, Wilcock RJ 2017. Responses of stream macroinvertebrate communities and water quality of five dairy farming streams following adoption of mitigation practices. New Zealand Journal of Marine and Freshwater Research 51: 127–145.

APPENDIX 1 – MT MESSENGER ONE-ON-ONE MEETING – OUTCOMES

NZ TRANSPORT AGENCY WAKA KOTAHI
Mt Messenger Bypass

Department of Conservation
Te Papa Atawhai

Mt Messenger One-on-One Meeting – Outcomes

Topic:	Freshwater
Date:	Wednesday 28 March 2018
Location:	T&T Hamilton
Attendees:	Tom Drinan (DOC), Keith Hamill (Mt Messenger Alliance), Richard Duirs (DOC), Graeme Ridley (Mt Messenger Alliance), Laurence Barea (DOC), Roger MacGibbon (Mt Messenger Alliance)
Facilitators:	Ben Inger (DOC), Peter Roan (Mt Messenger Alliance)

Environment Court Practice Note:

The participant experts, Tom Drinan and Keith Hamill, confirm they have read the Environment Court Practice Note 2014 Code of Conduct, and agree to abide by it (including Part 7 and Appendix 3).

The following sets out the assumptions and outcomes of this one-on-one expert meeting which are agreed to by the participants, Tom Drinan and Keith Hamill:

Key Facts and Assumptions:

Topic 1:

1. Detailed description of the existing freshwater environments.
   - Benchmark to assess effects and determine management requirements for no-net loss target.
   - Survey effort relative to the extent of waterways to be affected.

Points of agreement:

Survey effort – happy with work completed and detailed in supplementary report. Locations upstream of culverted areas where additional work could have occurred (site constraints have limited some of the effort). Some uncertainty remains around species, though inferences made on species that could be present are reasonable. Species present will drive the requirement for fish passage.

Benchmark for no-net loss – SEV used. The 'habitat potential' value has been used as the basis for calculation. Assessment follows SEV method. Tom will review the information again to confirm that assessment is as he would expect it to be; Tom will liaise with Keith if additional methodology description on SEV is needed. Tom is comfortable with approach as he now understands it.

Unresolved issues (and the reasons in each case):

Survey effort – Tom would have liked more survey in upstream catchments. Keith believes effort is fit for purpose. Difference between them however is not substantive.

Topic 2:

2. Biological importance of the headwater streams and achieving no-net loss.

Points of agreement:

Agree that headwater systems in intact forest are high value ecosystems (Rarity, biodiversity etc) . Ammongst other effects, effects on headwaters could include physical loss, loss of connectivity. SEV is used extensively across NZ (but was developed in Akl for urban streams).

Unresolved issues (and the reasons in each case):

Tom believes SEV alone may not be an appropriate tool for assessing habitat effects in headwater catchments. SEV plus some additional approaches could better determine mitigation required. Keith is uncertain that the values warrant a different approach. Keith will go away and think about this some more and come back with further thoughts.

Topic 3:

3. Water take from the Mimi River and Mangapepeke Stream (proportion of flow vs. water level, and screening measures).

Points of agreement:

Managing take appropriately is necessary. Appropriate screening of intake will be required and best practice will be used to determine requirements.

Unresolved issues (and the reasons in each case):

Method for managing take is not agreed. Options exists. Tom not comfortable with the proposed restriction using % of level. Keith has outlined an approach in the ELMP. Keith is largely comfortable with approach proposed. Keith will review options for managing take and liaise with Tom.

Topic 4:

4. Fish/invertebrate passage and habitat connectivity issues for culverts and other options (including passage devices [e.g., baffles, spat rope, etc.]) to avoid the adverse effects of culverts.

Points of agreement:

Agree that there is a hierarchy of approaches for fish passage, from arch culverts and bridges, through to methods for passage through culverts (fish and invertebrates).

Invertebrate dispersal – agreed that culverts can have an effect. Limited information available to resolve appropriate mitigation / designs to address. Without monitoring this effect is difficult to quantify. Any residual effect should be identified. This matter will get picked up in the compensation discussions between Roger & Laurence

Unresolved issues (and the reasons in each case):

Tom would like to see use of bridges and arch culverts, particularly for permanent culverts. Tom doesn't agree with the proposed fish passage measures (for both low and flat gradient culverts). IN absennse of arched culverts / bridges, would like to see oversized culverts and embedded into streambed with resting areas, with substrate in culvert. Monitoring of performance would also be needed. Keith – embedding incorporated into the design (but to lower level than Tom would like to see). Keith's preference would be for oversized culverts with resting areas. Keith will go back to the design team and review options for responding to concerns raised.

Invertebrates – Tom believes effect will occur; Keith believes effect at community level is possible.

Topic 5:

5. Fish passage during construction (temporary).

Points of agreement:

Temporary culverts will be in place for short to medium term in duration (months to years). These culverts are generally short in length. Fish passage will be provided for in all temporary culverts (to check). CWMP will be updated to reflect the design provisions for fish passage (including at the northern fill site).

Unresolved issues (and the reasons in each case):

None – but review of CWMP might identify matters of concern.

Topic 6:

6. Sediment loss to waterways during construction.

Context outlined by Richard and Graeme.

Points of agreement:

Construction monitoring programme and response process will be shared with Tom. The programme will need to be sensitive enough to determine whether an effect has occurred. How will the effect be responded to and can it be mitigated / offset / compensated is the question. What the response could be will be discussed in the offset / compensation discussion and will likely focus on a process to resolve effects. Focus of monitoring currently is kahikatea wetland in mimi. Tom would like to see additional focus onto the biological response to sediment, but provision needs also to be practical. Keith and Graeme will look at this and address in monitoring programme; Nick Singers also needs to be involved in this consideration.

Unresolved issues (and the reasons in each case):

Other matters might arise after construction monitoring plan has been reviewed.

Topic 7:

7. Offset compensation in the event of the erosion and sediment control devices failing.

Points of agreement:

Risk of failure of device is low. Consideration of how any effect would be compensated for (say in event of failure) will occur as part of the compensation discussion (Roger & Laurence). This would reflect differences in ecological values.

Unresolved issues (and the reasons in each case):

None – other than as might arise in subsequent discussion

Topic 8:

8. Details of Ecological Design Principles and Stream Restoration Plan measures.

Points of agreement:

Principles of design set out in appendix to ELMP (but this wasn't with the document circulated). If this is ready to circulate then MMA will circulate. Principles provide guidance to designers. Agreed that would be best practice for ecologist to provide inputs into design development to confirm principles have been incorporated.

Unresolved issues (and the reasons in each case):

Other matters might arise after principles have been reviewed.

Topic 9:

9. Mitigating and offsetting freshwater-related effects, including amount required and the location of the offset areas.

Points of agreement:

Riparian enhancement areas are being confirmed and landowner discussions are being progressed. Large extend of the required area has been identified. Agree that the approach of extending downstream from the forested habitat is appropriate. If a disconnected location / fragmented riparian scenario becomes necessary due to inability to gain landowner consent then this may not achieve same benefits as locations closer to the works, and in that scenario additional provisions for offset might be needed. Consent condition that captures requirements / locations for riparian enhancement could be drafted

Unresolved issues (and the reasons in each case):

None assuming that above occurs.

Topic 10:

10. Fish recovery protocols for all waterways affected.

Points of agreement:

Fish recovery protocol has been prepared (but it isn't in the ELMP circulated). It will be circulated to DOC.

Unresolved issues (and the reasons in each case):

Tom – will be uncomfortable with not actively fishing all watercourses (the plan doesn't allow for this on some small watercourse). Keith believes rescue only is needed in some of the smaller streams as described in protocol

Topic 11:

11. Woodchip/wood residue near waterways associated with vegetation clearance activities.

Points of agreement:

There is a potential effect that needs to be managed. Proposal is that mulch will not be stored in proximity of watercourse (a separation is proposed but detail is not stated). Provision will be captured in the ELMP & CWMP.

Unresolved issues (and the reasons in each case):

None – but concerns might arise following review of CWMP / ELMP

Topic 12:

12. Timing restrictions for in-river works.

Points of agreement:

Concern here is physical effect of in-river works (disturbance), though noted that much of this work will occur offline. Restrictions on instream works during spawning seasons could provide benefits (e.g. inanga, redfin bully and giant kokopu). Keith will review this possibility with construction team and report back. If there is a residual effect, then this will need to be considered in compensation discussions. Definition of in stream works would also be beneficial.

Unresolved issues (and the reasons in each case):

Unknown – but subject to review following further information on where and when the works will occur, and acceptability of restrictions.

APPENDIX 2 – SUSPENDED SEDIMENT YIELDS FROM NEW ZEALAND RIVERS

Figure 8. River suspended sediment yields to coast (Mt/y), totalled by region. Figures in brackets give yields without hydro-lakes. Sourced from Hicks et al. (2011).

APPENDIX 3 – SITE LOCATIONS OF THE STREAM SURVEYS UNDERTAKEN BY MR HAMILL

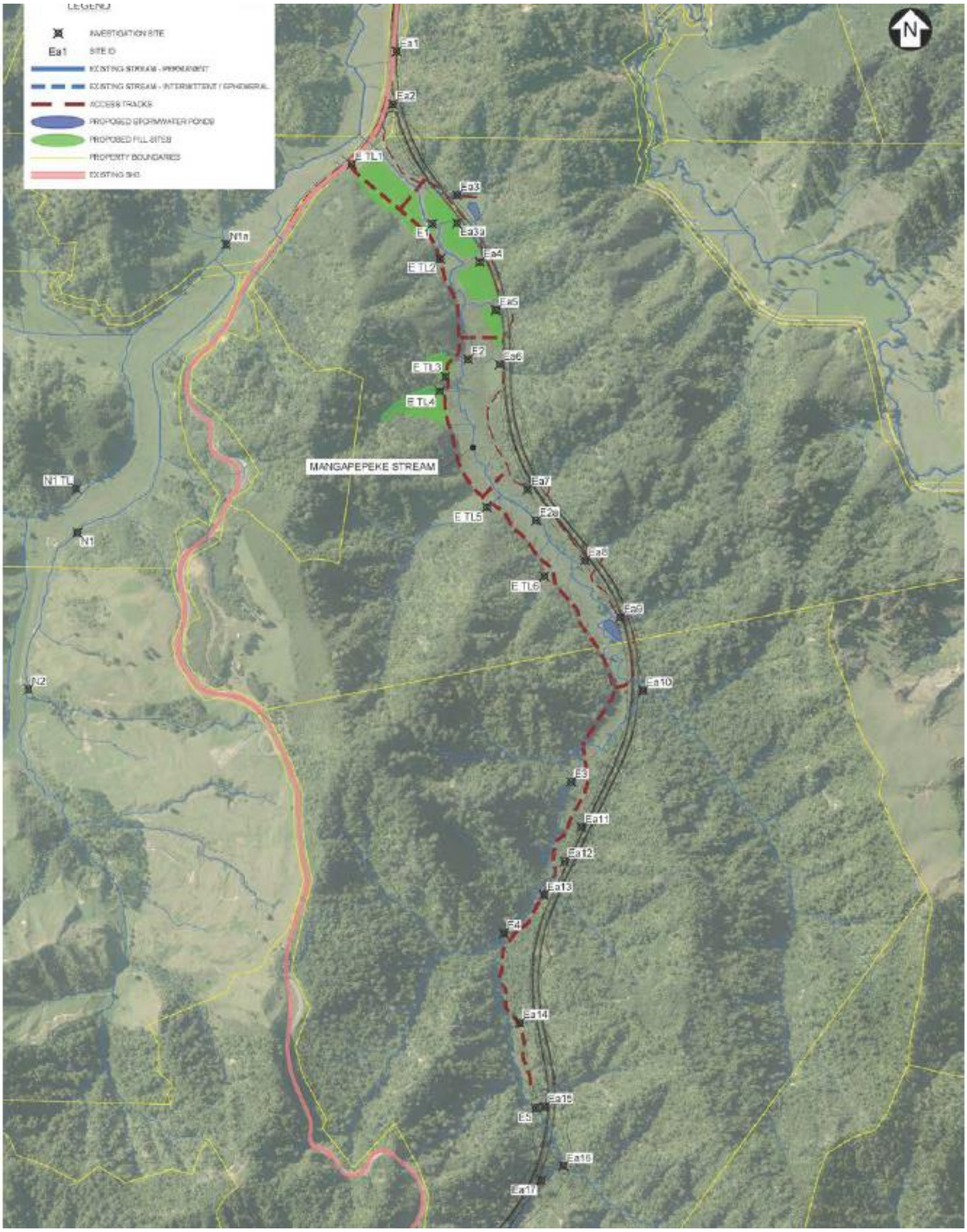


Figure 9. Sampling locations and proposed affected waterways in the Mangapepeke Stream catchment. It is important to note that not all sites/waterways were surveyed.

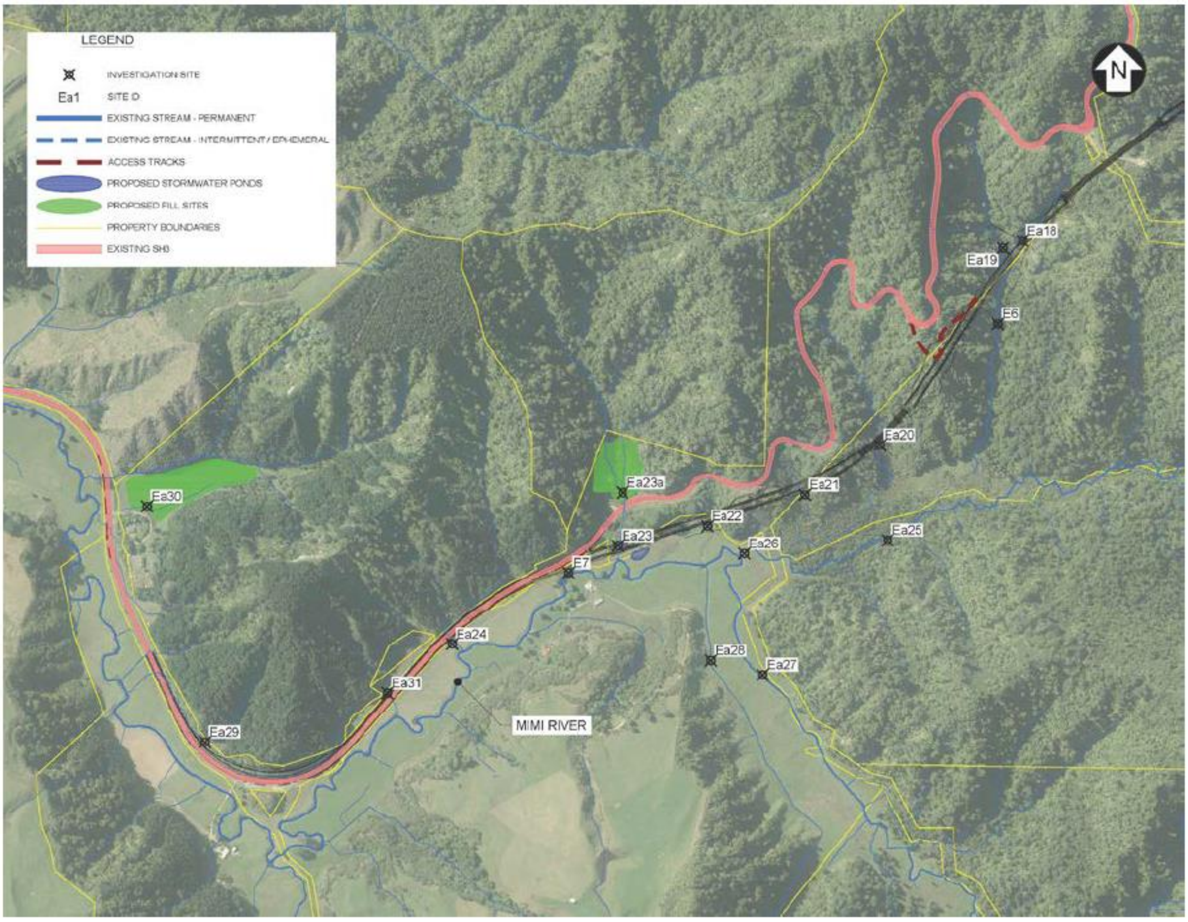


Figure 10. Sampling locations and proposed affected waterways in the Mimi River catchment. It is important to note that not all sites/waterways were surveyed.

APPENDIX 4 – THE NEW ZEALAND THREAT CLASSIFICATON SYSTEM (NZTCS)

1. The NZTCS is a national system led by the Department of Conservation (DOC). It uses objective criteria and information drawn from a range of experts to assess the risk of extinction faced by New Zealand plants, animals and fungi. Each taxon is placed in a category that reflects its level of risk. The system is specifically designed for New Zealand's unusual ecological and geographic conditions.

2. The system is used to assess the status of any plant, animal or fungus that has a wild population established in New Zealand, and for which there is sufficient information available. It uses the best available information on the population trend (rate of decline or increase) and the size of the population (or, if population size cannot be measured, the area occupied by that population) to place each taxon into a category that directly reflects its rate of extinction. All listings are reviewed about every three to five years to detect changes in status over time.

3. Species listed in the parent category 'Threatened' are grouped into the following three subcategories: 'Nationally Critical', 'Nationally Endangered', and 'Nationally Vulnerable' (Appendix 5). Taxa in these three subcategories face a high risk of extinction in the wild.

4. Species listed in the parent category 'At Risk' are grouped into the following four subcategories: 'Declining', 'Naturally Uncommon', 'Recovering' and 'Relict' (Appendix 5). Declining taxa do not qualify as 'Threatened', because they are buffered by a large total population size and/or slower decline rate. However, these taxa may be listed as 'Threatened' in the future if the declining trends continue. The category 'Naturally Uncommon' is adopted to distinguish between biologically scarce and threatened taxa. 'Recovering' allows for threatened taxa whose status is improving through management action, and 'Relict' is used to encompass taxa that have experienced very large historic range reductions and now exist as remnant populations that are not considered unduly threatened.

5. The number of 'Threatened' and 'At Risk' native freshwater fish taxa has increased over time (Table 4). This increase can be partially attributed to (i) a more accurate estimate of their population size and/or area of occupancy; (ii) loss and/or degradation of habitat due to land use intensification; (iii) competition and/or predation by introduced species; or (iv) increased genetic knowledge (Goodman et

al. 2014). Nevertheless, since 2001 there has been a notable increase in the number of freshwater fish species that are threatened with, or at risk of, extinction.

Table 4. Changes in the conservation status of 'Threatened' and 'At Risk' freshwater fish taxa since 2001.

Category	**2001**	**2004**	**2009**	**2013**
Total number of 'Threatened' fish taxa	10	10	15	23
Total number of 'At Risk' fish taxa	16	20	20	19

6. Based on the 2013 listings, 74% of native freshwater fish taxa and 25% of freshwater invertebrate taxa have a conservation status of 'Threatened' or 'At Risk' (Goodman et al. 2014; Grainger et al. 2014). Many of these threatened taxa are taonga species – īnanga, shortjaw kōkopu, giant kōkopu, kōaro (whitebait species), kanakana/piharau (lamprey), tuna (longfin eel) and kākahi (freshwater mussel). Also, some taxa form the basis of culturally, recreationally and commercially important fisheries.

7. The most recent listing of the conservation status of New Zealand freshwater fish taxa under the New Zealand Threat Classification System was published in 2014 (Goodman et al. 2014). It should be noted, however, that the conservation status listing of New Zealand freshwater fish is currently being reviewed.

APPENDIX 5 – NEW ZEALAND THREAT CLASSICIFICATION SYSTEM

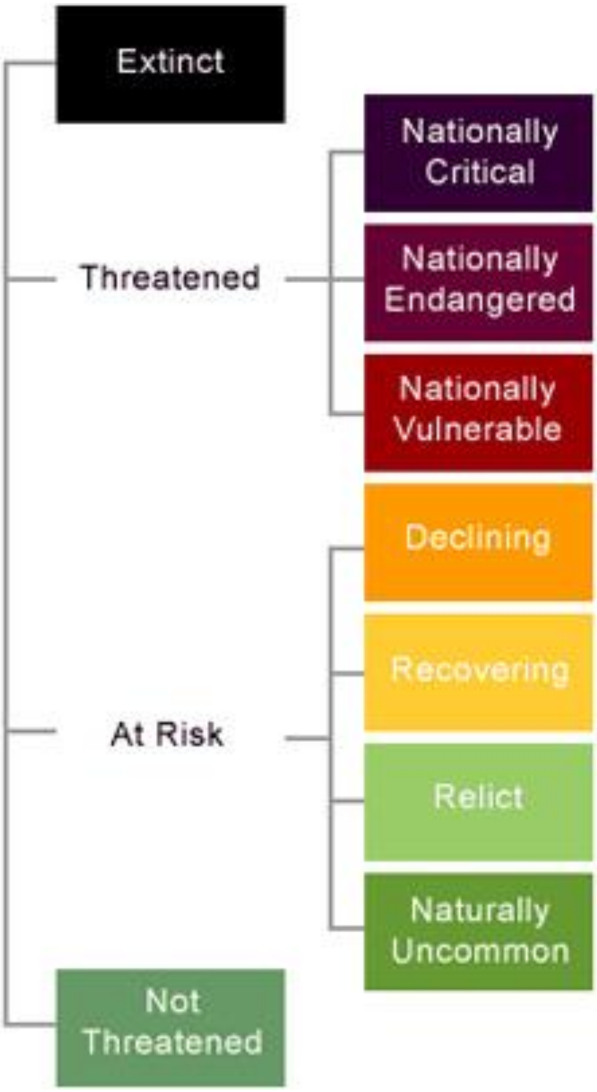


Figure 11. New Zealand Threat Classification System categories (Townsend et al. 2007; source: Department of Conservation)[94].

[94] http://www.doc.govt.nz/nature/conservation-status/, accessed 27 September 2017.

APPENDIX 6 – AQUATIC INVERTEBRATES OF NOTABLE CONSERVATION VALUE RECORDED FROM NEARBY THE PROJECT AREA

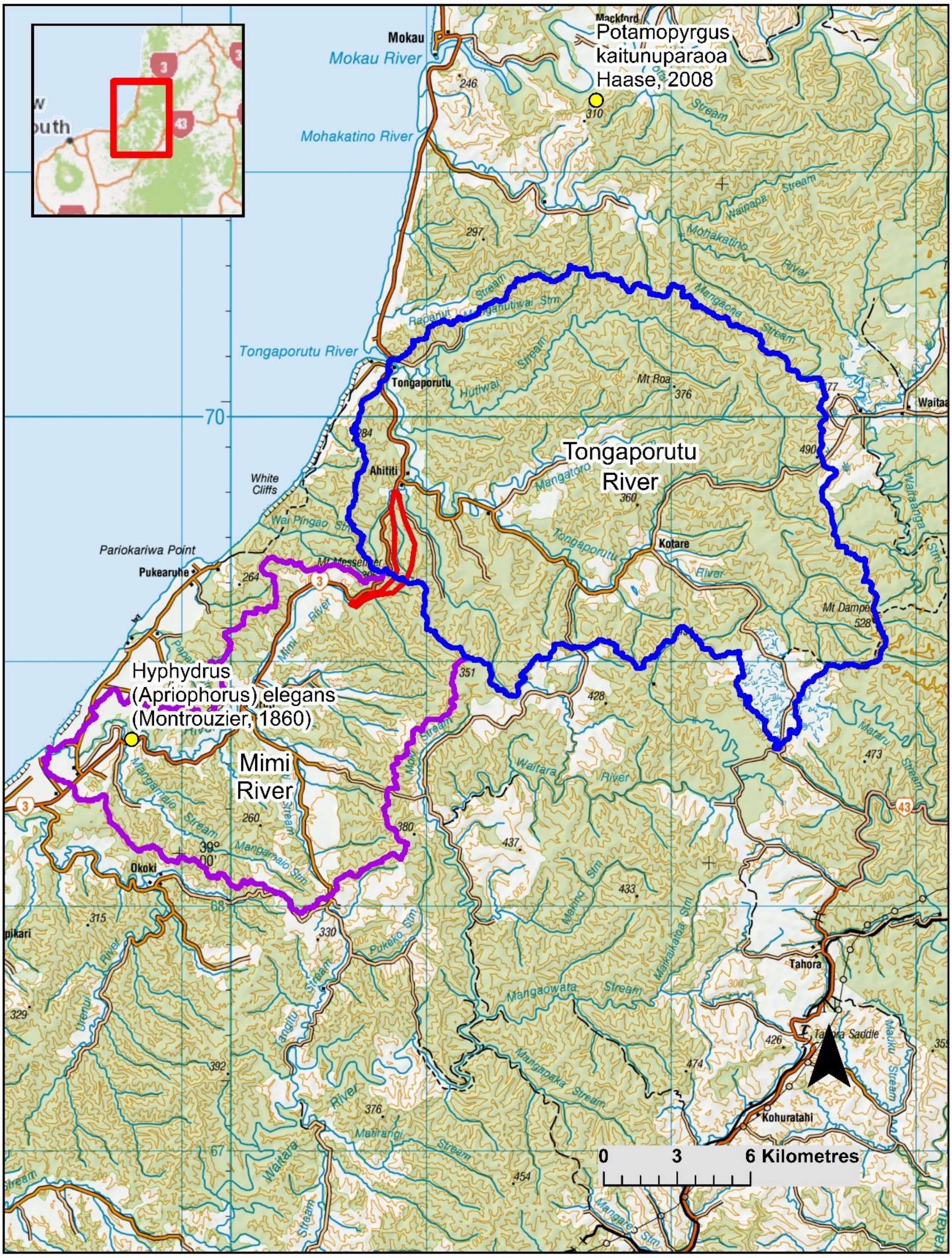


Figure 12. Aquatic invertebrates of notable conservation value recorded from the lower Mimi River catchment, and the Mokau River catchment. Data sourced from DOC's threatened freshwater invertebrate database.

APPENDIX 7 – NZFFD RECORDS FROM NEARBY THE PROJECT AREA

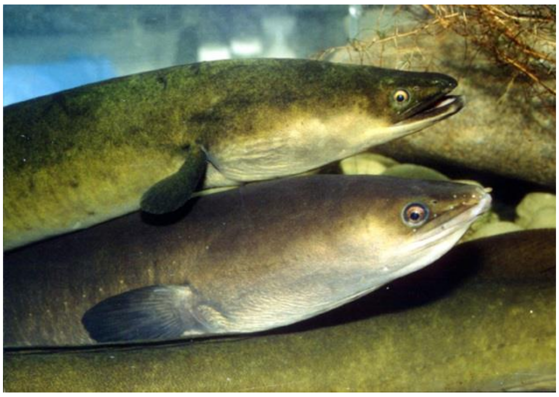
Figure 13. NZFFD records from the Tongaporutu River catchment.

<u>Fish taxa abbreviations</u>: angdie: longfin eel; anguil: unidentified eel; galarg: giant kōkopu; galfas: banded kōkopu; galmac: īnanga; gobcot: common bully; gobgob: giant bully; gobhut: redfin bully; gobiom: unidentified bully; parane: kōura; parcur: *Paratya curvirostris* (freshwater shrimp).

Figure 14. NZFFD records from the Mimi River catchment.

__Fish taxa abbreviations__: angdie: longfin eel; anguil: unidentified eel; galarg: giant kōkopu; galaxi: unidentified galaxiid; galbre: kōaro; galfas: banded kōkopu; galmac: īnanga; galpos: shortjaw kōkopu; gobhut: redfin bully; gobiom: unidentified bully; parane: kōura; parcur: *Paratya curvirostris* (freshwater shrimp).

APPENDIX 8 – PHOTOGRAPHS OF SOME OF THE NATIVE FRESHWATER FISH RECORDED IN (AND NEARBY) THE PROJECT AREA



Shortfin eel

Giant kōkopu

Kōaro

Banded kōkopu

Īnanga

Shortjaw kōkopu

Giant bully

Redfin bully

APPENDIX 9 – FENZ: DESCRIPTION OF CLASSIFICATION METHOD, AND ADDITIONAL OUTPUTS FOR BOTH THE TONGAPORUTU AND MIMI RIVER CATCHMENTS

1. The FENZ classification used for this task was developed as a multivariate equivalent to the rule-based REC, with the primary aim of defining a classification that best explains biological dissimilarities across sites (Leathwick et al. 2010a). It comprised of Generalised Dissimilarity Modelling, followed by multivariate classification; initially using non-hierarchical mediod clustering, followed by hierarchical clustering (Leathwick et al. 2011). The catchment-scale classifications were based on the segment-scale FENZ classification groups (Level IV – 300 group) they contain. The resulting classification tree is then interpreted at increasing level of complexity to identify numbers of groups where types of rivers are discernible. The levels provided in the classification are 50, 60, 75, 80, 100, and 120 river-type groupings. For this exercise, I used the 120 river-type grouping (finer resolution level of classification), as these rivers are the most ecologically comparable to that of both the Tongaporutu and Mimi rivers.

2. Having established the context for assessing the conservation significance of both the Tongaporutu and Mimi rivers by grouping them separately with other rivers of comparable ecological characteristics, I then compared their respective conservation rankings and estimates of ecological integrity contained within the FENZ database (Leathwick et al. 2010a).

3. The FENZ conservation rankings prioritise New Zealand's rivers and streams using planning units whereby first- to third-order streams are treated as individual entities, while fourth and larger-order rivers are sub-divided into planning units containing their third-order sub-catchments and mainstem. The analysis uses segment-scale information describing the spatial distribution of different riverine ecosystems from the FENZ Level III (200 group) river classification groups, together with estimates of catchment condition/ecological integrity (termed 'pressures' in the FENZ database) as affected by human activities (introduced fish, mines, dams, catchment clearance, urbanization, and modelled nitrogen load). Ecological integrity calculations also consider the longitudinal connectivity inherent in rivers, which reflects the need for maintenance of fish passage to/from the sea (Leathwick et al. 2010a). Ecological integrity scores vary between '1' (pristine site) to '0' (totally degraded site).

4. Ranking values were calculated using Zonation (Leathwick et al. 2010b). Ranking values indicate sub-catchments or catchments required to protect a representative range of all New Zealand's river ecosystems. For example, ranking values in the range from 0 – 10% indicate the set of sub-catchments that would maximize the representation of a full range of river ecosystems if only 10% of rivers are to be protected, values in the range 10 – 20% indicate the additional sub-catchments required if protection is to be extended to 20% of rivers, etc. Highly ranked sub-catchments generally contain the highest-ranked examples of the ecosystem classes for which they provide representation; however, the use of connectivity constraints results in preference being given to those sub-catchments in which upstream and downstream sub-catchments also have high levels of ecological integrity.

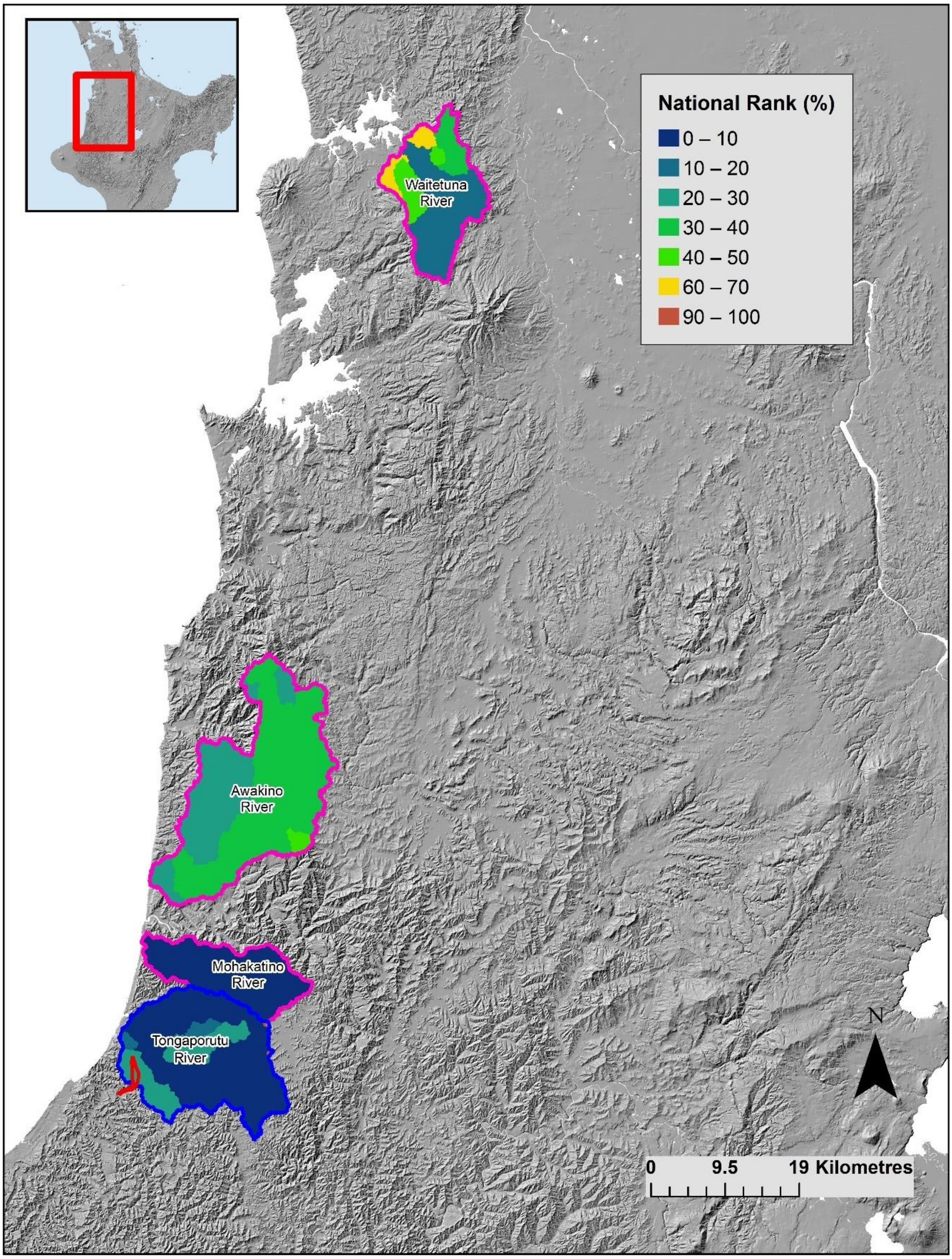


Figure 15. National sub-catchment ranks for the Tongaporutu River and similar catchments.

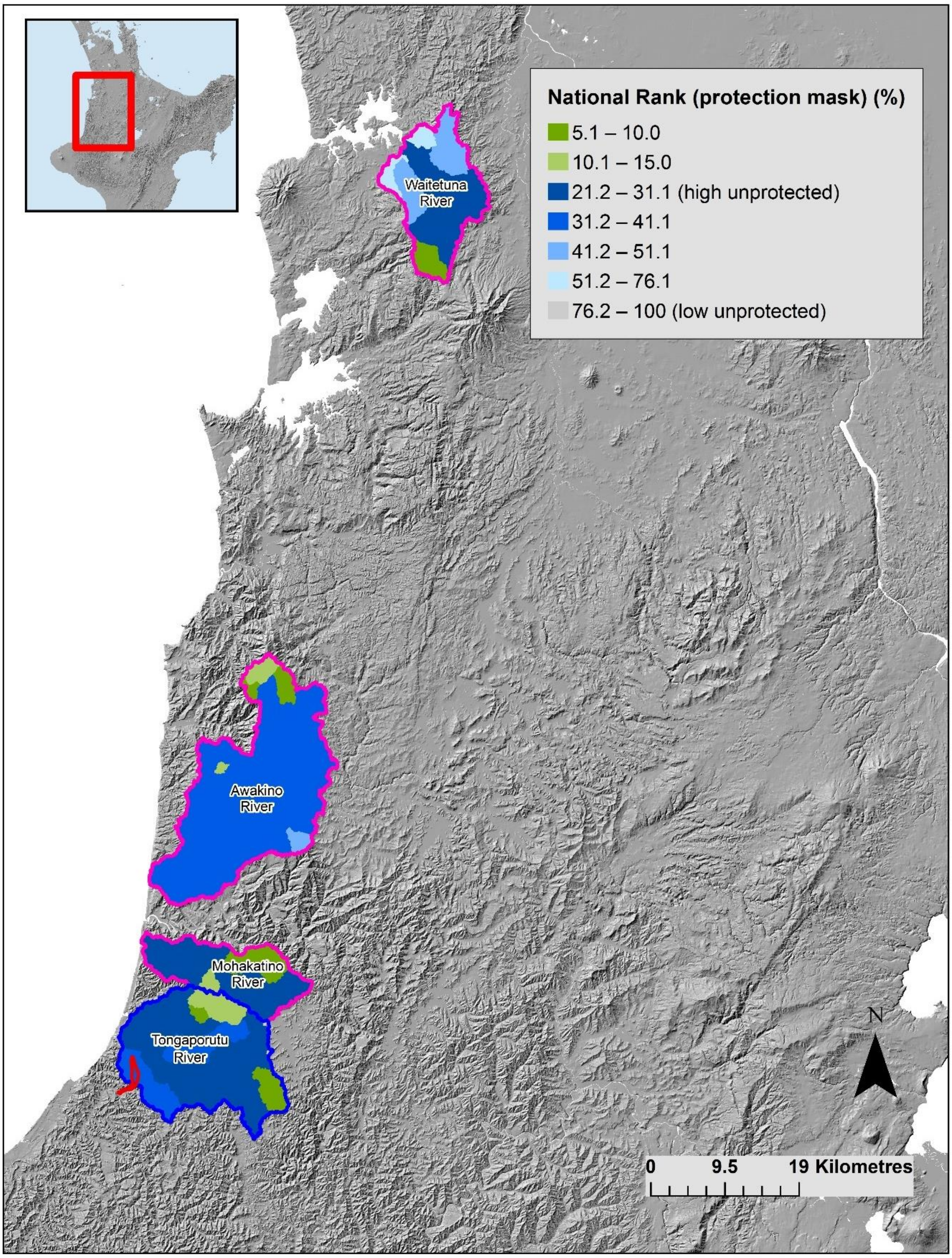


Figure 16. National sub-catchment ranks with protected sub-catchments included for the Tongaporutu River and similar catchments.

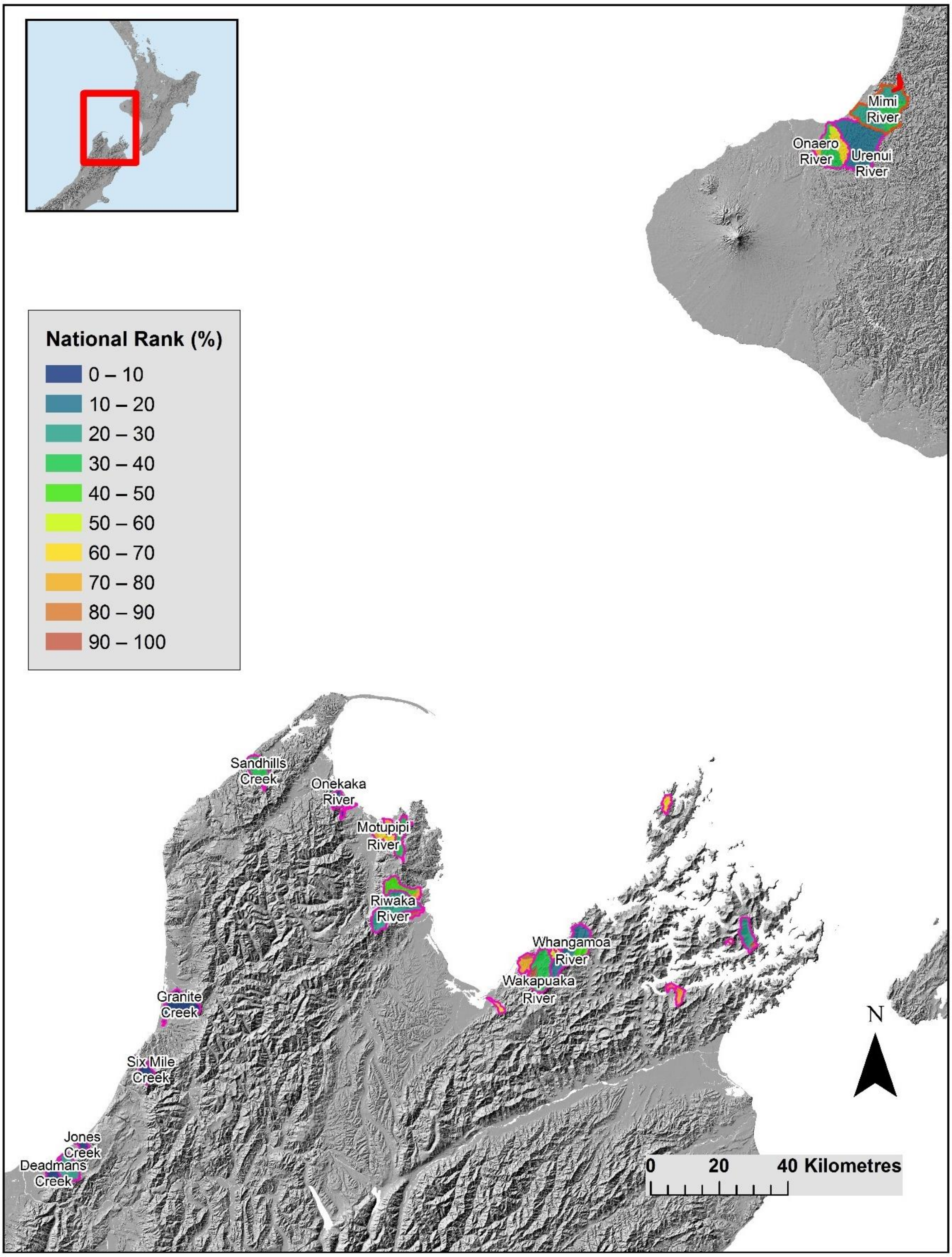


Figure 17. National sub-catchment ranks for the Mimi River and similar catchments.

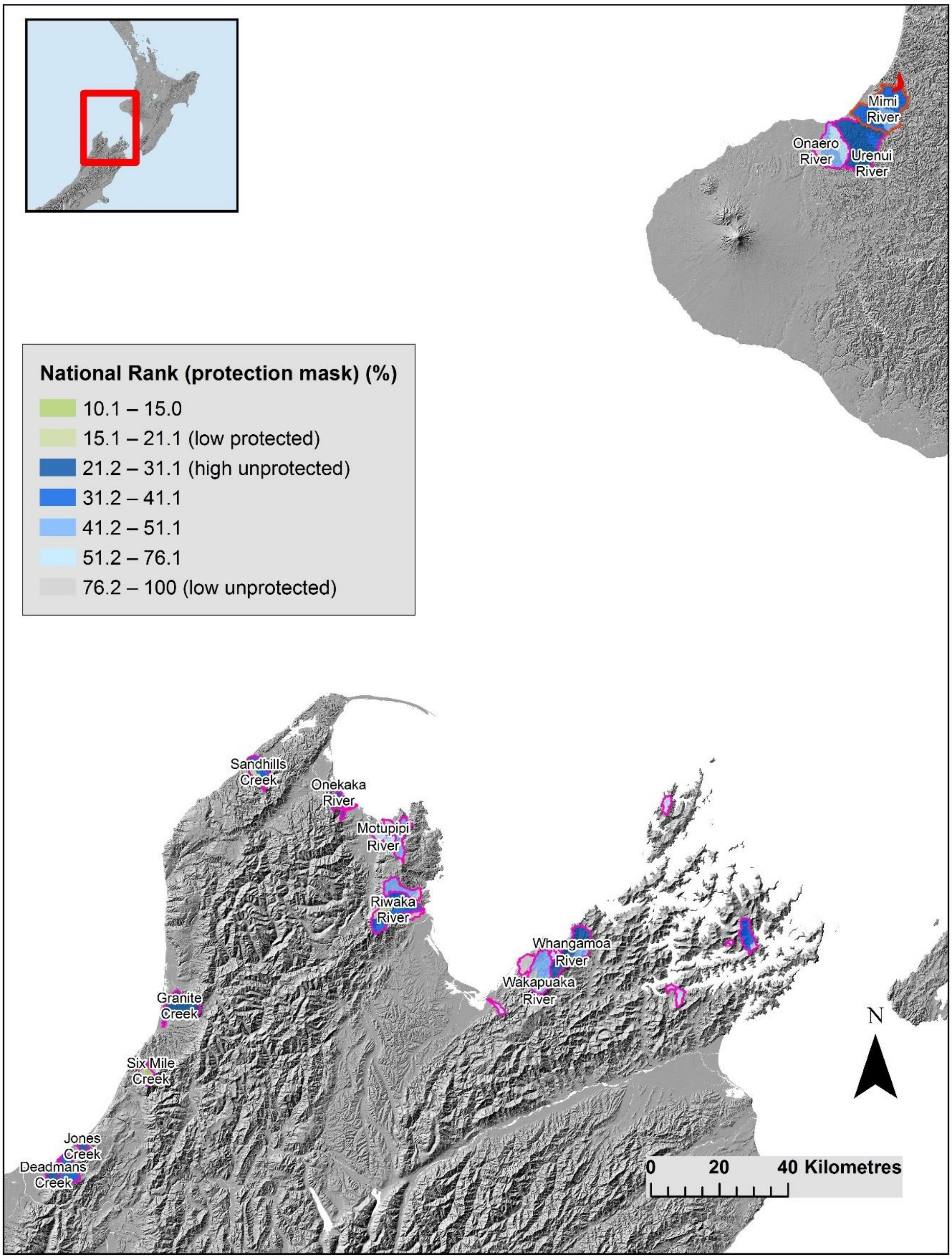


Figure 18. National sub-catchment ranks with protected sub-catchments for the Mimi River and similar catchments.

APPENDIX 10 – MAP OF SIGNIFICANT INANGA SPAWNING SITES IN NORTH TARANAKI

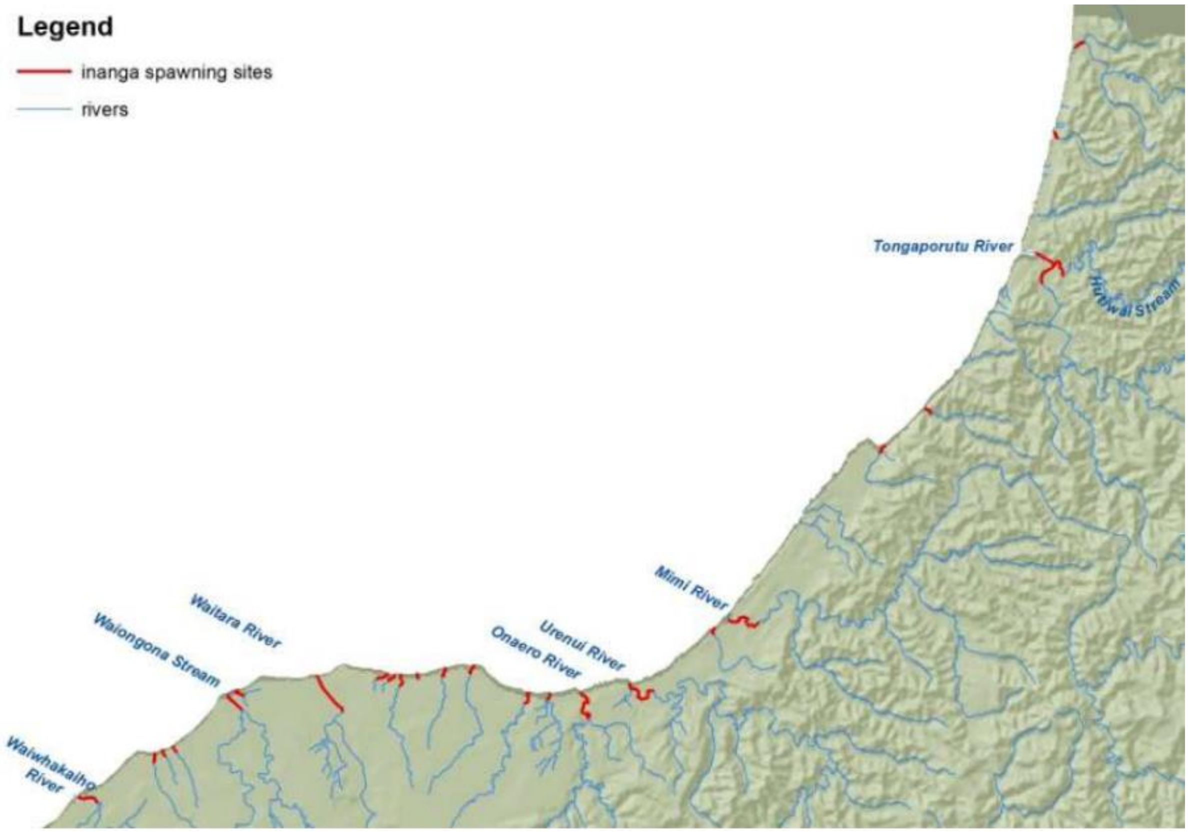


Figure 19. Significant inanga spawning sites in north Taranaki (reproduced from Appendix II of TRC [2013]).

APPENDIX 11 – BLACK MUDFISH ACCIDENTAL RECOVERY (WAIKATO EXPRESSWAY)

Hamilton Section

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19 February 2018

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Kia ora Andrew

Black Mudfish Accidental Discovery – Culvert L, Sector 2, Waikato Expressway, Hamilton Section

I wish to notify you of a black mudfish habitat which was discovered by City Edge Alliance staff in December 2017. This letter will outline what we found as well as some helpful information from Kessels Ecology which could be used in the future for similar circumstances.

The black mudfish were found in the original channel of Culvert L, either side of the haul road, chainage 4950 and GPS location -37.712228°, 175.259451° as part of the construction of the Waikato Expressway: Hamilton Section.

The site had been inspected by an Environmental Advisor previously and deemed to be dry, therefore earthworks, including culvert L excavation took place on 20 December 2017 without prior fish rescue, as per the Fish Management Plan. After some excavation, a black mudfish (Neochanna diversus, currently classified as 'At Risk – Declining' 1) was found. Following the find, works in the area immediately ceased and Kessels Ecology was contacted; Freshwater Ecologists were sent out to the site to assess the situation and develop an appropriate management strategy.

All spoil removed from the waterway was searched, and 12 black mudfish were found. Three black mudfish were caught using hand nets in water pooled in the excavated section of the waterway, contributing to a total of 16 black mudfish caught and relocated on December 20th 2017. All black mudfish were adults in good condition, however, three had injuries from the excavation and may not have survived following release. All were released, approximately 50m downstream into the same waterway where suitable habitat was found.

As it was highly likely a substantial population of black mudfish was present, earthworks remained suspended and further fishing was conducted throughout the length of the waterway of culvert L. Two nights of fishing took place from the 20th to the 22nd of December. From fishing, over this period 14 black mudfish, one shortfin eel (Anguilla australis, 'Not Threatened'), and one banded kokopu (Galaxias fasciatus, 'Not Threatened') were caught.

The mudfish were released in the same area previously used for release, in order to keep the population together and increase maintained likelihood of viable population maintenance. The banded kokopu was also released further downstream, while eels were relocated to a downstream (~500 m) wetland of the same subcatchment to reduce predation impacts, and reduce homing instinct effects.

Fishing recommenced on January 8 2018. Three black mudfish and one longfin eel (Anguilla dieffenbachia, 'At Risk - Declining') were caught from the first night of fishing, resulting in a reset. The mudfish caught were again moved downstream to the relocation site of previous mudfish, and the eel to the less proximate wetland. Two black mudfish were caught on January 10th, traps were then moved to focus on the downstream area more heavily which had previously had a lower density of traps. As only one shortfin eel was caught (relocated to downstream aforementioned wetland), fishing was discontinued and excavation was permitted to continue under ecologist supervision, with spoil searches conducted.

During the subsequent excavation of the partially-excavated and untouched portions of the waterway on 11th January, only one mudfish was found on the spoil. Unfortunately, due to mechanical injury sustained it subsequently died. Three shortfin eels were recovered uninjured from the spoil and were released at the off-site wetland.

On 12th January, with an ecologist on site for supervision the culvert pipe was raised to flush water and any residing fish into the excavated section immediately downstream. Two black mudfish and one shortfin eel were caught in this water using hand-nets. Traps were then set overnight in this section to catch any remaining fish. A further seven mudfish and one shortfin eel were caught. Hand-netting after lifting the traps did not catch any more fish and a visual inspection of the culvert pipe did not indicate that any fish remained within it. Again, mudfish were relocated to the downstream site previously used, and the eel to the less proximate wetland downstream. Further trapping was discontinued as it was deemed unlikely that many mudfish remained, and protocols of the Mudfish Management Plan had been adequately followed.

A total of 45 black mudfish were caught and relocated from the site, and it is likely that the earlier population was larger, meaning this site a significant mudfish habitat. Records of findings were entered into the New Zealand Freshwater Fish Database (NZFFDB) by Kessels Ecology, to ensure their presence can be considered in any future proposed works in the area. The Mudfish Management Plan also prescribes future yearly mudfish surveys for the purpose of reconfirming the presence of mudfish in the relocation site, to maintain knowledge of the population dynamics following translocation, and indicate if any issues occur. The release site will therefore be surveyed in late 2018 during peak activity/survey suitability timing for mudfish (around November).

The City Edge Alliance has not communicated the presence of mudfish to adjoining landowners and is unaware of whether or not future development is proposed within this catchment.

This was an unexpected black mudfish location, several findings which may be useful in the future include:

- While mudfish can be rescued during spoil searches, it has a far higher mortality rate than trapping (14 mudfish were retrieved from the spoil, however four subsequently died, versus no deaths amongst the 31 trapped mudfish).

- Fish resided inside the culvert with slower flowing water. Tipping the water out of the culvert then hand-netting and subsequent trapping saved a further 10 mudfish and one eel.

- The spoil searches took place on hot days, causing the mud to heat up and dry quickly. Re-wetting the spoil using a water cart/dump bucket was an effective solution and helpfully assisted in bringing more mudfish to the surface.

- Most of the excavated mudfish were found on the surface of the spoil, however this does not negate the importance of rifling through it, and especially through vegetation within it.

If you have any questions with regards to the matters addressed above, please don't hesitate to contact me.

Yours sincerely

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