

**BEFORE AN EXPERT PANEL
TEKAPO POWER SCHEME**

FTAA-2503-1035

Under the **FAST-TRACK APPROVALS ACT 2024**

In the matter of an application for replacement resource consents in relation to the
Tekapo Power Scheme

By **GENESIS ENERGY LIMITED**
Applicant

**STATEMENT OF EVIDENCE OF KATHRYN JANE MCARTHUR
AQUATIC ECOLOGY AND WATER QUALITY**

22 August 2025

Qualifications and experience

1. My full name is Kathryn (Kate) Jane McArthur. I am an independent freshwater ecologist and water quality scientist based in Kahuterawa near Palmerston North.
2. I hold a Bachelor of Science degree with Honours in Ecology and a Master of Applied Science with Honours in Natural Resource Management, both from Massey University. My post-graduate research included the influence of land use on freshwater macroinvertebrates and the interaction between policy and science in resource management, focussing on water quality objectives and limits in regional plans. I have 20 years of post-graduate experience in freshwater resource management.
3. I started my own consultancy (KM Water) in August 2020. Prior to starting KM Water, I was the Practice Leader – Water with The Catalyst Group for eight years. My consultancy work has included providing expert advice and evidence on eleven regional plans across Aotearoa New Zealand. Before this, I held the role of Senior Scientist – Water Quality with Horizons Regional Council (Manawatū-Whanganui Region). In this role I coordinated monitoring programmes for State of the Environment (SOE), periphyton, macroinvertebrate, indigenous fish, and point-source discharges, and produced expert evidence for many resource consent hearings, enforcement actions, and the Horizons ‘One’ Plan Council-level and Environment Court hearings (the Horizons ‘One’ Plan being a combined regional plan/regional policy statement).
4. I have authored and co-authored a range of reports and publications, including technical reports on water quality and aquatic biodiversity to support the Horizons One Plan and the draft Nelson Resource Management Plan. I have authored and co-authored papers in peer-reviewed journals on the relationship between flow and nutrients in rivers; nutrient limitation; methods for monitoring indigenous fish; the calculation of in-river nutrient loads and limits, and the setting of water quality objectives and limits in water policy. I have provided evidence in these topic areas before the Environment Court and in Board of Inquiry, Special Tribunal, and council hearings processes across the country.
5. I have provided ecological, water quality, and freshwater policy advice to Nelson City Council, Northland Regional Council, Ngāti Kahungunu Iwi Incorporated, Te Rōpū Taiao o Ngāti Whakare, Te Taiwhenua o Heretaunga, Te Rūnanga o Ngāti Whātua, Te Rūnanga o Ngāti Mutunga, Ngāti Pāhauwera Development Trust, Hawke’s Bay Regional Council, the national Iwi Leaders Group, the Department of Conservation, the Ministry for the Environment, Forest & Bird, Fish and Game, Environmental Defence Society and the Biodiversity Collaborative Group. I have recently been, or am currently involved in, freshwater plan processes in Northland, Auckland, Waikato, Bay of Plenty, Hawke’s Bay, Manawatū-Whanganui, Wellington, Tasman, Nelson, Canterbury, and Southland. I am the project manager for the tangata whenua workstream to develop a freshwater plan (under the NPS FM 2020) for the Mohaka and Waihua catchments, Hawkes Bay.
6. I was a member of the National Objectives Framework reference group for the National Policy Statement for Freshwater Management (2017) and a representative on the

Biosecurity New Zealand National Steering Committee for the long-term management of Didymo from 2006 to 2010. Since 2016, I have co-led national workshops on best practice freshwater science and policy development for the New Zealand Planning Institute. I am a guest lecturer in environmental planning, freshwater resource management practice, and science at Massey, Victoria and Canterbury Universities.

7. I have been a member of the New Zealand Freshwater Sciences Society since 2001 and was the Society's President from 2018 to 2022. I am a member of the Resource Management Law Association of New Zealand (RMLA) and was the RMLA scholarship recipient in 2010 for my master's thesis work on water quality policy and limits for the Manawatū River.
8. I am an accredited and experienced RMA hearings commissioner with a hearing chair endorsement and was appointed by the Minister for the Environment as a Freshwater Commissioner under the NPS FM (2020) RMA amendments.
9. I undertook a site visit to the upper Waitaki catchment on 17 and 18 March, focused on the Pūkaki and Ōhau River environments and the associated Waitaki Power Scheme (WPS) diversion and canal infrastructure. I have previously undertaken an ecological and water quality assessment of the lower Ōhau, Twizel and Takapō rivers in relation to consent applications for land use intensification before the Environment Court. I have assessed the ecological effects and provided evidence before the Environment Court on the consenting of the remainder of the Waitaki Power Scheme (WPS) operated by Meridian Energy. I am familiar with the river systems of the mid-Waitaki catchment between Lakes Takapō, Pūkaki, Ōhau and Benmore.

Code of conduct for expert witnesses

10. I confirm I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person; this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.
11. As a member of the New Zealand Freshwater Sciences Society, a constituent organisation of the Royal Society of New Zealand - Te Apārangi, I am also bound by the Royal Society of New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities.¹

¹ <https://royalsociety.org.nz/assets/Uploads/Code-of-Prof-Stds-and-Ethics-1-Jan-2019-web.pdf>

Scope of evidence

12. I have been asked by The Royal Forest and Bird Protection Society of New Zealand (Forest and Bird) to prepare expert evidence in relation to:
 - (a) The ecological values of the Takapō River
 - (b) The ecological effects of the Tekapo Power Scheme (TPS) on the Takapō River as a result of damming and diversion
 - (c) The ability of the proposed consent conditions to manage the effects of the TPS
 - (d) The indigenous biodiversity and ecological compensation package (IBEP) and draft 'Kahu Ora' strategy
 - (e) An assessment of the proposed IBEP against best practice aquatic compensation principles, and the NPS FM (2020) from a technical perspective
 - (f) Official Information Act documents and reports
13. In preparing this statement I have read the evidence of Dr Rachel McClellan, Ms Helen Marr and Mr Michael Harding and I have noted where I rely on the evidence of others.
14. I have also read the following:
 - (a) The reports appended to the application on behalf of Genesis: Appendix M – Native Fish by Waterways Consulting (Richard Allibone), Appendix L – Aquatic Effects by Cawthron (Roger Young, Simon Stewart, Robin Holmes, Karen Shearer, Scott Edhouse), Hydrological and Hydrogeological Analyses by PDP (Scouller, Nicol and Veendrick) and Appendix 5 – Memo from Kenneth Hughey
 - (b) The assessment of ecological effects (AEE) for the Genesis Tekapo re consenting, dated April 2025
 - (c) The scientific papers and reports cited and listed within this evidence
 - (d) Project River Recovery (PRR) Annual Reports from 2016 to 2024
 - (e) Official Information Act (OIA) documents, including Lewis and Maloney (2020)
 - (f) Technical information pertaining to the application for renewed resource consents by Meridian Energy for the remainder of the combined Waitaki Power Scheme (WPS)

Executive summary

15. The existing environment that I have applied for my assessments has taken a broader approach than the scope of the Genesis technical reports. While dams and structures of the TPS are part of the existing and long-term future environment, the diversion of

water between from Lake Takapō and the Takapō River into the Tekapo Canal is a regulated and manipulatable system. Didymo has had a significant adverse effect on the ecology of the Takapō River and the effects of didymo are exacerbated by diverted flows.

16. The technical reports appended to the application have not identified all ecological effects on braided river extent, habitat and values because the scope of those reports is limited by the definition of the existing environment. Using a broader definition of the existing environment that allows for changes in flows from current operations, I have assessed effects against key five components which together comprise ecosystem health, as described by Clapcott et al. (2018).
17. From that assessment I conclude the loss of flow has resulted in significant adverse effects on braided river habitat extent and ecological values in the Takapō River. Effects include loss of connectivity with braid plains and flood plains, resulting in reduced morphological and habitat heterogeneity, habitat quality and natural ecological disturbance regimes.
18. Diversion of flow and dewatering of the Takapō River results in a total loss of habitat for 6.6 km of riverbed and a loss of biomass of invertebrates and fish from potential catchment populations. Diversion of flows from the natural channel limits the sediment bedload transport, essentially starving the river of fine sediment and resulting in an armoured bed, fewer braids, bed and channel degradation from reworking of sediment from the bed and banks, and ineffective scouring of periphyton during high flow events. Whilst some reduction in fine sediment load can be expected in lake-fed rivers there are residual effects from diverting the fine sediment in flows away from the Takapō River.
19. The absence of flushing flows in the Takapō River results in significant adverse effects on habitat, benthic ecology and indigenous fish. Inadequate flushing and flood flow frequency in the mid to lower reaches of the river causes poor macroinvertebrate health, degrades the quality of physical habitat and disrupts ecological processes.
20. Eels are largely absent from the Takapō catchment and the effects of their absence on ecological processes are largely unknown. Any remaining eels of breeding age and size are unlikely to safely complete their downstream breeding migration as flows are diverted through power station turbines rather than rivers, resulting in ~100% mortality.
21. The TPS operations, without any environmental flows in the Takapō Rivers, has had and will continue to result in significant and adverse effects on river extent and values, including ecosystem health, indigenous biodiversity and hydrological functioning. Changes to the manipulated flows in the upper Takapō River to improve environmental flow regimes will benefit ecosystem health and reduce significant adverse effects. No mitigations of this kind are proposed in the application.
22. I recommend four potential options for the restoration of residual/minimum flows and flushing flows in the Takapō River to increase the extent of physical habitat in the river and improve ecosystem health and other freshwater values.

23. From a technical perspective the effects of the current operation do not sustain the life supporting capacity of the Takapō River and its ecosystems and indicate ecological integrity, form, functioning and resilience of the braided river system are degraded. These findings may be relevant to assessing the likelihood of achieving Objective 1 and appropriately considering Policies 4 and 38 of the Waitaki Catchment Water Allocation Regional Plan.
24. Residual effects remain unaddressed by mitigation actions or consent conditions and are not directly accounted for within the IBEP. Clear conservation outcomes for 'more than minor' residual effects are required to meet the definition of aquatic compensation under the NPS FM (2020), after sequential application of the effects management hierarchy. Considering and accounting for more than minor residual adverse effects is critical to implementing effective aquatic compensation.
25. I reviewed the IBEP and draft Kahu Ora 10-year strategy against the best practice principles of aquatic compensation and Appendix 7 of the NPS FM (2020). In summary, I found the evidence did not adequately demonstrate compliance with aquatic compensation principles. It was difficult to establish a clear progression from the IBEP objective to the planned and costed actions in the Kahu Ora Strategy. This concern could be addressed by providing greater clarity on objectives, conservation outcomes, residual effects, baseline state and measures of improvement. These currently lack the specificity and transparency necessary to provide confidence that adequate and enduring compensation will occur.
26. Given all the information I have reviewed and assessed, I conclude that when combined the consent conditions and mitigations proposed within them, alongside the IBEP compensation proposal, do not adequately compensate for the loss of river extent and values or the residual adverse effects of the Tekapo Power Scheme.

Ecological assessment and the existing environment

27. I understand that given their landscape-altering and enduring nature, the dams and structures of the scheme can be considered part of the existing and long-term future environment. However, the diversion of water between the lake, river and canal is a regulated and manipulatable system that is, in my opinion, difficult to conceptualise as one steady state 'environment' over the 35 years since the consents were issued. Therefore, on the advice of legal counsel, I have based my assessments on an existing environment that is broader than the limits of the current scheme operations.
28. I understand that the legal position on the existing environment is not settled. I have considered the potential for environmental flow mitigations and associated improvements in hydrological connectivity, ecosystem health and fish passage to address adverse effects.
29. I have considered the effects of the scheme operations as described in the technical reports and bounded by the proffered consent conditions in respect of the diversion and alteration of flows, the dewatering of the upper river and consequent losses of aquatic

habitat extent, quality, connectivity, flow variability and ecosystem health. To understand the degree of residual effects for the purposes of recommending mitigation and/or assessing appropriate compensation I have considered the ecosystem health/ecological integrity of the Takapō River under environmental flow regimes that more closely resemble a 'non-diverted' state.

30. This is consistent with ecological theory on the dynamic nature of rivers whereby "The ecological integrity of river ecosystems depends on their natural dynamic character" (Poff et al. 1997). It is the degree of alteration from that dynamic state which defines the effects of the scheme on the ecological integrity of the Takapō River.

Accounting for the effects of didymo

31. The spread of the invasive diatom *Didymosphenia geminata* (didymo) into the Waitaki catchment in early 2006 has had a pervasive and adverse effect on benthic ecology. Whilst the invasion of didymo was not caused by the operation of the power schemes, the alteration of the flow regime in the scheme affected rivers is known to exacerbate the adverse effects of didymo (Hogsden and Kilroy 2023).² Exacerbated effects occur at sites with dominant didymo cover resulting from absent or insufficient flushing flows.

The effects of the TPS on ecosystem health and ecological values of rivers

32. I have read and generally agree with the descriptions of the instream ecological and habitat values of the Takapō catchment as set out in the technical reports on native fish (Waterways Consulting), aquatic effects (Cawthron) and hydrological functioning (PDP). I do not agree with some of the conclusions reached by those experts on the degree of effect of the scheme on river values. However, disagreements largely arise from differences in approach to the 'existing environment' with respect to diversion and alteration of flow effects, and consideration of potential flow remediation options.³ Effects on the extent, values, and quantum of flow-affected river habitat and aquatic life are not well-described. Furthermore, where the appended technical reports do identify adverse effects resulting from the operation of the TPS, the AEE does not acknowledge, address or attempt to mitigate these effects through proposed consent conditions.
33. The Cawthron report and Appendix 5 Memo from Dr Hughey identify the overall effects of the TPS as less than minor. The method of determining the degree of effect (i.e., less than minor) is subjective and is not formed through analysis using a consistent methodology or framework (e.g., Roper-Lindsay et al. 2018; Storey et al. 2011; also see section 2 in Clapcott et al. 2018). Expert determinations of effect are useful to inform mitigation actions, aquatic offsets and compensation. However, expert opinion as the

² Hogsden K and Kilroy C 2023. Assessment of environmental effects of the Waitaki Power Scheme: Benthic ecology. NIWA report no. 2021122CH prepared for Meridian Energy. 36p.

³ I acknowledge the limitation identified by Dr Allibone in determining the effects on indigenous fish as a result of the lack of fish survey data prior to scheme construction.

basis of determining the level or magnitude of effect can be less transparent than following a defined methodology or framework.

34. Ecological assessment requires a holistic approach to understanding the relationships between organisms and their environment, both biotic (living) and abiotic (non-living) components. Clapcott et al. (2018) describe five core components of their biophysical framework to assess ecological integrity/ecosystem health:

- (a) aquatic life,
- (b) physical habitat,
- (c) water quality,
- (d) water quantity and
- (e) ecological processes.

35. The five-component framework provides a useful structure to assess the effects of the TPS on each component in a way that also contributes to a holistic understanding of the ecological health of the affected river environments. This framework was also the basis for the definition of ecosystem health in the NPS FM (2020). I have considered each of the components of ecosystem health in the review of the effects on the Takapō River which follows.

Aquatic life

36. The aquatic life component of ecosystem health is indicated by the state of microbes, plants, invertebrates, fish and waterbirds.⁴ The Takapō River aquatic plant community is dominated by periphyton, including invasive didymo.

Periphyton

37. Periphyton cover in the mid and lower Takapō River regularly exceeds guidelines for recreational and aesthetic values at levels which are known to negatively impact benthic macroinvertebrates (Matheson et al. 2012 & 2016). Whilst didymo is certainly problematic and causes nuisance blooms, not all nuisance growth in the Takapō is didymo. The Cawthron report shows periphyton survey data at Table 6, page 36⁵ and the proportion at each site comprised of didymo cover. This data shows didymo was dominant at site 8 (75%) and site 2 (40%), with the other sites ranging between 0 and 20% cover by didymo. Sites in the lower river regularly exceed periphyton national bottom lines, sometimes due to didymo and sometimes due to other types of periphyton. I agree with the conclusions reached in the Cawthron report that high periphyton

⁴ Effects on waterbirds are covered in the evidence of Dr McClellan.

⁵ Noting this is from a single survey in March 2019.

biomass, particularly in the lower reaches are likely due to 1) didymo invasion, and 2) long periods between high flow events.

38. The magnitude of flushing flow required to dislodge periphyton differs by river and is influenced by the availability of sand to assist in scouring periphyton from the rocks. Kilroy et al. (2017) report 1.5 to 10 times the median flow is needed, and the PDP report suggests either 3, 6, or 10 times median flow. The Cawthron report anticipates 6 to 10 times median is likely required in the Takapō, given the available bed material, and I agree that this is probably the case.
39. The Genesis AEE document states, near the top of page 178, that *"If all the natural flow was allowed down the Takapō River, it is very likely that there would still be abundant didymo blooms that would affect macroinvertebrate communities and other aquatic life and the effectiveness of flushing flows on improving macroinvertebrate communities is probably limited"* [emphasis added].
40. Whilst I agree that there would still be didymo blooms under a natural flow regime in the Takapō River, there is no evidence presented in the technical assessments that natural flushing flow effectiveness in improving macroinvertebrate community health would be 'limited' and I do not agree that this is the case. The Cawthron report does not specifically state this, instead it identifies that long periods between flushing flows contribute, alongside didymo invasion, to nuisance periphyton growth. Whilst this is also the case for other (non-regulated) natural lake outflow rivers that are affected by didymo, flow regulation contributes to and exacerbates bloom events and their persistence.⁶ Furthermore, the periphyton community in the Takapō River is of mixed composition and likely to have a variable response to 'resetting' flow events.
41. The Cawthron report identifies that individual flushing flows will have temporary effects on periphyton biomass and cover,⁷ I agree because all flushing flows have temporary 'resetting' effects on periphyton. However, the magnitude, timing, frequency and duration of flushing flow events are critical factors (along with fine abrading sediment load) in determining the effectiveness of any environmental flow regime, or reintroduction of flow variability, to improve ecosystem health. I do not agree with the overall conclusion of the Cawthron report that the effects of the TPS on aquatic ecosystems are no more than minor.
42. Matheson et al. (2012 and 2016) recommend periphyton guidelines to provide for various levels of macroinvertebrate health and trout fishery values (Table 1), using a weighted composite cover method that combines mat and filamentous algae.

⁶ Hogsden and Kilroy (2023) note that in the upper Ōhau River "...limited data suggest that the WPS as it currently operates in the Upper Ohau River (i.e., reduced flow variability) affects periphyton removal processes and contributes to prolonged didymo-dominated accumulations, which has a more than minor effect on benthic ecology." [emphasis added]

⁷ Cawthron report page 34.

Table 1. Periphyton weighted composite cover (periWCC) classes – note these are not directly correlated with periphyton biomass chl-a bands in the NPS FM. *Source Matheson et al. (2012 and 2016).*

Periphyton cover % (periWCC) Annual maximum	MCI classes	QMCI classes	Ecological condition (periWCC)
<20	>120	>5.99	Excellent
20 - 39	100 – 119	5 – 5.99	Good
30*	-	-	-
40 - 55	80 – 99	4 – 4.99	Fair
50**	90	4.5	-
>55	<80	<4	Poor

* Aesthetic and contact recreation cover threshold from Biggs (2000) and the CLWRP (2018).

** Estimated periWCC% matched to MCI/QMCI NBL using the relationships from Matheson et al. (2012).

43. The CLWRP has a 30% filamentous periphyton cover freshwater outcome for lake-fed rivers (which includes Takapō). That level of cover falls within the ‘good’ category for ecological condition (Table 1) based on Matheson et al. (2012) and is my recommendation as a threshold to define an acceptable level of improvement in periphyton to provide for healthier macroinvertebrate communities.

Macroinvertebrates

44. Macroinvertebrate community health is significantly influenced by periphyton growth. Therefore, managing nuisance cover is critical to improving conditions for other forms of aquatic life. Macroinvertebrate communities in the Takapō River are indicative of moderate water quality, with more tolerant taxa (indicating lower health) abundant when periphyton biomass is high. The Cawthron macroinvertebrate sampling (Table 9, page 41) shows a decline in macroinvertebrate community index (MCI) scores between the upstream site (site 2) and sites in the mid and lower reaches (sites 5 and 8). Flow variability also decreases between these sites in a downstream direction, and this will influence periphyton and thereby macroinvertebrates. Quantitative macroinvertebrate community indices (QMCI) show the opposite pattern and appear to be influenced by large numbers of invertebrates that are closely associated with high periphyton (and didymo) biomass.⁸
45. Cawthron studies found macroinvertebrates were of moderate to high densities and biomass in the Takapō River and suggested that the river supports a good macroinvertebrate community food resource for fish and birds, despite including taxa that are usually found in rivers with high periphyton biomass. The report concludes that the continued operation of the TPS is not expected to have a more than minor effect on existing river values. Again, this conclusion is predicated on the existing environment

⁸⁸ Snails, chironomid midges and Oxythira caddis flies.

being one where the Takapō River is diverted into the TPS, and the values assessed are those found in the existing environment, not those which may exist in the absence of the diversion or under an environmental flow regime.

46. In my opinion, the diversion of water from the Takapō River results in a significant loss of macroinvertebrate and fish biomass and health and has a moderate effect (in combination with didymo) on the existing aquatic life in the river in its diverted state. Increased flow variability is likely to result in improvements in periphyton biomass, macroinvertebrate health, potential fish habitats and thereby ecosystem health values.

Fish

47. The Waitaki catchment supports diverse indigenous freshwater fish communities, with an exceptional diversity of indigenous fish found in a single survey at the mouth of the Waitaki River and Lagoon (author's unpublished analysis). The distribution and diversity of indigenous fish, particularly migratory taxa, is impacted not only by dam barriers throughout the catchment (Jellyman and Harding 2012) but by the diversion of water into canals and through power stations, hydrologically disconnecting fish from habitats and migratory pathways.
48. There are 145 individual fish observation records for the Takapō and Pūkaki Rivers in the New Zealand Freshwater Fish Database (NZFFD), collected between 1979 to 2017. The lower Pūkaki River, where flowing water starts to coalesce from subsurface contributions in the vicinity of the Takapō confluence, holds records for upland bully, Canterbury galaxias and more recently kōaro, as well as introduced brown and rainbow trout. Canterbury galaxias and kōaro are at risk – declining species (Dunn et al. 2018). The NZFFD for the Takapō River contains records for alpine galaxias (at risk – naturally uncommon), Canterbury galaxias, common bully, upland bully, kōaro, and brown and rainbow trout.
49. While Canterbury and alpine galaxias are not considered threatened species,⁹ they are population and range restricted, non-migratory, and therefore vulnerable species of conservation value. There is no reason why flow restoration to the Takapō River would not result in provision of additional habitat for these species, depending on the degree of reconnection with the braid plain and side channels; granted that flow reconnection would also provide habitat access for trout. Trout and indigenous fish like common bully will likely recolonise the Takapō River from Lake Takapō but the obvious route for natural fish reintroduction is from the lower Takapō River.

⁹ There are listed as 'at risk' species by Dunn et al. (2018).

50. The Waterways Consulting report on indigenous fish communities in the Takapō River identifies the effects of the TPS as arising because the scheme diverts water away from the river and into the canal system.¹⁰ The effects are summarised as:
- (a) Change in habitat with reduced flow altering habitat availability
 - (b) Changes in fish community and/or abundance resulting from habitat effects
 - (c) Impedance of fish passage from Takapō River into Lake Takapō
 - (d) Reduction in habitat quality due to lack of flushing flows
 - (e) Fish passage barriers at culverts carrying stream flows beneath Tekapo Canal
51. I agree that this provides a good general summary of the adverse effects on indigenous fish and their habitats, including those that have come about due to the loss of river habitat from flow diversion and lack of flushing flows. An additional effect is the stranding of indigenous fish following recreational or maintenance flow releases. I have recommended changes to the fish salvage consent conditions to mitigate some of the adverse effects resulting from fish strandings.
52. Dr Allibone also identifies potential positive effects of the TPS diversion of flows from the Takapō River as:
- (a) Providing more suitable habitat for indigenous fish that prefer low water velocities and shallow water habitats (bullies and galaxiids)
 - (b) Limitation on the presence of large Salmonids upstream of the Mary Burn and Grays River confluences
 - (c) Reduced fish mortality from reduced flood disturbance
 - (d) New habitat for fish in the Tekapo Canal
53. I do not agree with the positive effects identified by Dr Allibone, with the possible exception of limitations on large Salmonid occurrence as these fish have an adverse effect on indigenous fish in the rivers of the Mackenzie Basin, particularly the threatened and at risk galaxiids.
54. Some indigenous fish such as bullies and galaxiids prefer low velocity and shallow habitats. However, it does not necessarily follow that changing much of the Takapō River to these conditions by diverting flow leads to providing more suitable habitat for these species. No assessment is provided of whether the quantum of suitable habitat for these species would be greater in the Takapō River in the absence of total or partial

¹⁰ Waterways Consulting report by Dr Allibone page Section 6, page 22.

flow diversion. Put simply, the Takapō River would be a much larger river and have a more diverse range of habitats, including those identified as suitable for bullies and galaxiids if flows were not diverted. Furthermore, whilst physical conditions may reflect suitable habitats there are other considerations as to whether the fish can and will utilise that habitat, including but not limited to effects on biotic and abiotic ecological processes such as loss of refugia from predators, competition for space and food, loss of habitat from nuisance periphyton and subsequent changes to water quality (e.g., dissolved oxygen). Homogenous, shallow waterbodies are more readily affected by solar radiation and can be subject to rapid temperature changes and higher summer temperatures, which also adversely affect ecosystem health (Davies-Colley et al. 2013).

55. Reduced fish mortality from substantial reductions in high flow events is difficult to consider a positive effect when the adverse effects from reductions in flow variability are significant i.e., nuisance periphyton biomass, lower quality macroinvertebrate health, armoured bed and lower habitat heterogeneity.
56. Specific accounting of biodiversity gains and losses from exchanging the natural, heterogenous habitat of the Takapō River for the more homogenous habitat of the Tekapo Canal has not been undertaken and therefore there is significant uncertainty in the degree to which this habitat provides any benefit to indigenous aquatic life and ecosystem health. In my view the positive effects are unlikely to result in net benefits to ecosystem health, in view of the negative effects. The exchange does not meet the principles of biodiversity offsetting (e.g. no like-for-like exchange) so the degree of 'offset' provided by any positive effects cannot be calculated.
57. The diversion of flow from the Takapō River has resulted in a continuous loss of fish habitat and populations (abundance) over the last 35 years that is unaccounted for in descriptions of the ongoing adverse effects of the TPS. Aquatic life in the upper Takapō River (upstream of the confluence with Fork Stream) is almost entirely absent due to the diversion of virtually all flow into the Tekapo canal. The adverse effects of the dewatering of ~6.6 kilometres of riverbed are difficult to quantify but the potential biomass of absent macroinvertebrates and fish is large and, given the distribution of non-migratory, at risk, and threatened fish species, there is potential that long-term dewatering has had population level effects on some vulnerable species.
58. Introduction of salmonids is likely to have impacted on indigenous fish in the Takapō River prior to the diversion of flows for the TPS. However, habitat heterogeneity can provide areas for indigenous fish to find refuge from predators. Diverted flow and reduced flow variability has significantly reduced the gross quantum of available indigenous fish habitat and the heterogeneity of habitat type, including refugia.
59. The diversity and abundance of aquatic life that the Takapō River could potentially hold if an environmental flow regime were restored is largely unquantifiable as available area of wetted habitat is highly flow dependent. However, restoration of flows is likely to result in rapid colonisation of the wetted channel by aquatic macroinvertebrates within a relatively short timeframe (i.e., weeks to months) from adult invertebrates in nearby

terrestrial and aquatic systems utilising the new habitat to lay eggs. Periphyton, including didymo is also likely to be an early coloniser. Any environmental flow regime needs to incorporate flushing flows of a magnitude and frequency capable of regularly reducing didymo and other periphyton biomass. The degree to which suspended glacial silt in flows from Lake Takapō would influence the growth of didymo and other periphyton is unknown. Much of the suspended material that could be sourced from Lake Takapō in flow releases may be held up behind the Lake George Scott Weir, rather than move further down the river channel.

60. Spring upwellings in side channels and backwaters provide ideal habitat for lowland longjaw and bignose galaxiids. Reestablishment of flow to the upper Takapō may provide for reconnection of springs with side-braid or backwater features, habitats that are used for feeding and spawning (Jellyman et al. 2019). Such habitats are now rare in the diverted rivers of the combined WPS, and any remaining features no longer hold populations of lowland longjaw or bignose galaxiids.¹¹
61. Flushing flow restoration will need to consider other indigenous fish habitat needs, like low algal and macrophyte cover and improved macroinvertebrate health. Reestablishment and reconnection of potential habitats across the braidplain are critical considerations for environmental flow regimes that anticipate creation of habitat for non-migratory galaxiids, and other indigenous fish. To ensure the survival of non-migratory galaxiids, Woodford and McIntosh (2013) recommend “trout-free source populations must be maintained and new sources created” [emphasis added]. Creation of new source habitats for non-migratory galaxiids are not included in the IBEP, and actions outlined in the draft Kahu Ora 10-year strategy identify protection of only one existing site for lowland longjaw galaxias in Fork Stream.

Longfin eels

62. Longfin eels (*Anguilla dieffenbachii*) are endemic to Aotearoa New Zealand and are one of the largest, slowest growing and long-lived eel species in the world. According to the Waterways Consulting report, the Takapō River catchment and Lake Takapō has been identified as providing excellent habitat for longfin eels and historically, the Takapō catchment has contained abundant and large longfins.
63. Longfin eel populations across the Waitaki catchment have historically, and continue to be, particularly impacted by the combined WPS because eels require full catchment access from mountains to sea to sustain healthy and viable populations. Juveniles migrate from the marine environment into freshwater, and in the absence of dam barriers

¹¹ A spring tributary of the Ruataniwha Wetland that connects to the lower Ōhau River held lowland longjaw and bignose galaxiids in the early 2000s, lowland longjaw galaxias were also recorded once in the lower Ōhau River upstream of the Twizel confluence. The Project River Recovery (PRR) annual report for 2020/21 noted lowland longjaws were no longer found in the lower Ōhau River or Ruataniwha Wetlands. Canterbury Department of Conservation staff confirmed via email (23 June 2025) that lowland longjaw and bignose galaxiids are now considered absent and locally extinct in the lower Ōhau River catchment.

and flow diversions would penetrate far upstream into the catchment, dispersing throughout tributaries along the way. Breeding age adults must retrace this migration back to the sea to reach breeding grounds in the depths of the South Pacific Ocean. Migrant breeding eels are most significantly impacted by the combined WPS because water is diverted through power station turbines which likely cause 100% mortality of eels following the flow, as described in the expert evidence provided for Meridian Energy's consenting application.¹²

64. Dr Allibone's 2019 survey found a single longfin eel at one out of 30 sites fished, just downstream of the Fork Stream culvert beneath the Tekapo Canal. In 2020 Dr Allibone undertook a specific longfin eel survey of Lakes Alexandrina, McGregor, Takapō, Rapuwai Lagoon and Patterson Ponds (in conjunction with the survey undertaken by Meridian and Ngāi Tahu Rūnanga reported by Jellyman et al. 2020). Longfin eel were found in only two of the 59 fykes nets set, both of which were in Patterson Ponds. Fifteen sites in the Takapō River, Grays River, spring-fed streams in the Godley/Macauley Delta, Mary Burn and Irishmans Creek were electrofished for longfin eels. Three eels were caught or seen in the lower Grays River – no other eels were caught in the survey. Based on this data it is my view that, like the Pūkaki and Ōhau catchments, longfin eel are very likely to be functionally extinct in the Takapō catchment.
65. An elver trap and transfer programme (ETAT) was started in 2002 and picks up inward migrating juvenile eels at the Waitaki Dam, the furthest downstream barrier on the combined WPS.¹³ The ETAT programme has significantly increased in effectiveness over the last five years according to an evaluation of the programme undertaken for Meridian.¹⁴ Meridian and Waitaki Rūnanga stock rivers in the catchment with elvers caught at the dam, eels disperse from release sites into accessible areas of the catchment, abundant eels have been found more than 40 km upstream of their release site (Jellyman et al. 2020). Trapped elvers have never been released into the alpine lakes (Takapō, Pūkaki and Ōhau) or Lake Aviemore, despite substantial amounts of suitable habitat (Jellyman et al. 2002 in Jellyman et al. 2019), and populations in Lakes Takapō, Pūkaki and Ōhau are now assumed to be essentially zero. Significant declines in eels have occurred between the alpine lakes and Lake Benmore since 1990.¹⁵
66. While ETAT mitigates some of the effects of the combined WPS on inward elver migration, elvers are not released into all parts of the upper Waitaki catchment and cannot access suitable habitat on their own because of diversions and dams. Longfin eels no longer contribute to the ecosystem structure and function, ecological processes (e.g., predator-prey interactions or food web dynamics), or ecosystem health of the

¹² Application for renewal of resource consents for the Waitaki Power Scheme - Appendix N Jellyman EIC paragraphs 17 and 73.

¹³ It is not clear to what extent Genesis are involved in the elver trap and transfer (ETAT) or migrant trap and transfer (MTAT) programmes in the Waitaki catchment.

¹⁴ Application for renewal of resource consents for the Waitaki Power Scheme - Appendix N Jellyman EIC paragraphs 16 and 125.

¹⁵ Application for renewal of resource consents for the Waitaki Power Scheme - Appendix N Jellyman EIC paragraph 48.

Takapō River, Lake Takapō and the upstream tributaries. I agree with Dr Allibone that the nature and scale of effects on ecosystem health resulting from the absence of eels is uncertain.

67. I understand that an agreement has been reached as part of redress of cultural effects between Genesis and Meridian with Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki for management of tuna (longfin eel) including releases in the catchment. The absence of tuna from the ecosystems of the Takapō and other affected catchments still requires consideration in the assessment of ecological effects. Those ecological effects could be addressed alongside the cultural effects and accounting for ecological effects through consent conditions or aquatic compensation could be complementary to any cultural effects mitigation programme.
68. While providing benefits in some parts of the Waitaki catchment by returning eels into those fish communities, the ETAT does not improve the longterm population sustainability of longfin eels, or contribute to ameliorating or mitigating significant effects because the majority of these eels will not safely complete their breeding migration. The diversion of water through all of the scheme power station turbines results in the long-term and ongoing mortality of all adult eels migrating downstream to breed. There is no requirement for Genesis to investigate the possibility of screening intakes to avoid entraining migrating eels in the proposed consent conditions. Such an investigation will be warranted if management of longfin eels results in the eventual transfer of elvers into the upper Takapō catchment over the life of the consent. It could be useful to add a consent condition that anticipates such an occurrence in future.
69. Transferring elvers into the Waitaki catchment (via the ETAT) without an effective method in place to safely transfer them out again to complete their breeding cycle creates a population 'sink'.¹⁶ This has potentially wider ramifications for a species which has long been identified as 'at risk' and 'declining' nationally (Dunn et al. 2018) and is a taonga species with 'very high' vulnerability to climate change impacts (Egan et al. 2020).
70. A migrant trap and transfer programme (MTAT) has operated as part of the WPS in conjunction with Waitaki Rūnaka since 2003. The total number of eels transferred by the MTAT is not clear. Jellyman et al. (2020) note more than 125 migrant female longfins have been transferred into the lower Waitaki since better record keeping began in 2015 and that more than 1869 eels were caught between 2003 and 2020. In the period to 2020 one third of the captured eels were classified as migrants and moved into the lower Waitaki (Jellyman et al. 2020).

¹⁶ Population sinks are habitats that cannot sustain a population on their own, but are maintained by individuals immigrating from other habitats, often referred to as sources.

71. The MTAT programme will need to markedly increase in effort and scale by the 2027-28 migration season and be focused on the Benmore Dam, Lake Benmore and tributaries to meet the increase in breeding size eels previously transferred up-catchment by the ETAT programme. I understand that Meridian and Waitaki Rūnaka have or intend to have a process in place for the future MTAT.¹⁷ However, given the potential number of migrant eels that will require safe transfer downstream in the coming years from ETAT elver releases, I have doubts in the ability of the MTAT to adequately scale up to the degree necessary.
72. No technical evidence has been provided on the planned scale or ecological efficacy of any future MTAT programme. I cannot therefore assess the benefits of the programme or the residual adverse effects on eel populations and consequent effects on ecosystem health more broadly because of the impacts of the combined WPS on longfin eels.
73. The IBEP does not include compensation for the significant adverse effects of the combined WPS on longfin eels. This is discussed further in the section below addressing compensation.

Ecological processes

74. Ecological processes are the functional aspects of an ecosystem, the interactions between organisms, and with their chemical and physical environment (Clapcott et al. 2018). Habitat loss, decreased habitat heterogeneity, wetted habitat and changes to flow conditions can all have negative influences on ecosystem processes and on the ways that ecosystems function. For example, changes to habitat and flow can result in biotic interactions such as increased predation and competition for space and food, and create more favourable conditions for invasive species, allowing for the dominance of tolerant habitat-generalists. Increases in trophic state, for example nuisance periphyton growth, are causing reductions in dissolved oxygen below CLWRP thresholds of 80% saturation at night, and likely also affecting pH.
75. Changes in ecological processes and ways that ecosystems function can eventually result in changes to the structure of aquatic communities (i.e., the diversity and relative abundance of species). Structural changes to aquatic communities are more obvious and readily measurable than changes to ecosystem functions i.e., effects on ecological processes are more difficult to measure directly. For example, whilst we know there are significant adverse effects on longfin eel populations, evidence has not been provided on the effects on trophic complexity (food webs), competition, predation or other biotic interactions resulting from the removal of longfin eels from fish communities up-catchment of Lake Benmore.

¹⁷ I am not aware of any involvement in this programme by Genesis.

76. Continuous dissolved oxygen monitoring undertaken by Cawthron scientists suggest that *“algal blooms in the Tekapo River result in DO fluctuations that may cause ‘minor stress’ to sensitive organisms such as juvenile salmonids and some macroinvertebrates (Davies-Colley et al. 2013; Environment Canterbury 2018; NPS-FM 2020)”*. Stable flows and high periphyton biomass are causing adverse effects on ecological processes through diel photosynthesis-respiration cycles that are not typical of high-altitude rivers.

Water quality

77. I agree with the assessment in the Cawthron Report that water quality in the Takapō River is generally good when compared to other rivers nationally. However, nitrogen is elevated by land use intensification in tributary catchments and both nitrogen and *E. coli* show degrading trends at the Steel Bridge site just upstream of the Pūkaki confluence.¹⁸ Furthermore, nutrient concentrations collected at times of high periphyton biomass are the residual amounts after bioavailable (dissolved) nitrogen and phosphorus have been stripped from the water column by the upstream and surrounding periphyton standing crop, meaning nutrient inputs are higher than measured concentrations.
78. Didymo grows well in low-nutrient waterways, if nutrients increase (as trends show has occurred over the last ten years) other periphyton types may become more dominant, as they are at the mid-river sites.

Physical habitat

79. Physical habitat is fundamental to ecological integrity and a healthy river ecosystem. The aspects of an ecosystem that indicate the health of the physical habitat include physical structure and processes, extent, connectivity, substrate, and riparian vegetation quality. Clapcott et al. (2018) describe the physical habitat of an unhealthy ecosystem whereby *“the waterbody is altered to a degree that it can no longer support a diverse range of aquatic flora and fauna owing to the dominance of unsuitable habitat features, including relatively unstable structure, loss of riparian/floodplain vegetation and physical barriers that impede habitat connectivity within the waterbody (e.g. instream barriers) and with surrounding floodplains (e.g. stop banks).”* They also note that *“The freshwater environment is further assessed by habitat indicators that describe the physical form of the wetted area, the river channel and the riparian vegetation, which together determine the ‘life-supporting capacity’ of river habitat.”*
80. Braided rivers provide important habitat for indigenous species as they comprise a wide variety of instream habitats, substrate types and flow conditions. This inherent diversity of characteristics provides optimal habitats, often for a greater number of indigenous fish species than rivers with more homogeneous habitat. For example, the mesohabitats (medium sized habitat features) of braided rivers are characterised by an abundance of

¹⁸ <https://www.lawa.org.nz/explore-data/canterbury-region/river-quality/upper-and-lower-waitaki/tekapo-river-at-steel-bridge>

riffles, backwaters, runs and pools, which support fish species with differing habitat requirements and swimming abilities.

81. Braided river habitat is naturally uncommon in Aotearoa New Zealand and braided rivers have been identified as nationally endangered ecosystem types due to the reduction in their extent over the last 50 years (Holdaway et al. 2012). Loss of braided river habitat leads to subsequent losses of diversity in indigenous fish habitats, which is of particular concern given the decline in indigenous fish diversity, abundance and distribution at a national scale (Joy et al. 2018; Dunn et al. 2018). Continued loss of habitat will exacerbate declines in vulnerable species populations, contributing to degradation of indigenous biodiversity values.
82. Flow and sediment transport are impacted by TPS damming and diversion of flows. Storage of high inflows in Lake Takapō reduces the volume, peak and duration of flood flows down the catchment, reducing the effectiveness of floods to influence geomorphic processes. While this is the case naturally to some degree from the formation of the alpine glacial lakes, the operation of the TPS in storing and changing hydrological functioning through flow diversion adversely affects geomorphic processes and thereby river habitats. The starkest effects on physical habitat are in the upper Takapō River between the lake and the confluence with Fork Stream.
83. The Takapō is a semi-braided to braided river that has a coarse substrate and armoured bed in the upper reaches from near permanent diversion of flow to the Tekapo Canal. The river channel has no continuous flow for ~12% of its length, from the Gate 16 dam to 6.6 kilometres downstream where permanent flows are contributed from Fork Stream. The single thread channel is constrained by terraces, below which proper braid development begins. The upper Takapō River channel is large enough to contain an estimated mean annual flow of ~82 cumecs (Henderson et al. 2004).¹⁹ The loss of single thread and braided river habitat values from the Takapō River is significant in quality and extent. The Applicant has not made any quantified assessment of the extent of physical habitat lost through flow diversion (as a residual adverse effect) to better inform the quantum of aquatic habitat compensation required.
84. Substrate mobility in the Takapō River is limited, even during occasional spills, and sediment is armoured, therefore braids are unable to shift, and the form of the river is no longer dynamic in the manner of a typical braided river. However, spills from Lake Pūkaki, and to some extent Lake Takapō, improve habitat in the lower Takapō River by assisting to shift braids and rework the finer bed material there. Increases in spills to the Takapō (and Pūkaki) River will increase the potential for geomorphic processes to occur. From an ecosystem health perspective this suggests that increased spills are likely to provide some benefit to physical habitat and potentially improve ecosystem

¹⁹ The PDP hydrological report notes a mean flow of 84.5 cumecs calculated from inflows and lake levels between 1991 and 2022.

health in the middle and lower Takapō River at a minimum. But the degree of any benefit will be relative to the volume, peak and duration of spills and whether any residual flow to the Takapō River also occurs.

Water quantity and flows

85. Water quantity is one of the five biophysical components of ecosystem health/ecological integrity. Environmental flows can encompass minimum flow thresholds in addition to flow variability and flushing flows. Flushing flows are an important component of environmental flows for regulated (dammed and/or diverted) rivers, as acknowledged in relevant planning provisions for the Waitaki catchment (WCWARP 2006). Flushing flows provide important ecological functions for benthic communities, which are uniquely well-adapted to recolonising following environmental disturbance. Higher magnitude flushing flows are required in regulated (dammed) rivers with an absence of fine sediment load (Schmidt and Wilcock 2008), whereas in unregulated rivers sediment typically assists in scouring the bed during high flow events.
86. No environmental flows and inadequate variability in the existing flow regime, particularly between the Mary Burn and the Pūkaki confluences,²⁰ results in losses of river extent and values in the Takapō River. The technical reports appended to the application do not provide detailed information on the river-specific ecological values which could benefit from the introduction of environmental flow mitigations.
87. As a glacial, lake-fed river, pre-dam flows would have been relatively constant, increasing and decreasing seasonally, with large rainfall and snowmelt events in the upstream catchment providing flushing flow and flood flow events of varying magnitudes through time. Pre-dam historic flow statistics were not available for the Takapō River to inform the consideration of appropriate environmental flows, although a simulated natural record has been created by Henderson et al. (2004), a long term summary of mean flow from that record is depicted in Figure 1.

²⁰ The PDP hydrological report identifies this reach of the Takapō River receives ≤3 fresh/flood events per year of any magnitude.

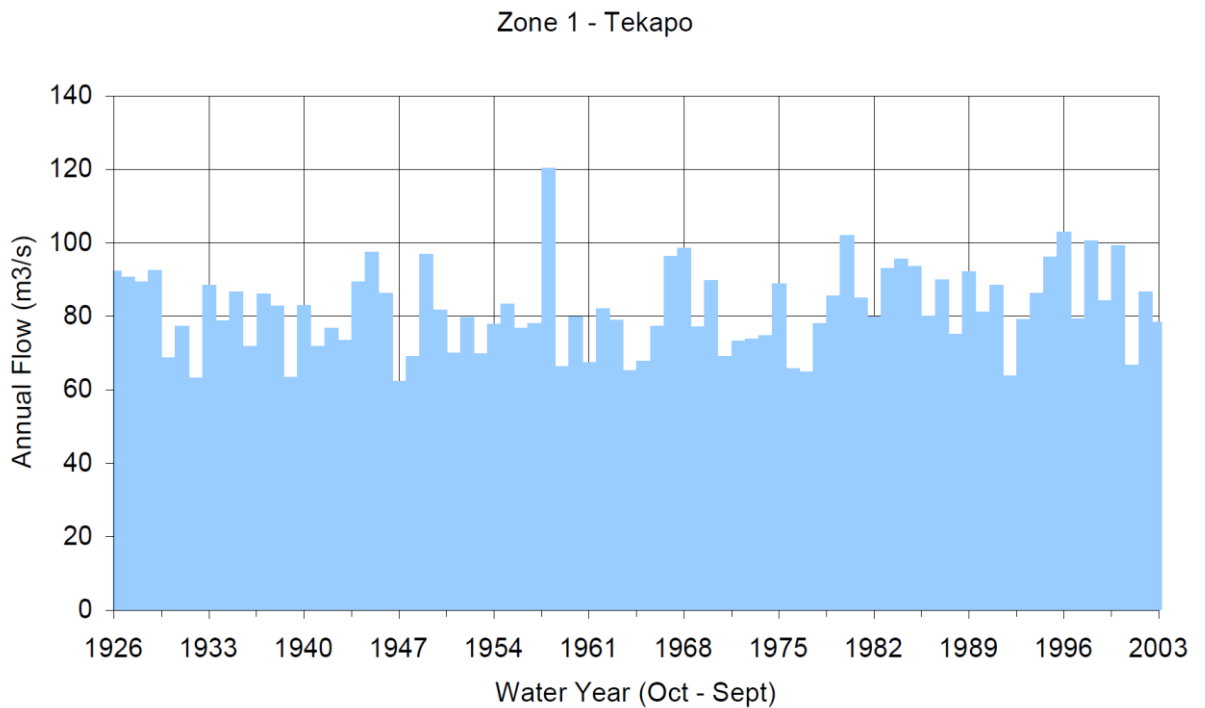


Figure 1. Annual natural [simulated] flows from Lake Takapō, 1926 – 2003, *reproduced from Figure 3.3 Henderson et al. 2004.*

88. Forest and Bird requested that I provide advice on suitable environmental flows to improve ecosystem health in the Takapō River. Defining an environmental flow regime is a complex and inexact exercise, typically applying a sequential investigative process (Griffiths and Booker 2019) that requires²¹ for each affected river:

- (a) The building of natural and altered hydrographs²²
- (b) An identified set of ecologically relevant flow variables
- (c) An understanding of the deviation of natural to altered flows²³

²¹ One internationally recognised framework for determining environmental flows regimes is the ecological limits of hydrological alteration (ELOHA; Olden et al. (2010)), which suggests steps similar to those described in Griffiths and Booker (2019) and can be found at:

<https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/ELOHA/Pages/ecological-limits-hydrolo.aspx>

²² Henderson et al. (2004) developed [simulated] natural flow records for outflows from Lake Pūkaki, Lake Ōhau and the Waitaki Dam. Natural flow records for Lakes Pūkaki and Ōhau can be assessed using the methods recommended by Griffiths and Booker (2019) to contribute to completing Step ‘c’.

²³ Griffiths and Booker (2019) undertook an analysis of indicators of hydrological alteration (IHA; Richter et al. (1996 and 1997)) for a range of variability assessment (RVA) for the lower Waitaki Dam as part of their review of methods to quantify the impacts of dams on river flows for the Ministry for the Environment. The results of this type of analysis are an important component to inform an environmental flow framework.

(d) The development of flow alteration–ecological response relationships from literature, expert knowledge and field studies²⁴

89. I have used the natural flow series for Lake Takapō (Henderson et al. 2004) and the statistics generated by Henderson (2021) and the PDP hydrology report as hydrological input data to work through the steps above, to the degree possible with the available information. I have applied a general ecological objective of improved ecosystem health to identify potential flow needs. Ideally, a range of variability (RVA) approach is applied to determine the flow statistics most likely to inform environmental flow setting (Griffiths and Booker 2019 based on Richter et al. 1996 and 1997). However, it is important to recognise that undertaking a process (like ELOHA) to determine the scientific recommendations for an environmental flow regime is a task that, in my view, would be significantly furthered by multi-disciplinary expert conferencing e.g., hydrology, ecology, geomorphology, vegetation management and mātauranga Māori. Keeping this in mind, I provide below some options for the consideration of the panel.
90. I have relied on long-term mean statistics from simulated natural flows to understand the scale of alteration from natural flows to existing flows in the Takapō River. Henderson et al. (2004) used lake inflow series as inputs for a model to produce simulated ‘natural’ outflow records for 1926 to 2003 from each lake in the combined WPS, as if the dams and other controls had not been built. Henderson (2021) then calculated a range of flow statistics from existing flow records across the combined scheme. Comparison of natural²⁵ and existing (altered) flow statistics can inform the development of an environmental flow regime (Table 2).

²⁴ Ideally, field studies testing the efficacy of various flow regimes to achieve ecological/conservation outcomes would complement and inform the scientific process steps suggested by the ELOHA framework, including development of hypotheses relating to instream values and hydrological characteristics, monitoring of ecological state, and long-term adaptive management of flow regimes.

²⁵ Flow statistics differ slightly between Henderson (2021) and the PDP hydrology report although they are still similar as they are largely based on the same measured flows. I have used information from Henderson et al. (2004) and Henderson (2021) where possible as these are the statistics I have relied on to assess the effects of the combined WPS for both consenting processes. The model for Lake Takapō outflows has a reported 5-year 7-day MALF statistic that is relevant to the default minimum flow in Table 3B xxii of the WCWARP and was reported to the hearing panel on Plan Change 3 to the Waitaki Catchment Water Allocation Regional Plan in a Joint Memorandum of counsel in response to minute 10, 12 November 2015.

Table 2. Long-term natural [simulated] outflows from Lake Takapō (Henderson et al. 2004; Table 3.1) and existing flow statistics for Takapō River sites from Henderson (2021) and PDP (2025) “*”.

Statistic	Lake Takapō outflow	Takapō at Lake George Scott weir ²⁶	Takapō d/s Fork Stream	Takapō d/s Mary Burn
Mean annual (flood) flow m ³ /s	238.15	-	23.5*	129.4*
Mean flow m ³ /s	81.8	5.9	3.8*	18*
Median flow m ³ /s	66.6 ²⁷	0.048	3.1*	10.2*
7-day MALF m ³ /s	-	0	1.9*	5.8*
5-year 7 day MALF m ³ /s	26	0	1.4	5.8
FRE3 no./year	-	2.6	3.4	2.2
FRE5 no./year	-	2.6	1.2	1.1
FRE6 no./year (PDP)	-	-	1.8*	1.7*
FRE10 no./year	-	-	1.3*	1.4*

91. Three, six and ten times the median flow (Table 3) have been identified in the PDP hydrological report as potentially periphyton scouring flows, Henderson (2021) also reported three (FRE3) and five (FRE5) times median flow frequencies. Based on my experience with moderately sized unregulated rivers, three times median flow is often inadequate to mobilise bed sediments enough to scour and remove nuisance periphyton. For the upper Takapō River, with less available fine sediment to assist in abrading periphyton during freshes and floods, greater flows will be needed to undertake this function i.e., six or ten times median flow as suggested in the Cawthron report. Less coarse and potentially more mobile bed material downstream of Mary Burn may better remove periphyton under lesser flow events. The frequency and duration of adequate flow events and the differential between flood flows and antecedent flow conditions will influence how effective an event is at removing built up periphyton and mitigating or reducing the impacts of nuisance growth on benthic communities and the fish and birds that rely on them for food.

²⁶ Lake George Scott Weir has limited or zero flow for 90% of the time (PDP report) and this influences the flow statistics. Maximum flow recorded in the PDP report for the weir is 296 cumecs.

²⁷ Based on daily inflows in Henderson (2021) as modelled outflow data was not readily available.

Table 3. Potentially ecologically relevant high-flow events calculated from statistics (m³/s) for Takapō River at outlet/Lake George Scott weir, downstream of Fork Stream and downstream of Mary Burn confluences under existing TPS operations.

Location	Median flow (Q ₅₀)	3 x median flow	5 x median flow	6 x median flow	10 x median flow
Takapō at outlet natural	66.6	200	333 ^{28*}	400*	660*
Takapō d/s Fork Stream	3.1	9.3	15.5	18.6	31
Takapō d/s Mary Burn	10.022	30.1	50.1	60.1	100.2

Environmental flow regime recommendations for the Takapō River

92. Default environmental flow regimes for waterbodies that are not specified in the WCWARP are provided for in Table 3B xxiii. The default minimum flow for these waterbodies is the 5-year 7-day mean annual low flow (MALF). For the Takapō River at the outlet from the lake, and thereby also from downstream of the Lake George Scott weir, the 5-year 7-day MALF would be 26 cumecs, based on the simulated natural flow record (Henderson et al. 2004). This was included in a table of natural [simulated] statistics provided to the hearing panel for consideration with respect to the Takapō and Pūkaki Rivers.²⁹
93. Current 5-year 7-day MALF statistics for the Takapō River are 1.4 cumecs below the Fork Stream confluence and 5.8 cumecs downstream of the Mary Burn. This represents a degree of flow alteration of approximately 94% at the Fork Stream reach and 78% downstream of Mary Burn. Richter et al. (2012)³⁰ recommend no more than 20% alteration from natural flows for moderate protection of ecological structure and function.

²⁸ *Noting that the mean annual flood flow estimated for the Takapō at outlet is 238.15 cumecs and therefore flushing flow in the vicinity of 200 cumecs would be closer to the natural range of average high-flow events.

²⁹ Plan Change 3 to the Waitaki Catchment Water Allocation Regional Plan in a Joint Memorandum of counsel in response to minute 10, 12 November 2015.

³⁰ The presumptive flow standard recommended by Richter et al. (2012) was derived by expert judgement based on a review of international scientific research. The authors concluded (p. 1318) that: (1) A high level of ecological protection will be provided when daily flow alterations are no greater than 10%; a high level of protection means that the natural structure and function of the riverine ecosystem will be maintained with minimal changes. (2) A moderate level of protection is provided when flows are altered by 11–20%; a moderate level of protection means that there may be measurable changes in structure and minimal changes in ecosystem functions. (3) Alterations greater than 20% will likely result in moderate to major changes in natural structure and ecosystem functions, with greater risk associated with greater levels of alteration in daily flows. 'Structure' in this context could refer to flow-related habitat, species composition and abundance of instream communities.

94. Ecological objectives for flow restoration ideally include restoring the extent of functioning river habitat, improvements to ecosystem health and fully reconnecting the Takapō River with its floodplain and downstream catchment. To achieve these objectives, I recommend development of an environmental flow regime that includes a residual/minimum flow at least consistent with the 5-year 7-day MALF, in combination with a flushing flow regime adequate to periodically remove accumulated periphyton (including didymo) and accounting for reduced fine sediment loads (e.g., 6 to 10 times median flow).
95. Ideally, the development of an environmental flow regime would utilise a process commensurate with ELOHA. In the absence of this work I suggest the following options for consideration by the panel:
- (a) **Option 1:** Restoration of flows to the Takapō River based on natural [simulated] flows, with a residual/minimum flow of 26 cumecs below Gate 16 and Lake George Scott weir, and regular flushing flows of at least ~200 cumecs or greater that can achieve periphyton cover of $\leq 30\%$.³¹
 - (b) **Option 2:** Restoration of natural low flows with a residual/minimum flow below gate 16 and Lake George Scott weir of 26 cumecs and the existing spill regime (i.e., no specified flushing flow).
 - (c) **Option 3:** Provide some physical habitat and improve ecosystem health upstream of Fork Stream by adding a residual/minimum flow of 5.8 cumecs³² below Lake George Scott weir and implement regular flushing flows of at least 6 times the existing median flow (at least 18.6 cumecs at the Fork Stream confluence and 60 cumecs at the Mary Burn confluence) that can achieve periphyton cover of $\leq 30\%$.³¹
 - (d) **Option 4:** Maintain the existing flow regime with no residual/minimum flow from gate 16 or Lake George Scott weir and implement regular flushing flows of at least 6 times the existing median flow (at least 18.6 cumecs at the Fork Stream confluence and 60 cumecs at the Mary Burn confluence) that can achieve periphyton cover of $\leq 30\%$.³¹
96. **Option 1** is the preferred option to address the existing adverse effects, based on the degree of change to the hydrological regime from the current state to a state closer to the natural hydrograph. Option 1 will substantially increase the extent of river habitat available to aquatic life downstream of Lake George Scott weir and flushing flows will likely provide a reset of periphyton biomass. **Option 2** will also result in substantial

³¹ Between the Fork Stream and Pūkaki River confluences based on monthly samples collected from November to April inclusive.

³² Equivalent to the existing 5-year 7-day MALF downstream of the Mary Burn confluence. The ecological efficacy of 5.8 cumecs as a minimum flow upstream of Fork Stream is highly uncertain because of the substantial degree of alteration from natural flows to the upper Takapō River.

increases in the extent of river habitat, but without adequate flushing flows, the ecological condition of the river may still be poor with respect to periphyton biomass, macroinvertebrates and fish. **Option 3** will provide some benefits to ecosystem health in the mid and lower reaches through flushing flows *and* will increase the extent of habitat available to aquatic life upstream of Fork Stream, but to a lesser degree than options 1 and 2. **Option 4** is likely to provide the same benefits to ecosystem health in the mid and lower reaches as option 3 but will not increase the extent of riverine habitat.

97. The current regularity of FRE6 or FRE10 events averages around one per annum at the Fork Stream and Mary Burn confluences, and all flushing flows to the Takapō River have decreased in recent years according to the PDP report. The existing flow regime is inadequate to control nuisance periphyton (and didymo) cover. If improvements to ecological health are sought it is my strong recommendation that a significant increase in flushing flow frequency will be essential to achieve a level of periphyton cover that supports healthier macroinvertebrates (i.e., 30% as per the CLWRP freshwater outcome for lake-fed rivers). Again, ideal flushing flow frequency should be informed by a full examination of statistics based on hydrological alteration (e.g., ELOHA-type methods).
98. The flushing flow events needed to periodically remove periphyton and elicit a positive ecological response in macroinvertebrate health will likely require adaptive management, given the uncertainties in the relationship between periphyton removal and low fine sediment bedload in the Takapō River. The ideal magnitude of flushing flow and the magnitude to duration relationship of flushing flows requires investigation that could be implemented through a carefully conditioned adaptive management regime.
99. Dr Hughey notes that the TPS impacts significantly on the Takapō River, but that these impacts have not changed over the course of the existing consent period. He goes on to note that the river maintains a “*significant flow along most of its length down to its delta with Lake Benmore*”. I do not agree with Dr Hughey’s assessment that the effects of the TPS are ‘no more than minor’³³ on the Takapō River, nor that the river retains a ‘significant flow’. I hold this view based on my calculations that the continued diversion of water from the Takapō River results in a 94% alteration of flow to the confluence with Fork Stream and a 74% alteration in flow below Mary Burn.
100. From an ecological perspective,³⁴ in the absence of an environmental flow regime, the significant adverse effects of flow diversion from the Takapō River require careful accounting within aquatic compensation. If an environmental flow regime *is* implemented based on elements of the existing (altered) flow regime (e.g., options 2, 3

³³ With the exception of effects on longfin eel.

³⁴ Noting my comments about the existing environment.

or 4) there will be residual adverse effects on river extent and values, and ecosystem health that still warrant compensation.

Policy assessment: Waitaki Catchment Water Allocation Regional Plan (WCWARP)

Objective 1

101. I have been asked to consider Objective 1 and Policies 4 and 38 of the WCWARP from a technical perspective. Objective 1 aims to sustain the qualities of the environment of the Waitaki River and beds, banks, margins, tributaries, islands, lakes, wetlands and aquifers and clauses a to g describe how this is to be achieved in an overarching sense. The clauses relevant to an ecological opinion are:
- b. safeguarding the life supporting capacity of the river and its ecosystems...
 - d. safeguarding the integrity, form, functioning and resilience of the braided river system
102. Ecosystem health, ecological integrity and life-supporting capacity are generally interchangeable terms which mean the same thing in an ecological context.³⁵ Many aspects of the five core components of ecosystem health (Clapcott et al. 2018) are in an impacted or poor state in the rivers of the Waitaki catchment affected by the TPS as described in detail above.
103. The aquatic life component of ecosystem health includes microbes, plants, invertebrates, fish and waterbirds.³⁶ Investigations show that periphyton, invertebrates and fish are impacted by the effects of the TPS water diversion. Because the Takapō River is dewatered for approximately 6.6 km there is currently little aquatic life or freshwater ecosystem health to assess in the upper reaches and after flow releases occur there is a high likelihood of fish stranding downstream. Downstream of the dewatered reach invertebrate community health is poor and whilst didymo has a significant impact on macroinvertebrates, it is not the only dominant form of periphyton. The lack of flow variability and inadequate flushing flows exacerbate nuisance growth of all types.
104. Fish community health is impacted by the reduction of habitat through flow diversion and there is a significant adverse effect on longfin eels. Nationally endangered lowland longjaw galaxias (Waitaki) continue to be extremely vulnerable to population declines in the face of multiple impacts (predation, invasive weeds, habitat degradation and loss). One of New Zealand's rarest fish, they are now only found at seven stream sites in the Waitaki catchment, two of which are in tributaries of the Takapō River. Local experts

³⁵ A healthy ecosystem has ecological integrity when it can maintain its evolving structure and function over time in the face of external stress (Clapcott et al. 2018).

³⁶ See the statement of Dr McClellan on waterbirds.

estimate current populations at 1,000 – 1,500 fish.³⁷ Recent local extinctions in the lower Ōhau, and near extinctions in the Corbies Creek tributary³⁸ suggest there is little resilience in this vulnerable fish population and without sustained direct intervention they are at high risk of extinction.

105. Following high-flow discharges, fish salvage efforts do not require indigenous fish salvage if they become stranded in pools after cessation of discharge from Gate 16 or the Lake George Scott weir. Allowing for stranding and mortality of indigenous fish in the dewatered channel of the Takapō River does not safeguard life-supporting capacity or provide for a healthy river ecosystem.

Policy 4

106. Policy 4 provides a list of relevant matters when considering setting environmental flows. Clauses (a) - healthy ecosystems of indigenous species, (e) - habitats including those of invertebrates, birds and fish, (f) - fish passage, including exclusion of non-indigenous species where appropriate, (g) - undesirable periphyton accumulation, (h) - effects on water quality, (l) - bedload and sediment transport processes, and (p) - existing flow regimes are all ecological matters which are informed by the assessment and have been taken into consideration when forming the recommendations in this statement.

Policy 38

107. As a method of achieving Objective 1, Policy 38 requires acknowledgement that the Takapō, Pūkaki and Ōhau Rivers are associated with the mana of Lakes Takapō, Pūkaki and Ōhau and that flows in these rivers could provide continuity of flow from the mountains to the sea. I assume that 'could' was purposeful and aspirational wording in policy 38 since there is clearly no continuity of flow from the mountains to the sea via the river beds of the Takapō, Pūkaki or Ōhau Rivers.
108. As I understand it the bed of the Takapō River is dry downstream of the control gates. After 6.6 km tributary inflows from Fork Stream to the Takapō River reestablish perennial flows progressively downstream. The Takapō River does not have continuous flow from the lake downstream with the rare exception of gate testing releases, recreational releases or spill events. Recommendations above for environmental flows which include a residual or minimum flow are, in a technical sense, consistent with what appears to be the intent of Policy 38.

Consent conditions and compensation

Proposed consent conditions

³⁷ <https://www.rnz.co.nz/national/programmes/ourchangingworld/audio/2018993524/our-changing-world-protecting-jaws-nz-rarest-freshwater-fish>

³⁸ <https://www.odt.co.nz/regions/north-otago/rare-native-fish-saved-just-time>

109. The draft Schedule One Conditions, dated 25 July 2025 were used as basis for the technical assessment that follows. The recommendations for environmental flow regimes above, and the suggested changes to some of the proposed conditions identified below, are, in my opinion, the least onerous way to address the effects identified in my assessment.
110. Condition 14 – Sports Fish Salvage Measures: indigenous fish should be specifically included in the fish salvage management plan, rather than included only as an ‘as practicable’ advice note. The Takapō River contains six indigenous fish species including four with an ‘at risk’ conservation threat status. Processes to identify and salvage indigenous fish will better safeguard the life-supporting capacity and ecosystem health of the Takapō River.
111. Indigenous fish salvage should also be included in any plans to dewater canals or other TPS infrastructure to mitigate fish mortality. Review of these plans should be undertaken every five years at the same time as review of sports fish salvage plans.
112. Condition 23 – Environmental Compensation: This condition requires the IBEP to be undertaken and outlines the objective of the programme. The objective requires improvement in the condition, resilience, indigenous biodiversity, ecological processes and other values of the braided rivers, including their braid plains and margins, lake margins and deltas, and wetlands and springs associated with lakes and braided rivers.
113. I have concerns with the wording of the IBEP objective and how achievement of ‘improvement’ will be measured and monitored throughout the life of the consent. The improvement trajectory and degree of improvement over time are not defined within the conditions. As an ecological objective the wording is nebulous. It is good practice, in my experience, that consent conditions for biodiversity offset or compensation packages are specific to the degree that the proposed benefits and the scale of those benefits can be reliably and clearly understood, including how they will be measured and monitored.
114. According to the condition advice note, the IBEP can be undertaken in conjunction with Meridian for the combined WPS. The residual adverse effects of the WPS and TPS have not been adequately described across both applications and the development of the IBEP has not followed best practice principles for aquatic offsetting. Therefore, potential benefits of biodiversity enhancement actions under the IBEP may be considered as compensation for multiple residual adverse effects of each generator. This allows each generator to essentially ‘double-dip’ on any proposed compensation benefits and is contrary to the principle of additionality.
115. I consider the objective of the IBEP in condition 23 does not specifically require the Applicant to respond to losses in wetted extent, habitat or instream values of the Takapō River, including ecosystem health, indigenous biodiversity or hydrological functioning and connectivity values. Compensation of the residual effects on river extent and values is therefore, in my opinion, inadequate.

116. Further, to achieve a best practice approach to aquatic compensation (and meet the requirements of the NPS FM (2020)) requires development of specific ‘conservation outcomes’ resulting from actions to compensate for any ‘more than minor’ residual effects on the river. Conservation outcomes should be stated in the objective, alongside specific actions responding to more than minor residual adverse effects. A sequential line of sight from residual effects of the TPS on river extent and values, through to the IBEP compensation actions and conservation outcomes would show that the proposed aquatic compensation meets best practice principles and the NPS FM requirements. Ideally, this would be underpinned by clear consent conditions requiring these actions be completed. The Applicant’s evidence has not demonstrated that the appropriate and sequential technical process has been undertaken to support development of the IBEP (see assessment of compensation below).
117. Condition 27: Reporting to audit the previous 10-year period of the IBEP would ideally be undertaken by qualified experts independent of the consent holder, to provide transparency as to the performance of the programme in achieving the required conservation outcomes, and to recommend changes where milestones were not achieved.
118. Condition 31(a): The stated focus for the first 10-year IBEP Strategic Plan in the Takapō River catchment is for i) restoration of key “representative sites” on the river, other waterbodies and connected environs within the braid plain, ii) wetland enhancement, iii) island creation, iv) management of pressures e.g. animal pests and weeds, and v) restoration of two bay areas of Lake Takapō. In addition to concerns raised above that the actions are not clearly linked to the residual effects, I have the following specific concerns with the wording of the consent condition, and associated wording in the draft ‘Kahu Ora’ report (also see following sections).
- (a) ‘Representative site’ improvements are a piecemeal approach that is not commensurate with the scale of residual adverse effects and is inconsistent with best practice approaches to aquatic compensation and Principle 3 of the NPS FM (2020).
 - (b) It is unclear how the creation of bird islands in the Takapō River will be successfully or practically implemented without commensurate changes to the existing flow regime to increase the volume and velocity of flows around islands to deter predators from nesting birds.³⁹
 - (c) The focused actions for Takapō do not appear to relate to aquatic areas or instream values – much of the focus is on pest and weed management, none of

³⁹ For further evidence on this matter refer the statement of Dr McClellan.

which is likely to benefit instream life in the absence of adequate environmental flow regimes.⁴⁰

- (d) Currently Kahu Ora proposes one site in the Takapō catchment for habitat maintenance for threatened fish over the next 10-years. It is not clear whether this IBEP action is to compensate for effects on aquatic life from the TPS as this action was also identified in the Meridian consent application as compensation for residual effects on indigenous fish from the rest of the WPS.

119. Condition 31(a): For the Takapō River clauses ii, iii and iv refer to wetland enhancement, island creation and management of the pressures on connected environments within the braid plain (e.g., animal pests and weeds). Whilst these actions may result in localised benefits to some aspects of aquatic ecosystem health it is difficult to understand how enduring benefits can be gained without also implementing an appropriate environmental flow regime with increased flushing and flood flows. Flood flows mitigate the establishment of vegetation on bare gravels and are an integral component of riverbed vegetation management that, if successful at scale, can enhance habitat heterogeneity and benefit instream aquatic life through increased geomorphic processes.

120. Issues associated with residual adverse effects not addressed in relation to conditions include:

- (a) Environmental flow regimes to mitigate the effects of ongoing diversion.
- (b) Fish mortality from passing through the TPS turbines at Tekapo A and B – no mitigations are considered, and the effects are not quantified.
- (c) No requirement to mitigate the significant adverse effects of the TPS portion of the combined WPS on longfin eel habitat, migration, and consequent ecosystem health. Significant residual adverse effects on longfin eel ecology will continue. Tuna are not accounted for by aquatic compensation and are excluded from the IBEP.

Aquatic Compensation and the NPS FM (2020)

121. Environmental compensation is designed to compensate for losses but does not have to demonstrate a no-net-loss outcome, as is required of biodiversity offsetting. Environmental compensation carries the greatest risk for biodiversity outcomes and because of this it is the last resort in the effects management hierarchy (Figure 2).⁴¹ To

⁴⁰ Assessments of the IBEP and consent conditions for river birds and terrestrial biodiversity are covered in the evidence of Dr McClellan and Mr Harding.

⁴¹ Maseyk et al. (2018): https://d1pepg1a2249p5.cloudfront.net/media/documents/Biodiversity-offsetting-under-the-resource-management-act-full-document-..._YbGa2tM.pdf

improve biodiversity outcomes Maseyk et al. (2018) recommend that best practice and offsetting principles are followed as much as possible in the development of compensation.

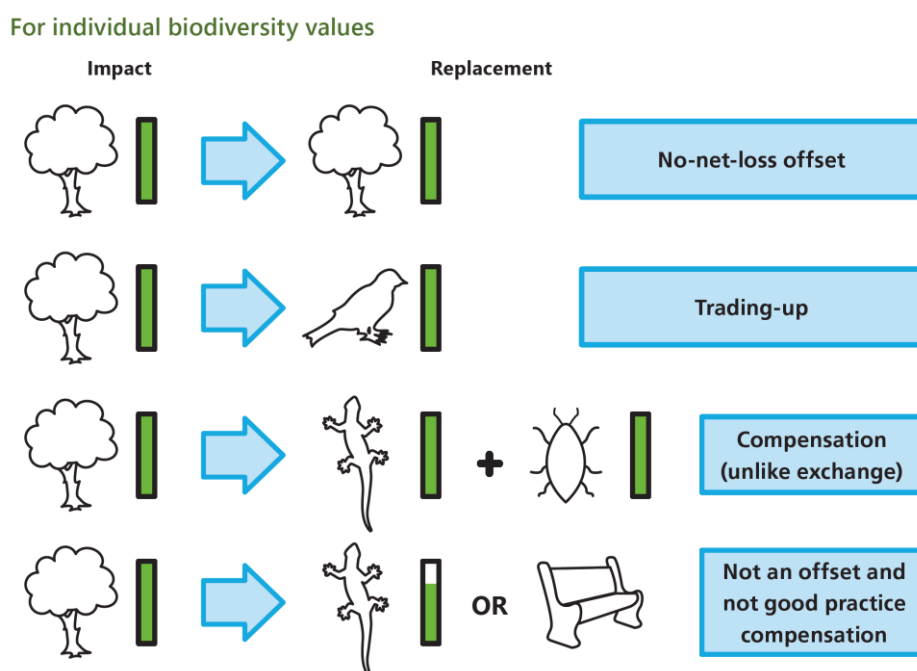


Figure 2. Effects management approaches along the offset-compensation continuum. The type of effects management approach are defined by the type and magnitude of the biodiversity outcomes, with green bars representing the amount of biodiversity value lost at the impact site, and the full or partial replacement of that value using the various approaches described. *Reproduced from Fig 4. Maseyk et al. (2018).*

122. Although environmental compensation does not require the same accounting rigour as offsetting, outcomes can be improved if offset principles are applied as a guideline when designing compensation packages. This was the approach taken in the drafting of Appendix 7 of the NPS FM (2020), which defines principles for aquatic compensation to improve the certainty of conservation outcomes. The principles in Appendix 7 therefore codify a best practice approach to environmental compensation for freshwater.
123. The effects management hierarchy in the NPS FM (2020) applies to the loss of extent or values of rivers and provides for aquatic compensation for more than minor residual effects after avoidance, remediation and minimisation have been applied. Throughout this evidence I have considered where the TPS causes adverse effects on the Takapō River such that there are losses in river extent or the river is less able to provide for the following ecological values:⁴²

⁴² NPS FM (2020) 3.21(1) definition of 'loss of value' (b) i-iii.

- (a) Ecosystem health
- (b) Indigenous biodiversity
- (c) Hydrological functioning

124. The definition of aquatic compensation in the NPS FM speaks to a “conservation outcome” resulting from actions that are intended to compensate for more than minor residual adverse effects after sequential application of the effects management hierarchy. ‘Conservation outcomes’ are not defined in the NPS FM, but aquatic compensation under that instrument is subject to complying with principles 1 to 6, having regard to the remaining principles, and ensuring methods and measures are in place such that compensation will be maintained and managed over time to achieve conservation outcomes.⁴³

125. Understanding and accounting for each of the more than minor residual adverse effects is critical to implementing effective and certain aquatic compensation. From a technical and ecological perspective, the requirements of the consent conditions and the ‘Kahu Ora’ 10-year IBEP strategy, fall short of meeting best practice for the following reasons:

- (a) No attempt was made to sequentially implement the effects management hierarchy or NPS FM (2020) aquatic compensation framework.
- (b) Conservation outcomes and objectives were not clearly defined at the outset to guide the direction and scale of compensation.
- (c) Instead ‘woolly’ conservation outcomes were retrofitted to meet the quantum of compensation offered.
- (d) A coherent description of the residual adverse effects and an attempt to quantify the losses of river extent and values⁴⁴ was not developed as a foundation to understand the scale of aquatic compensation required.
- (e) The baseline state of the values to be ‘improved’ by the IBEP was not adequately quantified – without understanding the baseline condition, improvement or maintenance through time cannot be known or measured.
- (f) Critical sources of knowledge did not inform the IBEP development, including assessments of potential protection levels to be achieved and relative costings of those protection levels (Lewis and Maloney (2020); ‘Synopsis’ (author and date unknown); OIA bundle; Appendix 3), the ‘best information’⁴⁵ was not utilised.

⁴³ NPS FM (2020) 3.24(3)(a)(ii) and (iii)

⁴⁴ NPS FM (2020) Appendix 7 Aquatic Compensation Principle 3.

⁴⁵ As per NPS FM (2020) 1.6.

126. I have found it difficult to establish a clear progression from what the IBEP intends to achieve to the planned and costed actions. This concern could be addressed by providing greater clarity on objectives, conservation outcomes, residual effects, baseline state and measures of improvement. These currently lack the specificity and transparency necessary to provide confidence that adequate and enduring compensation will occur.
127. I have reviewed the IBEP, the Appendix 5 Memo by Dr Hughey, and the draft Kahu Ora 10-year strategy against best-practice principles for aquatic compensation and the requirements of the NPS FM (2020), I provide this assessment in tabular form as Appendix 2 of this statement. In summary, I found the documents provided did not adequately demonstrate best practice aquatic compensation because:
- (a) Adherence to the effects management hierarchy is lacking, including no offset suitability assessment
 - (b) Aquatic compensation is not appropriate for all effects
 - (c) There was insufficient information to demonstrate that the scale of compensation will outweigh adverse effects
 - (d) Aquatic compensation for indigenous fish appears to compensate for both WPS and TPS schemes (double-dipping) whereas compensation for each scheme should be additional
 - (e) There was insufficient information to assess leakage (displacement of harm)
 - (f) There was insufficient clarity of monitoring to demonstrate successful long-term outcomes
 - (g) The assessment of landscape context was inadequate to demonstrate the best ecological outcome
 - (h) I was unable to assess time lags or trading up principles based on the information provided
 - (i) Scientific documentation of the compensation design process was inadequate, lacking consideration of key information or technical assessment of potential for an aquatic offset
128. Dr Hughey states he has considered the TPS proposal against the principles of aquatic compensation in the NPS FM and considers overall that the Application meets those principles but does not provide his analysis. I consider there is not enough information provided about the residual adverse effects, the expected conservation outcomes, the scientific process to determine the aquatic compensation package, or the comparison between the losses in extent and values and the expected positive effects of the compensation to consider the proposal compliant with the principles.

129. Dr Hughey also considers the IBEP *“likely to achieve far greater ecological outcomes than would be possible with a more reductionist approach based on attempting to remedy and mitigate impacts.”* I do not agree that the evidence demonstrates ecological benefits which will outweigh the effects and certainly not to a degree that is ‘far greater’. Furthermore, I also disagree that attempting to remedy and mitigate impacts is ‘reductionist’. I understand Dr Hughey’s use of ‘remedy and mitigate’ to be essentially the same as the requirement to avoid, remedy or minimise under the effects management hierarchy. Principle 1 of aquatic compensation requires these steps, in addition to consideration of aquatic offsets, to be ‘sequentially exhausted’. The stepwise process to determining aquatic compensation does not preclude a holistic approach to ecological health nor is it in opposition to integrated management.
130. Despite identification of significant and ongoing adverse effects on longfin eels, compensation for these effects are not included in the IBEP and not considered in the consent conditions. Effects on eels and consequent system-wide effects on aquatic life and ecosystem health are not adequately mitigated or compensated.

IBEP / Kahu Ora compensation

131. Having considered the residual adverse effects, the consistency of the evidence with technical aspects of the WCWARP, reviewed the consent conditions, and assessed the compensation approach against best practice and the principles of the NPS FM, I turn now to considering the draft IBEP and my specific concerns with the proposal. An overarching concern is that, while the IBEP programme is required for the life of the consent (35 years), values, sites and actions are drafted only for the first ten years. There are no guarantees that specific aquatic values or conservation outcomes will be protected or improved over the life of the consent as this is not specifically required by the consent conditions.
132. I have reviewed PRR annual reports from 2016 to 2024. While PRR has undoubtedly resulted in positive benefits to aquatic life, in particular the threatened galaxiids, funding for ‘concrete’ works has often come from external sources (e.g., NZ Defence Force, Canterbury Regional Council and the upper Waitaki Zone Committee). Planned compensation under the IBEP is not commensurate with residual adverse effects on aquatic values and in my opinion does not achieve positive effects that outweigh the adverse effects. For example, only one threatened fish site is identified for protective actions for the entire combined WPS upstream of the Waitaki Dam, and that site (Fork Stream) is in the Takapō catchment.
133. I have reviewed the Kahu Ora draft document attached as Appendix E to the application. I paid particular attention to activities planned for the Takapō River catchment as this relates directly to my expert evidence on the residual effects of the TPS diversion and alterations to hydrological and ecological functioning. However, actions to support aquatic life and ecosystem health in the upper catchment (above Lake Takapō) are also considered where appropriate.

134. Section 2.1 of Kahu Ora outlines the methodology for determining the actions and sites over the next ten years and acknowledges at the outset that these were guided by the fixed future budget (\$2.3M per annum) and the agreement document. While the process outlined in Figure 12 (page 24 of the Kahu Ora report) is not entirely consistent with the NPS FM sequential process there is some value to the steps identified in the diagram.⁴⁶ Without clear and specific conservation outcomes stated at the outset (as I have suggested for inclusion in the IBEP consent conditions and as required by the NPS FM) the scoring/ranking processes become relatively subjective exercises.
135. Step 2 of Kahu Ora relates to location selection, the selection process is opaque and appears subjective. For example, scoring for 'naturalness' of each variable from low to high. It is not clear how sites retaining a high degree of naturalness (and therefore good candidates for maintenance actions) were compared with sites that are low in naturalness (good candidates for restoration). Again, it is not clear how this process relates to the NPS FM principles for compensation.
136. A risk that does not appear to have been considered when taking a site-based approach is that only existing sites are considered. Threatened species habitats are often contracted in range and maintenance of current habitats will not necessarily provide for improvements to those species or population increases over the long term. As noted above, ensuring the survival of non-migratory galaxiids (Woodford and McIntosh 2013) will require the creation of new source habitats and populations.
137. Steps 3 and 4 relate to action and pressure selection and Step 5 costing actions and matching budget. Having recorded all actions to manage key pressures, the locations ranked as low and medium scored sites were excluded to fit the available budget. Fitting actions to meet an available budget, rather than following the effects management hierarchy to determine appropriate compensation is not consistent with the NPS FM principles as I understand them. In reviewing all material available associated with the development of the IBEP, it is this approach, which fits values, sites and actions to a budget envelope rather than compensating effects on residual values to meet specific conservation outcomes, that appears to have led the IBEP away from good practice and NPS FM requirements for aquatic compensation.
138. Section 2.3 outlines monitoring of delivery and benefits, which provides some comfort that the project will be monitored. Additional monitoring to determine baseline condition prior to commencement of actions would be a useful addition and the monitoring would benefit from specific inclusion of pre-action monitoring to measure the proposed trajectory of improvement required by the IBEP objective.
139. Section 2.4 notes the scope and constraints of the programme. The project area is noted to exclude small, low order tributary streams, with some exceptions for benefits to

⁴⁶ Noting that much of this work has been undertaken previously, e.g., Lewis and Maloney (2020), OIA bundle in Appendix 3.

braided river or wetlands species. Only one small tributary stream, a remaining stronghold habitat for threatened non-migratory galaxiids (Fork Stream), is in scope for the first ten years. There are several tributaries of the diverted rivers that provide the last remaining habitat for these fish in the mid Waitaki catchment. Restoring and protecting those streams would provide additional compensation of residual adverse effects on aquatic ecosystem health.⁴⁷

140. Section 3.1.3 Zone 1 priority actions do not include any actions in the upper catchments relating to fish i.e., upland longjaw galaxias, despite multiple mentions of threatened fish species within the descriptive text of Kahu Ora outlining the ecological values of the catchment. Upland longjaw galaxias are listed in the Kahu Ora Appendix 4 table of threatened and at risk species and habitat types but are not identified for any protective actions. Weed control may assist in improving habitat for upland longjaws and section 3.1.4 notes fish population trends will be measured at sites with upland longjaws present, but the linkage between the value and the actions is not well established.
141. Section 3.2.3 priority actions for Zone 2 include trout and weed control⁴⁸ in Fork Stream in the Takapō catchment. This will directly benefit the lowland longjaw population at that site. Fork Stream is the only site planned for work under Kahu Ora out of the seven remaining sites they inhabit. Monitoring of trout and lowland longjaw populations is also included. All other proposed actions in Zone 2 are not expected to deliver benefits specific to protection and improvement of indigenous fish or other instream aquatic species.
142. No other sites of threatened indigenous fish are included for the first ten-years of Kahu Ora across Zone 2, where four of the last seven sites for lowland longjaw galaxias are found. The Corbies Creek lowland longjaw sites is not identified for protection actions in Zone 3.
143. Kahu Ora does not provide enhancements of indigenous fish habitats that are commensurate with the residual adverse effects on aquatic life. Opportunities to significantly improve the extent and quality of habitats and increase populations of threatened fish may have been identified if a sequential scientific approach to aquatic compensation had been taken. In my opinion substantial opportunities have been missed to 'trade up' and provide significant outcomes for these species.

OIA documents

⁴⁷ The culvert allowing the flow of Fork Stream to pass beneath the Tekapo Canal provides an excellent opportunity to keep trout out of the whole Fork Stream catchment and opens up a large area of catchment which could be strategically managed to benefit multiple indigenous fish species, particularly the non-migratory and threatened galaxiids, providing new sites with suitable habitat to enable population growth.

⁴⁸ I have assumed that the weed control proposed for Fork Stream includes control of the invasive monkey musk which adversely affects lowland longjaw galaxias. However, Zone 2 milestones only reference removal of tree weeds (page 46).

144. I was asked to review the PRR costing report (Lewis and Maloney 2020), provided together with various other documents and emails in response to Forest & Bird's OIA request. I attach this bundle of documents as Appendix 3 to my evidence. I have focused my attention on the PRR costing report and the 'synopsis' (Document 4 pages 1 – 4; unknown author or date) as these are directly relevant to my evidence. I have not analysed the email correspondence in any detail. Many of the emails are out of date order and it is difficult to follow the trail of where decisions departed from the Lewis and Maloney (2020) approach.
145. The Project River Recovery mitigation work report by Lewis and Maloney (2020) was commissioned internally by DOC to inform funding negotiations in anticipation of the WPS and TPS scheme consenting, providing detailed cost estimates for actions to mitigate the impacts of hydroelectric generation on rivers and wetlands within the Waitaki Basin. Having identified the 'biodiversity values and actions programme targets', Lewis and Maloney (2020) created five scenarios for the development of costings, representing the range of intensity in work that could be undertaken to illustrate how to derive costs for achieving specific outcomes. The five scenarios and the estimated per annum costs were:
- (a) Scenario A: all biodiversity values fully managed at all places – all proposed work for rivers and wetlands in the Waitaki catchment was included (\$18.816 M).
 - (b) Scenario B: all values are mostly managed at most places – restore and protect most areas and all biodiversity (70-75% of total cost for all work). Lower priority rivers may be excluded for some tasks (\$13.598 M).
 - (c) Scenario C: Most values are managed at some places – restore and protect most biodiversity at most places (50-60% of total cost for all work). Restoration tasks excluded from lower priority rivers: Hakataramea, Upper Ōhau, Jollie, Fork, Edwards and Otamatapaio Rivers⁴⁹ (\$10.955 M).
 - (d) Scenario D: Most values are managed at a few places – restore and protect most biodiversity at key places. Restoration tasks will be excluded for some rivers and the number of sites reduced (\$5.692 M).
 - (e) Scenario E: A few key values managed at a few key places – aims to 'hold the line' and protect only key biodiversity at limited locations with limited restoration work (reduced to 10-15% of total aims). Only rivers in the upper catchments are included (\$2.135 M).
146. Table 8 of Lewis and Maloney (2020) on page 18 shows the outcomes for predatory fish management under the five scenarios with scenarios D and E resulting in 46% and 0%

⁴⁹ Exclusion of indigenous fish restoration actions begin to impact here with proportion of managed sites dropping from 100% to 77%.

of indigenous fish sites being managed. The effects of various funding scenarios on values and conservation objectives is easily understood and transparent throughout the report. The authors are careful to point out that not all proposed projects and actions are specific mitigation of hydro-electric scheme development but rather a mix of work that in their opinion will help mitigate impacts at place, or in another location as an 'offset' for impacts that are irreversible or not desirable to alter.

147. While they present Scenario E as a 'hold the line' approach, the authors note the current state of the rivers and their ecosystems is unlikely to be sufficient to sustain the species within them and act as a functioning ecosystem over the next 35 years, especially when the impacts of climate change are considered. From this I infer that the existing environment is not resilient, is degrading over time and is vulnerable to further change.
148. It is unclear why Lewis and Maloney (2020) and their methods, and the 'Synopsis' (OIA Document 4 pages 1 to 4) were not used to inform the determination of a compensation sum for the IBEP. The costing approach applied by Lewis and Maloney (2020) appears sound and transparent. The methodology, whilst not developed for that purpose, is more aligned with the requirements of the NPS FM (2020) than the IBEP and Kahu Ora draft report.
149. It is informative that the proposed IBEP annual sum is close to that of Scenario E in Lewis and Maloney (2020). Given all the information I have reviewed and assessed, this aligns with and affirms my conclusions that the IBEP does not adequately compensate for the losses of river extent and values or the residual adverse effects of the combined WPS.
150. Having reviewed this material, I remain of the opinion that the development of the IBEP and Kahu Ora has fitted values, sites and actions to a budget envelope, rather than compensating residual effects on defined values to meet specific conservation outcomes. Detailed information on values, effects and costings was available but was not carried through to the final IBEP or Kahu Ora and this appears to have led the IBEP away from good practice and NPS FM principles.

Conclusion

151. Using the biophysical framework of Clapcott et al. (2018), I have assessed the residual adverse effects on the five components of ecosystem health, indigenous biodiversity and hydrological function where possible. I provide a comparison of my assessment with application reports as Appendix 1.
152. The residual effects not adequately identified can be summarised as:
 - (a) No assessment of the loss of flow and habitat and hydrological function in the Takapo River from continued flow diversion – effects on braided river extent and values not identified
 - (b) Changes in sediment transport not assessed

- (c) No assessment of potential benefits or the reduction in residual adverse effects from any environmental flow regimes
 - (d) Fish stranding effects not considered
 - (e) Effects on longfin eel and potential mitigations not described
153. From a technical perspective the effects identified in my assessment do not safeguard the life supporting capacity of the river and its ecosystems or healthy ecological integrity, form, functioning and resilience of the braided river system as anticipated as an objective of the WCWARP.
154. The proposed consent conditions are insufficient to mitigate the identified effects, and residual adverse effects remain. Proposed aquatic compensation does not meet the best practice principles or expectations of the NPS FM with respect to responding to residual effects on river extent and values, including ecosystem health, indigenous biodiversity, threatened species or hydrological functioning. Compensation has not been developed using an approach that addresses the residual effects through adequate and demonstrably positive effects.

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Appendix 1

Table 1. Residual adverse effects of the Tekapo Power Scheme on the Takapō River.

Residual effect	Applicant assessment	Description of potential losses and benefits
Takapō River loss of ~6.6 km habitat by dewatering (diversion) Significant reduction in quantum and quality of ~38 km remaining habitat (flow diversion)	Acknowledged predominantly in relation to fish	Residual adverse effects: Losses of biomass of macroinvertebrates and fish, ecological processes, ecosystem function and structure, endangered braided river habitat type, hydrological connectivity, geomorphological activity and active braiding Potential ecological structure and population level effects, including for at risk indigenous fish species
		Potential benefits of environmental flow regime mitigation (including flushing flows): Reestablishment of aquatic invertebrate communities and benthic ecological processes e.g., food webs, biotic interactions, some ecosystem structure and function, disturbance regime, wetted habitat (residual flows) and subsequent increased biomass of aquatic life Hydrological reconnection and increase in some geomorphic processes (flushing flows) Some residual adverse effects are likely to remain, depending on the nature of any environmental flow regime Increased biomass of aquatic invertebrate communities and benthic ecological processes e.g., food webs and ecosystem structure and function

Residual effect	Applicant assessment	Description of potential losses and benefits
		Increased wetted habitat (minimum/residual flow), braiding, habitat heterogeneity (flushing flows) and geomorphic processes Reestablishment of disturbance regime and subsequent habitat quality and community level benefits from reductions in periphyton including didymo (flushing/flood flows) Significant improvements in ecosystem health likely from flushing flows Some residual adverse effects may remain, depending on the nature of any environmental flow regime
Flow releases – indigenous fish stranding and mortality	Not assessed (provisions made for sports fish only)	Loss of indigenous fish (unknown scale of effect) from stranding in pools after flow release recessions
		Potential benefits of indigenous fish salvage plan (recommendation for consent conditions) Salvage of some stranded fish will mitigate the adverse effect Residual adverse effects remain as not all fish can be salvaged; survival of indigenous fish post salvage and relocation is highly uncertain
Reduction of sediment bedload	Not directly assessed	Residual adverse effect: Loss of sediment transport contributing to poor habitat quality, river morphology, substrate composition and heterogeneity, connectivity to hyporheic zone due to bed armouring, scouring effects on periphyton (likely including didymo)

Residual effect	Applicant assessment	Description of potential losses and benefits
		Residual effects largely remain, even in the event of some flow regime restoration
Loss of hydrological variability and flushing flows	Acknowledged as an adverse effect – no mitigation recommended	Lack of flushing flows in combination with didymo and reduced sediment transport results in poor benthic ecology and degraded ecosystem health values
		Potential benefits of hydrological restoration (residual and flushing flows): Periodic reductions in periphyton growth (including didymo) resulting in improvements in macroinvertebrate health and ecological processes/water quality (i.e., through more stable diel dissolved oxygen)
Disconnection of fish passage by flow diversion	Acknowledged as an adverse effect	Residual adverse effect: Upstream eel migration (and other species) ceased into Lake Takapō and upper catchment tributaries
Cumulative WPS-wide effects on longfin eels and other migratory fish upstream and downstream	Acknowledged as an adverse effect — specific effects on longfin eel migration and power station mortality not assessed	Residual adverse effects: Lamprey, kōaro and torrentfish unable to migrate upstream, although kōaro have established lake-locked populations upstream potentially negating fish passage impacts Downstream migrating eels: 100% female mortality and barotrauma injury on smaller fish from passing through turbines, lack of successful breeding migration creating a population sink with potential for effects outside of the Waitaki catchment MTAT programme requires a marked increase in effort and effectiveness, without which significant residual effects on longfin eel downstream migration remain

Residual effect	Applicant assessment	Description of potential losses and benefits
		Residual adverse effects on longfin eels will be ongoing as the MTAT programme is unlikely to achieve the scale necessary to mitigate the effect, even with marked improvements Mortality of breeding age eels will continue for as long as migrating eels can still access power station inflows Significant effects remain unmitigated for all other migratory species

Appendix 2

Table 1: Ecological assessment of compliance with NPS FM (2020) principles for aquatic compensation.

Principle NPS FM (2020) Appendix 7	NPS FM direction	Ecological technical assessment
1. Adherence to effects management hierarchy:	Comply with	• Residual adverse effects on ecosystem health inadequately defined • Recommendations to avoid, remedy or minimise ecological effects absent/ignored in consent conditions/IBEP proposal • No technical assessment of suitability for aquatic offset
2. When aquatic compensation is not appropriate:	Comply with	• No assessment of appropriateness of aquatic compensation with respect to irreplaceable or vulnerable values i.e., threatened fish species⁵⁰ • Extent of effects of diversion of water from Pūkaki and Ōhau Rivers on indigenous biodiversity and ecosystem health uncertain, unknown, or little understood • Potential effects are significantly adverse

⁵⁰ Also see evidence of Dr McClellan and Mr Harding.

Principle NPS FM (2020) Appendix 7	NPS FM direction	Ecological technical assessment
3. Scale of aquatic compensation:	Comply with	• Scale of residual adverse effects inadequately assessed therefore no certainty that positive effects outweigh adverse effects • Assessments of Forest and Bird experts identify adverse effects that are not outweighed by positive effects
4. Additionality:	Comply with	• Kahu Ora Strategy appears to be additional to existing projects and functions • Aquatic compensation for indigenous fish (Fork Stream) appears to be counted against the effects of the WPS and the TPS, whereas compensation for the effects of each scheme should be additional
5. Leakage:	Comply with	• Because sequential technical approach was not taken to the design of compensation it is unclear whether IBEP will result in displacement of harm
6. Long-term outcomes:	Comply with	• Long-term monitoring inadequate e.g., longfin eels, threatened fish species
7. Landscape context:	Have regard to	• Assessment of IBEP as best ecological outcome has not adequately considered interactions between species, habitats

Principle NPS FM (2020) Appendix 7	NPS FM direction	Ecological technical assessment
		and ecosystems, spatial and hydrological connections, and ecosystem function
8. Time lags:	Have regard to	Calculated gains are unclear – unable to assess
9. Trading up:	Have regard to	- Conservation outcomes and residual effects not clearly stated so difficult to assess whether trading up is part of IBEP - IBEP proposal does not prove that values lost are not to Threatened or At Risk/Declining species or to species considered vulnerable or irreplaceable
10. Financial contribution:	Have regard to	Not relevant to ecological assessment
11. Science and mātauranga Māori:	Have regard to	- Sequential technical process not followed - No technical assessment of aquatic offset suitability - Critical sources of technical information disregarded
12. Tangata whenua or stakeholder participation:	Have regard to	Not relevant to ecological assessment
13. Transparency:	Have regard to	Not relevant to ecological assessment

Appendix 3 Official Information Act request documents provided by Forest and Bird