

**BEFORE THE ENVIRONMENT COURT  
AT CHRISTCHURCH**

**ENV-2010-CHC-115, 123, 124 AND 135**

**IN THE MATTER** of Appeals pursuant to Section 120 of the  
Resource Management Act 1991

**BETWEEN** **WEST COAST ENT INC**  
Appellant

**AND** **ROYAL FOREST AND BIRD  
PROTECTION SOCIETY OF  
NEW ZEALAND INC**  
Appellant

**AND** **WHITE WATER NEW  
ZEALAND INC**  
Appellant

**AND** **DIRECTOR GENERAL OF  
CONSERVATION**  
Appellant

**AND** **WEST COAST REGIONAL  
COUNCIL AND BULLER  
DISTRICT COUNCIL**  
Respondents

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**STATEMENT OF EVIDENCE OF  
DAVID JOHN KELLY  
FOR DIRECTOR-GENERAL OF CONSERVATION  
Dated: 17 May 2012**

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- AND**                    **MERIDIAN ENERGY LIMITED**  
**Applicant**
- AND**                    **FRIDA INTA**  
**Section 274 Party**
- AND**                    **WHANAU PIHAWAI WEST – RICHARD**  
**WAYNE BARBER AND IRI MAY BARBER**  
**MILNER**  
**Section 274 Party**
- AND**                    **J MacTAGGART**  
**Section 274 Party**
- AND**                    **ORION ENERGY NZ LTD,**  
**ALPINE ENERGY LTD, MAIN**  
**POWER NZ LTD AND**  
**ELECTRICITY ASHBURTON**  
**LTD**  
**Section 274 Party**
- AND**                    **NZ RAFTING INC**  
**Section 274 Party**
- AND**                    **ANN SHERIDAN**  
**Section 274 Party**
- AND**                    **BULLER ELECTRICITY**  
**Section 274 Party**

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## 1. QUALIFICATIONS AND EXPERIENCE

- 1.1. My full name is David John Kelly.
- 1.2. I have the following qualifications: PhD (University of Alberta, Canada), BSc (University of Victoria, British Columbia, Canada). I am a member of the New Zealand Freshwater Sciences Society (since 2001), the North American Benthological Society (since 1996), and the International Society of Theoretical Limnology (since 2007).
- 1.3. From 2006 until February 2012 I worked as a freshwater scientific advisor with the Department of Conservation (DOC), Research and Development Group, Freshwater Section. In March 2012 I took up a position as a senior scientist with the Cawthron Institute in Nelson in their Coastal and Freshwater Section. Prior to working at DOC, I worked for the National Institute of Water and Atmospheric Research (NIWA) in Christchurch as a freshwater scientist (2001-2006), and before this I obtained my Doctor of Philosophy degree at the School of Biological Sciences, University of Alberta, Canada (2001) in the field of freshwater ecology focusing on the management of forestry practices in rivers in British Columbia. My doctoral dissertation and previous work with the British Columbia Ministry for the Environment, Lands and Parks examined factors influencing the ecology of *Didymosphenia geminata* in coastal watersheds of British Columbia, where this invasive alga had recently proliferated in deforested rivers on Vancouver Island.
- 1.4. I have expertise in several relevant areas of freshwater management related to the Mokihinui Hydroelectric Project (MHP). I was the principal scientist within DOC for

managing its research on flow ecology, and I was one of three scientists who directed the freshwater technical work in DOC's Natural Heritage Management System (NHMS) which prioritizes the conservation values of freshwater environments across New Zealand. I have been regularly asked to provide advice to central government and regional conservancy operations on flow and water level management policy and resource management decisions. I served as the DOC representative in the peer review for the National Environmental Standard on ecological flow setting methodologies. I have provided expert evidence as a witness or reviewed other expert witness' material for a number of resource consent Regional Council hearings for the MHP, the Matahina hydro dam (EBOP), the Wairau River, the Central Plains irrigation scheme and the Manawatu-Wanganui Regional Council policy statement and regional plan appeal hearings (the One Plan).

- 1.5. I am familiar with the Mokihinui River, the Mokihinui gorge, and the proposed MHP to which these proceedings relate.
- 1.6. I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. I confirm that the issues addressed in this brief of evidence are within my area of expertise.
- 1.7. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I have specified where my opinion is based on limited or partial information and identified any assumptions I have made in forming my opinions.
- 1.8. My opinions rely in part on:

- (a) The reports and statements of evidence of other experts giving evidence on behalf of Meridian and the Director-General of Conservation relevant to my area of expertise, including the evidence-in-chief of :
- i. Mr R. Henderson,
  - ii. Mr I. Jowett,
  - iii. Mr N. Norton
  - iv. Dr A. Suren,
  - v. Dr C. Kilroy,
  - vi. Mr M. Bonnett,
  - vii. Dr D. Jellyman,
  - viii. Dr M. James,
  - ix. Dr J. Hayes,
  - x. Dr H. Hudson,
  - xi. Dr R. Allibone,
  - xii. Dr R. Death,
  - xiii. Dr M. Schallenberg
  - xiv. Dr J. Leathwick
  - xv. Dr K. Lloyd
  - xvi. Mr I. Whitwhick
  - xvii. Dr C. O'Donnell
  - xviii. Mr T. Shaw
  - xix. Mr G. Lister
  - xx. Dr M. Joy
- (b) The MHP Aquatic Ecology Management Plan (James 2011)
- (c) The MHP Proposal Description.

- 1.9. All references to the evidence of witnesses called by Meridian in this statement of evidence refer to the evidence-in-chief dated 2011, unless I state otherwise.

## **2. SCOPE OF EVIDENCE**

- 2.1. I have been asked by the DOC to prepare evidence in relation to the MHP in my area of expertise.

- 2.2. My evidence will deal with the following:

- (a) Conservation values of the Mokihinui River catchment and the effects of the MHP;
- (b) Effect of the proposed MHP on whole of catchment connectivity and ecosystem functioning.

- 2.3. In discussing these matters I draw together and summarise the evidence of various witnesses to be called by the Director-General of Conservation in relation to aquatic processes and ecological values of the Mokihinui River, and the effects of the MHP on those processes and values.

## **3. KEY FACTS AND OPINIONS**

### **Conservation values of the Mokihinui River catchment and the effects of the MHP**

#### Conservation Values of the Mokihinui River

- 3.1. The Mokihinui River has multiple biodiversity components that ranked this catchment in DOC's Waters of National Importance analysis (WONI) as a significant waterbody of both regional (Nelson-Paparoa biogeographic unit) and national importance. This high ranking is due to the diversity and representativeness of environment types for the region, its pristine state upstream and including the

Mokihinui gorge, and the number of threat listed aquatic and terrestrial species that reside in the catchment.

- 3.2. More recent work by the DOC in developing the FENZ (Freshwater Ecosystems of New Zealand) database has confirmed this high ranking, with the Mokihinui in the top 20% of large rivers in the country, and 3<sup>rd</sup> in the Nelson-Paparoa biogeographic unit.
- 3.3. The assessment of WONI provided by Mr Ned Norton et al. (2008) and his evidence comparing the physical and biological (algal, invertebrate, fish) diversity of the Mokihinui River to other rivers both nationally and within the same biogeographic unit is in my opinion of very limited value in terms of the conclusions that can be made from the analyses. Its value is limited by inadequate data for assessing distinct and rare biological communities, variable and uncertain taxonomic resolution between data-sets, failure to consider population size and/or viability for fish communities, and misinterpretations regarding how the WONI model has evaluated river catchment significance.
- 3.4. My assessment of data-sets comparing biological communities in the Mokihinui River supported by key findings of several other witnesses, suggest that the Mokihinui has highly diverse, distinctive, and unique aquatic communities and habitats in comparison to several other catchments in the region. In my opinion the characterization of aquatic communities as typical for the West Coast by some of the applicant's witnesses is inaccurate.

#### Potential Effects of the MHP on Conservation Values

- 3.5. In relation to the conservation ranking assessments in both WONI and FENZ, the MHP is likely to negatively affect multiple biodiversity values including major changes in

connectivity, alteration of habitats utilized by threatened species (e.g. blue duck, 9 fish species), loss of riverine gorge habitat and its distinctive and unique turf and seepage communities, an increased invasion potential for exotic species (e.g. *Didymosphenia geminanta*, exotic fish and macrophytes), and alteration of riverine habitats downstream of the MHP dam.

### **Effect of the proposed MHP on whole catchment connectivity and ecosystem function**

#### Effects of Upstream Migration

- 3.6. The MHP will result in changes to the distribution and migration patterns of adult and juvenile native fish species. This has the potential to affect the structure and composition of the fish community, the population dynamics of several species and the ecological function of the river system. Although the applicants Aquatic Ecology Management Plan (AEMP) will contribute towards minimizing some of these effects on migratory species through upstream trap and transfer, there are a number of effects that cannot be mitigated. Consequently, the residual adverse impact on native fish populations is significant, including 7 species that are presently threat listed.
- 3.7. The populations of eleven native diadromous species would depend on the effectiveness of trap and transfer (t&t) systems for sustaining their upstream passage. Although results from the applicants studies do indicate that trapping is possible for a number of the native species not previously managed through t&t, it is unknown if systems can be designed at the dam site to accommodate such temporally variable and large migration events. This has implications for both the maintenance of populations of the species being transferred, and for other piscivorous species

(e.g. longfin eels) residing in the upper catchment that depend upon migratory species as prey.

- 3.8. Several species would have their upstream range truncated by flooding the Mokihinui gorge (e.g. torrentfish, bluegill bully, redfin bully). Transferring these species into habitats upstream of the MHP reservoir could affect downstream migration due to interruption by the 14 km reservoir. The relocation of some species outside their natural range was also not considered by the applicant's witnesses. This poses risks to both the transferred populations as well as those presently occupying the habitat upstream of the reservoir. The effect of transferring populations upstream into a reduced area of riverine habitat was not assessed in terms of whether these habitats could accommodate increased densities, or whether they are already at their present carrying capacity. Thus there would be a risk of overall catchment declines in productivity.

#### Effects of Downstream Migration

- 3.9. A very significant effect of the MHP is on downstream migration of fish through the reservoir and past the dam. Some whitebait species (predominantly koaro) may cease to emigrate from the upper Mokihinui River to the coastal zone as larval whitebait, and instead may establish a smaller "landlocked" reservoir population. This will result in significantly slower growth and lower recruitment of juvenile larval koaro to the adult population above the MHP reservoir.
- 3.10. Downstream migration by larger piscivorous species such as longfin eels and brown trout will be affected by the dam operations, with significant mortality of fish passing through turbines or being impinged on intake screens (when screening is in place) to be expected. These effects

are difficult to mitigate within the current operational framework of the MHP, with downstream migration being only partially addressed in the applicants AEMP.

- 3.11. Downstream passage over the spillway or through turbines was inadequately assessed for a number of species expected to require passage upstream, particularly torrentfish, redbfin bully, bluegill bully and lamprey, all of which are threatened.

#### Effects on Gorge Aquatic Habitats

- 3.12. The flooding of the gorge and creation of the 14km reservoir will eliminate habitat for several species that utilize the gorge for all or part of their lifecycle. In particular, rare and/or undocumented flora and fauna which occupy seepage habitats and smaller low gradient river margins within the gorge will be entirely lost to flooding, and replaced with a low diversity lentic assemblage. Other flowing water-dependant threatened fish species (torrentfish, redbfin bully, lamprey) will have their present distributions truncated by the creation of the reservoir, with unknown effects on their life history requirements (such as spawning) and population trajectories.
- 3.13. Compared to what occurs presently, I do not expect that the MHP reservoir will provide as diverse and unique species assemblages due to the steep bathymetry and large daily fluctuations in water level. My assessment of suitable productive habitat for fish and invertebrate communities in the MHP reservoir is, at best, 6.25% of the total reservoir area. This assessment is made based on extensive measurements of water clarity in the Mokihinui River as well as patterns of aquatic plant growth observed in other landslide lakes in the region.

- 3.14. The forecast increase in boat access to the newly created reservoir increases risk of invasive species incursions in the catchment, such as invasive weeds (e.g. oxygen weeds) and exotic fish (e.g. perch and goldfish) which are widely distributed in other reservoirs and coastal lakes nationally and in the region. If introduced, these would be highly detrimental to the indigenous biota of the Mokihinui River. There was no provision within the applicants AEMP concerning the prevention or management of such potential incursions.

#### Effects on the Lower River

- 3.15. The managed flow regime in the lower Mokihinui River below the dam would diminish its productive capacity through lower base flows and large daily flow fluctuations for power generation. Overall this is expected to have significant effects on the habitat quality and productivity of the lower river, and will affect species inhabiting the lower river such as inanga, torrent fish, bluegill bully, redfin bully and common bully through its effects on food supplies.
- 3.16. How the new flow regime might affect migratory species such as longfin eels and whitebait species moving through the lower portion of the river on their way to the upper catchment is more complex and uncertain, depending upon the timing of migrations and the efficiency of t & t systems at the dam.
- 3.17. Stabilization of the riverbed and truncation of upstream sediment supply by the MHP dam would improve the suitability of habitat for the invasive alga *Didymosphenia geminata* (Didymo) that presently occurs in the river. However complex changes in the river's flow regime create uncertainty as to the extent to which Didymo might bloom in the river. There is significant risk that there will be

extended periods between large floods which are conducive to Didymo proliferation, I therefore conclude that there is a risk of Didymo impacting recreational values of the lower river, particularly whitebaiting.

#### Effects on Whole System Production

- 3.18. As previously stated, there are likely to be overall changes in the migration of fish populations and production of aquatic communities (both fish and invertebrates) in the lower river and the flooded Mokihinui gorge post MHP. In my opinion this could affect the overall productivity of the river system and create an imbalance to existing communities and their food sources, particularly those residing in the upper portion of the river catchment.

#### **4. CONSERVATION VALUES OF THE MOKIHINUI RIVER CATCHMENT AND THE EFFECTS OF THE MHP**

- 4.1. The Department of Conservation (DOC) has been developing systematic methods for prioritising its conservation effort for a considerable period (e.g. Stephens et al 2002). For freshwater ecosystems, this systematic approach was initiated within Central Government's Waters of National Importance (hereafter called WONI) programme, and resulted in the output of a draft framework and candidate list of river catchments for priority management (Chadderton et al. 2004). In 2005 DOC adopted the WONI work stream into its wider Natural Heritage Management System (NHMS) that also included terrestrial ecosystem management objectives. This necessitated improvements to classifying and prioritising freshwater ecosystems to align WONI products with the NHMS approach. These improvements were developed under the Freshwater Ecosystems of New Zealand (FENZ) work stream. They included a multivariate freshwater

environmental classification and the ecosystem ranking framework released in 2010 (Leathwick et al. 2010).

#### Conservation values of the Mokihinui River Catchment

4.2. In my council hearing evidence I discussed the conservation significance of the Mokihinui River in the context of the WONI framework as reported by Chadderton et al (2004). As part of WONI process, DOC was tasked with developing a methodology and candidate list of river catchments that are of high importance for their natural heritage values. The term natural heritage was interpreted by the DOC to include aspects of both the biological and physical habitat attributes, with the objectives of the WONI process being to provide:

- (a) Maintenance of viable populations of all indigenous freshwater species and subspecies;
- (b) Protection of a full range of remaining natural freshwater habitats and ecosystems;
- (c) Identifying the minimum number of catchments in the best possible condition to best represent the full range of indigenous biodiversity and freshwater environments in New Zealand.

4.3. As Mr Ned Norton has discussed in sections 4.4 - 4.13 of his evidence, it was the intention of this first WONI publication to provide a discussion of the methodology and the provisional list of catchments that would cover a full range of freshwater environments and species in New Zealand. The document and associated analysis assessed 4706 river catchments New Zealand wide in a biogeographic context (from Leathwick et al. 2007). A map

of the WONI biogeographic units is shown in Figure 1. The Mokihinui River was identified as the second most important river for contributing to biological and physical habitat representativeness within the Northwest Nelson-Paparoa biogeographic unit. At a national level, - the Mokihinui had the seventh highest natural heritage value score of the 4706 river catchments evaluated in the WONI model.

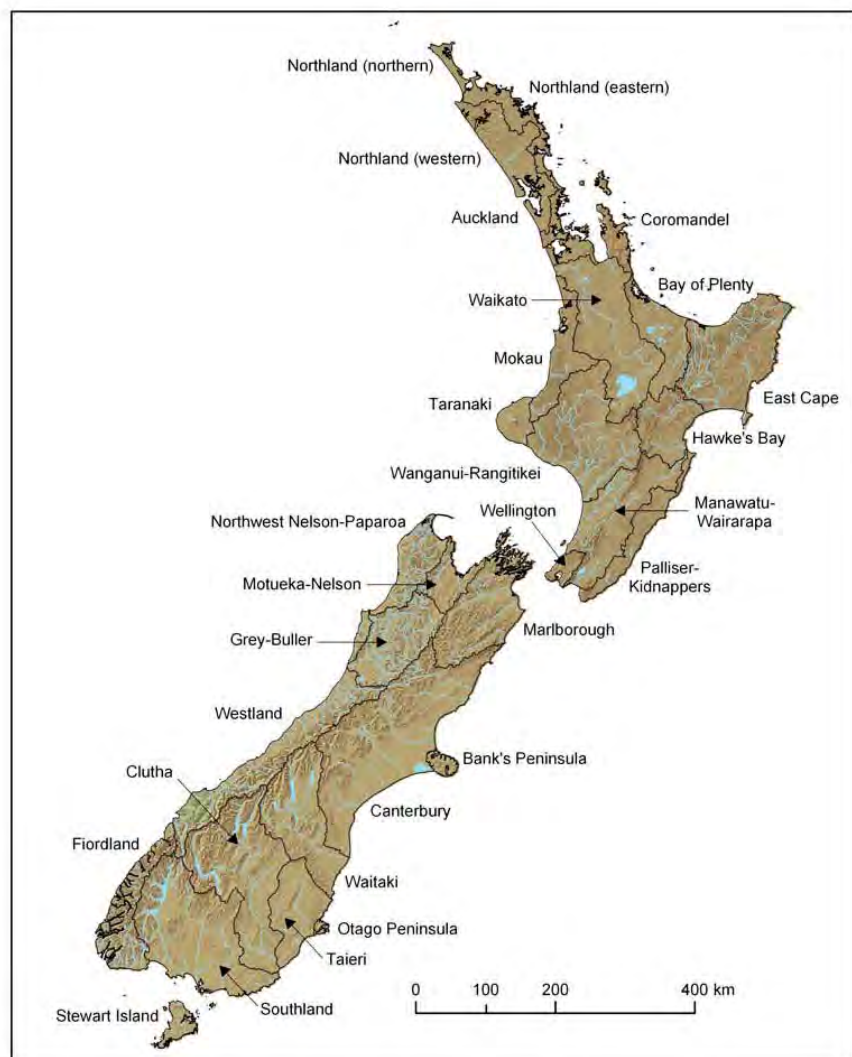


Figure 1. Freshwater biogeographic units of New Zealand (after Leathwick et al. 2007). Taken from Chadderton et al. (2004).

4.4. Conservation value (and the natural heritage value score) was assessed using values and criteria including representation of River Environment Classification (REC)

classes within the biogeographic unit, uniqueness of any REC classes within the biogeographic unit, cumulative human pressure (native vegetation clearance, dams, industrial discharges and introduced aquatic species), the number of threatened species (including plants, fish, amphibians, birds and bats) and connectivity to other nationally important waterbodies such as lakes or wetlands.

4.5. The basis for such a very high ranking of the Mokihinui River are outlined in Chadderton et al. (2004) and summarised below:

(a) *The degree of physical and geomorphological habitat heterogeneity of the river catchment.*

The Mokihinui catchment, due to the large area (60<sup>th</sup> largest catchment in New Zealand) and the heterogeneity of its landscape and geology (e.g. gorges, plateaus, mountain ranges, coastal flats, limestone, granite) comprise a highly diverse river environment. This was characterized by a large number of representative River Environment Classification (REC) classes (50 of 109) for the biogeographic unit.<sup>1</sup>

(b) *Human pressure on the catchment, which reflects the pristineness or condition of the environment.* There were a number of pressure measures applied to all river catchments nationwide. This included the

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<sup>1</sup> The REC is highly recognized and widely used as a management tool by regional councils and central government for characterizing river environment typology, and has been shown to be closely correlated with biodiversity values and composition of aquatic communities (Snelder et al. 2004).

proportion of indigenous catchment vegetation removed, restrictions to connectivity for migratory species (measured as the proportion of catchment upstream and downstream of impoundments >5m), agricultural land-use intensity (measured as cumulative nitrogen export calculated from the CLUES model), the number of significant point source discharges (i.e. mines, industrial, municipal) and the known number of alien species (weeds and invasive fish). The Mokihinui catchment is in the top 17% of catchments nationally in respect of the summed pressures, with nearly all of its catchment remaining in indigenous vegetation cover. The main pressures noted for the catchment were small scale historical mining, agricultural and urban development downstream of the Mokihinui Gorge, and the presence of introduced brown trout. Since the time of this report *Didymosphenia geminata* (hereafter called Didymo) has been detected in the main-stem of the river, although not at nuisance levels.

- (c) *The presence of threat-ranked indigenous species.* On a national level, the Mokihinui river system contains a disproportionately large number of threat listed species in comparison to other rivers. At the time of the 2004 analysis, this included a number of birds (blue duck, kiwi), a mammal (longtail bats), fish (longfin eel, giant kokopu, shortjaw kokopu, and lamprey) invertebrates (*Powelliphanta spp*) as well as the plants

addressed more fully in the evidence of Dr Kelvin Lloyd. Since 2004, the threat status of native fish has been revised and a further four species that also occur in the Mokihini River have been formally listed as 'declining'. These are koaro, bluegill bully, redfin bully and torrentfish (Allibone et al. 2010).

- (d) *Connection to significant freshwater habitats.* The Mokihinui catchment contains a regionally significant wetland ranked 7<sup>th</sup> in the biogeographic unit in the plateau area above the Mokihinui forks according to a national wetland prioritization exercise (Ausseil et al. 2008). As Dr Lloyd's evidence discusses, significant wetland habitats such as riverine turf communities and seepage habitats are also abundant along the length of the proposed inundation area in the Mokihinui Gorge. These wetland habitat types were not able to be included in the scope of the WONI project because they had not been adequately mapped for use in the wetland classification (P. Gearbeaux personal communication, April 16, 2012).

- 4.6. The attributes of this WONI evaluation of the Mokihinui River are reflected in a number of criteria for significance contained in national and regional policies including the National Policy Statement for Freshwater (Policy 9.2), the West Coast Regional Water Plan (sections 5.4 and 6.5) and the Buller District Plan (sections 4.7 and 4.8). These documents identify assessment criteria for the protection of significant indigenous vegetation, fauna and freshwater habitats including representativeness, distinctiveness, intactness, connectivity, and migratory habitat. On the basis

of the provisional Chadderton et al. (2004) WONI evaluation, and having regard to provisions within the national, regional and district plans I consider the habitats for aquatic indigenous fauna of the Mokihinui River to be of high regional and national significance.

#### Effects of the MHP on Conservation Values in the Mokihinui Catchment

- 4.7. As a consequence of the proposed MHP criterion scores for multiple attributes used to assess the conservation value of the Mokihinui River using the WONI model will be lowered. I now proceed to discuss these attributes.
- 4.8. *Loss of natural connectivity between the upper and lower sections of the Mokihinui catchment.* The effect of the impoundment on reducing connectivity for migratory species is significant, will increase the pressure scores and reduce the conservation value of the Mokihinui River in the WONI model. Dr Leathwick in his evidence has re-run the analysis in the FENZ prioritization tool to examine how this would affect the Mokihinui's national ranking and observed that its rank moved from a ranking of 14<sup>th</sup> to 44<sup>th</sup> in a 77 river catchment set. Although I have not conducted a comparable analysis for the Chadderton et al (2004) WONI model, from my experience working with the pressure models for the WONI tool I am confident that increases to this pressure indicator would be sufficient to drop the Mokihinui outside New Zealand's top 20 rivers and out of the top 8 rivers within the biogeographic unit. I discuss changes to components of the WONI model expected to be caused by the MHP in my points 4.9-4.13 below.
- 4.9. *Loss of riverine habitat following the inundation of the Mokihinui gorge.* Almost all of mainstem river habitat in the Mokihinui gorge will be lost due to inundation, and the

downstream reaches will become flow controlled. Both modifications lead to changes in their respective River Environment Class (REC class). The two extant river environment classes in the gorge mainstem are relatively rare for the West Coast region, together comprising 0.5% (or 309 of 59,643 river segments) of river segments in the REC river network. This is a significant loss of a rare river environment class. It amounts to between 2-35% of the particular REC class regionally and 1-20% nationally depending on REC level considered (Norton et al. 2008). In some cases this REC class provides most of the habitat area for some of the threatened species identified in the WONI evaluation (e.g. blue duck). The implications of the loss of this habitat for threat listed species that used this area of the gorge is covered in greater detail in the evidence of Dr R. Allibone (fish), Dr R. Death (aquatic invertebrates), Mr T. Shaw (Blue Duck), Dr K. Lloyd (vegetation) and Dr C. O'Donnell (aquatic birds).

- 4.10. *Inundation and clearance of indigenous forest through construction activities and flooding of the Mokihinui gorge.* This will be relatively minor in terms of its effect on pressure scores in the WONI model as it equates to only 0.45% of the Mokihinui catchment. However, our WONI pressure model is calibrated for effect on aquatic biodiversity not all biodiversity. Thus WONI does not account for the threat status or rarity of vegetation types and associated biodiversity cleared. Dr Lloyd's evidence discussing vegetation communities in the inundation area has shown that some rare plant assemblages including riverine turfs and bryophyte seepage communities will be lost as a result of the formation of the reservoir.
- 4.11. *Increased potential for invasion by exotic species.* Suren and Kilroy (2008) identified in the AEE, that the MHP will create favourable conditions for several potential invasive

species such as *Didymosphenia geminata* (Didymo), water weeds, and coarse fish that could be introduced to the reservoir. Although it is difficult to confidently forecast the change in invasive species incursions that might occur due to the MHP, it is likely to have effects into the future as recognized in the AEE. There were no specific mitigation measures identified in the AEMP technical documents (James 2011) to remedy invasive species risks, and they were generally thought to be no more than minor in terms of their significance in the evidence of Mr Bonnett (8.1-8.6) and Dr Kilroy (sections 5.38-5.44). I disagree with this assessment, and believe there to be a significant risk that invasive species may diminish the native biodiversity values in addition to the degradation caused by implementation of the MHP. These risks are discussed in further detail for exotic fish (sections 5.28-5.30) and Didymo (Sections 5.54-5.60) later in my evidence.

- 4.12. *Connectivity to regionally important wetlands and lakes.* It is unlikely that the MHP will directly affect the hydrology or vegetation communities of the Mokihinui Forks wetland. However, changes in connectivity for migratory fish species may alter the composition of this wetland's fish community. Wetland habitats are often sought out and occupied by a guild of native species that usually include kokopu, eels and mudfish. There is no evidence (in the AEE technical reports and in witness statements) of any assessment of the fish community composition of this wetland habitat. As discussed in section 3.12 of my evidence, seepage wetland habitats located throughout the gorge will be lost when they are inundated by the reservoir. While these habitats are a distinctive feature of the catchment, they also contain taxonomically distinctive and possibly previously unidentified species of macroinvertebrates and periphytic diatoms. Because these

species do not appear to occur in other parts of the Mokihinui catchment nor in neighbouring watersheds (as reported by Drs Suren (5.37-38) and Kilroy (section 5.23-24), there will be a loss of these wetland species from the Mokihinui catchment and possibly the region. In March 2011, Dr Allibone and I conducted fisheries surveys of lentic (pond) and seepage habitats located along the lateral margins of the Mokihinui Gorge near the confluence with the Rough and Tumble Creek. We observed a fish fauna quite distinctive from the main-stem and tributary populations with high densities of redfin bully and some koaro which diminished rapidly as the small tributaries steepened. These are likely to be key habitats for these species along the gorge and will be lost during the inundation of the reservoir. Although we surveyed only the one site, this type of habitat was prevalent in other areas of the gorge such as the mouths of Anderson's Creek, Unnamed creek upstream of Andersons flat and Pakihi Creek.

- 4.13. Overall the effect of the MHP will be to alter a number of attributes related to the community composition (gorge species, risk from exotic species) and functional ecology (migration, connectivity) that significantly increase pressure indicators in the WONI model for the Mokihinui River. This would result in a large decrease in the conservation ranking of this river on both a national and regional basis. The model is heavily weighted by human pressure and natural connectivity and also has a very strong effect on the conservation ranking of a particular river system.

#### **Comments on the AEE Reports and Evidence**

- 4.14. Mr Ned Norton has published (Norton et al 2008) an alternative analysis of the WONI ranking of the Mokihinui

River comparing data obtained during the AEE field surveys against available data for other catchments located in the biogeographic unit, the West Coast and the South Island. Mr Norton in his evidence discusses the results of the analysis in terms of biological diversity, physical diversity and natural character attributes of the catchment. However I see several shortcomings in the analysis and interpretation of results presented in Mr Norton's evidence. Some of the problems with these analyses were similarly encountered when the DOC was considering conducting the WONI analysis using taxonomic data. I describe these below.

- 4.15. First, I think it is important to recognise when conducting an analysis comparing biodiversity units (species and sub-species) between catchments, regions and nationally, that our fundamental understanding of the distribution of freshwater species, and their associated genetic diversity, is very limited, perhaps little more than embryonic. Even the basic taxonomy of some of the most widely distributed groups is poorly understood and far from complete. For example, individuals of a particularly common and ubiquitous mayfly genus in New Zealand, *Deleatidium*, cannot be identified to species level except in a few localities (Winterbourne et al. 2000). Similarly, genetic analyses of some the South Island non-diadromous galaxid species have revealed that what was initially thought to be a single species is in fact a species complex (multiple species) (e.g., McDowall and Wallis 1996). I raise these points to illustrate why caution is appropriate when comparing regional taxa lists because our fundamental recognition of the biodiversity units we are comparing cannot be relied upon. Mr Norton did not provide any guidance as to the sensitivity of his conclusions to the

impact of substantial taxonomic uncertainty in his regional taxa lists.

- 4.16. Secondly, although we are still developing our knowledge of species and sub-species distributions across the country, we do have some fundamental understanding of historical geological and glacial processes that would have shaped some of the biogeographic patterns observed around the country (Waters et al. 2001, Leathwick 2008b). We also have a reasonable understanding of how catchment development pressure can affect biological communities that inhabit them. The WONI evaluations are designed around such knowledge, the intention being to identify a complete set of river environment types in the most pristine condition despite inadequate knowledge of true species distributions. In my opinion this is a more robust approach to systematically comparing conservation values of river catchments at a National and Regional level until better biogeographical data and species taxonomy and distributions is available.
- 4.17. Mr Norton has cited sections from Dr Suren and Mr Bonnett and Dr Kilroy's evidence indicating that the species that were collected in NIWA's surveys of the Mokihinui River were not unique to the West Coast or the South Island, although it was recognised that biota were quite diverse, and contained the full complement of taxa representative of the northern West Coast region. The WONI analysis goal was to identify river catchments with a viable biota representative of the region. Low pressure is an indicator of high viability. Therefore I believe that the analysis in Norton et al. (2008) supports the reason why the Mokihinui River was identified as supporting a representative species assemblage with viable populations. Many other rivers in the region are significantly more greatly modified by agricultural and mining development.

4.18. I believe Mr Norton's statement (evidence sections 4.12 and 5.6) regarding the lack of unique or rare biological diversity in the Mokihinui main-stem or tributaries to be incorrect. Firstly, there are 13 fish species present in the catchment, including 9 species listed as threatened. These are shortjaw kokopu, longfin eel, koaro, inanga, lamprey, torrentfish, redfin bully, bluefin bully and giant kokopu. All of these populations are dependent upon the main-stem of the river for their migration and life history, even for species that are more likely to be found in smaller tributary streams as adult fish. In my opinion while I agree with Mr Norton and Mr Bonnet that these species can be found in other rivers on the West Coast, for the Mokihinui River to contain such a full complement of these species is atypical of the region. Recent analyses looking at effects of mining on in-stream communities (fish, invertebrate, periphyton) in the West Coast region (Clapcott et al. 2012) demonstrates that many rivers, particularly those located south of the Mokihinui, have lower numbers of fish and invertebrates and significant portions of their catchments are affected by acid mine discharges (Figure 2). This includes catchments of the Ngakawau, Waimangaroa, Buller and Grey Rivers.

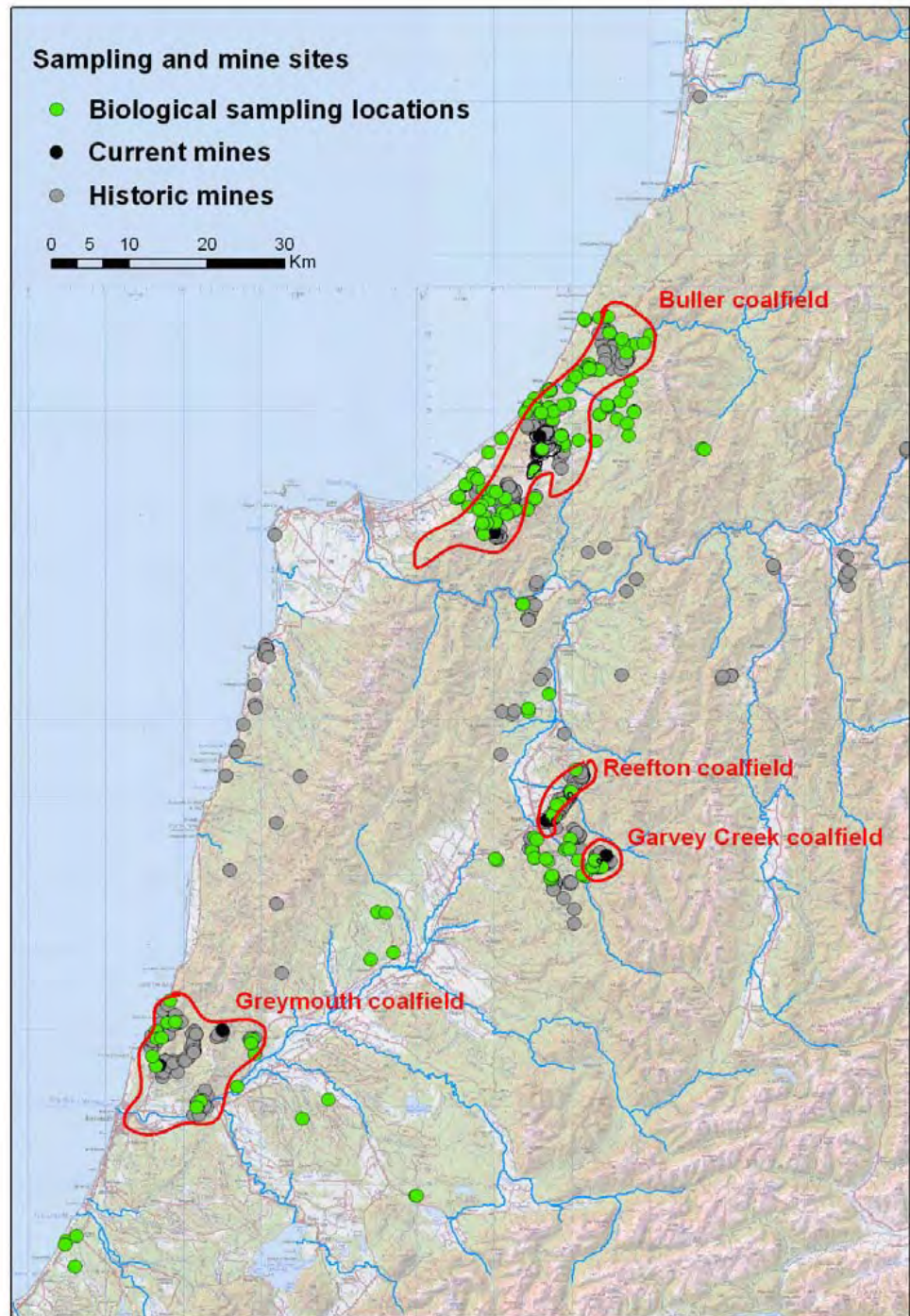


Figure 2. Locations of coal mine fields, current and historic coal mines, and biological monitoring sites for assessing mining effects on stream biota. Taken from Clappcott et al. (2012).

4.19. For a regional comparison of fish and invertebrate communities I have compiled data on the Mokihinui invertebrate and fish communities collected by the applicant, and compared this to community data collected for other West Coast rivers as part of the regional mining investigation (Clappcott et al 2012), which included sites in both mined and unmined streams (Table 1). Data reported are for routinely used metrics to assess macroinvertebrate community health and diversity, including the total number of species (richness), the macroinvertebrate community index (MCI), and the number and proportion of taxa from the indicator families mayflies, stoneflies and caddisflies (EPT). The Mokihinui River community metrics did not differ significantly from unmined sites in the Karamea and Waimagaroa Rivers, however it was significantly higher for most metrics (except %EPT) than unmined sites in the Ngakawau River. The Mokihinui River community metrics were also significantly higher than mine affected sites in all catchments. Thus, the condition and diversity of invertebrate communities in the Mokihinui River are high for the region, with similar values to some other pristine rivers. Areas affected by mining had invertebrate communities which were less diverse and healthy. Therefore in my opinion, the use of the term “typical of unmodified West Coast Rivers” stated by Dr Suren (section 3.1 of key findings and opinions), and used by Mr Norton in his assessment, does not adequately describe these communities. This is because it fails to provide a context of how common unmodified rivers are in the region.

Table 1. Summary of community metrics (mean and (standard deviation)) for macroinvertebrates collected from tributaries of the Mokihinui, Karamea, Ngakawau and Waimangaroa Rivers. Mainstem sites were omitted because these habitats were not sampled in rivers other than the Mokihinui.

<b>River system</b>	<b>N</b>	<b>Richness</b>	<b>MCI</b>	<b>EPT richness</b>	<b>% EPT</b>
Karamea	6	19 (6)	122 (8)	10 (2)	55 (11)
Mokihinui	8	14 (4)	117 (12)	7(3)	49 (13)
Ngakawau unmined	8	7 (4)	106 (33)	3(2)	52(33)
Ngakawau mined	13	5(5)	76(30)	2(3)	33(24)
Waimangaroa unmined	7	15(5)	125(7)	9(4)	58(13)
Waimangaroa mined	10	7(6)	96(40)	4(4)	49(31)

4.20. Analysis of the relationship between fish species richness and the occurrence of mining in the catchment showed that fish community composition was significantly affected by the intensity of mining within the catchment, with sites that were less or unaffected by mining having higher numbers of species. Figure 3 shows the relationship between mining history and intensity, and fish richness. The age of the mining excavation work was a significant factor associated with mining effects on fish species richness. This has some relevance to the Mokihinui River catchment, where most mining occurred in the lower catchment in the Chasm Stream and Coal Creek tributaries (near Seddonville) during the 1920s, with a smaller number of sites actively mined until the 1960s. Table 2 shows the total number of fish species observed in fish surveys for the Mokihinui (NIWA's investigation) and other West Coast rivers

surveyed as part of the West Coast mining investigation (Clapcott et al 2012). Overall the Mokihinui is species rich, equivalent to the Grey, Taramakau, and Waimangaroa Rivers. Some of the catchments affected by mining such as the Ngakawau River had lower species richness. This trend of low richness also occurred for the Buller. However there were fewer sites surveyed in the Buller, particularly towards the coast.

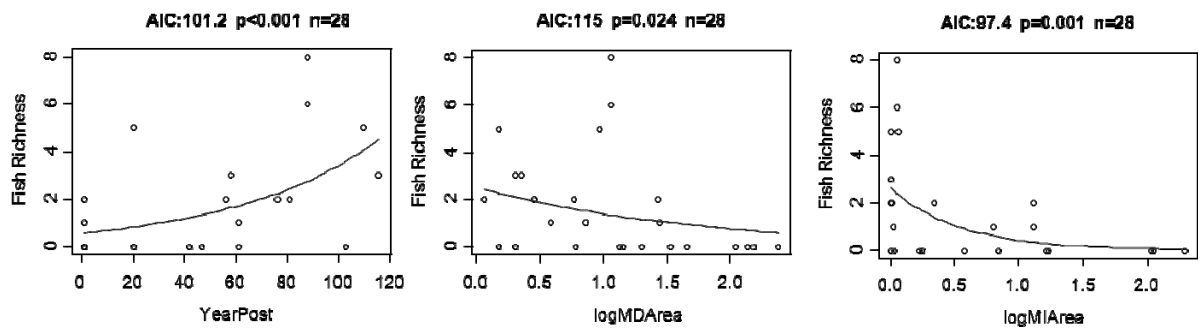


Figure 3. Poisson linear models between fish richness and number of years post mining (YearPost), mining density per catchment area (MDArea) and mining intensity per catchment area (MIArea). Taken from Clapcott et al. 2012.

Table 2. Compilation of fish community data supplied from NIWA and from a recent study on the impact of coal mining on the West Coast (Clapcott et al. 2012). A total of were 15 fish species identified. N = number of sites data was collected per catchment.

Catchment	Nes	Kaoro -Galaxias brevipinnis	Inanga- Galaxias maculatus	Shortjaw kokopu -Galaxias postvectis	Giant kokopu- Galaxias argenteus	Banded kokopu- Galaxias fasciatus	Dwarf galaxias -Galaxias divergens	Redfin bully- Gobiomorphus huttoni	Common bully- Gobiomorphus cotidianus	Bluegill bully- Gobiomorphus hubbsi	Upland bully -Gobiomorphus breviceps	Longfin eel -Anguilla dieffenbachii	Shortfin eel- Anguilla australis	Brown trout -Salmo trutta	Torrent fish- Cheimarrichthys fosteri	Lamprey- Geotria australis	Richness
Mokihinui	88	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	13
Ngakawau	27	1	1	1	0	1	0	1	1	0	1	1	0	0	0	0	8
Waimangaroa	24	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	12
Buller	13	1	1	0	0	0	0	1	0	0	0	1	0	1	1	0	6
Grey	13	1	1	0	0	1	1	1	1	1	1	1	0	1	1	1	12
Taramakau	4	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	13

4.21. This above assessment of native fishes as well as those contained in Norton et al (2008) has relied entirely on presence-absence data. This constrains interpretation of the between-catchment comparisons because the significance, abundance and/or viability of the fish populations cannot be ascertained from presence data alone. Unfortunately, robust quantitative fisheries survey data for regional or catchment wide comparisons is not available. Thus I feel the characterization of the Mokihinui River fish community as “typical of rivers in the region” by Mr Bonnet (section

3.1 key facts and opinions) and used by Mr Norton in his assessment, understates the significance of the native fish community of the Mokihinui River. Both the composition and abundances of the populations are important for assessing the biodiversity attributes of communities. In the case of the Mokihinui River, the remarkable abundance of some species and the very large size of some individuals (e.g. threatened longfin eel) indicate the presence of a substantially unexploited longfin eel population (sections 3.2 and 7.8 of Dr Jellyman's evidence). Substantially unexploited longfin eel populations are now exceptionally rare. I would also suggest (supported by Dr Allibone's evidence) that catch information for kokopu species in the Mokihinui reported in Table 13 of Norton et al. (2008), were probably underestimates of the actual abundances due to the unsuitability of electric fish surveys for detecting kokopu species and the limited range of habitats sampled in the Mokihinui catchment.

- 4.22. In the Norton et al (2008) report and in Mr Norton's evidence, other species populations such as blue-duck, Powelliphanta land snails, and long-tail bats that inhabit the Mokihinui gorge were not considered in Mr Norton's evaluation of the Mokihinui catchment's distinct or rare biodiversity. In particular, blue duck are highly dependent upon riverine habitats in the MHP affected area for foraging and breeding. Therefore, in my opinion they should be considered by Mr Norton in his assessment of rare or distinctive aquatic biodiversity values.
- 4.23. In response to the original AEE documents, submitters were critical of field collections conducted to assess the biological distinctiveness (or biodiversity) and rarity of periphyton, macroinvertebrates and fish because they were confined to a very narrow range of habitat types. As I mentioned previously (section 4.15, our present knowledge

regarding the distribution of rare species is rudimentary (i.e. there are many poorly described species and groups and many unsampled locations). However, it is well known that many of the rare invertebrate species (e.g. caddisflies and hydrobiosid snails) tend to be associated with distinctive or isolated habitats such as springs, seepages, or consistently stable side-streams (McGuinness 2001; Gray 2006). Drs Suren and Kilroy report that further sampling effort by Meridian in 2011 to include assessments of a wider range of habitats has revealed several previously undescribed (new to science) species of invertebrates and periphyton in seepage and stable tributary habitats of the Mokihinui gorge. In my opinion these findings provide significant support of earlier concerns, and in my opinion support the conclusion that the Mokihinui River has high biodiversity values.

- 4.24. Observations of new-to-science species within seepage habitats do not appear to be reflected in the evidence of Mr Norton. Despite all data to the contrary, Mr Norton noted (section 57 of his evidence) there is a “small risk” of some species reported for small tributary and seepage habitats being rare or distinct to the Mokihinui. These species were not located by the considerable sampling efforts conducted by the applicant in neighbouring catchments upstream of the Mokihinui Forks. This suggests that these communities are distinctive to the Mokihinui gorge and in all likelihood are rare. Additional macroinvertebrate sampling data considered from 31 sites in the region of varying size and stability (Clapcott et al. 2012) also did not observe these new undescribed taxa. This further supports the likelihood that these species are regionally rare and quite possibly endemic to the Mokihinui gorge.

### **Physical diversity**

- 4.25. I now turn to the evaluation of physical habitat diversity described by Norton et al. (2008) using the River Environment Classification (REC). In my opinion there are difficulties with the way in which Mr Norton has evaluated the usage of the hierarchical scales for examining physical diversity in the REC (2 through 6<sup>th</sup> levels). As Mr Norton recognized, certain layers in the REC were excluded from the Chadderton et al. (2004) WONI analysis. For example, landcover layers were removed because consensus opinion among the WONI development team was that landcover has been modified to such varying degrees around the country, that it no longer reflects the “potentiality” of species distributions or physical environments. Instead, the WONI model treated landcover modification as a pressure on the “potentiality” of the river catchment. The climate layer was removed because our evaluation was subdivided into 29 biogeographical zones, which reflected the different climates of each region.
- 4.26. In the Chadderton et al. (2004) WONI analyses, the network position (5<sup>th</sup> level) and valley landform (6<sup>th</sup> level) levels were retained as they contributed important attributes to define the physical and biological characteristics of the particular river segment. For example, network position is closely linked to such things as distance from the coast. This is regarded as one of the most important variables for determining fish community composition in New Zealand rivers (McDowall 2000, Leathwick et al. 2008b). Valley landform is associated with segment steepness which can be important for determining both physical (e.g., substrate composition) and biological (e.g., fish climbing ability) attributes that would not otherwise be accounted for in other classification layers..

- 4.27. I agree with the point made in Norton et al. (2008) that a high resolution scale of REC would unrealistically inflate the number of environment types. They cited 1266 at the 5<sup>th</sup> level of the REC and 2845 at the 6<sup>th</sup> level. However, using the layers as we have done in the WONI analysis with the climate and landcover layers removed, there were 215 REC environment types present in the South Island of which 108 are present on the West Coast. I do not believe this to be an unrealistic number of environment types given the high degree of physical diversity present in these areas. For comparison, the commonly used Land Environments of New Zealand (LENZ) has 400 environment types nationally at its finest Level IV scale (Leathwick et al. 2003).
- 4.28. A disproportionately larger number of the 215 REC classes are present in the Northwest Nelson-Paparoa region indicating that this region contains the greatest diversity of freshwater habitats in the South Island. Mr Norton does not explain or justify the decision not to run his analysis of REC habitat loss caused by the MHP on a similar basis to the WONI ranking model. He could have excluded climate and landcover, but included network position and valley landform to provide a clearer assessment of the importance of these affected segments in the WONI model.
- 4.29. Norton et al (2008) states that the MHP would modify between 2-35% of river length of REC classes in the Northwest Nelson-Paparoa biogeographic unit, and between 1-21% in the North-West coast region. I suggest that modification will be at the higher end of these ranges because of the importance of the 5<sup>th</sup> and 6<sup>th</sup> REC levels in accounting for variation in physical habitat and its associated biological communities.

- 4.30. Mr Norton has provided no assessment of the condition of these REC classes that would remain should the MHP inundate or regulate the Mokihinui segments. Several other rivers in this unit (and province) with similar REC classes exhibit acid mine drainage (e.g. Ngakawau River, Waimangaroa River), regulation (e.g. Matiri River), or agricultural development (e.g. Aorere) which probably limit their value for biodiversity conservation.
- 4.31. Norton et al (2008) make reference to redundancy in the list of the top 20 rivers cited for the national candidate list by Chadderton et al (2004). This was due to the fact that catchments identified in the list possess similar physical and biological attributes, particularly the West Coast and Stewart Island. It seems as though Mr Norton may have misinterpreted the purpose of this list. In the text referring to the table, Chadderton et al. (2004) explicitly state that this list of the 20 river catchments with the highest Natural Heritage Value scores would be a poor national list as it “would capture a small and highly biased proportion of the full range of New Zealand’s aquatic environments, habitats and communities”. The production of such national lists presents a difficulty because it ultimately requires that you prioritize/rate the “best of the best” examples from each biogeographic unit in some manner, even though they are ultimately not comparable.
- 4.32. Alternatively, Chadderton et al (2004) produced a series of catchments selected from each biogeographical unit that comprises coverage of most (>70%) environment types representative of the region, plus a few additional catchments (Type II catchments) added to account for threatened species or habitats not present in the catchments selected. Again, the Mokihinui was considered 2<sup>nd</sup> in its Northwest Nelson-Paparoa biogeographic unit, and would be one of three catchments identified in the unit to

contribute to the national list (Karamea, Mokihinui and Takaka Rivers) depending on the proportion of environment types considered for protection. Based on the list derived under a biogeographic framework, there would be far less redundancy in the ranking. The selection of catchments based on 80%-90% coverage of REC types is shown in Figure 4 below.

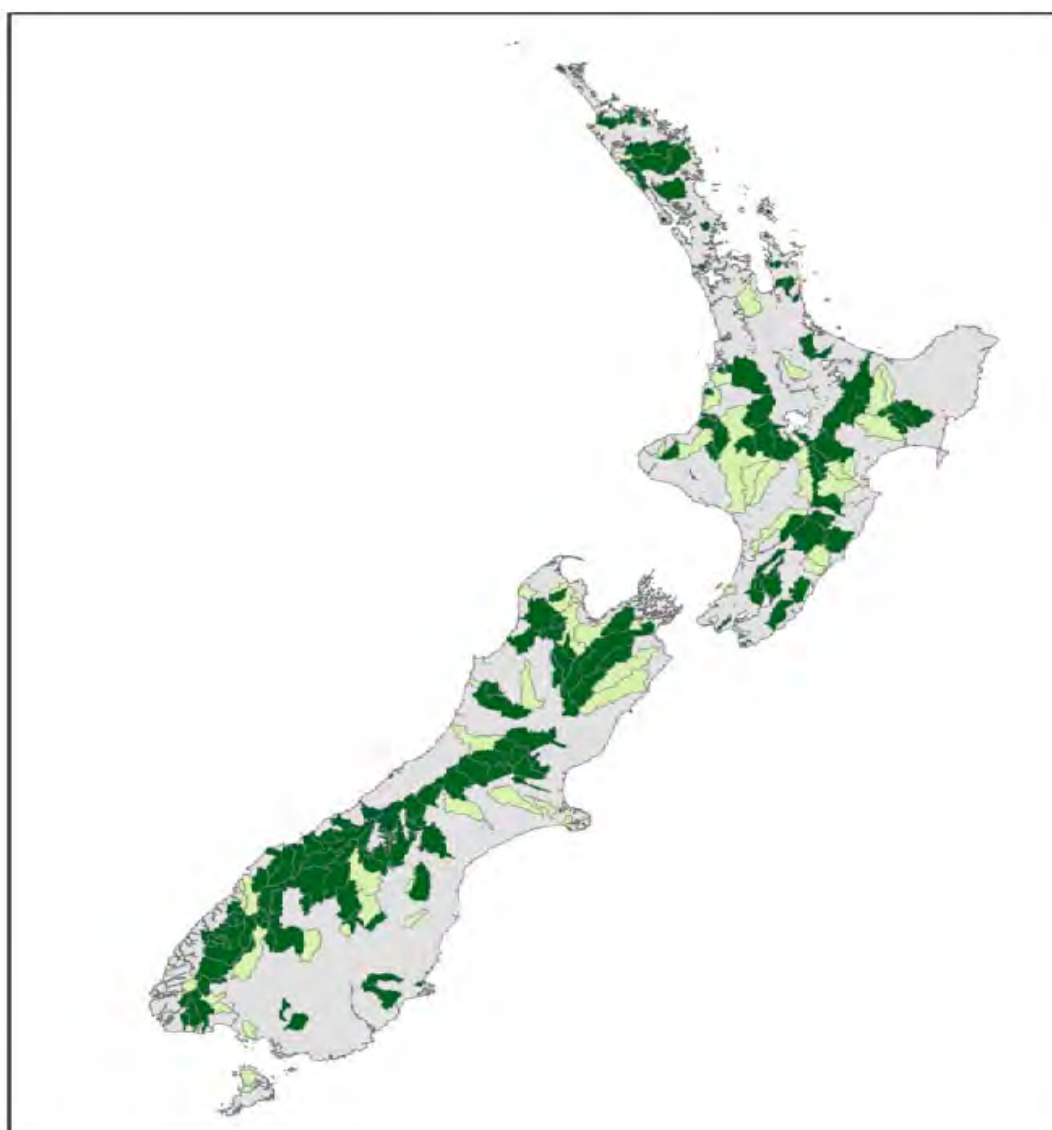


Figure 4. Minimum river catchments required to account for up to 80% (dark green) and 90% (light green) of all river classes within each biogeographic unit, derived from a hierarchical sort that down-weighted large catchments. Taken from Chadderton et al. (2004)

- 4.33. In summary, the Norton et al. comparison of the Mokihinui River algal, invertebrate, fish, and physical habitat diversity to other river catchments in the biogeographic unit provides few reliable insights. In my opinion this is a consequence of poor field sampling design for assessing distinct and/or rare biological community attributes, unknowns in taxonomic resolution and a lack of consideration of population size and/or viability for fish communities.

#### **Freshwater Environments of New Zealand (FENZ)**

- 4.34. DOC recently completed a decision support tool for ranking conservation values of river sub-catchments nationally. It is called the Freshwater Environments of New Zealand (FENZ). FENZ is optimised against a reference condition based on biological distribution information for unmodified river sites (Leathwick et al. 2008a). Dr Leathwick, as lead author of this tool, has focused his evidence on using and interpreting outputs from FENZ for assessing the national and regional conservation significance of the Mokihinui River catchment, therefore I will not explore this in detail.
- 4.35. In summary, I assign a high level of significance to the Mokihinui River. My opinion takes into account the near-pristine nature of the gorge and its catchment upstream (supported by Dr Leathwick's evidence), the distinctive natural character of the gorge (supported by Mr Lister's Evidence), the size of its migratory species populations of longfin eels and whitebait spp. (supported by Dr Allibone's evidence), the distinctive and possibly endemic seepage fauna within the gorge (supported by Dr Death's evidence) and the number of threat listed species present (support by Mr Shaw and Dr O'Donnell's evidence). In my opinion the addition of the MHP in the lower Mokihinui gorge will greatly diminish most of the values which underpin the

high significance of the Mokihinui and its catchment by degrading its physical environments, simplifying its biological communities, impairing its functional processes and necessitating human intervention in perpetuity to maintain a set of newly identified ecological values.

## **5. EFFECT OF THE PROPOSED MHP ON WHOLE CATCHMENT CONNECTIVITY AND ECOSYSTEM FUNCTION**

### Background

- 5.1. The freshwater fish fauna present in rivers of the South Island's West Coast are obligate migrants. Obligate migrants use coastal and estuarine resources at certain times and/or at particular periods of their lifecycle and inland freshwater habitats for other periods. Some species complete certain essential portions of their lifecycles (e.g., reproduction) well inland while others achieve this far away at sea (e.g. eels). Species habitat preferences and climbing ability usually determine the distance inland they travel. Some species such as koaro and longfin eels can migrate >100km inland within freshwater catchments. Other species such as giant bully, smelt and inanga are rarely found beyond the lower reaches.
  
- 5.2. Migration largely underpins the ecological functioning of these river systems and is necessary to support the populations of indigenous invertebrate, fish and bird communities that have adapted within these highly dynamic environments. For example, whitebait larvae hatching from eggs deposited by adult koaro in the headwaters of the catchment drift through the river system to exploit more productive estuarine environments where they grow into juvenile whitebait that migrate upstream to repopulate headwater portions of the river. Congregations of migratory piscivorous predators such as grebes, shags

and gulls are sustained by migratory congregations of species such as whitebait. Similarly large aquatic predators such as longfin eels, shortjaw kokopu and trout that populate the upper portion of these catchments also prey on these migratory species recruiting to upstream reaches. Thus species' use of resources derived from both coastal and inland river environments is supported largely by migration. Connectivity for migration is an essential element for sustaining the growth, production and life history requirements for populations in coastal rivers.

- 5.3. The direct linkage between migration in both maintaining populations of indigenous species and maintaining the ecological functioning and natural character of rivers, heightens the importance of migration corridors for these ecosystems. Migration routes should not only be looked at for their importance as habitats for species (because this may be intermittent), but also as corridors for enabling migrations of species between coastal and inland areas. These aspects are clearly recognized in a range of national and regional policies such as the National Policy statement for Freshwater Policy (9.2), the West Coast Regional Water Plan (sections 5.4 and 6.5) and the Buller District Plan (sections 4.7 and 4.8). These provisions all recognize the importance of managing the effects of activities on fish migration.

#### **Effects of MHP on fish upstream migration**

- 5.4. The Mokihinui River supports thirteen migratory fish species of which eleven will be directly affected by a dam located about 11 km from the coast. There is no comparable hydro-electric dam in such close proximity to the coast; the Matahina and Patea dams are 28km and 33km inland respectively. There are other man-made structures such as tidal and flood gates that intermittently

interrupt fish movement. The proposed Mokihinui dam will truncate the natural migratory range of species and convert river gorge habitats to a lentic reservoir habitat. Affected species include redfin bully, bluegill bully, torrentfish and the kokopu species. This topic is detailed in the evidence of Drs Allibone and Joy who have predicted the distributions of native fish in the Mokihinui catchment. In their model, dam impacts are greatest for those species which penetrate furthest inland. The percentage of ranges affected for koaro, longfin eel, and redfin bully are 54%, 33%, and 9% respectively.

- 5.5. Mitigation of fish passage impacts has focused on t & t of the upstream migrant fish populations. This is a high risk method for two reasons. First, the method has never been demonstrated for several of the affected species. Secondly, the method has never been used to transfer the very large numbers of juvenile fish (particularly koaro) migrating upstream. The Mokihinui River would be a most unusual situation for a t & t system. The t & t system will need to be designed to accommodate temporally variable and large runs of fish (potentially tonnes of whitebait over three months; refer to Dr. Allibone's evidence) and will be operated over a reasonably long seasonal time frame to allow transfer of a complete range of species. However, t & t methods have not been designed for any of the species in the Mokihinui except the two eel species, raising uncertainty as to whether the system can work effectively. Evidence presented in the AEE and by the applicants witnesses during the council hearings was criticized for the lack of detail provided on the design of the trap and transfer system. Technical specifications of how some fish species would be trapped and estimates for the quantities of fish to be transported past the impoundment were absent. While these issues have been partly addressed through further

experimental work by NIWA, there remain a number of uncertainties which I discuss below.

5.6. The ability to successfully t & t species expected to arrive at the dam is discussed in detail in the evidence of Dr Allibone. T & t has been used at many sites in New Zealand to transfer eels upstream of hydroelectric dams. However, less is known of its effectiveness for other species, and present records of transfers of other native species by t & t are largely seen as secondary by-catch within the system. Dr Allibone has identified a number of issues with the proposed design of the MHP dam. This includes trap effectiveness and attractant flows both of which could affect the ability of the system to catch an acceptable proportion of fish that reach the dam for transfer upstream. I concur with Dr Allibone that there are significant risks associated with operating previously untested t & t system for such a wide range of species not previously tested, and that there are logistical issues associated with the sheer magnitude of the migration events that occur in the Mokihinui River. Although migrations runs have been looked at by the applicant, anecdotally we know that inter-annual variation in migration runs is large and that over the past two-years, whitebait runs have been relatively small.

5.7. I have also identified some issues regarding the outcomes of the mitigation proposal in the AEMP. T & t could help maintain populations of widely distributed species (longfin eel, koaro, redfin bully) upstream of the inundation and in gorge tributaries above the inundation zone. It is unclear whether transport will compensate for the loss of natural range for the species, by increasing the density of individuals in the remaining smaller area of suitable habitat. Dr Jellyman estimated that longfin eel populations in the 14km reservoir are anticipated to be only 42% of

their present abundance in the gorge (Dr Jellyman section 7.7). Will the remaining areas of habitat support the additional 60% of the displaced population from the gorge? This question also applies to several listed threatened species (koaro, redfin bully, bluegill bully and torrentfish) but was insufficiently considered in the evidence of Mr Bonnet or Mr Norton. There is no data from which to determine whether these populations are at or near carrying capacity in the areas intended for transfer releases.

- 5.8. It is unclear how transfer upstream of the inundation area will affect populations of other fish species now present in the gorge and gorge tributaries, but which are not known to occur upstream of the MHP reservoir inundation area. This uncertainty affects torrentfish, lamprey, possibly shortjaw kokopu and possibly bluegill bully. These species do not normally live upstream from large lakes and it is difficult to know whether the habitat would be suitable to sustain these now isolated sub-populations with the MHP reservoir in place. Because we know little about the life history requirements for some of these species (e.g. torrentfish spawning) it is unclear how the 14km reservoir will affect the downstream spawning migration (Scrimageour and Eldon 1989). There are also other questions in regard to biogeography that arise if species are distributed to sections of the river not previously naturally inhabited by those species. It seems more likely to me that these species will not be successfully transferred so that the upstream section of their range will be lost and their distribution will be truncated and confined to the lower river. However, this section of the river is expected to be significantly modified through the alteration of its flow regime and will in my opinion undergo significant declines in the production of its fisheries due to the large daily flow-fluctuations further discussed in my evidence.

- 5.9. Mr Bonnet and Dr Jellyman commend t & t as an effective mitigation measure used at other hydro-electric dams to pass native fish species. I agree that t & t is capable of passing a number of species (predominantly climbing species) arriving at trap ramps. However, I note that the efficiency and success of the method remains unclear. The proportion of the run arriving at the dam wall that could be captured and transferred is unreported. Success in maintaining similar populations of affected species upstream of the dams has also not been reported. I suspect that although the quantities of juvenile fish transferred are large (thousands per site, millions nationwide), this probably accounts for only a very small percentage of the juvenile migrants arriving at these transfer sites. I also suspect that numbers transferred are in some cases not sufficient to maintain pre-dam abundances and age class structures upstream of the impoundments. Dr Joy has cited some work on eel populations upstream of the Patea dam and has found that longfin densities are small compared with densities both downstream of the dam and in other rivers in the region. The absence of published follow up monitoring data at other hydro-electric trap and transfer sites around the country means that there is substantial uncertainty as to whether this mitigation can work for the Mokihinui where the diversity of migrant species and their abundance are large relative to other sites where t & t systems have been used.
- 5.10. The AEMP does not include an evaluation of the cost effectiveness of other options for maintaining fish passage. Hayes et al. (2007) stated that it is possible but not practicable (given the low/unexceptional/ordinary value of the trout fishery) to consider a pool and weir or vertical slot fish passage system for the MHP. However fish passage needs to provide for all native fish species that require

passage. For trout he states that the population may not require passage to sustain the present population density and size, however for native diadromous species passage is absolutely essential. In my opinion the fish passage mitigation issues need to be evaluated on the basis of the combination of fish community migration requirements and not on a species by species basis, something which is not done in the AEE technical reports.

### **Effects of MHP on Downstream Migration**

- 5.11. In addition to upstream passage, several of the galaxiid species require drift of larval stages to the nearshore coastal environment where they rear as juveniles before “running” upstream as whitebait. Koaro populations in rivers with either natural lakes or man-made reservoirs can have a portion or the entire population “landlock”. For the Mokihiui, this would mean that larvae hatching in sections of the catchment upstream from the reservoir, instead of going to sea, may only migrate as far downstream as the reservoir (McDowall and Allibone 1994; Allibone and Caskey 2000; McDowall 2000). However, the work conducted by Mr Mitchell and reported in Mr Bonnet’s evidence is inconclusive as to whether fish will landlock to the newly formed reservoir.
- 5.12. Larval koaro rely on the resources contained in a yolk sack following their emergence from an egg, and the delayed downstream transport (on average 17 day water residence time in the reservoir) could mean that the fish would experience stress from hunger, mortality or become resident in the lake (Kusabs 1989). Although the work to assess larval koaro survivorship in transport without food was made from another species (banded kokopu), I will accept Mr Bonnet’s assessment that larvae are likely to be capable of surviving for a reasonable period (estimated to

be approximately 9 days) without feeding. This would vary with water temperature which controls metabolic rate. This information was not provided so I am uncertain whether he took this into account in his conclusion.

- 5.13. Transit time estimates for larvae under varying flow rates were also questionable. The calculations assume that larvae passively drift through the upper water column. It is unclear how reservoir water velocities might influence this process, and whether larval swimming speeds could actually exceed surface water velocities. Floeder and Spigel (2007) calculated reservoir surface water velocities in their hydrodynamic model and reported that they would likely be very slow, suggesting that larval swimming speed could potentially exceed these surface water velocities under many flow conditions. Thus if larval koaro did encounter food sources in the reservoir it is possible that they could actively swim and maintain their position in the reservoir in the absence of very high flows. This uncertainty affects estimated transport time through the reservoir and the probability that larval koaro “landlock” in the reservoir.
- 5.14. The second aspect not considered in the transport model was how inflows circulate within the reservoir. During months in which koaro larvae hatch (April-June), stream temperatures may at times be lower than surface reservoir temperatures. This would buffer thermal changes occurring diurnally or from cold weather periods allowing the colder denser inflows to underflow the surface layer of the reservoir, potentially carrying larval fish into deeper depth strata. As Floeder and Spigel’s (2007) modelling of the MHP reservoir demonstrated, this would predominantly occur in late autumn around the timing of larval koaro migrations. This might change the transport time of koaro through the upper mixed layer, or even transport larvae below the thermocline and into the anoxic hypolimnion.

Seasonal thermal stratification and the potential for anoxic conditions in the hypolimnion occur in April and May in other West Coast lakes such as Lake Brunner (D. Kelly, unpublished data for the West Coast Regional Council). Floeder and Spigel (2007) predicted stratified conditions through May but isothermal conditions in June. Thus, there could be losses of larval galaxiids due to delays in larval transport time, and possibly through larvae encountering hypoxic conditions. These sources of uncertainty have not been explicitly accounted for in Mr Bonnet's evidence.

- 5.15. If the larvae of koaro and other kokopu species recruit to the reservoir instead of the coastal marine environment, significant impacts for overall population dynamics and production of the fishery must be expected. Recruitment of juvenile fish (mainly koaro and shortjaw kokopu) to the adult population in "landlocked" situations is predominantly determined by fish rearing conditions in the reservoir and the abundance of food such as zooplankton present for juvenile koaro to feed on. Dr James has summarised the likely conditions of the newly formed reservoir in his evidence. I agree with many of his predictions concerning water quality and zooplankton communities expected in the reservoir. Thus, in my opinion there is a strong possibility that koaro populations will landlock to the reservoir. This was also recognised by Dr James in section 6.87 of his evidence. Dr James' evidence suggests quite a low diversity community, with relatively low productivity due to the limited light penetration of 5.8 m, daily water level fluctuations, sedimentation and the steep sided nature of the gorge. It is also probable (and recognized by Floeder and Spigel 2007) that zooplankton communities, the main food item for larval and smaller juvenile fish, will be temporally variable because of factors such as flushing rates, nutrient

variability and phytoplankton production (Booker 2000). These characteristics indicate that the reservoir will not be a highly productive environment for larval fish growth.

- 5.16. Many juvenile fish predicted to inhabit the MHP reservoir (e.g. koaro, common bully) will become predominantly benthic as they reach a certain size, living on the lake bed in shallow littoral areas (Kelly and McDowall 2004). Following LIDAR surveys of the Mokihinui gorge conducted by the applicant, a detailed bathymetric map of the reservoir was provided by NIWA. I made an assessment of the littoral area of the lake based on this map. My prediction of the total area of littoral habitats would be significantly less than Floeder and Spigel's (2007) prediction of 12.5% of the lake area. Their original estimate included all area between the light extinction depth (1% irradiance) and the mean level of the reservoir. However there will be significant areas that are either too steep for plants to grow given they require soft sediments for root development, or that are too exposed to significant wave action and exposed by frequent and rapid lake level fluctuations. Most of the shallow (3-6m depth) gently sloping area of the lake that is likely to be suitable for aquatic plants, occurs at either the upstream portion of the reservoir near the main inflow, or around the Anderson's flat area. Because the upstream section of the reservoir will experience high levels of sedimentation from flood waters, I would expect this section of the reservoir to be only marginal aquatic plant habitat.
- 5.17. My estimate of the predicted maximum depth (2.25 to 4.21m) to which aquatic plants will grow in the MHP reservoir differs from the 5.8 m depth reported in Floeder and Spigel (2007) and Dr James' evidence. During the whitebait season of 2010, I assisted Dr Allibone's whitebait escapement trial work by placing light sensors (with data

loggers) at two depths (1m depth difference) in the main-stem of the Mokihinui River near the Chasm Creek confluence. The purpose of this was to examine water clarity in the lower river in relation to the catch efficiency of whitebait fishers. From the data collected I calculated the average daily diffuse attenuation coefficient ( $K_d$ ) and extinction depth (maximum depth of macrophyte growth) of river water from October 16 until Dec 10, 2010). It was difficult to determine how Floeder and Spigel (2007) calculated extinction depth as their estimate was based on an unpublished regression model of the relationship between measurements of black disk distance and  $K_d$ . However, using Equation 3 of their report (taken from Schwarz et al. 2000), I calculated the maximum depth of macrophytes using values of  $K_d$  that I directly measured using light sensors. The continuous light data in Figure 5 (below) suggests that the extinction depth of the reservoir will be shallower than that reported by Dr James. I estimate a mean value of 3.00 m (range 2.25-4.21 m). I expect that continuous direct measurement of underwater light would be far more reliable than translations derived from spot measurements of black disk. However their data did cover a longer seasonal time frame than ours, and it may be that they encountered different water quality conditions. A significantly shallower maximum macrophyte depth limit would be of concern, particularly if it approaches the value of the expected daily water level fluctuations of 3m. This would mean plants near the lower boundary of this depth range (i.e., between 94-95 m asl) will spend most of their time below the extinction depth as the reservoir fills between generating events.

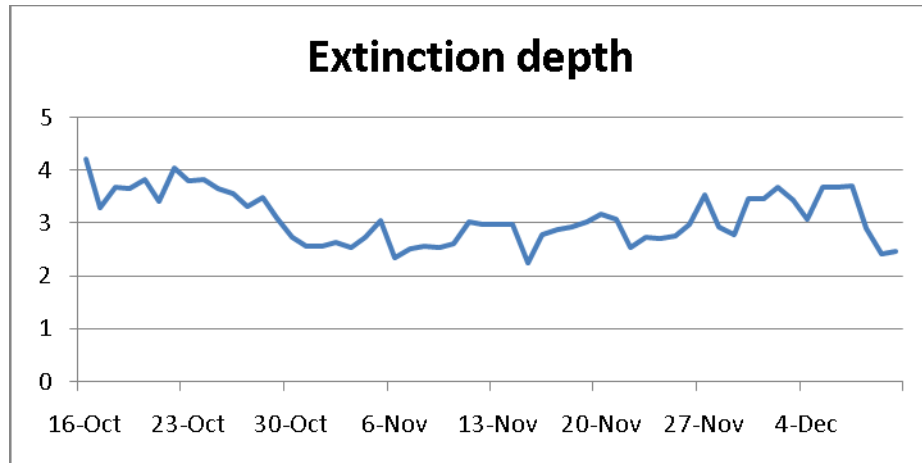


Figure 5. Extinction depth of the Mokihinui River near the chasm creek confluence measured using irradiance loggers between Oct-16 and Dec 10, 2010. Mean extinction depth was 3.00 m.

5.18. Dr James presents data for macrophyte depth ranges for earthquake lakes surveyed in February 2011 (Table 6 of his evidence). For Lake Marina, located within the Mokihinui catchment, the extinction depth for aquatic plants was 4 m. This is approximately 1.8 m less than the predicted value for the MHP reservoir. My expectation is that Lake Marina should have a deeper extinction depth than the MHP reservoir given that it is at a significantly higher elevation (560 m), has a much smaller drainage area and has two lakes immediately upstream that would act to attenuate suspended sediments in floodwater inflows. A map of the Lake Marina and its catchment is shown in Figure 6 below. Although I have not visited Lake Marina, from examining pictures of the lake provided in Dr James evidence (Figure 3), the presence of continuous forest and emergent plant vegetation communities to the lake edge, would suggest that the lake does not experience large water level fluctuations such as those for the MHP reservoir. These observations were also true for the other earthquake lakes surveyed, which had similar (Falls Creek Lake 4.4 m depth limit) or shallower (Lake Elmer- 2.7 m depth limit) macrophyte depth limits compared to Lake Marina. Thus I

believe my mean estimate of 3.0 m based on the light extinction depth data of the lower river is probably more accurate than that of Floeder and Spiegel (2007).

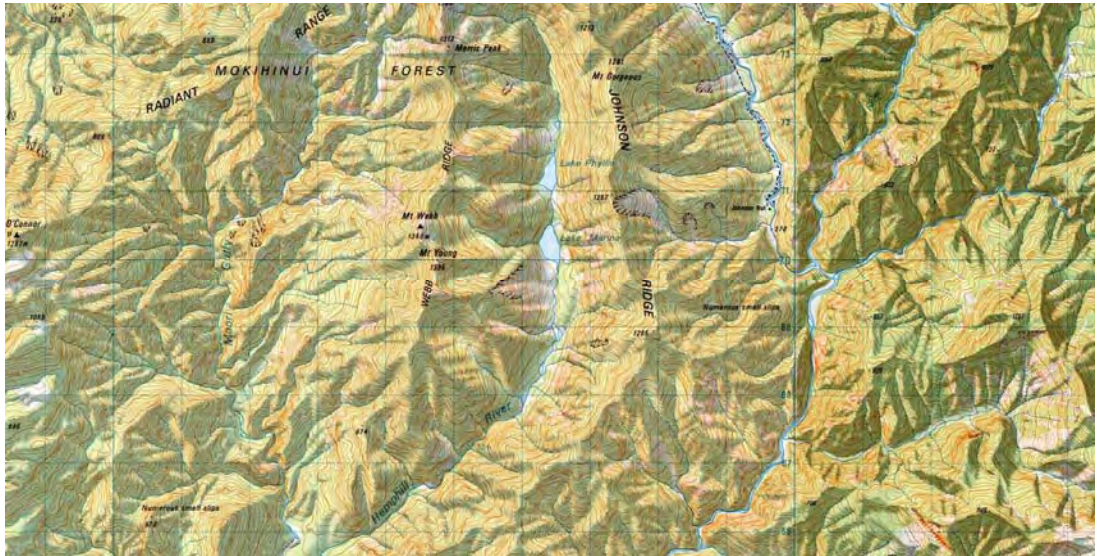


Figure 6. Map of the catchment of the landslide Lake Marina in the Mokihinui Catchment, with two smaller lakes (Lake Phyllis and unanmed) situated immediately upstream.

5.19. In section 6.74 of his evidence Dr. James gives the original estimate of littoral area as 12.5% of the surface area of the reservoir. This estimate is founded on an extinction depth of 5.8 m, but was considered by Dr James to be a potential upper limit. Given the previous points I made regarding the visual transparency of the river, sedimentation from floodwaters and the depth range observed in other earthquake lakes in the region. My upper estimate of littoral zone coverage is at best half Dr James' estimate at 6%. However given that we also know that water level fluctuations negatively affect macrophytes (Riis and Hawes 2002), and in the case of the MHP reservoir they are large and frequent, in my opinion there could be significantly less aquatic plant cover in the reservoir. This upper end of

my prediction (6% coverage), is consistent with Dr Schallenberg's estimate.

5.20. The combination of limited productive littoral habitat and variable planktonic communities suggest that the MHP reservoir will unlikely support a large resident native fishery (Kelly and McDowall 2004). This has been reiterated in the evidence of Dr James (section 6.85) who predicted a limited productivity fishery associated with the reservoir due to limited food production. Dr Jellyman predicted that the current longfin eel population in the MHP reservoir could be approximately 41% of its present biomass in the gorge, but this was based on a productive littoral area of 12.5%, whereas several other experts (Dr James, Dr Schallenberg) and I have stated this value will possibly be only half of this or less. Dr Jellyman's prediction (section 7.8) that additional eel production at deeper depths in the reservoir could possibly compensate for some of the loss in production is in my opinion improbable. Although I agree that eels have been observed at deeper depths, they mostly forage around lake margins. Moreover, it has been shown that the productivity of foodwebs in New Zealand lakes is strongly linked to autotrophic production (James et al. 2000, Kelly and Hawes 2005) including dietary sources for eels (Kelly and Jellyman 2007). Thus the overall size of the eel population will be related to the total amount of shallow productive area in the reservoir, as NIWAs national model presently predicts.

5.21. Although I have discussed downstream migration of species which may landlock to the reservoir, there are a number of other species that will also require downstream passage past the MHP dam either over the spillway or through turbines. While the requirements of some of these species were considered in detail by the applicant (e.g. eels

by Dr Jellyman), the downstream passage requirements of redfin bully, torrentfish, shortjaw kokopu and lamprey received only cursory consideration. This may in part be attributed to our limited knowledge of the timing and behaviour of migrations, or physiology of these species and their ability to endure pressure changes if they were to pass through turbines. Dr Allibone has considered downstream passage for a number of these species in his evidence, and I agree with the points he has made.

- 5.22. In conclusion, the interruption in the river connectivity by the MHP reservoir will create an environment that is likely to change the life history patterns and production of several native fish populations (i.e. koaro, common bully, longfin and shortfin eels) that presently use the Mokihinui gorge to forage or to migrate between the different habitats required for different parts of their respective life cycles. Landlocking of drifting larval populations of fish (mainly koaro) could occur, meaning that whitebait which normally migrate to the sea will remain in the reservoir. Because the reservoir will have low productivity, fewer fish will be produced compared to the present riverine populations which drift to the coastal environment. One effect of the populations becoming landlocked will be a reduction, or at worst case the loss of the contribution of the upper Mokihinui River whitebait to the Buller district's whitebait fishery. For some native species that presently use the gorge as adult fish, the reservoir will be a useable but less productive habitat (eels, koaro, common bully). For the remainder (redfin bully, torrentfish) it will be a completely unsuitable and unusable habitat.

### **Effects on Communities residing within the Gorge**

- 5.23. The effects of creating a reservoir in the gorge will be significant and many of these effects are not able to be

mitigated. The reservoir will displace (upstream) habitat for a number of fish species and will eliminate some important habitats such as seepages, low gradient streams and riffle/pool sequences. These effects have been recognised by other witnesses for the applicant including Dr's James, Suren, Kilroy, and Jellyman and Mr Bonnet. Thus I will only raise points of difference or points that were not discussed in their evidence, and discuss the significance of these effects in relation to the ecology of the Mokihinui River.

5.24. During the Council consent hearing evidence, several witnesses (including me) were critical of the applicant's assessment of biodiversity values of the Mokihnuui Gorge and wider catchment. They expressed concerns that the range of habitats sampled in the AEE reports was too limited (Bonnet et al. 2007; Suren and Kilroy 2007). We identified that small low gradient tributaries and seepage habitats within the gorge had been inadequately sampled. Subsequent to the consent hearing, witnesses for the applicant have expanded the range of habitats in which biodiversity assessments were made, and as a result have made major revisions to biodiversity values identified in the gorge. These revisions accord with concerns raised during the consent hearing. There is now a more widely held view that habitats to be inundated within the Mokihinui gorge will result in losses of distinct and likely unique biodiversity within the catchment and possibly within the biogeographic unit.

5.25. Seepage habitat flora and fauna is likely to be some of the most distinctive and unique (Collier and Smith 2006). This conclusion is supported by the evidence of Drs Suren and Kilroy. I similarly analysed similarity between invertebrate communities in the seepage habitats and small creeks sampled in the Mokihinui Gorge, the Mokihinui North

Branch and the neighbouring Karamea catchment (Figures 7&8). I found that invertebrate communities collected at seeps in the gorge differ from those found in the other localities. However Dr Suren also concluded that it is unlikely that these communities are confined to the Mokihinui catchment. I tested his conclusion in two ways. First, based on both Dr Suren's and my data, I compared community samples collected from the gorge seepages with those from other seepages in close proximity to the gorge (e.g., the North Branch of the Mokihinui). There were clear differences between the communities in the Mokihinui gorge to those collected from seepage habitats in the Mokihinui that will not be flooded (North branch) and those in the neighbouring Karamea catchment. Secondly, I reviewed our present scientific understanding of the colonization and dispersal processes of aquatic invertebrates in these habitats (primarily Collier and Smith 2006, Lancaster et al. 2008, Downes and Lancaster 2010). The purpose of this was to establish whether these processes would facilitate dispersal and mixing to in turn determine whether they would lead to neighbourhood similarity or would maintain community isolation. I found that our present scientific understanding lends more support to the idea that these communities are likely to become highly isolated. This would be particularly true for species with non-flying adult stages (of which there were many in these habitats). However even taxa with flying adult stages (collected in malaise traps) were not yet described and new to science. Thus, in my opinion, Dr Suren's view that seepage fauna within the gorge are probably present in other areas in the region is not only unsupported by the data, but also inconsistent with our understanding of the basic biology and ecology of these communities. Dr Death is also of the opinion that the weight of evidence suggests

that the seepage communities of the Mokihinui Gorge are distinctive and likely to be unique to the region.

5.26. The loss of these distinctive communities could also be considered significant even if these unidentified species were to be present in other locations. Given that we know almost nothing regarding biogeography of these species or the condition of environments in their natural range, the loss of these habitats cannot be considered as minor without further information to support such a position. If the assemblages were to naturally occur elsewhere in the region as Dr Suren has suggested, this could be in areas south of the Mokihinui which are affected by acid mine drainage such as the Ngakawau or Waimangaroa rivers. Alternatively they may not occur elsewhere. The loss of this habitat is not addressed by the applicants biodiversity offsets proposal or within the AEMP.

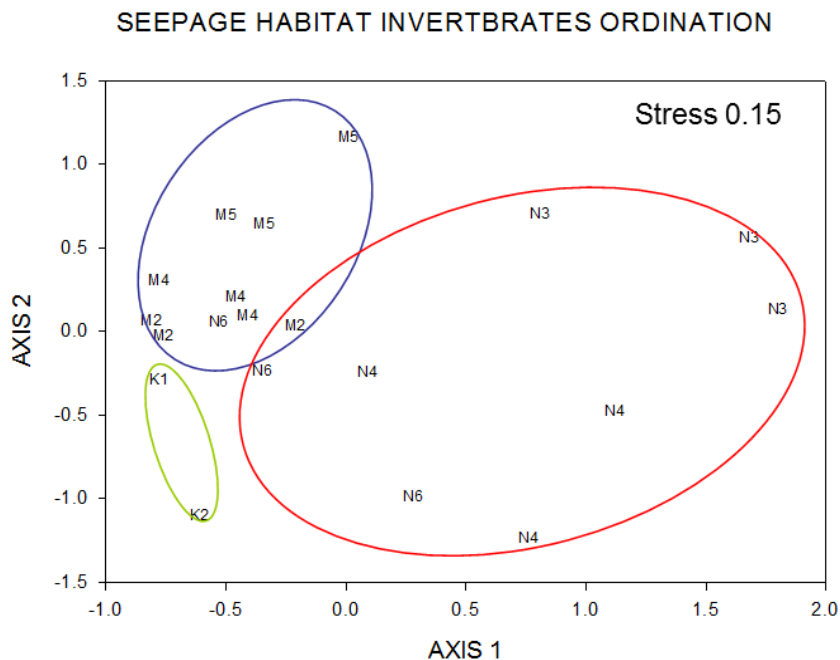


Figure 7. Ordination of presence/absence taxonomic data for seepage habitats of the Mokihinui gorge, Mokihinui North Branch, and Karamea Gorge.

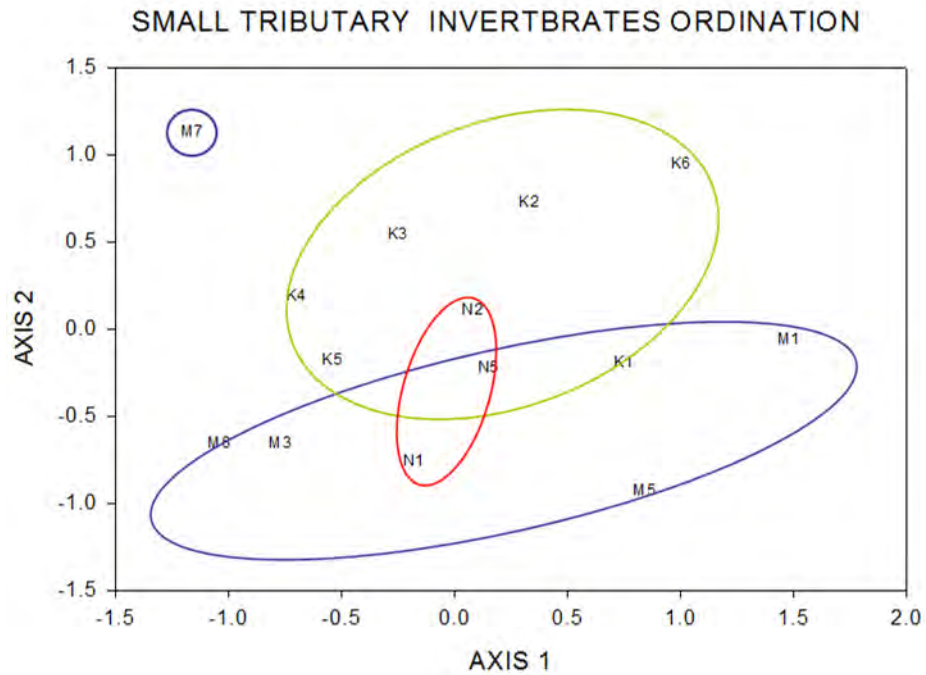


Figure 8. Ordination of presence/absence taxonomic data for small tributaries of the Mokihinui gorge (M1-7), Mokihinui North Branch (N1-6), and Karamea Gorge (K1-5).

5.27. There were also significant habitats for native fish communities formed by seepages and small tributaries along the lateral margins of the mainstem of the gorge. These habitats tended to form within scour pools and bedrock surfaces along the edge of the river mainstem below the vegetation line (See Figure 9 below). These habitats were sampled with electric fishing equipment and minnow traps during March 2011 by Dr Allibone and myself. We observed a community that was distinctively different to that present in the mainstem of the river. Dr Allibone's evidence provides a more thorough description of the gorge tributary native fisheries values.



Figure 9. Lentic pond along the lateral margin of the Mokihinui mainstem fed by seepages. Location is downstream of Rough and Tumble Ck. Confluence. Photo March 16, 2011.

### **Reservoir Species**

5.28. The newly formed reservoir will create habitat that could be colonized by several invasive species that are threats to native biodiversity. Although it is difficult to state with any certainty that any invasive species will colonize a particular habitat, it is well known that invasive species find their way into disturbed habitats, including newly created reservoirs (Champion et al. 2002). This may be through misguided individuals who perceive that introducing sports fish will enhance the values of the reservoir, or through accidental introductions facilitated by an increase in recreational use of the waterbody. These introductions are more likely to include water weeds, or possibly micro-organisms associated with water (e.g., zooplankton) or plant material (e.g., snails). Although there are other natural landslide lakes in the catchment which could constitute equivalent habitat, it is the accessibility of the reservoir and projected use of recreational watercraft that are the main factors increasing the likelihood of

invasive species introductions. At present, the Mokihinui River and its tributaries are dominated by native biota. Brown trout is the only exotic fish and *Didymosphenia geminata* has recently colonized the river.

- 5.29. In a national survey of coastal lakes, Drake, Kelly and Schallenberg (2010) observed a number of exotic fish species common in coastal lakes, with perch and goldfish being particularly common in the West Coast region (Figure 10). Of the 7 West Coast lakes sampled, 28% contained perch. This nearly doubled to 56% where lakes were accessible by road. Perch are of greatest conservation concern due to their highly piscivorous behaviour as adults. Adult perch would forage mainly on small native fish species common to the Mokihinui River. Juvenile perch are also known to create issues for water quality in reservoirs (e.g., Karori Reservoir, Wellington) because they facilitate algal blooms by cropping zooplankton populations to low densities (Hicks et al. 2007b). Perch have been introduced into other reservoirs such as the Patea dam and Karori Reservoir. This has had a significant adverse effect on the native biodiversity of these catchments which the DOC has had to manage (e.g. rotenone treatment of upper Karori Reservoir). Although I would not expect that the MHP reservoir would offer a productive habitat for perch, in my opinion they could nonetheless be significant predators of common bully and larval galaxiids (koaro) in the reservoir.

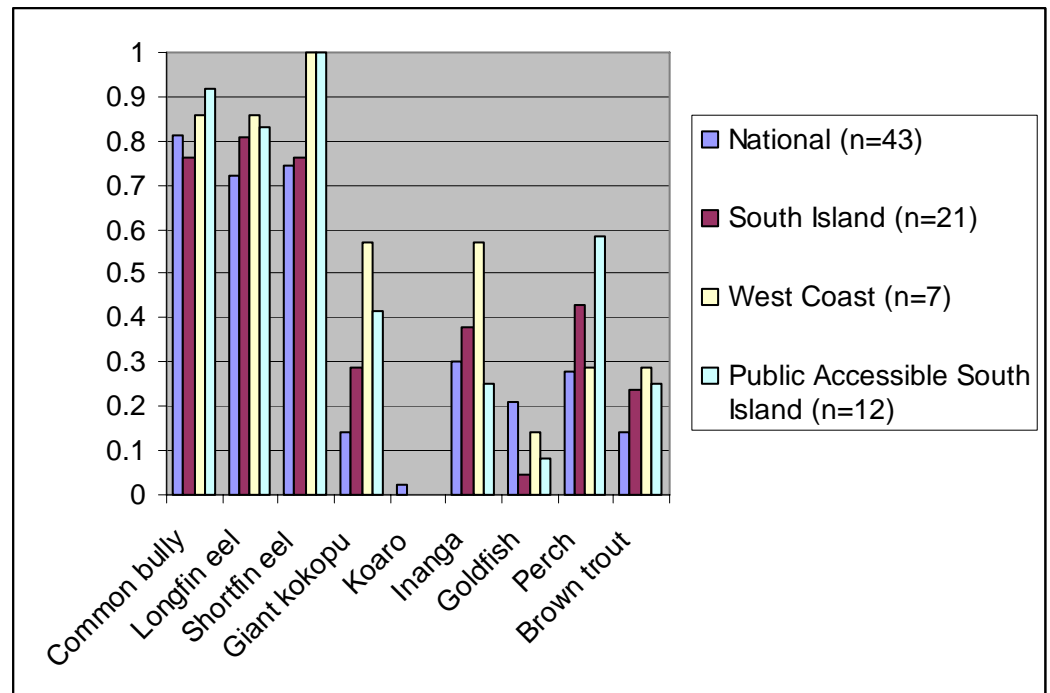


Figure 10. Summary of fish species present in a national coastal lakes survey with the proportion of lakes containing each species shown nationally, on the South Island, on the West Coast and in lakes that are road accessible in the South Island.

5.30. The size of the MHP Reservoir would not allow intervention measures such as piscicides if exotic fish did colonise the reservoir. Thus once present in all likelihood it would be impossible to remove them. This might similarly be the case for exotic macrophytes, although I agree with Dr James that they are unlikely to thrive in the MHP reservoir. However there was nothing included in the applicants AEMP that addressed the need for a pest species management plan for the reservoir. This should include provision for ways in which pest species (plants, fish and invertebrates) are prevented from being introduced to the MHP reservoir and a response management plan in the event of an incursion. This seems an important omission given the applicants promotion of the MHP reservoir as a recreational area and the creation of boating access.

- 5.31. Of the native species observed in the coastal lakes, common bully, shortfin eel, longfin eel, gaint kokopu and inanga were the most common species. Some of the lakes were closer to the coastal zone than the Mokihinui reservoir, and it is anticipated that inanga are unlikely to travel that far inland to the dam site. Dr James has made some estimates of the native invertebrate and periphyton species that are potentially able to colonise the reservoir (drawing on Drs Suren and Kilroy) and I concur with most of his predictions.
- 5.32. As stated earlier in my evidence, the percentage of the MHP reservoir area that will contain these shallow water invertebrate, periphyton and macrophyte communities is likely to be significantly lower than 12.5%. Thus although some of the species assemblages in the MHP reservoir could, in time, potentially be similar to other natural landslide lakes, they are likely to have lower abundances when compared with the other landslide lakes surveyed. This will mainly be due to the steeper bathymetry, significantly greater depth and larger daily water level fluctuations of the MHP reservoir. As discussed previously, the occurrence of lake marginal vegetation communities right to the waters edge in the Karamea River, Falls Creek and Mokihinui River natural earthquake lakes indicate that they don't experience large or frequent water level variations. There were also no barren varial zones on the lake margins such as those predicted to occur in the MHP reservoir. Because the limited depth to which these invertebrate, periphyton, and macrophyte communities can colonize these lakes (i.e. <4 m), water level fluctuations such as those proposed in the MHP reservoir will be particularly harsh on these habitats and communities.
- 5.33. In summary, several native species are anticipated to colonize the MHP Reservoir, and these in time will include

a range of lentic species, most of which presently occur in the Mokihinui catchment. Community composition may possibly be comparable to those of other landslide lakes in the region over time as the reservoir is gradually colonised. However, my expectation is that invertebrate, periphyton, and macrophyte communities will have significantly lower production and quality to those of the natural landslide lakes because of the considerably steeper bathymetry, greater depth and frequent water level fluctuations. The creation of the MHP reservoir will also create new habitat suitable for pest species which presently do not already occur within the catchment, with heightened risk due to the possible increase in recreational boating access. Incursions of perch and goldfish, in particular, have been observed in other accessible coastal lakes in the West Coast region. There seems to have been little provision for pest species management in the reservoir in the applicants AEMP which is of concern.

### **Effects of the MHP on the Lower Mokihinui River**

- 5.34. The flow regime proposed for the lower 11 km of the river downstream of the impoundment will result in an extreme environment for most resident and migratory aquatic species in the lower Mokihinui. This is both in terms of the low residual flows provided between generating events (16 m<sup>3</sup>/s) and the large daily flow fluctuations (16-126 m<sup>3</sup>/s twice daily).
- 5.35. There has been considerable work done within New Zealand and overseas to demonstrate that aquatic communities are adapted to the system-specific hydrologic conditions of their environments. Of this research, probably the most significant in terms of its uptake around the world for managing flows in rivers (particularly in North America, Africa, and Australia) is the Natural Flow

Paradigm (NFP- Poff et al 1997). The NFP examined the critical elements of the flow regime which underpin the requirements of a broad range of species (fish, floodplain vegetation, invertebrates) and ecosystem processes (e.g. scour, bed movement, wetland inundation, fish migration) in a range of river types. The NFPs main findings are that timing, periodicity, magnitude and rate of change of hydrological variation are critical to maintaining the systems functioning and biodiversity elements.

- 5.36. These findings are supported by research done in New Zealand rivers. Examples of this are the 100 rivers survey in New Zealand (Biggs et al. 1990), which identified a number of hydrologically distinct river environments (Jowett et al 1990) and the species assemblages that inhabited them (Quinn and Hickey 1990). Flow changes also trigger or facilitate various life-cycle events, including spawning and egg hatching (O'Connor & Koehn, 1998; Allibone & Caskey, 2000; Charteris et al., 2003), up- and down-stream migratory movements (Ots & Eldon, 1975; Kelso & Glova, 1993; O'Connor & Koehn, 1998) and movement between freshwater and the sea (Kelso & Glova, 1993).
- 5.37. The Nature Conservancy, one of the main environmental research organizations in the USA and co-authors of the NFP, have developed a series of tools to assess the degree to which different flow parameters are affected through modified flow regimes. The Index of Hydrological Alteration (IHA) tool calculates 32 flow parameters linked to various aspects of the flow regime (described in the NFP) and determines the degree to which these indexes are altered in comparison to the natural range of variation in flows. The tool calculates Range of Variability Approach (RVA) boundaries for these indexes to show the degree of

departure of the modified flows from the natural range of variation (Richter et al. 1996, 1997, 2003, 2006).

- 5.38. One of the key limitations to the use of the RVA is that it requires a long hydrological record (typically 20 years) to obtain strong statistical relationships due to inter-annual flow variability. In the case of the Mokihinui it was possible to obtain such a large data set, calculated from a partial record of the Mokihinui and then predictively modelled against a longer-term record for the Karamea River (Henderson and McKerchar 2007). Similarly, a record of flow under the proposed MHP was calculated based on hydropeaking at peak between 16 and 126 m<sup>3</sup>/s at peak loads was generated by Meridian's Plexos V4 model as described in Section 5 of Mr Henderson's Evidence. This data set was supplied to DOC by NIWA and forms the basis for the analysis I discuss in the following points.
- 5.39. I conducted some analysis using the Range of Variability Approach on daily flow fluctuations, comparing the difference between minimum and maximum daily flows, for both flow scenarios (i.e., natural and post MHP) over the 25 year flow record (1972-1994 and 2007-2010). I have included three graphs showing seasonal (spring, summer, winter) ranges (median and 25<sup>th</sup> and 75<sup>th</sup> percentiles) of the daily flow fluctuations under both flow scenarios (Figure 11). The three plots clearly show that daily flow variability will increase well in excess of the natural historic variation, with this particularly evident during summer and winter months. For October trends, the run-of-river approach taken during the whitebait season has lessened this effect. However the median daily flow variation (approximately 45 m<sup>3</sup>/s) under the MHP scenario is still outside the natural range variability. For July and February, the degree of daily variability is 2-3x greater on average, with the normal daily generating range of 110 m<sup>3</sup>/s (i.e., between 16 and 126

m<sup>3</sup>/s) representing approximately a 95<sup>th</sup> percentile event. This change in daily flow variability was also cited by other witnesses such as Mr Henderson (section 7.12), Dr Kilroy (section 6.16), and Dr Suren (section 6.22) as a significant alteration in the flow regime.

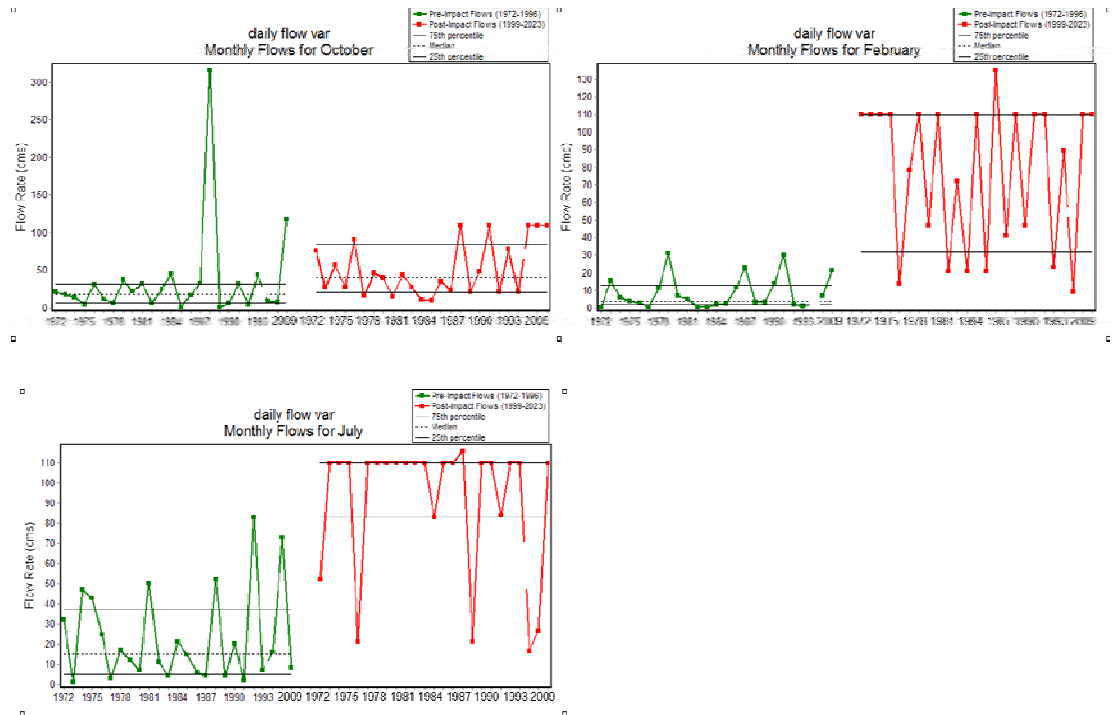


Figure 11. Monthly median values of the daily flow variation shown for the Mokihinui naturalised (green line) and MHP (red line) flow scenarios between 1972 and 2010. Note a gap in data between 1994-2007.

5.40. The effects of this change in intermediate variability is likely to be significant. This has been recognised in part by Drs Suren and Kilroy who have noted that the most obvious negative effects of such a change in daily variation will be the creation of a large varial zone along the river margins, which is unlikely to support much of an aquatic community due to repeated wetting and drying. Dr Suren (section 6.22) and Dr Kilroy (6.18) agree that the varial zone will be of low habitat value to both periphyton and invertebrate communities. The more mobile nature of the river sediments contained within this varial zone

downstream of the gorge does not allow for the colonization by high diversity bryophyte communities such as those present within the bedrock dominated gorge. Thus I would have a similar view of the varial zone habitat as other witnesses.

5.41. Within the more permanently wetted portions of the river my assessment of the effects of the modified flow regime on biota differs to those presented by other witnesses such as Dr Suren (section 6.28) and Dr Kilroy (section 6.28). Previous work relating flow variability to biological communities such as benthic invertebrates and periphyton have demonstrated that intermediate sized flood events, such as those exceeding three times the median flow (hereafter called FRE3), are important to a number of benthic measures such as abundance, species richness and diversity (Clausen and Biggs 1997). This was cited in section 6.21 of Dr Suren's evidence. However he reported that intermediate flow variability will only change to a minor degree under the MHP flow regime. I analysed the flow variability in hydrological data from the Plexos 4 output model to compute FRE3 under both the natural and MHP flow scenarios. Calculation of FRE3 frequency was somewhat dependant on rules governing the extent of flow recession before events were considered independent, and I used the rule that flows were to recede to less than 1.5x the median before the next flood event was considered a separate event.

5.42. I found that FRE3 naturally occurred at approximately 22 events per annum over the 25 year record, and this is in agreement with the evidence of both Mr Jowett and Dr Suren. In the Clausen and Biggs (1997) analysis, FRE3 of 22/yr was in the mid to upper range of variability for the 83 rivers they studied. Under the MHP flow scenario FRE3 frequency will increase approximately seven-fold to 152/yr.

This calculation of FRE3 is likely to be a conservative estimate because I only considered daily flow variation, and there are some periods in which the river will be raised to 126 m<sup>3</sup>/s twice daily. This value was well beyond the natural range of variability observed in the Clausen and Biggs (1995) study, but most of the benthic community parameters were changing negatively towards the high end of the gradient with increasing FRE3. Thus it is my expectation that such a large change in FRE3 will have highly deleterious effects on benthic communities in the lower river. Dr Death in his evidence has also expressed concern that changes in flow variability will have significant deleterious effects on invertebrate communities downstream of the MHP dam.

- 5.43. Sagar (1987) observed that the time period between floods was the most important factor for determining benthic invertebrate abundance in the highly variable flows of the Rakaia River, with approximately a 14 day period required for invertebrate recolonization to asymptote following intermediate-sized floods. This 14 day “time lag” for benthic recolonization has been recognized by ecologists when considering sampling of benthic communities, and has been adopted by the National River Networks as a non-sampling period for benthic invertebrate sampling in environmental monitoring. I calculated the duration between significant floods (Fre3) over the 25 year record under the natural and MHP scenarios and the results of their frequency distributions are presented as histograms in Figure 12. Although duration is quite naturally variable (range 1-104 days), under natural conditions the median time period is 12 days, with an average of duration of 16 days, suggesting there is a tendency for the river to experience a 14 day recolonization period following 44% of floods. Under the MHP flow regime this period was shortened to a median of 1 day (mean of 2.4 d), with only

2% of floods having a recolonization time of more than 14 days. These longer periods correspond predominantly to the whitebait season when the MHP would be managed more closely to run-of-river.

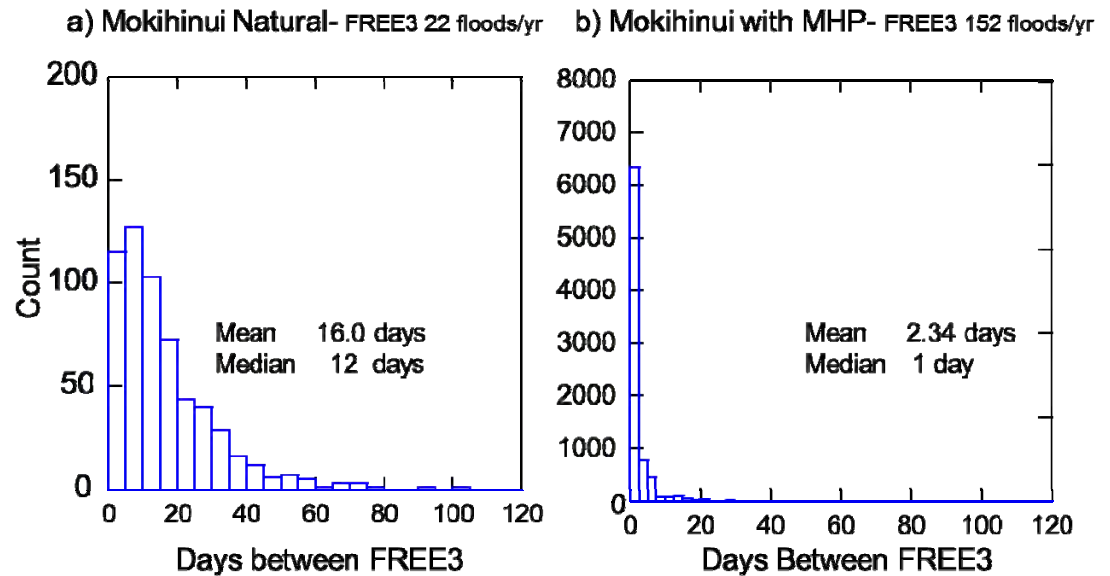


Figure 12. Histograms of the duration between FREE3 flood events for the a) Mokihinui naturalised and b) the Mokihinui with MHP flow scenarios between 1972 and 2010.

5.44. Implementation of a flow regime with such frequent FREE3 magnitude flood events is likely to have significant adverse effects on communities downstream of the dam. Although Mr Jowett and Dr Hudson have both tried to quantify the degree to which habitat loss could occur based on changes in species preferences for water velocity and depth, the responses of biota to such repeated flow fluctuations is likely to be far more complex. The data upon which these predictive habitat preference models have been derived and trained are collected from rivers without such unnatural daily flow fluctuations. Dr Leathwick's evidence discusses in detail the implications of extrapolating statistical modelling predictions to environments well beyond the limits of your calibration data, and relationships he has

seen between flow variability and species patterns. I fully concur with Dr Leathwick's conclusions on these matters.

- 5.45. While the use of RHYHABSIM modelling predictions can provide some insight into the areas of the riverbed that will experience conditions that instantaneously meet the normal habitat preferences of a particular species, the repeated daily changes in the environment are likely to be more complex and have unanticipated effects on the life history requirements of these species, such as foraging, competitive interactions, oviposition (egg laying) and juvenile rearing. In the absence of such detailed knowledge a sounder approach is to consider more correlative hydrological data such as FRE3 frequency in which community change is related to environments with similar flow patterns. As my previous points have indicated, significant changes in species richness and abundances can be expected.
- 5.46. In section 6.20-6.21 Dr Suren has cited work by previous investigators Harding (1994) and Young et al (2002) to make predictions of invertebrate communities downstream of the MHP dam. I do not agree with his assessment for a number of reasons. Where Dr Suren has cited that it is common for an increase in the density of invertebrates below surface-outlet dams, this trend was due to proliferation of communities that are intolerant of high flow variability, such as *Aoteapsyche* and *Austrosimulium*, which is a clear distinction for the MHP operations. In fact Harding (1994) concluded in his review of invertebrate communities below lake outlets and hydro-electric dams that "the four contrasting outlet types investigated in this study showed differences in species richness, invertebrate abundance and community composition. In particular, as the degree of man-made modification increased, both taxonomic richness and invertebrate abundance decreased".

Although Dr Suren states that invertebrate communities will be relatively similar pre and post MHP because flood frequency will not change (then citing FRE3 frequency in 6.21), my analysis of FRE3 frequency indicates that this is incorrect. Thus my expectation is that there will be significant decreases in abundance and richness of invertebrates as a consequence of high flow variability and a reduction in permanently wetted habitat.

- 5.47. Dr Jowett in section 6.13-6.14 of his evidence discusses the potential for the proposed daily 16-126 m<sup>3</sup>/s flow fluctuations to affect invertebrate productivity in the Mokihinui River downstream of the MHP dam. I agree with Mr Jowett's point that the effect of the flow fluctuations would depend on the magnitude of the fluctuation, but unfortunately he did not provide this information in Table 3 where he presents information on invertebrate densities relative to other rivers without such artificial fluctuations. The effect of flow fluctuations on invertebrate communities has been reported extensively from overseas studies (Kroger, 1973; Ward and Stanford 1979; Cushman 1985; Garcia de Jalon et al. 1988), with the finding that short term flow modifications clearly lead to a reduction in both the natural diversity and abundance of many native fish and invertebrates (reviewed in Ward 1976). In accordance with this finding, Mr Jowett reported that artificial flow fluctuations in the Patea River had significant impacts on the production of invertebrates downstream of the Patea dam (Jowett 2007a). Although Mr Jowett's evidence (section 6.15) has cited the example of the Waitaki River as having high invertebrate abundances downstream of the Waitaki dam, this river undergoes considerably smaller relative flow changes than what is proposed under the MHP, with only a 2.4X change in daily flow compared with the MHP which will have a

7.9X change in flow magnitude. Thus I would expect more significant effects on invertebrate production closer to those observed in the Patea River or the Clutha River (where invertebrate densities are considerably lower).

Table 3. Average invertebrate densities in New Zealand rivers that have human-induced hydro-peaking flow regimes, and the magnitude of peak versus base flows. Data sources are provided in the last column.

<b>River</b>	<b>Benthic * Invertebrate Density (m- 2)</b>	<b>Normal Daily Flow Range (m3/s)</b>	<b>Mean Peak : base Ratio</b>	<b>Data Source</b>
Mokihinui R. (MHP)	n/a	16-126	7.9	MHP AEE
Hawea R.	5921	15-80	3.9	Otago Regional Council
Waitaki R. (Kuroow)	3660- 5485	226-550	2.4	Canterbury Regional Council
Patea R.	232- 650	2-65	15	Dedual 2008
Monowai R.	1024	5-20	4	Bergy 2010
Clutha R. (Lower)	624	100-700	6.7	Otago RC
Waikato R. (Hamilton)	736	140-320	2.3	Env. Waikato
Rangitaiki R. (Te Toko)	4853	40-80	2	Millas 2009

\*From Ian Jowett's evidence-in-Chief Table 3

5.48. Dr Suren (section 6.24 of his evidence) has postulated that reductions in fine sediment transport to reaches below the dam could potentially compensate for losses in productivity from the creation of a large varial zone and increased daily

flow variability. I feel this to be unlikely for several reasons. Substrate conditions in the river downstream of the gorge at present do not appear to be armoured with fine sediment (See Figure 13), particularly along the river margins where WUA of benthic habitat is greatest (Figure 6). Dr Suren did not report the proportion of fines in the bed, but in Hicks et al. (2007) it was on average 2%. Recently sediment protocols have been developed for New Zealand rivers (Clapcott et al 2011), with a guideline value of <20% sediment for protection of biodiversity. Thus, within the lower Mokihinui River the present sediment content is only 10% of this guideline value, which would suggest sediment should not negatively affect benthic communities at present. Dr Hudson has further calculated that deep flushing of fine sediment (i.e., velocities that remove fine sediment deposited between gravels/boulders) occurs over >78% of the channel when flows exceed 30 m<sup>3</sup>/s (i.e., less than the current median flow). In my view, if there is currently perceived to be a detrimental effect on the benthic communities as a result of fine sediment deposition in the lower Mokihinui River this needs to be more thoroughly quantified in the evidence of witnesses for the applicant if reduction of sediment post MHP is to be cited as a compensatory effect of the dams construction.



Figure 13. River bed substrate of lower Mokihinui River at Burkes Creek confluence. Note the predominantly cobble and boulder substrata with minimal fines.

5.49. The effects of the increase in daily flow variation would be most severe for, but not exclusive to, less mobile species such as benthic invertebrates. Mr Jowett has provided some analysis around the loss in WUA from daily flow fluctuations, although he considered this over a much narrower range (16-46 m<sup>3</sup>/s) than the operating range proposed under the MHP (16-126 m<sup>3</sup>/s). This approach was also taken by Mr Jowett in his AEE report which was highly criticized in Council Hearing evidence (Jowett 2007b). His reasoning is that any further increase in variation beyond the median flow would occur in the normally unwetted portion of the river. Although this is partly true, it does not recognise the significantly greater change in hydraulic parameters (depth and velocity) that would occur to the permanently wetted portions in the river, which is a critical part of this analysis. Further analysis of habitat suitability using RHYHABSIM under a

16-126 m<sup>3</sup>/s daily flow range by Dr Hudson predicted loss of WUA for food producing benthic production (Waters 1976) was 91% and loss for Deleatidium habitat was 76% (Figures supplied by Dr Hudson). This would be a significant loss in the food production capacity of the river for fish populations residing in the lower river. Mr Jowett (2007) and Mr Bonnet have cited that forage fish could potentially make up for loss of invertebrate food supplies for some larger species, but it is unclear to me how the loss in production could be compensated for by the availability of forage fish as these are also dependant on benthic invertebrate production to sustain their populations.

- 5.50. In addition to the loss of productive habitat from daily flow variations, there will also be an overall decline in productive habitat area due to a decrease in residual flows between generating events when compared to natural base flow conditions. Using the Range of Variability Approach, I calculated that the median monthly 7-d minimum flows would be reduced from the natural range of between 27 m<sup>3</sup>/s (February) and 47 m<sup>3</sup>/s (May), to 16 m<sup>3</sup>/s for all months with the MHP in place (Figure 14). Calculation of the annual 7-d low flow accounts poorly for the normal seasonality of flow patterns in the Mokihinui River, as these very low flows (close to MALF) only tend to occur during late summer and early autumn. Moreover, as Mr Henderson has indicated, flows of MALF or lower only occur for 3% of the duration of flow, which will increase to 35% post MHP. I view the adoption of MALF as a more appropriate minimum flow for rivers in water short regions of the country such as the east side of the divide where flows below MALF are more common and typically in the range of 30% of the flow duration. This is also where much of our scientific understanding of the ecological responses of rivers to low flows has been gained.

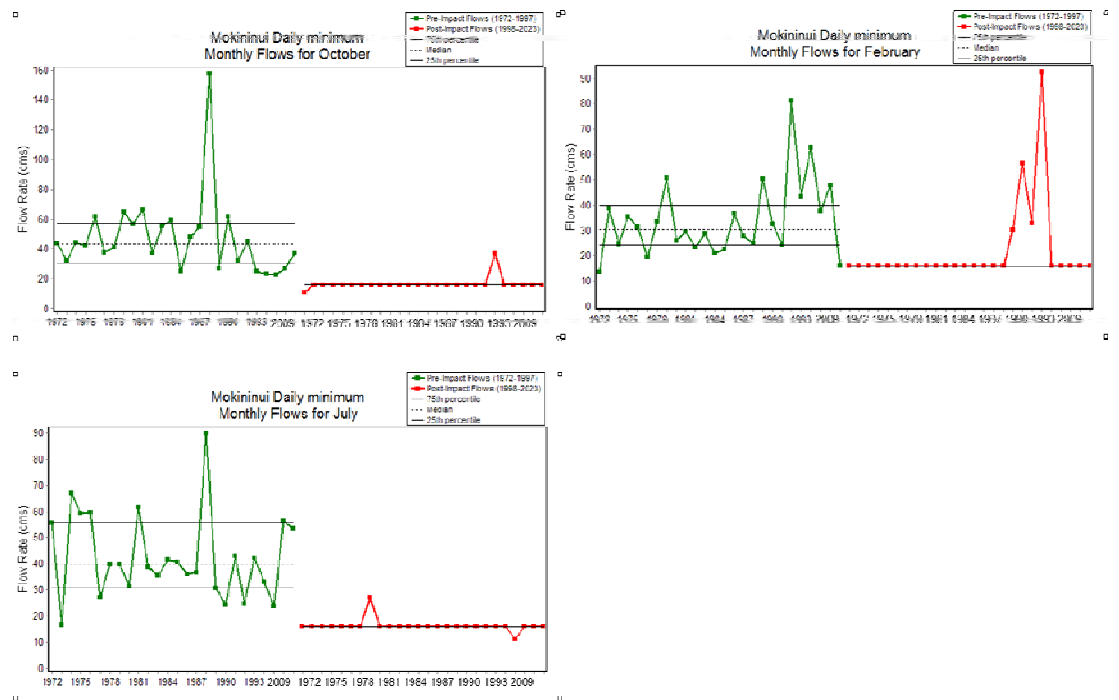


Figure 14. Monthly median values of the daily minimum flow shown for the Mokihinui naturalised (green line) and MHP (red line) flow scenarios between 1972 and 2010. Note a gap in data between 1994-2007.

5.51. I also examined the frequency of natural low flow events in the Mokihinui River during which flow receded to  $16 \text{ m}^3/\text{s}$  or less. I used the 25 year flow record generated by Mr Henderson between 1973 and 1997, and considered events only if they were not connected within the same week. From this analysis, shown in Figure 15, it can be seen that these natural low-flow events occur infrequently, with the mean duration between events being roughly half a year, or 194 days. The most frequent event length was within the same month, suggesting the river does go through extended dry periods in the same month. However, in some cases the river flows did not recede to  $16 \text{ m}^3/\text{s}$  for over two years, with 927 days being the longest period. Thus I have significant concerns that such a low minimum flow is being proposed for the lower river on a near- daily basis when it

naturally occurs so infrequently and over such short durations of the flow period (3% of total flow duration).

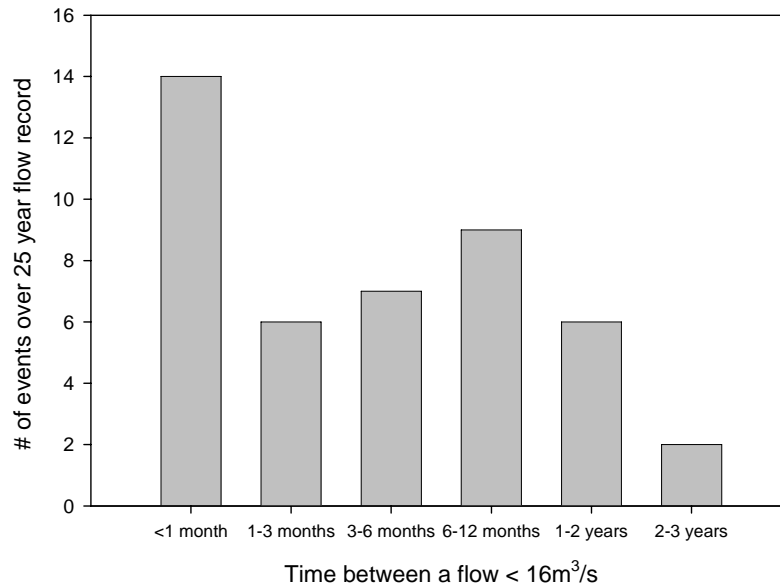


Figure 15. Histogram of the frequency of low flow events less than 16 m<sup>3</sup>/s in the Mokihinui River lower river over the flow record of 1973-1997. Data provided by R. Henderson, NIWA.

5.52. Mr Jowett (sections 6.3-6.7) indicated his RHYHABSIM analysis of the minimum flow of 16 m<sup>3</sup>/s (MALF) provided near optimum retention of WUA for fish and invertebrate species. Examining the figures 5-7 from Mr Jowett's evidence showed that maximum suitable habitat area for most species occurred between from 27-47 m<sup>3</sup>/s, close to the natural range of base flows, with declines in WUA occurring most prominently below 25 m<sup>3</sup>/s. However this is most likely minor in comparison to the change in habitat suitability that occurs in these habitats as flows are ramped to the generating range of flows of 126 m<sup>3</sup>/s. Dr Hudson's analysis of habitat suitability over this flow range demonstrates that only a very small portion of habitat is retained (typically <10%) over this range of flows. This would necessitate movement of mobile species, such as native fish, during generating events to areas of suitable

hydraulic conditions as flows are ramped. Many of these species are predominantly nocturnally active due to predation pressure by introduced salmonids, whereas generating events will be occurring more often during daylight hours (Henderson Section 7.12). Other non-motile species such as benthic invertebrates would not be able to conduct such movements. Thus I can only predict that these areas of the riverbed will become unsuited to any significant invertebrate populations.

- 5.53. My assessment of such a large reduction in favourable habitat for benthic invertebrate production, and the extremity of daily flow fluctuations, will mean that the lower portion of the river will be a very poor environment for fish populations. In my opinion the availability of forage fish (i.e., native species) cannot compensate for this loss in productive area as these populations are similarly dependant upon productive benthic habitat for their population viability.

***Didymosphenia geminata (Didymo)***

- 5.54. Dr Kilroy has discussed the potential for Didymo to affect the Mokihinui River post MHP in sections 5.38-5.44 of her evidence. I agree with many of the points she has made regarding the likelihood that Didymo is present within the catchment. I also agree that it probably does not presently form blooms in most parts of the mainstem due to flood frequency and sediment transport dynamics in the Mokihinui mainstem. However I think the pattern observed within New Zealand and other countries (Canada, USA) for Didymo to form nuisance blooms downstream of lake outlets and hydro-electric dams is indicative of a significant level of risk of Didymo blooms occurring in the Lower Mokihinui following the construction of the MHP dam. This is for a number of reasons which I now discuss.

- 5.55. It is not just magnitude and frequency of floods that influence periphyton growth dynamics in rivers, but the associated mobilization of bed materials at the time of floods which act to scour periphyton growths or turn over larger bed materials that periphyton grow on (Biggs 1995). The tendency for lakes and hydro-electric reservoirs to cut off upstream sediment supply both reduces the amount of fine (predominantly sand) and medium (gravel) sized particles that scour periphyton during high flows, and cause the bed to coarsen over time and become armoured and stable. Drs Hudson and Hicks have discussed in their evidence that this is likely to occur for the Mokihinui River downstream of the dam. The combination of these effects in the lower portions of the river downstream of the MHP reservoir will ultimately reduce the processes of periphyton biomass loss, which would contribute to development of thicker periphyton mats such as *Didymo*. Dr Kilroy's final conclusion (section 5.44) that frequent sediment laden floods in the lower river will prevent *Didymo* from growing to any significant extent seems at odds with assertions from other witnesses (e.g., Mr Jowett, Dr Suren) that increased water clarity and reductions in fines due to creation of the reservoir will enhance conditions for benthic communities.
- 5.56. Dr Kilroy in sections 6.21-6.23 asserts that an increase in substrate stability of the river and reduced fines will both contribute to a greater potential for peiphyton growth in the river, but that peak generating flows and natural floods will prevent any significant biomass developing. In my opinion, and as also stated by Dr Kilroy, the large number of interacting hydrological and sediment processes that would be changed following the MHP make it quite complex to predict the extent to which *Didymo* blooms will form. Dr Kilroy notes that the Waiau River below the Lake

Manapouri diversion is capable of significant Didymo blooms despite high flow variability. Other rivers such as the Hurunui River below Lake Sumner has consistently had significant Didymo coverage, and its flows regularly exceed generating flows in the MHP, with the river also having a similar range of base flows to the Mokihinui. A hydrograph of the Hurunui River is shown in Figure 16 for reference and comparison to the MHP flow ranges.

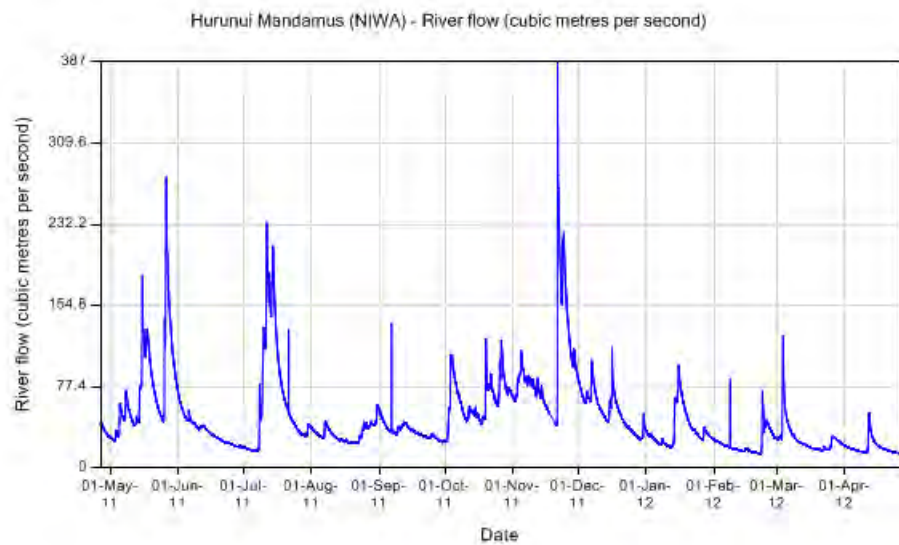


Figure 16. Hydrograph of the Hurunui at Mandamus between May 2011 and April 2012.

5.57. Dr Hudson has examined the proportion of the river habitat suitable for Didymo under the flow operating range between 16 and 126 m<sup>3</sup>/s. His analysis shows a peak in Didymo habitat area between 10-15 m<sup>3</sup>/s of flow, with a moderate decline in habitat above this flow range to 126 m<sup>3</sup>/s (Figure 17). However, even with flows of 126 m<sup>3</sup>/s, there were still large sections of the streambed suitable for Didymo. Figure 18 shows the suitability of the riverbed for Didymo across the river channel at 6 transect locations under flows of 16 and 126 m<sup>3</sup>/s, measured by the habitat suitability index (HSI). At 16 m<sup>3</sup>/s the river is highly suited to Didymo over most of the channel at all cross sections.

This portion of the channel suitable to Didymo recedes as flows increase to 126 m<sup>3</sup>/s, but the margins of the permanently wetted portions of the river still remain suitable at all cross sections, and at some cross sections the entire channel is still reasonably suitable for Didymo.

- 5.58. Recent work by Larned et al. (2012) demonstrated that Didymo mats can be highly resistant to dislodgement just from hydraulic turbulence, with the mat changing overall turbulence on the river bottom by filling interstitial gaps and reducing substrate roughness. Although it is difficult to be certain, it is my opinion that it would require significantly larger flood flows (>500 m<sup>3</sup>/s) topping the spillway to significantly reduce Didymo biomass because of a lack of sediment movement and scouring by fines. Although I was not involved, I understand from the results of Meridian's flow release on the Waitaki River in 2008/09, that a flow of 900 m<sup>3</sup>/s was required to effectively remove Didymo from the channel (Otago Daily Times, Jan 28, 2009). If only larger floods (i.e., >500 m<sup>3</sup>/s) are effective at removing Didymo in the Mokihinui, floods of this magnitude will occur less frequently (approximately monthly). Therefore there will be considerable periods where Didymo biomass could accumulate to higher levels.

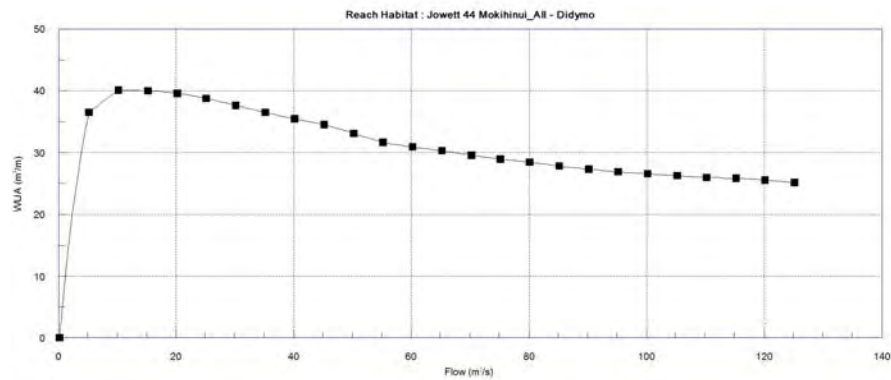


Figure 17. Mean weighted usable area (WUA) for the invasive algae *Didymo* at 24 transects within the lower Mokihinui River below the proposed MHP dam. Figure provided by Dr Henry Hudson.

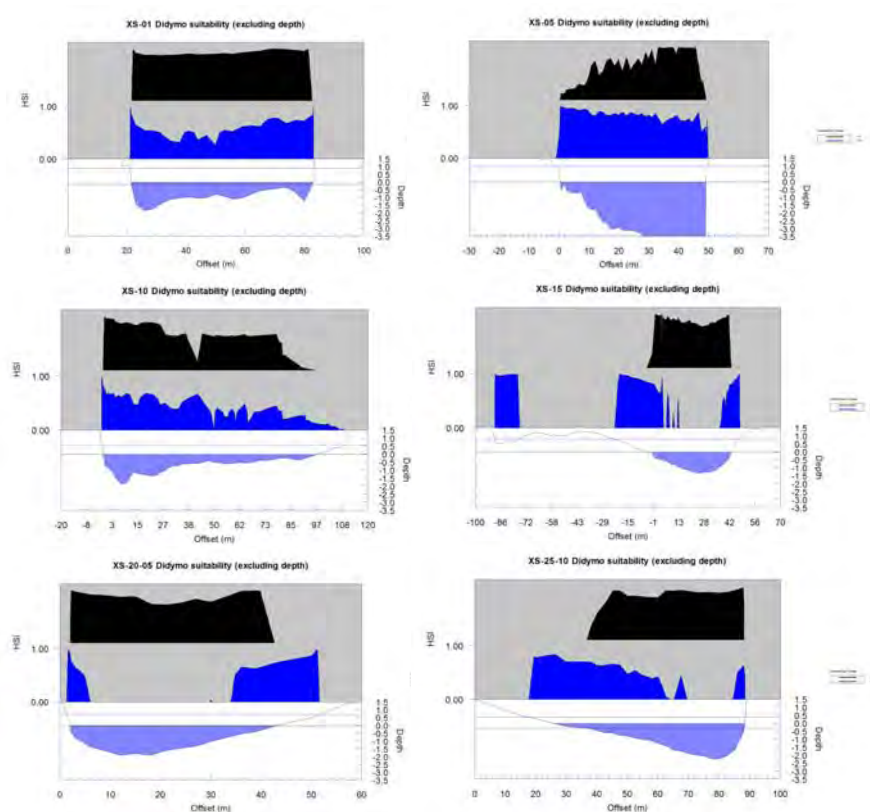


Figure 18. Estimates of habitat suitability index (HSI) across the river channel for the invasive algae *Didymo* during flows of 16 and 126 m³/s at 6 transects within the lower Mokihinui River below the proposed MHP dam. Figure provided by Dr Henry Hudson.

5.59. Dr Kilroy (Section 5.43) has suggested that phosphorus concentrations in the Mokihinui River downstream of the gorge can at times exceed preferred conditions for Didymo blooms (i.e.,  $>2$  ug/L) and thus may make the river unsuited to such blooms. However, this included only a single measurement of phosphorus that exceeded this 2 ug/L threshold, and measurements of phosphorus concentration were collected in the absence of the MHP reservoir and so do not account for any within reservoir nutrient cycling processes. In support of this, in Table 4 I provide nutrient concentration data for Lake Brunner and its main inflow the Crooked River, as well as the lake outlet at the Arnold River. Over a three year period the average attenuation of dissolved phosphorus by the lake was 70%, meaning that tributary outflows were 70% lower in phosphorus concentration than inflowing concentrations. The MHP reservoir will most certainly have significant effects on phosphorus cycling and transport through the Mokihinui gorge to the lower river as discussed in the evidence of Drs James and Schallenberg. I would also express a word of caution in interpreting phosphorus concentrations as a critical determinant for assessing Didymo growth potential below the MHP dam, as blooms do occur in rivers with much higher phosphorus concentrations. For instance, in the Opuha River, downstream of the dam, Didymo blooms are frequently severe and dissolved reactive phosphorus concentrations typically exceed 2 ug/L and are often more than double this concentration (Kelly 2005).

Table 4. Mean annual nutrient concentrations for in-lake and inflow/outflow tributaries in the Lake Brunner catchment between 2003-05. Data from the West Coast Regional Council.

Year	Site	Dissolved Reactive Phosphorus (mg/m <sup>3</sup> )	Total Dissolved Phosphorus (mg/m <sup>3</sup> )	Total Phosphorus (mg/m <sup>3</sup> )	Nitrate (mg/m <sup>3</sup> )	Dissolved Inorganic Nitrogen (mg/m <sup>3</sup> )	Total Nitrogen (mg/m <sup>3</sup> )
2003 (n=4)	Crooked R. Inflow	4.9	7.5	10.0	106.0	117.2	195.9
	Brunner mid-lake	0.9	3.5	7.3	116.0	124.5	204.5
	Arnold R. Outflow	1.2	3.0	7.0	113	118.5	197.6
2004 (n=6)	Crooked R. Inflow	7.4	11.0	18.4	94.7	109.3	211.3
	Brunner mid-lake	0.9	2.8	7.60	70.81	93.0	182.7
	Arnold R. Outflow	0.9	2.9	7.2	35.9	34.9	175.6
2005 (n=6)	Crooked R. Inflow	3.7	6.7	9.7	110.6	124.4	194.6
	Brunner mid-lake	0.6	3.0	5.8	70.2	107.0	165.5
	Arnold R. Outflow	2.0	Not measured	8.0	30.0	36.0	155.0
Mean in-lake Attenuation		70%	67%	36%	43%	46%	12%

5.60. Nuisance growths of *Didymo* in the river could significantly impact the whitebait fishing in the lower river. The fishery is predominantly a scoop-net fishery. Scooping

Didymo off the river bottom and drifting clumps of sloughed Didymo would create a nuisance to scoop netting, as would separating small whitebait from clumps of algae. Recreational usage of the Mokihinui River including whitebaiting are discussed in more detail in Mr Wightwick's evidence.

- 5.61. In summary, I agree with Dr Kilroy that the implementation of the MHP would create a river environment more conducive to Didymo growth through its effect on stabilizing the riverbed substrate and minimizing sediment transport below the dam. However, I disagree with her points regarding both phosphorus concentrations in the river as well as peak generating flows and floods acting to keep didymo biomass low. This is based on patterns we have observed in other lake fed and dammed rivers in New Zealand and internationally, as well as modelling work showing Didymo having high habitat suitability over the entire range of MHP operational flows. In my opinion only significant floods (estimated at  $>500 \text{ m}^3/\text{s}$ ) would effectively remove Didymo from armoured riverbed substrates, but these occur less frequently (approximately monthly) and there will be extended periods in which Didymo could grow to higher levels. In my opinion Didymo will pose a significant risk of nuisance to recreation in the lower river following the implementation of the MHP.

#### **Effects of the MHP Whole-Ecosystem Function**

- 5.62. Based on the likely changes to fish migration, fish passage, and flow ecology cited in the previous sections it is expected that the Mokihinui River will experience significant changes in fish population dynamics throughout the river. It is probable that any landlocked reservoir populations of (predominantly) koaro will be less

productive and this will result in lower recruitment of juveniles to the adult populations located throughout the upper section of the catchment. This will be augmented by whitebait runs passing over the dam by t & t of whitebait produced from other neighbouring river catchments, but ultimately the contribution of the Mokihinui River to the regions whitebait species populations and aquatic biodiversity will be negatively affected.

- 5.63. There has been little recognition of the Mokihinui as a potential source of native fish species recruits to other rivers of the region (whitebait) or nationally (longfin eels). Several of the other river systems along this coastline are impacted by mining, and do not have such significant native fish populations as the Mokihinui. As such this river may provide a source of recruits to these other river systems. Although Mr Bonnet has more clearly identified mitigation options for the transfer of recruits upstream of the dam to the upper part of the catchment (mainly for eels), ultimately it is the transfer of migrating mature adults (longfin eels) or juveniles (whitebait species) outward to the sea that measures their contribution to viable populations, and thus conservation and fisheries management. As mentioned in the AEMP, the operation of the t & t is implied in an adaptive context, there is little quantitative information on this process in terms of expected outcomes, and most of the information is largely pertaining to eels with a large number of questionable assumptions made for other species. There also needs to be some evaluation of the potential loss to regional and national stocks if such adaptive management initiatives are not as successful as has been intended. This is to an understanding of the risk associated with this proposed development.

- 5.64. Adult piscivorous fish species such as longfin eels and brown trout that reside predominantly upstream of the proposed impoundment could be negatively affected by a decrease in recruitment of whitebait species. Although dietary composition of either brown trout or longfin eels was not investigated in the AEE technical reports, it can be expected that these species would draw some of their energetic intake from smaller fish species such as koaro or bullies (e.g., redfin and bluegills). If whitebait populations are landlocked to the MHP reservoir, a decrease in the production of whitebait populations would be a significant risk to the energetics of these large piscivore populations. Given the national significance of both the headwater brown trout and longfin eel populations the potential adverse impacts on these species are, in my view, an important consideration.
- 5.65. The lower portion of the Mokihinui River will lose a significant proportion of its productive habitat area for benthic invertebrates through declines in residual flows and large daily flow fluctuations. Overall, in my assessment this is likely to have a major effect on the productivity of the lower river, and in turn this is likely to affect higher trophic-level species such as fish and bird populations. The lower river including the Mokihinui gorge is essential for providing a temporary habitat for juvenile longfin eels and whitebait species that are in the process of migrating to the upper river, and its modification could have consequences for recruitment of species to the upper portion of the river beyond just the fish passage issues. Fish populations that predominantly reside in the lower portion of the river, such as inanga, torrentfish, bluegill bully, redfin bully and giant kokopu are all likely to be negatively affected by this reduced productivity.

- 5.66. Hayes et al. (2007) has cited as a potential favourable consequence of the reservoir formation, common bullies invading the reservoir and acting as a food supply to eels and trout. Although common bullies are a native species, artificially extending their distance of colonization inland will be at the expense of other threatened native species such as torrent fish, redfin bully and koaro. It is likely that common bullies establishing in the reservoir would extend their distribution well up and possibly above the Mokihinui forks. I would not view this invasion by common bullies as a positive outcome for the river as stated by the applicant.
- 5.67. From the brown trout otolith micro-chemistry data presented by Hayes et al. (2007), it was apparent that a substantial proportion of trout sampled (4 of 7 individuals) from the North Branch appear to be accessing the gorge (where the new reservoir would be formed) and in some cases can move as far downstream as the estuary. Thus it would seem that this part of the trout population could be substantially impacted by the removal of free-access to the lower portions of the river and the estuary. For reasons I have previously discussed, I believe it is unlikely that the production of food resources in the reservoir would compensate for this change in connectivity for migrating trout. The conclusions from the otolith micro-chemistry analyses were founded on a very small number of samples (e.g., only 7 trout samples for the Mokihinui North Branch). Although migrations of other large piscivorous species such as longfin eels was not specifically investigated by otolith microchemistry, it is possible that other piscivorous species such as longfins could similarly move downstream to exploit resources when they are abundant. This was not discussed to any extent by Mr Bonnet or Dr Jellyman.

- 5.68. The combination of decreasing recruitment of coastal whitebait populations in the upper section of the catchment due to whitebait landlocking and the inability of large piscivorous species to freely access the lower river to exploit coastal derived fish populations, could result in a significant change in the ecology of the river system. The degree to which large predatory fish might cue into these migrations is uncertain. There was no work conducted in regard to the diet of fish species, and how changes in migration patterns of diadromous species could affect wider foodweb processes. Although I cannot state with any certainty how important fish migrations might be for sustaining populations of piscivores in the upper catchment, the magnitude of whitebait migrations in the Mokihinui lends support to a view that this could be important.

## **6. CONCLUSIONS**

- 6.1. The Mokihinui River has multiple biodiversity components that ranked this catchment in DOC's WONI and FENZ conservation planning tools as a significant waterbody of both regional (Nelson-Paparoa biogeographic unit) and national importance.
- 6.2. This high ranking is due to the diversity and representativeness of environment types for the region, its pristine state upstream and including the Mokihinui gorge, and the number of threat listed aquatic and terrestrial species that reside in the catchment. My assessment of datasets comparing biological communities in the Mokihinui River, supported by key findings of several other witnesses, together indicate that the Mokihinui has highly diverse, distinctive, and unique aquatic communities and habitats in comparison to several other catchments in the region.

- 6.3. The MHP is likely to negatively affect biodiversity values including major changes in connectivity, alteration of habitats utilized by threatened species (e.g. blue duck, 9 fish species), loss of riverine gorge habitat and its distinctive and unique turf and seepage communities, increase the invasion potential for exotic species (e.g. *Didymosphenia geminata*, exotic fish and macrophytes) and alter habitat quality downstream of the MHP dam by changing the flow regime.
- 6.4. The MHP will result in changes to the distributions and migration patterns of adult and juvenile native fish species. It has the potential to affect population dynamics of several species and the ecological functioning of the river system.
- 6.5. The applicants Aquatic Ecology Management Plan (AEMP) will contribute towards minimizing some of these effects on migratory species through upstream t & t, but the residual adverse impacts are significant on native fish populations, including 7 species that are presently threat listed.
- 6.6. There remains considerable uncertainty in regard to species not previously managed through t & t and whether systems can be designed at the dam site to accommodate such temporally variable and large migration events. Relocation of some species outside their natural range and the effect of transferring populations upstream into a reduced area of riverine habitat were not assessed by the applicant. In my opinion this poses a risk of contributing to overall declines in some populations within the catchment.
- 6.7. A very significant effect of the MHP is on downstream migration of fish through the reservoir and past the dam because some species (predominantly koaro) may “landlock” to the reservoir. This will result in significantly

slower growth and lower recruitment of juvenile larval koaro to the adult population above the MHP reservoir, and lessen the contribution of the Mokihinui River to the regional whitebait fishery. Downstream migration by larger fish species such as longfin eels and brown trout will be affected by the dam operations, with significant mortality to be expected.

- 6.8. The effects of the MHP on downstream migration of torrentfish, redfin bully and lamprey are unknown. These effects are difficult to mitigate within the current operational framework of the MHP. Downstream migration is only partially addressed in the applicants AEMP.
- 6.9. Flooding of the Mokihinui gorge and creation of the 14km reservoir will reduce habitat for several species that utilize the gorge for all or part of their lifecycle, and eliminate habitat for some rare and/or undocumented flora and fauna which occupy seepage habitats and smaller low gradient river margins within the gorge.
- 6.10. It is not expected that the MHP reservoir will provide as diverse and unique species assemblages as occurs presently due to the steep bathymetry and large daily fluctuations in water level. It may also increase the risk of incursion by exotic species such as pest fish and water weeds that are presently absent from the catchment.
- 6.11. My assessment of suitable productive habitat for fish and invertebrate communities in the MHP reservoir is, at best, 6% of the total reservoir area; approximately half of what the applicants witnesses have suggested.
- 6.12. The managed flow regime in the lower Mokihinui River below the dam would diminish its productive capacity through lower base flows and large daily flow fluctuations

for power generation. Overall this is expected to have significant effects on the habitat quality and productivity and affect food supplies and energetics of inanga, torrent fish, bluegill bully, redfin bully and common bully.

- 6.13. The effects of this flow regime on migratory species such as longfin eels and whitebait species moving through the lower section of the river on their way to the upper catchment is more complex and uncertain.
- 6.14. Suitability of habitat downstream of the MHP dam for the invasive alga *Didymosphenia geminata* is likely to improve, but complex changes in flows and sediment processes create uncertainty regarding the extent to which Didymo might bloom in the river. There is a significant risk that if Didymo blooms did occur it will impact on the recreational values of the lower river, particularly whitebaiting.
- 6.15. There are likely to be overall changes in the migration of fish populations and production of aquatic communities (both fish and invertebrates) in the lower river and the flooded Mokihinui gorge post MHP. In my opinion this could affect the overall productivity of the river system and create an imbalance to existing communities and their food sources.
- 6.16. My overall assessment is the proposed MHP will result in significant adverse effects on many elements and key ecological processes in a river ecosystem of very high conservation value.

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