IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of a board of Inquiry appointed under section 146 of the resource Management Act to consider an application by Mighty River Power Limited for resource consents to construct, operate, and maintain a wind farm at Turitea.

STATEMENT OF EVIDENCE OF DR MICHAEL KEVIN JOY

Dr. Mike Joy
Senior Lecturer; Environmental Science/Ecology
Ecology group-Institute of Natural Resources-(PN-624)
Te Kura Matauranga o nga Taonga a Papatuanuku
Massey University
Private Bag 11 222
Palmerston North 4442
New Zealand
Ph. 64 6 3569099 ext 7363
Mob. 021 936205
Fax. 64 6 350 5623

1 Qualifications and experience

1. I hold a BSc, MSc (1st Class Hons) and a PhD in Ecology from Massey University. For the last fifteen years I have been a researcher in freshwater ecology, especially native fish distribution and freshwater bioassessment. I have been employed at Massey University Palmerston North since 2003 as a lecturer, now Senior Lecturer, in Ecology and Environmental Science.
2. I am a member of the New Zealand Freshwater Sciences Society, the New Zealand Ecological Society, the Australian Society of Fish Biology and the New Zealand Royal Society.
3. In the last seven years I have published more than 15 peer reviewed scientific papers on freshwater ecology and bioassessment, mostly in relation to New Zealand freshwater fish, and the majority of these papers are published in international journals (Appendix 1). I have published two book chapters on native fish and bioassessment (note these papers and chapters are original research as opposed to a list of reports on sampling for consent processes. I have also published many reports for most regional councils in the North Island, and have supplied software to run bioassessment models developed for these regions.
4. In the last seven years I have sampled fish and invertebrate communities from freshwaters at more than 1000 sites in the North Island, 550 of these were for my PhD study between 2000 and 2003.
5. I have peer reviewed the ecological components of Assessment of Environmental Effects (AEEs) for the Palmerston North City Council for three Manawatu wind farms - Tararua II, Te Rere Hau and Motorimu.

2 My evidence is neutral in regard to the presence of the wind farm and relates only to construction effects

3 Purpose and Scope of submission

I confirm that I have read and understand the Environment Court Code of Conduct for Expert Witnesses and I comply with that code in presenting this submission. I consider that this submission is within my area of expertise and I

have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

I will comment on:

- Effects of sediment on biological communities and failings in how sediment is measured.
- Effects of sediment on waterways.
- The effects of permanently piping sections of flowing, intermittent and ephemeral streams.
- Impacts of flocculation chemicals used in settlement ponds, if these are under-engineered and breached.
- What should be monitored, and how, in relation to stream communities.
- The Assessment of Environmental Effects (AEE) in the Mighty River Power Turitea wind farm resource consent application in particular the evidence of Dr Coffey.

4 Introduction

I have read most of the documentation relating to freshwater issues for the proposed Turitea wind farm. I feel that not enough emphasis is placed on the effects of deposited sediment on stream ecosystems, or on the importance of taking duration into account when considering the effects of suspended sediment. More emphasis must be made on the need for continuous sediment monitoring, and assessment of deposited sediment. Throughout the documentation from the applicant, the Greater Wellington Regional Councils Erosion and sediment control guidelines[1] are referred to as the solution to sediment problems during construction. However, it is obvious in the Wellington Region over the last few years that sediment is a significant issue for freshwaters and harbours. This suggests the Greater Wellington sediment guidelines are either not strong enough, they are not followed by developers or consents are being breached, but probably a combination of all three.

[1] Denton and Robson, 2002: Erosion and sediment control guidelines for the Greater Wellington Regional Council

4.1 Effects of sediment on biological communities and failings in how sediment is measured

The effects of sediment on stream biological communities are many and complex, but first must be considered at two levels; that is (1) suspended sediment, and (2) deposited sediment[2]. Unfortunately the first, suspended sediment is most easily measured and is thus the most often measured. However, depending on duration suspended sediment is generally of lesser importance in relation to measuring sediment's effect on biological communities.

Suspended sediment impacts in many ways, including:

- clogging the gills of fish and stream invertebrates – this can be lethal if it persists for some time but is species specific and there are no general rules.
- reducing visibility for visual feeders
- reducing light reaching into the stream for photosynthesis - which reduces algae and macrophytes, thus food availability for invertebrates and fish.

Deposited sediment impacts include:

- the blocking and sealing of interstitial spaces (the spaces between stones where most stream fauna live or rest)
- sealing of bed surface (colmation) – which isolates interstitial water from overlying river water and underlying hyporheic water (water under the stream bed). Movement across the boundary between water under the stream bed and surface water is crucial for stream life in the hyporheic zone
- degrading or destroying the interstitial habitat for invertebrates and fish[3&4]
- degrading fish spawning habitat.[5]

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[2] Ryan, P. A. 1991. Environmental effects of sediment on New Zealand streams: a review. New Zealand Journal of Marine and Freshwater Research **25**:207-221.

[3] Rowe, D. K., and T. L. Dean. 1998. Effects of turbidity on the feeding ability of the juvenile migrant stage of six New Zealand freshwater fish species. New Zealand Journal of Marine and Freshwater Research **32**:21-29.

[4] Recent work (Mcewan & Joy In Prep, It's all about substrate; a microhabitat study of New Zealand native fish) radio tagging native fish in a stream near Palmerston North has shown that most native benthic fish use the labyrinth of interstitial spaces up to a meter below the stream bed

Deposited sediment is generally not measured by regional councils in New Zealand or the Ministry for the Environment in New Zealand, even though it is considered to be one of the most pervasive impacts on New Zealand freshwaters[6&7] and coastal environments[8]. Furthermore, recent work has shown that there are significant impacts on harbours, coastal and near shore ecosystems[9]

4.2 The affects of the of permanently piping sections of flowing, intermittent and ephemeral streams

The piping of streams has major implications for stream ecology; the most notable are listed below:

- Loss of stream habitat for fish and invertebrates within pipes.
- The creation of migratory bottle necks where predators can pick off all migrating fish.
- The potential, if pipes are angled steeply, to impede or halt fish passage by creating velocity barriers (making flows too fast for migrating fish to negotiate).
- If piped sections are too long upstream, flying invertebrate adults can lose contact with the stream, and thus stream invertebrate communities can be impacted.
- The potential for the lower end of pipe sections to become perched (above water level), halting upstream fish migration.

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[5] McDowall, R. M. 1990. New Zealand Freshwater Fishes: A Natural History and Guide. Heinemann Reed, Auckland.

[6] Ryan, P. A. (1991). "Environmental effects of sediment on New Zealand streams: a review." New Zealand Journal of Marine and Freshwater Research **25**: 207-221.

[7] McEwan, A. M.K. Joy and B.O.David. 2008. Its all about substrate: microhabitat requirements of freshwater fish living in a pristine stream in New Zealand Conference Talk, New Zealand Freshwater Sciences Society Conference 2008. Plymouth Hotel, New Plymouth, New Zealand.

[8] Morrison, M. A., M. Lowe, et al. (2008). A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. New Zealand Aquatic Environment and Biodiversity Report, NIWA**:** 96 pp.

[9] A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand M.A Morrison et. al. NIWA NZ Aquatic Environment and Biodiversity report 2008

The amount of piping used must be minimised and flow guidelines for fish passage adhered to so that fish passage is not impaired[10].

4.3 Impacts of flocculation chemicals used in settlement ponds, if these are under-engineered and breached

Because flocculation chemicals usually include aluminium, which has many toxic effects on fish and stream invertebrates[11], if they are not contained they can be lethal in streams and eventually the estuary. Similar chemicals used to clear water in water supply plants in Palmerston North (Turitea Stream) and Wellington (Wainuiomata River) have had lethal impacts on stream life when these plants have accidently back-flushed into streams[12]. Thus, these ponds must be oversized to withstand any possible rainfall event i.e. 1 in 50 year event, to ensure this does not happen.

4.4 Recommendations - What should be monitored and how in relation to stream communities

1. *Suspended sediment:* to effectively monitor suspended sediment, it must be done continuously or as near as continuous as possible. I note that the water quality monitoring done at the wind farm project West Wind[13] failed to pick up obvious serious sediment pollution, so lessons can be learned from this monitoring regime's failures[14]. A number of the parameters measured are totally superfluous. For example, dissolved oxygen, pH and temperature vary diurnally, so one-off measures are meaningless. Effort would be better put into other measurements, such as deposited sediment or continuous monitoring. It is the daily variation and or

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[10] Auckland Regional Council (2000) Fish passage guidelines for the Auckland Region. *ARC Technical Publication No. 131*;
James, A., and M. K. Joy. 2008. A preliminary assessment of potential barriers to fish migration in the Manawatu River catchment, North Island, New Zealand. A report to Horizons Regional Council EnviroLink Contract Ref: 437-HZLC45, Massey University.

[11] Winterbourn, M. J., W. F. McDiffett, and S. J. Eppley. 2000. Aluminium and iron burdens of aquatic biota in New Zealand streams contaminated by acid mine drainage; effects of trophic level. The Science of the Total Environment **254**:45-54.

[12] Mike Joy and Russell Death unpublished observations.

[13] Tonkin and Taylor Project Westwind Monitoring report July 7 2008.

[14] Because monitoring is not continuous one-off samples will inadvertently miss many impact events, and no monitoring of deposited sediment then the real long-term impacts are not measured

minimum and maximum values for oxygen, pH and temperature that are important for these parameters, not one-off measures.

2. *Deposited or settled sediment*: the relative importance of deposited sediment versus suspended sediment depends on the duration of suspended sediment. Suspended sediment is lethal if it continues at high levels for hours. If however, it is for short periods, then the deposited material is more hazardous. A number of simple measures can and should be used to monitor deposited sediment, for example:

    - NIWA's quorer is a simple method for estimating deposited fine sediment[15]. This is a bottomless bucket placed on the stream bed, the substrate is mobilised with a stirrer and a water sample taken. Also, residual pool depth can be measured to indicate deposition over time.

5 Statement of Evidence of Dr Brian Coffey

In general, I agree with Dr Coffey's statement of evidence and conclusions but I don't share his confidence that the implementation of the GW sediment control guidelines will result in the protection of the waterways.

He uses the term Best Management Practice (BMP) and promotes its implementation. However, these are the same statements, practices and the same sediment control guidelines used by applicants for the Project West Wind wind-farm project recently constructed south west of Wellington. These practices proved to be totally inadequate in the West Wind project[16]. At the West Wind site I have observed on two occasions sediment flowing down streams into the ocean, overflowing retention dams, and slip scars below roading visible from many kilometres off shore. These impacts have been noted by others[17] but it is too late to mitigate as the damage there has already been done.

6 Conclusions

[15] http://www.niwa.co.nz/ncwr/tools/quorer
[16] The failings of the sediment control practices were obvious with sediment slicks down streams and offshore
[17] http://wellington.scoop.co.nz/?p=3445

The impacts on stream ecology is multifaceted and site dependant, however, in general, physical changes such as sedimentation often override all other impacts in New Zealand streams where forest has been cleared. In the case of the proposed Turitea wind farm project, the construction work will potentially impact on streams by increasing sedimentation rates. The streams in the vicinity are already stretched to the limits of their ecological resilience by many existing factors, and any increase may push them beyond this point this is revealed by the fact that a suite of sensitive native migratory fish are now missing from the Manawatu Catchment[18]. The degradation of aquatic ecosystems are never linear declines, they inevitably have sudden collapse[19] and predicting the threshold for such is impossible. As a result the precautionary principle should apply and the sediment control measures necessarily used in this case must be oversized to the extent required to ensure there is no chance of increased sediment entering waterways. Even if the Board chooses not to invoke the precautionary principle, strict continuous monitoring of sediment entrainment and deposition must be employed so that immediate action can be taken should any sedimentation occur.

Mike Joy

19 May 2009

[18] Joy, M. K. 2008. Predicting Freshwater Fish Distribution at a Regional Scale. *Presented at* New Zealand Geographical Society 24th Conference, Wellington New Zealand.

[19] Begon, M., J. L. Harper, and C. R. Townsend. 1990. Ecology: Individuals, Populations and Communities., 2nd ed. edition. Blackwell Scientific Publications, Oxford.

Appendix 1: Research/Scholarship

Selected refereed journal papers

Atkinson, N. K. and M. K. Joy. 2009. Longitudinal size distributions of bluegill bullies (*Gobiomorphus hubbsi*) and torrentfish (*Cheimarrichthys fosteri*) in two large New Zealand rivers. New Zealand Journal of Marine and Freshwater Research **43**.

Lewis, R. M., A. Bergeren, D. Armstrong, R. Boulton, and M. K. Joy. 2009. Artificial nest use to predict nest survival at reintroduction sites. New Zealand Journal of Ecology **33**.

Atkinson, N., and M. K. Joy. 2008. Response of Gobiomorphus hubbsi (bluegill bully) to odours of conspecific fish in the presence of natural stream odours: does habitat have an influence? New Zealand Journal of Marine and Freshwater Research **42**.

Olden, J. D., M. K. Joy, and R. G. Death. 2006. Rediscovering the species in community-wide predictive modeling. Ecological Applications **16**:1449-1460.

Low, M., M. K. Joy, and T. Makan. 2006. Using regression trees to predict patterns of male provisioning in the stitchbird (hihi). Animal Behaviour **71**:1057-1068.

Joy, M.K. & Death, R.G. (2004) Predictive modelling and spatial mapping of freshwater fish and decapod assemblages: an integrated GIS and neural network approach. *Freshwater Biology*, **49**, 1036-1052.

Joy, M.K. & Death, R.G. (2004) Application of the index of biotic integrity methodology to New Zealand freshwater fish communities. Environmental Management, **34**, 415-428.

Olden, J.D., Joy, M.K., & Death, R.G. (2004) An accurate comparison of methods for quantifying variable importance in artificial neural networks using simulated data. *Ecological Modelling*, **178**, 389-397.

Death, R.G. & Joy, M.K. (2004) Invertebrate community structure in streams of the Manawatu-Wanganui region, New Zealand: the roles of catchment versus reach scale influences. *Freshwater Biology*, **49**, 982-997.

Duignan, P. J., P. M. Hine, M. K. Joy, N. Gibbs, G. W. Jones, and C. Okeoma. 2003. Disease surveillance in freshwater fish from the lower North Island. Surveillance **30**:6-8.

Joy, M. K., and R. G. Death. 2003. Biological assessment of rivers in the Manawatu-Wanganui region of New Zealand using a predictive macroinvertebrate model. New Zealand Journal of Marine and Freshwater Research **33**:367-379.

Joy, M. K., and R. G. Death. 2003. Assessing biological integrity using freshwater fish and decapod habitat selection functions. Environmental Management **32**:747-759.

Joy, M. K., and R. G. Death. 2002. A discriminant analysis investigation of reference site fish assemblages in the Manawatu-Wanganui region, North Island, New Zealand. Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie **28**:319-322.

Joy, M. K., and R. G. Death. 2002. Predictive modelling of freshwater fish as a biomonitoring tool in New Zealand. Freshwater Biology **47**:2261-2275.

Joy, M. K., and R. G. Death. 2001. Control of freshwater fish and crayfish community structure in Taranaki, New Zealand: dams, diadromy or habitat structure? Freshwater Biology **46**:417-429.

Joy, M. K., and R. G. Death. 2000. Development and application of a predictive model of riverine fish community assemblages in the Taranaki region of the North Island, New Zealand. New Zealand Journal of Marine and Freshwater Research **34**:243-254.

Joy, M. K., and R. G. Death. 2000. Stream invertebrate communities of Campbell Island. Hydrobiologia **439**:115-124.

Joy, M. K., I. M. Henderson, and R. G. Death. 2000. Diadromy and longitudinal patterns of upstream penetration of freshwater fish in Taranaki, New Zealand. New Zealand Journal of Marine and Freshwater Research **34**:531-543.

Chapters in books

Joy, M. K. (2006). Fish in freshwaters. Pages 166-172 *in* B. Harvey and T. Harvey, editors. Waitakere Ranges. Waitakere Ranges Protection Society, Auckland.

Joy, M.K. & Death, R.G. (2005). Neural network modelling of freshwater fish and macro-crustacean assemblages for biological assessment in New Zealand. In *Modelling community structure in freshwater ecosystems* (eds S. Lek, M. Scardi, P.F.M. Verdonschot, J.P. Descy & Y.S. Park), pp. 518. Springer, Berlin Heidelberg New York.

Selected research/technical publications

Belgrave, M., A. Bennett, J. Millner, A. James, M. Joy, D. Belgrave, S. Gardiner, J. Procter, and J. Watson. 2008. RAUKAWA WATERWAYS AND ENVIRONMENTAL IMPACT. Massey University.

Rowe, D., K. Collier, C. Hatton, M. K. Joy, J. Maxted, S. Moore, M. Neale, S. Parkyn, N. Phillips, and J. Quinn. 2008. Stream Ecological Valuation (SEV): a method for scoring the ecological performance of Auckland streams and for quantifying environmental compensation =- 2nd edition.

James, A., and M. K. Joy. 2008. A preliminary assessment of potential barriers to fish migration in the Manawatu River catchment, North Island, New Zealand. "A report prepared for Horizons Regional Council, June 2008." - "Massey University, Foundation of Research, Science & Technology." - Includes bibliographical references (p. 120-121). EnviroLink Contract Ref: 437-HZLC45, Massey University.

Joy, M. K. (2008). A Fish Index of Biotic Integrity using quantile regressions Fish QIBI for the Auckland Region, Massey University.

Joy, M. K. (2007). A new fish Index of Biotic Integrity using Quantile regressions: the Fish QIBI for the Waikato Region.

Kelly, F., T. Champ, T. McDonnell, M. Kelly-Quinn, S. Harrison, A. Arbuthnott, P. Giller, M. Joy, K. McCarthy, P. Cullen, P. Jordan, D. Griffiths, and R. Rosell. 2007. Investigation of the Relationship between Fish Stocks, Ecological Quality Ratings (Q-Values), Environmental Factors and Degree of Eutrophication. ENVIRONMENTAL PROTECTION AGENCY, Dublin.

Rowe, D., Quinn, J.F., Collier, K., Hatton, C., Joy, M.K., Maxted, J., Moore, S.J., & Parkyn, S.M. (2005). Ecological valuation: a method for scoring the ecological performance of perennial Auckland streams, Rep. No. HAM2004-073. national Institute of Water and Atmospheric Research, Hamilton.

Joy, M.K. (2005). A fish Index of Biotic Integrity (IBI) for the Wellington Region. Massey University, Palmerston North.

Joy, M.K. (2005). A Fish Index of Biotic Integrity (IBI) for the Waikato Region. Massey University, Palmerston North.

Joy, M.K. (2005). Point-click-fish a predictive model of fish occurrence for the Hawkes Bay region. Centre for Ecosystem Modelling and Management; Massey University, Palmerston North.

Joy, M.K. (2004). A Predictive Bioassessment Model using Fish for Southern Ireland. Massey University, Palmerston North.

Joy, M.K. (2004). A Fish Index of Biotic Integrity (IBI) for the Auckland Region. Massey University, Palmerston North

Joy, M. K. 2002. Freshwater fish survey of the Wellington Region a report to the Wellington Region Council. Massey University, Palmerston North.

Joy, M. K. 2002. Freshwater fish survey of the Wellington Region: a report to the Wellington Regional Council. A report to the Wellington regional Council Massey University, Palmerston North.

Joy, M. K. 2002. Lake Pounui Fish Survey. A report prepared for the Wellington Regional Council Massey University, Palmerston North.

Joy, M. K., and R. G. Death. 2002. The potential for enhancement of fish communities of a fish pass on the Orongorongo Intake Dam. A report to the Wellington Regional Council. Massey University, Palmerston North.

Phillips, J., and M. K. Joy. 2002. Native fish in the Manawatu-Wanganui Region. State of Environment Report 2002/EXT/489, horizons.mw, Palmerston North.

Rebergen, A. R., and M. K. Joy. 1999. Freshwater fish survey of the Aorangi Range, Wairarapa. Department of Conservation, Masterton.

Joy, M. K. 1999. Freshwater fish in the upper Manawatu River: a contribution to a life supporting capacity study. A Report to the Manawatu-Wanganui Regional Council Massey University, Palmerston North.

Joy, M. K. 1999. Freshwater fish survey of the Manawatu dune lakes. A Report to the Manawatu-Wanganui Regional Council Massey University, Palmerston North.

Joy, M. K. 1999. Native Fish Diversity and Distribution in Selected Tributaries of the Oroua River: a contribution to a Study of the Life Supporting Capacity of the Oroua River. A Report to the Manawatu-Wanganui Regional Council Massey University, Palmerston North.

Joy, M. K. 1998. Freshwater fish diversity and distribution in the Ohakune area: a contribution to a study of the environmental impact of vegetable washing. A report to the Manawatu-Wanganui Regional Council Massey University, Palmerston North.

Joy, M. K. 1998. Native fish diversity in the Oroua River and tributaries: a contribution to a study of the life supporting capacity of the Oroua River. A report to the Department of Conservation and the Manawatu-Wanganui Regional Council.

Software

Joy, M.K. (2005) A Fish Index of Biotic Integrity (IBI) for the Wellington Region, Bioassessment software, Massey University Palmerston North.

Joy, M.K. and 2005 Point-click-fish. GIS predictive software for the Hawkes Bay Region New Zealand.

Joy, M.K. (2004) A Fish Index of Biotic Integrity (IBI) for the Auckland Region, Bioassessment software, Massey University Palmerston North.

Joy, M.K. and 2003 Point-click-fish. GIS predictive software for the Wellington Region Massey University New Zealand.

Selected addresses to professional bodies

Joy, M. K. 2008. State of the environment or state of denial; freshwaters in crisis. *At* Sustainable New Zealand: Rhetoric or Reality? ECO 2008 conference, Wellington.

Joy, M. K. 2007. Using Predictive models to assess the extent of freshwater fish habitat and biodiversity loss. *At* Water: an inconvenient truth; joint meeting of the New Zealand and Australian Freshwater Sciences Societies.

Joy, M.K. & Death, R.G. (2004) Using GIS and neural networks to create fish habitat suitability maps. *Presented at:* Fourth International Workshop on Environmental Applications of Machine Learning and the Fourth European Conference on Ecological Modelling, BIed, Slovenia

Joy, M.K. & Death, R.G. (2004) Application of the Index of Biotic Integrity to New Zealand freshwater fish communities. In 38th Annual Conference of the New Zealand Limnological Society, Waiheke Island, Auckland

Death, R.G. & Joy, M.K. (2004) Mapping distribution of freshwater fish and decapods in GIS: extending point samples to regional coverage. *Presented at:* Annual Conference of the North American Benthological Society, Vancouver, Canada

Joy, M. K., and R. G. Death. 2003. Using neural networks and GIS to predict the spatial occurrence of freshwater fish and decapods. *Presented at:* Ecological Society of Australia Conference. Armidale, NSW, Australia

Joy, M.K. & Death, R.G. (2003) Point-click-fish a predictive bioassessment modelling tool. *Presented at* The Australian Society for Fish Biology annual conference, Victoria University, Wellington New Zealand

Joy, M.K. & Death, R.G. (2002) Neural network modelling of freshwater fish and macro-crustacean assemblages for biological assessment in New Zealand. *Presented at:* 3rd Conference of the International Society for Ecological Informatics, Rome, Italy