BEFORE THE ENVIRONMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region.
between	**FEDERATED FARMERS OF NEW ZEALAND** **ENV-2010-WLG-000148**
and	**MERIDIAN ENERGY LTD** **ENV-2010-WLG-000149**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**PROPERTY RIGHTS IN NEW ZEALAND** **ENV-2010-WLG-000152**
and	**HORTICULTURE NEW ZEALAND** **ENV 2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157**
	Appellants
and	**MANAWATU-WANGANUI REGIONAL COUNCIL** *Respondent*

STATEMENT OF TECHNICAL EVIDENCE BY DR JOHN MARTIN QUINN ON THE TOPIC OF SUSTAINABLE LAND USE AND ACCELERATED EROSION ON BEHALF OF MANAWATU-WANGANUI REGIONAL COUNCIL

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horizons regional council

Solicitor: John W Maassen/Nicholas Jessen

Administrator: Barry Gilliland

Address: 11-15 Victoria Avenue
Private Bag 11025
Palmerston North 4442

Telephone: (06) 952 2800
Facsimile: (06) 952 2929
Email: barry.gilliland@horizons.govt.nz

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My qualifications/experience

1. My tertiary qualifications are a BSc (Hons) (First Class, Zoology major) from the University of Otago and a PhD from Massey University, where I wrote a thesis on the effects of wastewater discharges around Palmerston North on sewage fungus and water quality in the Manawatu River. My early professional experience involved 18 months as an advisor to the National Water and Soil Conservation Authority's Water Resources Council. For the last 26 years I have worked for NIWA and its predecessors as a research and consulting scientist. My main focus has been on the ecology of rivers in relation to the effects of a variety of human activities, including wastewater discharges, forestry and agricultural land use and riparian management. I have been involved in the National Rivers Water Quality Network since its establishment in 1989. I was an instigator of the Whatawhata Sustainable Land Management Project in 1996 and continue to research the effects on stream characteristics of changes, implemented in 2001, in landuse and management of this hill-land farm on stream water quality and ecology. I have led development of conceptual and predictive models of the links between land management practices and waterway values in each of the 5 "Dairy Best Practice Catchments". I have managed long-term studies on the effects of forest management practices (including the influence of riparian buffers) on Coromandel Peninsula streams since 1993. I led the development of the Riparian Management Classification. I have led NIWA research programmes on "River Ecosystems and Land Use Interactions" and currently lead NIWA's "Restoration of Aquatic Ecosystems" programme. I have published over 85 scientific papers in peer-reviewed journals or books and have written over 130 consulting reports. In 2003, I was awarded a Royal Society of New Zealand Science and Technology Bronze Medal for my contributions to river ecosystems research.

2. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Notes. I agree to comply with that code of conduct.

Scope of evidence

3. My evidence provides a brief overview of the scientific literature on the effects of riparian buffers on contaminant inputs to streams from rural land use. I focus on sediment because this is the key contaminant of concern in the Proposed One Plan Land Chapter, but also overview key findings on buffer effects on nutrient inputs and effects on stream habitat. I do not cover effects on terrestrial biodiversity, downstream flood control, recreation or aesthetics.

Riparian buffer Issue in the Proposed One Plan:

4. The Proposed One Plan as Amended by Decisions includes rules that preclude or seek to control land use activities that take place within the riparian zone. Council has circulated an amended version of the rules that it supports as relief to various appeals. The amended rule framework, which I have read, includes permitted activity rules for small and large scale land disturbance, cultivation and vegetation clearance. A common feature of those rules is that they each preclude activities:

   (a) within 0-5m of a lake, permanent river, or a river with an active bed with greater than 1m; or

   (b) within 0-10m of a wetland, a Schedule AB trout spawning site, or a Site of Significance Aquatic;

   unless permitted by a resource consent.

5. The 'managed' activity areas created by the Rules occur within the "Riparian zone", which is defined scientifically as "areas of direct interaction between land and surface water" (Gregory et al. 1991). Riparian "buffers" are areas of the riparian zone managed to reduce the effects of land use activities on surface water. The intimacy of the riparian zone and surface waters means that its management can have a disproportionately large influence relative to the area of land it occupies in the catchment on stream habitat (e.g. shade and associated temperature, instream plant growth, cover for fish, and input of leaf litter, wood and terrestrial food resources for fish), channel morphology, stream bank stability, and contaminant inputs (Lowrance et al. 1997). Consequently, riparian buffer management is applied widely overseas and

in New Zealand in forests and intensive agriculture areas (e.g. Parkyn et al. 2002 , Quinn, J.M. 2005) and is a key part of the toolkit for managing the effects of rural diffuse source pollution (McKergow et al. 2008, McKergow et al. 2007).

Overview of riparian buffer functions to protect aquatic biodiversity and water quality

6. Riparian buffers have the potential to protect aquatic values by:

(a) reducing soil disturbance in the area that is closest to the stream and therefore likely to result in contaminant input to surface water during runoff or flooding events;

(b) if appropriately fenced, preventing direct input of livestock excreta (and associated sediment, nutrients, pathogens and livestock medicinal residues) to the surface water and the riparian area, preventing livestock treading damage to the streambanks and riparian areas, avoiding compaction of riparian soils (reducing infiltration of runoff), and eliminating grazing damage to riparian vegetation and associated effects on stream bank stability, water quality and habitat functions (e.g. Belsky et al. 1999, Nguyen et al. 1998, Rutherfurd & Abernethy 1999, Trimble & Mendel 1995, Williamson 1994, Williamson et al. 1996);

(c) reducing input to surface water of contaminants in surface runoff (particularly sediment, associated nutrients and pathogens) by providing an area of dense vegetation and/or litter and uncompacted soils (encouraging infiltration) that enhance trapping of particulates via physical, chemical and biological processes of deposition, filtration, infiltration, precipitation adsorption, biochemical uptake and removal (e.g. Lowrance et al. 1997, Smith 1989, Yuan et al. 2009);

(d) reducing input to surface water of contaminants in shallow subsurface groundwater flow by enhancing plant uptake and microbial denitrification (e.g. Cooper 1990, Gilliam 1994, Groffman et al. 1996, Matheson et al. 2002);

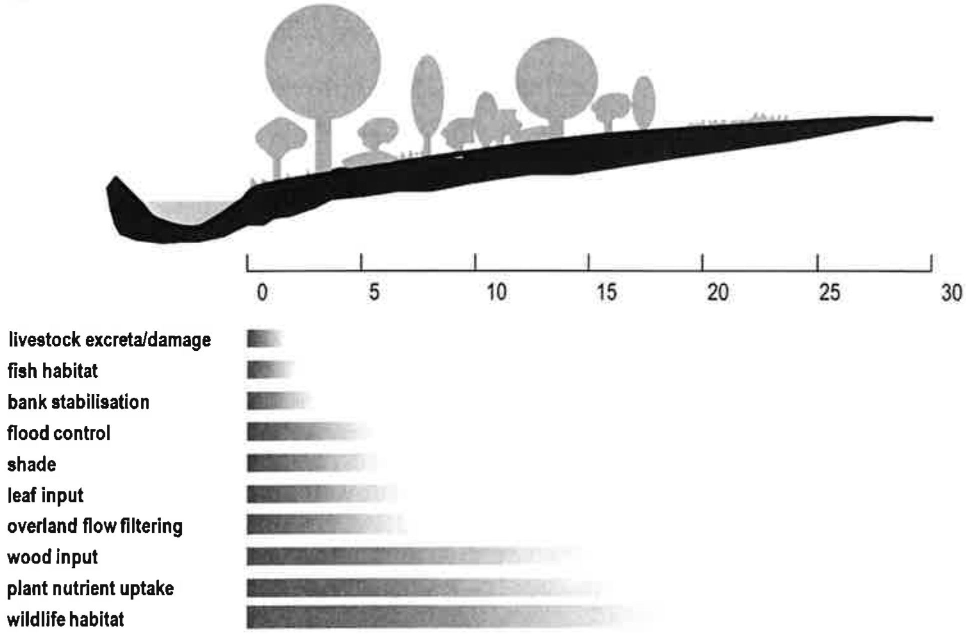
(e) if appropriately vegetated, providing stream and riparian habitat conditions that are similar to those in naturally vegetated catchments and so maintaining near natural conditions (e.g. of lighting, temperature, litter input, instream cover for fish) that enhance indigenous biodiversity (e.g. Boothroyd et al. 2004, Collier et al. 1995a, Jowett et al. 2009, Meleason & Quinn 2004, Quinn, J.M. et al. 2004, Quinn, J.M. et al. 2009, Quinn, J.M. et al. 1992, Rutherford et al. 1999).

(f) influencing the timing and duration of local and downstream flooding via the effects of vegetation type on the hydraulic roughness of floodplain areas inundated during floods. Sedges, shrubs and trees are stiffer and taller than grasses and can therefore slow the downstream passage of a flood wave, potentially reducing the peak flow/water level downstream (Anderson et al. 2006, Coon 1998).

Generalised influences of riparian buffer width on riparian functions

7. Different riparian functions have different optimal buffer widths that provide a compromise between benefits and land lost from traditional productive use. These widths are summarised in Figure 1, adapted from Dosskey (1997). These generalized optimal widths vary with site-specific factors such as stream width, stream bank height and shape, land slope angle and length. Riparian buffers often provide the best overall benefit in agricultural settings when vegetation is managed in tiers, with permanent woody vegetation along the stream margin, production woody vegetation on the landward side of this and a managed grass filter strip between the production trees and the agricultural land (e.g. Lowrance et al. 2000, Schultz et al. 1995).

8. Figure 1: Generalised widths to provide riparian functions



The effects of sediment loss into waterways.

9. Sediment loss to waterways is a natural process but accelerated levels of loss can degrade aquatic values in several ways (Clapcott et al. 2011, Ryan 1991, Waters 1995). Excessive sediment impacts including degradation of aesthetics (water clarity and deposits, (e.g. Davies-Colley, R. J. et al. 1993)), flood flow conveyance (via channel infilling), reservoir and estuary volume, water quality and biodiversity. Biodiversity is degraded via effects including reduced instream primary production due to light attenuation in the water column (e.g. Davies-Colley, R. J. et al. 1992), infilling of the hyporheic (within gravel) spaces with flow on effects to the hyporheic fauna (e.g. Boulton et al. 1997) and spawning habitat for some fish species, including trout, smothering of the streambed by sediment deposits (e.g. Clapcott et al. 2011, Matthaei et al. 2006, Sutherland et al. 2010), and reduced visibility for sight-feeding aquatic organisms (especially fish and birds). Some migratory fish species actively avoid turbid waters (Rowe et al. 2000). Sediment inputs to surface water can also convey varying levels of attached nutrients (particularly phosphorus), metals, pathogens and agrichemicals that may act as pollutants in their own right.

Factors influencing riparian buffer removal of sediment from surface runoff

10. As outlined above (Paragraph 6), riparian buffers can reduce input to surface water of sediment in surface runoff by via physical, chemical and biological processes of deposition, filtration, infiltration, precipitation adsorption, biochemical uptake and removal. This occurs by:

(a) dense vegetation and/or litter layers causing surface runoff to pond which allows time for particles to settle;

(b) rough vegetation creating a tortuous pathways with a large surface area of vegetation for particle trapping; and

(c) infiltration of runoff into riparian soils (hence decreasing runoff) if they are free-draining and unsaturated. (Yuan et al. 2009). The efficiency of sediment retention is also influenced by: the particle size of the suspended sediment (greater for coarse, heavy particles (e.g. sands) than fines (e.g. clays) (Lee et al. 2000); the rate of flow and sediment loading into the buffer; and the degree of flow channelization. Highly channelized flows (e.g. in rills) often pass through buffers with little attenuation, whereas diffuse sheet-flow provides opportunities for interaction with the ground cover vegetation, litter and soils that promotes sediment removal.

11. A recent review of international research on filter-strip buffers for sediment retention in agricultural landscapes (Yuan et al. 2009) found that removal efficiency increased with buffer width and decreased somewhat with land slope. This analysis found that the sediment trapping efficiency was at least 80% for all buffer widths of greater than approximately 5 m. Yuan et al. (2009) did not find strong evidence for differences between sediment removal efficiency of grass and forested buffers when comparisons were made over all studies reviewed. Buffers wider than 6 m had slightly greater (+ c. 12%) sediment removal efficiency than 4-6 m wide buffers and buffers on steeper slopes (> 5%) were slightly less (up to 10%) efficient than those on lower slopes (<5%).

12. The riparian guidelines produced by NIWA (Collier et al. 1995b) summarise the results of numerous computer simulations using a model, validated against a New Zealand dataset, to estimate the optimal width

(defined by the point of inflection of the removal efficiency vs buffer width plot) of a dense grass filter strip for sediment removal from surface runoff as a percentage of the slope length of the adjacent land (Appendix 1). The model estimates take into account hillslope angle, soil drainage and the clay content category. Estimates of sediment removal efficiency and optimal buffer width range widely. Removal efficiency is greatest (95%) and optimal buffer width least (1% of the hillslope length) for low slope (<7%) land with low clay content (<20%) topsoils. In contrast, under the worst-case scenario, where the hillslope is high (>20%), soil drainage low (<4 mm/h infiltration rate) and clay content high (>40%), the guidelines estimate an optimal filter width of 30% of the hillslope but that this would have only 20% sediment removal efficiency. These guidelines provide a method for estimating optimal buffer widths of dense grass vegetation and their likely sediment removal efficiencies.

13. The wider (10m) activity exclusion zones adjacent to particularly sensitive water bodies in the POP are justified because buffer efficiency at trapping sediment and other contaminants generally increases with buffer width (Yuan et al. 2009). Wetlands warrant a higher level of protection because historic land development has greatly reduced their extent in the Manawatu and they are prone to infilling with sediment. Trout spawning areas are also particularly sensitive to sedimentation because trout eggs are laid within the river bed (Alabaster & Lloyd 1980).

14. The setback rules in the POP will not necessarily result in development of effective riparian buffers. This will also require management of the land and vegetation within the setback areas so that livestock access is managed and suitable vegetation develops to provide the various potential ecosystem services of riparian buffers. Achieving this additional management is likely to require a mix of education and/or incentives (e.g., subsidies, planning assistance) and/or new practice requirements from industry and/or government. Livestock exclusion from surface waters is covered for most dairy farms by the Dairying and Clean Streams Accord, but this does not apply to dry stock farms that are predominant in the Manawatu Region and the Accord excludes livestock from the stream not the riparian area (so that land within 5 m of the stream could be grazed).

15. Active management of riparian buffers to enhance and maintain their protective functions for aquatic habitat and water quality may occasionally involve cultivation (e.g. to establish a grass filter strip with desirable species composition) and removal/replacement of overly mature woody vegetation (e.g. to maintain active nutrient uptake from groundwater). The POP rules will ensure that the Regional Council is informed of these activities, providing the opportunity for input of technical advice.

16. If the combination of the POP rules and other initiatives were to result in creation of 5m wide effective riparian grass filter strips (i.e. with dense grass similar to those where the research summarised above has been conducted) on permanent rivers (over 1m wide) and lakes, we could expect to see significantly reduced input of sediment to surface flow from surface runoff. The literature indicates this reduction could be up to 80% for well managed buffers, but modelling indicates the reduction will be lower as hillslope angle, length and clay content increase and soil infiltration decreases. The net effect on total sediment input will depend on the magnitude of other sediment sources, including streambank erosion, mass movements (landslides, mud flows, gully complexes), and runoff in flowpaths that by pass riparian areas such as from unsealed tracks and laneways, tile drains and rapid-flow channels.

17. Whilst establishing grass filter strips in the riparian zone will be effective in reducing sediment in overland flow, they will only produce fewer benefits for many other ecological values/services than the presence of shrub/tree vegetation. Long grass can increase bank stability, provide some cover habitat for fish, improve whitebait spawning habitat (Hickford & Schiel 2011), and provide some shading (particularly on small streams with channel less than 1 to 2m wide). However, shrubs and trees are needed in the riparian area to provide high levels of shade, natural forest litter and wood inputs, and hydraulic roughness that can reduce downstream flooding. The height of vegetation required to achieve effective shading increases with channel width (Davies-Colley, R.J. & Quinn 1998). Achieving a moderate-high level of stream shading through riparian vegetation is expected to reduce summer stream temperatures

and instream periphyton growth (Quinn, J.M. et al. 2009, Quinn, J.M. & Wright-Stow 2008), with flow on benefits to indigenous stream biota.

18. I conclude that establishment of effective riparian buffers throughout the rural areas of the Manawatu region would produce significant benefits for surface water quality aquatic habitat and indigenous biodiversity. The land use activity rules in the POP as amended by decisions provide part of the framework for development of effective riparian buffers by making cultivation, vegetation removal and land disturbance activities subject to setbacks within 5 to 10m of the edge of various surface water types. This will reduce major disturbances in the riparian area, raise awareness of the need to treat these areas carefully and provide a platform for related activities required for development of effective buffers.

Dr John Martin Quinn

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