BEFORE THE PROPOSED NATURAL RESOURCES PLAN HEARINGS PANEL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of maintenance of drains provisions

STATEMENT OF PRIMARY EVIDENCE OF MICHAEL GREER ON BEHALF OF WELLINGTON REGIONAL COUNCIL

TECHNICAL – IN REGARD TO PROVISIONS FOR MAINTENANCE OF DRAINS (RULE R121)

28 February 2018

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1. SUMMARY

1.1 My name is Michael John Crawshaw Greer.

1.2 I have been asked to provide technical evidence on the approach taken by the Wellington Regional Council (the Council) for the development of the rule for maintenance of drains (Rule R121) in the Proposed Natural Resources Plan (the proposed Plan).

1.3 My key conclusions are:

(a) The heavily modified watercourses that make up drainage networks are often thought to be of no ecological value because of their “unappealing” aesthetics, the often intensively developed state of the landscapes they flow through, and the fact that they are perceived as infrastructure rather than natural water courses. However, these waterways are important aquatic habitats, providing essential migratory corridors and permanent habitat to many native fish species, and supporting diverse and abundant invertebrate communities.

(b) In general, the waterways people perceive to be drains are not new man-made habitats. They are instead the highly modified form of what were, historically, much larger natural waterbodies. If the aquatic values that were historically supported in drained areas are to be preserved or restored, the protection of drains is required, as often they are the only remains of what were once thriving ecosystems.

(c) The multitude of effects of drain clearing and the ecological value of drains means that it is vital that the effects of this activity are managed through the provisions in the proposed Plan.

(d) Clause (f) could be improved by allowing for deepening and widening of the channel to construct artificial fish refuges.

(e) Clause (g) should be deleted as in some circumstances it may increase the environmental impacts of drain clearing without improving drainage.

(f) A requirement should be added to clause (h) to ensure that kākahi (freshwater mussels) are also recovered from the spoil after drain clearing.

(g) Clause (i) could be improved by ensuring that spoil removed from the bed is placed in a way that not only prevents it from re-entering the waterway, but also allows trapped fish and kōura to make their own way back to the stream.

(h) Clause (j) could be improved by providing alternatives to the partial clearance practices stipulated in the notified version of the proposed Plan. Specifically the retention of entirely un-cleared sections at regular intervals along the targeted reach and the installation of artificial refuge bays.

(i) Clause (k) could be improved by changing the wording to better reflect the intent of the clause, which is to minimise the downstream transport of sediment by leaving un-cleared sections of aquatic plants at the downstream end of cleared reaches. The clause could also be improved by allowing for a range of different methods to be used to trap sediment released during drain clearing works.

2. INTRODUCTION

2.1 My name is Michael John Crashaw Greer. I work for Council as a Senior Environmental Scientist in the Environmental Science Department.

2.2 I hold a PhD degree in Ecology and a Bachelor of Science in Zoology from the University of Otago. The title of my PhD is 'The effects of macrophyte control on freshwater fish communities and water quality in New Zealand streams'.

2.3 I have significant experience conducting research into the effects of drain maintenance on water quality and freshwater fish. My PhD research was focused exclusively on the topic of drain maintenance. Furthermore, I have published three peer reviewed journal articles on the effects of drain maintenance, and have contributed to the Department of Conservation's and Environment Canterbury's internal guidance documents for managing the effects of this activity.

2.4 I have worked for local government, the Department of Conservation and NIWA. I have over 6 years of work experience in freshwater ecology. As of the 28th of February 2018 I have been employed by the Greater Wellington Regional Council for 1 year. Prior to that I was employed by the Canterbury Regional Council as a Water Quality and Ecology Scientist (ii).

2.5 I have read the section 42A officers' reports prepared by Pam Guest on the drain maintenance provision in the proposed Plan.

2.6 My evidence relates to the approach taken by Council on the development of the rule for maintenance of drains (Rule R121)

3. CODE OF CONDUCT

3.1 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note and that I agree to comply with the code. My evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter to detract from the opinions which I express.

4. SCOPE

4.1 I have been asked to provide evidence on the following matters:

(a) The ecological value of the highly modified rivers and streams, often seen as drains, and the need to protect these systems through provisions in the proposed Plan;

(b) The reasons why drain maintenance is conducted;

(c) The effects of drain maintenance and the need for provisions in the proposed Plan to limit these effects;

(d) The technical basis behind the clauses of Rule R121 in the notified version of the proposed Plan; and

(e) How the clauses of Rule R121 could be improved.

4.2 Although the options that I consider take into account submissions received on the proposed Plan, my conclusions are limited to technical matters and I do not provided recommendations on policy

5. ECOLOGICAL VALUE OF DRAIN ECOSYSTEMS

5.1 The heavily modified watercourses that make up drainage networks are often thought to be of no ecological value because of their “unappealing” aesthetics, the often intensively developed state of the landscapes they flow through, and the fact that they are perceived as infrastructure rather than natural water courses. However, these waterways, commonly called drains, are important aquatic habitats. Drains increase connectivity within landscapes and provide important habitat for aquatic fauna (Colvin et al., 2009; Herzon & Helenius, 2008). The taxonomic richness of invertebrates and fish in drains is often comparable to nearby natural streams (P. D. Armitage, Blackburn, Winder, & Wright, 1994), and in some regions they contain a more diverse faunal assemblage than unmodified waterways (Simon & Travis, 2011). Drains are also used as refuges by fish and invertebrates that are declining or absent in natural water courses (Armitage et al., 2003; Gómez & Araujo, 2008; Killeen, 1998; Painter, 1998).

5.2 The majority of New Zealand’s migratory fish species use drains as corridors for movement between other important freshwater habitats and the sea, and these watercourses likely provide particularly important temporary habitats for eels and members of the whitebait (Galaxiid) family (Hudson & Harding, 2004). Drains also provide permanent fish habitat, particular where more natural habitats have been lost or degraded (Hudson & Harding, 2004). More than 20 native fish species have been found to utilise drains (Hudson & Harding, 2004) and they are particularly important to 'at risk' (Goodman et al., 2014) wetland species, like the giant kokopu (*Galaxias argenteus*) and brown mudfish (*Neochanna apoda*), as they often represent the only aquatic habitat available in catchments where wetlands have been extensively drained and converted to pasture.

5.3 Drains provide habitat for a wide range of aquatic invertebrate species. Invertebrate communities in drain ecosystems frequently contain over 30 species, often at high densities (Hudson & Harding, 2004). Communities are usually dominated by snails, worms and crustacean species, but can also include important taxa like caddisflies, damselflies, shrimp (*Paratya* sp.) and kōura (*Paranephrops* sp.) (Young et al., 2004).

5.4 Because drains are often thought of as man-made, it is assumed that if they were not constructed the habitat they provide would not exist and that even with regular human disturbance the mere existence of these waterways is actually having a positive environmental effect. However, most of the waterways referred to as drains are actually highly modified natural water courses, and represent the last remnants of historical wetland complexes or spring-fed streams. An example of this is provided in Figure 1. Figure 1A shows the historic extent of the Te Opai Lagoon area (c. 1961) near Lake Wairarapa, and Figure 1B depicts the drainage network that now exists in the area (2017). The differences between Figure 1A and Figure 1B clearly demonstrate that the drainage channels that are now found in the area are not new, man-made habitat, and do not represent an improvement upon what was historically there. They are instead the highly modified form of the natural lagoon. If the aquatic values that were historically supported in areas like Te Opai Lagoon are to be preserved or restored, the protection of drains is required, as often they are the only remains of what were once thriving ecosystems.

Figure 1: A) Aerial photograph taken in 1961 depicting the historic (pre-drainage) extent of open water in the Te Opai Lagoon area near Lake Wairarapa. B) Aerial photograph of the Te Opai Lagoon area post drainage (2017). The blue lines represent the drainage network

6. THE NEED FOR DRAIN MAINTENANCE

6.1 Proliferation of macrophytes (aquatic plants) and excessive sedimentation in unshaded, eutrophic, low-gradient streams is detrimental to agriculture, and aquatic plant and sediment management is common in New Zealand (Garner, Bass, & Collett, 1996; Hudson & Harding, 2004; Kaenel, 1998). In lowland areas the productivity of agricultural operations is dependent on the drainage capabilities of the surrounding waterways (Blann et al., 2009; Lalonde & Hughes-Games, 1997). Pasture growth is reduced in poorly drained areas (Schulte et al., 2006), and excess moisture must be removed from the soil quickly and efficiently to promote conditions that are favourable for agricultural production (Blann et al., 2009; Gibbs, 2006; Lalonde & Hughes-Games, 1997). Accelerated macrophyte growth associated with increased nutrient input and reduced shading, combined with excessive sedimentation can increase flow resistance within a waterway to the point that hydraulic capacity is reduced (Jones et al., 2012; Luhar et al., 2008; Wilcock et al., 1999). Elevated water tables in adjacent areas (Jones et al., 2008) then saturate the pasture increasing flood risk during periods of heavy rain or high flows (Hearne & Armitage, 1993; Kaenel, 1998). To maintain adequate drainage, macrophytes and sediment are regularly mechanically cleared from the streams that drain agricultural land (Hudson & Harding, 2004).

7. EFFECTS OF DRAIN MAINTENANCE AND THE NEED FOR MANAGEMENT

7.1 New Zealand studies have demonstrated that mechanical excavation of aquatic plants and sediment significantly reduce native fish abundance, and that the reasons for this are complex (Greer, 2014). It is generally believed that the removal of individuals with vegetation is the primary mechanism through which drain clearing effects fish and invertebrate populations. However, equally important is habitat loss and reduced water quality (increased sediment suspension and reduced dissolved oxygen concentrations).

7.2 During excavation of aquatic plants large numbers of fish and invertebrates are removed with the vegetation, and international studies indicate up to 20 percent of the fish population can be removed from the waterway (Serafy et al., 1994). Without human intervention the majority of stranded individuals die (Young et al., 2004).

7.3 Increased suspended sediment is also a major source of environmental damage following drain clearing (Greer, 2014; Greer et al., 2017). Until recently, it was thought that any increases in suspended sediment following drain clearing were temporary and the effects on aquatic ecosystems were minor (Brookes, 1988; Wilcock et al., 1998; Young et al., 2004). However, recent research conducted by myself and others (Greer et al., 2017) showed that this is not always the case. In that study, large amounts of fine sediment were re-suspended during drain clearing, resulting in a 120,000 percent increase in suspended sediment concentration (Greer et al., 2017). Furthermore, without plants to trap the sediment, suspended sediment concentrations remained elevated for more than two months (Greer et al., 2017). Although there have been no studies focused on quantifying the effect drain clearance has on sediment levels in the Wellington Region, it is reasonable to assume patterns in sediment suspension after drain clearing will reflect what has been observed in other regions.

7.4 Suspended sediment has a multitude of direct and indirect undesirable effects on freshwater fish populations. Feeding performance is impaired by reduced visibility (Greer et al., 2015; Hazelton & Grossman, 2009); the availability of key food sources (invertebrates and plants) are reduced (Davies-Colley et al., 1992; Quinn et al., 1992); and gill function is impaired (Lake & Hinch, 1999; Sutherland & Meyer, 2007). Sediment released during drain clearing can also have significant effects on downstream receiving environments. Fish and invertebrate habitat suitability may be reduced by re-suspended sediment settling out on the bed, and benthic fish and invertebrates may be smothered by the sediment and die (Ryan, 1991).

7.5 A major harmful effect of sediment suspension after drain clearing is de-oxygenation of the water. If sediment suspended by mechanical excavation has a large percentage of organic material or reduced compounds, dissolved oxygen in the water column may be depleted and large fish kills can occur. In the past I have recorded significant reductions in dissolved oxygen concentrations following drain clearing in Waikato Streams (Greer, 2014). This de-oxygenation was severe and persistent enough to kill most New Zealand fish species. In that study I also noted that large numbers of fish died after drain clearing in streams in both the Waikato and Southland regions. The risk of deoxygenation during drain clearing is likely to exist wherever bed sediments have a large organic component, and there is no reason to assume that it does not occur in some of the drains in the Wellington Region.

7.6 Habitat loss after drain clearing reduces the number and diversity of fish and invertebrate species. Aquatic plants play an important role in increasing habitat complexity in streams, and are utilised by fish for cover and spawning habitat (Greer et al., 2012; McDowall, 1990). Aquatic plants also increase the availability of invertebrate prey for fish (Collier et al., 1999). Excavation removes almost all of the plants from the waterway (Greer, 2014; Greer et al., 2012; Kaenel et al., 1998), causing native fish to leave excavated waterways (Greer et al., 2012). Drain clearing also smooths the sides and floor of the drain further reducing the range of available habitats. Although there have been no studies focused on quantifying the effect drain clearance has on habitat quality in the Wellington Region, it is reasonable to assume habitat loss after drain clearing will reflect what has been observed in other regions.

7.7 Given the multitude of effects of drain clearing (described in para. 7.1 to para. 7.6) and the ecological value of drains (described in Section 5), it is vital that the effects of this activity are managed through the provisions in the proposed Plan.

8. TECHNICAL BASIS FOR THE CLAUSES OF RULE R121

8.1 In this section I explain the rationale for the clauses of Rule R121 in the notified version of the Proposed Plan and identify any technical issues. In Section 9, I suggest amendments to address the identified issues.

Clause (e)

8.2 The sediment condition (g) of the general conditions for activities in the beds and lakes of rivers (Section 5.5.4 of the proposed Plan) was excluded from clause (e) of Rule R121, as it is extremely unlikely that it can be met during normal drain clearing operations. Extreme and persistent increases in suspended sediment are common side effects of drain clearing (para. 7.3). Therefore, inclusion of condition (g) of Section 5.5.4 would render the permitted activity status of drain clearing redundant. However, elevated sediment is clearly a significant issue associated with drain management and I consider that other conditions should be included in Rule R121 to ensure that as much sediment as possible is trapped and removed from the water course (refer to discussion of clauses (i) and (k) below.

Clause (f)

8.3 The purpose of clause (f) is to ensure that detrimental changes to the shape of the bed and banks are avoided. The removal of macrophytes and deposited sediment decreases water depth, increases current velocity and increases channel depth. However, repeated clearing can over widen and deepen channels, slowing water movement, and detrimentally altering the structure of aquatic habitat (Gibbs, 2006). Furthermore alterations to the shape of the beds and banks decreases bank stability, this increases the risk of bank collapse.

Clause (g)

8.4 The purpose of clause (g) is to reduce the rate at which fish and invertebrates are stranded during drain clearing. Weed rakes (rake type excavator buckets with a slatted back) allow fish and invertebrates caught in the spoil to escape back into the channel (Hudson & Harding, 2004). The use of these rakes is especially useful in waterways known to contain species like longfin eels that utilise plants for cover, or in areas where rare or threatened species are present.

8.5 It should be noted that weed rakes are inefficient at removing sediment and are not appropriate for use in operations where silt removal is a primary objective. Indeed, if large amounts of fine sediment are present in the channel, the use of a weed rake may actually be detrimental, because re-suspension of sediment will smother fish habitat, reduce clarity and deplete oxygen supply. Consequently, the use of weed rakes should be limited to gravel bed streams or drains with very little deposited fine sediment on the bed.

Clause (h)

8.6 The purpose of clause (h) is to reduce the mortality rates of fish and kōura removed from drains during clearing. Searching the banks for stranded fish and invertebrates and returning them to the waterway significantly reduces the population level effects of mechanical drain clearing (Hudson, 2005; Young et al., 2004). Fish and invertebrate recovery is particularly important in areas known to contain species like longfin eels that utilise aquatic plants for cover, and in areas where rare or threatened species are present. In waterways where high levels of silt are present, recovered fish should be returned upstream of the targeted section of waterway to ensure they are not subjected to lethal water quality conditions or recaptured by the excavator. Ideally fish should be returned to the water way immediately (or at the most within an hour of removal). Where this is not possible they should be placed into a tank of cool water so that they can be returned in an ‘unstressed’ condition by the end of the day.

Clause (i)

8.7 The purpose of clause (i) is to reduce the risk of the sediment removed from drains during clearing re-entering the waterway. Placing spoil away from the waterway prevents sediment removed by the excavator falling back into the channel during floods or re-entering through surface run-off (Barrett et al., 1998; Hudson, 2005; Madsen et al., 2001).

8.8 It is important to note that spoil should not be placed further from the waterway than is necessary to prevent re-entry, since this may reduce the number of stranded eels that are able to return themselves to the channel (see para. 9.4.)

Clause (j)

8.9 The purpose of clause (j) is to ensure that refuge areas are provided in cleared reaches, so that fish and invertebrates do not have leave in order to find cover. Plants provide important habitat for invertebrates and fish in soft bottomed streams, and maintaining part of the plant bed minimises the impacts of drain clearing on aquatic fauna (Greer, 2014; Greer et al., 2012). Where restoration of hydraulic capacity is of the utmost importance, refuges can be provided by limiting plant removal to one side, or just the center of the channel, so that a strip of vegetation is left along one or both banks. However, where high value species are present and full restoration of hydraulic capacity is not required, leaving entire sections of waterway undisturbed at regular intervals along the length of the channel is likely to be most beneficial (Greer et al., 2012).

Clause (k)

8.10 The purpose of clause (k) is to ensure that drain clearing is conducted in such a way that short sections of aquatic plants are left at the downstream end of cleared reaches to trap sediment. Plant material and the sediment retained within these sections can then be removed at the end of drain clearing operations in one go, thereby limiting the potential for downstream ecological effects caused by sediment. However, in the notified version of the proposed Plan, the wording of clause (k) does not align with its intent. Clearing in a downstream direction is logistically difficult, as it means there is limited visibility for the operator. Furthermore, it is not necessary to work in an upstream to downstream direction to provide natural sediment traps.

9. IMPROVEMENTS TO CLAUSES OF RULE R121

Clause (f)

9.1 In my opinion clause (f) could be improved by allowing for deepening and widening of the channel to allow construction of artificial fish refuge structures (see para 9.8 and para 9.9 for justification).

Clause (g)

9.2 In my opinion clause (g) should be deleted as, in some circumstances, it may lead to increased environmental impacts from drain clearing while limiting improvements to drainage. As stated in para. 8.4, weed rakes are inefficient at removing sediment and their use should be limited to gravel bed streams or drains with very little deposited fine sediment on the bed. As such, I consider that bucket selection should not be stipulated in the permitted activity conditions but be addressed as part an information programme to be implemented alongside Rule R121.

Clause (h)

9.3 In my opinion clause (h) should be amended to ensure that kākahi (freshwater mussels) are also recovered from spoil during drain clearing operations. These animals are an important component of aquatic ecosystems, are a valuable mahinga kai species and, being sedentary, are susceptible to being stranded during drain clearing (pers. comm. Greg Burrell)

Clause (i)

9.4 In my opinion clause (i) could be improved by ensuring that spoil removed from the bed is placed in a way that, not only prevents it from re-entering the waterway, but also allows trapped fish and kōura to make their own way back to the stream. Eels in particular are often able to make their own way back to the waterway from the spoil, provided it is deposited in the correct manner. To increase the chances of stranded eels returning to the waterway spoil should be placed the **minimum** distance from the waterway required to ensure it does not re-enter the channel during heavy rain (this will be dependent on bank gradient, maximum water height etc. and will likely need to be determined on a case by case basis). Spoil should also be spread evenly along the bank, not placed in discrete built up mounds (Barrett et al., 1998; Beentjes et al., 2005; MfE, 2001), and, if the bank is built up and sloped on both sides, be placed on the 'ridgeline' to encourage eels to move towards the waterway rather than adjacent dry areas (Barrett et al., 1998; Beentjes et al., 2005; MfE, 2001).

Clause (j)

9.5 In my opinion clause (j) could be improved by providing alternatives to the partial clearance practices stipulated in the notified version of the proposed Plan. The intent of clause (j) is to ensure that at least some refuge areas exist in cleared reaches post-excavation, and, in my opinion, this can be achieved through mechanisms other than clearing only one side or the middle of the drain. Additional methods of providing refuge areas that should be added to clause (j) are described in para 9.7 to para. 9.9.

9.6 The first method of retaining refuge areas that I consider to be appropriate for inclusion in clause (j) is the retention of entirely un-cleared sections at regular intervals along the targeted reach. This approach can significantly reduce the impacts of drain clearing on fish abundance, and there is evidence that it may actually improve habitat quality for certain fish species like giant kokopu, as it provides both the open water habitats they prefer to feed in and the plant cover they prefer to shelter in when they are not active (Greer et al., 2012).

9.7 Further research is needed to determine what proportion of the stream should be left undisturbed to significantly reduce the ecological effects of drain clearing. However, it is my opinion that, until scientifically robust guidelines become available, a clause stipulating that 10 m of stream should be left un-cleared every 200 m is appropriate. This would ensure:

- The retention of at least 5% of the available cover;

- That the distance between refuge areas does not exceed what species like giant kokopu can or will travel in a 24 hour period (Greer, 2014; Greer et al., 2012); and
- That the retained plants do not pose a significant hindrance to drainage.

9.8 The second method of retaining refuge areas that I consider to be appropriate for inclusion in clause (j) is the construction of fish refuge bays filled with artificial habitat (linked to clause (f)). Fish habitat lost during drain clearance can be replaced with artificial refuge structures made of PVC piping, concrete masonry unit or bogwood, and, in my experience, cover-loving species like giant kokopu may even prefer these structures to natural sources of cover such as macrophytes (unpublished radio-tracking data from Greer (2014)). Consequently, the presence of artificial refuge structures after drain clearing is likely to reduce the number of fish that leave, and allowing for the construction of these refuges in clause (j) may help minimise the effects of drain clearing.

9.9 Research into the design and benefits of artificial refuge structures in New Zealand is in its early stages, and further research is needed to establish optimal design criteria and installation rates. However, it is my opinion that, until scientifically robust guidelines become available, a clause stipulating that a refuge bay measuring at least 1m ×1m be installed every 200 m is appropriate. This would ensure:

- That the availability of in-stream cover is not reduced by 100%; and
- That the distance between refuge areas does not exceed what species like giant kokopu can or will travel in a 24 hour period (Greer, 2014; Greer et al., 2012).

Clause (k)

9.10 In my opinion clause (k) could be improved by changing the wording to better reflect the intent of the clause. The clause should simply stipulate that in order to minimise the potential for downstream sediment transport, an un-cleared section of aquatic plants should be left at the downstream end of cleared reaches until works have finished. In my opinion this is a far clearer approach than stipulating a direction of travel, which does not necessary guarantee effective sediment trapping (see para 8.10).

9.11 Further research is needed to determine the length of un-cleared stream required to significantly reduce downstream sediment transport. However, it is my opinion that, until scientifically robust guidelines become available, a requirement to retain an un-cleared section at least seven times the width of the watercourse is appropriate. This reflects the mixing zone definition in the proposed Plan, and will ensure that the potential for natural sediment traps to reduce sediment concentrations downstream of this zone is maximised.

9.12 Clause (k) could also be improved by allowing for a range of different methods to be used to trap sediment released during drain clearing operations. As the intent of the clause is to minimise the downstream transport of sediment, it is my opinion that, in addition to natural sediment traps, it should also allow for the installation of artificial sediment retention devices, such as filter fabrics, straw bales or constructed sediment traps. The use of these devices has also been recommended in a number of existing good management practice documents (Gibbs, 2006; Hudson, 2005; MfE, 2001).

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