BEFORE WAIKATO REGIONAL COUNCIL
HEARINGS PANEL

UNDER	the Resource Management Act 1991 (**RMA**)
IN THE MATTER OF	Proposed Plan Change 1 to the Waikato Regional Plan and Variation 1 to that Proposed Plan Change: Waikato and Waipa River Catchments

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REBECCA SYLVIA EIVERS

PRIMARY EVIDENCE ON BEHALF OF THE AUCKLAND/WAIKATO & EASTERN REGION FISH AND GAME COUNCILS ("FISH & GAME")

SUBMITTER ID: 74985

Hearing Block 2

Dated: 3 May 2019

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1. QUALIFICATIONS AND EXPERIENCE

1.1 My full name is Rebecca Sylvia Eivers.

1.2 I am employed as Water Quality and Wetland Scientist for Streamlined Environmental Ltd. I have been in this role since June 2018.

1.3 I have a BSc (Psychology and Zoology, 2001) and an MSc (Hons – First Class, Environmental Science, 2006) from the University of Canterbury, and a PhD from The University of Waikato (2018). My masters' thesis was entitled "The response of stream ecosystems to riparian buffer width and vegetative composition in exotic plantation forests", and my PhD thesis "Constructed treatment wetlands: Tools to attenuate diffuse agricultural pollution and enhance the biodiversity of eutrophic peat lake ecosystems".

1.4 I have 15 years' experience in New Zealand and the United Kingdom as a freshwater ecologist and scientist working in stream, wetland and lake environments focusing on freshwater resource management issues.

1.5 I have a comprehensive understanding of water quality impacts on ecological health, biodiversity and ecosystem resilience, particularly regarding macroinvertebrate, fish and zooplankton communities.

1.6 Prior to working for Streamlined Environmental I worked for the Waikato Regional Council as Wetland Scientist.

1.7 I am a member of the New Zealand Freshwater Sciences Society, the National Wetland Trust, and the international Society of Wetland Scientists. I am a past member of the Lake Ecosystem Research New Zealand (LERNZ) group, and the New Zealand Ecological Society.

1.8 I have expert knowledge of land use impacts on water quality, sources of contaminants (nitrogen, phosphorus, sediment, heavy metals and pathogens) as well as transport mechanisms and pathways.

1.9 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.

1.10 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.

2 SUMMARY STATEMENT

2.1 I provide comment on ambiguities within Policy 1 of PC1. While I generally support Policy 2, I understand the detail of FEP's is to be the subject of further hearing processes.

2.2 In relation to the definition of "low", "medium" and "high" contaminant discharge or intensity of farming (the terminology differs in Policy 1 as compared to the relevant rules), in my opinion it is the *risk* of contaminant discharge from activities that PC 1 should focus on. This is related to the identification of "critical source areas", as well as matters identified by the Officers, such as stocking rates and the type of grazing. For this purpose, I provide a proposed list of High risk activities, stock behaviour and infrastructure ("Grade A"), as well as a list of activities that are moderate to low risk and would need to be undertaken 10 metres or further from a watercourse ("Grade B").

2.3 For setbacks for stock exclusion, I consider these are essential for the reasons set out in my evidence. I recommend a setback of a minimum of 5 metres from watercourses, except for intermittent artifical watercourses with a channel width of ≤ 1 m. For these smaller artifical watercourses, I accept the Officer's recommendation of a 1 metre setback.

2.4 I note that the Director-General of Conservation's witnesses recommend larger setbacks, particularly for more significant waterbodies, and I agree that may be required.

2.5 I consider it essential that clarity is provided to landowners on where the distance is to be measured from, because the layperson's understanding of the "bed" differs from the RMA/planning definition of "bed". It must be clear that the "bed" encompasses the wider area which is subject to indundation from time to time. This area, called the lower floodplain zone, is important for the lifecycle stages of native migratory galaxiid fish species, including inanga in particular. A narrower interpretation could have signfiicant adverse implications for the effectiveness of the fencing (including for the landowner, if fencing is taken-out in flood events).

3 SCOPE OF EVIDENCE

3.1 I have been asked to provide evidence on matters being addressed in Block 2 of the proposed Waikato Regional Plan Change 1, regarding:

- o Diffuse discharge management; and
- o Setbacks for stock exclusion.

3.2 I have considered the following key documents in preparing this evidence:

- Proposed Plan Change 1 ("PC1");
- Section 42A Officer's Report for Block 2 and appendices;
- Vision and Strategy for the Waikato River;
- Fish and Game's original submission, submission on Variation 1 and further submission.

4 EFFECTIVE MANAGEMENT OF DIFFUSE DISCHARGES

4.1 The management and reduction of diffuse discharges of nitrogen (N), phosphorus (P), and sediment is critical to protecting and restoring the aquatic ecosystems and health of the Waikato and Waipā river catchments, inclusive of all connected streams, rivers, lakes and wetlands.

4.2 The management and reduction of diffuse discharges of microbial pathogens such as *Escherichia coli* (*E. coli*) is crucial to achieving freshwater objectives with values pertaining to mahinga kai, swimability, contact recreation and human health, as required by the Vision and Strategy for the Waikato River, and the National Policy Statement for Freshwater Management (MfE, 2014).

4.3 Policy 1 of PC 1 refers to farming activities with "low", "moderate" and "high" levels of contaminant discharge to waterbodies. I understand that these "levels" are further defined in the rules (which refer to intensities of farming).

4.4 PC 1 also refers to the 75th percentile nitrogen leaching value. My evidence does not comment on that matter. (Ms Marr's evidence deals with issues related to the diffuse discharge of nitrogen including provision for a Nitrogen Reference Point "NRP").

4.5 Clauses b2, b3 and b4 of Policy 1[1] are open-ended, vague and require further specification. I consider that clauses b3 and b4 require clarity on the level of permissible contaminant discharge associated with the land uses. This is further discussed by Ms Marr. In relation to clause b2, it is entirely unclear what controls would be included in a resource consent if good management practices are *not* occurring, and why this would be acceptable.

4.6 I strongly support the use of FEPs and I understand the content of FEPs is to be the subject of further hearing processes. In the meantime, I recommend the following changes to Policy 2 (noting that Fish & Game intends to make further comments on the relationship between FEPs and the nitrogen 'allowance'):

> *"a. Take a tailored and risk based approach to define <u>management</u> ~~mitigation~~ actions on the land that will reduce <u>or mitigate</u> diffuse discharges of nitrogen, phosphorus, sediment and microbial pathogens.".*

4.7 That is, "<u>management actions</u>" should be defined to reduce or "mitigate" diffuse discharges, as opposed to the reference to "mitigation actions".

4.8 The rules provide for:

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[1] b2 *"Where Good Farming Practices are not adopted, to specify controls in a resource consent that ensures contaminant losses will be reducing".*
b3 *"Except as provided for in Policies [1(a) and] Policy 16, generally granting only those land use and discharge consent applications that demonstrate clear and enduring reductions in diffuse discharges of nitrogen, phosphorus, sediment and microbial pathogens."*
b4 *"Except as provided for in Policies [1(a) and] Policy 16, generally not granting land use consent applications that involve a change in the use of the land, or an increase in the intensity of the use of land, unless the application demonstrates clear and enduring reductions in diffuse discharges of nitrogen, phosphorus, sediment and microbial pathogens".*

- Permitted activity rule 3.11.5.2 “Low intensity farming”;
- Controlled activity rule 3.11.5.2A (Option) “Medium intensity farming”; and
- Other.

4.9 The definition of “Low intensity” farming, for the purposes of Rule 3.11.5.2, includes:

- 2A “*The farming activities do not form part of an enterprise*”;
- 2B “*No commercial vegetable production occurs*”;
- 2C “*No dairy farming or grazing of cattle occurs*”;
- 2D *“No feedlots or sacrifice paddocks are used on the property”*; and
- 2E “*No more than 5% of the land used for farming is used for cropping, including winter forage crops*”.

4.10 Where the property area is greater than 20ha, additional requirements are (*inter alia*):

- the stocking rate is less than 6 stock units per ha;
- the only farming activity is the raising, trainig or housing of horses; or
- the stocking rate of the land is less than 6 stock units but less than 10 stock units per ha, no part of the property over 15 degrees slope is cultivated and no part of the property over xx[2] degrees slope is grazed and no winter forage crops are grazed *in situ*.

4.11 (The provisions regarding stock access to waterways is discussed further in a separate section of my evidence).

4.12 The Officer’s recommendations are intended to encapsulate farming activities with a lower *risk* of discharge. In my opinion it is the *risk* of

[2] Number not stated in the Officers Report.

contaminant discharge from farming activities that the provisions of PC 1 should focus on and this risk factor, should be more clearly specified.

4.13 While I recognise that there is a desire for certainty, there is an inherent difficulty in accurately and meaningfully defining “low”, “medium” and “high”, owing to well documented wide-ranging spatial and temporal variability in diffuse contaminant discharges associated with farming activities (Eivers et al. submitted, Glendell et al. 2014, Flávio et al. 2017).

4.14 In my opinion an essential element of risk is absent from the current provisions. I agree with the inclusion of dairy grazing as a factor creating a higher risk of contaminant discharge. For the other matters, a broader reference to the risk from “critical sources areas” is required.

4.15 The Land and Water Forum (LAWF) Fourth Report defined a critical source area as:

> *“An area that accounts for the majority of contaminant (e.g. N, P, sediment, E. coli) loss from a field, farm or catchment despite occupying a minority of the field, farm or catchment’s area.”*

4.16 A condition which captures *all* variants of critical source areas would be clearer and more effective than listing various farming activities with a high risk of contaminant discharge, such as those specified in clauses 2D and 2E above.

4.17 Irrespective of the type of livestock, the size of the farm, the number of stock units, nitrogen reference point, or fertiliser and feed use, *critical source areas* are ubiquitous within farming and (depending on their level of intensity or risk) require deliberate and active management to both minimise the generation of contaminants, and their subsequent transport to water.

4.18 A schedule defining and grading critical source areas would provide clarity of the types of farming activities, infrastructure and stock behaviour that create such areas.

4.19 The following “Grade A” items, involve activities, stock behaviour and infrastructure with known and agreed ‘high risk’ of contaminant discharges:

Grade A - High Risk CSA:

- Effluent ponds
- Effluent irrigation
- Feed pads
- Stand-off pads
- Feed storage areas, including pits for *in situ* silage and imported feeds
- Fertiliser storage pits
- Raceways
- Sacrifice paddocks
- Winter forage crops grazed *in situ*
- Break-feeding
- Crop cultivation

4.20 The following ‘Grade B’ items refer to those activities with moderate to low risk:

Grade B – Moderate-Low risk CSA:

- Feed storage areas, including hay barns, wrapped silage stacks, and grain silos
- Holding pens or paddocks
- Stock yards
- Water troughs (refer Figure 1)
- Mobile feed wagons (refer Figure 2)
- Shade trees (refer Figure 3)
- Summer and autumn forage crops grazed *in situ*

4.21 These ‘Grade B’ activities should be a minimum distance of 10 m from waterbodies, including artifical drains, overland flow paths, small wetlands, seeps, and intermittent streams.

4.22 Some of these activities are illustrated in the below Figures:

Figure 1. Critical source areas associated with water troughs (white circles) less than 5 m from a watercourse along the edge of a raceway.

Figure 2. Critical source area associated with a mobile feed waggon (white circle). Note its proximity is less than 5 m from an intermittent watercourse.

Figure 3. Shade tree on the edge of a watercourse in a paddock grazed by cattle. Note the high concentration of cattle faeces or cow pats (white circles).

4.23 Including a Schedule of Critical Source Areas would be an effective mechanism for educating land owners, making it clearer and simpler for farmers to understand:

- the water quality and ecological impacts of particular farming activities, infrastructure and stock behaviours; and
- the corresponding management actions required to avoid, minimise or mitigate the adverse effects of such activities on aquatic life.

4.24 In this respect, the Officers noted a number of submissions seeking standardised 'minimum practices' or actions for lower risk activities.[3]

5 STOCK EXCLUSION, SETBACKS, AND RIPARIAN BUFFERS

5.1 I strongly support the requirement to exclude cattle, horses, deer and pigs from waterbodies.

5.2 Bank erosion along the tributaries to the Waikato and Waipā Rivers, including artificial and modified watercourses, is known to be a significant source of sediment (Ritchie 2011). The majority of sediment delivery occurs during heavy rain storm events and *via* overland flow

[3] Section 42A Report at [365].

paths (Sherriff et al., 2016). Fencing setbacks to exclude stock from the mid and upper banks of watercourses, is essential to avoid the impacts of pugging, bank slumping, erosion and defecating in a sensitive environment, and to allow for the establishment and protection of riparian plants.

5.3 Riparian zones are an integral part of the ecosystem of watercourses and waterbodies, defined as the area where direct interaction between land and water occurs (Gregory et al. 1991, Naiman and Décamps 1997). Interactions include shading of the water by riparian vegetation, inundation of vegetation by water at normal high flows, provision of spawning habitat for aquatic invertebrate and fish biota, inputs of small wood and leaf litter as food resources, and inputs of large woody debris providing in-stream habitat as cover and shelter (Harding et al. 2009).

5.4 Riparian zones are also referred to as riparian "buffers" owing to the protective effect these areas can have on adjacent watercourses and waterbodies. It is well known that, relative to their proportion of cover in an entire catchment, riparian buffers have a disproportionately large influence on stream water quality and habitat (Harding et al. 2009). This is due to their immediate proximity to the stream, river, lake or wetland, and their function in reducing contaminant inputs from the broader landscape.

5.5 Accordingly, efforts to protect, establish and restore riparian buffers are critical to improving and maintaining the water quality and health of aquatic ecosystems, and should thus be included, or at least provided for, in PC 1.

5.6 All waterbodies need to be considered for stock exclusion and provision of riparian buffers, including intermittent and permanent streams, rivers, lakes and wetlands, inclusive of small headwater streams and seeps.

5.7 Moreover, livestock other than cattle, horses, deer and pigs can augment 'critical source areas' through trampling, causing slumping and erosion of stream banks, pugging of wet areas, direct impacts of grazing on vegetation in riparian and wetland areas, indirect damage on vegetation due to 'camping', and through inputting nutrients and microbial pathogens from stock defecating. As such, the exclusion of other stock from waterbodies should be considered, at least in the context of the FEP and PA rules, including sheep, goats, alpacas, llamas, donkeys, and ponies.

Intermittent Streams

5.8 The Officer's Report states:[4]

> *"Excluding cattle, horses, deer and pigs from intermittently flowing waterways was considered during the development of PC1, however it was considered impracticable, given the drawbacks of enforcing compliance. Instead, it was considered appropriate to include the consideration of stock exclusion from intermittently flowing waterways through the FEP process. Officers are of the view that there are many waterbodies that may flow for almost all of the year that ought to have stock access limited."*

5.9 Intermittent streams, small wetlands and seeps are characteristically wet with standing or flowing water during the rainy seasons of late autumn, winter and spring. During the drier months of summer and early autumn, these environments are typically damp, creating favourable conditions for prolific growth of herbaceous plant species, often highly palatable to stock (Kauffman and Krueger 1984). Grazing and camping in these areas by livestock can lead to increased contaminant generation and subsequent discharges of nutrients, sediment and *E. coli* to downstream waterbodies during heavy rain events (Collins 2004, Sunohara et al. 2012, McKergow et al. 2012).

5.10 Intermittent waterways, small wetlands and seeps are frequently key vectors of contaminant runoff to permanent waterbodies as they are routinely inappropriately managed by farmers and treated as though they do not exist. Figure 4 and Figure 5 clearly demonstrate this oversight, and signify the importance of stock exclusion from (and prohibiting forage crops from being planted across) intermittent waterways, small wetlands and seeps.

[4] At [897].

Figure 4. Direct discharge of contaminants to a permanent stream via and ephemeral watercourse (Image c/o Dr Adam Daniel).

Figure 5. Severe pugging causing sediment, nutrient and faecal matter contamination of an ephemeral watercourse due to inappropriate planting and grazing of forage crops.

5.11 The severity of land use impact on the watercourses in Figures 4 and 5 relates to the intensity of land use, associated with grazing forage crops *in situ* as well as break-feeding, without a setback from the stream/wetland seep.

5.12 I therefore agree with the Officers that the existing phrasing *"continually contains"* is problematic. However I also consider the attempt to define 'more significant' intermittent watercourses as problematic, and do not agree with the proposed wording in "Option to add".[5] For example, the watercourse shown in Figures 4 and 5 is likely a spring-fed seepage wetland, running as a small stream during wetter seasons.[6] The watercourse in its currently impacted condition wouldn't meet the Officer's definition of an intermittent stream, and doesn't resemble a small wetland, therefore could be overlooked.

5.13 Small, shallow streams and artificial watercourses are also more inclined to cooling as a result of riparian planting (Gibbs 2007), therefore focussing efforts to fence and plant these often intermittent tributaries should be prioritised.

5.14 Provisions for the management of intermittent watercourses, small wetlands and seeps must be included in PC1, given the significant adverse effects on aquatic life associated with poor and inappropriate use and management of these environments which cause them to become critical source areas. In my opinion it is therefore crucial that intermittent streams, small wetlands and seeps are included as waterbodies in Schedule C of PC1 *"Stock Exclusion"*.

Setback distance

5.15 The Officer's Report proposes that Schedule C (clauses 1 and 2) would be as follows:

> *"1. The water bodies <u>on land with a slope of up to X</u> degrees must be fenced to exclude cattle, horses, deer and pigs, unless those animals are prevented from entering the bed of the water body by stock proof natural <u>or constructed</u> barrier formed by topography or vegetation.*

[5] Currently includes:
"a. The bed of a river (including any stream and modified river or stream) or artificial watercourse that is permanently or intermittently flowing [OPTION TO ADD and where the bed is predominantly unvegetated and comprises exposed fine sediment, sand, gravel, boulders or similar material or aquatic vegetation]; and
b. The bed of any lake; and
c. Any wetland, including a constructed wetland."

[6] This can be deduced by taking account of the flowing water despite the small catchment size and fine weather.

2. New temporary, permanent or virtual fences installed after 22 October 2016 must be located to ensure cattle, horses, deer and pigs will be excluded from the bed of the water body. The fences must be located at a distance of not less than ~~cannot be within one metre of the water body (excluding constructed wetlands)~~:

a. 1 metre from the outer edge of the bed for land with a slope of less than 15 degrees; and

b. 3 metres from the outer edge of the bed for land with a slope between 15 and 25 degrees; and

c. 10 metres from the outer edge of the bed for artificial or modified watercourses that are the full responsibility of a territorial authority or Waikato Regional Council for maintenance purposes.

5.16 I do not agree that the setback should be differentiated based on slope as is proposed in these provisions. Watercourses are typically largest at the bottom of catchments where adjacent slopes are frequently less than 15 degrees. A 1 metre setback setback distance will not be sufficient for large watercourses, and notably tidally influenced watercourses where the protection of spawning areas for inanga is of significant importance (Holmes et al. 2016).

5.17 Allowing space for riparian buffers to be developed, either *via* natural succession or active planting, is required. The enduring benefits of riparian buffers and the associated ecosystem services must be considered, particularly in balance with the initial economic costs associated with fencing and planting (Gregory et al. 1991, Daigneault et al. 2017).

5.18 Fencing will be ineffective and inefficient where setbacks are too close to the channel and/or in the floodplain, and are likely to be damaged in flood events, which are expected to be more frequent and severe due to climate change impacts.

5.19 For these reasons, I recommend a setback of a minimum of 5 metres from watercourses, except for intermittent artifical watercourses with a channel width of ≤ 1 m. For these intermittent artifical watercourses, I accept the Officer's recommendation of a 1 metre setback (the approriateness and suitability of which is demonstrated in Figure 6).

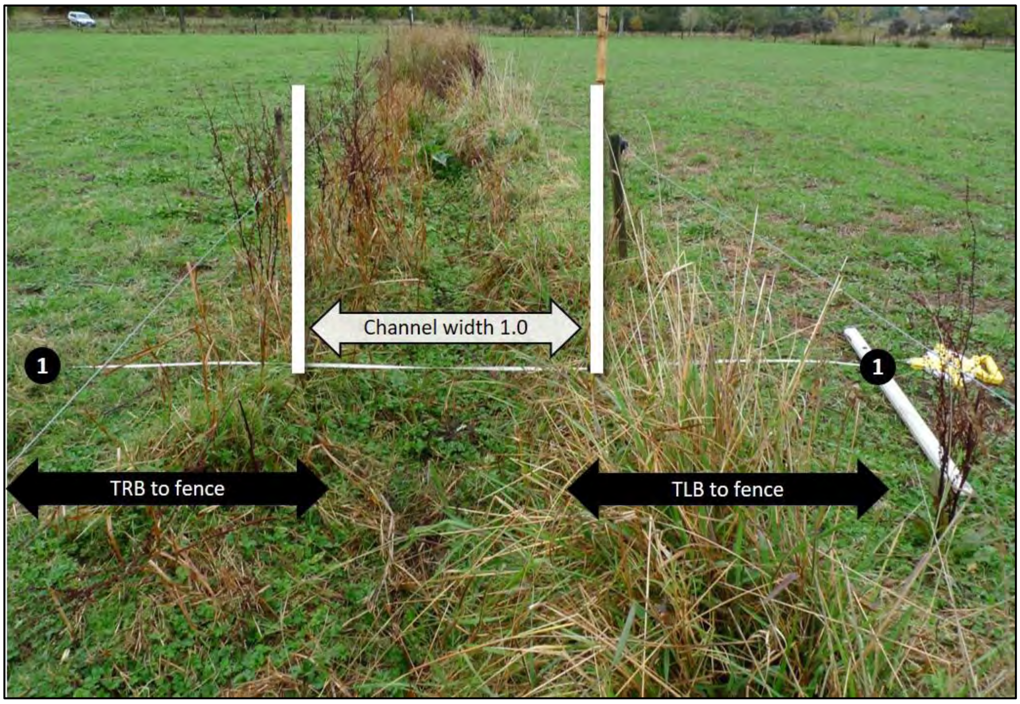

Figure 6. Site 1, an example of an intermittent artificial watercourse with adjacent slope less than 15 degrees. The channel width and distances from the edge of the bed (vertical white lines) to the PC1 proposed fence (1 m setback, black circles) on the True Left Bank (TLB) and the True Right Bank (TRB) are given in meters.

5.20 For clarification, intermittent artificial watercourses typically exist to facilitate drainage of agricultural land in areas that have high water tables and/or poorly drained soils which become problematic during wetter months. They do not have natural catchments and prior to drainage and cultivation for agriculture, would have existed as wetlands.

5.21 I note that the Director-General of Conservation's witnesses recommend larger setbacks, particularly for more significant waterbodies, and I agree that may be required.

5.22 I have been advised that the definition of "bed" of a watercourse, under the RMA, includes reference to the banks of the watercourse and "*the space of land which the waters of the river cover at its fullest flow*". Although this excludes areas alongside a river which occasionally flood in extreme events,[7] it does include a consideration of the river's fullest usual flow in the ordinary course of events.

5.23 This definition issue is very important because the lower floodplains of a river or stream can provide spawning habitat (by "floodplains" here, I refer to the area intermittently covered by flow during river cycles in the course of an ordinary year). These floodplain areas are crucial areas for spawning, enabling the full life cycle of native diadromous galaxiids, our whitebait species, including *Galaxias argenteus* (giant kokopu), *G. brevipinnis* (koaro), *G. fasciatus* (banded kokopu), *G. maculatus* (inanga), and *G. postvectis* (shortjaw kokopu), (McDowall 2000).

5.24 Therefore I consider that setbacks should be a minimum of 5 metres from the outer edge of the bed (regardless of the slope of the land) provided it is clarified to landowners what the "*outer edge of the bed*" means. Without clarification, landowners will have difficulty decyphering where the fence setbacks should be taken from. Inclusion of the wider bed in the definition from which the setback is to be measured, is critical.

5.25 The cross-sectional profiles of watercourses vary broadly with topography, location within a catchment (upper or lower), the source of flow, and the size of the watercourse (Harding et al. 2009). Five typical valley and stream cross-sectional profiles are described in the 'Stream Habitat Assessment Protocols for Wadeable Rivers and Streams in New Zealand', reproduced below in Figure 7. Further, the profile of a watercourse (excluding artificial drains and modified watercourses) varies along reaches, or sections, of the watercourse due to different instream habitats including runs, pools and riffles (Figure 8).

[7] Distinguishing the bed from the 'margins' or 'floodplains' that might surround a river: *Dewhirst Land Co Ltd v Canterbury Regional Council* [2018] NZHC 3338 at [40] – [42]:
"*… to make sense of this s 2 definition of river "bed" in light of the context and purpose of the provision, the words 'usual or non-flood' would need to be implied and added before the words 'fullest flow'. …*
[41] As I see it, this means that implied into the words used in the existing provision 'fullest flow' is the notion that this means the river's fullest usual flow over a reasonable period of years of river activity cycles, and not including flood waters that would flow onto the margins and flood plain adjacent to the river.
[42] Therefore, in scrutinising where those river banks with usual flow would lie, a reasonable visual observation and a consideration of the river's natural character and the riverine qualities of the river bed would be required as part of the exercise."

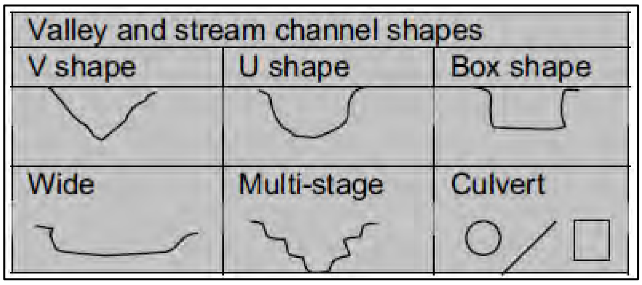

Figure 7. Valley and stream channel shapes or cross-sections typical of watercourses in New Zealand; reproduced from Harding et al. (2009).

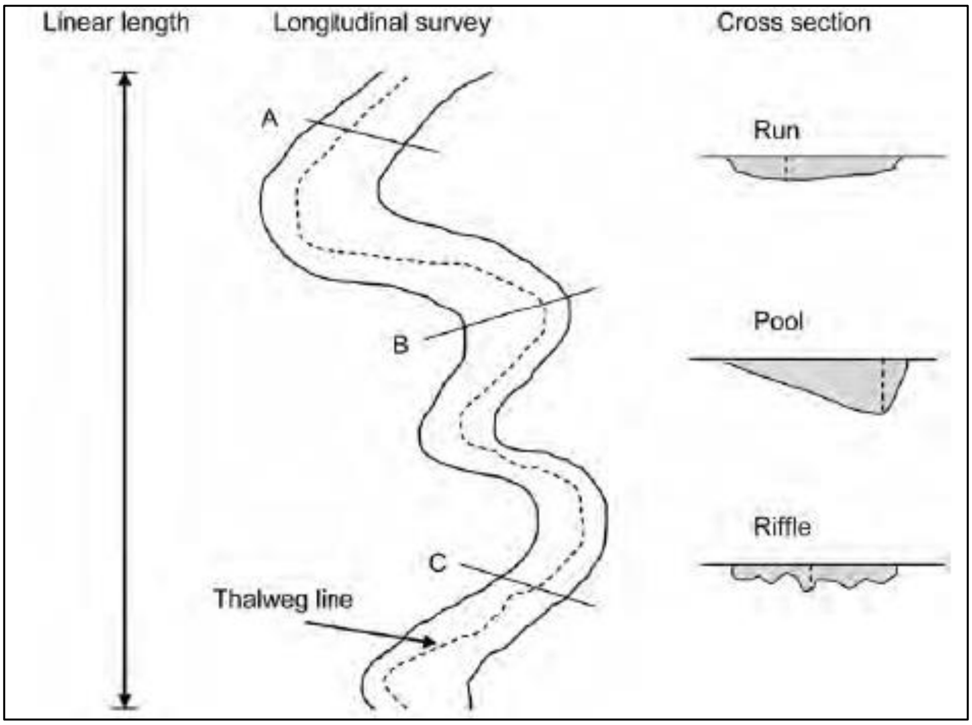

Figure 8. An example of the longitudinal variability of run, pool, and riffle stream habitat cross-sections down a watercourse; reproduced from Harding et al. (2009)

5.26 I am concerned that if the matter is not clarified, the point at which the distance is measured from will be highly variable amongst farms and, as stated, this is a significant issue for the life cycle stages of some (indigenous) fish.

5.27 Figures 9 and 10 below show examples of small and large tidally influenced watercourses with lower floodplains suitable for spawning habitat, particularly for inanga.

Figure 9. Site 2, an example of a SMALL permanent, tidally influenced watercourse with adjacent slope less than 15 degrees. The crest of the upper banks (grey circles), and the <u>recommended 1 m setback</u> from the crest of the upper banks (white dashed line) are shown. The cross-hatching indicates areas of suitable spawning habitat for native diadromous galaxiids (whitebait species, including inanga).

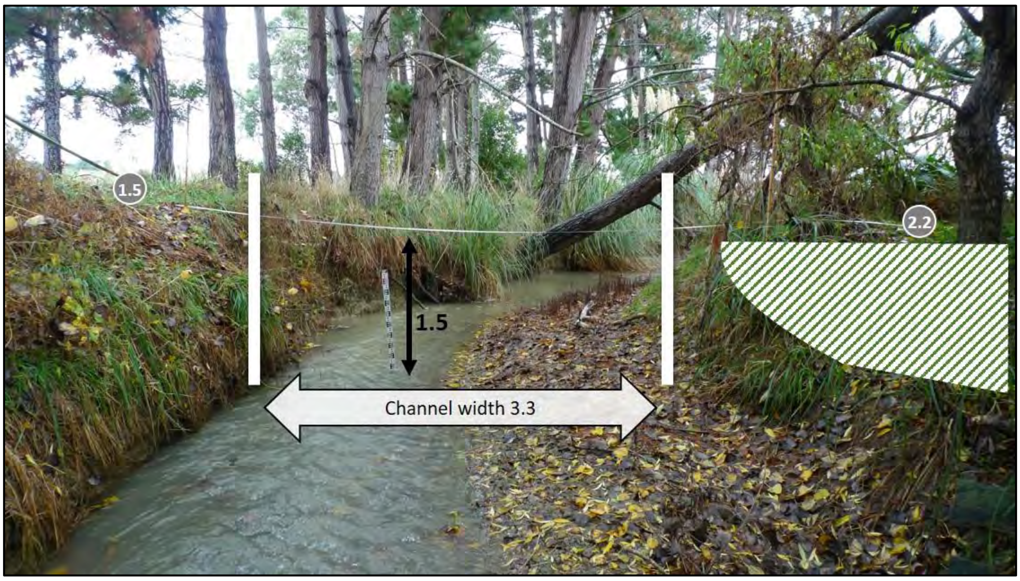

Figure 10. Site 3, an example of a LARGE permanent, tidally influenced watercourse with adjacent slope less than 15 degrees. The channel width and distances to the crest of the upper banks are given in meters (grey circles). The cross-hatching indicates areas of suitable spawning habitat for native diadromous galaxiids (whitebait species, including inanga).

5.28 As stated, sufficient margin between the upper banks of the watercourse and the fence is important to enable riparian vegetation to establish. In Appendix 1 to my evidence I set out research undertaken by Waikato Regional Council's River and Catchment Services/Integrated Catchment Management Directorate, conducting riparian planting trials using native

Carex grasses along drains, both artificial and modified watercourses, to determine whether planting is a cost effective and more environmentally beneficial way of managing drainage channels compared to mechanical cleaning and weed spraying (WRC 2011). In addition to meeting these management requirements, the planting of these *Carex* species also provides bank stability and shade, and contributes to reducing in-stream sediment (and weed growth) in the drainage channels.

5.29 The recommendations from the first planting trial (WRC 2011) were to consider planting *C. secta* and/or *C. geminata* along the mid to upper banks of drainage channels to stabilise banks, provide shading to cool water temperatures and to minimise excessive growth of macrophytes and aquatic weeds, and to provide filtration of faecal matter, sediment and nutrients from runoff, whilst allowing access for mechanical cleaning if required.

5.30 The trials illustrate that fences too close to the waterbody prevent riparian vegetation establishing, reducing the vegetative buffer that is critical for filtration and shading, by up to ~0.5 m. Adverse impacts of stock grazing on the establishment of both *C. secta* and *C. geminata* were observed at each site. These impacts were associated with a too narrower margin (~0.3 m) between the upper banks of the watercourse and the fence, as well as the bottom wire of the fence being non-electric, which is standard practice to avoid shorting-out should vegetation touch the wire. Stock frequently push their heads under fences to graze as far as their necks and the fence will allow (e.g. Figure 11 and Figure 12), reducing the vegetative buffer, critical for filtration and shading, by up to ~0.5 m.

Figure 11. Dairy cattle grazing beneath fence.

Figure 12. Sheep grazing beneath electric fence.

5.31 For waterways which do not require access for maintenance such as mechanical cleaning, land owners and drainage management personnel are directed to riparian planting guidance outlined in the Council's "Best Practice Guidelines for Vegetation Management and In-stream Works" (TR 2007/41, Section 4.3 - Native Planting) (Gibbs, 2007b), and the "Best Practice Environmental Guidelines for Land Drainage" (TR 2006/06) (Gibbs, 2007a). In my opinion these are both excellent resources and should be used as the foundation of the rules in PC 1 for stock exclusion, setbacks and riparian buffers, with the recommended modifications I have set out in this evidence.

APPENDIX

"River Catchment Services Planting Trial in Land Drainage Areas" Report No. 2011/26. Waikato Regional Council, Hamilton, New Zealand (2011)

1. Over the past 12 years the Waikato Regional Council's River and Catchment Services/Integrated Catchment Management Directorate have been conducting riparian planting trials using native *Carex* grasses along drains, both artificial and modified watercourses, to determine whether planting is a cost effective and more environmentally beneficial way of managing drainage channels compared to mechanical cleaning and weed spraying.

2. The first trial was run from 2007 to 2011. Four subsequent trials are still being run with the outcomes yet to be scientifically evaluated (pers. comms. Warren Coffey, WRC Catchment Management Officer, Integrated Catchment Management Directorate, April 2019).

3. Key outcomes of the project were:

    a. To determine whether planting *Carex* species along waterways negates the need for spray maintenance;
    b. To determine whether it is possible to mechanically clean waterways that have been planted with *Carex;*
    c. To verify the optimal *Carex* species for planting along drainage waterways (species that provide the most shade, have the most vigorous growth without encroaching into the channel and restricting capacity); and
    d. To determine whether planting *Carex* species along waterways has a positive impact on the waterway ecosystem.

4. At the time of writing, the minimum financial cost per annum for drainage maintenance (averaged from 2007 to 2011) to the Council was approximately $410,000, including:
    a. $239,000 on spraying, over 1711km, equating to ~ $0.15 m^{-1};
    b. $171,000 on mechanical cleaning, over 190 km, equating to ~ $0.90 m^{-1};

c. Variable additional costs associated with erosion control works to repair eroding banks, slumping and slips; and
d. Additional resourcing costs associated with WRC staff managing contracts and liaising with landowners.

5. The ‘business as usual’ drainage maintenance costs equate to approximately \$1.05 m^{-1} annually, excluding the unquantified costs of erosion maintenance and staff resourcing.

6. The actual cost of the initial planting trial (300 m), including the plants, weed matting, spraying and planting labour, was a one-off cost of ~\$38 m^{-1}.

7. The calculated future expense to extend the trial across all appropriate WRC managed waterways for land drainage was a one-off cost of ~\$25 m^{-1}.

8. Therefore, in approximately 25 years, the cost of the planting scheme would be recouped, and the Council would be able to allocate ~\$410,000 per year to other areas of River and Catchment Services/Integrated Catchment Management.

9. A visit to two of the more recent WRC planting trial sites on April 15th, 2019, showed the plantings of *Carex secta* and *C. geminata* had successfully established, providing bank stability and shade, and contributing to reduced in-stream sediment and weed growth in the drainage channels. Thus planting these species provides a cost effective way to achieve the objectives.

10. Photos of the permanent watercourse WRC-D1 are given in Figure 13 and Figure 14, and the intermittent watercourse WRC-D2 in Figure 15 and Figure 16.

11. Note that both watercourses drain near-flat catchments with slopes less than 15 degrees. This is of significance as the setbacks for fencing currently proposed for these types of watercourses is 1 m from the outer edge of the bed.

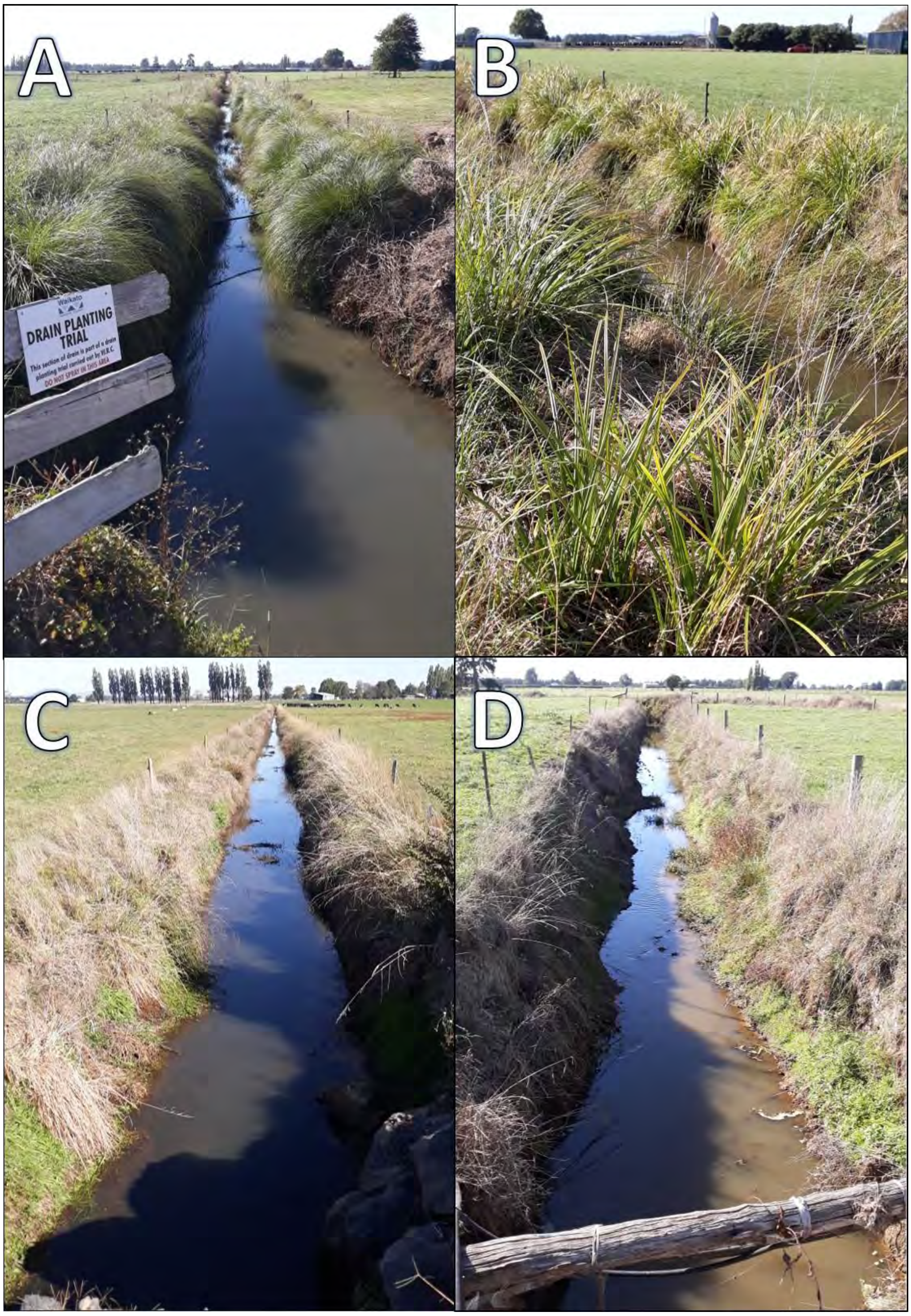

Figure 13. Drainage planting site WRC-D1, permanent watercourse, showing A) *Carex secta*, B) *C. geminata*, C) the upstream control reach, and D) the downstream control reach.

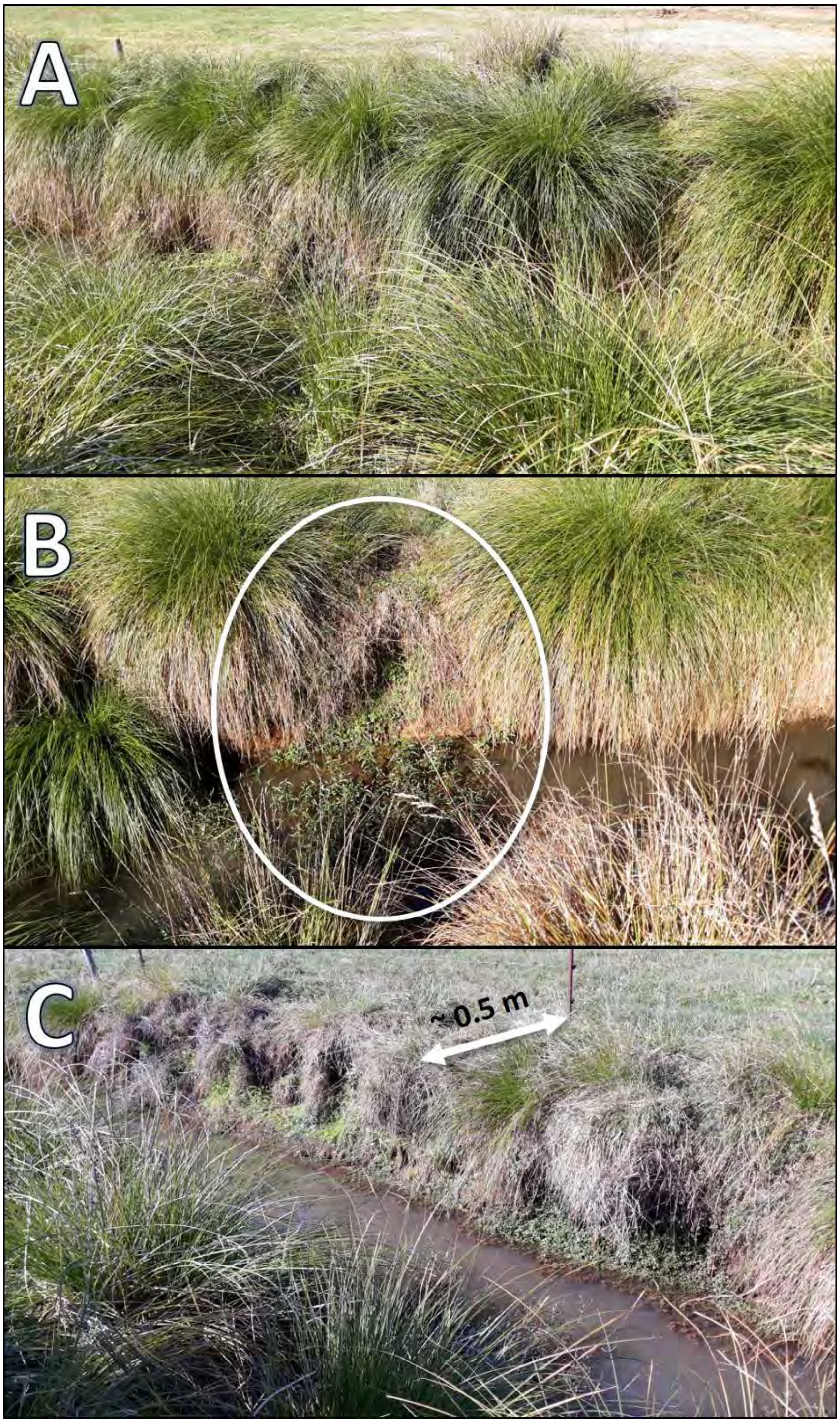

Figure 14. Drainage planting site WRC-D1, permanent watercourse, showing A) excellent plant cover of *Carex secta* with associated stable banks and channel shading, B) a dead *C. secta* with a corresponding slump in the bank, depositing a slug of sediment into the channel upon which a mat of aquatic weed has established, and C) bank slumping and aquatic weed growth in a section where the *C. secta* failed to successfully establish, due to grazing impacts (pers. comms. landowner) owing to the narrow distance (~0.5 m) between the fence and the upper bank of the watercourse.

Figure 15. Drainage planting site WRC-D2, intermittent watercourse, showing A) *Carex secta* successfully established on the True Right Bank, but less well established on the True Left Bank due to a narrow fenced margin and grazing impacts by stock, B) the upstream control reach with prolific growths of marcophytes and pastural weed species, C) *C. secta* successfully established however the outer edges impacted by stock grazing, and D) less well established *C. geminata* also affected by grazing impacts.

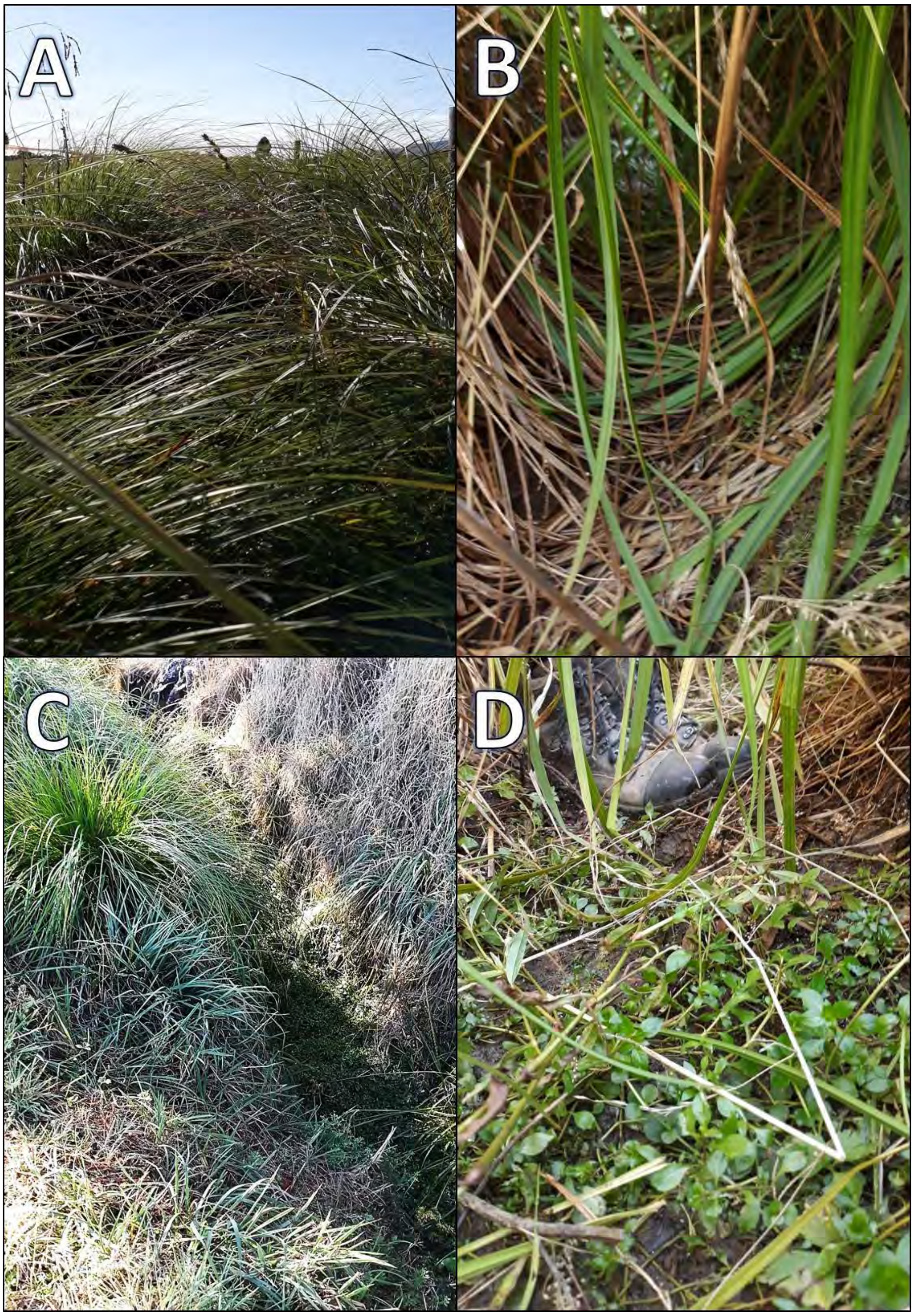

Figure 16. Drainage planting site WRC-D2, intermittent watercourse, showing A) complete channel cover by *Carex secta*, B) sediment and weed-free channel below the *C. secta* canopy, C) patchy growth of *C. secta* due to shading by a large macrocarpa tree and associated macrophyte growth in the damp channel, and D) macrophyte growth in the damp channel due to a gap in canopy cover by *Carex* plants.

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