Evidence Received

Proposed Plan Change 9
Tūtaekurī Ahuriri Ngaruroro Karamū
Catchment Area

PART 5

May 2021

HAWKES BAY
REGIONAL COUNCIL
TE KAUNIHERA Ā-ROHE O TE MATAU-A-MĀUI

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List of Evidence Received in Numeric order

Original Sub #	Evidence #	Organisation Name – Individuals Name
PART 1		
12	1	Ministry of Education - Alec Duncan
13	1	Fire and Emergency New Zealand – Alec Duncan
29, 194, 208, & 238	1	Hawke's Bay Winegrowers Association, Gimblett Gravels Winegrowers Association, Villa Maria Estate Limited, Pernod Ricard Winemakers New Zealand Limited (collectively 'The Winegrowers') - Andrew Laughton Dark
	2	Hawke's Bay Winegrowers Association, Gimblett Gravels Winegrowers Association, Villa Maria Estate Limited, Pernod Ricard Winemakers New Zealand Limited (collectively 'The Winegrowers') – Edwin John Massey
	3	Hawke's Bay Winegrowers Association, Gimblett Gravels Winegrowers Association, Villa Maria Estate Limited, Pernod Ricard Winemakers New Zealand Limited (collectively 'The Winegrowers') – Emma Taylor
	4	Hawke's Bay Winegrowers Association, Gimblett Gravels Winegrowers Association, Villa Maria Estate Limited, Pernod Ricard Winemakers New Zealand Limited (collectively 'The Winegrowers') – Fabin Yukich
	5	Hawke's Bay Winegrowers Association, Gimblett Gravels Winegrowers Association, Villa Maria Estate Limited, Pernod Ricard Winemakers New Zealand Limited (collectively 'The Winegrowers') – Mark St Clair
54	1	Apatu Farms Ltd – Anthony Davoren
63 & 207	1	Hastings District Council & Napier City Council – Annette Sweeney
	2	Hastings District Council & Napier City Council – Annette Sweeney (Appendix A)
	3	Hastings District Council & Napier City Council – Brent Chapman
	4	Hastings District Council & Napier City Council – Cameron Drury
	5	Hastings District Council & Napier City Council – Mark Clews
	6	Hastings District Council & Napier City Council – Paulina Wilhelm
	7	Hastings District Council & Napier City Council – Russell Bond

Original Sub #	Evidence #	Organisation Name – Individuals Name
PART 2		
66	1	Ngaruroro Irrigation Society – Anthony Davoren
82	1	Lowe Corporation – Andy Lowe
	2	Lowe Corporation – Gerard Willis
120	1	Ngāti Kahungunu Iwi Incorporated – Grey Wilson
	2	Ngāti Kahungunu Iwi Incorporated – Peter Fraser
PART 3		
132	1	Te Taiwhenua o Heretaunga – Marei Boston Apatu
	2	Te Taiwhenua o Heretaunga – Tank Hearings Presentation
	3	Te Taiwhenua o Heretaunga – Maurice Wayne Black
	4	Te Taiwhenua o Heretaunga – Maurice Wayne Black (Appendix 1)
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	13	Te Taiwhenua o Heretaunga – Maurice Wayne Black (Appendix 10)
	14	Te Taiwhenua o Heretaunga – Maurice Wayne Black (Appendix 11)

Original Sub #	Evidence #	Organisation Name – Individuals Name
	15	Te Taiwhenua o Heretaunga – Maurice Wayne Black (Appendix 12)
PART 4		
135	1	Ravensdown – Anna Wilkes
	2	Ravensdown – Carmen Taylor
180	1	Horticulture New Zealand – Andrew Dooney
	2	Horticulture New Zealand – Catherine Sturgeon
	3	Horticulture New Zealand – Damien Farrelly
	4	Horticulture New Zealand – Gill Holmes
	5	Horticulture New Zealand – Michelle Sands
	6	Horticulture New Zealand – Stuart Ford
193	1	Heinz Watties Ltd – Anthony Davoren
195	1	Federated Farmers New Zealand – Rhea Dasent
197	1	Beef + Lamb New Zealand – Gerry Kessels
	2	Beef + Lamb New Zealand – Dr Michael Greer
	3	Beef + Lamb New Zealand – Tom Orchiston
203	1	The Oil Companies – Philip Brown
	2	The Oil Companies – Annexure 1
	3	The Oil Companies - Annexure 2
	4	The Oil Companies - Annexure 3

Original Sub #	Evidence #	Organisation Name – Individuals Name
201	1	Royal Forest and Bird Protection Society of New Zealand Incorporated – Thomas Kay
	2	Royal Forest and Bird Protection Society of New Zealand Incorporated – Thomas Kay (Appendix 1)
	3	Royal Forest and Bird Protection Society of New Zealand Incorporated – Thomas Kay (Appendix 2)
	4	Royal Forest and Bird Protection Society of New Zealand Incorporated – Thomas Kay (Appendix 3)

BEFORE THE INDEPENDENT HEARING PANEL
APPOINTED BY HAWKE'S BAY REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the hearing of submissions on Proposed Plan Change 9 (PPC9) – Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments (TANK)

EVIDENCE OF ANTHONY DAVOREN
FOR HEINZ WATTIES LTD

7 MAY 2021

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Ref: Lara Blomfield

INTRODUCTION

Qualifications and Experience

1. My name is Anthony Davoren.

2. I am a director of SWIMS Consulting Ltd, a company that provides consultancy services to applicants and submitters as an expert witness, orchard management companies, consulting companies and grower co-operatives (e.g. Zespri). Prior to establishing SWIMS Consulting Ltd, I was employed as an Irrigation Management Consultant at Aqualinc Research Ltd. I owned HydroServices Ltd, a company specialising in soil moisture measurement and irrigation management from 1983 to 2016.

3. I hold a Bachelor and Masters (1st Class) in Science from University of Waikato, majoring in Earth Sciences; and a PhD in Engineering Science from Washington State University.

4. I have 38 years professional experience measuring soil moisture, irrigation management and acting as an expert witness at resource consent and regional plan hearings. I have been an expert witness at resource consent and Environment Court hearings for:

    4.1. Canterbury Groundwater Zones;

    4.2. Irrigation of industrial and urban wastewater hearings for Canterbury Meat Packers and Selwyn District Council (Leeston);

    4.3. Selwyn District Council Rolleston urban wastewater discharge (resource consent hearing only);

    4.4. Manawatu District Council for the Feilding wastewater treatment plant discharge consent;

    4.5. Southland District Council in respect of the Te Anau wastewater discharge consent;

    4.6. Ngaruroro Water Conservation Order; and

    4.7. Otago Regional Council Plan Change 7.

Code of Conduct

5. While this is not a hearing before the Environment Court I confirm that I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with the Code and I agree to comply with it. I confirm that

the evidence and opinions I have expressed in my evidence are within my areas of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope and purpose of evidence

6. My evidence addresses the following matters:

   6.1. Policy 37 (a) and (b) – regarding the interim 90Mm^3 allocation and re-allocation of water;

   6.2. Transfer of consents;

   6.3. Policy 37 (d) (i) and (iii) – using the average recorded water use in any of 10 years preceding 2 May 2020;

   6.4. Rules TANK 5 and 6 – N loss ranking according to Schedule 29 Table 1.

7. In preparing this evidence I have relied on the following reports and presentations prepared for the TANK process, and:

   7.1. Hearing Report on Proposed Plan Change 9 (including Appendices) - Tūtaekurī Ahuriri Ngaruroro Karamū Catchment Area. Hawke's Bay Regional Council Publication No.5550, 15 April 2021.

   7.2. Proposed Plan Change 9 Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchment, Publication Number: 5456, Notification date: 2 May 2020.

   7.3. Ngaruroro and Tūtaekurī flow data from HBRC.

   7.4. TANK presentation reports of 22 March 2017, 27 July 2017, 2 August 2017 and 14-15 August 2018.

   7.5. Affidavit of Jeffrey Cameron Smith to the Special Tribunal for the Ngaruroro and Clive Rivers Water Conservation Order.

Policy 37 (a) and (b)

8. The rationale for this policy and the allocation limit of 90 million cubic metres per year (Mm^3/yr) is summarised at paragraphs 1206-1209 of the Section 42A Report.

9. While the allocation limit is said to be interim "until there has been a review of the relevant allocation limits within this plan"[1], there are

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[1] Appendix 1: Recommended Changes to Proposed Plan Change 9 - Tūtaekurī Ahuriri Ngaruroro Karamū Catchment Area, Policy 37, page 24.

uncertainties with the allocation limit and the review. Water meter use analysis would demonstrate whether this limit is realistic. and if it is exceeded by use and in which water years.

10. The 90Mm^3/year limit is considered to be the approximate abstraction for municipal, industrial and irrigation use according to Smith (2017)[2] in his affidavit and was assessed in the s32 Report[3] as use from the groundwater in the 2012-13 water year. It has been set as the allocation limit.

11. The s32 Report estimates actual use is 78Mm^3/year or approximately 48% of the (paper) allocation of 163Mm^3/year. The estimated use of 48% is similar to an analysis of Heinz Watties and Apatu Farms Ltd (presented in their expert witness evidence[4]) water meter data annual volumes as a proportion of annual allocation of 41%. This suggests the actual use could be as low as 67Mm^3/year and groundwater may not be over allocated.

12. There is no proposal as to when the review might take place and be completed. While Policy 42 requires the council to commence a review after water has been re-allocated and consents reviewed and within 10 years of the operative date, I consider this is too long and there needs to be greater certainty of the completion date.

13. I support the transfer of groundwater and surface water permits that have already been exercised and the transfer should be enabled. Key to the transfer is the interim allocation limit of 90Mm^3 per year and that actual use is likely less than the allocation.

14. Any permit to take and use groundwater is already included in the interim limit and the "environment". Transferring the permit elsewhere in the Heretaunga Plains Aquifer area should be enabled so long as:

    14.1. Well interference effects are less than minor or can be mitigated (reduce the rate of take or volume) at the new location; and

    14.2. Any nutrient losses are no greater than from the current location.

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[2] Affidavit of Jeffery Cameron Smith, 27 February 2017 for Special Tribunal for the Ngaruroro and Clive Rivers Water Conservation Order.
[3] Mitchell Daysh Report for Hawke's Bay Regional Council Section 32 Evaluation Report March 2020. TANK Catchments Plan Change to Regional Resource Management Plan – Change 9.
[4] Evidence of Anthony Davoren for Apatu Farms Ltd., 7 May 2021

15. This is no different to the trade and transfer of water permits in fully allocated groundwater zones in Canterbury where interference effects must be assessed and mitigated, and nutrient limits must be met.

Policy 37(d) (iii)

16. HW submitted to delete the clause to adopt the highest water use in any of the preceding years preceding August 2017 when assessing Actual and Reasonable use.

17. HBRC has amended the date to refer to the average water use data for the 10-year period preceding 2 May 2020.

18. I do not agree that the period of record should be restricted to 10 years. If there is a longer length of water meter data than 10 years prior to 2 May 2020 then it should be used. A longer length of record would be statistically more robust, and more likely capture higher irrigation demand seasons and better define the 95% reliability of supply (Paragraph (c) of the Actual and Reasonable meaning).

19. I have concerns with the amended meaning for Actual and Reasonable (b) in Chapter 9, Glossary of Terms Used[5]; i.e. the average annual amount as measured by accurate water meter data in the ten years preceding 2 May 2020 if accurate water meter data is available. (If insufficient or no accurate data is available either clause a) or c) will apply).

20. The average amount (volume) used will not capture the irrigation demand season to meet the 95% reliability of supply (Paragraph (c) of the Actual and Reasonable meaning). It will be less than that and the definition of Actual and Reasonable requires the lesser figure to be applied.

21. I demonstrate this with data from two HW properties with 9-11 years of accurate water meter data (Table 1, Appendix 1). The analysis shows:

    21.1. Example 1. The average volume is 156,596m^3, the 95th-percentile demand is 190,922m^3 and if the definition of Actual and Reasonable (as recommended by Council officers) is applied, only 82% of the volume required in the 95%-ile season would be allocated.

    21.2. Example 2. The average volume is 63,812m^3, the 95th-percentile demand is 107,668m^3 and if the definition of Actual and reasonable is applied only 59% of the volume required in the 95%-ile season would be allocated.

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[5] Appendix 1: Recommended Changes to Proposed Plan Change 9 - Tūtaekurī Ahuriri Ngaruroro Karamū Catchment Area, Glossary of Terms Used, page 90.

Year	Example 1	Example 2
	Volume m^3/year	Volume m^3/year
2010-11		55523
2011-12		30116
2012-13	148127	117679
2013-14	138417	78402
2014-15	192616	20992
2015-16	155473	78747
2016-17	166750	37510
2017-18	133639	39135
2018-19	128099	28587
2019-20	188382	97656
2020-21	157863	75604
Mean	**156596**	**63812**
95%-ile	**190922**	**107668**
Proportion (mean/95%-ile)	**0.82**	**0.59**

Table 1. Annual volume m^3 used in the water years (1 July to following 30 June) for two HW arable properties.

22. While allocating the average use might be consistent with 37(d)(ii)], it is not consistent with Policy 47(c) or the definition in "Actual and Reasonable" allocating water for irrigation with a "95% reliability of supply".

23. I have run an Irricalc model at Bridge Pa for the seasons 2010-11 to 2019-20 to determine the 95th-percentile irrigation demand season (Appendix 2).

24. The 95th-percentile or 95% reliability of supply season demand is 570mm/year (5740m^3/ha/year). The 2012-13 season was the highest demand season and the percentile is greater than 95%. The 2018-19 demand (540mm/year) was less than the 95th-percentile demand but still exceeded the mean (for the period of record of 465mm/year).

25. Allocating the average use will severely compromise the ability of irrigators to meet crop demand.

TANK 6

26. HW submitted that a per hectare nutrient loss measure should be used.

27. The Conditions/Standards/Terms in Rule 6 as notified referred to Schedule 29, Table 2 which set Nitrogen loss thresholds per property or farm enterprise.

28. Council officers have recommended significant changes to Schedule 29 including the inclusion of a new Table 1: Land Use Types and Nitrogen Leaching Risk.

29. I do not think that Schedule 29 Table 1 is a sensible or sound alternative to the original Table 1 or the suggested amendment proposed by HW to manage nutrient leaching.

30. Schedule 29 is highly subjective, does not consider differences in farm systems within any risk category, does not encourage mitigation measures to reduce nutrient leaching, and assumes all farm systems in a particular risk category have the same leaching and loss and risk of leaching.

31. Schedule 29 addresses only N leaching risk. Many enterprises (for example hill country sheep and beef or deer) will have a much greater risk of P loss than N.

32. Each Level assumes every farming enterprise in the Land use type will have the same or fall within a range of unspecified nutrient loss. This is not the case. Every enterprise in a category will have a different nutrient loss depending on soil type, topography and farming systems.

33. I am not aware of and consider it is unlikely an enterprise is solely "intensive winter grazing". It is more likely that an area of winter forage crops forms part of a farming enterprise. Furthermore, soil type and slope will have a significant effect on the potential nutrient loss, in some locations that loss will be N leaching and in others P loss.

34. To consider dairy and arable to have the same leaching risk is not correct and is not supported by any modelling. My experience from Overseer modelling, is that dairy will in almost every location have a higher N loss than arable.

35. Irrigated land incorporating any irrigation is identified as the highest N leaching risk, but in my experience horticulture, even if irrigated, generally leaches less Nitrogen than many of the listed 'higher risk' land uses.

36. TANK 6 is contingent on the outcome of the test in TANK 5(a) which states "A change in land use types means a change from one leaching level to a higher leaching level as shown in Table 1 of Schedule 29".

37. TANK 5 provides that a change of land use from (say) a low leaching activity to a higher leaching activity requires consent as a controlled activity. TANK 6 applies if the activity does not meet the conditions of TANK 5 – so it captures land uses that go from high leaching (e.g. dairy) to low leaching (e.g. arable) because that would not meet TANK 5(a). Restricted discretionary consent would be required.

38. I do not think that was what was intended. The only sensible reason for defaulting from Rule 5 to Rule 6 would be if the landowner does not comply with condition (d) of Rule 5 – i.e. is not a member of a Catchment Collective.

39. Quite apart from that, unless Schedule 29 is changed to something more meaningful and certain, it:

    39.1. will be easily contested with nutrient modelling; and

    39.2. could result in protracted debate about whether an applicant has not met the condition(s) or standard(s) and so which activity status applies.

40. Schedule 29 should at the very least, given the objective is to manage nutrient loss to water, directly address nutrient limits and targets. For example:

    40.1. A farming enterprise(s) must achieve a reduction of nitrogen or phosphorous loss (e.g. 10% or 15%) from a good management baseline as determined by OverseerFM (or other model) by "2025".

    40.2. Such an approach would firstly provide knowledge of the potential (N and/or P) loss and secondly give HBRC time to develop nutrient limits for catchments and sub-catchments. This would put an onus on both the enterprise(s) to "know" their impact and demonstrate improvement, and the council to improve their monitoring of surface and ground water to inform the establishment of limits.

    40.3. The recent Mayfield Hinds Valetta Irrigation Scheme consent application decision[6] provides an example of such an approach:

    > "This consent is granted on the basis that the significant adverse effects on the receiving water will be reduced and there will be measurable environmental improvements" and "also gives the Applicant (substitute farming enterprise) sufficient time to demonstrate that land use practices can change to significantly reduce nutrient inputs and to address environmental degradation".

    And sets nutrient loss reductions to be achieved by 2025 and 2030.

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[6] Mayfield Hinds Valetta Irrigation Scheme consent application decision, 21 April 2021

41. Freshwater Farm Plans (FFP) are described in Schedule 30 and are to be completed 3, 6 or 9 years after the Plan operative date. A key component of the FFP is a nutrient budget. However there are no on-farm limits or targets to provide growers with certainty and clarity they are meeting any Plan requirement.

42. The Plan should provide for assessment of nutrient loss modelling to demonstrate that moving from one risk category to another avoids or can mitigate changes. This would avoid the potential for debate regarding activity status.

CONCLUDING COMMENTS

43. I consider that TANK 6 and Schedule 29 Table 1 (and by inference Policy 21 and TANK 5) require amending. Table 1 is highly subjective does not provide any clarity to a farming enterprise. Nutrient loss limits have not been addressed in Schedule 29 or Table 1.

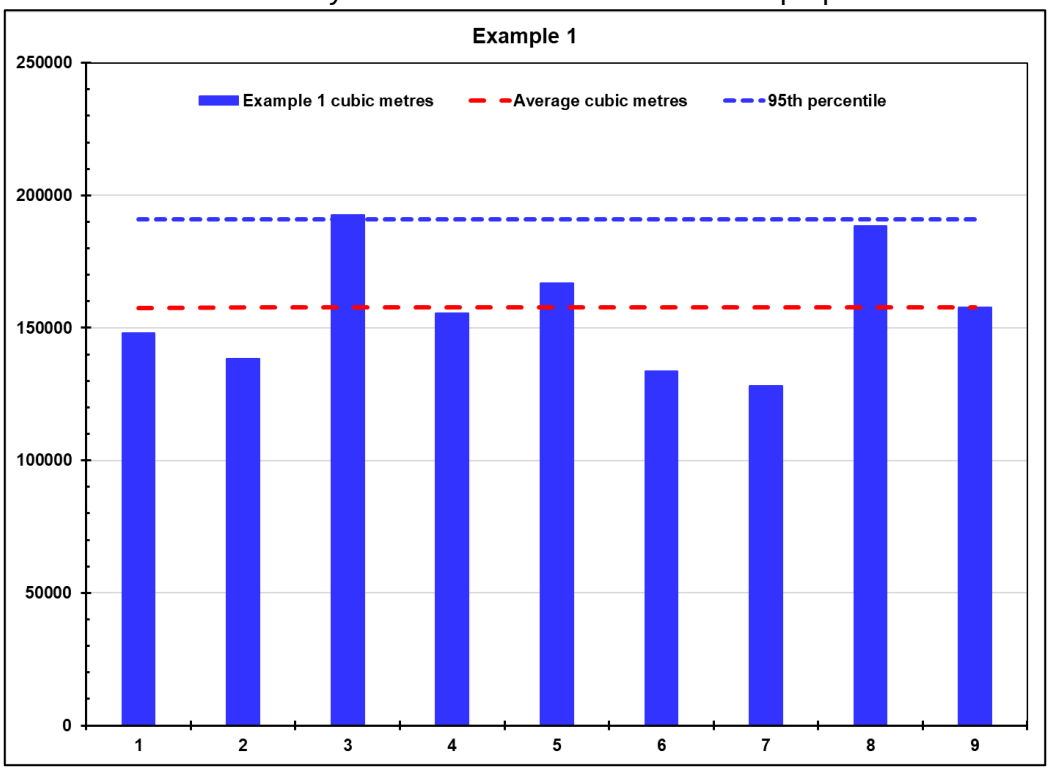
44. I support the transfer of groundwater and surface water permits that have already been exercised and the transfer should be enabled. Other than nutrient losses, the effects of these permits exist in the environment and are already included in the groundwater and surface water allocation limits.

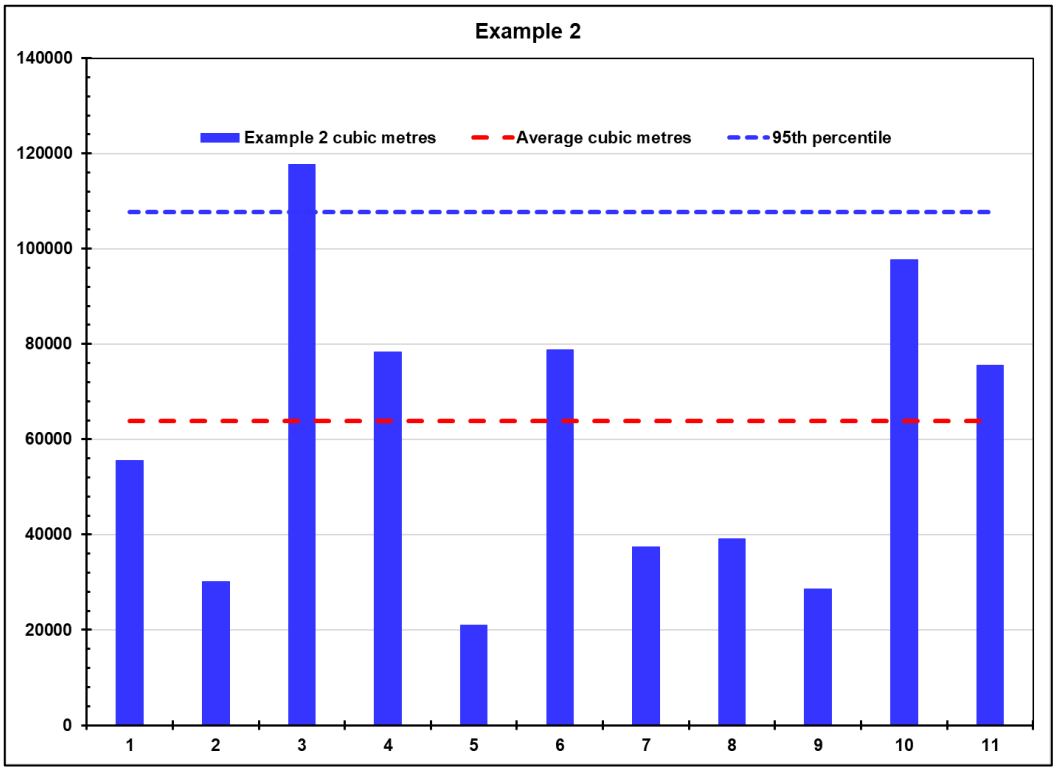
45. The amended meaning for Actual and Reasonable (b) in Chapter 9, Glossary of Terms Used is not supported. Adopting the average annual amount as measured by accurate water meter data in the ten years preceding 2 May 2020 will not provide for the demand in the 95th percentile season as demonstrated by the examples from HW water meter records.

Anthony Davoren
7 May 2021

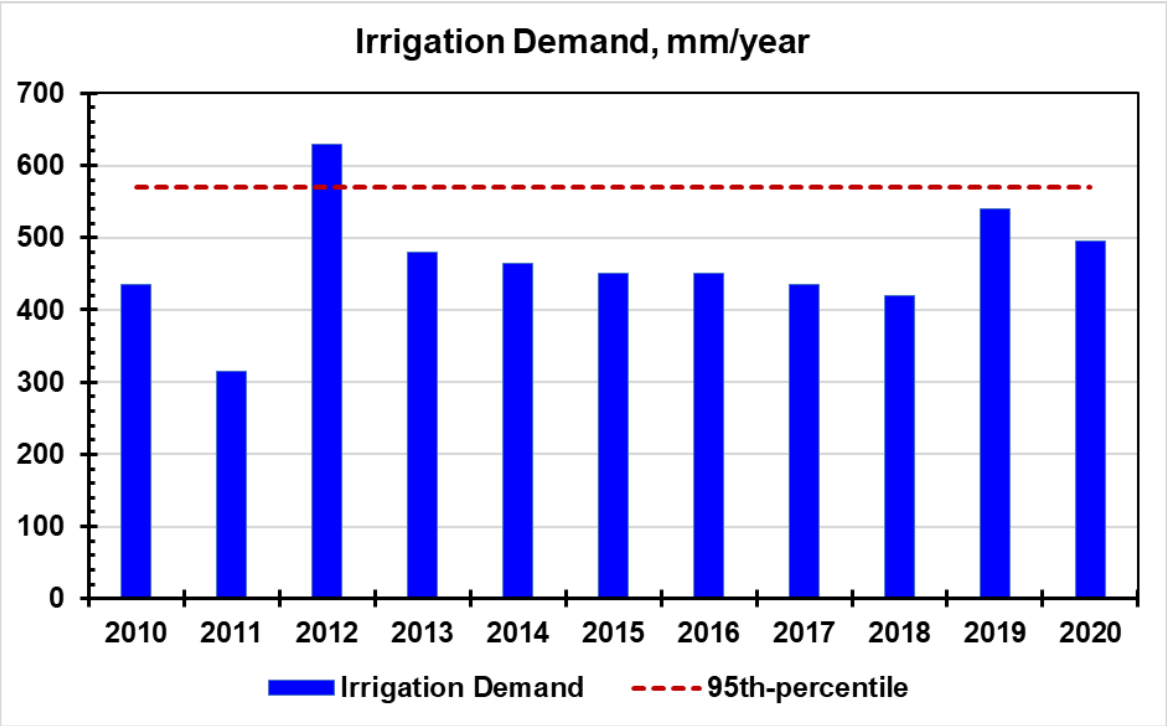
Appendix 1

Water meter volume analyses for two Heinz Wattie's arable properties.





Appendix 2. Irricalc irrigation demand modelling results at Bridge Pa for seasons 2010-11 to 2019-20.



Appendix 3

https://www.ecan.govt.nz/get-involved/news-and-events/2021/questions-addressed-on-mayfieldhindsvaletta-irrigation-schemes-application-for-consent-renewal/

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the hearing of submissions on *Proposed Plan Change 9 – Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments* to the Hawkes Bay Regional Resource Management Plan

BY FEDERATED FARMERS OF NEW ZEALAND

TO Hawkes Bay Regional Council

Statement of Evidence

Rhea Dasent
On behalf of Federated Farmers

7 May 2021

INTRODUCTION

1. This Statement of Evidence is for Plan Change 9 (Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments) to the Hawkes Bay Regional Resource Management Plan.

2. My name is Rhea Jane Dasent and I am a senior regional policy advisor for Federated Farmers of New Zealand. I am authorised to speak on behalf of Federated Farmers.

3. I have over a decade of experience in resource management issues to do with farming, having worked for Federated Farmers as a regional policy advisor since 2009. My role is to provide policy advice and advocacy on behalf of Federated Farmers members in processes arising under the Resource Management Act, Local Government Act and Local Government (Rating) Act. I analyse, submit, present at hearings and conduct Environment Court appeals on behalf of members. My work is informed and mandated by our elected representatives and local members.

4. I hold a Bachelor of Science Degree and a Bachelor of Arts Degree from Victoria University of Wellington, and I have previous experience as a resource consent officer working for local government. My views are closely aligned with those of Federated Farmers, due to my farming background.

5. My family have farmed our property on Dasent Road in the Ngaruroro Catchment of Hawkes Bay over 110 years. I have practical farming experience, being employed on the family farm. My farm is representative of many farms within the TANK catchments: family-owned and operated, one employee (being myself), dry stock, free range pastoral, unirrigated, and of medium size at 190ha.

My farm in November with good grass growth. Note how spaced out animals are with empty paddocks in between stocked paddocks, to regenerate pasture.

6. Federated Farmers is a voluntary membership-based organisation that represents farmers and other rural businesses. Federated Farmers has a long and proud history of representing the needs and interests of New Zealand's farmers and as such has a keen interest in PC9.

7. Federated Farmers made a submission and further submissions on PC9. These submissions are representative of our members' views and experiences with the management of the resources in the Region and reflect the fact that the proposed Plan Change will have a significant impact on our members' daily lives as farmers, members of the local community, and as land and water users.

8. I wish to acknowledge and support submissions made by individual members of Federated Farmers.

OVERALL POSITION

9. Federated Farmers submitted seeking that water and land use values associated with farming are provided for in a practical and fair manner.

10. We want to continue farming as a permitted activity, because it was lawfully established and the majority of people and communities within the TANK catchments rely on farming for their social and economic well beings.

11. We want provisions that are consistent with national legislation, to avoid any confusing contradictions and unnecessary duplication. Many of the concerns we raised in our submission have now been addressed at national level, such as stock exclusion, changes between land uses, and farm plans.

12. We want stock drinking enabled to reflect its extremely high importance as a farming value. We support the Section 42a Report's recommendation to clarify that stock drinking and Section 14.3(b) water uses are excluded from the $20m^3$ and $5m^3$ volume limits.

13. We want rules that are practical to implement on farm. The Section 42a report recommendations for a simplified Schedule 29 and Table 1 based on conventional understanding of land use change are supported.

SOCIAL AND ECONOMIC WELLBEING

14. Our submission emphasises that economic and social wellbeing are important aspects when managing the TANK catchments.

15. Primary production such as farming is a key land use of these catchments, and many people and communities rely on farming for their wellbeing. Food is something all people need, and our farmers take pride in providing sustainable, good quality food for our nation's tables and overseas markets. The past use of land and water for farming is what built our local towns and communities, and the economic wellbeing that we enjoy today. The importance of farming to the nation was highlighted in 2020 during the coronavirus pandemic, as we looked to farmers to continue to provide us with food security as a nation, and to earn overseas income when other industries could not.

16. My own farm is interconnected with a lot of businesses and people throughout the Hawkes Bay. We interact with many small local family-owned business, like

our livestock agent, tree-trimming, hay and silage contractors, fuel delivery services, rural bankers to name a few. Our beef supplies supermarkets that are part of the Foodstuffs group. These businesses and people rely on farms like ours in order to earn a living, just like we rely on their services to run our farm. There is a web of goods and services and the social and economic relationships in our community, relating to farming.

17. Federated Farmers consider that it is important that the objectives and policies reflect the fact that land and water use in the TANK catchments are an essential part of social and economic wellbeing.

STOCK EXCLUSION

18. Federated Farmers' submission seeks that the potential conflict between stock exclusion requirements, and the reliance farmers have on stock access to waterways for drinking, is sorted out. We submitted on Policies 11 and 13 Policy 22, Policy 27, Rules 3 and 4 on this topic.

19. In our submission, our main concerns revolved around the need for farms to retain some stock access to surface water for drinking. This happens on large farms with steep terrain that make it hard to provide troughs in every paddock. On farms near the Ruahine and Kaweka Ranges, up the Napier-Taupo Road and in Wairoa, hill country terrain can make it difficult to impossible to take water at a point source and pipe it to troughs and provide enough regular supply for water to be constantly available to livestock. These farms will have some form of reticulation where they can, but some paddocks will entirely rely on access to surface water. Stock need permanent access to man-made stockwater dams.

20. These same terrain challenges mean that some farms are unable to fence waterways, simply because the landscape is too steep, or because dense bush or dangerous cliffs prevent post-and-wire fences being built. I know of a farmer who finds his river gravel soil very difficult to drive in posts or even standards securely, and his ability to exclude stock is also compromised.

21. We also consider that emergency water supply for livestock also needed to be considered. My own farm needed stock access to surface water as an emergency water supply when our bore failed and we could not supply troughs. Due to last year's drought and low rainfall for the last 18 months, our bore was low over summer. A run of very hot days meant our cattle were drinking more than usual and the bore ran dry for a week. We had to rapidly move stock into paddocks that had stockwater dams and a creek to ensure they wouldn't become dehydrated and die. Similarly, hazard events such as landslide or earthquake can rip out pipes and troughs, and mean that farmers need to water livestock until these are fixed.

22. However after raising these farming concerns about the practicality of stock exclusion in our submission, the National Policy Statement for Freshwater Management and the associated National Environmental Standards and section

360 regulations were released (and these documents included provisions for stock exclusion).

23. Notwithstanding our concerns about the practicality of stock exclusion, we acknowledge that PC9 cannot be less stringent than the regulations and we support the Section 42a Report recommendation to delete provisions for stock exclusion being POL TANK 22 and Rules TANK 3 and 4, discussed in paragraph 826 onwards.

24. We agree with the Section 42a Report that the national regulations achieve the desired goal and therefore rules in PC9 are unnecessary. It is our strong opinion that duplication is undesirable, and the potential inconsistencies and uncertainties between two sets of rules is a problem that farmers do not need (and is in no one's best interests). We agree with paragraph 836 which says *Having two different but overlapping sets of regulatory provisions for the same activity results in unnecessary complexity and increases the administrative burden for the Council. It also results in additional costs and confusion for landowners*.

SECTION 14.3(B) TAKES AND USES

25. Federated Farmers' submission opposed the overall reduction of permitted takes, the limit of only $5m^3$ per day for new takes, and the inclusion of Section 14.3(b) takes and uses into Rules 7 and 8. We support the Section 42a Report recommendations to clarify that Section 14.3(b) takes are excluded from the limits or restrictions on water takes.

26. Federated Farmers prefers the existing "allowed" status that Section 14.3(b) takes and uses have in the rest of the Regional Resource Management Plan. Water takes and uses for domestic and stock drinking needs under Section 14.3(b) should be accounted for in any catchment water take allocation, should not require resource consent, and should not be affected by low flow limits or cessations.

27. I cannot overstate the importance of Section 14.3(b) takes and uses for farmers. It is vital and must continue to be enabled. It would be totally unacceptable to restrict farmers' ability to provide enough drinking water for their livestock, and for their households. I understand that this right is not unfettered, but is bound by the condition that it does not, or is not likely to, have an adverse effect on the environment. I agree with this condition in the RMA, and consider that there is no need for further regulations by the Regional Plan.

28. The Regional Resource Management Plan (RRMP) already gives S.14.3(b) takes and uses *allowed* status, meaning it is exempt from the RRMP rules and subject only to the conditions in RMA Section 14.

RRMP Provision reference	Text
Rule 53 Minor Takes & Uses of Ground Water	• *The take and use of water for reasonable domestic needs, stock drinking purposes and fire fighting, including from locations within the groundwater management zones in Schedule VI is not required to be included in this measurement*
Rule 54 *Minor Takes and Uses of Surface Water* Footnote 133	*133 The taking of water for an individual's reasonable domestic needs and the reasonable needs of an individual's animals drinking water is not restricted by this rule.*
POL TT8.1(d)	*Applying the Table 5.9.4 and 5.9.5 water allocation limits only to consented takes and not to takes allowed under section 14(3)(b) of the RMA…*
POL TT9.1	*Not including any taking of water allowed under s14(3)(b) of the RMA or Rules 53 and 54…*
POL TT9.1(f)	*The taking of water allowed by section 14(3)(b) of the RMA may continue without further restriction;*
POL TT14.1(a)	*The taking of water allowed by section 14(3)(b) of the RMA shall continue to be allowed without further restriction under this Plan;*

29. Rules 53 and 54 of the RRMP are significant, because these are what water takes and uses for the TANK catchments were subject to prior to PC9. Farmers can take the water their livestock need, so long as they are within the conditions set by Section 14.3(b) of the RMA.

30. For example, what is a "reasonable" take for animal drinking needs will depend on the circumstances. It would be reasonable for livestock to drink more water during summer than during winter. It would be reasonable for more water to be used when the farm is fully stocked, than when the farm is 50% stocked.

31. Federated Farmers' submission was concerned that, as notified, PC9 was a substantial departure from this existing regime including Section 14.3(b) takes into the volume limits: existing takes (as of May 2020) to a maximum of 20m^3 per day, and new takes to a very small 5m^3 per day, with no graduation depending on the size of the property. We were extremely concerned these thresholds are much too small to enable livestock drinking water as a permitted activity, and will result in many farmers having to obtain resource consent.

32. As notified, the same limits would apply to large 500ha farms taking water to provide animal drinking in troughs, and to small 1.6ha lifestyle properties that are only using domestic water. If they couldn't meet the permitted conditions,

farmers would face the risk that their consent applications be declined, or conditions imposed that mean they can't provide enough water. Farmers were understandably worried that the number of animals their farm could hold would be determined by the 20m^3 limit.

33. Even in regional waterbodies classified as "outstanding" status in Plan Change 7, Section 14.3(b) takes and uses will have allowed status.

34. The Section 42a Report discusses stock drinking in paragraph 1247, which says *Some submission points seek that OBJ TANK 16, 17 and 18, and associated policies and rules are amended to provide for stock drinking water as a priority. I recommend the panel accept these submissions in part due because they align with Section 14(3)(b) of the RMA and align with to amendments to OBJ TANK 16 and consequential amendments*.

35. Federated Farmers is relieved that paragraph 1248 recommends to reject a submission seeking that stock drinking ceases at minimum flows. Animal welfare would be at stake.

36. Federated Farmers strongly supports the Section 42a Report recommendation to clearly exclude takes for stock drinking water needs in TANK 7 b)(iii) and TANK 8 b)(iii) from the 5m^3 limit for new takes.

Rule	Activity	Status	Conditions/Standards/Terms
TANK 7 Surface Water take	**The take and use of surface water in the TANK water quantity areas ~~Management Zones~~ including under Section14(3)(b) of the RMA and from a dam or water impoundment** [194.83]	**Permitted**	a) Any take first commencing after 2 May 2020 is not from any of the following: Maraekakaho Water ~~Management Unit~~ Quantity Areas Ahuriri Water ~~Management Unit~~ Quantity Areas Awanui Stream Water Quantity Area ~~and its tributaries~~ Poukawa Water ~~Management Unit~~ Quantity Areas Louisa Stream Water Quantity Area ~~and its tributaries~~ Paritua-Karewarewa Water Quantity Area. [132.21] b) The take ~~does~~ shall not exceed 5 cubic metres per day per ~~any one~~ property except: (i) Takes existing as at 2 May 2020 ~~may continue to take up to 20 cubic metres per property per day and to meet the reasonable needs of animals for drinking water~~; (ii) Takes to meet reasonable domestic needs[4] [17.7] (iii) Takes for stock drinking water [129.8] (iv) Takes occurring for a period of less than 28 days within any 90 day period, the total volume taken on any property shall not exceed 200 cubic metre per 7 day period. c) The taking of water ~~does~~ shall not cause any stream or river flow to cease. d) Fish, including eels, shall be prevented from entering the reticulation system. e) The activity shall not cause changes to the flows or levels of water in any connected wetland. f) The take shall not prevent from taking water any other lawfully established efficient groundwater take, or any lawfully established surface water take, which existed prior to commencement of the take.

37. Federated Farmers agrees with the discussion in paragraphs 1844 and 1845 of the Section 42a Report *The drafting of Rules TANK 7 and 8 as notified causes confusion because condition b)(i) combines both existing uses and takes for*

reasonable needs of stock drinking water together….. I recommend that Rules TANK 7 and 8 are amended to separate condition b)(i) into multiple points to clarify that they are not limited to 5m^3 per day, or 20m^3 either. We consider that the other source of the confusion is the way Section 14.3(b) takes are in the second column titled *Activity* so the reader thinks all the conditions apply to stock drinking when in fact they are excluded.

38. All in all, Federated Farmers is satisfied that Section 14.3(b) takes and uses and stock drinking are now provided for (without limiting the application of that section) and not subject to the volume limits.

LAND USE CHANGE

39. Federated Farmers submitted that Table 1 of Schedule 29 and associated Rules 5 and 6 were inappropriate. We support the Section 42a Report recommendation to simplify Table 1 in Schedule 29.

40. Federated Farmers' submission said there were too many variables affecting nutrient yield to be confident that pursuing assessments, when this threshold is triggered, will be a worthwhile expenditure of resources. By this we meant that farms are very individual and there is a need for flexibility, and that farmers would find it difficult and expensive to assess whether every change on their farm breached the N thresholds (let alone arrive at appropriate N thresholds to assess them against).

41. Change is inherent with farming, and the requirement to check if the activity is still within the permitted rule during every change would be daunting. However in saying that farming changes, it is still change on a minor scale and within the existing farm system, and not often a wholescale change from one type of farming to another, such as from drystock to dairy.

42. My own intergenerational family farm has experienced a lot of change over the decades. We originally were a sheep breeding farm from 1907-1996, then we changed to beef finishing. Both the sheep breeding and beef finishing involve meat production using extensive rotational grazing, with stock numbers determined by the amount of naturally grown pasture available. Over this time we have experienced two world wars, the emergence of early agricultural mechanisation, the 1930s depression, the 1931 Napier earthquake, new post-war markets, deregulation in the 1980s, Cyclone Bola in 1988, and the drought of 2020 and Covid-19. These all required us to adapt, change, innovate and be flexible to the conditions.

43. Not only do we experience long term change, but during the year we need to adapt to external conditions. Because we are unirrigated and rely solely on natural rainfall, we have to be flexible with how many animals we have and how we feed them. We carry more stock from April-November when grass growth is good, less over the dry summer months. Some years have low grass growth so we want to plant fodder crops to make sure we have enough feed. Last year we made more hay and silage than usual, because we were replenishing our stored

feed after running out during the prolonged drought. I reared calves for the first time last year so we are currently carrying more younger animals than we normally do. Some years we have so much grass growth in spring that we need to buy more stock than usual to keep pasture under control and retain its quality on paddocks that aren't flat enough to cut hay.

44. I would consider these all normal and expected changes on-farm that would be experienced by farmers in the TANK catchments, and should not need remodelling or estimates of N leaching to re-assess whether the threshold are exceeded or not, because the total farm is still the same land use.

45. Having to estimate the N loss for every normal on-farm change contributes to regulatory drag and cost for very little benefit (particularly when relying on Overseer to estimate N leaching and dealing with issues like Overseer version change). Based on my farming experience, my fear is that farmers will feel unable to adjust their farming system seasonally to account for external factors. I certainly would. They will also feel like it is unfair to be held to or compared against abstract and arbitrary N leaching rates in Schedule 29.

46. As a farmer, I greatly appreciate the Section 42a Report's comment in paragraph 806: *Given the complexity and technical challenges posed by Rule TANK 5 and 6 and the associated Schedule 29, further work was done to develop a less complicated approach.* I support the less complicated approach with the graduation from low level leaching to high level leaching land uses, relying on conventional understanding of land uses.

47. I agree with paragraphs 819 and 820: *As noted earlier, the rules do not prevent land use change. Innovation and flexibility are enabled, including in contemplating land use change being managed collectively. Alternative approaches, most of which require property scale nitrogen allowance were assessed and discounted in terms of costs and effectiveness.*

48. Federated Farmers agrees with the Section 42a recommended changes to Schedule 29 , which is a more pragmatic threshold to assess the types of changes that would require greater scrutiny.

49. Federated Farmers supports the allowance for crop rotation and rotational grazing being the same area equivalent but moving location around the farm, not being classified as "land use change." Rotation is common and normal practice and needs to be recognized and enabled.

FARM ENVIRONMENT PLANS

50. Federated Farmers submitted that farm environment plans should apply only to farms above 50ha, and we wanted plans only to apply to nationally regulated activities like stockholding areas for larger and older cattle and intensive winter grazing. We submitted that farming activities should be permitted activities subject to standards and that those under 50ha did not need the extra step of individual plans for every farm, which could be a burden on farmers and the Council.

51. The Section 42a Report discusses what farm size the permitted activity rule TANK 1 should apply to, from paragraph 915 onwards.

52. We now accept the Section 42a Report recommendation that farm environment plans apply to properties over 20ha, for the reason that is consistent with Part 9A of the RMA. We support consistency and agree with paragraph 923 where is says *Alignment will reduce the levels of complexity in local and national regulation.*

53. We support the permitted status of use of production land in TANK 1. Existing farming activities ought to be provided for as permitted. Farming is well-established in these catchments, as a lawful activity. Many farms will be like mine: established over 100 years ago by families, in order to provide food for their nation and earn a livelihood for themselves. Most will have retained their predominant farm type such as sheep and beef.

54. Federated Farmers urges that privacy concerns around Farm Environment Plans and any resource consents needed are addressed. Farmers will have to supply their private business information as part of these processes, which could then become publicly available because they become council records. Farmers need to know that their private business information is being provided to the Council in confidence.

Rhea Dasent
For Federated Farmers
7 May 2021.

BEFORE THE INDEPENDENT COMMISSIONERS
APPOINTED BY THE HAWKE'S BAY REGIONAL COUNCIL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Proposed Plan Change 9 to the Hawke's Bay Regional Council's Regional Resource Management Plan - Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments

AND

IN THE MATTER of the First Schedule to the Act

ON BEHALF OF **BEEF + LAMB NEW ZEALAND**
Submitter

EVIDENCE IN CHIEF OF GERARDUS HENRICUS ANTHONIUS KESSELS

7 May 2021

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QUALIFICATIONS AND EXPERIENCE

1. My full name is Gerardus (Gerry) Henricus Anthonius Kessels.

2. I am an independent contracting ecological and environmental planning consultant.

3. I hold a Bachelor of Science degree majoring in zoology, completed in 1988 and a Master of Resource and Environmental Planning (first class honours, specialising in collaborative management and wetland ecology) completed in 1999, both from Massey University.

4. I am a member of the Freshwater Sciences Society of New Zealand, the New Zealand Ecological Society, the Ornithological Society of New Zealand, the Waikato Botanical Society and an affiliate member of the New Zealand Planning Institute.

5. I am a certified Independent Hearing Commissioner with a current 'Making Good Decisions' certificate.

6. I have 31 years of experience in the fields of freshwater and terrestrial ecology and resource management planning. This includes five years with the Department of Conservation (DOC), three years with Opus International Consultants and 18 months contracted to Tonkin & Taylor as a Principal Ecologist. I am currently Principal Ecologist and Managing Director of Kessels & Associates Ltd (trading as Bluewattle Ecology).

7. Much of my professional career has been involved in undertaking ecological investigations, monitoring and assessments and restoration planning within New Zealand, and principally in the Waikato region. I have been involved in many studies and projects relating to freshwater, land use activities, biodiversity, the restoration of riparian margins of streams and lakes, and wetland/ lake biodiversity and water quality, particularly for the rural sector and local government.

8. My Master's thesis investigated conserving biodiversity through collaborative management, investigating interactions between ecosystems and DOC's management of the Whangamarino Wetland.

9. I have been contracted by the Waikato Regional Council (WRC) on numerous occasions to study and assess the effects of agricultural-related activities on the ecological values of streams, rivers, lakes and wetlands within the Waikato region. I have been involved in the preparation of several rural and urban integrated catchment management plans for WRC, Hamilton City Council and Thames Coromandel District Council. I am currently assisting Central Hawkes Bay District Council with biodiversity matters as part of their preparation of the Proposed Central Hawkes Bay District Plan.

10. I was the Waikato, King Country and Western Coromandel Regional Representative for Queen Elizabeth the Second National Trust for the Waikato Region for five years, during which time I assisted many landowners in protecting and restoring degraded freshwater and terrestrial ecosystems in the Waikato and Waipā catchments.

11. I have undertaken many riparian and wetland assessment and restoration plans for rural landowners, tangata whenua, non-government organisations and government organisations such as DOC and territorial authorities. For example, currently I am assisting Matahuru marae restore a wetland and stream side ecosystems at Lake Waikare.

12. I have been involved in policy development pertaining to biodiversity and natural resource matters, acting directly for the councils, or for organisations summiting during the plan consultation and appeal processes. I have been involved in policy and regulatory mechanisms concerning biodiversity and land use for district plans for Central Hawkes Bay District Council, Kapiti Coast District Council, Hamilton City Council, Waikato District Council, Franklin District Council, Hauraki District Council, Thames Coromandel District Council, Waipa District Council and Waitomo District Council.

13. In preparing this evidence I have reviewed reports, and statements of evidence of other experts relevant to my area of expertise, including:

    (a) Proposed Plan Change 9 Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments;

(b) Hawke's Bay Biodiversity Strategy 2016[1];

(c) The National Policy Statement for Freshwater Management 2020[2];

(d) Final TANK Section 32 Report 2 May 2020; and

(e) The officers s42A report.

14. I have read the Code of Conduct for Expert Witnesses in the Environment Court's 2014 Practice Note and agree to comply with it. I confirm that the opinions I have expressed represent my true and complete professional opinions. The matters addressed by my evidence are within my field of professional expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

15. This brief of evidence provides my review of the efficacy of collaborative, catchment based, and landowner focussed mechanisms to deliver integrated management of natural resources, enhance ecosystem health and biodiversity as they relate to my areas of expertise in achieving the objectives of Proposed Plan Change 9 to Hawke's Bay Regional Council's (HBRC) Regional Resource Management Plan (RRMP) in Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments (hereafter '**TANK**').

16. I consider the approaches and methods which are likely most effective for the management of farming activities in relation to achieving freshwater ecosystem health and biodiversity require sub catchment planning that is led by the community, includes representatives from different parts of that community and is developed in conjunction with iwi groups, regional council staff and researchers, providing the basis for an integrated and collaborative process.

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[1]Hawke's Bay Biodiversity Strategy 2015-2050, 2016. https://www.hbrc.govt.nz/assets/Document-Library/Strategies/biodivstratNovember2015v3.pdf (Accessed 3 May 2020)

[2] Ministry for the Environment, 2020. National Policy Statement for Freshwater Management 2020.

EXECUTIVE SUMMARY

17. I have found through my research studies and experience that sub catchment scale, community based approaches to restoration, mitigation and monitoring of water quality and biodiversity values lends itself to more effective, collaborative solutions, than top down, 'command and control' approaches.

18. In particular, the potential benefits of collaborative processes can be wide ranging and have long lasting impacts. These approaches and methods have the following matters in common:

    (a) They enable flexibility, adaptation, and innovation.

    (b) They seek to engage farmers and provide a sense of ownership of the solutions / practices;

    (c) They are spatially appropriate and scalable to allow for local solutions (on-farm and sub-catchment) to regional problems; and

    (d) They enable an effective management and mitigation focus on achievement of desired ecosystem health and biodiversity enhancement outcomes, especially where multiple stressors and diffuse effects are involved.

19. I support the tailored, integrated sub catchment management approach of the TANK plan change. Rigid policy and compliance structures do not provide the necessary mechanisms to enable sustainable and effective management of diverse farming systems and catchments.

20. The proposed implementation methods and rule set of TANK are likely to encourage and incentivise best practice in terms of enabling widespread collaborative management through instigation of Catchment Collectives and farm environment plans at sub-catchment levels.

21. Creating implementation methods and rules which allow for greater input into the mitigation and monitoring requirements by landowners in sub catchments and farm environment plans is likely to result in the implementation of a wider, more flexible sub catchment focused and more site-appropriate range of riparian and edge of field mitigation tools. This approach will also create greater opportunities to measure the effectiveness of these local measures. A better platform for increased and more

measurable positive outcomes, particularly for hill country lands, as well as a more rapid and enduring uptake, will likely be the result of this approach.

22. Establishing networks of monitoring key indicators of success within sub catchments will also mean that information gathered across sub catchments is able to support a process of continuous learning and provides the opportunity for farmers, schools, iwi, councils, researchers and rural professionals to share knowledge and resources, as well as validating the broader HBRC monitoring network.

COMMAND AND CONTROL VERSUS COLLABORATIVE APPROACHES

23. Policy which focuses on 'command and control' type regulatory approaches[3], are unlikely to deliver on integrated and holistic sustainable management of natural resources as effectively as a mix of implementation and regulatory methods that allow for more community and sub catchment focused initiatives. I have found through my research studies (Kessels (2000)[4] and Kessels (2004)[5]) and experience, such as working with various landowner and mana whenua groups, that sub catchment scale, community-based approaches to ecological restoration, mitigation and monitoring (or ecosystem management approaches) lends itself to more effective, collaborative solutions as opposed to top down, 'command and control' approaches.

24. Holling et al (1998)[6] suggest there is a crisis in resource management and advocate rethinking resource management science because of its non-linear, multi-sectoral, multi-scale and dynamic complexities. They advocate systems approaches and adaptive management. The 1980 World Conservation Strategy states that long-term management of natural

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[3] Which can be defined as an approach to public policy is one where political authorities mandate people, by enacting a law, to bring about a behaviour, and use an enforcement machinery to get people to obey the law through required to meet standards. A standard is generally a mandated level of performance enforced through a piece of legislation.

[4] Kessels, G.H.A. 2000. Conserving Biodiversity through collaborative management. An investigation of interactions between ecosystems and societal systems and the Whangamarino Wetland. Masters thesis. Massey University, Palmerston North, NZ.

[5] Kessels, G. 2004. In Search Off The Right Mix: An investigation of tools for biodiversity management. Report for Local Government New Zealand, Kessels & Associates.

[6] Holling, CS, Berkes, F and Folke, C. 1998. Science, sustainability, and resource management". In Linking social and ecological systems: management practices and social mechanisms for building resilience, Edited by: Berkes, F and Folke, C. 342–362. Cambridge: Cambridge University Press

resources depends on the support and co-operation of local people (WCEC 1987)[7]. This statement has been validated by research studies of community driven catchment-based ecosystem health restoration initiatives in New Zealand, some of which I present in paragraphs 28-35 below. The fact that collaborative approaches have been promoted in New Zealand in the National Policy Statement - Freshwater 2020 NPS-FW), and amendments to the Resource Management Act (RMA), suggest these approaches are effective.

25. Ecosystem management approaches to natural resource management is a viable alternative approach to command and control. An ecosystem management approach rests on understanding that the inherent complexity 'lag' and cumulativeness between action and effects in terms of land use on ecosystems creates a great deal of uncertainty in predicting outcomes of management actions. In the New Zealand policy context, ecosystem management approaches assist in strengthening the relationship between ecological health and life supporting capacity of ecosystems (referring to Part 2 of the RMA and NPS-FW as priority value as primary policy drivers). In a practical sense, policy approaches that necessitate flexibility, anticipation, and adaptation, rather than reaction and control (Lister 1998)[8], are more likely to achieve more enduring positive outcomes. The Motueka integrated catchment management provides a useful example of this approach, which I refer to in greater detail in paragraph 36.

26. Ecosystem management is based on a collaboratively developed vision of desired future ecosystem conditions at a local level (Lucy 1994)[9]. The spatial extent of the management unit is defined by ecological and not political boundaries. It integrates ecological, economic and social factors in a particular management unit, which in turn is a pathway to provide ownership and empowerment of the local people to share in the

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[7] World Commission on Environment and Development (WCED). 1987. Our Common Future. UNEP, New York (Australian edition).

[8] Lister, N.E. 1998. A Systems Approach to Biodiversity Conservation Planning. Environmental Monitoring and Assessment Vol. 49: pp 123- 155.

[9] Lucy, W.H. 1994. If Planning Includes Too Much, Maybe It Should Include More. API Journal Vol. 60 No. 3. pp305-318.

management and monitoring of the natural resources in their area (Sunde et al, 1999)[10].

27. Ecosystem management, as an alternative approach to more prescriptive natural resource management approaches, draws on the connection of freshwater ecological health rather than a focus on specific attributes. In providing for ecological health, life supporting capacity is safeguarded. Ecological health takes a broader perspective that recognises the interconnectedness of ecosystem processes.

BENEFITS & EXAMPLES OF ECOSYSTEM MANAGEMENT APPROACHES

28. There are a large number of existing examples of community based, ecosystem management approaches to addressing water quality and freshwater ecosystem and biodiversity health, which appear to be assisting national and regional policy directives in New Zealand.

29. New Zealand Landcare Trust, for example, works with more than 150 land care groups in New Zealand, and many of these are effective at improving freshwater ecosystem health and enhancing biodiversity (NZ Landcare Trust, 2019)[11].

30. In the Whangape catchment of the Waikato region, Beef and Lamb New Zealand (B+LNZ) and Waikato Regional Council (WRC) have supported community catchment initiatives since at least 2016. This led to farmers becoming more involved, building understanding, and "being empowered to address the issues" (Hungerford, 2019)[12].

31. Drawing on my own experiences, whilst acting as a regional representative for QEII National Trust I become aware of the efforts tangata whenua, landowners, WRC, the Waitomo District Councils, the Department of Conservation and the tourism industry made collaboratively to address sediment runoff issues, which were affecting the glow-worm population of the caves. This was largely achieved by Iwi, regulatory agencies and stakeholders working collectively to implement mitigation and monitoring

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[10] Sunde, C; Taiepa, T; & Horsley, P. 1999. Nature Conservation Management Initiatives for Whanganui Iwi and the Department of Conservation. School of Resource and Environmental Planning, Massey University.
[11] http://www.landcare.org.nz/Landcare-Community (accessed February 2019)
[12] Hungerford, R. 2019. Evaluation report on sub catchment planning. Report prepared for Waikato Regional Council by momentum research and evaluation ltd.

measures relating to runoff and leaching from above-ground land use practices on upstream farms (Pavlovich 2001)[13].

32. The Whatawhata Integrated Catchment Management Project (ICM) demonstrates the potential combined benefits which can arise from collaborative models (in this case environmental and economic). Commencing in 1996, the Whatawhata ICM project involved multiple stakeholders, including Māori, landowners, farm staff, local government, a group representing farmers and researchers from different disciplines. The group set the vision of a "well managed rural hill country catchment" (Quinn et al., 2007)[14].

33. The ICM plan developed by this diverse collaborative group involved identifying the main issues in the catchment (i.e. erosion, stream degradation and a poorly performing beef and sheep breeding enterprise), the catchment was Land Use Capability (LUC) mapped, and potential and practical mitigations to address the issues were identified (i.e. indigenous forest restoration, strategically located plantation pine forest, intensification of the farming enterprises on the more versatile LUC classes, changes in stock type, poplar planting for soil stabilisation and excluding livestock from streams), prioritised and implemented.

34. Significant improvements were reported for the Whatawhata project between 1995 to 2003, including the economic surplus of the pastoral enterprise, in relation to industry average, improving by 43%, decreases in the export of suspended sediment (- 76%), total phosphorus (- 62%), and total nitrogen (- 33%). In streams water clarity was improved, aquatic invertebrate community indices improved, and stream temperatures declined (Quinn et al., 2007).

35. In addition, researchers of the Whatawhata ICM project concluded that participants of collaborative processes were likely to have improved access

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[13] Pavlovich 2001. The Twin Landscapes of Waitomo: Tourism Network and Sustainability through the Landcare Group. Journal of Sustainable Tourism 9(6):491-504

[14] Quinn, J.M., Dodd, M.B., Thorrold, B.S. 2007. Whatawhata catchment management project: the story so far. Proceedings of the New Zealand Grassland Association 69: 229-233.

to the four capitals: human, natural, financial/physical and social than traditional approaches (Botha, 2019)[15].

REQUIREMENTS FOR SUCCESSFUL COLLABORATIVE APPROACHES

36. Fenmemor et al (2011)[16] state, on the basis of a review of the Motueka integrated catchment management (ICM) research programme, that: "*A primary observation from this research is that catchment management is more likely to achieve agreed objectives when it empowers stakeholders, taking into account their aspirations and values, and adapting as those aspirations and values change. Unless an effective social context and decision-making framework is provided, complex or wicked problems like land and water management are unlikely to be addressed or resolved. This not only risks environmental damage, but also a lost opportunity for social cohesion. It may also reduce the potential for social cohesion in the future.*"

37. Sinner & Newton (2018)[17] provide further New Zealand based evidence and examples of effective management of diffuse contaminant leaching and run off at a community based, sub catchment scale, concluding that: "*because outcomes at a sub catchment and catchment scales are the result of multiple stressors originating from multiple properties, RMA[18] policies and rules aimed at individual properties may not achieve the objectives specified in regional plans. WMGs[19] offer a way through this problem, and many groups have emerged around New Zealand over the past 15 to 20 years to address local issues. To use this approach more widely under the National Policy Statement for Freshwater Management, however, will require a more deliberate and structured approach, so that the combined actions of all the groups in a given catchment will achieve the community's desired outcomes for that catchment.*"

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[15] Botha, N. (2019) The benefits and challenges of farmer-led, collaborative, sub- catchment policy methods and plans for consideration in the Waikato Catchment: A literature review. Report prepared for Waikato Regional Council by Botha Ltd.

[16] Fenemor, C Phillips, W Allen, RG Young, G Harmsworth, B Bowden, L Basher, PA Gillespie, M Kilvington, R Davies-Colley, J Dymond, A Cole, G Lauder, T Davie, R Smith, S Markham, N Deans, B Stuart, M Atkinson & A Collins (2011) Integrated catchment management—interweaving social process and science knowledge, New Zealand Journal of Marine and Freshwater Research, 45:3, 313-331,

[17] Sinner, J; Newton M. 2018. Water Management Groups: Preliminary Guidance. Prepared for Ministry for the Environment. Cawthron Report No. 3199. 15 p.

[18] Resource Management Act 1991

[19] Water management groups

38. Sinner & Newton (2018) also provide preliminary guidance advice for regional councils how community based, water management groups can be structured, and what regional council plans should contain to improve the likelihood that groups will achieve the freshwater outcomes sought by their communities.

39. The results of these two key pieces of research show that key elements required to support and empower a water management group (or a Catchment Collective as defined in TANK) can be summarised as:

- Ensuring the group structure is at a sub catchment scale and representative of all stakeholders within that sub catchment, and that ideally the group has legal status;
- Specification of more than one outcome, e.g. a range of water quality and habitat standards, for every water management group confluence point;
- Policies and methods which provide clear criteria or conditions for a group to be recognised and what its environment plan must contain;
- A regional plan should specify that a group's environment plan must be approved by the regional council prior to implementation;
- The environment plans need to contain several key elements including – goals, mapping of land use and effects of each land use practice, mitigation actions, monitoring and reporting strategies, review and auditing processes, an adaptive management approach to account for the complex and non-static ecosystem management dynamics at play, and consequences for non-achievement.

CREATING CERTAINTY OF ACHIEVING THE DESIRED OUTCOMES

40. Measuring the efficacy of a catchment collective approach in terms of achieving the desired objectives of regional plans has been limited to date in New Zealand (Doehring et al, 2020)[20]. However, catchment collective groups, when supplemented by regional council existing water quality and

[20] Doehring, K., Young, R.G, Robb, C. 2020. Demonstrating efficacy of rural land management actions to improve water quality - How can we quantify what actions have been done? Journal of Environmental Management. Vol. 270.

environmental monitoring programmes, do provide opportunities to better understand indicators of land management actions.

41. In this regard, it is important that catchment collective groups have sound administrative and management structures, and that they can demonstrate measurable improvements they may make to ecosystem health and biodiversity improvement at sub catchment levels. Indicators of success should involve monitoring of a range of water quality and ecological health metrics. But also, indicators can be quantification of the location and/or intensity of the action management actions such as the area of riparian planting, kilometres of stream bank fenced, number of farms adopting sediment reduction practices). These indicators need to quantify actions that occur at varying intensity and scale (Doehring et al, 2020).

42. I see no constraints to catchment collective groups being able to undertake this type of monitoring effectively. As Sinner & Newton (2018) note: "*One approach to managing these diffuse effects is to allocate limits for individual pollutants to individual properties. This is usually based on models that may not accurately reflect physical processes and cumulative effects, leaving environmental outcomes in doubt and land users questioning the models (Duncan 2014). Another approach is to require land users to adopt specific 'good management practices'. This provides some certainty of actions and costs but delivers uncertain environmental outcomes and, without other controls, may allow further intensification. Hence, both approaches have limitations and may not deliver what the community expects. Collective management offers a way to focus more on achievement of desired outcomes, especially where multiple stressors are involved. By assigning environmental responsibilities to a water management group rather than an individual landowner, land users have more flexibility to identify place-specific mitigations. Members are accountable to each other as well as to the wider community, creating peer pressure to improve performance."*

BEST PRACTICE MITIGATION AT A FARM SCALE

43. I am in support of the identification and adoption of mitigations at the farm scale applied through Farm Environmental Plans (FEPs), with direct input by individual landowners key. This approach should be integrated across a catchment and ideally applied to co-ordinate with sub-catchment management plans developed by Catchment Collective groups.

44. Management of contaminant losses from farms often needs to occur at the individual farm scale using tailored FEPs to be effective. A targeted approach to a range of management and mitigation measures that also involves critical source and high ecological value area identification and management is likely to an effective approach to attenuating a broader range of contaminants on hill country farms in many situations.

45. There are a range of proven on-farm management methods, riparian buffer zone and edge-of-field mitigation methods available which can be applied at an FEP or sub catchment scale by a community catchment group. Doole et al (2016)[21] suggest that for drystock farms the greatest efficiency and long-term gains in reducing contaminant discharges is best achieved when specific mitigations are:

- Chosen on the basis of suitability to the farm;
- Implemented on the basis of cost-effectiveness; and
- Implemented in critical source areas.

46. Edge-of-field mitigation measures, combined with tailored riparian buffer zones, when applied strategically at a farm and sub-catchment scale, and combined with on farm management activities, can provide effective alternative approaches to attenuate the runoff of sediment and nutrients, within productive farming landscapes, while enhancing biodiversity values (Parkyn 2004)[22]. These include a range of riparian management options, including:

- Headwater or riparian wetlands: Fenced wetlands as hotspots for nutrient removal;
- Rotational grazing: Filter strips with varied stock grazing practices, such as occasional light grazing by sheep;
- Forested or planted native or production trees: a buffer of native trees to return ecological function to the stream and provide water quality benefits; and
- Multi-tier system: a combination of buffers where native forest trees may be used beside the stream to enhance ecological function and

[21] Doole, G.; Quinn, J.M. Wilcock, B.J. Hudson, N. 2016. Simulation of the proposed policy mix for the Healthy Rivers Wai Ora process. Prepared for the Technical Leaders Group of the Healthy Rivers/Wai Ora Project. Report No. HR/TLG/2016-2017/4.5

[22] Parkyn, S. 2004. Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No: 2004/05. Ministry of Agriculture and Forestry, Wellington, NZ.

biodiversity, a buffer of production trees may occur outside of that and at the outer edge beside agricultural land a grass filter strip may be used.

47. There are also a range of edge-of-field mitigation measures which can be adopted by individual farmers, or at a sub catchment level. They include: detention bunds, constructed wetlands, sedimentation ponds and traps, swales, and water distribution networks. Edge-of field measures are most effective when they are combined, for example sedimentation and wetland combinations.

48. Doole (2015)[23], provides a useful description and tabulation of the efficacy of a range of different edge-of-field mitigation strategies (Table 14). This shows that for detention bunds, efficacy for N reduction is 10% and 30% for P reduction. For small constructed wetlands the efficacy is 20% reduction for N and 35% for P, while for medium constructed wetlands the efficacy is 40% reduction for N and 70% for P.

49. Constructed wetlands are an effective mitigation tool for reducing sediment and nutrient inputs to waterways. For example, effective removal of N inflows in the wetlands of the Tutaeuaua sub-catchment of Taupo was attributed to denitrification in that wetland (Collins et al 2005)[24].

50. Like collective approaches, FEPS are likely to be more effective and implemented by individual landowners if they are actively involved throughout the FEP process. As Doehring et al (2020) conclude, the success of these land management actions: "..*will depend on gaining landowner confidence and addressing concerns about confidentiality."*

51. In addition, by using FEPs as a recording platform of land management practices, and as a part of the wider matrix of information sources and data, these plans can provide a valuable contribution to monitoring and understanding land management actions, and to applying adaptive

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[23] Doole, G. 2015. Description of mitigation options defined within the economic model for Healthy Rivers Wai Ora Project. Description of options and sensitivity analysis. Prepared for the Technical Leaders Group of the Healthy Rivers/Wai Ora Project. Report No. HR/TLG/2015-2016/4.6

[24] Collins, R.: Elliott, S; Adams, R. 2005. Overland flow delivery of faecal bacteria to a headwater pastoral stream. Journal of Applied Microbiology 99:126-132

management approaches where further actions can be targeted at local scales (Doehring et al, 2020).

TANK PLANNING PROVISIONS SUPPORT COLLABORATIVE APPROACHES

52. The TANK plan change supports collaborative approaches to the management of land use in relation to water quality and biodiversity values of the catchments it covers. I support the approach in broad terms.

53. TANK, through Objective 1(c), provides for for an integrated, holistic and coordinated approach to the management of the Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments: 1 (c): "*support good decision making by resource users including rural and urban communities through marae and hapū initiatives, community or other catchment management programmes and monitoring initiatives, urban stormwater programmes, landowner collectives, farm management plans and industry good practice programmes.*"

54. Policies 1,2,3,4 and 5 outline the priority management approach taken where water quality targets shown in Schedule 26 are not being met.

55. Policies 23,24,25 provides for Industry Programmes and Catchment Management and requires HBRC to support and encourage their establishment and implementation.

56. TANK provides a Permitted Activity pathway for productive land use through 'Catchment Collectives' and Farm Plans subject to meeting the requirements of Schedule 30 and:
    - To be provided by Council on request.
    - Information on the implementation of the mitigation measures supplied to Council on request.

57. In terms of having certainty that the collaborative approach encouraged by TANK will lead to effective outcomes, I note that the section 42A report makes specific mention of Policy 26 (which lists the ways in which Council can enforce or encourage compliance) as follows: "*The policy [Pol TANK 26] recognises that issues may arise within Collectives as much as they might arise in relation to compliance with plan rules. The research into the barriers to the success of collective management identified management of conflict and compliance as key areas that required specific attention. This*

policy addresses that need and reflects that Council may provide conflict resolution services in situations where Collectives may need assistance. Each Collective will need to develop conditions of membership (and these may be based on industry or council templates). If individuals don't comply with local conditions, this policy provides an avenue for resolution without the collective having to play a policing role over their own neighbours. In addition, the Council will continue to enforce compliance with Rules TANK 1 and 2. The Council can adopt a range of enforcement measures including abatement notices, enforcement orders and prosecutions as necessary in these circumstances." (Paragraphs 892-893). The section 42A report therefore clarifies that Council is able to provide certainty that enforcement measures, both at a catchment collective level and at a farm scale, can be applied to ensure compliance. I agree with this analysis and would support any amendments to Schedule 30 that require the members of a Catchment Collective to agree to participate in Council's conflict resolution service.

58. The policy framework of TANK thus encourages the adoption and implementation of a sub-catchment approach to prioritisation of implementation of mitigation and management measures through supporting and encouraging Catchment Collectives, application of best practicable options and mitigation or offsets at a farm scale via Farm Environment Plans as detailed in Schedule 30, and regulatory backstops should these approaches require enforcement. re the necessary policy provisions to achieve a successful outcome using CC.

NOTE TO THE HEARING PANEL REGARDING S42A RECOMMENDATIONS

59. I note paragraph 907 of the s42A Hearing Report invites submitters to provide evidence on measures that enable industry leaders and landowners to understand water quality issues and to implement necessary measures in a reasonably timely manner. I therefore drafted my evidence with that request in mind.

60. Refer paragraph 57 above.

CONCLUDING STATEMENT

61. My opinions are based on my current understanding and review of the evidence, literature and data referenced in my evidence brief, including reports supplied by Hawkes Bay Regional Council. In particular, I have

relied on the information and evidence of others, particularly where it is relevant, but outside of my areas of expertise. I reserve my final opinions subject to review of further evidence provided by other experts and Council staff, and any subsequent caucusing.

DATED this 7TH of May 2021

Mr Gerry Kessels

Before the Proposed Plan Change 9 (PPC9) Tūtaekurī, Ahuriri, Ngaruroro and Karamū (TANK) Catchments Hearings Panel

In the matter of of the Resource Management Act

And Water quality and ecology

Statement of primary evidence of Dr Michael John Crawshaw Greer on behalf of Beef + New Zealand (water quality and freshwater ecology)

Date: 7th May 2021

INTRODUCTION

1 My full name is Dr Michael John Crawshaw Greer. I am employed as a Senior Scientist (Freshwater) by Aquanet Consulting Limited.

2 I was instructed by Beef + Lamb New Zealand (Beef + Lamb) to prepare evidence in respect of technical matters related to the Objectives and Schedules (26) in Proposed Plan Change 9 – Tūtaekurī, Ahuriri, Ngaruroro and Karamū (TANK) Catchments (PPC9).

QUALIFICATIONS AND EXPERIENCE

3 I hold the qualifications of a PhD degree in Ecology (2014) and a Bachelor of Science in Zoology from the University of Otago (2010).

4 I have worked for local government, the Department of Conservation and NIWA. I have over 9 years of work experience in freshwater ecology and water quality. Since the 4th of March 2018 I have been employed by Aquanet Consulting Ltd. Prior to that I was employed by the Greater Wellington Regional Council (GWRC) as a Senior Environmental Scientist and Environment Canterbury as an Ecology Scientist.

5 Since joining Aquanet I have been engaged by 15 different regional, district or city councils; the Department of Conservation and various private companies/corporations to provide a variety of technical and scientific services in relation to water quality and aquatic ecology.

6 I have authored or co-authored a number of reports that have informed or are informing the development and implementation of regional plan change processes:

6.1 For Environment Canterbury: I was the lead author of the report that formed the basis of the inanga spawning provisions in Plan Change 4 to the Land and Water Regional Plan (LWRP), and the technical report underpinning the water quality standards in Part B of Plan Change 5 of the LWRP.

6.2 For GWRC I am the technical lead for the Surface Water Quality and Ecology expert Panel for Te Whanganui-a-Tara Whaitua process and am the lead author of the technical report outlining the expert panel process and outputs.

7 Since 2017 I have been acting on behalf of the GWRC during the council hearing and environment court appeal processes for the Proposed Natural Resources Plan Proposed Natural Resources Plan (PNRP) for the Wellington Region. This has involved writing and presenting evidence for council and environment court hearings, contributing to mediation and attending expert conferencing on matters relating to the freshwater quality and aquatic ecosystem health, stream reclamation and drain management provisions in the PNRP. I also acted on behalf of Federated Farmers New Zealand during the environment court appeals on Plan Change 10 (Lake Rotorua Nutrient Management) to the Bay of Plenty Regional Natural Resources Plan, and as part of that process engaged in expert conferencing on the nutrient load limits set in the plan.

8 I have worked as a technical advisor on behalf of the consenting authority, the applicant and/or submitters on well over 120 resource consent applications, compliance assessments and/or prosecution cases for a wide range of activities, including stream reclamation, water abstraction, water storage and discharges to land and water.

9 My work routinely involves providing assessment of effects on water quality and/or aquatic ecology, recommending or assessing compliance with resource consent conditions, and designing or implementing water quality/aquatic ecology monitoring programmes at the scale of a specific activity and at a wider catchment or regional scale. As part of my previous role at GWRC I designed the Urban Streams Monitoring Programme which is run in conjunction with Wellington City Council and led the Rivers Water Quality and Ecology monitoring programme. While at Aquanet I have designed the monitoring programmes for the Levin and Foxton Beach Global Stormwater consents and contributed to the monitoring protocols behind the Department of Conservation's Freshwater Tier 1 Biodiversity Monitoring Programme Pilot.

10 I have authored or co-authored a number of catchment and region-wide water quality reports for the GWRC (Whaitua Te Whanganui-a-Tara and Ruamāhanga Whaitua), Environment Southland (Whole Region), and Environment Canterbury (Lower Waitaki Water Zone and Waimakariri Water Zone).

11 Between 2015 and 2017 I sat on the New Zealand Fish Passage Advisory Group. During that time, I secured funding from regional councils around the country for the development of *The New Zealand Fish Passage Guidelines and* drove the inclusion of *minimum design standards for fish passage at instream structure*s that can be carried over directly into regional plans.

12 I am a member of New Zealand Freshwater Sciences Society.

CODE OF CONDUCT

13 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing my evidence and will continue to comply with it while giving oral evidence before the Hearing Commissioners. My qualifications as an expert are set out above. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SUMMARY

14 My name is Dr Michael John Crawshaw Greer.

15 I have been asked by Beef + Lamb to provide water quality and ecology evidence in relation to their submission on the Freshwater Quality Objectives in Schedule 26 of PPC9.

16 My statement of evidence addresses the following matters:

16.1 Whether the Freshwater Quality Objectives in Schedule 26 are aligned with the wording of the relevant Catchment Objectives;

16.2 The areas in the TANK catchments where Freshwater Quality Objectives are not being met and the primary land-uses in those areas;

16.3 The ability of Hawke's Bay Regional Council's monitoring network to detect future changes in water quality caused by changing practices on sheep and beef farms; and

16.4 The technical rigour of the individual Freshwater Quality Objectives in Schedule 26 and my recommended changes to the schedule.

17 From a technical perspective the ambiguity of the wording of the values in OBJ TANK 10 to OBJ TANK 13, combined with the inconsistencies in the level of environmental protection provided by the objectives in Schedule 26 means that it is unclear:

17.1 How one would assess whether the ecosystem health values are provided for; and

17.2 Whether some of the Schedule 26 freshwater objectives actually provide for the values.

18 If it is the intent of the PPC9 to achieve a value of excellent ecosystem health in the Upper Ngaruroro and Upper Tūtaekurī Rivers FMQU, good ecosystem health in the Lower Ngaruroro and Lower Tūtaekurī Rivers FMQUs and fair ecosystem health in the Lower tributaries (as the macroinvertebrate objectives suggest), then it is my opinion that it should be explicitly stated in the clauses of OBJ TANK 11 to OBJ TANK 13. Furthermore, where the objectives in Schedule 26 should be updated to be consistent with those values.

19 Water quality data in the latest state of the environment report from HBRC suggest that a number of the Schedule 26 Freshwater Objectives

are not being met throughout the TANK catchments. However, while agriculture is the predominant land-use in most Freshwater Quality Management Units (FMQUs) in many (but not all) instances its contribution to objectives not being met appears to be limited and/or of little ecological consequence. Specifically:

19.1 Through most of the TANK catchments macroinvertebrate communities are indicative of good or excellent aquatic ecosystem health. However, agriculture and cropping may be driving degraded macroinvertebrate community health throughout the lowland tributaries in the area. A likely explanation for this is excessive macrophyte growth bought about by a lack of riparian shading. This increased macrophyte growth may not be a direct effect of ongoing agricultural land-use, but rather the result of prior vegetation clearance and legacy sediment effects.

19.2 While the Schedule 26 pH targets are not meet at most State of the Environment sites in the TANK catchments, this is likely the result of natural processes rather than the effects of land-use.

19.3 The Schedule 26 ammonia objectives are not met in a number of streams due to occasional spikes causing the maximum concentration threshold to be exceeded. However, agriculture's contribution to this is difficult to ascertain given that ammonia is more commonly associated with point-source rather than diffuse discharges.

19.4 The dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) Schedule 26 objectives are not met throughout much of the TANK catchments, and in catchments without significant cropping agriculture is the most likely cause of this. However, non-compliance with the DIN and DRP objectives does not appear to affect ecosystem health in any meaningful way, as they are not linked to periphyton or macrophyte growth.

19.5 The Schedule 26 visual clarity objectives are generally met in the Upper Ngaruroro and Upper Tūtaekurī Rivers and Lowland Tributaries FMQUs. However, agriculture may the reason why the relevant clarity objectives are not met through much of the Ngaruroro and Tūtaekurī Tributaries and Lower Ngaruroro and Lower Tūtaekurī Rivers FMQUs. Similarly, agriculture is the most likely cause of the Schedule 26 *E. coli* targets not being met through much of the Lowland Tributaries and Ngaruroro and Tūtaekurī Tributaries FMQUs.

19.6 Agriculture does not appear to be causing the Schedule 26 periphyton cover, turbidity or nitrate objectives to be exceeded through most of the TANK catchments.

20 It is likely that HBRC's existing monitoring network in the TANK catchments is sufficiently robust that changes in water quality and ecology associated with shifting land-use practices should be detectable in most sub-catchments. However, it is probable that changes in the following sub-catchments can only be assessed by applying mass-balance approaches to water quality data collected at nearby sites (parenthesised N, T and Ks denote sub-catchments in the Ngaruroro River, Tūtaekurī River and Karamū stream catchments respectively):

- Whanaukini Stream (N);
- Otamauri Stream (N);
- Mangatahi Stream (N);
- Kikiwhero Stream (N);
- Otakarara Stream (T);
- Waikonini Stream (T);
- Waiiti Stream (T);
- Irongate Stream (K);
- Louisa Stream (K); and
- Mangarau Stream (K).

21 This means that the current network can probably not detect any variability in water quality trends between the catchments listed above, nor can it be used to detect any changes in their aquatic ecology.

22 My recommended changes to Schedule 26 are summarised in Table 1. My main concerns with the current objectives are around the use of largely untested provisional guidelines (macrophytes, cyanobacteria, temperature), the incorrect selection of nutrient criteria for periphyton growth from Matheson *et al.* (2016) and the use of periphyton cover instead of biomass, which is a compulsory attribute in the National Policy Statement for Freshwater Management.

23 The recommended changes to Schedule 26 set out in Table 1 would increase the number of streams meeting the DIN and DRP objectives. However, this is unlikely to affect periphyton growth in the TANK catchments as it is already low in most places despite the current DIN and DRP objectives being exceeded.

Table 1: Recommended changes to the freshwater objectives in Schedule 26 and whether those changes are supported by HBRC's suggested amendments (Appendix 1B of the S42A report).

Attribute	FMQU	Recommended change	Change consistent with HBRC's suggested amendments
DIN	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to 0.1 mg/L (average conc.)	No
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to 0.63 mg/L (average conc.)	
	Ngaruroro and Tūtaekurī Tributaries		
	Lowland Tributaries	Change to reflect current state	
TP	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to 0.014 mg/L (average conc.; currently DRP)	
DRP	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to 0.011 mg/L (average conc.; currently DRP)	
	Ngaruroro and Tūtaekurī Tributaries		
	Lowland Tributaries	Change to reflect current state	
Temperature	All	Delete	Yes
Turbidity			
pH			
E. coli	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to • Median ≤130/100mL • 95th Percentile ≤540/100mL • % exceedances over 260/100 mL <20% • % exceedances over 540/100 mL <5%	
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to • Median ≤130/100mL • 95th Percentile ≤1000/100mL • % exceedances over 260/100 mL <30% • % exceedances over 540/100 mL <10%	
Deposited sediment	Upper Ngaruroro and Upper Tūtaekurī Rivers	Delete seasonal objective of 15% cover for salmonid spawning	
	Lowland Tributaries	Delete for naturally soft-bottomed streams	
Periphyton biomass	Upper Ngaruroro and Upper Tūtaekurī Rivers	Amend to ≤50 mg chl-a/m^2	No
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Amend to ≤120 mg chl-a/m^2	Yes
	Ngaruroro and Tūtaekurī Tributaries	add ≤120 mg chl-a/m^2	No
Cyanobacteria	All	Delete	No
Macrophytes	Lowland Tributaries		
Macroinvertebrates	Lowland Tributaries	Only stipulate MCI-sb for naturally soft-bottomed streams	Yes

SCOPE OF EVIDENCE

24 My statement of evidence addresses the following matters:

24.1 Whether the Freshwater Quality Objectives (the objectives) in Schedule 26 are aligned with the wording of the relevant Catchment Objectives (OBJ TANK 10 – OBJ TANK 13);

24.2 The areas in the TANK catchments where the objectives are not being met and the primary land-uses in those areas;

24.3 The ability of Hawke's Bay Regional Council's monitoring networks to detect future changes in water quality caused by changing practices on sheep and beef farms; and

24.4 The technical rigour of the individual objectives in Schedule 26 and any recommended changes to the schedule.

25 In preparing my evidence I have considered the following:

25.1 The relevant literature on the effects of water quality on aquatic ecosystem health and human health. A list of these documents are provided in para. 115 to para. 143;

25.2 The relevant parts of the Hearing Report on Proposed Plan Change 9 - Tūtaekurī Ahuriri Ngaruroro Karamū Catchment Area[1] (The S42A report) report including:

25.2.1 Appendix 1B Recommended Changes to PPC – Schedules;

25.2.2 Appendix 9 Technical Memo – Water quality attributes – Schedule 26; and

[1] Hearing Report on Proposed Plan Change 9 - Tūtaekurī Ahuriri Ngaruroro Karamū Catchment Area. 15 April 2021. Hawke's Bay Regional Council Publication No. 5550

25.2.3 The Hawke's Bay Regional Council (HBRC) technical report that provides the technical background on how the Freshwater Quality Objectives in Schedule 26 were chosen (Haidekker, 2019)[2].

26 My conclusions are limited to technical matters and I do not provide recommendations on the PPC9 policy framework. My evidence is also limited to the matters of water quality and aquatic ecology in rivers. I do not consider any matters related to estuarine or wetland water quality or ecology except where there is a direct link with the rivers objectives in Schedule 26.

WHETHER THE SCHEDULE 26 FRESHWATER QUALITY OBJECTIVES PROVIDE FOR THE VALUES IDENTIFIED IN OBJ TANK 11 TO OBJ TANK 13

27 In 2015 the Ministry for the Environment (MfE) released a guidance document outlining the approach regional councils should use to implement the National Objective Framework (NOF) in the National Policy Statement for Freshwater Management (NPS-FM) 2014 (MfE, 2015). This approach involved:

27.1 Identifying **values** – Values are intrinsic qualities or uses that people and communities appreciate about freshwater bodies and wish to see recognised in the on-going management of those freshwater bodies.

27.2 Identifying **attributes** that need to be managed to provide for each value – Attributes are characteristics or properties of fresh water that need to be managed for a particular value.

[2] Haidekker, S. (2019) Supporting water quality information for the development of limits and targets by the TANK Group: Rivers and Streams. Hawke's Bay Regional Council Technical Report RM19-252. Napier, New Zealand: Hawke's Bay Regional Council.

27.3 Choosing f**reshwater objectives** for each attribute at a level that provides for each value – A freshwater objective is an environmental outcome that describes the environmental state required for the identified values for fresh water to be achieved.

27.4 Setting **limits** that control the maximum amount of resource use to a level that enables freshwater objectives to be met – A limit is a specific quantifiable amount that links the freshwater objective (the desired state) to use of the freshwater resource.

27.5 Determining **methods** that ensure that limits and freshwater objectives are met.

28 While there is uncertainty about the applicability of the approach set out above to the NOF in the NPS-FM 2020, especially given the new terms introduced in that document (visions, environmental outcomes, etc.), the logic of setting freshwater objectives at a level that provides for the identified values is still relevant from a scientific standpoint.

29 It is my understanding from reading PPC9 and the S42A report that OBJ TANK 11 to OBJ TANK 13 set out the values for each Freshwater Quality Management Unit (FMQU), while Schedule 26A sets freshwater objectives in order to achieve those values.

30 An assessment of the appropriateness of this approach from a policy perspective is outside of the scope of my evidence. However, from a technical perspective the ambiguity of the wording of the values in OBJ TANK 10 to OBJ TANK 13, combined with the inconsistencies in the level of environmental protection provided by the objectives in Schedule 26 means that it is unclear:

30.1 How one would assess whether the ecosystem health values are provided for; and

30.2 Whether some of the Schedule 26 freshwater objectives actually provide for the values.

31 Applying the term “healthy” to aquatic ecosystems, aquatic life and aquatic plants in the clauses of OBJ TANK 11 to OBJ TANK 13 makes it difficult to determine when the value is met. The four-stage NPS-FM attribute states (A-D) for aquatic ecosystem health are based on the poor-fair-good-excellent scale that has been used describe macroinvertebrate community health in New Zealand for many years (Stark and Maxted, 2007). Thus, applying this terminology to the values related to water quality and ecology in OBJ TANK 11 to OBJ TANK 13 would make the intent a lot clearer and would enable more effective reporting against the values.

32 The macroinvertebrate community is an important component of the stream ecosystem. Macroinvertebrates are a critical part of the food web and are affected by physical, chemical and biological conditions. In addition, their sedentary nature and relatively long life span means that they represent local conditions and show the effects of both short and long-duration stressors. Sensitivity to pollution and other physico-chemical stressors differs between macroinvertebrate taxa, and the composition of the invertebrate community in a stream can provide valuable information about how the state and trends in water quality and habitat are impacting ecosystem function. Consequently, benthic macroinvertebrates are one of the most widely used biological indicators of river and stream ecosystem health.

33 The Macroinvertebrate Community Index (MCI) objectives in Schedule 26 of PPC9 and Appendix 1B of the S42A report suggest that the desired level of ecosystem health is excellent in Upper Ngaruroro and Upper Tūtaekurī Rivers (UNUTR) FMQU, good in the Ngaruroro and Tūtaekurī Tributaries (NTT) and Lower Ngaruroro and Lower Tūtaekurī Rivers FMQUs (LNLTR), and fair in the Lowland Tributaries (LT) FMQU. However, other objectives in Schedule 26 contradict this, with the periphyton biomass objective for the Upper Tūtaekurī River set at the NPS-FM 2020 B attribute state, when the A state aligns with the corresponding ‘excellent’ MCI and the periphyton cover objectives for that river.

34 If it is the intent of the PPC9 to achieve a value of excellent ecosystem health in the UNUTR FMQU, good ecosystem health in the NTT and LNLTR FMQUs and fair ecosystem health in the LT FMQU, then it is my opinion that it should be explicitly stated in the clauses of OBJ TANK 11 to OBJ TANK 13. Furthermore, the objectives in Schedule 26 should be updated to be consistent with those values (see para. 82 to par. 111)

BENCHMARKING AGAINST FRESHWATER QUALITY OBJECTIVES AND IDENTIFICATION OF POTENTIAL DRIVERS WHERE THEY ARE NOT MET

35 The following sections of my evidence (para. 37 to para. 59 and Table 2) benchmark water quality data from HBRC's State of the Environment (SoE) monitoring network and NIWA's National River Water Quality Network (NRWQN) monitoring networks against the Schedule 26 objectives, and provides a qualitative narrative assessment of the contribution of different land-uses to objectives not being met.

36 Due to time constraints all water quality (except pH for the NRWQN monitoring site on the Ngaruroro River) and landcover data[3] used in this assessment have been sourced from Haidekker and Madarasz-Smith (2020). This means that the Schedule 26 objectives for deposited sediment, dissolved oxygen, temperature and periphyton biomass cannot be benchmarked due to data limitations.

37 Data from the SoE site on the Poporangi Stream and the NRWQN site on the Ngaruroro River at Chesterthorpe have also not benchmarked as flow binned summary statistics for those sites are not provided in Appendix A of Haidekker and Madarasz-Smith (2020). While data are also not provided for the NRWQN site on the Ngaruroro River at Kuripapango, it is the only site on the Ngaruroro River on the UNUTR FMQU and provides the only indication of natural state in that catchment. As such, I have drawn on data presented in tables and text of Haidekker and

[3] All landcover figures are generalised estimates and may not reflect upstream landcover at a specific SoE site

Madarasz-Smith (2020) to bench mark this site. This was not done for the other two sites mentioned above due to time constraints and the presence of SoE sites close by meaning that it was not necessary to describe the general state of water quality in the relevant FMQUs.

Macroinvertebrates

38 The macroinvertebrate community is an important component of the stream ecosystem and are one of the most widely used biological indicators of river and stream ecosystem health (see para.32 and para. 33).

39 MCI scores are generally indicative of good or excellent macroinvertebrate community health throughout the upper parts of Ngaruroro and Tūtaekurī river catchments (Haidekker and Madarasz-Smith, 2020), with the relevant Schedule 26 objectives met at all sites in the UNUTR and NTT FMQUs (Table 2) and at all but the most downstream sites in the LNLTR FMQU (Table 2). In contrast, there is evidence of degraded macroinvertebrate community health throughout the lowland parts of the TANK catchments, with the relevant Schedule 26 objectives not being met at the most downstream sites in the LNLTR FMQU (objective set at good community health) and at all but one site in the LT FMQU (objective set at fair community health) (Table 2).

40 The specific drivers of degraded macroinvertebrate community health in the lower parts of the TANK catchments cannot be determined with certainty from the available (at time of writing) data. Nevertheless, it is not unexpected given that lowland streams are often the most degraded in the catchment due to increasing agricultural and urban intensity in the downstream direction (i.e., most intensive land and large urban centres occur on low gradient land close to the coast). Both urban and agricultural land-use can lead to habitat modification, increased contaminant concentrations and greater sediment input (Piggott *et al.*, 2012; Walsh *et al.*, 2005). Thus, it is common to see poorer macroinvertebrate community health in the lower parts of river catchments (Niyogi *et al.*, 2007).

41 One possible explanation for degraded macroinvertebrate community health in the LT FMQU that has been identified by HBRC[4] is excessive macrophyte growth bought about by a lack of riparian shading. This explanation is supported by the local studies (Matheson *et al.*, 2017), my own benchmarking against the Schedule 26 macrophyte objective for the LT FMQU (Table 2), and an assessment of the available dissolved oxygen data (minimum concentrations at certain sites < 3 mg/L). At high densities macrophytes can reduce habitat availability for invertebrates, reduce stream hydraulic capacity, increase sediment deposition and alter daily oxygen and pH patterns (Hearne and Armitage, 1993; Kaenel and Uehlinger, 1998; Wilcock and Nagels, 2001; Wilcock *et al.*, 1999). Thus, they can be important drivers of poor macroinvertebrate community health when present at nuisance levels (Matheson *et al.*, 2012).

42 Increased macrophyte growth in the LT FMQU may not be a direct effect of ongoing land-use (there is a high level of uncertainty around the effects of nutrient availability on macrophyte growth (Matheson *et al.*, 2012)), but rather the result of prior vegetation clearance and legacy sediment effects (Matheson *et al.*, 2017). Nevertheless, a high proportion of the land-cover in the LT FMQU is in agriculture (>50% sheep and beef in at all SoE sites) and cropping (>28 for sites on the Clive River and the Herehere Stream sites) and the ultimate cause is likely to be those land-uses (Table 3). Thus, the potential for future improvements in MCI in the LT FMQU is likely to be dependent on improved riparian management practices on land used for agriculture and horticulture.

43 The predominant land-use upstream of the SoE sites in the LNLTR FMQU that are not meeting the Schedule 26 objective is agriculture (>30% in sheep and beef) (Table 3). Thus, degradation in MCI from the desired good state is likely due to that land-use or some as yet unexplained natural mechanism.

[4] https://www.hastingsdc.govt.nz/assets/Document-Library/Publications/Water-Symposium/dr-andy-hicks.pdf

Table 2:Assessment of SOE and NRWQN sites against the current Schedule 26 objectives.

Zone	Site	pH	Clarity	Turbidity	DIN	DRP	NH_4-N	NO_3-N	*E.coli*	(P)eriphyton/ (M)acrophytes	Invertebrates
Upper Ngaruroro and Upper Tūtaekurī Rivers	Tūtaekurī R. @ Lawrence Hut	×	✓	✓	✓	×	✓	✓	✓	✓(P)	✓
	Ngaruroro R. @ Kuripapango	×	✓	✓	✓	✓	✓	✓	✓	?(P)	✓
Lower Ngaruroro and Lower Tūtaekurī Rivers	Ngaruroro R. @ Whanawhana	✓	✓	✓	✓	✓	✓	✓	✓	✓(P)	✓
	Ngaruroro R. D/S Hawkes Bay Dairies	×	×	×	✓	✓	✓	✓	✓	✓(P)	✓
	Ngaruroro R. @ Fernhill	×	×	×	✓	✓	✓	✓	✓	×(P)	×
	Tūtaekurī R. U/S Mangaone	×	×	✓	×	✓	×	✓	✓	✓(P)	✓
	Tūtaekurī R. @ Brookfields Br.	×	×	✓	×	×	×	✓	✓	✓(P)	×
Ngaruroro and Tūtaekurī Tributaries	Mangaone R. @ Rissington	×	×	✓	×	×	×	✓	×	✓(P)	✓
	Mangatutu S. @ Mangatutu Stn Br.	×	×	✓	×	×	×	✓	×	✓(P)	✓
	Ohara S. @ Big Hill Rd	✓	✓	✓	✓	✓	✓	✓	✓	✓(P)	✓
Lowland tributaries	Maraekakaho S. @ Maraekakaho	✓	✓	✓	✓	×	✓	✓	✓	?	×
	Ohiwia S. @ Broughtons Br.	×	✓	✓	×	×	×	✓	✓	?	×
	Waitio S. @ Ohiti Rd	×	✓	✓	✓	×	✓	✓	✓	✓(M)	✓
	Tūtaekurī Waimate S. @ Chesterhope	✓	✓	✓	✓	×	×	✓	✓	?	×
	Awanui S. @ Flume	✓	×	✓	×	×	×	✓	×	×(M)	×
	Poukawa S. @ Stock Rd	✓	✓	✓	✓	×	×	✓	✓	×(M)	×
	Karewarewa S. @ Paki Paki	✓	✓	✓	×	×	×	✓	×	×(M)	×
	Herehere S. @ Te Aute Rd	×	✓	✓	✓	×	×	✓	×	✓(M)	×
	Raupare S. @ Ormond Rd	✓	✓	✓	✓	×	×	✓	×	×(M)	×
	Clive R. U/S Whakatu Rail Br.	×	×	✓	×	×	×	✓	×	?	×
	Taipo S. @ Church Rd	✓	×	✓	✓	×	×	✓	×	✓(M)	×

Table 3:Predominant land-uses upstream of HBRC SoE sites.

Zone	Site	Predominant land-uses
Upper Ngaruroro and Upper Tūtaekurī Rivers	Tūtaekurī R. @ Lawrence Hut	• 77% native cover[1] • 21% exotic forest
	Ngaruroro R. @ Kuripapango	• **12% sheep and beef** • 82% native cover
Lower Ngaruroro and Lower Tūtaekurī Rivers	Ngaruroro R. @ Whanawhana	• **12% sheep and beef** • 82% native cover
	Ngaruroro R. D/S Hawkes Bay Dairies	• **33% sheep and beef**[2] • 56% native cover
	Ngaruroro R. @ Fernhill	• **33% sheep and beef** • 56% native cover
	Tūtaekurī R. U/S Mangaone	• **53% sheep and beef**[3] • 25% native cover • 18% exotic forest
	Tūtaekurī R. @ Brookfields Br.	• **54% sheep and beef**[4] • 24% native cover • 18% exotic forest
Ngaruroro and Tūtaekurī Tributaries	Mangaone R. @ Rissington	• **61% sheep and beef**[3] • 17% native cover • 18% exotic forest
	Mangatutu S. @ Mangatutu Stn Br.	
	Ohara S. @ Big Hill Rd	• **62% sheep and beef**[2] • 21% native cover
Lowland tributaries	Maraekakaho S. @ Maraekakaho	
	Ohiwia S. @ Broughtons Br.	
	Waitio S. @ Ohiti Rd	
	Tūtaekurī Waimate S. @ Chesterhope	• **59% sheep and beef**[4] • 30% cropping
	Awanui S. @ Flume	• **61% sheep and beef** • 28% cropping • 7% urban
	Poukawa S. @ Stock Rd	
	Karewarewa S. @ Paki Paki	
	Herehere S. @ Te Aute Rd	
	Raupare S. @ Ormond Rd	
	Clive R. U/S Whakatu Rail Br.	
	Taipo S. @ Church Rd	• **>50% urban**[5]

[1] based of landcover data for the Ngaruroro River at Whanawhana
[2] based of landcover data for the Ngaruroro River at Fernhill
[3] based of landcover data for the Tūtaekurī River at Puketapu
[4] based of landcover data for the Tūtaekurī River at the coast
[5] based on a visual assessment of landcover maps. Breakdowns not provided in Haidekker and Madarasz-Smith (2020)

Periphyton

44 Periphyton are primary producers and an important foundation of many river and stream food webs, particularly in rivers with hard, cobbly substrate. Periphyton also stabilise substrata and serve as habitat for many other organisms. However, an over-abundance of periphyton can reduce ecological habitat quality (Matheson *et al.*, 2012). Large standing crops of periphyton can smother stream-bed substrate, thereby reducing the amount of suitable habitat available for fish and invertebrates. High densities of periphyton can also cause large daily fluctuations in dissolved oxygen concentrations and pH. Therefore, it is important to manage rivers

and streams to reduce the risk of nuisance growths. Periphyton biomass covering the riverbed (measured in milligrams of chlorophyll a per metre squared of riverbed) is the most commonly used periphyton measure for assessing ecosystem health and is a compulsory attribute in the NPS-FM 2020. However, the periphyton Weighted Composite Cover (periWCC) is now a frequently used metric for quantifying visual periphyton cover and is also included in the Schedule 26.

45 Nuisance periphyton blooms do not appear to be a significant issue in the UNUTR, NTT or LNLTR FMQUs, with only one site on the lower Ngaruroro River slightly exceeding the Schedule 26 objective for periphyton cover[5] (Table 2).

Macrophytes

46 Macrophytes, which encompass macro-algae (charophytes), mosses and liverworts (bryophytes), ferns and angiosperms, are a common occurrence in waterbodies, and are found across a broad range of habitat types. These plants are a natural component of the biodiversity and functioning of stream and river systems – in particular, those with stable, slow flows. However, excessive macrophyte growth, generally associated with introduced rather than indigenous species (Matheson *et al.*, 2012), is detrimental to ecosystem function. Due to a lack of empirical data, robust macrophyte cover and volume thresholds for the onset of detrimental effects on ecosystem health do not currently exist (Matheson *et al.*, 2012). However, HBRC have adopted Matheson *et al.'s* (2012) provisional guideline for the protection of instream ecological condition in Schedule 26 (cross sectional area/volume (CAV) < 50%).

47 As previously stated in para. 41, nuisance macrophyte growths are ubiquitous in the LT FMQU (Table 2), and the cause of this is likely to be associated with agriculture (>50% land cover in sheep in beef at all sites) and cropping (>28 land cover Clive River and the Herehere Stream sites)

[5] Note – The Schedule 26 periphyton biomass objective can not be benchmarked from the available (at time of writing) data.

as they are the predominant land-uses in this area (Table 3). However, previous vegetation clearance and sediment input may well be a more important driver than current land-use practices (Matheson *et al.*, 2017).

Water Quality

Visual clarity

48 The Schedule 26 visual clarity objectives are generally met in the UNUTR and LT FMQUs but not the NTT or LNLTR FMQUs (Table 2). Given that the most upstream SoE sites on both the Ngaruroro and Tūtaekurī rivers meet the objective, degraded (beyond the objectives) visual clarity in the NTT and LNLTR FMQUs is unlikely to be the result of natural processes and may be caused by sediment input from land used for agriculture (>30% upstream landcover in sheep and beef farming) (Table 3).

49 That the visual clarity objectives were met at most SoE sites in the LT FMQU is not unexpected. Water velocity in lowland streams is typically slow and stable, meaning that sediment quickly settles on the stream bed, rather than travelling downstream in suspension where it can influence visual clarity. Nevertheless, land-use upstream of the four SoE sites in that FMQU that do not meet the target is predominately agriculture (>50% land cover in sheep in beef at all sites) and cropping (>28 land cover Clive River and the Herehere Stream sites) (Table 3), which are likely the cause of reduced visual clarity there.

Turbidity

50 Agriculture does not appear to be affecting whether the rivers in the TANK catchments meet the Schedule 26 turbidity objectives, with only two SoE sites (both on the Ngaruroro River in the LNLTR FMQU) failing to meet relevant thresholds (Table 2). However, given that the most upstream sites in the Ngaruroro River meet the relevant turbidity objective, degradation at the aforementioned sites is more likely to be the result of sediment input from agriculture (>30% upstream landcover in sheep and beef) rather than natural processes (Table 3).

pH

51 The pH of a river is strongly influenced by geology and source of water (Davies-Colley *et al.*, 2013); in agricultural catchments the mechanism by which anthropogenic activities can influence pH is through increased periphyton and/or macrophyte growth caused by elevated nutrient concentrations (land-use intensification), increased light availability (removal of riparian vegetation) and reduced summer low flows (water abstraction).

52 Throughout the TANK catchments there is a significant amount of the agriculture (~30-65% of land cover in sheep and beef farming) (Table 3). However, there is little evidence of excessive plant growth in the UNUTR, NTT or LNLTR FMQUs that could explain the occasionally high pH observed in those areas (Table 2). Furthermore, both SoE sites in the upper Ngaruroro and upper Tūtaekurī rivers regularly exceed the Schedule 26 pH objective, despite the vast majority of the upstream catchment being in native bush (Table 3). This suggests that in the UNUTR, NTT and LNLTR FMQUs occasional pH measurements above the Schedule 26 objective may be due to natural processes.

53 In the LT FMQU, most SoE sites meet the relevant Schedule 26 pH objective despite the excessive macrophyte growth there (para. 47 and Table 2). Indeed, only four sites in that FMQU, appear to not be meeting the objective; these are located on the Ohiwia, Waito and Herehere streams and the Clive River. Exactly why those streams experience high pH is unclear as periphyton and macrophyte data from the Waito and Herehere streams suggest excessive plant growth is not the driver. Nevertheless, if there is a human cause it is likely due to the indirect effects of agriculture (>50% land cover in sheep in beef at all sites) and cropping (>28% of landcover upstream of the Clive River and the Herehere Stream sites) (Table 3).

Ammonia and nitrate

54 The Schedule 26 ammonia objectives are generally not met throughout all FMQUs in the TANK catchments (Table 2) due to occasional spikes

causing the maximum concentration threshold to be exceeded. High instream ammonia concentrations are generally the result of point sources, while nitrate is more commonly associated with diffuse discharges. Thus, the contribution of agriculture to the objectives not being met is difficult to ascertain. Furthermore, the benchmarking results presented in Table 2 should be considered provisional as pH and temperature adjustment was not undertaken as part of that exercise, and the NPS-FM 2020 ammonia toxicity attribute states presented in Haidekker and Madarasz-Smith (2020) suggest that such an adjustment may improve compliance with the objectives at some sites.

55 The available data suggests that all SoE sites in the TANK catchments are meeting the Schedule 26 nitrate standards (Table 2). Accordingly, there is no evidence to suggest that land-use is affecting compliance with these thresholds.

Dissolved inorganic nitrogen and dissolved reactive phosphorus

56 It is important to note upfront that the non-compliance with the dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) Schedule 26 objectives does not appear to affect ecosystem health in any meaningful way, as they are not linked to periphyton or macrophyte growth (see para. 86 to para. 90). The benchmarking presented in Table 2 provides a crude demonstration of this. The only site that does not meet the Schedule 26 periphyton objective meets the DIN and DRP targets, while a further four sites fail to meet the DIN and DRP objectives but meet the periphyton objective.

57 The DIN and DRP Schedule 26 objectives are not met through much of the TANK catchments (Table 2). In most catchments, agriculture is the most likely cause of this, as it is the predominant land-use in most FMQUs (generally >30% landcover in sheep and beef where objectives not met) (Table 3). However, there are exceptions. There is a significant amount of cropping in the Awanui Stream, Clive River and Herehere Stream catchments (>28% landcover) which is thought to generate far larger nitrogen and phosphorus loads per unit area than sheep and beef farming in the TANK catchments (Williamson and Diack, 2018).

E. coli

58 The Schedule 26 *E. coli* targets appear to be met through much of UNUTR and LNLTR FMQUs, but not and LT and NTT FMQUs (Table 2). Where the targets are not being met, agriculture is the most likely cause; sheep and beef farming being far and away the most predominant source of potential faecal contamination in most catchments (Table 3). The only exception to this is Taipo Stream where there is some risk of wastewater contamination within the urban part of the catchment. Note – this assessment should be considered provisional as the available (at time of writing) data did not allow for benchmarking against the exact statistics set out in Schedule 26.

Conclusions

59 Water quality data in the latest SoE report from HBRC suggest that a number of the Schedule 26 objectives are not being met throughout the TANK catchments. However, while agriculture is the predominant land-use in most FMQUs in many (but not all) instances its contribution to objectives not being met appears to be limited and/or of little ecological consequence. Specifically:

59.1 Through most of the TANK catchments macroinvertebrate communities are indicative of good or excellent aquatic ecosystem health. However, agriculture and cropping may be driving degraded macroinvertebrate community health throughout the LT FMQU. A likely explanation for this is excessive macrophyte growth bought about by a lack of riparian shading. This increased macrophyte growth may not be a direct effect of ongoing agricultural land-use, but rather the result of prior vegetation clearance and legacy sediment effects.

59.2 While the Schedule 26 pH targets are not meet at most SoE sites in the TANK catchments, this is likely the result of natural processes rather than the effects of land-use.

59.3 The Schedule 26 ammonia objectives are not met in a number of streams due to occasional spikes causing the maximum concentration threshold to be exceeded. However, agricultures contribution to this is difficult to ascertain given that ammonia is more commonly associated with point source rather than diffuse discharges.

59.4 The DIN and DRP Schedule 26 objectives are not met through much of the TANK catchments and in catchments without significant cropping agriculture is the most likely cause of this. However, non-compliance with the DIN and DRP objectives does not appear to affect ecosystem health in any meaningful way, as they are based on the wrong nutrient criteria in Matheson *et al.* (2016) (see para. 85 to para. 91) and, therefore, not linked to periphyton or macrophyte growth. This is supported by the absence of a widespread periphyton problem in the UNUTR NTT and LNLTR FMQUs, despite the DIN and DRP objectives not being met.

59.5 The Schedule 26 visual clarity objectives are generally met in the UNUTR and LT FMQUs. However, agriculture may the reason why the relevant clarity objectives are not met through much of the NTT and LNLTR FMQUs. Similarly, agriculture is the most likely cause of the Schedule 26 *E. coli* targets not being met through much of the LT and NTT FMQUs.

59.6 Agriculture does not appear to be causing the Schedule 26 periphyton cover, turbidity or nitrate objectives to be exceeded through most of the TANK catchments.

ABILITY OF EXISTING MONITORING NETWORKS TO DETECT EFFECTS OF CHANGING LAND-USE PRACTICES ON SHEEP AND BEEF FARMS

60 In this section of my evidence, I assess whether HBRC's existing SoE monitoring network (including the NRWQN sites) is sufficiently robust

to detect the effects of changes in land-use practices (including from sheep and beef farming) on water quality and ecology.

61 This assessment is based purely on the spatial distribution of sites. Due to time constraints, I am unable to assess the representativeness of the network (i.e., how effective it is at picking up changes in different stream types), as that would require a detailed monitoring network review. As such, this assessment considers whether the network can detect changes in water quality and/or ecology in each sub-catchment, rather than whether it can accurately describe the state of water quality and ecology in the different stream types.

Ngaruroro River catchment

62 Based on the spatial distribution of SoE sites, the existing monitoring network in the Ngaruroro catchment appears to be sufficiently robust to allow for the detection of shifts in water quality and ecology bought about changes in land-use practices at the sub-catchment scale. However, it is likely that changes in the Whanaukini, Otamauri, Mangatahi and Kikiwhero stream sub-catchments can only be detected based on longitudinal differences between sites on the main stem of the Ngaruroro River (using mass-balance approaches). This means that it is unlikely that variability in water quality trends between those sub-catchments can be determined using the existing monitoring network, and that changes in aquatic ecology are unlikely to be detected[6]. My full assessment of the monitoring network in the Ngaruroro catchment is set out in para. 63 to para. 68 and outlined in Table 4.

63 The NRWQN site on the Ngaruroro River at Kuripapango acts as a reference site and allows for changes in water quality and ecology not associated with shifts in land-use practices to be detected (e.g., changes caused by natural climate variability etc.).

[6] Unlike water quality, it is not possible to determine changes in ecology in a sub-catchment by applying mass-balance approaches to data at receiving environment sites.

64 The SoE site at Ngaruroro River at Whanawhana allows for changes in the effects of the limited upstream sheep and beef farming on water quality and ecology to be detected.

65 The SoE sites in the Ohara and Poporangi streams should be sufficient to detect the water quality and ecology effects of changing land practices in the wider Poporangi Stream catchment. However, there is not a SoE site on Whanaukini Stream or downstream of its confluence with the Poporangi Stream. Thus, any difference in water quality, aquatic ecology or land-use practice between the Whanaukini Stream and the rest of the Poporangi Stream catchment may not be detected from the existing monitoring network.

66 The SoE site on the Ngaruroro River at Hawkes Bay Dairies provides an indication of the state of water quality and ecology in that reach. Along with the SoE site at Whanawhana and those on the Ohara and Poporangi streams it could also be used to detect the water quality effects of changing land-use practices in upstream sub-catchments with out monitoring sites through the use of mass-balance approaches (i.e., the Whanaukini and Otamauri streams). However, any variability in water quality trends between those catchments will not be detected using this approach, nor will any changes in aquatic ecology.

67 With the exception of the Kikowhiro and Mangatahi streams sub-catchments, there are SoE sites in all major sub-catchments downstream of the Hawkes Bay Dairy SoE site on the Ngaruroro River. There are also two sites on the Ngaruroro River itself. These sites provide excellent spatial coverage and should allow for the water quality and ecological effects of changing land-use practices to be detected throughout the mainstem of lower Ngaruroro River and every sub-catchment that flows into it except the Kikowhiro and Mangatahi streams.

68 As the Kikowhiro and Mangatahi streams are the only major non-monitored inputs between the SoE sites on the Ngaruroro River at Hawkes Bay Dairy and Fernhill, it is likely that changes in water quality in those sub-catchments could be assessed by applying mass-balance approaches to water quality and flow data from the existing monitoring network.

However, this approach cannot account for differences in water quality trends between those catchments nor can it be used to detect changes in aquatic ecology.

Tūtaekurī River catchment

69 The resolution of the monitoring network in the Tūtaekurī River catchment is much lower than in the Ngaruroro River catchment, meaning that its ability to detect changes in water quality and ecology across major sub-catchments is less.

70 Of the five major sub-catchments downstream of SoE site on the Tūtaekurī River Lawrence Hut, only two are monitored; the Mangatutu Stream and the upper Mangaone Stream. Accordingly, it is likely that the water quality effects of shifts in land-use practices in the Otakarara, Waikonini and Waiiti[7] stream catchments can only be assessed from the existing network by applying mass-balance approaches to data collected from sites on the main stem of the Tūtaekurī River. Furthermore, changes in aquatic ecology in those catchments are unlikely to be detected at all. Para. 71 to para. 74 provide a detailed assessment of the monitoring network in the Tūtaekurī catchment (additional detail can be found in Table 4).

71 The SoE site on the Tūtaekurī River at Lawrence Hut is almost in reference (natural) state and it is likely that changes in water quality and ecology not associated with shifts in land-use practices can be detected from data collected there.

72 The SoE sites in the Mangatutu and upper Mangaone streams will likely allow for the detection of any changes in water quality and aquatic ecology bought about by shifts in land-use practices in those sub-catchments. However, there is not a site on the Waiiti Stream or downstream of its confluence with the Mangaone. Therefore, the existing monitoring network may not allow for any differences in water quality,

[7] Flows in the Mangaone Stream below the monitoring site

aquatic ecology or land-use practice between that catchment and the wider Mangaone Stream to be detected.

73 The SoE site on the Tūtaekurī river upstream of its confluence with the Mangaone stream allows for changes in the water quality and ecology effects of upstream agricultural land-use to be identified. Furthermore, using mass-balance approaches, data from that site and others in the catchment could be used to assess the water quality effects of changing land-use practices in unmonitored upstream sub-catchments (i.e., the Otakarara and Waikonini streams). As previously stated that approach, however, does not allow for differences in water quality trends between catchments to be detected, and it cannot be used to detect changes in aquatic ecology.

74 The most downstream site on the Tūtaekurī River (Brookfields Bridge) provides an indication of state of water quality and ecology that reach. It is also possible that it may allow for any changes in water quality in the Waiiti Stream sub-catchments to be assessed through mass-balance approaches. However, this is by no means certain given the number of small sub-catchments discharging between the Brookfield Bridge site and the Mangaone Stream.

Karamū River Catchment and Ahuriri Estuary catchment

75 As with the Ngaruroro catchment, the monitoring network in the Karamū River network is sufficiently robust that changes in water quality and aquatic ecology associated with changes in land-use practices should be detectable in most sub-catchments. Only three major sub-catchments, the Irongate, Louisa and Mangarau streams, are not monitored, and it is likely that changes in water quality (but not ecology) in those streams can be assessed by applying mass-balance approaches to data from other SoE sites in the catchment.

76 The monitoring sites on the Awanui, Poukawa, Herehere and Karewarewa and Raupaere streams provide a high level of spatial coverage and allow for the water quality and ecology effects of changing land-use practices to be detected in almost every sub-catchment.

77 The SoE site on the Clive River provides an indication of state of water quality and ecology in that reach and in concert with the sites on the Awanui, Poukawa, Herehere and Karewarewa and Raupaere streams should be useful in assessing the water quality (but not ecology) effects of changing land-use practices in the Irongate, Louisa and Mangarau streams.

78 There is only one monitoring site in the Ahuriri Estuary catchment. However, given the small size of the catchment and the even distribution of land-use throughout this is adequate in my opinion.

Conclusions

79 It is likely that HBRC's existing monitoring network in the TANK catchments is sufficiently robust that changes in water quality and ecology associated with shifting land-use practices should be detectable in most sub-catchments. However, it is probable that changes in the following sub-catchments can only be assessed by applying mass-balance approaches to water quality data collected at nearby sites (parenthesised N, T and Ks denote sub-catchments in the Ngaruroro River, Tūtaekurī River and Karamū stream catchments respectively):

- Whanaukini Stream (N);
- Otamauri Stream (N);
- Mangatahi Stream (N);
- Kikiwhero Stream (N);
- Otakarara Stream (T);
- Waikonini Stream (T);
- Waiiti Stream (T);
- Irongate Stream (K);
- Louisa Stream (K); and
- Mangarau Stream (K).

80 This means that the current network can probably not detect any variability in water quality trends between the catchments listed above, nor can it be used to detect any changes in their aquatic ecology.

81 Table 4 summarises the assessment presented in para. 62 to para. 78.

Table 4: List of sub-catchments in the TANK catchments, and whether changes in water quality and ecology in those sub-catchments can be detected at existing monitoring sites.

Tank catchment	Sub-catchment	Changes in water quality and/or ecology detectable from data collected at:	Changes in water quality and/or ecology detectable
Ngaruroro River	Upper Ngaruroro R.	Ngaruroro R. @ Kuripapango	Water quality and ecology
	Mainstem Ngaruroro R.	• Ngaruroro R. @ Whanawhana • Ngaruroro R. D/S Hawkes Bay Dairies • Ngaruroro R. @ Fernhill • Ngaruroro R. @ Chesterthorpe	
	Poporangi S. (exc. Whanaukini S.)	• Ohara S. @ Big Hill Rd • Poporangi S. @ Big Hill Rd	
	Whanaukini S.	Δ between: • Ngaruroro R. @ Whanawhana • Ngaruroro R. D/S Hawkes Bay Dairies	Water quality (changes cannot be isolated from nearby sub-catchments)
	Otamauri S.		
	Mangatahi S.	Δ between • Ngaruroro R. D/S Hawkes Bay Dairies • Ngaruroro R. @ Fernhill	
	Kikiwhero S.		
	Maraekakaho S.	Maraekakaho S. @ Maraekakaho	Water quality and ecology
	Ohiwia S.	Ohiwia S. @ Broughtons Br.	
	Poukawa S.	Poukawa S. @ Stock Rd	
	Waitio S.	Waitio S. @ Ohiti Rd	
	Tūtaekurī Waimate S.	Tūtaekurī Waimate S. @ Chesterhope	
Tūtaekurī River	Upper Tūtaekurī R.	Tūtaekurī R. @ Lawrence Hut	
	Mainstem Tūtaekurī R.	• Tūtaekurī R. U/S Mangaone • Tūtaekurī R. @ Brookfields Br.	
	Mangatutu S.	Mangatutu S. @ Mangatutu Stn Br	Water quality and ecology
	Otakarara S.	Δ between: • Tūtaekurī R. @ Lawrence Hut • Tūtaekurī R. U/S Mangaone	Water quality (changes cannot be isolated from nearby sub-catchments)
	Waikonini S.		
	Mangaone S. (exc. Waiiti S.)	Mangaone R. @ Rissington	Water quality and ecology
	Waiiti S.	Δ between • Tūtaekurī R. U/S Mangaone • Tūtaekurī R. @ Brookfields Br.	Potentially water quality (changes cannot be isolated from downstream sub-catchments)
Karamū River	Mainstem Awanui S./ Karumū R./ Clive R.	• Awanui S. @ Flume • Clive R. U/S Whakatu Rail Br.	Water quality and ecology
	Poukawa	Poukawa S. @ Stock Rd	
	Karewarewa	Karewarewa S. @ Paki Paki	
	Irongate S.	Δ between • Awanui S. @ Flume • Clive R. U/S Whakatu Rail Br.	Water quality (changes cannot be isolated from nearby sub-catchments)
	Louisa S.		
	Mangarau S.		
	Herehere S.	Herehere S. @ Te Aute Rd	Water quality and ecology
	Raupare S.	Raupare S. @ Ormond Rd	
Ahuriri Estuary	Taipo S.	Taipo S. @ Church Rd	

REVIEW OF THE SCHEDULE 26 FRESHWATER OBJECTIVES AND RECOMMENDED CHANGES

82 In my opinion, the Schedule 26 objectives for the following attributes are appropriate from a technical perspective, and have been set at a level that provides for the values in OBJ TANK 11 to OBJ TANK 13:

- PeriWCC – Noting that the primary measure should be periphyton biomass (see para. 100 to para. 106);
- Visual clarity;
- Dissolved oxygen;
- $ScBOD_5$;
- Nitrate;
- Ammonia; and
- Heavy metals and metalloids, pesticides and organic contaminants, radioactive contaminant.

83 Based on S42A report (Appendix 1B) it does not appear that HBRC are proposing any major amendments to these attributes, and the minor amendments they are suggesting are appropriate in my opinion.

84 The remaining objectives in Schedule 26 have either been set based on incomplete science, or at a level that does not support a value of excellent ecosystem health in the UNUTR FMQU, good ecosystem health in the NTT and LNLTR FMQUs or fair ecosystem health in the LT FMQU. My reasoning for this is set out para. 85 to para. 111.

DIN and DRP

85 The process by which the DIN and DRP objectives in Schedule 26 have been selected appears to have been fundamentally flawed, and this has resulted in the selection of thresholds that were never designed to be used as nutrient criteria for the management of periphyton growth.

86 Section 2.1.4 of Haidekker (2019) states that the nutrient criteria that have been included in Schedule 26 were selected from the DIN and DRP guidelines in Matheson *et al.* (2016), and that this approach is consistent with guidance from MfE that nutrient guidelines based on broad scale

models can be used to set nutrient criteria for periphyton growth (MfE, 2018).

87 Haidekker (2019) is right in that the use of the recommended nutrient criteria in Matheson *et al.* (2016), is consistent with the MfE's guidance. However, the freshwater objectives in Schedule 26 do not reflect those nutrient criteria. Instead, they are periphyton growth risk thresholds used as inputs in Bayesian Belief Network (BBN) model developed by Matheson *et al.* (2012).

88 Inputs to BBNs are often decided based on expert opinion, and the periphyton growth risk thresholds in Matheson *et al.* (2012) were developed by simple visual inspections of bivariate plots between nutrient concentrations and long green filamentous periphyton cover. As such their use in a regional plan as nutrient criteria is not consistent with the guidance from the MfE used to justify their inclusion in Schedule 26 (Haidekker, 2019). Furthermore, they were based on relationships with long green filamentous periphyton cover, rather than the periWCC (which is in Schedule 26) or periphyton biomass (a compulsory attribute in the NPS-FM 2020).

89 The actual Matheson *et al.* (2016) nutrient criteria that correspond to the periphyton biomass objectives recommended in para. 102 are provided in Table 5 along with comparisons with the existing Schedule 26 nutrient criteria. (Note – biomass is a compulsory attribute in the NPS-FM while periphyton cover is not).

Table 5: The Matheson et al. (2016) nutrient criteria that correspond to the periphyton biomass objectives recommended in para. 102 compared to the current Schedule 26 objectives for DIN and DRP. Nutrient criteria are designed to achieve 85% compliance with periphyton biomass objectives.

FMQU	Peri. biomass objective	Schedule 26 P obj.	Correct P criteria from Matheson (2016)	Diff.	Schedule 26 N obj.	Correct N criteria from Matheson (2016)	Diff.
Upper Ngaruroro and Upper Tūtaekurī Rivers	≤50 mg chl-a/m^2	0.003 mg/L DRP	0.014 mg/L total P	>350%	0.05	100	100%
Lower Ngaruroro and Lower Tūtaekurī Rivers	≤120 mg chl-a/m^2	0.015 mg/L DRP	0.011 mg/L DRP	-37%	0.15	0.63	~400%
Ngaruroro and Tūtaekurī Tributaries					0.3		~200%

90 As I have not had time to do an in depth assessment of what appropriate nutrient criteria would be for the TANK catchments, I am not able to conclude one way or the other whether the nutrient criteria set out in Table 5 will achieve the periphyton biomass objectives recommended in para. 102. However, they are far more robust than what are currently included in Schedule 26, and likely reflect the best available thresholds at this time. However, I still recommend that HBRC continue to work on refining them in the future given that the DRP thresholds appear unnecessarily stringent given that periphyton objectives through much of the TANK catchments are being met at much higher concentrations (Table 7).

91 The Schedule 26 objectives for DIN and DRP in the LT FMQU are based the ANZECC (2000) default triggers, with the critical value being estuarine ecosystem health (Haidekker, 2019). It is entirely unclear how the current thresholds provide for the estuarine ecosystem health or any of the other in-stream objectives in Schedule 26 (i.e., macrophyte growth) given that they are not based on controlling plant growth or maintaining a given nutrient load into the estuary. As such, I recommend they be set at current state until such time as relevant thresholds can be developed that provide for the values in PPC9.

92 I note that in HBRC's changes to Schedule 26, they have replaced the existing DRP criteria with attribute states from the NPS-FM 2020 despite PPC9 plan being notified after that document became operative. While the NPS-FM 2020 includes DRP attribute states, it also requires that exceedance criteria be set for periphyton growth. The thresholds set out in Table 5 act as the latter.

93 Given that the mechanism through which DRP effects broader ecosystem health is through plant growth, any attempt to incorporate the NPS-FM 2020 attribute state into this plan change should ensure that the target attribute state aligns with the periphyton nutrient exceedance criteria set out in Table 5 (or current state for the LT FMQU). The approach used to develop the generic attribute state thresholds in the NPS-FM 2020 relies on simple correlative relationships between nutrients and a range of biotic endpoints but fails to consider the mechanisms behind those relationships. The approach used to develop those endpoints has been proposed (by

submitters) in regional plan hearings for at least three years but has consistently been rebuffed. Indeed, the original journal article outlining the approach has yet to meet the standard for peer review publication despite being presented at hearings for several years.

Temperature

94 The freshwater objectives presented for temperature are not commonly used in regional plans, and it was previously decided not to include them in the NPS-FM 2014. Accordingly, it is my opinion that they should not be included in Schedule 26 until such time as their applicability becomes clearer. From my reading of Appendix 1B of the S42A report this change is also supported by HBRC, as temperature is not included in their amended version of Schedule 26 (at 2040).

Turbidity

95 Visual clarity is not only a more robust measure of suspended sediment than turbidity (turbidity measurements are instrument dependent and turbidity units are relative not standardised), but also more meaningful to the public and has greater mechanistic effects (i.e., directly affects the visual capability of fish and the amenity value of the stream) (Franklin *et al.*, 2019). That, combined with MfE's decision to remove the turbidity attribute state from the draft NPS-FM 2020 and replace it with visual clarity attribute means that there is little benefit in including both a turbidity and visual clarity attribute in Schedule 26. Thus, it is my opinion the turbidity objectives should be deleted. This change appears to be supported by HBRC as turbidity is not included in their amended version of Schedule 26 (Schedule 1B of the S42A report).

pH

96 It does not appear that the pH objectives in Schedule 26 are relevant or achievable given the frequency at which they are not met at reference sites (see para. 51). As such I recommend they be deleted until such time as more applicable catchment specific targets are developed. I understand

from Appendix 1B of the S42A report, that this change is also supported by HBRC.

E. coli

97 It is unclear how the statistics cited for the *E. coli* freshwater objectives have been selected as they do not align with any standard in use now or at the time they were written. However, based on the current Schedule 26 *E. coli* objectives, it appears that their intent is to achieve something akin to the NPS-FM 2020 A attribute state in the UNUTR FMQU and attribute state B everywhere else. If this is the intent of the plan then the following objective should be set:

- UNUTR FMQU
  - Median ≤130/100mL;
  - 95th Percentile ≤540/100mL;
  - % exceedances over 260/100 mL <20%; and
  - % exceedances over 540/100 mL <5%.
- All other FMQUs
  - Median ≤130/100mL;
  - 95th Percentile ≤1000/100mL;
  - % exceedances over 260/100 mL <30%; and
  - % exceedances over 540/100 mL <10%.

98 This change is consistent with HBRC's suggested amendments in the S42A report (Appendix 1B).

Deposited sediment

99 The deposited sediment objectives set out in Schedule 26 are sourced from guidelines developed by Clapcott *et al.* (2011), and Appendix 1B of the S42A report does not suggest a change to this general approach. In principal, I support the objectives as they stand. However, to give effect to those guidelines and the intent of the NPS-FM 2020 a number of amendments need to be made:

99.1 The macroinvertebrate objectives for the LT FMQU specifically require the soft-bottom version of the MCI be used;

indicating that HBRC acknowledge that at least some streams within that FMQU may naturally have a bed dominated by fine sediment. This is supported by the River Environmental Classification (REC)[8] data for that FMQU which shows many of streams meeting the NPS-FM 2020 definition of naturally soft-bottomed. Given that the NPS-FM 2020 does not require potentially unachievable deposited fine sediment cover objectives to be set in naturally soft-bottomed streams, Schedule 26 objectives should not be set there. From my reading of Appendix 1B of the S42A report, this change is also supported by HBRC, as their amended Schedule 26 lists "hard-bottomed streams" in the monitoring sites column for this attribute.

99.2 It is unclear why Schedule 26 sets a seasonal (May to October) deposited sediment cover objective of 15% in the UNUTR FMQU for the protection of salmonid spawning. The background technical documents supporting PPC9 suggest this is aligned with the Clapcott *et al.* (2011) guidelines. However, this is not correct; the 20% cover guideline in Clapcott *et al.* (2011) is for the protection of benthic biodiversity and salmonid spawning. As such, it is my opinion that the secondary deposited sediment cover for UNUTR FMQU should be deleted. This appears to be supported by HBRC based on Appendix 1B of the S42A report.

Periphyton biomass

100 It is unclear why periphyton biomass outcomes have only been set in Schedule 26 for the Lower Ngaruroro River and Upper Tūtaekurī River given that it has been a compulsory attribute in the NPS-FM since the 2014 (periphyton cover has never been included in that document). From the reading of the supporting technical documentation for PPC9

[8] The REC is a database of catchment spatial attributes, summarised for every segment in New Zealand's network of rivers

(Haidekker, 2019), it appears that HBRC have only applied a biomass objective where they monitor for it. However, the NPS-FM process requires councils to set objectives and then design a monitoring programme based on how those objectives have been set; not vice a versa. Accordingly, it is my opinion that periphyton biomass objectives should be set for every FMQU (except in LT where plant communities are dominated by macrophytes).

101 It is important to note that setting additional periphyton biomass objectives does not necessarily have to increase HBRC's monitoring effort in the TANK catchments. My benchmarking of periphyton cover data indicates periphyton is only a problem at sites on the lower reaches of the Ngaruroro River where HBRC already have a monitoring site (Table 2). For all other sites, where there is a low risk of periphyton growth, the NPS-FM 2020 explicitly allows HBRC to continue monitoring against a periphyton biomass objective using visual cover assessments.

"At low risk sites monitoring may be conducted using visual estimates of periphyton cover. Should monitoring based on visual cover estimates indicate that a site is approaching the relevant periphyton abundance threshold, monitoring should then be upgraded *to include measurement of chlorophyll-a.)"*

102 In order to support a value of excellent ecosystem health in the UNUTR FMQU and good ecosystem health in the NTT and LNLTR FMQUs (assumed value based on Schedule 26 macroinvertebrate objectives) and to be consistent with the Schedule 26 periphyton cover objectives the following periphyton biomass objectives should be set:

- UNUTR FMQU ≤50 mg chl-a/m^2;
- NTT FMQU ≤120 mg chl-a/m^2; and
- LNLTR FMQU ≤120 mg chl-a/m^2 (consistent with the suggested amendments in Appendix 1B of the S42A report).

103 The suggested objective for the UNUTR FMQU differs from what is currently in Schedule 26, which sets the threshold at ≤120 mg chl-a/m^2 for the Upper Tūtaekurī River. However, Appendix 1B of the S42A report

applies that objective to a site in the lower Tūtaekurī River. Thus, it appears that the earlier reference to the upper catchment may have been a typographical area. Nevertheless, it is worth noting that the current periphyton biomass objective for the Upper Tūtaekurī River contradicts the periphyton cover objective for that FMQU and does not provide for an excellent level of ecosystem health (a biomass as ≤50 mg chl-a/m^2 is recommended to protect benthic biodiversity (Biggs, 2000)).

Cyanobacteria

104 Benthic cyanobacteria grow attached to the substrate of rivers and streams. In New Zealand rivers the dominant bloom-forming benthic cyanobacteria genus is *Microcoleus* (formally thought to be *Phormidium* (Heath *et al.*, 2010; Wood *et al.*, 2007). *Microcoleus* blooms are primarily associated with river or stream environments where they form leathery dark brown or black mats, but they can also establish in lakes and ponds (Quiblier *et al.*, 2013). *Microcoleus* can produce four lethal neurotoxins, known collectively as anatoxins, which cause convulsions, coma, rigors, cyanosis, limb twitching, hyper salivation and/or death. The presence of anatoxins in *Microcoleus* mats is widespread. McAllister *et al.* (2016) found 67% *Microcoleus* dominated mats samples collected from across New Zealand contained anatoxins. However, the concentration of all four variants is highly spatially and temporally variable (Heath *et al.*, 2011; Wood *et al.*, 2012, 2010).

105 The human health risks associated with benthic cyanobacteria are less well known than the risks associated with their planktonic counterparts in lakes, and the MfE/MoH (2009) guidelines are the only existing numeric thresholds against which the potential health risks associated with benthic cyanobacteria can be assessed. The MfE/MoH (2009) guidelines recommend coverage thresholds for potentially toxigenic cyanobacteria as part of three-tier surveillance, alert and action sequence for managing the public health risk associated with benthic cyanobacteria.

106 Schedule 26 of PPC9 sets a freshwater objective for benthic cyanobacteria cover of < 20% for all FMQUs. This guideline is aligned with the ‘alert’ threshold in the MfE/MoH (2009) guidelines, and signals that a

proliferation event is not necessarily likely and detaching mats are not likely to be washed on the shoreline where they could pose a health risk (MfE/MoH, 2009). Although the guideline value of <20% cover is a useful public health notification tool it still requires significant refinement and is not appropriate for inclusion in PPC9.

107 Since the release of the MfE/MoH (2009) interim guidelines in 2009, knowledge of benthic cyanobacteria has advanced significantly. Accordingly, MfE, with the support of regional councils, has commissioned a team of researchers to review and update the guidelines. One of the possible updates to the guidelines is a shift from the coverage-based assessments currently used to assess the risk to human health, to toxicity-based assessments (Wood *et al.*, 2018).

108 MfE has also been working with researchers to develop a benthic cyanobacteria attribute for inclusion in the NPS-FM. Research undertaken as part of the attribute development has advanced the understanding of benthic cyanobacteria toxin production and the risks to human health significantly. If a benthic cyanobacteria attribute is included in the NPS-FM, it is mostly likely to be toxicity based rather than coverage based (Dr Mark Heath pers. comm. 2018).

109 Given the strong possibility that the eventual thresholds for cyanobacteria the NPS-FM and updated MoH/MfE guidelines will be toxicity based rather than cover based, it is unwise to incorporate the existing coverage based guidelines in to PPC9. It is important to note that even if future cyanobacteria guidelines remain cover based, they are likely to be significantly altered from what is in Schedule 26.

Macrophytes

110 Due to a lack of empirical data, robust macrophyte cover and volume thresholds for the onset of detrimental effects on ecosystem health do not currently exist (Matheson *et al.*, 2012). Currently, Matheson *et al.'s* (2012) review of the New Zealand instream plant and nutrient guidelines provides the only numeric cover and volume thresholds against which the potential effects of macrophytes can be assessed. Matheson *et al.* (2012)

presents a macrophyte CAV guideline of less than 50% of the channel for the protection of instream ecological condition, which has been adopted into Schedule 26. However, this threshold is provisional, and requires significant refinement (Matheson *et al.*, 2012). As such it is my opinion that it should not be included PPC9.

Macroinvertebrate community health

111 In my opinion the level at which the Schedule 26 macroinvertebrate objectives have been set for each FMQU is appropriate, and I agree that the amendments to the specific numbers and metrics proposed in Appendix 1B of the S42A are aligned with the latest attribute states in the NPS-FM 2020. However, for those streams in the LT FMQU that are not naturally soft bottomed, the macroinvertebrate objectives should reference the hard-bottomed version of the MCI, as the NPS-FM 2020 does not allow for the use of the soft-bottomed variant in streams with high deposited fine sediment cover caused by land-use. Based on Appendix 1B of the S42A report such a change appears to be supported by HBRC.

Conclusions

112 My recommended changes to Schedule 26 are summarised in Table 6 and HBRC SoE sites are re-bench marked against the recommended amended objectives in Table 7. The main result of the recommended changes to Schedule 26 is a significant increase in the number of streams meeting the DIN and DRP objectives Table 7. However, this is unlikely to affect periphyton growth in the TANK catchments as it is already low in most places despite the current DIN and DRP objectives being exceeded.

Table 6: Recommended changes to the objectives in Schedule 26 and whether those changes are supported by HBRC's suggested amendments (Appendix 1B of the S42A report).

Attribute	FMQU	Recommended change	Change consistent with HBRC's suggested amendments
DIN	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to 0.1 mg/L (average conc.)	No
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to 0.63 mg/L (average conc.)	
	Ngaruroro and Tūtaekurī Tributaries		
	Lowland Tributaries	Change to reflect current state	
TP	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to 0.014 mg/L (average conc.; currently DRP)	
DRP	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to 0.011 mg/L (average conc.; currently DRP)	
	Ngaruroro and Tūtaekurī Tributaries		
	Lowland Tributaries	Change to reflect current state	
Temperature	All	Delete	Yes
Turbidity			
pH			
E. coli	Upper Ngaruroro and Upper Tūtaekurī Rivers	Change to • Median ≤130/100mL • 95th Percentile ≤540/100mL • % exceedances over 260/100 mL <20% • % exceedances over 540/100 mL <5%	
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Change to • Median ≤130/100mL • 95th Percentile ≤1000/100mL • % exceedances over 260/100 mL <30% • % exceedances over 540/100 mL <10%	
Deposited sediment	Upper Ngaruroro and Upper Tūtaekurī Rivers	Delete seasonal objective of 15% cover for salmonid spawning	
	Lowland Tributaries	Delete for naturally soft-bottomed streams	
Periphyton biomass	Upper Ngaruroro and Upper Tūtaekurī Rivers	Amend to ≤50 mg chl-a/m^2	No
	Lower Ngaruroro and Lower Tūtaekurī Rivers	Amend to ≤120 mg chl-a/m^2	Yes
	Ngaruroro and Tūtaekurī Tributaries	add ≤120 mg chl-a/m^2	No
Cyanobacteria	All	Delete	No
Macrophytes	Lowland Tributaries		
Macroinvertebrates	Lowland Tributaries	Only stipulate MCI-sb for naturally soft-bottomed streams	Yes

Table 7:Assessment of HBRC SOE sites against the recommended changes to the Schedule 26 objectives.

Zone	Site	pH	Clarity	Turbidity	DIN	DRP	NH_4-N	NO_3-N	*E.coli*	Periphyton	Invertebrates
Upper Ngaruroro and Upper Tūtaekurī Rivers	Tūtaekurī R. @ Lawrence Hut	N/A	✓	N/A	✓	×	✓	✓	✓	✓	✓
	Ngaruroro R. @ Kuripapango		✓		✓	✓	✓	✓	✓	?	✓
Lower Ngaruroro and Lower Tūtaekurī Rivers	Ngaruroro R. @ Whanawhana		✓		✓	✓	✓	✓	✓	✓	✓
	Ngaruroro R. D/S Hawkes Bay Dairies		×		✓	✓	✓	✓	✓	✓	✓
	Ngaruroro R. @ Fernhill		×		✓	✓	✓	✓	✓	×	×
	Tūtaekurī R. U/S Mangaone		×		✓	✓	×	✓	✓	✓	✓
	Tūtaekurī R. @ Brookfields Br.		×		✓	×	×	✓	✓	✓	×
Ngaruroro and Tūtaekurī Tributaries	Mangaone R. @ Rissington		×		✓	×	×	✓	×	✓	✓
	Mangatutu S. @ Mangatutu Stn Br.		×		✓	×	×	✓	×	✓	✓
	Ohara S. @ Big Hill Rd		✓		✓	✓	✓	✓	✓	✓	✓
Lowland tributaries	Maraekakaho S. @ Maraekakaho		✓		✓	✓	✓	✓	✓	N/A	×
	Ohiwia S. @ Broughtons Br.		✓		✓	✓	×	✓	✓		×
	Waitio S. @ Ohiti Rd		✓		✓	✓	✓	✓	✓		✓
	Tūtaekurī Waimate S. @ Chesterhope		✓		✓	✓	×	✓	✓		×
	Awanui S. @ Flume		×		✓	✓	×	✓	×		×
	Poukawa S. @ Stock Rd		✓		✓	✓	×	✓	✓		✓
	Karewarewa S. @ Paki Paki		✓		✓	✓	×	✓	×		×
	Herehere S. @ Te Aute Rd		✓		✓	✓	×	✓	×		×
	Raupare S. @ Ormond Rd		✓		✓	✓	×	✓	×		×
	Clive R. U/S Whakatu Rail Br.		×		✓	✓	×	✓	×		×
	Taipo S. @ Church Rd		×		✓	✓	×	✓	×		×

NOTE TO THE HEARING PANEL REGARDING HBRC'S SUGGESTED AMENDMENTS TO SCHEDULE 26

113 In my opinion, the following objectives in the amended version of Schedule 26 proposed in the S42A report (Appendix 1B) are appropriate:

- PeriWCC;
- Visual clarity;
- Dissolved oxygen;
- $ScBOD_5$;
- Nitrate;
- Ammonia;
- Heavy metals and metalloids, pesticides and organic contaminants, radioactive contaminant;
- Temperature;
- Turbidity;
- pH;
- *E. coli*;
- Deposited sediment; and
- Macroinvertebrates.

114 The other objetcives are not appropriate in my opinion for the reasons set out in para. 85 to para. 111.

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Date: 07/05/2021

Dr Michael John Crawshaw Greer

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BEFORE COMMISIONERS APPOINTED
BY THE HAWKES BAY REGIONAL COUNCIL

IN THE MATTER	Of the Resource Management Act 1991
AND	
IN THE MATTER	of the First Schedule of the Act
AND	
IN THE MATTER	of Hawkes Bay Regional Council Plan Change 9 – Tūtaekurī, Ahuriri, Ngaruroro and Karamū (TANK) Catchments.
AND	
IN THE MATTER	of submissions under clause 6 First Schedule.
BY	**BEEF + LAMB NEW ZEALAND LIMITED** **Submitter**

BRIEF OF EVIDENCE OF TOM SPENCER ORCHISTON

7 MAY 2021

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BACKGROUND

Qualifications and Experience

1. My full name is Thomas Spencer Orchiston.

2. I am employed by Beef + Lamb New Zealand (B+LNZ) as an Environment Capability Manager. This role aims to build the environmental capability of sheep and beef farmers to improve overall environmental outcomes on farms.

3. I hold a Bachelor of Science and a Postgraduate Diploma in Environmental Science from Otago University (2002).

4. I have a certificate in Sustainable Nutrient Management from Massey University (2010) and an AsureQuality Advanced Auditing Skills Certificate (2016).

5. My previous work experience includes 10 years for AgResearch Ltd as a Research Associate involved in soil, water and climate research based projects; 4 Years with Crop and Food Research investigating sustainable and efficient landuse through crop diversification and; 3 years with Landcare Research measuring carbon sequestration and plant biodiversity in indigenous forests and shrublands.

6. I have been an auditor for a farm assurance programme that provided sustainable, high value meat from low chemical input New Zealand farms for export.

7. I have been a part of the New Zealand Institute of Primary Industry Management technical advisory group on farm planning certification.

8. I have been involved in development of B+LNZ refreshed farm plan documentation and training of facilitators to deliver the B+LNZ farm plans.

9. I have completed a Land Use Capability course held in Hawke's Bay.

10. I have been co-author in five peer-reviewed journal articles, lead or co-author of eight conference papers or reports.

SCOPE OF EVIDENCE

11. I have been asked by B+LNZ to prepare evidence in relation to the sheep and beef sector generally and the management solutions to reduce contaminant loss from sheep and beef farming.

12. My evidence discusses:

    (a) The profile of the sheep and beef sector both generally and in Hawkes Bay.

    (b) Externalities of concern to the sheep and beef sector.

    (c) Farm Planning as a Management tool to reduce contaminant loss from sheep and beef farms.

    (d) Catchment Communities to manage cumulative impact and outcomes.

    (e) The drinking water needs of stock.

    (f) Considerations of irrigation as a proxy for risk.

13. In preparing this evidence I have reviewed relevant sections of the Hawkes Bay Regional Councils Proposed Plan Change 9 (PC9), supporting reports and statements of evidence of other experts giving evidence relevant to my area of expertise, and relevant background documents and technical reports, including:

    (a) Relevant sections of the Proposed Plan Change 9 Tūtaekurī, Ahuriri, Ngaruroro and Karamū Catchments.

    (b) The officers s42A Report.

    (c) Ngaruroro, Tūtaekurī, Karamū river and Ahuriri Estuary catchments:State and trends of river water quality and ecology. Report for Hawke's Bay Regional Council.

    (d) B+LNZ submission and further submission.

    (e) Expert evidence of Dr. Michael Greer and Mr. Gerry Kessells

14. I have read the Code of Conduct for Expert Witnesses in the Environment Court’s 2014 Practice Note and agree to comply with it. I confirm that the

opinions I have expressed represent my true and complete professional opinions. The matters addressed by my evidence are within my field of professional expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

EXECUTIVE SUMMARY

15. Sheep and Beef farms are complex and diverse systems. There is a high degree of variation in landscapes and natural resources requiring flexibility in the way it is managed. Approaches that are overly prescriptive inhibit innovation and prevent desired environmental outcomes being achieved. A flexible approach to farm planning is needed to suit a range of farmers and farm systems.

16. Sheep and beef farming is an integral part of Hawkes Bays and New Zealand's economy. Farming provides valuable jobs and income for the community. Farms can be both profitable and achieve desired commuity environmental values.

17. Matching the appropriate farm system and on-farm management is a key part of pastoral agriculture to optimise farms long-term productivity and environmental success. Consideration of underlying characteristics of the farm such as geology, soil, slope, topography, vegetative cover, erosion potential and climate are a crucial part of ensuring this. Farm Planning is an effective way to do this.

18. Freshwater ecosystem health may be impacted by farming operations. Freshwater ecosystem health assesses a range of physical, chemical and biological parameters to determine the overall state of a waterway. It is important for farming operations to minimise negative impacts and reduce associated risks through on-farm actions, mitigation, management and planning.

19. Key contaminants of concerns for sheep and beef farms are those that are lost in overland flow (these are sediment, phosphorus and faecal bacteria). Thus, identifying and applying farm-specific mitigation strategies to critical source areas is a key strategy to successfully reduce the impact of sheep and beef farming practices on freshwater health.

20. Key tools for this are LUC mapping and farm-specific tailored farm plans that are created with farmer involvement to deepen their understanding of the risks and opportunities associated with farming activities.

21. One-size-fits-all policy approaches are unlikely to achieve the desired outcomes for sheep and beef farms due to the complexity and diversity of the systems.

22. Community led initiatives and catchment groups that have significant farmer input and leadership, as well as appropriate resourcing and support, have the greatest likelihood of achieving the objectives reflective of the community's values. While support from external organisations contributes to overall success, groups need to develop their own path (rather than following one prescribed to them) and be led and driven by the community.

PROFILE OF THE SECTOR

23. The New Zealand sheep and beef sector contributes to 4.2% of gross domestic product and $4.6 billion in household income, including flow on effects (Heilbron, 2020).

24. Its total value of red meat exports and wool for the 2019-20 season was $10.4 billion. Over 90% of production from the sheep and beef sector is exported.

25. The sheep and beef sector provides jobs for over 92,000 people directly employed on-farm, in processing and support services.

26. The Hastings district covers an area of over 5200 km^2 and extends from Whirinaki in the north to Waimarama in the south. In this district there were 333 commercial sheep and beef farms in 2017. The B+LNZ Economic Service defines commercial sheep and beef farms as, among other things, those that are over 750 Stock Units (a stock unit is defined as the feed demand equivalent to a 55 kg ewe rearing one lamb which requires around 595 kg dry matter/yr, e.g. a hill country beef cow equals 5.5 Stock Units).

27. In the Hastings district sheep numbers have remained relatively stable over the past five years at 1.1 million while beef cattle have increased by approximately 18% over the same period (Figure 1). Stock units for sheep have slightly declined and beef stock units have increased (Figure 2).

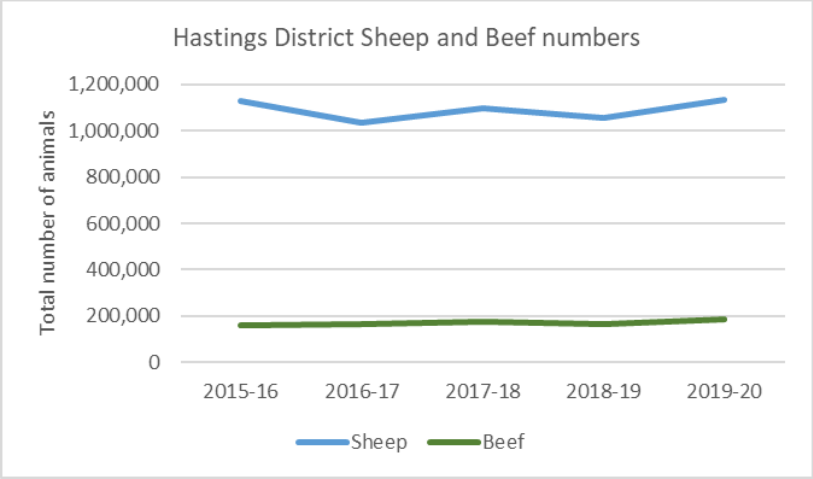

Figure 1: Trend in Livestock numbers, Hastings. Source StatsNZ, B+LNZ Economic Service

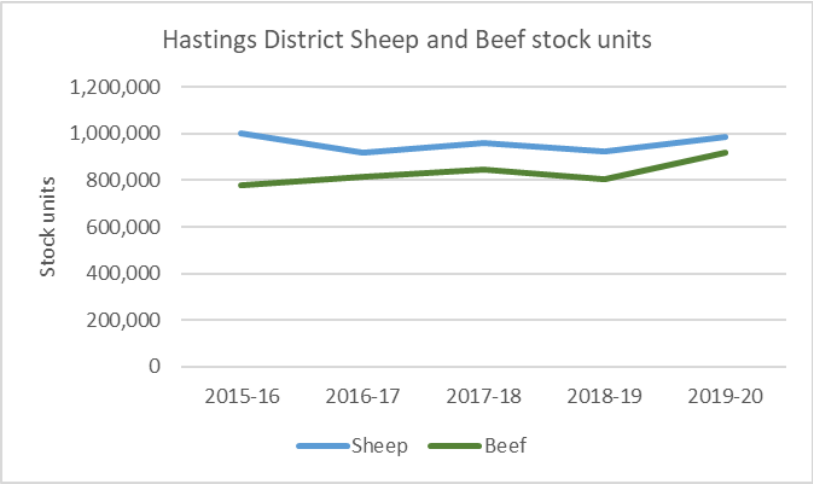

Figure 2: Trend in stock units, Hastings. Source StatsNZ, N+LNZ Economic Service.

28. Appendix 1 describes the B+LNZ Sheep and Beef Farm Survey ("Survey"), the source of data for the following sections.

29. Sheep and beef farms are complex and diverse. Sheep and beef farms are located on a variety of landscapes and operate in a variety of climates. B+LNZ characterises farms into eight Farm Classes, which combine both physical and financial characteristics. The Farm Classes that are relevant in the Hastings District/ Hawke's Bay region are Farm Class 3 - North island Hard Hill Country, Farm Class 4 – North Island Hill Country, and Farm Class 5 – North Island Finishing. These are described in more detail in Appendix 1.

30. There are estimated to be 165, 515 and 465 commercial farms in farms classes 3, 4, and 5, respectively, in the Hawke's Bay (Table 1).

Table 1: Estimated Hawke's Bay Sheep and Beef farms and area, by Farm Class 2019-20

Farm Class	Commercial farms	Grazing hectares	Non-Grazing hectares Forestry, scrub, bush, wetlands etc	Total Area hectares (Survey estimate)	Grazing hectares %
Class 3 North Island Hard hill country	165	144,900	29,500	174,400	83%
Class 4 North Island Hill country	515	269,000	55,100	324,000	83%
Class 5 North Island Intensive finishing	465	164,000	18,100	181,800	90%
All Classes	1,145	577,900	102,700	680,200	85%

Source: B+LNZ Economic Service, StatsNZ

31. The B+LNZ Survey data for the Hawke's Bay shows that the average farm area of Farm classes 3, 4 and 5 in 2018-19 were 1057, 629, and 391 ha, respectively (Table 2).

32. Stocking rates were 8.1, 8.6 and 9.1 SU/ha for farm classes 3, 4, and 5, respectively, in 2018-19 (Table 2; Appendix 2: Stocking rates by Farm Class). This is an equivalent stocking rate of less than 1.5 cows per hectare (Appendix 2: Stocking rates by Farm Class).

33. Of those farms surveyed in the Hawke's Bay region there were no sheep and beef farms that had any form of irrigation.

34. Of those farms surveyed across the whole East Coast region (East Cape to Wairarapa), for the 2018-19 season there was no irrigation on Farm Class 3, minimal irrigation on Farm Class 4 (2.1% of farms) and a small percentage of Farm Class 5 farms with irrigation (6.7%).

35. Irrigation on sheep and beef farms is often a small percentage of the total farm area under irrigation as there is often only a fraction of the farm area that is suitable for irrigation due to topography, soil types and proximity to water supply schemes.

Table 2: Key physical and financial features of commercial sheep and beef surveyed farms in Hawke's Bay 2018-19

Physical, production and financial statistics		Farm Class 3: North Island Hard Hill Country	Farm Class 4: North Island Hill Country	Farm Class 5: North Island Intensive Finishing
Farms in Sample	No.	14	35	25
Total Farm Area	ha.	1,057	629	391
Grazeable Area	ha.	878	522	352
Grazeable Area	% of Total	83	83	90
Irrigation [1]	% of farms	0	0	0
Sheep	No.	4,836	2,709	1,947
Cattle – Beef	No.	574	456	319
Deer	No.	0	19	0
Sheep to Cattle[2] Ratio	% Sheep	62	55	52
Sheep	SU	4,408	2,443	1,682
Cattle – All	SU	2,745	2,037	1,535
Deer	SU	0	33	0
Total	SU	7,153	4,513	3,220
Stocking Rate	SU/eff. ha.	8.1	8.6	9.1
Lambing Performance	%	116.3	126.5	128.5
Calving Performance	%	86.1	83.1	89.5
Wool Revenue	% of total	5%	5%	3%
Sheep Revenue	% of total	60%	54%	49%
Sheep+Wool Revenue	*% of total*	*65%*	*59%*	*52%*
Cattle Revenue	% of total	33%	34%	38%
Dairy Grazing Revenue	% of total	0%	4%	2%
Sub-Total	% of total	98%	96%	93%
[1] Based on farms paying irrigation charges				
[2] All cattle, i.e. beef plus dairy cattle. Stock units.				

36. Total Gross Revenue Output from the pastoral sector in Hastings District for 2018-19 was $260 million, of which almost $214 million was from sheep and beef farms. Further information on Gross Revenue at a Hawke's Bay and East Coast level is provided in Appendix 4: Aggregate Farm Revenue.

37. The sheep and beef sector's ability to adapt has been an important factor in its success since the 1990s. Sheep numbers were 58 million in 1990 and have dropped to 27.4 million in 2017 while beef cattle numbers have dropped from 4.6 million in 1990 to 3.6 million in 2017 (Mackay, Scobie, Rhodes, & Devantier, 2019). This has also resulted in an approximately 30% reduction in greenhouse gas emissions contributed from the sector.

During this time there have also been significant productivity gains that have been possible through innovation and efficiencies such as:

(a) improved animal genetics;

(b) increased fecundity;

(c) improvements in animal management, feeding and welfare; and

(d) optimisation of farming systems to align with the natural capital of the land.

38. Productivity gains include:

(a) Increased average lambing percentage from 100 percent to 130 percent since 1991 (B+LNZ, 2020);

(b) increased lamb carcass weight per ewe and hogget from 9kg to 19kg (+104%) (B+LNZ, 2020);

(c) increased steer weight from 297 kg/head to 312 kg/head (B+LNZ, 2020).

39. Sheep and Beef farms collectively have over 2.8 million hectares of New Zealand's indigenous vegetation including native forest and shrublands (Norton & Pannell, 2018). This represents almost one quarter of the indigenous vegetation in New Zealand.

40. Sheep and beef farms have significant areas in forestry as well as areas set-aside in manuka, scrub, lakes, wetlands and riparian planting. In the East Coast over 15% of the total farm area of Farm Class 3 and 4 sheep and beef farms is forestry and set-aside areas (Appendix 3: Forestry and set-aside areas). For Farm Class 5 this is around 7% of the whole farm area.

41. Case and Ryan (2020) estimated woody vegetation (including indigenous and exotic forest) on sheep and beef farms in New Zealand could offset between 63 and 118 percent of on-farm agricultural greenhouse gas emissions. The total carbon sequestration potential on sheep and beef farms was estimated to be between 10,394 kt CO_2e and 19,665 kt CO_2e (Case & Ryan, 2020).

42. In comparison, a report by the Ministry for the Environment on net emission and removals from vegetation and soil on sheep and beef farmland,

suggested that net removals of carbon dioxide were equivalent to 33 percent of on-farm agricultural emissions (MfE, 2020). This accounted for net emissions from forest harvest and used different sequestration rates to those used in the Case and Ryan (2020) report.

43. There is a high degree of complexity in sheep and beef farms due to a high degree of spatial and temporal variation in:

    (a) physical landscape,

    (b) climate, and

    (c) biological systems (both farmed and native).

44. Add to this the individuality of the farmer and their personal business considerations and we see that each sheep and beef farm has a different set of parameters and constraints which must be considered to ensure good environmental and business outcomes.

45. For the sheep and beef sector to continue to meet environmental and freshwater requirements, flexibility around farming practices and mitigation strategies is needed to ensure farm systems can continue to adapt to climate and market changes and fluctuations while also optimising land use.

EXTERNALITIES OF CONCERN TO THE SHEEP AND BEEF SECTOR

46. Freshwater ecosystem health may be impacted by farming operations. It is important for farming operations to minimise negative impacts and reduce associated risks though on-farm actions, mitigation, management, and planning.

47. Sediment, phosphorus, faecal microbes and nitrogen can all potentially impact on freshwater systems. Overland flow or runoff can carry sediment, phosphorus and faecal microbes to freshwater bodies. Nitrogen is generally carried with water though the soil profile and leaches out of the soil profile to groundwater. Careful land and stock management is needed to reduce the risk of losing these contaminants to waterways.

48. Sediment, phosphorus and faecal microbes carry the greatest risk of loss due to the landscape where sheep and beef farming typically occurs, with stock type and on farm management practices being the other key factors.

49. Sediment and phosphorus loss are often closely linked as the phosphorus can bind to sediment and is subsequently transported. In areas where erosion is a risk, sediment and phosphorus loss are largely driven by the generation of overland flow which acts as a vector to mobilise and transport the contaminants into waterways. As such slope, underlying geology, soil type and vegetative cover are important factors that contribute to the risk as well as patterns of rainfall and runoff generation.

50. Sediment loss can be caused by animal grazing pressure when there has been a loss of ground cover alongside breakdown of soil aggregates into small micro-aggregates and fine particles. Following this, the particles are transported in surface runoff. This sometimes occurs during winter grazing of animals.

51. Phosphorus contamination of surface water from sheep and beef farms is typically the result of eroded sediment from surrounding land but may also be a result of the use of phosphorus containing fertiliser. Consideration of phosphorus containing fertilisers needs to be taken into account in areas where phosphorus enrichment of waterways is an issue, the use of low soluble phosphorus fertilisers can reduce the P loss from overland flow in grazed pastures (McDowell & Catto, 2005).

52. Faecal microbes contain organisms that are part of the gut biome of animals. Sometimes there may be pathogenic organisms present that can be harmful to animal or human health. Other microbes such as *Echerichia coli (E. coli)* may be present and are usually harmless but can act as indicators of faecal contamination and also potential pathogenic risk. These organisms are deposited in dung and can be deposited directly in waterways if animals have unrestricted access to them. When faeces are deposited on pastures the faecal bacteria can be mobilised during rainfall which generates overland flow and is transported in the water to reach waterways. Overland flow is also believed to be a major contributor of the total microbial load delivered to streams (Vinten et al., 2004). Sheep are less attracted to waterways than cattle and are less likely to directly deposit faeces into waterways (Collins et al., 2007).

53. Critical source areas (CSAs) are areas of a catchment where a source of nutrients or contaminants coincides with a transport mechanism, usually water (McDowell & Srinivasan, 2009). CSAs are relatively small areas

where ephemeral flow accumulates and has enough energy to mobilise and transport a disproportionate amount of sediment, nutrients or contaminants (Betteridge et al., 2012). Once the contaminants have been entrained in a flow pathway, they may be transported to waterways in overland flow. These areas are often low-lying parts of farms such as gullies and swales but may also be represented by non-paddock features such as laneways.

54. Careful management of CSAs is an important way to reduce environmental losses to waterways. Reducing the risk of overland flow occurring in CSA or minimising mobilisation of a contaminant source will help to reduce the overall risk of losing contaminants to waterways. Management options include retaining vegetation cover in the CSA, appropriate stock management, non-tillage, stock exclusion at certain times, and maintaining good soil structure.

55. Contaminant losses from sheep and beef farms can often occur over short time scales from relatively small areas where high contaminant concentration and rapid transport processes coincide (Monaghan et al., 2007). Management of CSAs is an excellent way to mitigate the environmental risk associated with sheep and beef farming activities, with up to 80 percent reduction of sediment and phosphorus loss being able to be achieved by CSA management (McDowell, van der Weerden, & Campbell, 2011; Monaghan, Laurenson, Dalley, & Orchiston, 2017).

56. In his evidence, Dr. Michael Greer states in pargraph 58 that where *E. coli* targets are not being met that *"agriculture is the most likely cause; sheep and beef farming being far and away the most predominant source of potential faecal contamination in most catchments"*.

57. *E. coli* is predominantly lost via overland flow pathways. These pathways are most often associated with CSAs. The mitigation tools to address the risk of *E. coli* loss are best developed at an individual farm scale via a farm plan with potential mitigations including:

    a. leaving CSAs ungrazed for certain grazing activities (e.g. winter crop grazing).

    (a) gully retirement;

(b) strategic riparian margin plantings or rank grass based on predominant flow pathways;

(c) strategic grazing of crops and pastures during high-risk periods.

58. Blanket fencing rules are unlikey to achieve the desired effect, are costly, and do not account for the diversity and complexity of sheep and beef farms.

59. The Tūtaekurī is in a high priority zone for sediment loss and erosion. The Ngaruroro catchment is also affected to some extent by sediment loss. In these areas, farm planning will help farmers plan for longer term goals around stock exclusion, land use and sediment control options. Enabling farmers to have flexibility in their farm planning while providing sufficient support though community and farmer led catchment groups will help to minimise land use driven sediment inputs to waterways in the TANK area.

60. The faecal contamination in the TANK area is likely contributed to by septic tanks, urban areas and agricultural activities (Rutherford, 2009). Ngaruroro and Tūtaekurī catchments generally had low levels of faecal bacteria *(E. coli)* and are suitable for primary recreation. The Ngaruroro mainstem is in excellent condition in the middle to upper catchment.

61. The Karamū and Ahuriri catchments both have reduced ecosystem health with nutrient enrichment and faecal contamination (Haidekker and Madarasz, 2020).

62. As noted by Dr Michael Greer in his evidence (paragraphs 41 and 42) there is reduced macroinvertebrate community health in the lower Tūtaekurī that may be partly explained by the lack of riparian shading. This reduced macroinvertebrate community health is not necessarily a reflection on the broader land use in the catchment and may be effectively mitigated by increasing the amount of riparian margin plantings. Riparian planting increases shading which reduces temperatures, thereby making it more habitable for macroinvertebrate life. Farm plans would be an effective mechanism to create on-farm change that could increase riparian planting. If this is done on a catchment scale, long-term improvements in macroinvertebrate community health would be observed.

HOW TO EFFECTIVELY MANAGE AND REDUCE CONTAMINANT LOSS FROM SHEEP AND BEEF FARMS

63. Natural capital has been defined as the *"stocks of natural assets that yield a flow of valuable ecosystem good and services into the future"* (Dominati, Patterson, & Mackay, 2010), (Costanza & Daly, 1992). In terms of farm systems, they include the farm's soils and geology, climate and air, freshwater, and living things (biodiversity).

64. Matching the appropriate farm system and on-farm management is a key part of pastoral agriculture to optimise farms for long-term productive and environmental success through careful consideration of underlying characteristics of the farm such as geology, soil, slope, topography, vegetative cover, erosion potential and climate.

65. B+LNZ has an environmental strategy that has emphasis on four key areas:

    (a) cleaner water;

    (b) thriving biodiversity;

    (c) healthy soils;

    (d) carbon neutrality

66. Farm plans and catchment community groups are crucial elements required to deliver on the four key areas listed above.

67. Farm Environment Management Plan (FEMP), Farm Environment Plan (FEP), Environmental Farm Plan (EFP), Land and Environment Plan (LEP), Whole Farm Plans (WFP) and Farm Plan are different terms for similar documentation that outlines how a farmer or landowner will manage their operations and activities in a way that takes into consideration environmental and business outcomes. For the purposes of this document I will refer to the above collectively as farm plans.

Farm planning background

68. In New Zealand farms plans have been used as a tool since around the 1950s in response to the Soil Conservation and Rivers Control Act 1941 (Stokes, Macintosh, & McDowell, 2021). They were first developed as soil conservation plans from ideas that were adopted from the United States. Initially many individual farm plans were prepared by Catchment Boards and were largely focussed on soil conservation and control of erosion prone

soils (Powell & Heath, 2018). This was the start of a more integrated approach to on-farm management (Stokes et al., 2021).

69. Soil conservation plans became a fundamental base unit of soil conservation in the 1960s and were nationally recognised. During the 1980s the national programme ceased, and the development of Resource Management Act 1991 saw the devolution of responsibility from central government to regional councils. Councils different interpretations of how to implement resource management obligations led to a fragmented and diverse range of farm plan programmes (Manderson, Mackay, & Palmer, 2007).

70. The New Zealand Land Resource Inventory (LRI) was used to define national Land Use Capability units (LUC) and helped to provide a consistent approach to land evaluation (Stokes et al., 2021).

71. During the 1980s and 1990s the national farm planning process extended beyond just soil conservation to include water bodies, biodiversity and greenhouse gases (Stokes et al., 2021).

72. In recent years farm plans have become increasingly recognised as an important way for farmers to improve their farming systems and practices. Importantly, farm plans are also a means of recording and demonstrating these improvements.

73. Accreditation schemes offered by processors often require farm plans to demonstrate that farming is being carried out in a sustainable way and robust information is needed to maintain or access to market premiums (Stokes et al., 2021).

Natural capital

74. Natural capital has been defined as the *"stocks of natural assets that yield a flow of valuable ecosystem good and services into the future"* (Dominati, Patterson, & Mackay, 2010), (Costanza & Daly, 1992). In terms of farm systems, they include the farm's soils and geology, climate and air, freshwater, and living things (biodiversity).

75. Matching the appropriate farm system and on-farm management is a key part of pastoral agriculture to optimise farms for long-term productive and environmental success through careful consideration of underlying

characteristics of the farm such as geology, soil, slope, topography, vegetative cover, erosion potential and climate.

Soil Conservation

76. Soil conservation principles have been a key part to the development of farm planning. The Soil Conservation and Rivers Control Act 1941 established catchment boards to assist with the construction of erosion and flood control measures (Cairns, Handyside, Harris, Lambreschtsen, & Ngapo, 2001).

77. Soil Conservation aims to reduce different types of erosion (particularly that from farmland) in order to reduce the impact of sediment that may reach waterways. Sediment can cause a number of issues such as increasing the likelihood of flood events, reducing production and changing or reducing the ecosystem health of waterways through habitat modification. Erosion can also reduce the productive potential of farms though soil loss and deposition of sediments onto pastures.

78. Erosion is a natural process but can be exacerbated by some types of landuse and some farming activities. Different geological substrate, climates, topographies, soil types and amount of vegetative cover may make different areas and regions more susceptible to certain types of erosional processes. These are therefore important factors to consider when determining appropriate land use.

79. Soil conservation principles for farmland may include measures such as ensuring stable soils though good soil structure, retaining vegetative cover, strategic use of planted trees to increase slope stability, reducing tillage and cultivation on vulnerable soils, controlling and minimising runoff and stock management.

Land Use Capability

80. The Land Use Capability system is an assessment tool that can help farm and catchment scale planning by using biophysical assessments to help determine the natural capital of the landscape, providing for opportunities as well as identifying limitations of certain land types. It has two key components the Land Resource Inventory (LRI) and the Land Use Capability (LUC) classification.

81. The LRI is compiled first and assesses physical factors considered to be critical for long-term land use management. They are:

(a) rock type;

(b) soil type;

(c) slope;

(d) erosion risk;

(e) vegetation cover.

82. The LUC classification uses the LRI to systematically categorise land parcels into eight classes and determines the capacity for sustained long-term production while taking into account the physical limitations of the land (Lynn et al., 2009).

83. The LRI is supplemented with information about possible limitations about climate, erodibility, wetness or soil that further refine the classification of the LUC.

84. LUC is a key part of advanced farm planning. It provides a system that assesses and categorises the natural capital of a farms land resources and limitations that may be present. LUC can also be further enhanced by identification of critical source areas, waterways and sensitive environments.

85. Having the correct scale for mapping LUC is important. Farm scale maps, around the 1:10,000 scale, can enable farms to understand their natural resources and identify opportunities and risks. This can help prioritise actions to maintain and enhance natural resources such as soil, water and biodiversity. LUC mapping has been carried out in the past at a district and regional scale and is available for most of New Zealand at the 1:50,000 scale.

86. New tools and technology that have been able to enhance the use of LUC mapping and interpretation include, global positioning systems (GPS), Lidar, geomagnetic surveys, digital elevation mapping (DEM) and geographic information systems (GIS) software.

Farm Planning

87. Beef + Lamb New Zealand's approach to farm planning is designed to help farmers:

(a) Ensure the sustainability and profitability of their farming business by adapting to climate change, understanding and managing greenhouse gas emissions, protecting the health of soil and freshwater and biodiversity.

(b) Meeting their own values and objectives as well as the wider communities or catchment values and objectives.

(c) Provide an evidence base to tell farming stories and meet the needs of consumers and regulatory bodies.

88. The B+LNZ environment module is the first part of a wider farm plan that will also include modules such as biosecurity, health and safety, human resources, and animal welfare

89. The B+LNZ farm plan environment module is broken into sections that include:

(a) Identification of resources (natural, physical, and human)

(b) Managing soil health

(c) Freshwater ecosystem health

(d) Integrating native biodiversity

(e) Responding to climate change

(f) Waste and chemical management

(g) Forage cropping (including winter grazing)

(h) Irrigation management

90. The process for developing each section in the B+LNZ farm plan environment module broadly includes:

(a) Setting values or objectives

(b) Assessment or stocktake

(c) Risk assessment (using a risk matrix)

(d) Action plan and implementation

(e) Monitoring and review

91. An important step included in the B+LNZ farm plan is identification and consideration of local catchment or community objectives and values when landowners are developing their own for their farm. Acknowledging wider community objectives in this process can lead to integration and alignment at the farm and catchment level. Individual landowners can see how they can contribute positivity to meeting the objectives of the wider community.

92. A risk matrix is provided to farmers to assess land use and management practices long-term. It also provides them with a way to prioritise on-farm management actions. By carrying out a risk assessment themselves, with support and guidance where necessary, farmers can make well informed and considered decisions.

93. It is important for farmers to be encouraged to recognise the environmental work they have already completed on the farm and be proud of their achievements. It is an important step to record this information in the farm plan. Recording, monitoring, and reviewing, are integral to the farm planning process.

94. By using LUC and land resource mapping at the appropriate scale and allowing for a range of management actions, tailored farm plans that are developed by farmers provide an approach that is relevant at both the farm and catchment level. Farmers being involved in the building and development of farm plans, with required assistance and adequate support, will lead to greater engagement from farmers long term as they will have deeper understanding of the values, opportunities and issues on their farms which can extend to those within their communities.

95. Tailored farm plans that are developed by farmers can help inform wider catchment plans. They do this by supplying information on the broader scale issues that may be present in certain areas of a catchment. Conversely, tailored farm plans can also use catchment plans to help identify where collective actions on a number of farms may contribute to greater overall environmental gains on individual farms and also within the catchment.

96. Individual farm plans should be active and flexible to change and evolve over time. This ensures they remain relevant to the individual farm and landowner as well as communities and catchments by supplying up to date information. Flexibility to develop and modify farm plans ensures an evolving understanding and awareness of issues, as well as an ability to capitalise on opportunities that are presented that may contribute to better personal, social, economic, or business outcomes.

97. Farm planning needs to take a broader approach to sustainability than acting solely as a regulatory compliance tool. Farm planning should consider the economic, environmental, and social wellbeing of a farming business. It can work at different temporal scales and act to provide long-term strategic direction as well as inform day-to-day decision making.

98. Powell and Heath (2018) recognised the need to develop suitable and diverse pathways for farmers to develop a plan; included in which is being involved in their development to both gain a deeper understanding and to reduce excessive costs.

99. Farmers need to retain control of their farm plan and the information it contains. They need to able to decide what information to share, who to share it with and when it is shared. Some of the information held in farms plans may be very personal and sometimes may have sensitive information such as financial data.

100. Farm plans are an important tool that can be used as proof of compliance with market assurance programmes such as the New Zealand Farm Assurance Programme (NZFAP) New Zealand Farm Assurance Programme Plus (NZFAP Plus) which provides evidence to environmentally discerning markets and consumers of environmentally sustainable farming practices.

101. Farm plans provide flexibility and a tailored approach to understanding and categorising a farm's natural capital assets such as geology, topography, soils, climate, biodiversity and water. It also a provides a mechanism to assess environmental risks and strengths, and a way to review these over time. Farm plans developed in this way also take into account wider business, social and cultural goals.

102. Farm plans when developed by farmers, with the appropriate support and guidance, ensure that farmers have a greater understanding of the relevant issues that they are faced with on their property. Providing a less prescriptive approach to farming allows the necessary flexibility that leads to greater resilience, innovation, and adaptability within the primary sector.

103. In the Hawkes Bay region between 2014 and 2020, B+LNZ provided 38 farm planning workshops that were attended by a total of over 560 people. Over the same period, over 4,500 people attended a B+LNZ farm planning workshop in New Zealand. This represents a significant industry-good investment in farm planning. This has helped farmers build and develop their own individual farm plans.

104. In the Aparima catchment (six individual sub-catchment groups) in Southland a farmer survey was conducted in 2019 and 2020. The surveys have shown that farms with farm plans were significantly more likely to have water resource management practices (such as stock exclusion, buffer zones and riparian planting) and nutrient management practices (such as targeted fertiliser use and nutrient budgeting) implemented. Also farms with farm plans were more likely to report sound winter grazing practices (ResearchFirst, 2020).

105. The results from the Aparima catchment show that farm plans can make a difference to implementing on-farm actions and result in change. Freshwater health is directly affected by landuse and on-farm actions. The uptake of farm plans and subsequent improvement in uptake of established good farming practices that directly affect freshwater health and water quality would suggest that implementation of farm plans leads to better overall freshwater health outcomes. A direct link of changes in land-use to changes in freshwater health is difficult to measure in waterways in the short-term due to the high variability and variables that are present.

106. Farm plans will be an integral delivery mechanism for the He Waka Eke Noa primary sector partnership. They will be used to measure and manage greenhouse gas emission. There is an expectation for all farms to have this in place by 2025. While primarily aimed at greenhouse gas emissions in this context, farm plans will become an essential part of all farmers management tools.

TANKS Schedule 30

107. Access to and control of the content of a farm plan is an issue that needs to be further considered in HBRC's PPC9. In Schedule 30 section C 2.1 the Farm Environment Plan will be submitted to HBRC. How will this information be secured and who will have access to it? Some farmers may have sensitive information in their farm plans that they may not want made available to others. If the information is not perceived to be "safe", farmers will be less inclined to provide it.

108. Schedule 30 Section C 1.1.a "A farm plan must be prepared by a person with the professional qualifications necessary to prepare a farm plan". Having farmers involved in the farm planning process is essential for long term success. They need to be given the opportunity to choose how, and by whom they would like it prepared. Some farmers may choose to have assistance with farm plan preparation, while others will prefer to prepare the plan themselves.

109. Schedule 30 section B 4.2. Information will be required where appropriate about (amongst others) c) "the results of any environmental monitoring carried out by the catchment collective or industry programme". While monitoring and review are important to measuring progress, the extent of monitoring expected, by who and how it is funded are important considerations. If professional monitoring is expected above and beyond the Councils state of environment monitoring, a funding mechanism is likely required. Alternatively, tools such as the Stream Health Check (detailed in para 116) can be carried out by farmers and their families at no cost are effective tools for measuring improvement. Farmers and catchment collectives may be less inclined to submit results if they think it could lead to ramifications for individuals or the group. Data collected by a catchment group is most powerful when it is retained and managed by the group so that they can assess the implications, make informed decisions and act accordingly. This will enable trust to be built rather than potentially being a process that causes stress and distrust about how that information will be used by the council.

Catchment groups

110. Catchment community groups are an effective way to achieve larger scale environmental outcomes. Collective responsibility and actions over a larger area can result in long-term gains in freshwater ecosystem health. Holmes et al. (2016) found that habitat quality improved in stream areas where there was a collective effort by farmers in a community led catchment group to put in riparian stock exclusion and management. Sediment reductions showed the strongest response.

111. B+LNZ catchment community programme aims to support farmers taking a leadership role to establish or run catchment community groups. An important part of catchment groups is defining why the group is coming together and what is a shared vision for the future.

Figure 3: Catchment Action Cycle.

112. At a catchment scale and driven though farm plans and catchment groups, farmer practice change can be linked to changes in water quality outcomes (Scarsbrook, 2011).

113. A community-based approach to catchment groups and farm planning is essential to build trust and relationships. With the appropriate support and guidance, farmers and communities will be able to effectively manage the natural resources in their area.

114. Freshwater ecosystem health is an important component that catchment groups should consider. Freshwater ecosystem health is a measure of the overall state of a waterway. It takes in account chemical, physical and

biological parameters assessing parameters such as habitat quality, surrounding vegetative cover, what the stream bed is composed of and what aquatic life there is, such as macroinvertebrates and fish, and aquatic plant life (O'Brien et al. 2016). Traditionally there has been a large emphasis on the water quality part of freshwater ecosystem health. This usually focuses of a range of chemical measurements but often includes a selection of nitrogen, phosphorus, sediment and *E.coli*. These variables are often used and have set limits in particular waterways. They don't necessarily give an accurate indication of ecosystem health.

115. The Macroinvertebrate Community Index (MCI) is a tool that has been developed for use by freshwater ecologists to assess the biological health of a waterway. Macroinvertebrates are sensitive to a range of chemical, physical and biological conditions in stream and are a useful indicator of overall ecosystem health as set out in the evidence of Dr Greer.

116. There are a range of tools that can make very basic assessments of ecosystem health and are often suitable for people to carry out with minimal training such as community members, landowners or farmers. Examples are, the Stream Health Monitoring and Assessment Kits (SHMAK), Rapid health Assessment and the Stream Health Check. The latter of these is used as a tool developed for use by farmers and landowners in the B+LNZ Farm Plan. It is a relatively quick method that requires only a basic understanding and asks a range of questions designed to assess the habitat, stream life, surrounding land use and makes has a weighted index that are summed to give an overall score. The scores given directs users to look at a range of risk factors and drivers that may be contributing to reduced ecosystem health and landowners can consider how they can be managed. It is not intended to replace sound expert advice, but outcomes of the assessment will be an indicator if further action or assistance is necessary. It is worth getting expert advice before carrying out large scale and expensive mitigations.

117. The basic assessment tools are very useful tools for building engagement in freshwater health. They are hands-on and practical and highly visual which suits a range of personalities. They are great tools for use with community and catchment groups and training days can inspire farmers and community members to undertake assessments in their local streams and

waterways. Used on a regular basis, the results can inform farm plans and monitor long term trends in a waterways. If desired, the results can also be compared between farmers in a catchment group setting and can help build social capital and develop the overall understanding of waterways within the group.

118. Taking into account the natural capital of the land and using the LUC sytem within the context of a catchment group can help bring about catchment scale change and target appropriate land use change and on-farm management as noted by Mr Kessels in his evidence in paragraph 33. New technologies and systems allow for catchment scale mapping of specific parameters to model future gains that may be made from implementing mitigation strategies or land use changes.

IRRIGATION AS A PROXY FOR RISK

119. Irrigation can cause nutrient losses to water in two main ways:

(a) By inducing soil drainage

(b) By causing surface runoff

120. The level of risk associated with irrigation is related to the farming practices that are deployed because of the irrigation. Irrigating previously non-irrigated dryland increases the productivity of that land. This can result in increased pasture production, increased stocking rates, higher rates of fertiliser application, higher crop yields, and the ability to grow different crop types. These all have the potential to increase the nutrients present in the farm system.

121. However, there are management practices that can reduce the risk of water (and thus nutrient) loss from farming systems.

122. An increase in irrigated area does not automatically lead to a high contaminant loss system. The range and degree of impact of irrigation on N leaching losses (and P losses via surface runoff) is varied and depends on a number of factors including:

(a) Irrigation type;

(b) Irrigation management;

(i) irrigation management tools such as soil moisture monitoring, irrigation scheduling (using a soil water balance) are used; and

(ii) irrigators are well maintained.

(c) Soil type;

(d) Climate;

(e) Farm system; and

(f) Mitigations adopted by farmers/land managers.

123. Due to the diverse and complex nature of sheep and beef farms having a 10 ha threashold for irrigation before triggering a consent is flawed. I believe that it should be more nuanced than this taking into consideration:

(a) The percentage of the farm area under irrigation;

(b) The farming system employed on the irrigated area; and

(c) The irrigation system (design and management/monitoring systems)

124. Irrigation can be conducted without significant, farm-level, negative impacts on N leaching. It is important that irrigation systems/consents are considered on a case-by-case basis or at least consider the individual situation and farmsystem -specific characteristics.

STOCK DRINKING WATER

125. Breeding ewes need approximately 3 L of water per day. Beef cattle need up to 45 L of water per day (Fleming, 1996). These requirements are based on a pasture-based diet where some of the water requirements are met by the feed that they are eating. In a situation where stock are eating more dry supplements such as hay or straw, their requirements for water will increase.

126. During dry, hot weather stock will need to have increased allowance for water as they use more to stay cool. Stock water consumption may increase to 5 L per day for ewes and up to 11 L per day for lactating ewes on dry feed. Beef cattle water demand may go up to 60 L per day during hot, dry weather (Stewart & Rout, 2007). Therefore, more allowance needs to be

made for stock to have access to this increased demand for drinking water. Having access to sufficient drinking water is an animal welfare requirement.

127. Hawke's Bay region reaches dry to extremely dry conditions on an annual basis and drought conditions approximately 1 year in 10 (Figure 4). This needs to be taken into consideration when allowing for adequate stock water supply.

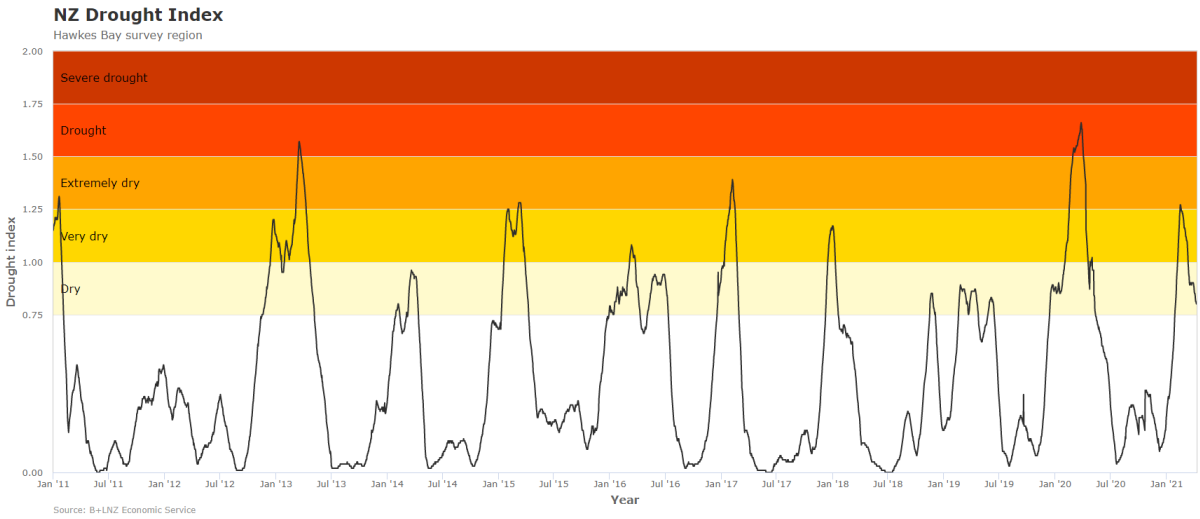

Figure 4: Drought Index Hawke's Bay region (January 2011 to January 2021). Source B+LNZ, NIWA.

128. Reticulated water systems deliver clean fresh water to stock though a piped system that is delivered from a source to troughs that are placed in paddocks. Troughs are usually kept topped up by a gravity fed or pumped system.

129. In some areas, reticulated water systems can be a way to reduce environmental losses caused by stock directly accessing waterways to drink from. This can then reduce direct faecal deposition to waterways and may also reduce sediment loss directly to waterways by stock causing disturbance of the waterway beds and banks.

NOTES TO THE HEARING PANEL REGARDING S42A RECOMMENDATIONS

130. I support the officers recommendations that submission points seeking greater levels of regulation and resource consent requirements <u>be rejected</u> (s42A para 931) for reasons outlined in my evidence, namely that the diversity and complexity of farm systems requires a flexible management approach.

131. I support that where possible and appropriate, national, and regional regulation is aligned because this provides clarity and certainty to farmers and communities (s42A para 934 & 935).

Tom Orchiston

7 May 2021

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APPENDICES

APPENDIX 1: B+LNZ SHEEP AND BEEF FARM SURVEY AND FARM CLASSES

1. The data in this section largely comes from the B+LNZ Sheep and Beef Farm Survey ("Survey"), which is conducted by B+LNZ's Economic Service. The sample is randomly selected from the business frame used in the country's census of agricultural producers to reflect New Zealand's livestock base.

2. A core part of this is the Sheep and Beef Farm Survey, which was initiated after a 1949 Royal Commission, which was instructed by the government of the day to "Inquire into and Report Upon the Sheep-Farming Industry", concluded "there is no consistency of facts on which we can rely".

3. The Survey has been running continuously since 1950, which means it has reached its 70th year and makes it the longest running primary sector survey on.

4. It has not remained static but has evolved and changed to meet needs of the industry and issues of the time.

5. The Survey framework and the operational structure of B+LNZ's Economic Service supports making credible forecasts of production and farm outcomes.

Data Limitations and Constraints

6. The Sheep and Beef Farm Survey is a sample survey in which the sample is randomly selected from the business frame used in the country's census of agricultural producers to reflect New Zealand's livestock base. Statistical methods can be used to reliably represent the real world, albeit with some measure of variability/uncertainty. Generally, the discipline of statistics reduces such uncertainty, but absolute knowledge cannot be assured until the population of farms across a region and timeframes envisaged by policy measures is surveyed. That is not practicable for such policy development.

7. Hawke's Bay region aggregation is used in this document to provide perspective and where necessary ensure the confidentiality of individual

farmers. The Hawke's Bay region is indicative of and encompasses the Hastings district and TANK catchments.

8. Sheep and beef farms are complex and diverse. Sheep and beef farms are located on a variety of landscapes and operated under a variety of climates. B+LNZ characterises farms into eight Farm Classes, which combine both physical and financial characteristics. The Farm Classes that are relevant in the Hastings District/ Hawke's Bay region are:

Farm Class 3 – North Island Hard Hill Country - Steep hill country or low fertility soils with most farms carrying six to 10 stock units per hectare. While some stock are finished a significant proportion are sold in store condition.

Farm Class 4 – North Island Hill Country - Easier hill country or higher fertility soils than Class 3. Mostly carrying between seven and 13 stock units per hectare. A high proportion of sale stock sold is in forward store or prime condition.

Farm Class 5 – North Island Finishing - Easy contour farmland with the potential for high production. Mostly carrying between eight and 15 stock units per hectare. A high proportion of stock is sent to slaughter and replacements are often bought in.

APPENDIX 2: STOCKING RATES BY FARM CLASS

Stocking Rates by Farm Class

9. Stocking rates averaged 8.1, 8.6 and 9.1 SU/ha for Farm Classes 3, 4 and 5, respectively in 2018-19. These comprise 62%, 55% and 52% sheep for the three Farm Classes (Table 2).

10. Over the 30-year period from 1990-91 to 2020-21, the average stocking rate on Farm Class 3 farms has remained much the same, increasing by <1 SU/ha. Sheep as a percentage of cattle have declined from 74% to 62%. On Farm Classes 4 and 5 farms the average stocking rates has declined slightly over the past 30 years, and sheep as a percentage of cattle have declined on both Farm Classes (**Figure *5***).

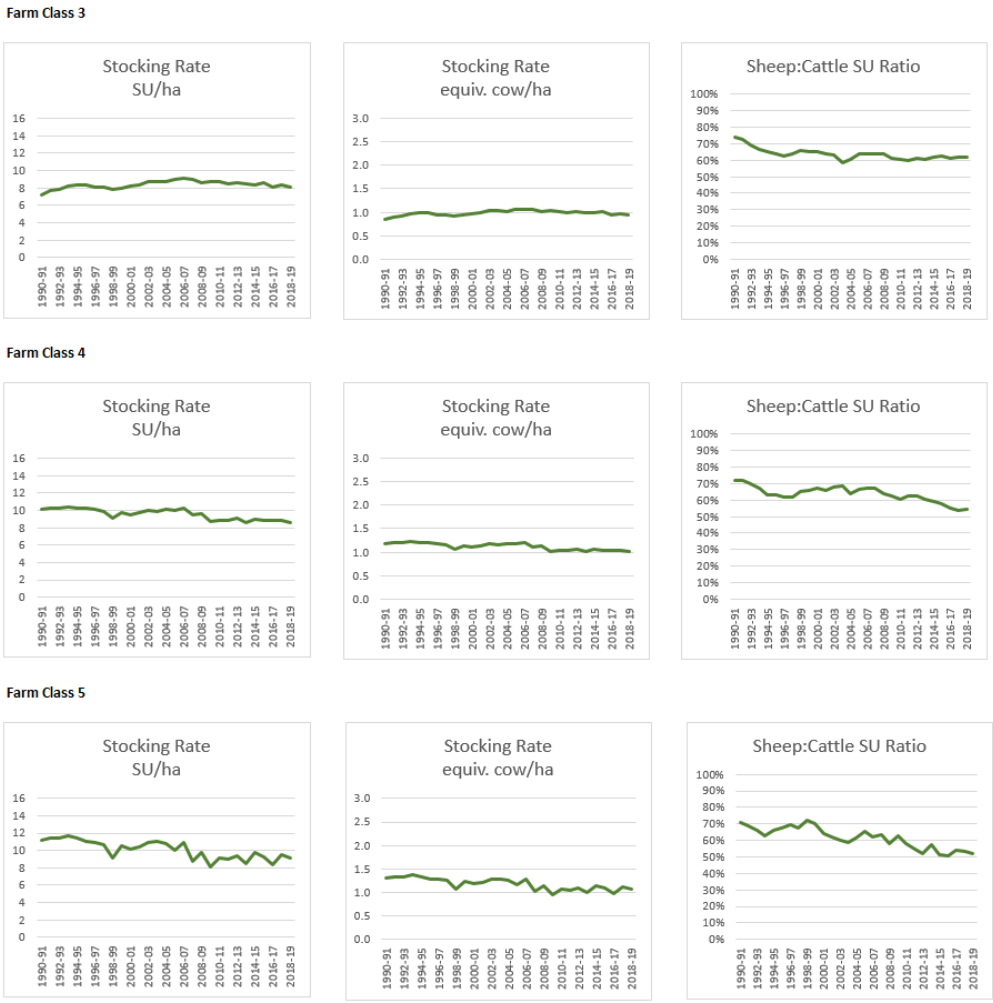
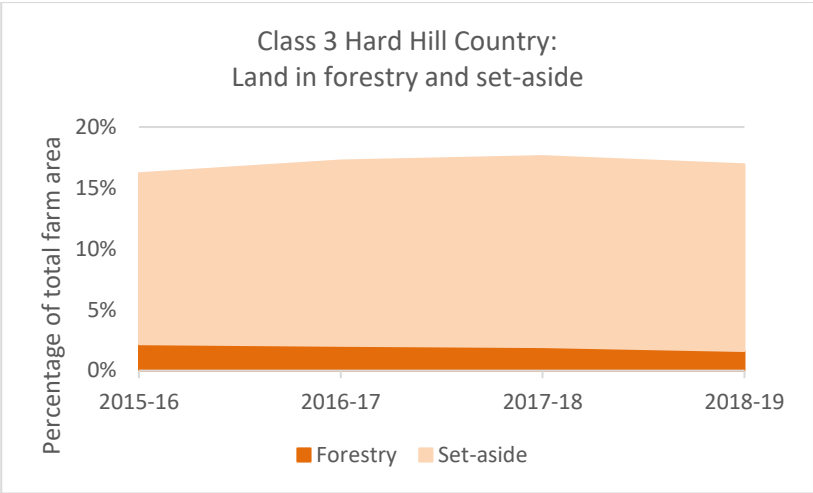


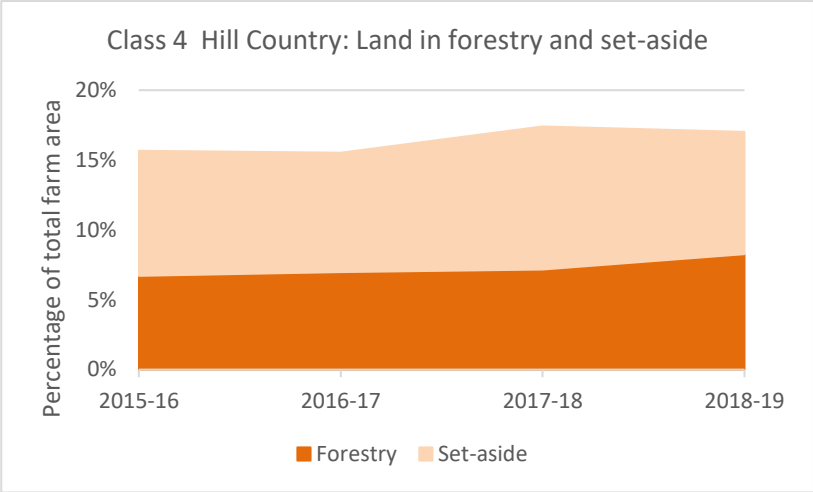
Figure 5: Stocking rate on Farm Classes 3, 4, 5 for commercial Sheep and Beef farms in Hawke's Bay. Source B+LNZ

APPENDIX 3: FORESTRY AND SET-ASIDE AREAS

11. **Figure *6*** on the following page shows the average percentage of total farm area that is forestry or set-aside for the Hawke's Bay Survey farms. These graphs also show that the proportion on the set-aside areas to forestry areas increases as the stocking rate decreases. On average, Farm Class 3 and Farm Class 4 farms have a similar total proportion of their farm in non-grazed areas (forestry plus set-aside) but Farm Class 3 have a higher set-side:forestry ratio than the other farm classes.

12. Set-aside areas include areas of manuka, scrub, lakes, riparian areas and wetlands. These areas provide ecosystem services such as habitat for native fauna. Forestry is defined (for the purpose of the Survey) as tended forestry and does not include agro-forestry, which are areas of land that are grazed underneath forestry trees.





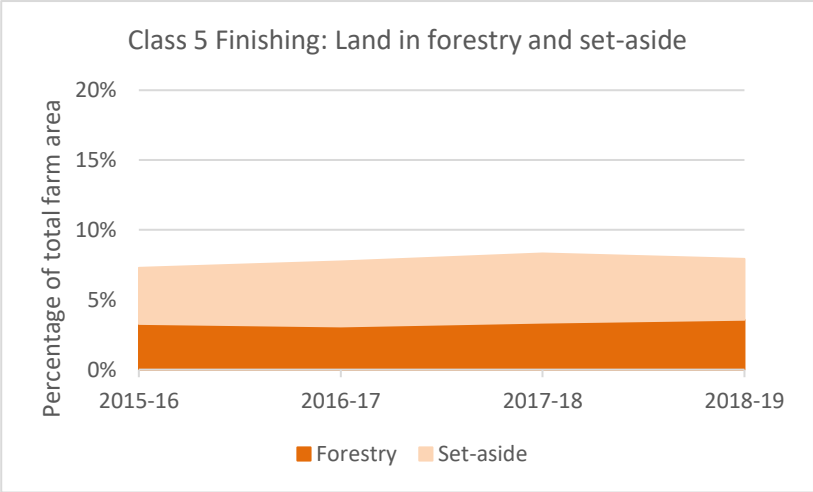


Figure 6: Average Percentage of area in forestry and set-aside, East Coast North Island. Source B+LNZ

APPENDIX 4: AGGREGATE FARM REVENUE

13. Gross Revenue Output from pastoral farming is significant for the Hastings District, Hawke's Bay and greater East Coast regions. Gross Revenue is spent within the district or region on farm inputs and for farm family living. Total Gross Revenue Output from the pastoral sector in Hastings District for 2018-19 was $260 million, of which almost $214 million is from sheep and beef farms (**Figure *7***).

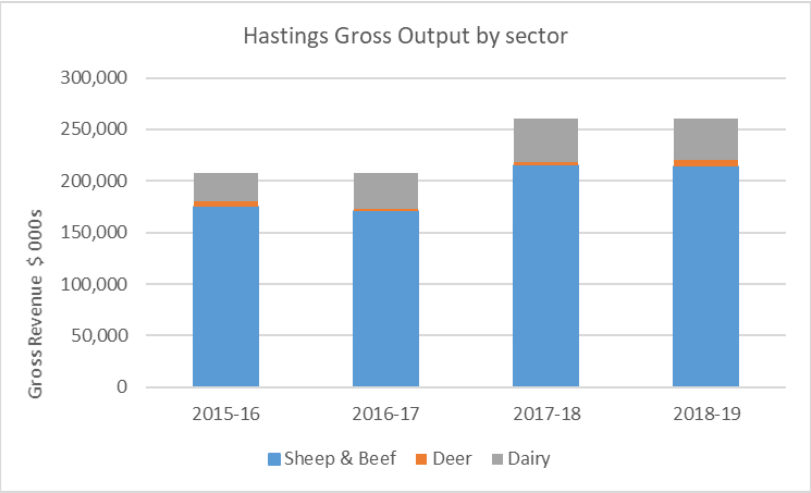


Figure 7: Estimated Aggregate Gross Revenue Output from Pastoral Farming, Hastings District. Source B+LNZ Economic Service, DairyNZ Economics Group.

14. Total Gross Revenue Output from the pastoral farming sector in 2018-19 for Hawke's Bay was estimated at $704 million, of which $547 million (78%) was from sheep and beef farms (**Figure *8***). Across the wider East Coast region, pastoral farming sector Gross Revenue Output in 2018-19 was an estimated $1.9 billion of which sheep and beef contributed 70% ($1.3 billion; Figure *9*).

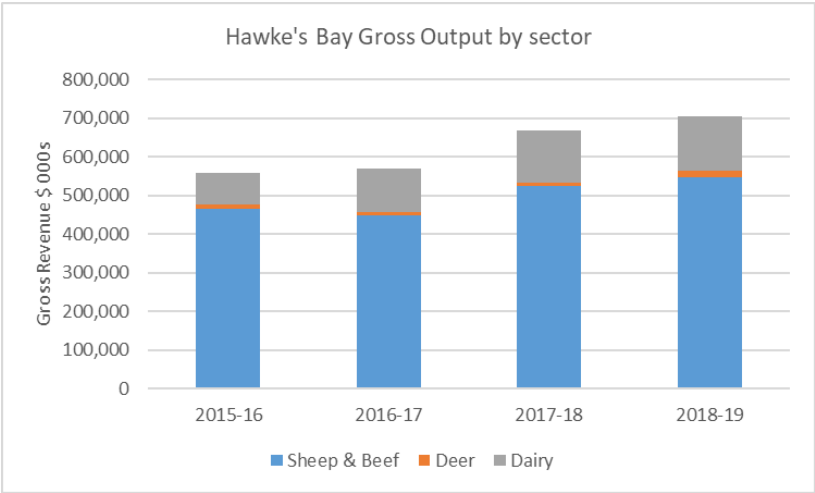


Figure 8: Estimated Aggregate Gross Revenue Output from Pastoral Farming, Hawke's Bay region. Source B+LNZ Economic Service, DairyNZ Economics Group.

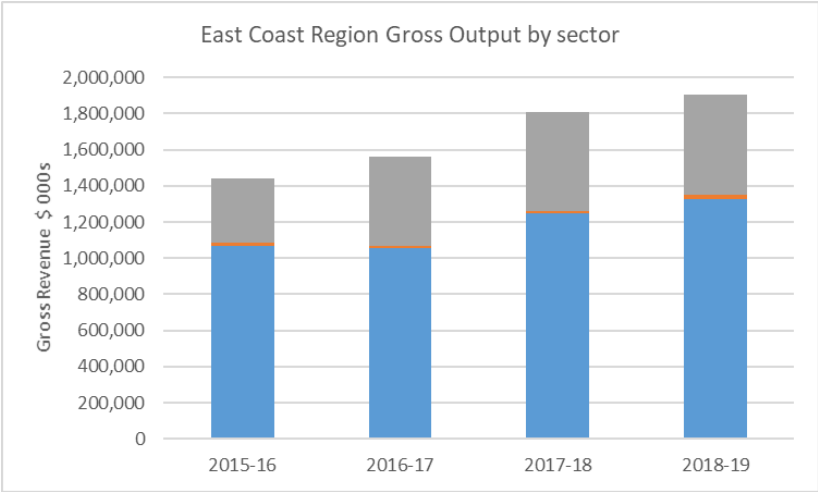


Figure 9: Estimated Aggregate Gross Revenue Output from Pastoral Farming, East Coast North Island. Source B+LNZ Economic Service, DairyNZ Economics Group.

BEFORE A HEARINGS PANEL FOR PROPOSED PLAN CHANGE 9 TO THE HAWKE'S BAY REGIONAL RESOURCE MANAGEMENT PLAN

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of submissions and further submissions of Z Energy Limited, BP Oil New Zealand Limited, and Mobil Oil New Zealand Limited to Proposed Plan Change 9 of the Hawke's Bay Regional Resource Management Plan

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STATEMENT OF EVIDENCE OF PHILIP ALEXANDER BROWN FOR

Z ENERGY LIMITED, BP OIL NEW ZEALAND LTD, AND MOBIL OIL NEW ZEALAND LTD (*THE OIL COMPANIES*)

(SUBMITTER 203)

7 MAY 2021

EXECUTIVE SUMMARY

1.1 This statement of evidence relates to proposed Plan Change 9 (***PPC9***) to the Hawke's Bay Regional Resource Management Plan (***RRMP***). It focuses on the submissions of Z Energy Limited, BP Oil New Zealand Limited and Mobil Oil New Zealand Limited (***the Oil Companies***). All amendments sought are set out in this evidence. Not all submissions are addressed within the body of this evidence, which focuses primarily on those areas where I disagree with the recommendations in the Reporting Planner's report under section 42A (***s42A***) of the Resource Management Act 1991 (***RMA***). A summary of the Oil Companies' submissions subject to this hearing, including where I accept the recommendations of the s42A report, is set out in **Annexure 1**.

1.2 My evidence focuses primarily on how the Reporting Planner's recommendations address water takes associated with temporary construction dewatering activities. In my opinion, the provisions do not provide appropriately for temporary construction dewatering activities which, while not always considered non-consumptive, are short term, infrequent, and essential construction activities. I consider there to be a real risk that takes necessary for the installation and upgrade of underground infrastructure in particular catchments may be prohibited and that this may have unintended consequences for a range of similarly necessary activities which require dewatering, for instance the retention of aging assets due to inability to upgrade the same.

1.3 This evidence also addresses stormwater discharges to water or onto land where it may enter water from industrial or trade premises. As recommended by the Reporting Planner, any discharge from an industrial or trade premise with more than 1,000m^2 of impervious area, or any discharge that contains hazardous substances will default to a discretionary activity status pursuant to Rule TANK 23. In my view this approach fails to recognise that the extent of impervious area is not determinative of risk and that most (if not all) discharges from impervious surfaces will contain hazardous substances, at least in trace amounts. Further, in my opinion the proposed approach does not appropriately recognise the role of industry guidance. This is of particular relevance to the Oil Companies given the good practice provided by the Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand (Ministry for the Environment, 1998, ***MfE Guidelines***).

INTRODUCTION

Qualifications and Experience

2.1 My full name is Philip Alexander Brown. I hold a Bachelor of Planning degree (Hons) from the University of Auckland and I have practiced resource management for four years.

2.2 I have provided planning advice to the Oil Companies since joining 4Sight Consulting in August 2019. This includes resource consent applications and policy advice on various regional and district planning documents, including in relation to issues such as contaminated land, hazardous substances, natural hazards, dewatering, and discharges. Of most relevance to the matters that I address in my evidence, I have worked on projects addressing water takes and discharges to facilitate a range of activities at petroleum industry sites around the country. Prior to joining 4Sight and in my previous planning roles I have provided consenting, policy advice, and preliminary scoping input for a number of commercial clients across a range of projects.

2.3 Along with my colleague Mark Laurenson, I prepared submissions and further submissions to PPC9 on behalf of the Oil Companies. In preparing this evidence I have reviewed PPC9, Council's s32 and s42A Reports, and the relevant submissions of other parties.

Environment Court of New Zealand Practice Note 2014 – Expert Witnesses

2.4 While this evidence is not prepared for the Environment Court, I have read the Environment Court's Practice Note 2014 as it relates to expert witnesses. My brief of evidence was prepared in compliance with the Code of Conduct and I agree to comply with the Code in giving my oral evidence. I am not, and will not behave as, an advocate for the Oil Companies. I am engaged by the Oil Companies as an independent expert and 4Sight Consulting provides planning services to the Oil Companies (collectively and separately), along with a range of other infrastructure, corporate and public agency clients. I have no particular interest in the outcome of the proceedings other than as a user of the Plan.

2.5 The reasons for my opinions are set out in the subsequent sections of this evidence and I confirm I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

3.1 The Oil Companies' core business relates to the operation and management of individual service station networks, airport and commercial refuelling facilities and bulk storage (***terminal***) facilities at ports. The Oil Companies also supply petroleum products to individually owned businesses. Hydrocarbons are the principal substance managed by the Oil Companies. Within the TANK catchment, the Oil Companies own, operate and/or supply a number of service stations, truck stops and commercial refuelling facilities.

3.2 My evidence focuses on key matters relevant to these activities and in particular addresses temporary construction dewatering takes and stormwater discharges from industrial or trade premises.

3.3 Included at **Annexure 1** is a list of the Oil Companies' submissions and further submissions, as well as the s42A recommendations and my position in relation to the same. My evidence focuses on where I disagree with the recommendations of the s42A report.

3.4 For the avoidance of doubt, any reference I make in my evidence to the provisions of PPC9 is to the s42A version of provisions, unless I specifically refer to the notified provisions.

TEMPORARY CONSTRUCTION DEWATERING TAKES

Background

4.1 Dewatering can be required for a range of activities. For the Oil Companies it is most typically associated with the installation of underground fuel storage tanks, but it is also often required to facilitate the installation of underground pipelines and foundations, typically at terminals. As relevant to the assets of the Oil Companies in the TANK catchment, I focus here on the dewatering of groundwater associated with tank installation. That said, I note temporary dewatering activities are undertaken by

a range of other parties, including network utility providers who frequently dewater shallow excavations and trenches to enable their operations, maintenance, and upgrades.

4.2 Dewatering for underground fuel tank installation is typically required where groundwater is less than five to six metres below ground level and is essential to enable the safe and appropriate installation of underground fuel storage tanks in line with the relevant code of practice (HSNOCOP44). In particular, dewatering enables contractors to safely access the base of the tank pit to anchor tanks to beams to prevent them floating out of position. While dewatering may, in a technical sense, be considered a form of abstraction, it is the result of the interception of groundwater rather than any desire to take and or use that water. Significant measures are in fact taken to minimise the volume of water taken, including in most instances the sheet piling of the perimeter of a proposed tank pit to minimise lateral movement of water through the walls of the excavation.

4.3 Tank installs are infrequent activities, with tanks typically having a 20 to 25 year life cycle. The duration of dewatering takes is the time taken to excavate below the water table to complete the tank pit base preparation, install the tank, and backfill the excavation. This is approximately three to five days of typically continuous pumping but contingency is generally sought for at least 10 days to allow for variation in local conditions and unforeseen circumstances, for instance if works are stopped during unpredicted bad weather or during technical malfunctions. Rates of take are estimated by the rate of pumping and can be up to 40 litres per second during the initial drawdown phase, decreasing to 0-20 litres per second within 24 hours to maintain the lowered water level, but are typically lower due to limited permeability in the base of tank pits. Until an excavation is undertaken and pumping commences, it is not possible to accurately predict rates and therefore volumes required.

4.4 Treated dewatering water is typically discharged to the reticulated stormwater network where available at a particular site. However in some circumstances discharges may occur either to ground (typically via soakpits), to the reticulated wastewater network (typically where higher levels of contamination are expected), tankered off site to an appropriately authorised facility or, in unusual circumstances, discharged to surface water. The method and location of the discharge is relevant to the determination of whether such takes are non-consumptive. I have attached at

Annexure 2 a copy of the Z Energy Dewatering Management Procedure to provide an example of how the industry approaches such operations.

4.5 Given the crucial nature of these temporary construction dewatering activities, the Oil Companies' submission sought amendments to the notified provisions to provide for groundwater takes for construction dewatering, including amendments to relevant rules and policies with a particular focus on seeking to avoid a potential prohibited activity status for takes in over allocated catchments.

Implications of s42A Recommendations

4.6 Rule TANK 8 (permitted activity rule) addresses groundwater takes in the TANK catchments. As proposed by the Reporting Planner, this rule will not provide a permitted activity pathway for typical temporary construction dewatering takes undertaken by the Oil Companies due to the standards addressing volume (five cubic metres, increasing to 20 cubic metres if non-consumptive) and rate of take (10 litres per second) being significantly below those typically required to facilitate tank installations (as addressed above). Consequently, these takes would cascade to Rule TANK 11 which provides for groundwater takes as a discretionary activity. If such takes are required in a fully allocated catchment, compliance with Rule TANK 11 would only be achieved if the water takes were non-consumptive. This interpretation of non-consumptive is therefore important to the application of the rule.

4.7 A definition of non-consumptive is not proposed by the Reporting Planner, however a related definition of consumptive water use is proposed, as follows:

Consumptive water use *means any use of fresh water that alters the flows and or levels in a water body on either a temporary or permanent basis, but excludes any non-consumptive use where:*

a) the same amount of water is returned to the same water body at or near the location from which it was taken; and
b) there is no significant delay between the taking and returning of the water.

For the purposes of allocation limits and specified rationing provisions in the rules, the term 'consumptive use' does not apply to water used in hydro-electric power generation or water use or diversions which substantially return the water used to the same water body.

4.8 This definition establishes that consumptive water use alters the flows or levels in a water body, on either a temporary or permanent basis. Exclusions are provided for takes that return the same amount of water to the same water body at or near the location from which it was taken, and where there is no significant delay between the take and the return. I consider that a temporary construction dewatering take which is subsequently discharged to reticulated networks or tankered off site may not be considered to be returned to the same water body at or near the location from which it was taken, and therefore may not be considered non-consumptive.

4.9 In such an instance, if the take is from an over-allocated catchment, it would be prohibited activity under TANK 12. While it might be perceived that this issue could be avoided by discharging dewatering water to ground soakage for instance, this is often not feasible for a range of reasons, including volumes of water, soil conditions, and the physical constraints of typical retail petroleum industry sites.

4.10 There is widespread recognition of the limited potential for adverse effects associated with temporary dewatering takes, which is reflected through how such activities are considered under various regional plans throughout the country. I have included at **Annexure 3** specific dewatering rules from the Northland, Auckland, Bay of Plenty, and Canterbury regional plans. Each regional plan takes a different approach to dewatering but all provide permitted activity pathways, with limits on volume only provided in defined areas of Northland (specific coastal aquifers where the dewatering is within 200m of mean high water springs).

4.11 In my opinion, it is important to provide for temporary construction dewatering takes given their limited potential for adverse effects and also to avoid unintended outcomes, for instance the retention of aging infrastructure due to difficulties facilitating activities necessary to replace the same. To set a prohibited activity status I consider it is important to be clear that there is no potential to inadvertently prohibit a range of activities with little to no potential adverse effects. The temporary dewatering of excavations to facilitate installation of underground of tanks that I have addressed is one such activity.

Relief Sought

4.12 In order to ensure that temporary construction dewatering is appropriately provided for, I consider that the definition of non-consumptive should be amended as follows (amendments shaded in grey):

Consumptive water use *means any use of fresh water that alters the flows and or levels in a water body on either a temporary or permanent basis, but excludes any non-consumptive use where:*

a) the same amount of water is returned to the same water body at or near the location from which it was taken; and

b) there is no significant delay between the taking and returning of the water.

For the purposes of allocation limits and specified rationing provisions in the rules, the term 'consumptive use' does not apply to:

- *water used in hydro-electric power generation; ~~or~~*
- *water use or diversions which substantially return the water used to the same water body;*
- *Groundwater takes for temporary construction dewatering, including where dewatering water is discharged to reticulated networks.*

4.13 I would not oppose an alteration to the above definition to clarify that the temporary construction dewatering shall be undertaken over a period that does not exceed 10 working days (noting that this is the usually sought for contingency to facilitate temporary construction dewatering for tank installations, as discussed in paragraph 4.3). However, imposing such a limitation may restrict other dewatering activities undertaken by other parties with similarly limited potential for adverse effects and which are necessary for a range of activities.

4.14 I also consider amendments are required to Rule TANK 8. The s42A version of Rule TANK 8 includes standards which limit permitted takes to 20 cubic metres of water per day (refer to TANK 8(b)(v)) for non-consumptive use and aquifer testing. The basis upon which this limit of 20 cubic metres has been proposed is unclear to me. In addition, standard (c) requires that the rate of take shall not exceed 10 litres per second other than aquifer testing for which the rate of take is not restricted.

4.15 I do not consider that it is necessary to restrict temporary construction dewatering takes to a limit of 20 cubic metres per day and 10 litres per second. As I have set out in the preceding evidence, the potential for adverse effects resulting from temporary construction dewatering activities is limited. In my opinion, such limitations on the rate and volume of these takes will unduly restrict a range of activities, potentially resulting in underlying long-term infrastructure issues. To address this, I consider that it is appropriate to provide specifically for temporary construction dewatering takes as a permitted activity. This could be achieved as follows (amendments shaded in grey):

Rule: TANK 8 – Groundwater Take

Activity: The take and use of groundwater in the TANK Water Management Zones including under Section14(3)(b) of the RMA.

Status: Permitted activity

Conditions/Standards/Terms

a) Any take first commencing after 2 May 2020 is not from the Poukawa Water Quantity Area ~~Freshwater Management Unit (quantity)~~

b) There is only one point of take per property and the take does not exceed 5 cubic metres per day except;

(i) Takes existing as at 2 May 2020 ~~may continue to take up to 20 cubic metres per property per day and to meet the reasonable needs of animals for drinking water~~

(ii) Takes to meet reasonable individual domestic needs

(iii) Takes for stock drinking water needs

(iv) Groundwater takes for temporary construction dewatering activities

(v) Takes occurring for a period of less than 28 days within any 90 day period, the total volume taken on any property shall not exceed 200 cubic metre per 7 day period.

(vi) The taking of water for non-consumptive uses including aquifer testing is ~~not restricted~~ limited to 20 cubic metres per day

(vii) The rate of take shall not exceed 10 l/s other than for aquifer testing for which the rate of take is not restricted.

(viii) The take shall not prevent from taking water, any other lawfully established efficient groundwater take, or any lawfully established surface water take, which existed prior to commencement of the take.

(ix) The take shall not cause changes to the flows or levels of water in any connected wetland.

(x) Backflow of water or contaminants into the bore shall be prevented.

4.16 I would not be opposed to my proposed clause (iv) being limited to 40 litres per second and 10 consecutive days, which would provide for typical dewatering undertaken by the Oil Companies. However, this limitation may restrict other dewatering activities undertaken by other parties with limited potential for adverse effects.

4.17 If dewatering takes do not comply with Rule TANK 8, then they fall to Rule TANK 11. Subject to an amendment to clarify temporary construction dewatering takes are non-consumptive and not 'consumptive water use' as defined, I support the s42A version of Rule TANK 11, which provides a discretionary activity pathway for such takes.

4.18 I consider a consequential amendment is required to related policies to align with TANK 8 and TANK 11. In my opinion, this would be most appropriately achieved by broadening POL TANK 53 to frost protection and non-consumptive takes given the similarities in terms of effects. In this regard, I consider that POL TANK 53 could be amended as follows (amendments shaded grey):

Frost Protection and non-consumptive use
POL TANK 53
When considering applications to take water for frost protection and non-consumptive use, the Council will avoid, remedy or mitigate actual and potential effects of the take on its own or in combination with other water takes;

a) from groundwater in the Heretaunga Plains Groundwater Quantity Area ~~Water Management Unit~~ on;
   (i) neighbouring bores and existing water users;.
   (ii) connected surface water bodies;
   (iii) water quality as a result of any associated application of the water onto the ground where it might enter water;

b) from surface water on;
   (i) instantaneous flow in the surface water body;
   (ii) fish spawning and existing water users;
   (iii) applicable minimum flows during November to April;

(iv) water quality as a result of any associated application of the water onto the ground where it might enter water;

By;

c) <u>requiring applicants to demonstrate non-water reliant alternatives have been investigated and provide evidence as to why they are not appropriate;</u>

d) taking into account any stream depletion effects of groundwater takes;

e) imposing limits in relation to minimum flows or groundwater levels;

f) requiring water metering, monitoring and reporting use of water for frost protection.

4.19 Notwithstanding that parties may not have anticipated changes to this effect to POL TANK 51 in particular, I consider this proposed change, which is to better align rules pertaining to non-consumptive takes with POL TANK 53, is within scope of both PPC9 and submissions.

Metering

5.1 The Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 (***The Regulations***) do not require the metering of permitted or non-consumptive[1] takes. If the changes that I seek to Rule TANK 8 are accepted, temporary construction dewatering takes would be permitted and therefore not required to be metered under the Regulations or the Plan. If the changes sought to Rule TANK 8 are not accepted and a permitted pathway is not enabled for these takes, I consider that an amendment to POL TANK 45 to exempt temporary construction dewatering activities from metering requirements would be appropriate. My view reflects that these takes are infrequent, temporary, and short term, with very limited potential effects on water allocation and therefore appropriately estimated based on pumping rates. I consider this to be particularly important for dewatering, as accurate metering is not practicable when a pipe is not full – which is often the

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1

<u>The Resource Management (Measurement and Reporting of Water Takes) Regulations 2010</u>
Regulation 4:

……

2) However, these regulations do not apply to a water permit if the taking of water under the permit is non-consumptive in that—

(a) the same amount of water is returned to the same water body at or near the location from which it was taken; and

(b) there is no significant delay between the taking and returning of the water.

case when dewatering. In my experience, processing officers dealing with these takes recognise typically adopt a pragmatic approach. The amendments I seek to POL TANK 45 (below) would support that approach.

Relief Sought

5.2 Amend POL TANK 45 as follows (amendments shaded grey):

General Water Allocation ~~Policies~~

When assessing applications to take water the Council will;

a) provide that the taking and use ~~abstraction~~ of water that has been taken and impounded or stored at times of high flow ~~and stored~~ and released for subsequent use, is not subject to allocation limits;

b) require water meters to be installed for all water takes authorised by a water permit and water use to be recorded and reported via telemetry provided that telemetry will not normally be required for non-consumptive uses or where the consented rate of take is less than 5l/sec ~~or where there are technical limitations to its installation~~;

c) ensure water allocation from tributaries is accounted for within the total allocation limit for the relevant zone and that the total abstraction from any tributary does not exceed 30% of the MALF for that tributary unless otherwise specified in Schedule 31;

d) offset the stream depletion effects of any groundwater takes in Zone 1, that were not previously considered stream depleting, by managing them as if they were in the Heretaunga Plains Groundwater Quantity Area ~~Water Management Unit~~; and

(i) require contributions to an applicable lowland stream enhancement programme at a rate equivalent to the stream depletion effect consistent with ~~Policy~~ POL TANK 39;

or

(ii) require the water take to cease when the minimum flow for the affected river is reached if a permit holder does not contribute under clause (i) where there is an applicable lowland stream enhancement; and

(iii) allow further technical assessments to determine the extent of stream depletion effect.

STORMWATER DISCHARGES FROM INDUSTRIAL OR TRADE PREMISES

6.1 To be a permitted activity under Rule TANK 19, a discharge must originate from an activity with less than 1,000m^2 impervious area, and it must not be from a site used for the storage or transfer of hazardous substances. The impervious area threshold would preclude typical refuelling facilities, while the exclusion of the storage or transfer of hazardous substances would exclude any other refuelling facilities, including MfE Guideline compliant discharges where runoff from areas where hazardous substances are stored and used is passed through an oil-water separator prior to release.

6.2 The Oil Companies sought a permitted pathway under this rule for MfE Guideline compliant stormwater discharges from petroleum industry sites. The Reporting Planner has rejected this submission on the basis that such discharges can be appropriately provided for as restricted discretionary activities, as follows:

I believe [restricted discretionary activity] is the appropriate activity status for sites that contain hazardous substances and services stations should be no exception for this rule. I do accept that we could insert a new matter of discretion for Rule TANK 20 being the compliance with relevant codes of practice and guidelines to ensure these factors are a consideration in the consent decision making process.[2]

6.3 I support the intent of the Reporting Planner's recommendation but do not consider that it is achieved by the changes proposed by the Reporting Planner to Rule TANK 20 or Rule TANK 22. In particular, Rule TANK 20 specifically excludes industrial or trade premises while Rule TANK 22 excludes discharges which contain hazardous substances.

[2] s42A Hearing Report, paragraph 2181.

6.4 As service stations, truck stops, and commercial refuelling facilities would fall under the RMA definition of an industrial or trade premise[3] and despite good practice will always contain some hazardous substances (as will runoff from impervious surfaces generally), stormwater discharges from these sites would default to discretionary activity status under Rule TANK 23, despite the apparent intention of the Reporting Planner.

6.5 To provide an appropriate pathway and better achieve what I understand to be the intent of the Reporting Planner, I consider that Rule TANK 22 should be amended to remove the absolute exclusion of hazardous substances, at least in relation to MfE Guideline compliant sites, and should apply irrespective of the impervious area, noting that otherwise sites with less than 1,000m^2 will continue to fall to be discretionary activities. I also note the Reporting Planner supports the Oil Companies' submission that identified the correct terminology of industrial or trade premise as per the RMA definition[4], however the title of Rule TANK 22 refers to an industrial and trade premises. In addition, I consider it would be appropriate to refer to an *available* reticulated network in clause (e) to reflect that while there may be a reticulated network at a property boundary, it may not be available to a particular party for a range of reasons, for instance distance on larger lots or unwillingness of a network operator to accept a particular discharge. I do not consider it reasonable or appropriate that this scenario causes a particular discharge to fall to be discretionary. This amendment would also align with POL TANK 28(c), which specifically refers to stormwater discharges to *available* networks. To address these matters, I consider that Rule TANK 22 could be amended as follows (amendments shaded in grey):

Rule: TANK 22 Stormwater discharge from industrial or~~and~~ trade premises
Activity: Discharge of stormwater to water or onto land where it may enter water from any industrial or trade premises ~~with 1,000 m^2 or more of impervious areas~~
Status: Restricted discretionary activity
Conditions/Standards/Terms

[3] **industrial or trade premises** means—
(a) any premises used for any industrial or trade purposes; or
(b) any premises used for the storage, transfer, treatment, or disposal of waste materials or for other waste-management purposes, or used for composting organic materials; or
(c) any other premises from which a contaminant is discharged in connection with any industrial or trade process;—
but does not include any production land

[4] s42A Hearing Report, paragraph 2115.

a) An application for resource consent must include a~~n Urban Site Specific~~ Stormwater Management Plan (Schedule 34)

b) The diversion and discharge;

(i) shall not cause permanent bed scouring or bank erosion of land or alter the natural course of any water body

(ii) shall not cause or contribute to flooding of any property,

(iii) shall not cause any permanent reduction in the ability of the receiving environment to convey flood flows

(iv) shall not contain hazardous substances except oil and grease, and the stormwater is passed than an oil interceptor system prior to discharge.

c) The diversion and discharge shall not cause any of the following to occur after reasonable mixing:

(i) production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials

(ii) any emission of objectionable odour

(iii) any conspicuous change in colour or the visual clarity

(iv) result in any freshwater becoming unsuitable for consumption by farm animals

d) the diversion and discharge shall not cause to occur or contribute to:

(v) the destruction or degradation of any habitat, mahinga kai, plan or animal in any water body or coastal water

(vi) the discharge of microbiological contaminants, including sewage, blackwater, greywater or animal effluent.

e) There is no available reticulated stormwater network at the property boundary

f) Any structure associated with the point of discharge or diversion is maintained in a condition such that it is clear of debris, does not obstruct fish

6.6 In my opinion it is appropriate that discharges not complying with Rule TANK 22 default to discretionary activity status under Rule TANK 23. I support this approach and consider that it is appropriate for non-compliant MfE stormwater discharges to be considered as discretionary activities.

6.7 The Oil Companies' submission sought amendments to POL TANK 28 to specifically reference industry guidelines and best practice. The Reporting Planner does not support this amendment, on the basis that these matters are provided for under POL

TANK 29 which addresses source control[5]. I consider that POL TANK 28 (Stormwater Infrastructure) is the key provision relating to mitigating the adverse effects of stormwater discharges from industrial or trade premises, and that it should include specific reference to alignment with relevant industry guidelines and best practice standards. This approach would be consistent with the matters of discretion in Rule TANK 22, for discharges from industrial or trade premises and would help promote use of recognised industry guidelines and good practice, like the MfE Guidelines, and help give effect to the overarching of PPC9. To achieve this, I consider that POL TANK 28 could be amended so that an additional clause is added to specify *alignment with relevant industry guidelines and best practice standards*.

6.8 Finally, I note that Rule TANK 21, which purports to provide for stormwater diversion and discharges from local authority networks as a controlled activity, precludes any discharges containing hazardous substances. I consider this exclusion will effectively preclude most (if not all) network discharges from complying with this rule as these discharges will invariably contain some level of detectable hazardous substance. If consents are granted for network discharges under this rule, network operators might be reluctant to accept discharges from a range of activities, including those with existing lawful connections. Applying this zero-tolerance threshold to hazardous substances is not effects based, does not align with consents typically granted for network discharges, and will not promote sustainable management. For instance, it may lead to a range of existing activities, including those of limited risk, requiring discharge permits, despite an available network. For these reasons, I consider Rule TANK 21 as drafted should be deleted as it will not provide appropriately for network discharges which will fall to be considered discretionary activities under Rule TANK 23 in any event.

[5] s42A Report, paragraph 2115.

CONCLUSIONS

7.1 As relevant to the Oil Companies' submissions, I am generally supportive of the Reporting Planner's recommendations, except as highlighted in this evidence. I have focused in particular on how the provisions address key activities to the Oil Companies, namely temporary construction dewatering activities and stormwater discharges. To address these matters appropriately, I consider a number of changes to specific wording are appropriate, as set out above.

Philip Brown
7 May 2021

Annexure 1 – Recommendations in response to the Oil Companies' submissions and further submissions

ANNEXURE 1 –HAWKE'S BAY REGIONAL PLAN CHANGE 9 – RECOMMENDATIONS IN RESPONSE TO THE OIL COMPANIES' SUBMISSIONS AND FURTHER SUBMISSIONS

Submission/ Further Submission	**Submission (amendments sought through the Oil Companies submission are shown in underline or strikethrough)**	**Recommendation of Reporting Planner (amendments proposed through S42A report shown in underline or strikethrough)**	**Comment**
203.1	Retain OBJ TANK 1 as notified.	Amendments to OBJ TANK 1 to clarify specific matters.	Accept the recommendation.
203.2	Retain OBJ TANK 4 as notified.	Amendments to OBJ TANK 4 to clarify specific matters.	Accept the recommendation.
203.4	Amend OBJ TANK 9 as follows: *Activities in source protection areas for Registered Drinking Water Supplies are managed to ensure that they do not cause source water in these zones to become unsuitable for human consumption, and that risks to the supply of safe drinking water are appropriately managed.*	Accept, and amend OBJ TANK 9 as follows: *Activities in source protection areas for Registered Drinking Water Supplies are managed to ensure that they do not cause source water in these zones to become unsuitable for human consumption, and that risks to the supply of safe drinking water are appropriately managed.*	Accept the recommendation.
203.5	Retain OBJ TANK 10 to 15 (Catchment Objectives) as notified.	Amendments to OBJ TANK 10, 14 and 15 to clarify specific matters.	Accept the recommendation.
203.6	Retain OBJ TANK 16 to 18 (Water Quantity Objectives) as notified.	Amendments to OBJ TANK 16 to 18 to clarify specific matters.	Accept the recommendation.
Further submission on original submissions 63.5 and 207.5	Support the proposed intent of introducing a new policy (referred to as Policy 37A) to guide situations where the granting of new takes will be considered, provided that it also provides for temporary construction dewatering.	Reject Submissions 63.5 and 207.5, as they do not provide clarity or consistency.	Accept the recommendation.
203.7	Retain POL TANK 1, 2 and 5 (Priority Management Approach), as notified.	Amendments to POL TANK 1, 2, 3 to clarify specific matters.	Accept the recommendation.
203.8	Retain POL TANK 6 (Protection of Source Water in the Heretaunga Plains) as notified.	Amendments to POL TANK 6 to clarify specific matters.	Accept the recommendation.
203.9	Amend POL TANK 7(d)(iii) as follows: *When considering applications to take water for a Registered Drinking Water Supply, the Council will:*	Accept, and amend POL TANK 7 as follows: *When considering applications to take water for a Registered Drinking Water Supply, the Council will:*	Accept the recommendation.

	……. *d) have regard to:* *…* *iii. the level of consultation with land owners <u>and occupiers</u> in the Source Protection Zone.*	*…….* *d) have regard to:* *…* *the level of consultation with land owners <u>and occupiers</u> in the Source Protection Zone.*	
203.10	Amend POL TANK 8(b)(vi) as follows: *The Council will, when considering applications to discharge contaminants or carry out land or water use activities within:* *……* *b) A Source Protection Zone, avoid or mitigate risk of contamination from the activity of the source water for the water supply by taking into account criteria including but not limited to:* *…….* *vi. the effectiveness of any mitigation measures to avoid or mitigate risk of contaminants entering the source water and the extent to which the effectiveness of the mitigation measure can be verified <u>including with regard to relevant codes of practice and guidelines</u>;*	Accept, and amend POL TANK 8 as follows: *The Council will, when considering applications to discharge contaminants or carry out land or water use activities within:* *……* *b) A Source Protection Zone, avoid or mitigate risk of contamination from the activity of the source water for the water supply by taking into account criteria including but not limited to:* *…….* *v. <u>any risks</u> ~~ensuring the water supplier is aware~~ of any abstraction of groundwater where abstraction has the potential to have more than a minor impact on flow direction or speed and/ or hydrostatic pressure* *vi. the effectiveness of any mitigation measures to avoid or mitigate risk of contaminants entering the source water and the extent to which the effectiveness of the mitigation measure can be verified <u>including with regard to relevant codes of practice and guidelines</u>;* *<u>viii. Outcomes of consultation with the Registered Drinking Water Supplier with respect to the risks to source water from the activity,</u>*	Accept the recommendation.

		including measures to minimise risks and protocols for notification to the Registered Drinking Water Supplier should an event presenting a risk to groundwater occur.	
203.11	Amend POL TANK 9 by removing clause (g) as follows: *The Council will work with the agencies which have roles and responsibilities for the provision of safe drinking water, including Napier City Council, Hastings District Council, Hawkes Bay District Health Board and Drinking Water Assessors and through multi-agency collaboration to:* ~~……~~ ~~g) *implement a multi-barrier approach to the delivery of safe drinking water for Registered Drinking Water Supplies, through the consideration of source protection measures, and water treatment and supply standards.*~~	Accept, and amend POL TANK 9 as follows: *The Council will work with the agencies which have roles and responsibilities for the provision of safe drinking water, including local government agencies, the national regulator, health agencies and registered water suppliers ~~Napier City Council, Hastings District Council, Hawkes Bay District Health Board and Drinking Water Assessors and~~ through multi-agency collaboration to:* ~~……~~ ~~*implement a multi-barrier approach to the delivery of safe drinking water for Registered Drinking Water Supplies, through the consideration of source protection measures, and water treatment and supply standards.*~~	Accept the recommendation.
203.12	Amend POL TANK 10(b) as follows: *The Council will manage point source discharges (that are not stormwater discharges) so that after reasonable mixing, contaminants discharged either by themselves or in combination with other discharges do not cause the objectives for water quality in Schedule 26 to be exceeded and when considering applications to discharge contaminants will take into account:* *….* *b) the degree to which a discharge is of a temporary nature, or is associated with necessary maintenance, replacement or upgrading work.* *….*	Reject proposed amendment to POL TANK 10, and make amendments to the policy (resulting from other submissions).	Accept the recommendation.
203.13	Amend POL TANK 28 as follows:	Reject reference to suitable mitigation and source control in POL TANK 28, but accept the amendment regarding 'trade or industrial activity' as per the RMA definition. Other	Evidence.

	The adverse effects of stormwater quality and quantity on aquatic ecosystems and community well-being arising from existing and new urban development (including infill development) industrial and trade premises and associated infrastructure, will be reduced or mitigated no later than 1 January 2025, by: *…..* *g) adopting, where practicable, a good practice approach to stormwater management including adoption of Low Impact Design for stormwater systems and <u>suitable mitigation where hazardous substances are stored and used</u>;* *…..* *j) encouraging, through education and public awareness programmes, greater uptake and installation of measures that reduce risk of stormwater contamination, <u>including source control</u>;* *k) requiring, no later than 1 January 2025, the preparation and implementation of a site management plan and good site management practices on industrial ~~and~~ or trade premises with a high risk of stormwater contamination and those in the high priority areas……*	amendments made, resulting from other submission points from other submitters. As follows: *The adverse effects of stormwater quality and quantity on aquatic ecosystems and community well-being arising from existing and new urban development (including infill development) industrial and trade premises and associated infrastructure, will be reduced or mitigated no later than 1 January 2025, by:* *…..* *g) adopting, ~~where practicable,~~ a good practice approach to stormwater management including adoption of Low Impact Design for stormwater systems;* *…..* *j) encouraging, through education and public awareness programmes, greater uptake and installation of measures that reduce risk of stormwater contamination;* *k) requiring, no later than 1 January 2025, the preparation and implementation of a site management plan and good site management practices on industrial ~~and~~ or trade premises with a high risk of stormwater contamination <u>in the TANK catchments</u> and those in the high priority areas……*	
203.14	Amend POL TANK 29 by adding in a clause (d) to recognise the important role of reducing contaminants through source control, as follows: *Sources of stormwater contamination and contaminated stormwater will be reduced by:* *…* *d) <u>Council working with the agencies which have roles and responsibility for the management of stormwater and through multi-agency collaboration to lobby central government</u>*	Reject, and amend POL TANK 29 as follows: *Sources of stormwater contamination and contaminated stormwater will be reduced by:* *(a) specifying requirements for the design and installation of stormwater control facilities on sites where there is a high risk of freshwater contamination arising from either the direct discharge of stormwater to freshwater, the discharge of stormwater to land where it might enter*	Accept the recommendation.

	seeking national measures and industry standards to reduce the discharge of contaminants in stormwater, including zinc and copper from metal roofs, car tyres and brake linings.	*water or the discharge to a stormwater or drainage network;* *(b) requiring the implementation of good site management practices on all sites where there is a risk of stormwater contamination arising from the use, or storage of contaminants including the management of solid contaminants and debris to avoid these entering stormwater;* *(c) controlling, and if necessary avoiding, activities that will result in water quality standards not being able to be met.*	
203.15	Amend POL TANK 30 as follows: *Aquatic ecosystem health improvements and community wellbeing and reduced stormwater contamination will be achieved by HBRC working with the Napier City and Hastings District Councils requiring discharges from stormwater networks to meet (after reasonable mixing).....*	Accept in part, and amend POL TANK 30 as follows: *Aquatic ecosystem health improvements and community wellbeing and reduced stormwater contamination will be achieved by HBRC working with the Napier City and Hastings District Councils requiring discharges from stormwater networks to meet:* *.....* *(b) for attributes not accounted for in Schedule 26, the ANZECC Guidelines 2018 will be used to achieve, after reasonable mixing:* *i. the 80th percentile level of species protection in receiving waters by 1 January 2025; and* *ii. the 95th percentile level of species protection by 31 December 2040.*	Accept the recommendation.
203.16	Retain POL TANK 31, as notified.	Amendments to POL TANK 31 to clarify specific matters.	Accept the recommendation.
203.17	Amend POL TANK 36 as follows: *The Council recognises the actual and potential adverse effects of groundwater abstraction in the Heretaunga Plains Water Management Unit on:* *….* *and will adopt a staged approach to groundwater management that includes;*	Accept the proposed amendment, and amend POL TANK 36 as follows: *The Council recognises the actual and potential adverse effects of groundwater abstraction in the Heretaunga Plains ~~Water Management Unit~~ Groundwater Quantity Area on:* *….*	Accept the recommendation.

	f) avoiding further adverse effects by not ~~allowing~~ granting water permits for new water use; *…….*	*and will adopt a staged approach to groundwater management that includes;* *f) avoiding further adverse effects by not ~~allowing~~ granting new consents to take and use groundwater ~~new water use~~;* *…….*	
203.18	Support POL TANK 37 (Managing the allocation and use of groundwater in the Heretaunga Plains Water Management Unit), provided that it supports permitted activity provisions with low potential for adverse effects.	Amendments to POL TANK 37 to clarify matters.	Accept the recommendation.
203.19	Support POL TANK 45 (Groundwater Allocation Policy), provided that there is a permitted activity pathway for temporary construction dewatering takes to avoid a technical requirement for water metering which is not practicable given the nature of these takes.	Amendments to POL TANK 45 to clarify matters.	Evidence.
203.20	Support POL TANK 52 (Over-Allocation Policy), provided that there is a permitted activity pathway for temporary construction dewatering takes to avoid a technical requirement for water metering which is not practicable given the nature of these takes.	Reject the submission point and amend POL TANK 52 to clarify maters.	Accept the recommendation.
203.21	Amend POL TANK 53 so that it also applies to temporary construction dewatering, as follows: *Frost protection and temporary construction dewatering* *When considering applications to take water for frost protection or temporary construction dewatering, the Council will avoid, remedy or mitigate actual and potential effects of the take on its own or in combination with other water takes; ...*	Reject the submission point, and amend POL TANK 53 to clarify other matters.	Evidence.
203.22	Amend Rule TANK 8 to provide a permitted activity pathway for temporary construction dewatering activities, as follows: *Activity – The take and use of groundwater in the TANK Water Management Zones including under Section14(3)(b) of the RMA* *Status – Permitted*	Amend Rule TANK 8 as follows: *Activity – The take and use of groundwater in the TANK Water Management Zones including under Section14(3)(b) of the RMA* *Status – Permitted*	Evidence.

	Conditions/Standards/Terms *…….* *b) There is only one point of take per property and the take does not exceed 5 cubic metres per day except;...* *….* *iii. The taking of water for aquifer testing <u>and construction dewatering for up to 10 consecutive days</u> is not restricted* *c) The rate of take shall not exceed 10 l/s other than <u>for temporary construction dewatering which shall not exceed 40 l/s</u> and aquifer testing for which the rate of take is not restricted.*	*Conditions/Standards/Terms* *…….* *b) There is only one point of take per property and the take does not exceed 5 cubic metres per day except;* *i. Takes existing as at 2 May 2020 ~~may continue to take up to 20 cubic metres per property per day and to meet the reasonable needs of animals for drinking water.~~* *ii. <u>Takes to meet reasonable individual domestic needs.</u>* *iii. <u>Takes for stock drinking water needs.</u>* *iv. Takes occurring for a period of less than 28 days within any 90 day period, the total volume taken on any property shall not exceed 200 cubic metre per 7 day period.* *v. The taking of water for <u>non-consumptive uses including</u> aquifer testing is not restricted <u>limited to 20 cubic metres per day</u>.* *…….*	
203.23	Amend Rule TANK 11 as follows: *Activity - The take and use of surface (low flow allocations) or groundwater* *Status – Discretionary* *Conditions/Standards/Terms* *a) The activity does not comply with the conditions of Rules <u>TANK 8</u>, TANK 9 or TANK 10.* *b) Either*	Amend Rule TANK 11 as follows: *Activity - The take and use of surface (low flow allocations) or groundwater* *Status – Discretionary* *Conditions/Standards/Terms* *a) The activity does not comply with the conditions of Rules <u>TANK 7, TANK 8</u>, TANK 9 or TANK 10 <u>where relevant</u>.*	Evidence.

	(i) The application is either for the continuation of a water take and use previously authorised in a permit that was issued before 2 May 2020 or is a joint or global application that replaces these existing water permits previously held separately or individually in the following Management Units; *i. Ahuriri* *ii. Poukawa* *iii. Ngaruroro groundwater* *iv. Tūtaekurī groundwater* *v. Heretaunga Plains* *or* *(ii) The total amount taken, either by itself or in combination with other authorised takes in the same water management unit does not cause the total allocation limit in the relevant management unit as specified in Schedule 31 to be exceeded except this clause does not apply to takes for:* *i. frost protection;* *ii. takes of water associated with and dependant on release of water from a water storage impoundment;* iii. *temporary construction dewatering.*	*b) Either* *(i) The application is either for the continuation of a water take and use previously authorised in a permit that was issued before 2 May 2020 or is a joint or global application that replaces these existing water permits previously held separately or individually ~~in the following Management Units;~~* *~~i. Ahuriri~~* *~~ii. Poukawa~~* *~~iii. Ngaruroro groundwater~~* *~~iv. Tūtaekurī groundwater~~* *~~v. Heretaunga Plains~~* *or* *(ii) The total amount taken, either by itself or in combination with other authorised takes in the same water quantity area ~~management unit~~ does not cause the total allocation limit in the relevant management unit as specified in Schedule 31 to be exceeded ~~except this clause does not apply to takes for~~:* *or* *(iii) The take is for:* *i. frost protection; or* *ii. takes of water ~~associated with and~~ from or dependant on release of water from a water storage impoundment, or managed aquifer recharge scheme; or* *iii. Water takes that are non-consumptive.*	
203.24	Amend Rule TANK 12 as follows: *Activity – The take and use of surface or groundwater* *Status – ~~Prohibited~~ Non-complying* *Conditions/Standards/Terms* *a) The activity does not comply with the conditions of Rule TANK 11* *No application may be made for this activity.*	Reject and retain Rule TANK 12 as notified.	Accept the recommendation.

203.25	Amend Rule TANK19 Small scale stormwater activities (permitted activity rule) as follows: *Activity - The diversion and discharge of stormwater into water, or onto land where it may enter water from any new or existing and lawfully established:* *……* *(c) industrial or trade premise with less than 1,000 m2 ~~of impervious areas~~ used for the storage, use or transfer of hazardous substances;* *OR* *(c) industrial or trade premise with an industrial or trade activity area of less than 1,000 m2 ~~of impervious areas~~;* *……* 1. A definition of ITA could also be adopted, similar to that in the Auckland Unitary Plan. 2. Alternatively, Council could differentiate the pathway for industrial or trade premises by preparation of a risk matrix for the range of industrial or trade activities, reflecting that MfE Guideline compliant sites are not high risk. 3. Amend standard a(iv) so that it does not exclude all hazardous substances and provides for activities that are appropriately regulated, for instance stormwater discharges from petroleum industry sites managed in accordance with the MfE Guidelines, at least for existing lawfully established activities.	Amend Rule TANK 19 as follows: *The diversion and discharge of stormwater into water, or onto land where it may enter water from any new or existing and lawfully established:* *(a) any activity with less than 1000 m^2 impervious area ~~residential activities;~~* *~~(b) non industrial or trade premise;~~* *~~(c) industrial or trade premise with less than 1,000 m2 of impervious areas;~~* *~~(d) rural building.~~*	Accept the recommendation.
203.26	Amend Rule TANK 20 Small scale stormwater activities (restricted discretionary activity rule) as follows: *Activity - The diversion and discharge of stormwater into water, or onto land where it may enter water from any new or existing and lawfully established:* *….*	Amend Rule TANK 20 as follows: *The diversion and discharge of stormwater into water, or onto land where it may enter water from any new or existing and lawfully established:* *(a) any activity with less than 1000 m^2 impervious area ~~residential activities;~~* *~~(b) non industrial or trade premise;~~*	Accept the recommendation.

	(c) industrial or trade premise with less than 1,000 m2 ~~of impervious areas~~ used for the storage, use or transfer of hazardous substances; *OR* *(c) industrial or trade premise with an industrial or trade activity area of less than 1,000 m2 ~~of impervious areas~~;* *……*	*~~(c) industrial or trade premise with less than 1,000 m2 of impervious areas;~~* *~~(d) rural building.~~* *……* *Restricted discretionary standards:* *(a) The activity does not comply with the conditions of Rule TANK19; and* *(b) the activity is not from an industrial or trade premise*	
203.27	Oppose Rule TANK 21, as PPC9 needs to recognise that stormwater network discharges will almost invariably contain hazardous substances and should be considered on that basis. *Activity - Diversion and discharge of stormwater from an existing or new local authority managed stormwater network into water, or onto land where it may enter water* *Status – Controlled*	Reject submission point, and amend Rule TANK 21 (in response to another submission).	Evidence.
203.28	Support Rule TANK 22, subject to provision of potential permitted and RDA pathways for MfE Guideline compliant discharges not meeting the provisions of TANK 19 and TANK 20. *Activity – Discharge of stormwater to water or onto land where it may enter water from any industrial or trade premises.* *Status – Restricted Discretionary*	Reject submission point, and amend Rule TANK 22 (in response to other submissions) as follows: *Activity – Discharge of stormwater to water or onto land where it may enter water from any industrial or trade premises with 1,000 m2 or more of impervious areas.* *Status – Restricted Discretionary*	Evidence.
203.29	Support Rule TANK 23 as notified. *Activity – The diversion and discharge of stormwater into water, or onto land where it may enter water.* *Status – Discretionary*	Retain Rule TANK 23 as notified.	Accept the recommendation.
203.30	**Schedule 26**: Freshwater Quality Objectives Retain as notified.	Amendments to address other submission points.	Accept the recommendation.
Not specified	**Schedule 27**: Freshwater Quality Objectives Retain as notified.	Amendments to address other submission points.	Accept the recommendation.
Not specified	**Schedule 31**: Flows, Levels and Allocation Limits Retain as notified.	Amendments to address other submission points.	Accept the recommendation.

Not specified	**Schedule 34:** Urban Site Specific Stormwater Management Plan Oppose, because PPC9 needs to recognise that stormwater network discharges will almost invariably contain hazardous substances and should be considered on that basis.	References to Schedule 34 now only refer to a Stormwater Management Plan and have removed the reference to 'urban site specific'.	Accept the recommendation.
203.31	**Schedule 35** – Source Protection for Drinking Water Supplies Retain as notified.	Amendments to address other submission points.	Accept the recommendation.
203.32	**Allocation limit for Groundwater** definition. Retain as notified.	Retain as notified.	Accept the recommendation.
203.33	**Registered Drinking Water Supply (or Supplies)** definition. Retain as notified.	Retain as notified.	Accept the recommendation.
203.34	**Source Protection Zone (SPZ)** definition. Retain as notified.	Retain as notified.	Accept the recommendation.
203.35	**Source Protection Extent** definition. Retain as notified.	Retain as notified.	Accept the recommendation.
Further submission on original submission 129.40	Support the proposed replacement of the definition of 'allocation limit', provided that it is supported by appropriate definitions to clarify what is non-consumptive.	Accept submission point 129.40 and amend the definition of allocation limit as follows: ***Allocation limit <u>for surface water</u>*** *means the maximum quantity that is able to be allocated in water permits and abstracted <u>for consumptive water use</u>, expressed in litres per second and calculated as the <u>average rate required to abstract the maximum weekly or 28 day volume allocated to each water permit and summed for all water permits in the applicable management unit</u> ~~sum of weekly maximum water permit allocations for a river, or management zone averaged over one month and includes abstraction in Zone 1.~~*	Accept the recommendation.
Further submission on original submission 129.42	Support the proposed insertion of a new definition for 'consumptive water use', provided that it also provides for groundwater takes associated with temporary construction dewatering activities.	Support submission 129.42, and propose a definition of consumptive water use as follows: ***<u>Consumptive water use</u>*** *<u>means any use of fresh water that alters the flows and or levels in a water body on either a temporary or permanent basis, but excludes any non-consumptive use where:</u>* *<u>a) the same amount of water is returned to the same water body at or near the location from which it was taken; and</u>* *<u>b) there is no significant delay between the taking and returning of the water.</u>*	Evidence.

		For the purposes of allocation limits and specified rationing provisions in the rules, the term 'consumptive use' does not apply to water used in hydro-electric power generation or water use or diversions which substantially return the water used to the same water body.	

Annexure 2 – Z Energy Dewatering Management Procedure

PROCEDURE

Dewatering Management Procedure

HS-ENV-PRO-001

ZORM

FINAL

Revision Summary

Version	Author	Reasons for Change	Approver	Date Approved
0.4	A Lukey / M Robertson	Final Document	M Robertson	25/07/13
0.5	M Robertson	Updated Title for ZORM		05/01/15
0.6	M Robertson	New procedure template		
0.7	Burton Consultants	Updated to reflect current practise and experience, and provide for the use of flocculants	M Robertson	10/10/16

Document classification	Unclassified
Document location	Controlled copies of this document are accessible in electronic form via the Z Energy server. All paper versions are uncontrolled documents.
Document authority	Deviation/variation from this procedure can only be done with the approval of General Manager - HSSE or delegated authority

1: Summary of Dewatering Process – Flow Chart

PRELIMINARY INVESTIGATION (this provides background to the process)

Tank pit area

Desk top assessment to establish geology, ground water level, recharge rate and likelihood of contamination.

Receiving Environment

Determine appropriate discharge method (eg: stormwater network, sewer, land (soak pit or sprinkler)) and capacity, and ultimate receiving environment
Determine sensitivity of receiving environment and capacity of both infrastructure and receiving environment

PROCESS

Stage 1
Sheet Piling of Tank Pit

Stage 2
Excavation of Tank Pit

Stage 3
Removal of Visible Hydrocarbons Within the Tank Pit
if necessary

Stage 4
Water Removal by Pump / Well Pointing
***and* TSS removal** to BPO standard
***and* if necessary Further Hydrocarbon Removal**

Stage 4
Discharge to S/W System, sewer, or land as appropriate

Treatment options can be added into sequence or taken out of sequence, observation dependant.

Monitoring

Visual observation – recorded in log sheet

Soil and Water Quality Testing by SQEP *(in accordance with MfE Guidelines)*

2: Purpose and scope

To be followed where dewatering Is required for Tank Installation (Including replacement), unless otherwise required by a specific Resource Consent for Dewatering (Water Take and Discharge or Diversion) or other relevant approval.

Robust dewatering practices will significantly reduce the volume of contaminants leaving a site, helping to protect downstream receiving environments from sedimentation and water quality degradation.

Dewatering is not required for tank removal activities because access is not required to the base of the tank pit.

3: Process Phase – Stage 1: Sheet Piling of Tank Pit

Stormwater diversion and sediment control measures shall be put in place around the tank pit to avoid the influx of potentially contaminated (sediment laden) stormwater. These measures shall be in place prior to the commencements of tank pit works.

Excavation for tank installation shall be carried out with the use of sheet piling to retain the walls of the tank pit, unless site conditions render this impracticable (eg: where rock in the form of basalt or boulders are encountered). If conditions encountered on site render sheet piling inappropriate, then the Council shall be advised, input of the Geotech Engineer shall be sought to ensure stability of unsupported faces and the SQEP shall reconsider the necessary dewatering treatment train.

An engineered sheet pile design shall be installed at a depth sufficient to ensure suitable 'toe' for the sheets. Typically tank pits are 4.5m to 5.5m deep, with sheet piling in the order of 6m deep.

A continuous interlocking wall of sheet piling will restrict water ingress within the tank pit excavation from a horizontal plane. This will mean that only vertical water ingress will need to be dealt with via dewatering, slowing the recharge rate.

4: Process Phase – Stage 2: Excavation of Tank Pit

Upon completion of sheet piling the tank pit excavation will commence. During this activity an excavator will be used to remove material from the area in which tanks are proposed to be installed. Some water will be removed along with the excavations and the trucks carrying wet soil to be disposed of off-site will be leak proof.

Where practicable existing tank pits are re-used to minimise volume of earthworks around the installation.

5: Process Phase – Stage 3: Removal of Visible Hydrocarbons Within the Pit (As Necessary)

During the removal of materials from the tank pit area any visibly hydrocarbon impacted soil that may be present around the tank will typically be removed. Any such soils will be disposed of at an approved landfill. The tank will be disposed of in accordance with HSNO Regulations.

If the water in the pit shows signs of hydrocarbon contamination, this will be treated to ensure that there is no more than 15mg/l of hydrocarbons in the water to be discharged from the site during the dewatering process. 15mg/l is the acceptable standard adopted in the Ministry for the Environment (*MfE*) Guidelines: *Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand*, MFE, 1998 (*MfE Guidelines*).

Compliance with the standard can be effectively ensured through observation. A visual approach ensures that water is not discharged that would cause sheen in the receiving environment (lab tests cannot do this and are slow). A visible sheen can start to form before the threshold of 15mg/l is reached. Benzene, toluene, ethylbenzene and xylenes (BTEX) concentrations in dewatering discharges at petroleum industry sites in New Zealand are not generally considered an issue for discharges to surface waters due to their high volatility. The fate of BTEX in surface waters is documented in the MfE guidelines and in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* document (*ANZECC 2000 guidelines*), and is the reason why only TPH discharge standards are specified in the MFE guidelines.

ANZEEC 2000 Guidelines, volume 2 page 187 states:

> *"the high volatility and relatively low water solubility of these chemicals indicates that they would be rapidly lost to atmosphere from a water body,… Biodegradation is also very rapid… Photo degradation is similarly rapid…"*

If present, this sheen shall be removed by undertaking a surface skim of any hydrocarbon that sits on top of the water (via a sucker truck). This shall be carried out by an authorised collection company and will remove the worst of the contamination.

At this stage water shall be discharged, unless further observations and/or tests indicate further treatment is required prior to discharge.

Further treatment of visible hydrocarbons through the dewatering process (if necessary)

Further treatment of visible hydrocarbons through the dewatering process may be required, for example if a site has a history of being heavily contaminated, or where the agitation of the soil allows some of the product trapped between soil pores to be washed into the tank pit where it coalesces and rises to the surface, allowing for removal. These will only be used should observations and/or test results indicate further treatment is necessary.

Supplementary treatment methods include:

- Use of absorbent socks, pillows and pads to absorb any contaminate observed at any stage during the dewatering process;

IF NECESSARY Absorbent Socks, Pillows and Pads

If high levels of hydrocarbon are observed at any stage of the excavation/dewatering process, additional surface skimming can also be undertaken.

- Surface skimming of the water in the pit periodically using a sucker truck as soil is excavated;
- Other approaches recommended by the SQEP.

6: Process Phase – Stage 4: Water Removal and Treatment

During this period of the works, water removed for discharge is treated for TSS and/or dissolved phase hydrocarbons if and as required.

There are two phases to dewatering. There is an initial drawdown and stabilisation period when higher rates may be pumped to remove the water in the pit. Typically this water contains elevated levels of sediment. The second phase is a maintenance period where the pumping is maintaining the drawdown in the pit. Water discharged during this stage is typically clearer with lower suspended sediment levels.

In all cases, the following methods shall be employed:

1. **Water and Primary Sediment Removal:** Use of either well-pointing or a submersible pump;
2. **Dissolved Phase Hydrocarbon Removal:** Where dissolved phase hydrocarbons are identified (odourous) water will be aerated prior to entering a settling tank;
3. **Secondary Sediment Removal:** Use of a baffled settling tank, sized to provide sufficient capacity appropriate to the treatment requirements;
4. **Tertiary Sediment Removal:** Where the level of TSS exceeds the standard, use of a further treatment device, such as a filter sock.

The treatment options in 2-4 are discussed below. They can be added into the sequence or omitted from the sequence, observation dependant.

Note that:

- Stormwater diversion and sediment control measures are established in the Stage 1 phase; and
- Visible hydrocarbons (if present at any time throughout the water removal and treatment phase) can be removed as indicated in the Stage 3 phase.

6.1 Water and Primary Sediment Removal

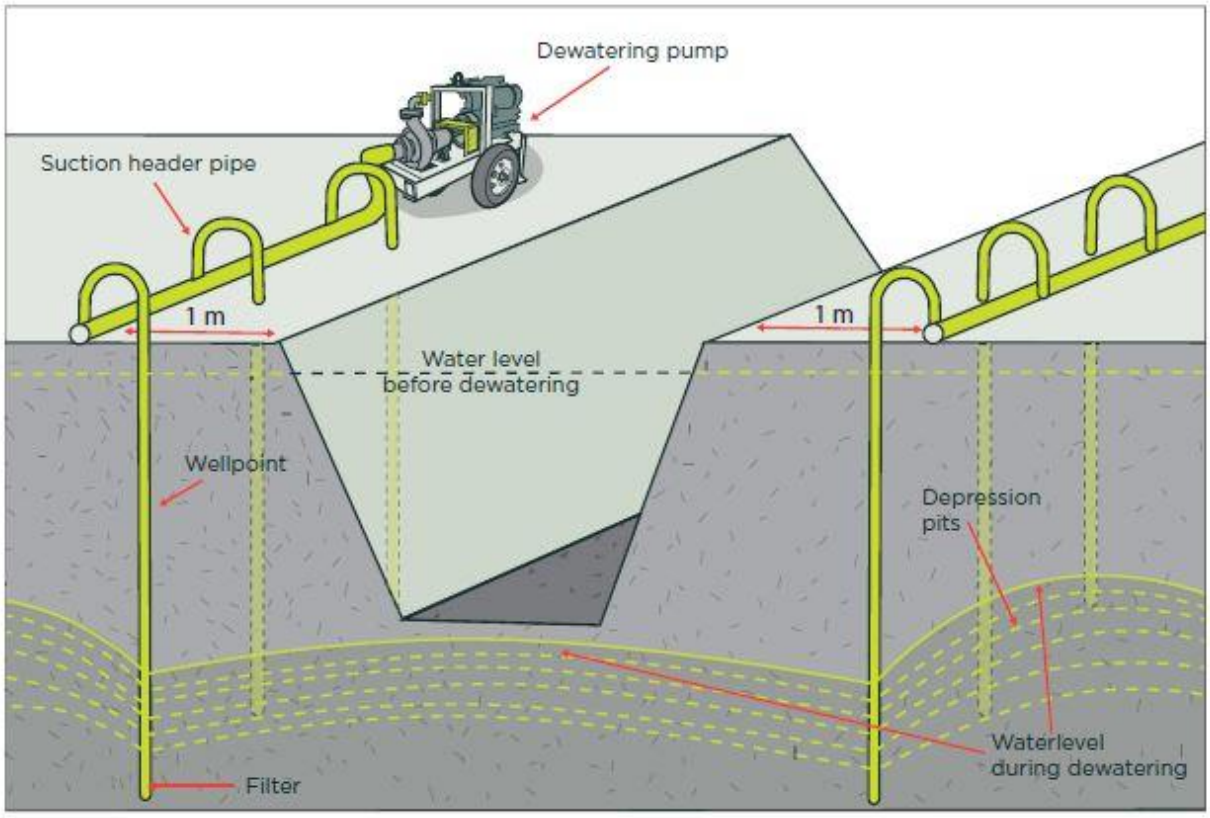
PUMPING is the primary method of TSS control, and is adapted to suit the conditions.

Pumping involves the use of the lowest point in the trench for the collection of water. The low point has a pump installed which removes groundwater that has seeped into the pit. A 'pump well' shall be formed by placing a coarse graded gravel filter around the submersible pump to minimise mobilisation of fines. The use of filters reduces undermining and produces cleaner discharge water by providing primary filtration of pit water.

Occasionally **WELL POINTING** is adopted, for example when there is a need to reduce the total water table around the pit. However this is not common practise even on sites where there is a high water table, as experience indicates that the major flows into the pit would be lateral and therefore stemmed by the sheet piling. If well pointing is adopted, then the contractor will be responsible for meeting any permitted activity conditions and/or obtaining any necessary regional consents for the spear/s.

Where well pointing is anticipated to be required, a soil investigation shall be undertaken before the works commence. This should include tests for soil contamination and soil strength (useful for the sheet piling design).

For **well pointing**, taking from below the water table (generally a minimum of 1.5m) will mean that the water being discharged is cleaner than that visible in the tank pit and encountered initially in the works. Accordingly, if well pointing is adopted, then the invert of the drawdown water level should typically be maintained just below the trench invert and above the spear intake at all times. This will restrict the pumping of sediment and/or solid forms of contaminant. The placement of spears may, however, be influenced by the soil structure. For example, it might be appropriate to drive spears to variable depths depending on the soil type layers).



The initial drawdown period of the water take should be timed to avoid wet weather if this will place flow capacity demands on the infrastructure receiving the discharge. If poor weather occurs during the balance of the dewatering works, the water take should continue (essentially to avoid another initial period of higher discharge rate directly after a significant rain event).

As noted above drawdown pumping will initially occur at a higher rate. In most circumstances this his may be up to 40 litres per second max, generally reducing to between 10 and 20 litres per second max in the maintenance phase to keep the water table at the required level. The pump rate is determined by the capacity of the pump, the capacity of system being discharged to, the recharge rate and the quality of the discharge (noting that the rate may need to be slowed to ensure effective treatment). If the discharge is to reticulated infrastructure, the infrastructure operator may have limited the rate of discharge, and this will need to be complied with. Further, for any pump rate adopted, the treatment train will need to be adequate to cope with the volume and rate of water.

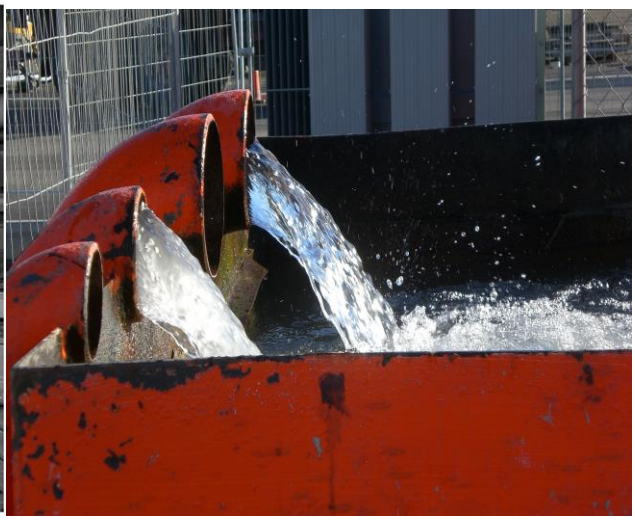
The water take will, as necessary, occur on a 24 hour basis. This minimises the quantity of discharge to which the BPO is applied.

De-watering will generally be required over a period of approximately 3-10 days, but flexibility may be required to address unforeseen circumstances, such as very high infiltration rates, tidal influx and/or machinery malfunction. If there is a need to exceed the 10 day period, then the relevant Council will need to be advised as early as practicable, and their approval may be required.

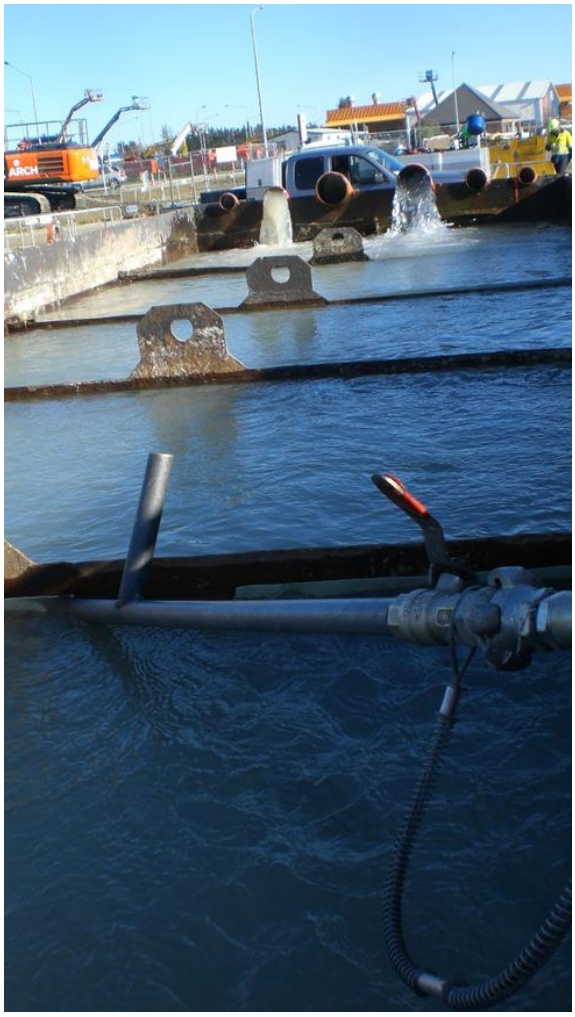
6.2 Dissolved Phase Hydrocarbon Removal Within the Treatment Train

Dissolved phase hydrocarbons may be present and are characterised by hydrocarbon odours when water is aerated.

Aeration introduces air into the discharge, facilitating volatilisation and aerobic breakdown. If treatment for BTEX is deemed necessary based on hydrocarbon odours, aeration shall be used to strip the volatile contaminants from the water. Aeration shall be via an aeration wand comprising a steel tube with drilled perforations connected to an air compressor and/or tray aerator. Tray aerators usually comprise a stack of four or five horizontal trays that have small holes at regular intervals (eg: bread trays) and provide a cascade for dewatering water. The required surface area of trays will be calculated based on the loading rate.



Aeration can also be included if a sheen is observed on water in the treatment train. Note that in the photo water discharging into the tank is being aerated while the baffles act as an interceptor so any sheen accumulates and becomes visible. If sheen is observed, the pump rates are dropped to enable the sheen to be addressed.



6.3 Secondary Sediment Removal

Secondary sediment removal will involve a boom and baffled settling tank temporarily located on site. The size of the tank will be dependent on the pumping rate (and vice versa) and the retention time that is required to allow sediment to settle.

Water will be discharged directly from the top of the tank, but generally below the water surface, which will assist in capturing sediment during the dewatering phase. Settled water should be observed for sheen while in the tank, because the settling tank also enables the pumped water to be aerated to help remove any dissolved contaminants. While there should be minimal, if any, visible hydrocarbons in the discharge at this stage, the boom and baffle in the settling tank will also allow sheen and hydrocarbon emulsions to collect in the corner of the tank, which can then be skimmed and disposed of off-site.

All hoses and pipework shall be securely fastened, for example, by using hoops, clamps and/or straps to the ground or other suitable solid structure to prevent hose/pipe slippage and loss of containment.

At this stage water shall be discharged *unless* observational monitoring of the discharge from the tanks identifies an inappropriate sediment level (see Section 9), in which case tertiary sediment removal will be adopted into the treatment train.

All captured wet sediment shall be removed from the site in a "wet truck".

6.4 Tertiary Sediment Removal

If further treatment of the water discharge is required, a further sediment removal stage shall be added. An appropriate capacity of tertiary sediment removal mechanism should be maintained.

An example of a tertiary sediment removal mechanism is a filtration sock fitted to the pipework discharging water from the settling tank.

A filtration sock removes course sediment and is more commonly used as an alternative to hay bales. Water discharging from the filtration sock is channelled, generally through a sandbag channel, along clean ground to the discharge point prior to discharge. The size of the sock will be determined by the quantity of water requiring treatment.

6.5 Use of Flocculants

In a small number of situations, carefully controlled dosing with a flocculent / agglomerating agent may be employed to reduce suspended sediment levels.

A review of the use of flocculants by Auckland Council (TP226)[1] concluded:

> *"The overall conclusion is that there appears to be a small risk to the natural aquatic environment arising from potential losses of unbound residual flocculants from treatment ponds on construction sites. Impacts are likely to be low level and also likely to not be significant in relation to other factors which govern the health of aquatic communities. The benefit of reduced sediment levels in discharges is considered to outweigh the risk of any low level impacts attributable to residual flocculants."*

Recognising that management focus should remain on best management practices, to ensure that the most appropriate product is used in a particular application and that water treatment chemicals are applied in accordance with product specifications to achieve the target dosage range, if dosing with a flocculent / agglomerating agent is proposed, a Chemical Treatment Management Plan (*CTMP*) shall be prepared by a SQEP and approved by the relevant Council prior to works commencing. The CTMP shall include the following as a minimum:

a) The MSDS sheet for the product to be used;

b) A summary of any previous trial work;

c) Details of optimum dosage (including assumptions) and the mechanisms to control dosing to ensure the correct application rates;

d) Monitoring, maintenance and contingency programme (including a record sheet); and

e) A spill contingency plan including the removal of chemicals from the site upon completion of the chemical treatment.

[1] *Ref: Auckland Regional Council TP226 "Overview of the Effects of Residual Flocculants on Aquatic Receiving Environments"*

6.6 Stormwater Diversion

Stormwater diversion techniques will be installed as required to minimise entry of stormwater via overland flows. Sometimes after heavy rain, stormwater will collect in the pit. Generally this is clean, and can be pumped out of the pit and discharged to stormwater.

7: TSS Discharge Standards

Relevant standards such as MfE Guidelines and relevant local standards need to be considered. The Ministry for the Environment's *Environmental Guidelines for Water Discharges from Petroleum Industry sites in NZ*, 1998, states that (refer Appendix C, Section 8.2):

> *In order to comply with the provisions of the RM Act and preserve receiving water quality, every site manage should endeavour to minimise releases of contaminants to the environment. The point of compliance is usually the point at which the discharger loses control of the effluent. Generally the maximum levels of contaminants allowable in stormwater systems which discharge into the environment or into reticulated district systems are:*
>
> *Total petroleum hydrocarbons = 15mg/litre) averaged over the*
> *Total suspended solids = 100 mg/litre) design storm event*
> - *unless other levels can be justified by either a site-specific or generic assessment of effects.*

The MfE Guidelines clearly relate to ongoing discharges from operating sites and strive to attain a high standard from a relatively low sediment load.

Dewatering, as an infrequent temporary construction activity of short duration, is atypical of site discharges from an operational service station, and may contain elevated sediment levels over the initial period of works (until stabilisation). Stabilisation occurs relatively quickly, generally within 24 hours, after which essentially clean water will be discharged from the pumps. Such scenarios are considered to be more appropriately addressed through a percentage reduction from the very high initial levels, and are best considered in relation to the best practicable option to achieve the necessary reductions over time. Once stabilisation has occurred, the sediment levels in the discharge should be able to meet the 100mg/litre standard, and it is no longer appropriate (or necessary) to apply a percentage reduction. While all practical measures will be taken to ensure that discharges post stabilisation TSS levels do not exceed 100 mg/L, for discharges up until stabilisation, the Auckland Council (2009)[2] notes that:

> *…toxicological understanding has been advanced on the effects of short-term, high concentrations of TSS, which can occur during major storms. The work reported has found that New Zealand stream biota are quite resilient in the most part to TSS, so infrequent, very high TSS levels are not especially toxic.*

Given that dewatering activities occur at service stations infrequently and that stabilisation is expected to occur within a 24 hour period, it is anticipated that the effects of the proposed short term TSS 100mg/l standard exceedance will be similar to a heavy storm event.

The reduction in sediment levels over time can be observed in the sequence of water samples, on the page over.

[2] The acceptability of such discharges is addressed in a 2009 review of available information by Auckland Council entitled *The Impacts of Stormwater in Auckland's Aquatic Receiving Environment*.

The reduction in sediment levels over time can be observed in the following sequence of water samples:

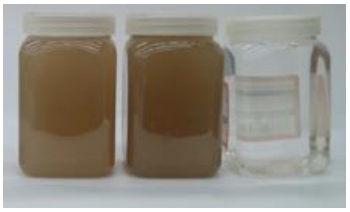
INLET to settlement tank

Inlet upon start up **Inlet after 1 hour pumping**

OUTLET to settlement tank

Outlet upon start up **Outlet after 1 hour pumping**

Outlet after 2 hours pumping



Outlet after 4, 8 and 19 hours pumping (19 hours represents stabilisation in this case)

The receiving environment shall be visually monitored to ensure that **at no time** shall the discharge contribute to or create the following outcomes:

(a) *The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;*
(b) *Any conspicuous change in colour or visual clarity;*
(c) *The emission of objectionable odour;*
(d) *The rendering of fresh water unsuitable for consumption by farm animals;*
(e) *Any significant adverse effects on aquatic life.*

Comparative Image

Looking at outlet of settling tank after start up

Looking at outlet of settling tank after stabilisation (19 hours in this case)

8: Discharge Paths

There are two main discharge paths: to the reticulated stormwater system and to land. Disposal to the sewer is also an option in some circumstances. Discharge to water might be necessary and acceptable in unusual circumstances, but must be assessed on a site by site basis.

a. Discharges to Reticulated Stormwater Systems

This is generally the preferred method of discharge. Prior to discharge to the reticulated system, regional discharge consent and/or the written approval of the network utility operator may need to be obtained. Any applicable conditions on consent or approval must be met.

Note that if there is only a relatively small volume of water extracted from the pit and there is no visible evidence of hydrocarbon contamination, then a contractor might wish to store the water on-site and then discharge it back into the tank pit once the install is complete, instead of discharging it to the stormwater system. If the consents envisage the discharge going to the reticulated network, then discharging back to the tank pit *might* not be allowed. **If in doubt, check with the regional council's compliance officer**.

b. Discharges to Land

This method is generally adopted where there is no ability to discharge to the reticulated system. The discharge will typically be either to soakage pits or, where there is sufficient land and not too much water, via sprinkler dispersal. Sediment treatment is not generally required if this methodology is adopted, unless there is evidence of soil contamination. Prior to such discharge, regional discharge consent may need to be obtained.

c. Discharge to Sewer

This option is generally be adopted where there is a significant risk of high levels of contaminants in the discharge, and where the 15mg/l standard may be difficult to meet. Prior to discharge, the written approval of the network utility operator must be obtained.

9: Monitoring the Process

Hydrocarbons have a limited solubility in groundwater that is affected by many factors including the range of constituents present in the source. With a limited range of fuels at retail sites groundwater impact falls within a discrete range. Soluble constituents have high volatility and a low odour detection threshold. Accordingly they are amenable to visual and olfactory monitoring for screening purposes.

The process will be monitored throughout. Two types of monitoring shall be adopted: monitoring by a SQEP, who will oversee the process and observational monitoring by the site manager or his/her nominate. These are discussed further below.

It is important that a log is maintained of all discharge timing and observations. An example is attached, though this may be tailored to suit particular site specific discharge requirements.

There may also be specific monitoring requirements imposed as conditions of consent and/or written approval. These will need to be met at all times.

Otherwise, Z requires the contractor to adopt the following monitoring methodology.

9.1 Monitoring by a SQEP

Monitoring shall be carried out by the SQEP. Once dewatering has commenced and the pumping rate stabilised (generally after 24 hours) a representative sample shall be analysed for TSS and TPH, and the presence or absence of a detectable odour shall be confirmed. The results shall be made available to the regional council (and/or infrastructure operator) upon request. The purpose of this sampling is to validate the observational monitoring following stabilisation to confirm that the treatment methodology is robust.

The proposed approach is simple, responsive and, on the basis of experience, considered to be sufficiently accurate. The purpose of this sampling is to prompt and record observational monitoring over a period of time to confirm that the treatment methodology is robust.

9.2 Site Monitoring

Analytical testing of water quality samples can be used to supplement and confirm the visual approach but is too slow to be able to inform decisions on the spot. Accordingly a conservative observational approach based on olfactory and visual monitoring is adopted.

Site monitoring consists of two core approaches:

1. Observational On-Site; and
2. Observational Off-Site.

Site monitoring will occur throughout the works, and observations will be recorded in the visual log sheet. The purpose of this site monitoring is to ensure that the desired outcomes are achieved throughout the process, to obtain a basic record of the works and to provide an opportunity to modify the process, if and as necessary.

a. TSS Methodology

The observational On-Site approach involves collecting water samples from the inlet and the outlet PRIOR TO DISCHARGE in clean containers, at 1, 2, 4, 8 and 12 hours after start up, to ensure that a reduction in sediment is occurring. If a reduction is not occurring such that stabilisation will occur within 24 hours, then the discharge must cease and additional treatment mechanisms adopted. Once stabilisation has occurred, the observational on-site approach involves collecting water samples in clean containers and ensuring that the sample essentially looks and smells like fresh water. That should ensure that a standard equivalent to 100mg/litre is maintained (refer example of a 100mg/l laboratory sample below).

If stabilisation does not occur within 24 hours, the SQEP must be contacted to review and amend the treatment train. Additional treatment methods must be added to reduce the level of contaminants in the discharge as soon as practicable.

If dewatering works are stopped before the stated time period, inspection at the stated time period is not required.

b. Hydrocarbons Methodology

The dewatering discharge shall be inspected in the settling tank for visible oil sheen or for detectable odour which, if present, shall trigger treatment to ensure that hydrocarbons are not entrained in the discharge at an unacceptable level.

9.3 Monitoring of the Receiving Environment

The observational off-Site approach involves monitoring water quality at the receiving environment, subject to reasonable mixing. The purpose of the monitoring is to ensure that the standards of the RMA are met, after reasonable mixing.

If any off-site effects attributable to the discharge are observed, the discharge must CEASE IMMEDIATELY and the SQEP must be contacted to review and amend the treatment train. Additional treatment methods must be added to reduce the level of contaminants in the discharge as soon as practicable. The discharge is not to recommence until the SQEP advises that the BPO to achieve stabilisation within the shortest time practicable has been adopted.

10. Records and Reporting

It is the contractor's responsibility to keep records of the dewatering activity, including start and finish dates, weather conditions, pump rates and monitoring records.

Completed log sheets for each dewatering operation shall be forwarded to the Environmental Manager at Z Energy Limited within two weeks of the completion of the dewatering activity, unless the Environmental Manager has already been advised that no dewatering was required.

If there are any reporting conditions on the dewatering consents then the contractor shall ensure that the Z Project Manager is given all relevant information within sufficient time to enable them to report to the Council, in compliance with those conditions.

INDICATIVE SITE MONITORING VISUAL LOG SHEET: DEWATERING

Site:

Intended Dates of Work:

Site Conditions (description):

Condition	Expected	Actual
Ground Water Level		
Recharge Rate		
Soil Conditions		

Describe the Receiving Environment As Identified by the SQEP:

Describe the Reasonable Mixing Zone As Identified by the SQEP:

Observational Testing: First 24 Hours

Weather Conditions

Observation Data	Describe Conditions	On-Site - circle 'Y' if condition present or 'N' if condition absent. If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet		Off-Site - circle 'Y' if condition present or 'N' if condition absent. . If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet	
Start Up **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
1 hour **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
2 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N

Observation Data	Describe Conditions	On-Site - circle 'Y' if condition present or 'N' if condition absent. If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet		Off-Site - circle 'Y' if condition present or 'N' if condition absent. . If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet	
4 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
8 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
12 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N

Observational Testing: After 24 Hours

Number of Days into Dewatering:

Weather Conditions:

Observation Data	Describe Conditions	On-Site - circle 'Y' if condition present or 'N' if condition absent. If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet		Off-Site - circle 'Y' if condition present or 'N' if condition absent. . If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet	
Start Up **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
1 hour **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
2 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N

Observation Data	Describe Conditions	On-Site - circle 'Y' if condition present or 'N' if condition absent. If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet		Off-Site - circle 'Y' if condition present or 'N' if condition absent. . If 'Y' is circled, CEASE WORKS IMMEDIATELY AND CONTACT THE SQEP and then record process to ensure compliance achieved on a separate sheet	
4 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
8 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N
12 hours **Name:** **Date:** **Time:**	Weather: Pump Rate: Receiving Environment:	• Visible sheen • Objectionable odour • Increased sediment load compared to previous sample	Y N Y N Y N	• Conspicuous sheen or floatable materials • Conspicuous change in colour or clarity • Objectionable odour • Any obvious adverse effects on aquatic life (eg: dead plants or fish / eels)	Y N Y N Y N Y N

Annexure 3 – Regional dewatering rule examples

C.5.1.6 Water take associated with bore development, bore testing or dewatering – permitted activity

The taking and use of groundwater associated with bore development, bore testing, or dewatering by pumping is a permitted activity, provided:

1) if the take is from a coastal aquifer:
   a) the site of the bore or ground dewatering does not occur within 200 metres of mean high water springs, and
   b) the daily volume of the water taken does not exceed 100 cubic metres per day, and
   c) the activity is completed within seven days of its commencement, or
2) if the take is from the Aupōuri aquifer management unit:
   a) the activity is completed within seven days of its commencement for takes up to 1000 cubic metres per day, or
   b) the activity is completed within three days of its commencement for takes up to 2500 cubic metres per day, or
3) if the take is in another area, the activity is completed within seven days of its commencement and the average rate of take does not exceed 1000 cubic metres per day, or
4) if the activity is dewatering for construction, installation or maintenance of underground equipment or foundations where the sides of the excavation are sheet piled or boxed to stem the lateral flow, the activity is completed within 10 days of its commencement, and
5) the activity does not adversely affect the reliability of water supply of an authorised water take, and
6) the activity is not in a natural wetland or does not cause any permanent change to water levels in any natural wetland, and
7) any resulting ground settlement or reduction in groundwater levels does not cause adverse effects on buildings, structures, underground infrastructure or services.

For the avoidance of doubt this rule covers the following RMA activities:

- Taking and use of groundwater associated with bore development, bore testing, or dewatering by pumping (s14(2)).

Note:

Any discharge associated with the take and use of groundwater for bore development, bore testing or dewatering by pumping may be permitted by Rule C.6.9.6 Discharges to land or water not provided for by other rules – permitted activity.

Auckland Unitary Plan (Operative in Part)

Table E7.4.1 Activity Table

Activity		Activity status		
		All zones	High- Use Stream Management Areas Overlay	Wetland Management Areas Overlay
(A17)	Dewatering or groundwater level control associated with a groundwater diversion permitted under the Unitary Plan	P	P	RD
(A27)	Diversion of groundwater caused by any excavation (including trench) or tunnel	P	P	RD

E7.6.1.6. Dewatering or groundwater level control associated with a groundwater diversion permitted under Standard E7.6.1.10, all of the following must be met:

(1) The water take must not be geothermal water;

(2) The water take must not be for a period of more than 10 days where it occurs in peat soils, or 30 days in other types of soil or rock; and

(3) The water take must only occur during construction.

E7.6.1.10. Diversion of groundwater caused by any excavation, (including trench) or tunnel

(1) All of the following activities are exempt from the Standards E7.6.1.10(2) – (6):

(a) pipes cables or tunnels including associated structures which are drilled or thrust and are less than 1.2m in external diameter;

(b) pipes including associated structures up to 1.5m in external diameter where a closed faced or earth pressure balanced machine is used;

(c) piles up to 1.5m in external diameter are exempt from these standards;

(d) diversions for no longer than 10 days; or

(e) diversions for network utilities and road network linear trenching activities that are progressively opened, closed and stabilised where the part of the trench that is open at any given time is no longer than 10 days.

(2) Any excavation that extends below natural groundwater level, must not exceed:

(a) 1ha in total area; and

(b) 6m depth below the natural ground level.

(3) The natural groundwater level must not be reduced by more than 2m on the boundary of any adjoining site.

(4) Any structure, excluding sheet piling that remains in place for no more than 30 days, that physically impedes the flow of groundwater through the site must not:

(a) impede the flow of groundwater over a length of more than 20m; and

(b) extend more than 2m below the natural groundwater level.

(5) The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site from the edge of any:

(a) trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation;

(b) tunnel or pipe with an external diameter of 0.2 - 1.5m that extends below natural groundwater level must be 2m or greater; or

(c) a tunnel or pipe with an external diameter of up to 0.2m that extends below natural groundwater level has no separation requirement.

(6) The distance from the edge of any excavation that extends below natural groundwater level, must not be less than:

(a) 50m from the Wetland Management Areas Overlay;

(b) 10m from a scheduled Historic Heritage Overlay; or

(c) 10m from a lawful groundwater take.

Bay of Plenty Regional Water and Land Plan

Rule 42

Rule 42 **Permitted – Take of Water and Discharge of Sediment Contaminated Water from the Dewatering of Building and Construction Sites**

The:

1 Take of water, and
2 Temporary discharge of sediment contaminated water to water or to land where the contaminant may enter water,

for the purposes of dewatering of building and construction sites is a permitted activity subject to compliance with the following conditions:

(a) The discharge shall not be water taken from contaminated land (refer to Definition of Terms and Advisory Note (3), or a trade or industrial site.
(b) There shall be no direct discharge of water to water in Lake Rotorua, Rotoiti, Rotoehu, Rotoma, Okataina, Okareka, Tikitapu, Rotokakahi, Tarawera, Okaro, Rotomahana, or Rerewhakaaitu. Discharge to these lakes shall pass through a filter system or a land soakage pond prior to overland flow, and the suspended solids concentration shall comply with condition (g).
(c) The discharge shall not contain any wastes (including, but not limited to, wastewater or condensates) from a trade or industrial process.
(d) The discharge shall not cause a conspicuous change in the colour of the receiving waters as measured at a downstream distance of three (3) times the width of the stream or river at the point of discharge.
(e) Where the discharge is to a receiving water body that is classified as Water Supply, the discharge shall not contain any substance that renders the water unsuitable for treatment (equivalent to coagulation, filtration, disinfection or micro-filtration) for human consumption.
(f) The discharge shall not contaminate an authorised water take (refer to Advisory Note 4).
(g) Where the discharge is to a surface water body, the suspended solids concentration of the discharge shall not be greater than 80g/m³.
(h) Where the discharge is to land soakage where there is overland flow to a surface water body, the suspended solids concentration of the discharge shall not be greater than 150g/m³.
(i) The volume of discharge from the activity site shall not be greater than 80 litres per second.
(j) The discharge shall not damage or destroy aquatic ecosystems. This includes, but is not limited to, the smothering of flora and fauna by sedimentation of aquatic habitats.
(k) The take of water, or the discharge, shall not cause or induce subsidence, erosion to the bed or banks of any surface water body, or to land, where the erosion is persistent or requires active erosion control measures to bring it under control. Erosion includes:
    (i) Instability of land or the banks of the surface water body.
    (ii) Scour to the bed of the surface water body.
(l) The discharge shall not cause flooding or ponding on any land or property owned or occupied by another person, unless the written approval of the affected person(s) has been obtained.
(m) Where the activity prevents the normal use of any existing bore or well in the vicinity due to draw-down, the activity shall be halted immediately.

Advisory Note

1. Where the discharge is made to a closed/piped stormwater system, permission for the discharge shall be obtained from the city or district council.
2. For the purposes of Rule 42, 'building or construction site' means an activity for the construction or maintenance of a building, structure, or infrastructure.
3. In relation to condition (a), contact the Regional Council for more information on the location of contaminated land.
4. It is recognised that there are natural geothermal inflows or volcanic soils in the Bay of Plenty region that have high natural background levels of metals above those in New Zealand drinking water standards. These metals are part of the ambient environment, and naturally enter water bodies.

Explanation/Intent of Rule

To allow the dewatering of building and construction sites, where it may be necessary to undertake such activities at short notice. It would not be practicable or efficient to require a resource consent in these circumstances.

Canterbury Land and Water Regional Plan

Permitted Activity Rule 5.119

Site Dewatering - Groundwater

Interpretation

The taking of water for dewatering for carrying out excavation, construction, maintenance or repair including for infrastructure or geotechnical testing is not required to comply with the take Rules 5.123 to5.132. Specific rules in Section 6 to 15 can however over-ride these Section 5 rules.

5.119 The taking of water from groundwater for the purpose of dewatering for carrying out excavation, construction, maintenance and geotechnical testing and the associated use and discharge of that water is a permitted activity, provided the following conditions are met:

1. The take continues only for the time required to carry out the work but the take shall not last for a period exceeding 6 months; and
2. The take or discharge is not from, into, or onto contaminated or potentially contaminated land; and
3. The take does not lower the groundwater level more than 8 m below the ground level of the site or cause subsidence of any other site; and
4. The take does not have a moderate, high or direct stream depletion effect on a surface waterbody, determined in accordance with Schedule 9, unless the abstracted groundwater is being discharged to the surface waterbody to which it is hydraulically connected; and
5. An assessment of interference effects, undertaken in accordance with Schedule 12, does not show that any community, group or private drinking-water supply bore will be prevented from taking water; and
6. At the point and time of any discharge to surface water, the rate of flow in the river or artificial watercourse is at least five times the rate of the discharge; and
7. The concentration of total suspended solids in any discharge to a surface waterbody does not exceed:
   (a) 50g/m^3 where the discharge is to any Spring-fed river, Banks Peninsula river, or to a lake or wetland; or
   (b) 100 g/m^3 where the discharge is to any other river or to an artificial watercourse; and
8. The discharge after reasonable mixing with the receiving waterbody meets the visual clarity standards in Schedule 5; and
9. The point of discharge is not within a Community Drinking-water Protection Zone as set out in Schedule 1.

BEFORE THE HEARING PANEL

UNDER	the Resource Management Act 1991
IN THE MATTER OF	Hawke's Bay Regional Council's Proposed Plan Change 9 (TANK)

STATEMENT OF EVIDENCE OF THOMAS JAMES KAY
ON BEHALF OF ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INCORPORATED

Geomorphology / Ecology

Introduction

1. My name is Thomas James Kay.

2. I am a Regional Conservation Manager at Forest & Bird. The focus of my role is advocacy for Forest & Bird in the Hawke's Bay, Gisborne, and Bay of Plenty regions. I also provide advice to Forest & Bird on resource management matters in regard to freshwater ecology. This evidence is provided in that expert capacity.

3. Having grown up in the region, I am very familiar with the TANK catchments and water bodies. This includes having kayaked on the 'Oxbow' (Kuripapango) and 'Lower Gorge' (Kuripapango to Whanawhana) sections of the Ngaruroro River; the Tūtaekurī-Waimate Stream; the Karamū Stream/Clive River; and the Ahuriri Estuary. Several of the sites I surveyed for my MSc thesis were also within the TANK catchment and the region.

Qualifications and Experience

4. I have a Bachelor of Science in Environmental Science from Massey University with 'Massey Scholar' endorsement.

5. I have just (May 2021) completed a Master of Science in Ecology at Massey University. My thesis looked at existing methods for assessing physical habitat quality in rivers; whether sediment and substrate composition in rivers/streams could be measured using images taken with a drone; and the further development and application, through a case study, of the 'Habitat Quality Index' (also known as the Natural Character Index) as a measure of change in river habitat quality in response to activities such as flood protection engineering works.

6. As a matter of transparency, given I refer to their work and evidence within this evidence, my thesis was supervised by Professor Russell Death and co-supervised by Professor Ian Fuller.

7. I am a member of the New Zealand Freshwater Sciences Society and the Engineering New Zealand Rivers Group.

8. My experience includes having provided advice to Forest & Bird in regard to freshwater ecological issues on the Ngaruroro Water Conservation Order (WCO) case.

9. I advised Forest & Bird on the use of the NCI/HQI to assess natural character and habitat quality as a tool to achieve the outcomes sought by them for the TANK water bodies. This led to the inclusion of this tool in the submission.

Code of conduct

10. I have read and agree to comply with the Code of Conduct for Expert Witnesses produced by the Environment Court 2014 and have prepared my evidence in accordance with those rules as if this matter was before the Court. My qualifications as a freshwater ecological expert are set out above. I confirm that the issues addressed in this evidence are within my area of expertise, except where I have indicated that I am relying on others opinions. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

11. This evidence is prepared for Forest & Bird to address their submission (dated 14 August 2020) on the TANK plan change / Proposed Plan Change 9 (PC9), in particular:

    - The management and protection of physical habitat and natural character through the use of the Natural Character / Habitat Quality Index.
    - Incorporation of the Natural Character / Habitat Quality Index in the plan as (1) a measure of the condition of natural character and physical habitat and (2) a mechanism to prevent their degradation and enable their improvement
    - The addition of an attribute to Schedule 26 to manage physical habitat quality
    - Reference to the NCI/HQI in policies, methods, and/or rules
    - The use of the NCI/HQI for restoration projects, for assessing resource consents, and for integrating into flood management plans or 'codes' for river engineering works
    - Any other consequential amendments to ensure the protection of physical habitat quality is included in the plan

12. Sections of this evidence draw on the evidence provided by Professor Ian Fuller for Forest & Bird's Environment Court proceedings on the Special Tribunal's recommendation for a Water Conservation Order (WCO) on the Ngaruroro River. Professor Fuller's evidence is provided in full in Appendices 1 & 2.

13. This evidence covers:

    i. A comment in regard to the s42A report and amendments to PC9
    ii. A description of river geomorphology and natural character
    iii. Adverse effects on natural character and physical habitat
    iv. The current state and management of the natural character and physical habitat of TANK rivers/streams
    v. An explanation of the Natural Character Index (NCI) and Habitat Quality Index (HQI), and examples of where it has been used
    vi. Application of the NCI and HQI to PC9
    vii. A summary

Section 42A Report

14. As far as I am aware, having reviewed the s42A report and appended schedules, changes to PC9 have not incorporated the NCI and HQI as sought by Forest & Bird's submission.

River Geomorphology and Natural Character

15. In regard to natural character and physical habitat in rivers and streams, the RMA (s6) directs regional councils as a matter of national importance to

> recognise and provide for…
>
> i. the preservation of the natural character of… rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:
>
> ii. …
>
> (c) the protection of areas of… significant habitats of indigenous fauna

16. The NPS for Freshwater Management (2020) has a number of directions relating to natural character and habitat in rivers and streams, in particular:

> **Objective** (1) …to ensure that natural and physical resources are managed in a way that prioritises:
>
> (a) first, the health and well-being of water bodies and freshwater ecosystems…

and

- **Policy 1:** Freshwater is managed in a way that gives effect to Te Mana o te Wai
- **Policy 7:** The loss of river extent and values is avoided to the extent practicable.
- **Policy 9:** The habitats of indigenous freshwater species are protected
- **Policy 13:** The condition of water bodies and freshwater ecosystems is systematically monitored over time, and action is taken where freshwater is degraded, and to reverse deteriorating trends.
- **Policy 14:** Information (including monitoring data) about the state of water bodies and freshwater ecosystems, and the challenges to their health and well-being, is regularly reported on and published.

17. PC9 Objectives (as amended by the s42A report) also includes direction in regard to natural character and habitat quality:

> **OBJ TANK 8**
>
> Riparian margins are protected or improved where necessary to provide for Aquatic ecosystem health and mauri of water bodies in the TANK catchment ~~is improved by appropriate management of riparian margins~~ and to:
>
> …
>
> b) improve aquatic habitat and protect indigenous species including fish spawning habitat;

…

d) enhance natural character and amenity;

OBJ TANK 10

…in the **Ahuriri** freshwater catchments … the mauri, water quality and water quantity are maintained and enhanced where necessary to enable:

b) healthy ecosystems that contribute to the health of the estuary;

OBJ TANK 11

…in the **Ngaruroro River catchment** … the mauri, water quality and water quantity are maintained in the mainstem above the Whanawhana Cableway and in the Taruarau River, and are improved in the tributaries and lower reaches where necessary to enable;

a) healthy ecosystems;
b) healthy and diverse indigenous aquatic plant, animal and bird populations especially …bird habitat on braided river reaches …
c) …
d) protection of the natural character, instream values and hydrological functioning of the Ngaruroro mainstem and Taruarau and Omahaki tributaries;

OBJ TANK 12

…in the **Tūtaekurī River** catchment … the mauri, water quality and water quantity are maintained in the upper reaches of the mainstem and are improved in the tributaries and lower reaches where necessary to enable:

a) healthy ecosystems;
…
d) protection of the natural character, instream values and hydrological functioning of the Tūtaekurī mainstem and Mangatutu tributary;

OBJ TANK 13

… in the **Karamū and Clive Rivers** catchment … the mauri, water quality and water quantity are improved to enable

a) healthy ecosystems;

18. PC9 policies also refer to improving fish spawning habitat (P11); avoiding, remedying, or mitigating the adverse effects of activities on aquatic ecosystems and habitat (P54); and carrying out regular ecosystem habitat assessments (P35); among other direction relating to the health of freshwater ecosystems.

19. In order to achieve these objectives, it is important for decision makers to have a basic understanding of what constitutes river 'habitat' and what defines the 'natural

character' of a river. This means having an understanding of river geomorphology: essentially, how rivers are formed and change.

20. Rivers consist of various combinations of physical features, such as riffles, runs, pools, backwaters, and bars. An example of this is provided in Figure 1.

21. These features, in combination with the characteristics of the channel (straight, sinuous, etc.) and floodplain (wide, confined by terraces, gorged, etc.), as well as flow/discharge regimes and sediment supply, determine a river's unique form. These characteristics vary by catchment, and are restricted by variables such as rainfall and runoff, geology, land cover (e.g. vegetation), gradient, erosion rates, and valley-floor confinement.

22. Rivers and streams are, overall, stable in form and make frequent adjustments to their geomorphology within that form in response to subtle changes in catchment conditions, such as flow or sediment supply, which differ in every drought, storm, or flood.

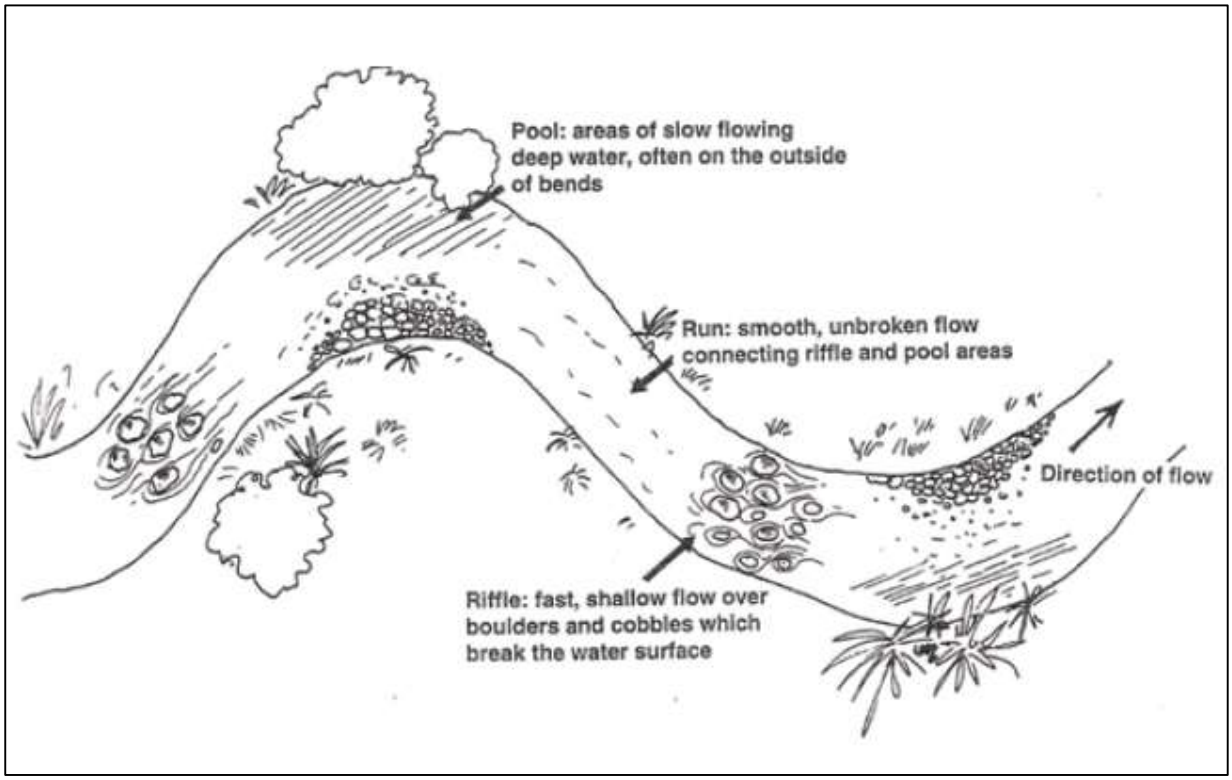


Figure 1: *Riffle, run, and pool habitats. These features provide habitat for invertebrates, fish, and birds, and in combination contribute to the natural character of a river (from Clapcott et al, 2011).*

23. These frequent adjustments mean the arrangement of features (riffles, runs, pools, backwaters, etc.) in a river is constantly changing, though their prevalence and the overall form of the river is likely staying the same. For example, a large flood will often rearrange the arrangement of features in a river but not change its form. This sort of adjustment is a regular occurrence in braided and semi-braided rivers, where

bars and channels are constantly being rearranged, while the overall the 'form' of the river remains stable.

24. Figure 2 illustrates a 'continuum' of river forms and how they can vary based on different catchment conditions, such as sediment supply and gradient.

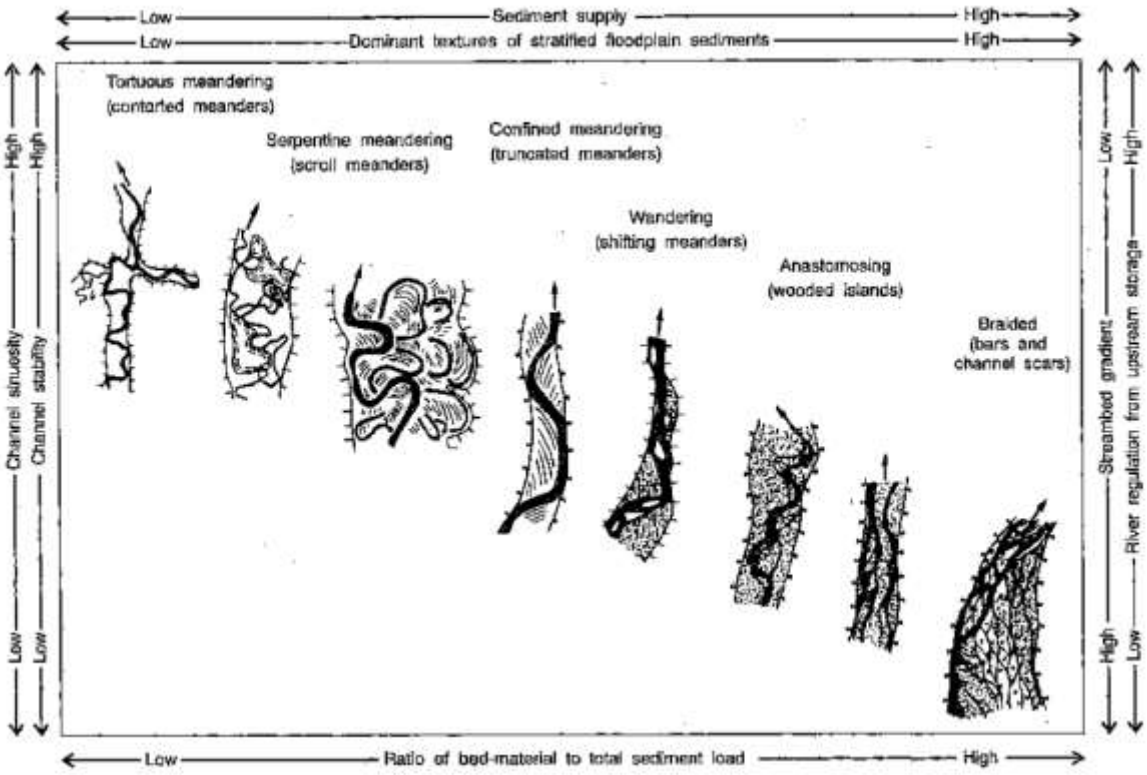


Figure 2: *The continuum of alluvial river channel types (Fig 16.1, from Mosley, 1992, cited in Fuller, Appendix 2 to this document).*

25. Where there is a wide range of these features and representation of these variables, habitat quality is generally likely to be high. Where these features are lacking, generally habitat quality is likely to be low. Figure 3 provides an example this.

26. The representation of form and features in a river or stream also determines which species the habitat is suitable for. For example, fast-flowing, smaller rivers with lots of riffles/rapids provide habitat for Whio (Blue duck), while large braided rivers provide habitat for Tarapuka (Black-billed gulls).

27. The overall form of a river, in combination with the 'mosaic' of features (the riffles, runs, pools, etc.) within the river, defines its 'natural character'.

28. The overall form of a river (or reach, since rivers often change form from the headwaters to the coast) and it's features provide valuable habitat for native riverine species, including invertebrates, fish, and birds. These features include not only riffles, runs, and pools, but also variables such as the amount of in-stream cover, substrate composition, sediment cover, riparian vegetation, and shading.

Table 1 illustrates which of these features are known to be important for different native fish species (noting the table is by no means exhaustive).

29. Effective methods to measure change in river form and features—i.e. natural character and physical habitat quality—are vital to ensure that regional councils are meeting the requirements of policy direction in regard to natural character and physical habitat, including their objectives for enhancement, improvement, or restoration. Without effective monitoring tools and strong direction towards maintenance (as a bare minimum) and improvement, further degradation of natural character and habitat quality is likely.

Figure 3: *Examples of rivers/streams with a high integrity of habitat quality (left) and low integrity of habitat quality (right) (adapted from Death & Fuller, 2018).*

Table 1: *Habitat variables known to be important for each of ten native species of fish (from Petrove et al., in Death et al. (n.d.c)).*

	Longfin eel	**Torrentfish**	**Giant kōkopu**	**Kōaro**	**Dwarf galaxias**	**Inanga**	**Shortjaw kōkopu**	**Lamprey**	**Bluegill bully**	**Redfin bully**
Substrate										
Percent Deposited fines (100 – %x)	x	x		x	x	x	x	x	x	x
Particle compaction	x			x	x		x		x	x
Inorganic substrate diversity	x	x	x	x	x	x	x	x	x	x
D_{50} (mm)	x	x	x	x	x	x	x	x	x	x
Instream cover										
Total area of Instream cover	x		x		x	x	x	x		x
Undercut banks	x		x				x			
Instream wood	x		x		x		x	x		x
Macrophytes	x				x	x				
Flow types										
Deep pools	x		x				x			
Backwaters	x		x			x	x			
Side braids				x		x	x			
Riffles	x	x	x	x	x				x	x
Runs		x	x	x	x	x		x		
Riverbank										
Riparian vegetation			x		x	x	x	x		x
Overhanging vegetation	x		x				x			
Stream bank height			x			x	x			
Inanga spawning habitat						x				
Floodplain width	x					x	x			
Sinuosity	x					x			x	

Adverse effects on natural character and physical habitat

30. Despite the importance of having a high integrity of river form and features to functioning river systems, and the importance of those systems to human health and the health of ecosystems, river form and habitat quality tend not to be given the consideration in resource management for maintenance, protection, and improvement other metrics, such as nutrient or pathogen concentrations, are given.

31. The Ministry for the Environment and Stats NZ's 'Our Freshwater 2020' report summarised some of the degradation to freshwater habitat thus:

> Many of the freshwater habitats that our native species rely on have been reduced or damaged – sometimes entire ecosystems have been degraded. This has made some species particularly vulnerable to extinction…
>
> Modifying waterways with dams, pipes, concrete or rock banks, and constraints to a natural shape (such as forcing a wide floodplain into a narrower channel), can destroy and damage habitat. Removing riverside (riparian) vegetation from the banks of a waterway also reduces habitat for native species like īnanga…
>
> (p. 18, Our Freshwater 2020, MfE and Stats NZ)

32. Pressure on rivers and streams continues to rise as a result of human activity (Maddock, 1999). This has occurred, and continues to occur, through in-channel activities such as gravel extraction or flood protection, river channelisation (e.g. with stop banks, planting, or riverbank 'reinforcement'), damming, land cover changes, and encroachment (e.g. of farmland), among other things.

33. With the frequency of extreme climatic events increasing there is a perception that further modification to river systems will be required, as communities attempt to alleviate the effects of climate change on agriculture, human health, or infrastructure (Death et al., 2015; Vaughan et al., 2009).

Current state and management of the natural character and physical habitat of TANK rivers/streams

34. The condition of the natural character and habitat of rivers and streams in the TANK catchments varies widely. While some reaches of some rivers are 'natural-state' (such as the upper Ngaruroro) others are degraded (lowland streams and rivers).

35. An example of the degradation from 'natural state' (in terms of natural character) can be seen in the lower reaches of the Ngaruroro River, from the Whanawhana cableway to the coast. An example reach is provided in Figures 3a and 3b, illustrating how floodplain and active channel widths in particular have been significantly reduced when compared to a historic baseline.

36. While the Ngaruroro River remains braided through this reach and is clearly still an impressive and ecologically significant river with significant habitat values (having been recognised as an outstanding habitat for native birds by a Special Tribunal hearing the case for a Water Conservation Order[1]) the *natural character* of the river in this reach has clearly been modified and degraded.

37. This is again illustrated in the Karamū/Clive River and the reaches of the Ngaruroro River closest to the coast, where the main stem of the Ngaruroro River was diverted as part of flood management some decades ago. Figures 4a and 4b illustrate how the Ngaruroro River main stem flowed in what is now referred to as the 'Clive River' channel.

38. While Figures 3-4 illustrate historical degradation of natural character through significant 'flood protection' works in the Ngaruroro River, degradation of natural character and loss of habitat continues to occur through ongoing smaller-scale works, the cumulative effects of which constitute significant degradation. For example, Figure 5 illustrates recent attempts by Hawke's Bay Regional Council to plant willow poles in the active channel of the Ngaruroro River. Further examples of this activity in the Ngaruroro are provided in evidence I presented for the Ngaruroro WCO case, attached to this submission as Appendix 3.

[1] https://www.epa.govt.nz/assets/FileAPI/proposal/NSP000041/Boards-decision/WCO_Ngaruroro_and_Clive_Rivers_Recommendation_Report_Final_erratum_2019.10.04.pdf

Figure 3a: *The Ngaruroro River at Maraekakaho in 2020.*

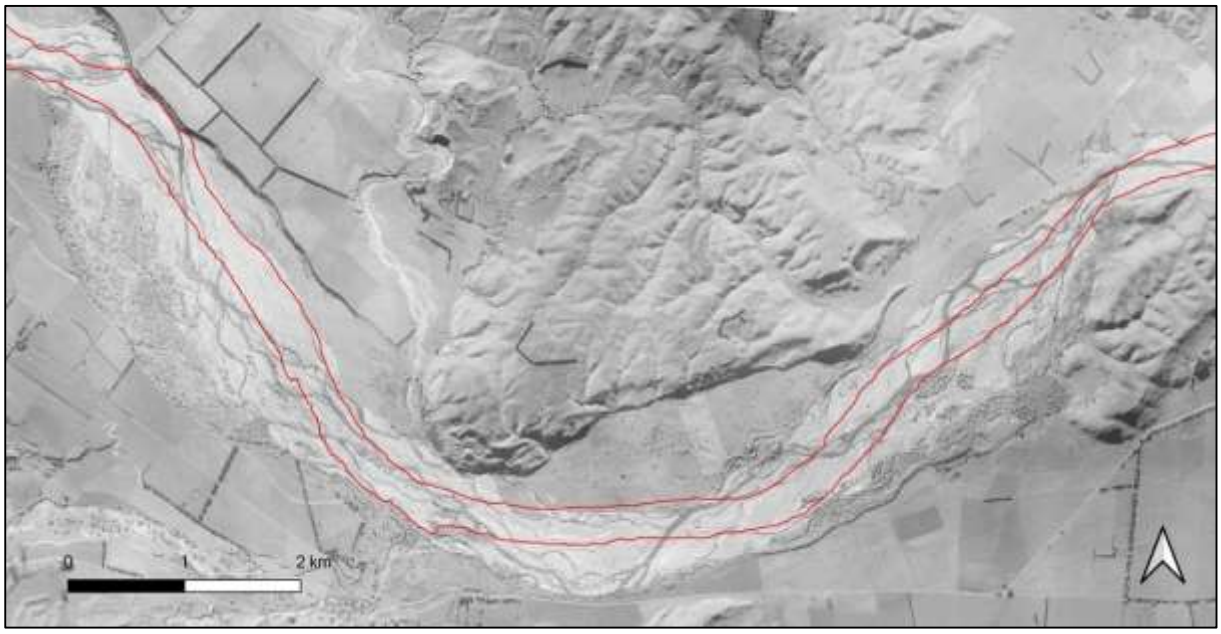


Figure 3b: *The Ngaruroro River at Maraekakaho in 1937 with the 2020 active channel outline laid over in red. Note the significant channel constriction, which, while it has not changed the river type (i.e. it is still a braided river), does illustrate a degradation of natural character and has reduced the area of physical habitat available.*

Figure 4a: *Ngaruroro and Karamū/Clive Rivers prior to diversion (1937).*

Figure 4b: *Ngaruroro and Karamū/Clive Rivers following diversion (2020). Note where the main stem of the Ngaruroro used to flow past Clive (Figure 4a) and how it no longer has the capacity to do this, instead flowing through an extremely straight 'flood' channel.*

Figure 5: *HBRC 'flood protection' 'edge' planting in the active channel of the Ngaruroro. This is a prime example of trying to further channelise a river—destroying braided river habitat in the process and adversely affecting natural character.*

39. This method of river management will not protect the ecological values of the river and is an obvious threat to natural character and habitat for native birds and fish. The cumulative impact of this activity could amount to a significant reduction in the width of the river corridor over time, reduce the area of unvegetated bar, and reduce the extent of braiding.

40. Channelisation and encroachment of rivers through the construction of stopbanks, river realignment/channelisation, and encroachment is widely accepted in academic literature as being a severe driver of ecological degradation and a reduction in natural character. It is this sort of activity that has narrowed the very lowest reaches of the Ngaruroro River (i.e. those nearest the coast) so significantly when compared to their 'natural' condition. Reaches of the Tutaekuri[2] and Ahuriri[3] have also been affected by similar works (and the Karamū has been impacted by realignments, including as above when the Ngaruroro main stem was shifted).

41. In order to maintain, protect, and restore natural character and physical habitat, river management approaches need to change, and better monitoring of natural character and physical habitat is required.

42. In terms of modern approaches to river management, I direct the panel to paragraph 69 of the evidence in reply of Professor Fuller in the case for a WCO on the Ngaruroro River (Appendix 2), which clearly states that modern approaches to river management emphasise a need to maintain and/or widen river corridors, rather than narrow them. This allows rivers to naturally adjust to fluctuations in their systems:

[2] https://www.hbrc.govt.nz/services/flood-control/major-schemes/
[3] Pages 6 and 24 of: https://www.napier.govt.nz/assets/Documents/Ahuriri-Masterplan/Ahuriri-Estuary-Masterplan-Final-10-August-2018.pdf
[3, 4] Also see images under 'NAPIER OPEN WATERWAYS WATER QUALITY' in http://hawkesbay.infocouncil.biz/Open/2021/05/EICC_12052021_AGN_AT.htm#PDF3_Attachment_14828_2

> Good practice in river management now recognises the need to provide room for the river to accommodate natural processes of adjustment (e.g. Piegay et al. 2005; Buffin-Belanger et al., 2015; Chone and Biron, 2016). That is, good practice now rarely allows for the further restriction or narrowing of river corridors. This practice is applied internationally and is beginning to be applied in New Zealand (Ramon Strong, Horizons Regional Council, pers. comm.)

43. Incorporating a robust methodology for measuring changes in natural character and habitat quality in PC9, as well as 'bottom line' limits on changes in natural character and habitat quality as sought by Forest & Bird will assist in ensuring a more informed and modern approach to river management is taken and drive a transition away from degradation to enhancement/improvement.

44. This can be achieved through the use of the Natural Character / Habitat Quality Index.

An explanation of the Natural Character Index (NCI) and Habitat Quality Index (HQI), and examples of where it has been used

45. Death et al. (n.d.a, n.d.b, n.d.c) developed the (essentially synonymous) 'Natural Character Index' (NCI) and 'Habitat Quality Index' (HQI) to assess change in the condition of a river's physical habitat in response to the lack of suitable available tools to assess the quality of physical habitat in rivers.

46. The NCI identifies and quantifies change in the natural character of a river over time. It involves assessing a river's 'current' form against its form at some point in the past. As Professor Ian Fuller states:

> … the NCI compares a parameter, or range of parameters, (relating to river geomorphology, such as channel width) observed in the present river form with that same parameter, or parameters, at the same site at a reference point in time. If no change in the overall assemblage of morphological units or river parameters measured has occurred (e.g. the width of a river channel is the same now as it was 10 years ago), the observed condition is the same as the reference condition and the ratio is 1.00. If there has been a reduction in the parameter (e.g. the channel has narrowed) the ratio will be less than 1.00 because the observed (current) condition is smaller than the reference (past) condition. In contrast, if there has been an increase in the parameter (e.g. the channel has widened) the NCI will exceed 1.00 because the observed condition is greater than the reference condition.
>
> (para. 30, Professor Ian Fuller, Appendix 1)

47. For example, Figure 6 shows how the width of the active channel at a number of points along a reach of the Rangitata River was measured in imagery from 1937 and 2016-2018 (Kay, 2020). The average width of this reach in 1937 was 569 m, while the average width in 2016-2018 was 382 m. The NCI for this parameter in this reach is therefore:

$$NCI_{active\ channel} = \frac{width\ in\ 2016/2018}{width\ in\ 1937} = \frac{382}{569} = 0.67$$

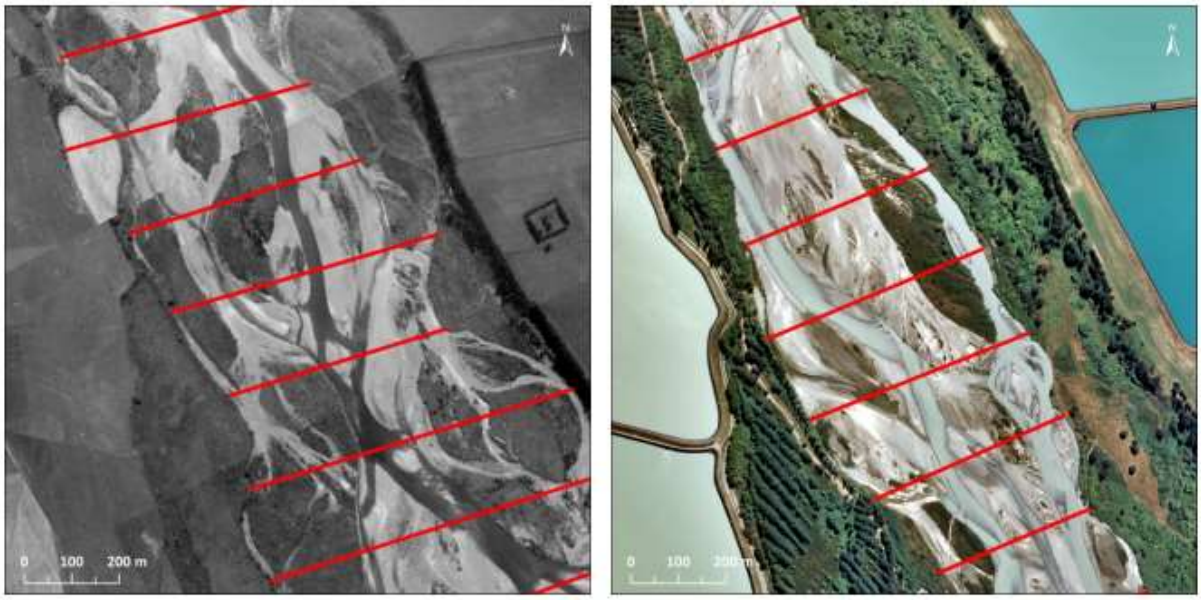


Figure 6: *An example of how a parameter of river geomorphology, in this case active channel width, can be measured at the same point at different times to assess change. This image shows the Rangitata River at Ealing in 1937 (left) and 2016-2018 (right). (Kay, 2020).*

48. Which, and how many, parameters are measured depends on the objective of the assessment, nature of the river, and availability of data (in the case above, imagery). Each parameter measured generates a separate NCI ratio and the median of these values can be used to provide an indication of the overall condition of the reach. This is illustrated in Table 1.

Table 1: *NCI scores for selected parameters in the Rangitata River, 1937 to 2016/2018. The $NCI_{overall}$ score reflects the median value of the active channel, floodplain width, and braiding index scores. Adapted from Kay, 2020.*

REACH	a	b	c	d	e	f	$NCI_{overall}$
Active channel	0.67	0.88	0.57	0.41	0.39	0.52	**0.55**
Floodplain	0.53	0.55	0.85	1.00	1.00	1.00	**0.92**
Braiding index	1.85	0.95	0.76	2.46	0.91	1.00	**0.98**
$NCI_{overall}$	**0.67**	**0.88**	**0.76**	**1.00**	**0.91**	**1.00**	

49. NCI assessment uses desktop analysis in GIS and is usually based on aerial imagery, from which key parameters can be measured. LiDAR data, historical maps, or other forms of geographical data can also be used. Assessments can be made of any period for which there is available data – usually years or decades.

50. Because of the scale at which the NCI is assessed, and because it is a desktop exercise, the NCI is most suitable for longer-term, larger-scale analyses of change in natural character or river habitat by measuring variables such as channel and floodplain widths, braiding indices, sinuosity, riparian vegetation, and the area of unvegetated bars. Other variables might also be appropriate.

51. While essentially synonymous with the NCI in that it uses the same before/after ratio method, I now tend to use the term 'Habitat Quality Index' (HQI) to refer to assessments of 'finer-scale' variables in a river (riffles, runs, pools, woody debris, substrate, etc.) across shorter time frames (days, weeks, months).

52. In this way, there can be a useful classification between:

    i. The **Natural Character Index**, which uses desktop analysis in GIS and is usually based on satellite/aerial imagery or maps, from which larger-scale variables relating to 'natural character' such as channel and floodplain widths, braiding indices, sinuosity, riparian vegetation, and the area of unvegetated bars can be measured. Assessments can be made of any period for which there is available data – usually years or decades, and;

    ii. The **Habitat Quality Index**, which uses aerial (including drone) imagery or on-the-ground measurements to assess smaller-scale variables relating to 'habitat quality', such as flow types (riffles, runs, pools), shading, substrate composition, sediment cover, riparian vegetation, and in-stream cover. Assessments can be made of any period for which there is available data – usually days, weeks, or months.

53. As stated by Fuller (Appendices 1 & 2), an NCI or HQI score is not a statement of a river's 'naturalness' or indication of how far it might be from being 'pristine'. Rather, it is an indication of change from a reference condition – which might be near natural or significantly degraded. Drivers of that change might be natural or human-induced.

54. In this way, the NCI and HQI can usefully be used in resource management frameworks and policy in that:

    iii. the **NCI** could be used to assess (and limit or set objectives for) changes to geomorphology and natural character; and guide policies, rules, and management plans on natural character, landscape values, river management, flood protection, and damming, among other things; and,

    iv. the **HQI** can be used as a finer-scale tool to assess the effects of a specific activity occurring under the regional plan (or set limits or objectives for the impacts of such work), such as in-stream works occurring under a resource consent or a river management plan, or restoration work. Where effects are

recorded (had they not been foreseen and addressed already), remediation work would need to be undertaken. Where restoration is intended, the HQI can help ascertain whether it is successful in achieving objectives.

55. Some examples of where the NCI and HQI (using my above definition to separate the two) have been used include:

NCI

- the Hutt, Waikanae, Otaki, Rangitikei, and Motueka Rivers, NZ; the Ebro, Spain; and the Sava, Croatia (Fuller et al., 2014, 2020)
- the Rangitata River (Kay, 2020)
- the Ngaruroro River (presented in evidence for the Ngaruroro WCO case, Appendices 1 & 2)
- the impacts of large flood events on the Waikanae River that occurred in 1998 and 2005, using available 'before' and 'after' aerial photographs (Fuller, work in progress).

HQI

- The Hutt River to assess the impact of in-stream flood management works on fish habitat (Death et al., n.d.a., n.d.c)
- The Waiohine River to assess the impact of in-stream flood management works on fish habitat (this was the case study for my thesis project)

Application of the NCI to PC9

56. As mentioned above, effective methods to measure change in river form and features—i.e. natural character and physical habitat quality—are vital to ensure that regional councils are meeting the requirements of policy direction in regard to natural character and physical habitat, including their objectives for enhancement, improvement, or restoration. Without effective monitoring tools and strong direction towards maintenance (as a bare minimum) and improvement, further degradation of natural character and habitat quality is likely.

57. I consider the Natural Character / Habitat Quality Index can be incorporated into PC9 to help achieve policy requirements by:

    i. Directing the use of the NCI/HQI as a monitoring tool[4] to ensure TANK/NPS/RMA objectives relating to habitat, natural character, and ecosystem health are being achieved,
    ii. Including minimum numeric thresholds against which NCI/HQI monitoring should be assessed (using a 'current state' [2020] baseline), whereby any score below these thresholds would be considered a degradation in natural character or habitat quality, and therefore a failure to meet objectives,

[4] e.g. as part of State of the Environment reporting

iii. Requiring significant activities with a potential impact on natural character or habitat quality to include NCI/HQI monitoring as part of their consent conditions,

iv. Including policies, objectives, and/or methods directing:

(a) the assessment of natural character and habitat quality against historical conditions to look at longer term change and identify opportunities for improvement

(b) the improvement/restoration of habitat quality and natural character where HQI/NCI scores show degradation

(c) the implementation of modern approaches to river management,

58. In regard to 62(ii), I have proposed a 'Schedule 26.X: Natural Character / Habitat Quality Limits' that incorporates NCI/HQI limits into PC9. This includes numeric and narrative limits on natural character and habitat quality for all TANK freshwater management units (Schedule 26.X: Table 1). These are minimum numeric thresholds against which NCI/HQI monitoring should be assessed (using a 'current state' [2020] baseline), whereby any score below these thresholds would be considered a degradation in natural character or habitat quality, and therefore a failure to meet objectives. These have been informed by:

- the nature of these management units (e.g. whether they are in headwaters/lowland areas),
- the NCI limits proposed by Professor Russell Death in his evidence on the Wellington Natural Resources Plan[5],
- reports and guidance on assessing impacts with the NCI/HQI,
- analysis of the Ngaruroro River undertaken for the Ngaruroro WCO case

59. Assessment of the above (whether it be part of ongoing monitoring or for a specific resource consent or activity) would be assessed with a standard NCI/HQI assessment using a median value as the 'overall' score. Notes on methodology are included in the schedule.

60. In addition to these limits, I have incorporated more specific limits on components of natural character in the lower Ngaruroro River. These were proposed by Professor Fuller for the lower Ngaruroro River as per his evidence for the Ngaruroro WCO case (Appendices 1 & 2).

61. I note that while Professor Fuller determined the NCI limits proposed for the WCO, as Forest & Bird's 'case manager' for the Ngaruroro WCO application, I assisted with the mapping of the Ngaruroro River to inform the analysis and determine these values and am therefore familiar with the process.

[5] https://pnrp.gw.govt.nz/assets/Uploads/HS3-Fish-and-Game-Dr-Death-Freshwater-objectives-Tabled-Evidence.pdf and https://pnrp.gw.govt.nz/assets/Uploads/HS3-S308-Russell-Death-Technical-Evidence.pdf

62. It is important to note that these specific limits would apply in addition to the median and minimum HQI/NCI limits, and that should any of these variables score below these individual component limits it would amount to degradation.

63. Proposed Schedule 26.X would need to be accompanied by an objective and/or policy (as per para. 57i and 57ii) stating (or with words to the effect that):

> The natural character and physical habitat of fresh water bodies is monitored and reported on, safeguarded such that ecosystem health is maintained or improved, and limits in Schedule 26.X are not exceeded.

64. In regard to 62(iii), PC9 should incorporate provisions that direct the use of the Natural Character and/or Habitat Quality Index as a requirement of any river management activities or resource consent applications with an 'in-stream' component or physical effect on the river geomorphology, and that any degradation in habitat quality and/or natural character as a result of works would need to be remediated. Schedule 26.X would provide the thresholds against which change would be assessed.

65. There should be direction that NCI/HQI analysis must be undertaken by a suitably qualified ecologist and/or geomorphologist (depending on what is being measured).

66. In regard to 62(i) and 62(iv), PC9 should also include methods stating:

> **Method X:** HBRC will report on natural character and habitat quality using the NCI/HQI as part of its State of its the Environment monitoring, including against Schedule 26.X limits.
>
> **Method Y:** HBRC will utilise the NCI/HQI to
>
> i. assess past and future change in the natural character and habitat quality of TANK water bodies,
> ii. investigate opportunities for restoration and improvement of habitat quality and natural character, including against historical condition
> iii. inform river management and flood protection planning and decisions (including the development of a modern approach to flood management), and
> iv. safeguard natural character and physical habitat in accordance with the limits in Schedule 26.X

SCHEDULE 26.X: NATURAL CHARACTER / HABITAT QUALITY LIMITS

TABLE 1: All Freshwater Quality Management Units					
Attribute	**Freshwater Quality Management Units**	**Reach**	**NCI / HQI Limit ***		**Narrative**
			Median	**Minimum**	
Natural Character[6] (NCI) / Habitat Quality[7] Index (HQI)	Upper Tūtaekurī	All	0.85	0.60	River form (including pool, run, riffle, and riparian margins) and function is suitable to support fish and macroinvertebrates through their life phases and protect ecosystem health.
	Tutaekuri tributaries	All	0.85	0.60	
	Lower Tutaekuri	All	0.85	0.60	
	Upper Ngaruroro	All	0.90	0.80	
	Ngaruroro Tributaries	All	0.85	0.60	
	Lower Ngaruroro**	All	0.85	0.60	
	Ahuriri	All	0.85	0.60	
	Lowland tributaries (including Ngaruroro)	All	0.85	0.60	

* Median and minimum refer to the component NCI/HQI scores – i.e. the lowest value in an assessment should not be < 0.6 and the median value not < the relevant median limit

** in addition to the NCI/HQI limits in table 1, the lower Ngaruroro River is subject to specific limits for the components of natural character listed in table 2.

TABLE 2: Additional Limits specific to Lower Ngaruroro Freshwater Quality Management Unit					
			NCI Limit		
Attribute	**Freshwater Quality Management Units**	**Reach**	Average channel width	Braiding Index	Area of unvegetated bar
Natural Character Index[7] (NCI)	Lower Ngaruroro	Whanawhana cableway (NZTM2000: 1891901E, 5615830N) to Matapiro Rd (NZTM2000: 1899143E, 5615058N)	0.93	0.78	0.88
		Matapiro Rd (NZTM2000: 1899143E, 5615058N) to top of HBRC Flood Management Scheme (NZTM2000: 1906679E, 5610950N)	0.98	0.85	0.90
		Top of HBRC Flood Management Scheme (NZTM2000: 1906679E, 5610950N) to Fernhill Bridge (NZTM2000: 1923019E, 5611264N)	0.99	0.86	0.86

[6] NCI assessments should be undertaken against a 2020 baseline using the methodology in: Fuller, I. C., Death, R. G., Garcia, J. H., Trenc, N., Pratt, R., Pitiot, C., Matoš, B., Ollero, A., Neverman, A., Death, A. (2020). An index to assess the extent and success of river and floodplain restoration: Recognising dynamic response trajectories and applying a process-based approach to managing river recovery. *River Research and Applications*, 1-13. https://doi.org/10.1002/rra.3672

[7] HQI assessments should be undertaken over the relevant time period using the methodology in: Kay, T. J. (2021), *A Methodology to Assess River Habitat Quality* [Master's thesis, Massey University]. URL to be confirmed.

Summary

67. Habitat and natural character are as important as water quantity and quality for ecosystem health in rivers and streams.

68. Degradation of natural character and physical habitat, and therefore ecosystem health, has occurred, and continues to occur, through in-channel works such as gravel extraction or flood protection, river channelisation (e.g. with stop banks, riverbank 'reinforcement', and planting), damming, land cover changes, and encroachment (e.g. of farmland), among other things.

69. Effective methods to measure change in river form and features—i.e. natural character and physical habitat quality—are vital to ensure that regional councils are meeting the requirements of policy direction in regard to natural character and physical habitat, including their objectives for enhancement, improvement, or restoration.

70. Use of the NCI and HQI, through policies/methods directing their use in monitoring, river management decisions, resource consenting processes, and through limits in PC9 will assist in achieving the objectives of the NPS Freshwater Management (2020), the RMA (1991), and PC9.

71. The Natural Character / Habitat Quality Index can be incorporated into PC9 to help achieve objectives by:

    i. Directing the use of the NCI/HQI as a monitoring tool[8] to ensure TANK/NPS/RMA objectives relating to habitat, natural character, and ecosystem health are being achieved,
    ii. Including minimum numeric thresholds against which NCI/HQI monitoring should be assessed (using a 'current state' [2020] baseline), whereby any score below these thresholds would be considered a degradation in natural character or habitat quality, and therefore a failure to meet objectives,
    iii. Requiring activities with a potential impact on natural character or habitat quality to include NCI/HQI monitoring as part of their consent conditions,
    iv. Including policies, objectives, and/or methods directing:

        (a) the assessment of natural character and habitat quality against historical conditions to look at longer term change and identify opportunities for improvement
        (b) the improvement/restoration of habitat quality and natural character where HQI/NCI scores show degradation
        (c) the implementation of modern approaches to river management,

[8] e.g. as part of State of the Environment reporting

Thomas James Kay

11 May 2021

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IN THE ENVIRONMENT COURT
AT AUCKLAND

I MUA I TE KOOTI TAIAO O AOTEAROA
TĀMAKI MAKAURAU ROHE

IN THE MATTER	of submissions under s 209 of the Resource Management Act 1991
BETWEEN	**NGA KAITIAKI O TE AWA O NGARURORO** (ENV-2019-AKL-000270) **CLINTON ELLIS, HEEMI JAMES BIDDLE, MARK ROSS, MATIU NORTHCROFT, NGAHERE WALL as trustees of East Taupo Lands Trust** (ENV-2019-AKL-000273) **WHITEWATER NEW ZEALAND INC.** (ENV-2019-AKL-000277) **ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INC** (ENV-2019-AKL-000278)

(Continued next page)

EXPERT EVIDENCE IN CHIEF OF IAN FULLER ON BEHALF OF ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INCORPORATED

Royal Forest and Bird Protection Society of New Zealand Inc
Solicitor acting: William Jennings / Peter Anderson
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HAWKE'S BAY REGIONAL COUNCIL

(ENV-2019-AKL-000272)

PETER HUGHES MACGREGOR, MATAORA NEVILLE TOATOA, NGAPUOTERANGI HOHEPA (KORO) TE WHAITI, SHERYLE ALLEN, MONA STEWART, TANIA HUATA KUPA, KAHUKURANUI HAKIWAI as trustees of the Owhaoko C Trust

(ENV-2019-AKL-000309)

ANGUS HARTLEY, BARBARA BELL, CYRIL MAKO, MARK ROSS, RICHARD STEEDMAN, NGAIRE ANN KAUIKASTEVENS, TERRY STEEDMAN as trustees of Owhaoko B & D Lands Trust

(ENV-2019-AKL-000274)

Introduction

1. My name is Ian Fuller. I am Professor in Physical Geography at Massey University. I have 25 years' experience as a university academic researching river processes.

2. I have been engaged by Forest and Bird to provide expert evidence on the Natural Character Index in relation to the application for a Water Conservation Order for the Ngaruroro River in Hawke's Bay.

Qualifications and experience

3. In 1992 I graduated with a BSc Hons 1st class degree in Geography from the University of Wales, Aberystwyth, UK.

4. In 1996 I graduated with a PhD in Physical Geography from the University of Wales, Aberystwyth, UK, researching alluvial response to environmental change.

5. I have worked as a university academic (Lecturer through to Professor) since 1996.

6. Between 1996 and 2003 I worked as a Lecturer in Physical Geography at the University of Northumbria, Newcastle upon Tyne, UK.

7. Since 2003 I have worked at Massey University in Palmerston North, appointed as a Lecturer in Physical Geography, then as Senior Lecturer (2006-2014), Associate Professor (2015-2017), and Professor in Physical Geography (from 2018). I am currently based in the School of Agriculture & Environment in the College of Sciences at Massey University.

8. I have held the position of Visiting Professor, École Normale Supérieure de Lyon, France (June-July 2018); and visiting Lecturer, University of Tsukuba, Japan (July 2014).

9. I am a Fellow of the Royal Geographical Society, New Zealand Geographical Society, and Higher Education Academy.

10. I am an Executive Committee member of Engineering New Zealand's Rivers Group.

11. I am a member of the Certified Environmental Practitioner (CEnvP) Geomorphology Specialist Environmental Advisory Committee (Environment Institute of Australia and New Zealand).

12. I have served as Vice-President (NZ) for the Australia and New Zealand Geomorphology Group and as National Scientific Member for New Zealand in the International Association of Geomorphology (2017-2019).

13. I have 25 years' post-doctoral experience researching river systems at a range of spatial and temporal scales, including river channel dynamics, sediment transfers, and the response of river systems to environmental change.

14. I have published 97 peer-reviewed publications on my research to date.

15. I have authored/co-authored 23 consultancy reports relating to fluvial geomorphology to date, including previous work for Greater Wellington Regional Council, Tasman District Council, Horizons Regional Council, Ministry for Environment, Auckland Council, Fish & Game (Wellington), and the Department of Conservation.

16. I have previously been an expert witness before the Environment Court on a matter pertaining to fluvial geomorphology.

17. I confirm that I have read the code of conduct for expert witnesses contained in the Environment Court Consolidated Practice Note (2014). I have complied with it while preparing my brief of evidence and will continue to comply while presenting evidence. I can confirm that the evidence and the opinions I have expressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

18. For the purpose of this submission for a Water Conservation Order (WCO) on the Ngaruroro River and its tributaries, I have been asked to provide evidence on the Natural Character Index.

19. In preparing this brief of evidence I have reviewed the following documents and evidence:

    - The Statement of Evidence of Kate McArthur on Native Fish values in the lower river (19 May 2020).

    - The Statement of Evidence of Des Smith on habitat values for birds in the lower Ngaruroro River (30 March 2020).

Summary of evidence

20. In this evidence I:

    a) Describe river geomorphology and natural character.

    b) Define the Natural Character Index (NCI), explain how it applies to measuring change in river condition, and provide examples of where it has been used before.

c) Make recommendations on how the NCI could be deployed as part of the Ngaruroro WCO, including the parameters that should be measured as part of an ongoing NCI assessment in a river of this type.

d) Discuss potential risks to the natural character of the Ngaruroro River.

River Geomorphology

21. Each river comprises a unique assemblage of physical features—such as riffles, runs, pools, backwaters, and bars. An example of some of these features is provided in Figure 1 (from Clapcott *et al*., 2011).

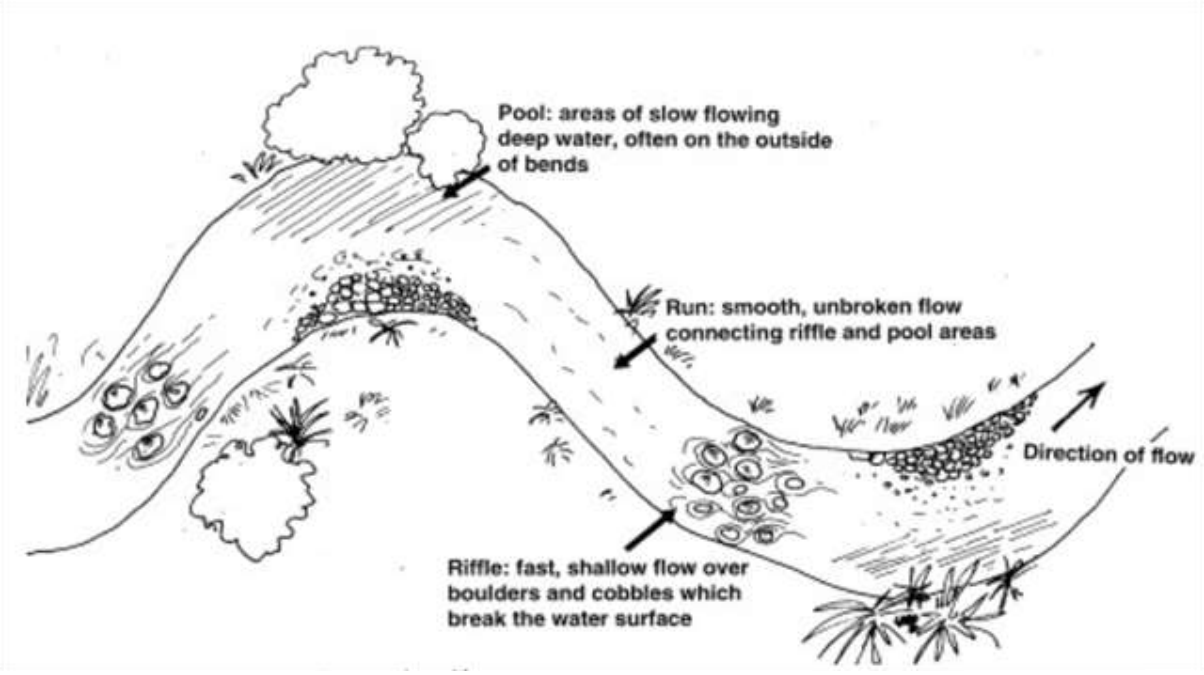

Figure 1. Idealised sketch identifying key physical features in a river (from Clapcott *et al*., 2011)

22. These 'morphological components' are the basic units of river geomorphology (or fluvial geomorphology)—the study of river forms and processes.

23. In combination with river channel and floodplain characteristics (such as channel and floodplain widths, and channel planform—i.e. whether a river is 'braided' or 'meandering'), these units create distinct river forms.

24. River form, or river geomorphology, reflects the way water and sediment moves through a catchment within topographic constraints imposed by surrounding terrain, whether it be a wide valley floor, a narrow gorge, or some other confining structure.

25. River channels are conservative and adjust their geomorphology towards a form that is, overall, stable and in concert with the sediment and flow regimes within a catchment. These regimes are restricted by the environmental conditions of that

catchment, such as rock type, land cover (i.e. vegetation), rainfall and runoff, river gradient, erosion processes, and valley-floor confinement.

26. Within that overall stable form, rivers are frequently adjusting in the landscape because they respond to discrete changes in runoff and sediment supply, which differ storm-by-storm and flood-by-flood. Flood events, in particular, may reorganise the assemblage and/or arrangement of morphological units in a river. This means that the *precise* combination of morphological components is not static—it adjusts to subtle changes in flow and sediment supplied to the river from the catchment. Braided and semi-braided rivers are particularly dynamic in this regard.

27. Within this context of frequent self-adjustment and reorganisation, natural, equilibrium river channel forms can be recognised. It is these forms that define the 'natural character' of the river.

28. Land-cover and land-use change as a result of human activity, as well as flood protection and engineering works, mean that many catchments and rivers are no longer in an entirely natural or pristine state, with sediment and flow regimes altered accordingly. Nevertheless, river geomorphology in these catchments adjusts to this modified state and develops an assemblage of components reflecting the prevailing sediment and flow regimes, and catchment conditions—i.e. the river adopts a modified, but stable, 'natural character'.

Natural Character Index

29. The NCI identifies and quantifies change in the natural character of a river over time. It involves assessing a river's 'current' form against its form at some point in the past.

30. More specifically, the NCI compares a parameter, or range of parameters, (relating to river geomorphology, such as channel width) observed in the present river form with that same parameter, or parameters, at the same site at a reference point in time. If no change in the overall assemblage of morphological units or river parameters measured has occurred (e.g. the width of a river channel is the same now as it was 10 years ago), the observed condition is the same as the reference condition and the ratio is 1.00. If there has been a reduction in the parameter (e.g. the channel has narrowed) the ratio will be less than 1.00 because the observed (current) condition is smaller than the reference (past) condition. In contrast, if there has been an increase in the parameter (e.g. the channel has widened) the NCI will exceed 1.00 because the observed condition is greater than the reference condition.

31. For example, in Figure 2, the width of the active channel at a number of points along a reach of the Rangitata River was measured in 1937 (left) and 2016-2018 (right) (Kay, 2020). The average width in 1937 was 569 m. The average width in 2016-2018 was 382 m. The NCI for this parameter in this reach is therefore:

$$NCI_{active\ channel} = \frac{width\ in\ 2016/2018}{width\ in\ 1937} = \frac{382}{569} = 0.67$$

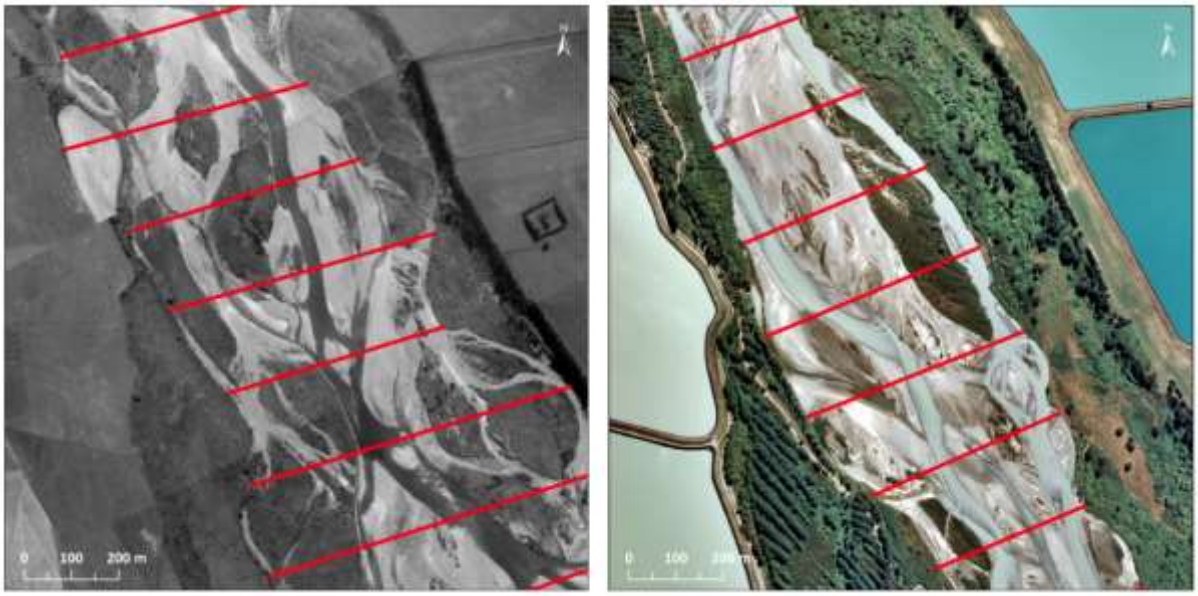

Figure 2. Rangitata River, 1937 (left) and 2016-2018 (right) (from Kay, 2020), red lines show the lengths of active channel measured.

32. The number of parameters measured will depend on the objective of the study and the nature of the river. Each parameter measured generates an NCI ratio of its own (as above). To assess the condition of a river reach as whole, the median of the discrete NCI values that have been measured is used. An example is shown in Table 1:

Table 1. NCI parameters for selected geomorphic characteristics in the lower 62 km of the Rangitikei River, 1940s – 2016 (after Fuller et al., 2020).

	1940s	**2016**	**NCI**
Floodplain area (km²)	35.37	21.55	0.61
Active channel area* (km²)	30.34	15.33	0.51
Unvegetated bars area (km²)	5.92	3.31	0.56
Wetted channel area [low-flow channel] (km²)	6.45	3.07	0.48
Braiding index (Brice, 1960)	2.17	0.3	0.14
Median			0.51

33. The NCI is not a statement of a river's 'naturalness' in relation to catchment or environmental pristineness. The NCI provides an index assessing the extent and trajectory of change in river geomorphology (river form) over time. The drivers of this change may be natural or anthropogenic.

34. Assessment of parameters relating to river geomorphology to derive the NCI for a river uses desktop analysis in a GIS, normally based on aerial photographs from which key attributes and/or morphological units can be mapped. In addition to aerial photographs, high resolution terrain data (e.g. LiDAR) and archive maps can also be used in NCI analysis (see Fuller *et al*., 2020).

35. The GIS environment limits the parameters contributing to an NCI assessment to those which may be confidently derived from airborne imagery or cartographic (mapped) sources. The NCI is not intended as a field-based index, but as an index to assess larger-scale change in river characteristics over time. As such, the NCI is most suited to assessing changes in, for example, channel and floodplain widths, channel planform (quantified using sinuosity for single-thread channels and braiding index for multi-thread channels), areas of bars, areas or lengths of riparian vegetation, and areas or numbers of pools and/or riffles.

36. The length of river assessed with the NCI should be long enough to capture the full suite of morphological units expected in that river as a minimum, i.e. it needs to be long enough to capture a representative sample of a river's form. While the NCI could be applied at a theoretical minimum of 5-7 times the active channel width (this is the average space between pools in a river and should capture most morphological units), a longer sample will produce more meaningful and more robust results, and reduce the likelihood of local anomalies distorting results.

37. The time scale of NCI application can vary from multiple months to multiple decades, depending on the nature, aims, and objectives of enquiry.

Application of the NCI

38. To date in New Zealand, the NCI has been applied to assess changes in river form over a multi-decadal scale, aimed at understanding changes in river geomorphology that are largely in response to deliberate engineering of river channels for flood management and erosion control. Examples include the Hutt, Waikanae, Otaki, Rangitikei, and Motueka Rivers (Fuller *et al*., 2014; 2020) as well as the Rangitata River (Kay, 2020). In these cases, the baseline reference condition was the earliest available aerial photos, which were used to assess the form of the river prior to mid-twentieth century river engineering. The most recently available aerial photos provided observations of present river condition.

39. The approach described here as the NCI has also been identified as the Habitat Quality Index (HQI). The NCI and HQI are one in the same. The nomenclature reflects the vagaries of academic peer review.

40. The NCI has also recently been used to assess the impacts of large flood events on the Waikanae River that occurred in 1998 and 2005, using available 'before' and 'after' aerial photographs (work in progress). The NCI is not limited to assessing the impacts of direct engineering intervention on river channels.

Application of the NCI to the Ngaruroro River

41. As an index assessing the extent of geomorphic change in a river, the NCI could be readily applied as a condition of the Ngaruroro WCO: the current state of the river would be the reference baseline condition. This would provide the reference against which any future change in river geomorphology is measured. The most recently available aerial photographs and/or LiDAR-derived digital elevation models would be fit for this purpose. I understand Hawkes Bay Regional Council has high resolution aerial imagery of the river available for the 2019/2020 summer and is in the process of gathering LiDAR data.

42. The Ngaruroro River has a diverse range of morphologies ranging from fully braided to confined gorge. As a braided to semi-braided or wandering river, the form of the Ngaruroro will be best assessed using the following parameters, which would contribute to an overall median NCI for each reach:

    a. The **Braiding Index**, following the method of Brice (1960), which states the extent of braiding is twice the total length of mid-channel bars in a reach divided by the mid-channel length of that reach. This index assesses the intensity of braiding in a reach. This is important in the Ngaruroro because

braided river habitat is rare in the North Island and critical for both indigenous fish and birds[1].

b. **Active channel width, area of unvegetated bars, and area of wetted channel features.** Braided rivers are characterised by an active channel, comprising multiple wetted channels and multiple bars, set between riverbanks or the valley side. They are generally clear of established vegetation, although vegetation patches may exist within the active channel corridor. Bars and wetted channels in the active channel often change in configuration during flood events, but the river form remains recognisable as a braided river. These key parameters should be measured in addition to the braiding index to refine an understanding of change and river trajectory in the Ngaruroro River:

    i. The **width of the active channel** at discrete locations (ideally coincident with Regional Council cross-section surveys) should be measured to determine whether there is any channel contraction in the Ngaruroro River downstream of the gorge. Active channel contraction is a likely response to flow reduction in the river. The river is mostly confined between river terraces (or farther downstream by stopbanks) so channel expansion is unlikely in this context. However, a large flood could result in lateral erosion leading to expansion.

    ii. **Bars within the active channel**, which can be classified as medial (mid-channel) or lateral (attached to the bank alongside the channel) features. The extent of vegetation coverage on bar surfaces should be assessed. The extent of vegetation coverage is significant to monitor because weed encroachment is recognised as a threat to nesting bird habitat[2]. Areas of bare surface (unvegetated bars), lightly vegetated bar surface (early weed colonisation), and heavily vegetated bar surface should be measured to understand how the overall habitat mosaic may change. To derive an overall NCI score, however, **only the ratio for bare surface would be used**, because if vegetation expansion encroaches on bare surface, the NCI for either parameter cancels out, e.g. a 10 % increase in vegetation cover generates an NCI ratio of 1.1, while a commensurate 10 % loss in bare surface generates an NCI ratio of 0.9, when included together in the overall median NCI for the reach they cancel, which removes the opportunity to properly identify changes happening in the active channel. Bar areas will be stage-dependent (i.e. dependent on the river level/flow – more water in the river means less exposed bars and vice versa), which means the discharge (river level/flow) at the

[1] As per the evidence in chief of Kate McArthur, 2020, and Des Smith, 2020.
[2] As per the evidence in chief of Kate McArthur, 2020, and Des Smith, 2020

time of aerial photo acquisition should be noted and ideally photography flown during similar flow conditions for the purposes of NCI assessment.

iii. Wetted channel features can be assessed. Areas of **channel backwaters**, which represent former wetted channels in the active channel that have since been abandoned by the shifting of braids, should be measured. It is to be expected that individual backwaters will fill with sediment and dry out with time, however, the process of braiding repeatedly generates a sequence of these former channels in the active channel corridor.

iv. If the resolution of aerial photography is sufficiently high and the water is flowing clear at time of acquisition, it should be possible to map areas of pools, riffles and runs in the wetted channels of the Ngaruroro River. Shallow riffles and runs provide important habitat for short-legged wading birds and a variety of threatened indigenous fish. Furthermore, the diversity of riffles, runs, pools, and backwaters in the Ngaruroro River provides important habitat for indigenous fish. These habitats are geomorphologically-defined and tied to the diversity of morphological units in the river, which means that assessing the river geomorphology is directly relevant to the habitats of threatened fish and bird species.

c. Since the focus of the WCO is on the river channel, there is no need to incorporate measurements of floodplain parameters that have been measured in assessments of NCI elsewhere.

43. Each parameter measured will generate an NCI value in its own right, which provides information on how that discrete characteristic has changed (or not). In addition, the median of the NCI values assessed should also be calculated, as this provides a more holistic assessment of overall river condition.

44. The parameters above should be measured within discrete reaches of the Ngaruroro River because the assemblage of morphological units making up the river form or character changes along its length. To discriminate change effectively requires partitioning of the river into discrete coherent reaches, otherwise measurements will be homogenised and of little value. I have analysed the degree of channel confinement, which provides a consistent and straightforward means of partitioning the lower Ngaruroro River:

a. Omahaki Stream confluence to Whanawhana: significantly confined, narrow valley floor (gorge) [approx. 6 km long]

b. Whanawhana to Matapiro Rd: limited confinement, wide valley floor occupied mostly by braidplain [approx. 8 km long]

c. Matapiro Rd to top of HBRC Flood Management Scheme: narrowed active channel confined by river terraces, occupied mostly by wandering-semi braided river [approx. 10 km long].

d. Top of HBRC Flood Management Scheme to Fernhill Bridge: active channel confined by stopbanks, occupied mostly by wandering-semi braided river [approx. 21 km long]

e. Fernhill Bridge to Chesterhope Bridge: active channel confined by stopbanks, occupied mostly by single thread wandering river [approx. 11 km long]

f. Chesterhope Bridge to river mouth: artificial cut mainly comprising single tidal channel, although some bar formation evident towards upstream end [approx. 6 km long]

45. Since the assemblage of morphological units naturally fluctuates within a river reach in response to flood events, some natural, local variability in NCI values over time can be expected. By assessing the entirety of the reaches identified above, localised changes will be averaged out. Nevertheless, a sustained period of low flow, or a succession of floods could naturally impact river form.

46. It has been suggested by Professor Russell Death (pers. comm. 2020) that reduction in the median NCI (derived from the combination of discrete parameters measured) should not exceed 15% and that a decline of more than 40% in any single component would indicate cause for concern and the need for potential mitigation. i.e. component NCI scores should remain >0.6 and median NCI scores >0.85 to maintain natural character.

47. In lieu of a detailed assessment to ascertain the NCI value range that might naturally occur in the Ngaruroro River, I recommend that a reduction in the median NCI should not exceed 15% and a decline in any single component should not exceed 40% to avoid a decline in natural character. This reflects our current understanding of NCI application.

48. These values could be refined for the Ngaruroro River by assessing the NCI in sample reaches using aerial photography before and after a sustained dry period, and before and after a significant flood event, to more precisely set the expected natural limits of NCI variability in this river.

49. I would recommend a frequency of NCI monitoring compatible with HBRC data collection in the river, e.g. at least every 5 years. Additional assessment can be made if observations of river condition present cause for concern.

Risks to natural character

50. The NCI is likely to drop significantly below 1.00 in response to a reduction in braiding intensity, likely accompanied by contraction in the active channel width and areas of bare gravel, increase in the areas of vegetated bars, and reduced backwater areas. This type of river trajectory is likely to reflect a change in flow regime in a river of this nature, namely a reduction in flood magnitude and/or frequency. The geomorphology of braided and semi-braided rivers like the Ngaruroro is refreshed by flood events. An absence or reduction in such events reduces change and potential geomorphic diversity. Flow regime and commensurate geomorphic activity could conceivably be threatened by over-allocation of water from the river, reducing the energy of floods to accomplish geomorphic work that maintains river form.

51. Regardless of any alterations to flow regime, unchecked invasive weed growth poses a significant threat to the areas of bare gravel in the active channel. Vegetation growth serves to lock sediment in place, reducing mobility of the river's bedload and increasing resistance to movement when flow inundates the bar surfaces during high flow events. Vegetation colonisation by invasive weeds can contribute to reduced geomorphic diversity, reducing braiding index and the number and diversity of wetted channel features. Vegetation growth may be exacerbated by a reduction in flood magnitude and frequency which would otherwise rework and freshen bar surfaces, stripping out seedlings before they can become established. However, it should be noted that exotics including lupin, broom, and willow grow exceedingly quickly such that they could potentially become established even with a regime of natural floods.

Flow

52. The NCI provides a means to assess geomorphic response and associated habitat change in response to any change in flow conditions over time. The adjustment of river morphology to a discrete flood event is in part dependent on the antecedent flow conditions, as well as the flood characteristics, particularly flood duration: the longer the time flow exceeds transport thresholds (the flow required to shift riverbed material), the greater the opportunity for geomorphic work to be performed (i.e. sediment transport, re-organisation of morphological units, erosion). If floods are reduced in energy by water abstraction, their ability to perform geomorphic work in the river is compromised. In turn this reduces the dynamics of the river and propensity for change and reworking of the active channel, which is fundamental to the maintenance of braided and semi-braided river forms and the habitats they provide.

53. It is imperative to protect flows above the FRE3 threshold because these flood events are responsible for maintaining braided form and character, and the associated habitat diversity in the Ngaruroro River. FRE3 represents the frequency of

events that exceed three times the median flow and has been used as an index of flow-driven disturbance in stream ecology (Booker, 2015).

Summary

54. River geomorphology reflects the way water and sediment move through a catchment. The form of the river will develop a natural assemblage of morphological units that reflects the prevailing sediment and flow regimes and catchment characteristics. The precise combination of morphological components, i.e. river form, frequently adjusts to changes in runoff and sediment on a storm-by-storm and flood-by-flood basis. River form is not static. Braided and semi-braided rivers are particularly dynamic. Equilibrium forms can nevertheless be recognised, which define the natural character of a river.

55. The Natural Character Index (NCI) compares the present characteristics of a given parameter with the previous characteristics of the same parameter at the same location at a reference point in the past. The NCI is not a statement of a river's naturalness in relation to environmental pristineness, it provides an assessment of the condition and change in equilibrium forms associated with the geomorphology of a river.

56. NCI analysis uses aerial photos, LiDAR, and maps scrutinised within a GIS and is most suited to assessing larger-scale changes in river geomorphology over time (months to decades). NCI has been used interchangeably with HQI and applied on several New Zealand rivers to date.

57. Application of the NCI to the Ngaruroro River as a condition of the WCO would provide an index assessing the extent of any change in river form over time. The focus of analysis should monitor:

    - braiding index [ratio];
    - active channel width [linear metres];
    - bars (type and extent of bare surface) [area];
    - pools [area];
    - riffles [area];
    - runs [area];
    - Backwaters [area].

58. An NCI should be generated for each parameter. The median of these NCI values will provide an overall perspective of river condition. Measurements should be made within six coherent reaches of the river.

59. At this stage, I recommend that a reduction in the median NCI should not exceed 15% and a decline in any single component should not exceed 40% to avoid a decline in natural character. This reflects our current best understanding of NCI application.

60. An assessment of NCI could be undertaken in sample reaches using existing aerial photography acquired before and after a sustained dry period and before and after a significant flood event, to rigorously set the expected natural limits of NCI variability in this river.

61. The greatest risks to the river maintaining its equilibrium forms (natural character) arise from (1) a reduction of flood flows (frequency and magnitude) through water abstraction and (2) unchecked invasive weed growth. The NCI provides a means to assess geomorphic response and associated habitat change in response to any change in flow conditions over time.

Prof. Ian Fuller

[3 September 2020]

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IN THE ENVIRONMENT COURT
AT AUCKLAND

I MUA I TE KOOTI TAIAO O AOTEAROA
TĀMAKI MAKAURAU ROHE

IN THE MATTER	of submissions under s 209 of the Resource Management Act 1991
BETWEEN	**NGA KAITIAKI O TE AWA O NGARURORO** (ENV-2019-AKL-000270) **CLINTON ELLIS, HEEMI JAMES BIDDLE, MARK ROSS, MATIU NORTHCROFT, NGAHERE WALL as trustees of East Taupo Lands Trust** (ENV-2019-AKL-000273) **WHITEWATER NEW ZEALAND INC.** (ENV-2019-AKL-000277) **ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INC** (ENV-2019-AKL-000278)

(Continued next page)

EXPERT REBUTTAL EVIDENCE OF IAN FULLER ON BEHALF OF ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INCORPORATED

27 NOVEMBER 2020

Royal Forest and Bird Protection Society of New Zealand Inc
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HAWKE'S BAY REGIONAL COUNCIL

(ENV-2019-AKL-000272)

PETER HUGHES MACGREGOR, MATAORA NEVILLE TOATOA, NGAPUOTERANGI HOHEPA (KORO) TE WHAITI, SHERYLE ALLEN, MONA STEWART, TANIA HUATA KUPA, KAHUKURANUI HAKIWAI as trustees of the Owhaoko C Trust

(ENV-2019-AKL-000309)

ANGUS HARTLEY, BARBARA BELL, CYRIL MAKO, MARK ROSS, RICHARD STEEDMAN, NGAIRE ANN KAUIKASTEVENS, TERRY STEEDMAN as trustees of Owhaoko B & D Lands Trust

(ENV-2019-AKL-000274)

Introduction

1. My name is Ian Fuller. I am Professor in Physical Geography at Massey University. I have 25 years of experience as a university academic researching river processes.

2. I have been engaged by Forest and Bird to provide expert evidence on the natural character index (NCI) in relation to the application for a Water Conservation Order for the Ngaruroro River in Hawke's Bay.

Qualifications and experience

3. My qualifications and experience are set out in my Evidence in Chief (EiC), dated 3 September 2020.

4. I confirm that I have read the code of conduct for expert witnesses contained in the Environment Court Consolidated Practice Note (2014). I have complied with it while preparing my written Evidence in Reply (EiR) and will continue to comply with it while presenting evidence. I confirm that the evidence and the opinions I have expressed in this statement are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

5. In preparing this EiR I have reviewed the following documents and evidence:

   - The Statement of Supplementary Evidence of Dr Vaughan Keesing (18 September 2020)

   - The Statement of Evidence of Dr Ian Jowett (24 September 2020)

   - The Statement of Evidence of Adam Forbes (24 September 2020)

Summary of evidence

6. In this evidence I clarify those points made in my EiC (4 September 2020) on which the above Respondents have commented.

7. I respond to statements made in Respondents' evidence.

8. I provide an expanded statement on the setting of NCI and WCO limits.

9. I provide an overall summary statement on New Zealand river management.

Response to Supplementary Evidence of Vaughan Keesing (18 September 2020)

10. I would like to clarify that it is not the intention of my EiC or the NCI to provide a description of the Ngaruroro geomorphology in its current condition or state (Keesing, para. 6), as per para. 29 of my EiC. The intention of my EiC was to describe how the NCI can be used to identify and quantify change in the natural character of a river over time.

11. I agree with Dr Keesing (para. 8) that it is critical that a time reference is specified when using the NCI. However, I disagree that the reference point needs to be pre-1840 for application to the Ngaruroro WCO. While a pre-1840 reference point would provide an indication of changes in the river from a relatively 'pristine' state, the intention of incorporating the NCI into the WCO is to set limits on degradation in the natural character of the river from its current condition (for which there is high quality aerial photo evidence), which supports outstanding values. Therefore, a 2020 baseline is appropriate (see para. 33-37 of my EiC).

12. I agree with Dr Keesing (para. 9) in terms of how the NCI works to assess the condition of a river reach and note the measurement areas (and parameters) he references are defined in my EiC (Fuller, para. 42, 44).

13. I agree with Dr Keesing (para. 10): the extent to which the Ngaruroro is outstanding is not the intention of the NCI to assess or determine, since it is an index assessing change over time.

14. I disagree with the factors limiting the application of the NCI to the WCO application identified by Dr Keesing (para. 11) because:

    a. the historic photograph record is irrelevant, because adopting the NCI as part of the WCO will involve comparing the future state of the river with the present (as discussed above)

    b. measurement limits of the parameters have been demonstrated not to be an issue in published literature (Fuller et al. 2020)

15. However, I agree with Dr Keesing (para. 11) that the NCI output is suited to assessing relative change in river geomorphology, not the value of the aquatic habitat. Though since the condition of the habitat is in part dependent on the physical template provided by the river geomorphology (as per the EiC of Kate McArthur, 2020; and Des Smith, 2020), the NCI may nevertheless be used to assess change in habitat condition.

16. In response to Dr Keesing (para. 12) I reiterate that river geomorphology provides the template for river habitat (see Fuller et al. 2019). I agree with his assertion that the NCI is a 'geomorphology snapshot' of the difference in some river parameters from time 1 to time 2 and agree with the list of variables identified that do not contribute to an NCI assessment. It is not the intention to use the NCI beyond an assessment of natural character and the physical template for river habitat. My statement that the NCI has been identified as the HQI (Habitat Quality Index) was simply a reference to its application in other contexts where it has used this name and, in some cases, has been used to measure changes in other variables.

17. It is precisely because the Ngaruroro is a dynamic system that an assessment of potential change in natural character would be beneficial in the context of the WCO (Keesing, para. 13).

18. It is beyond my expertise to comment further on the value of braided rivers to birds and indigenous fish (Keesing, para. 18a), since my statement referred to the Evidence in Chief of Kate McArthur and Des Smith (2020) on these subjects. They are best to respond to these statements.

19. However, in para. 18b Dr Keesing is incorrect: the braided nature of a river is not "governed by the quantities and frequencies of river flow and the extent of flood management works". Braided rivers relate to a complex interplay between flow (flood magnitude, frequency, and duration), bed-calibre sediment (quantity and grain size), stream power (a function of channel-bed gradient and discharge), and bank erosion. It is a plain statement of fact that the extent of braiding in the Ngaruroro has been reduced by 'flood management' activities governed and monitored by (what is now) Hawkes Bay Regional Council, namely riparian planting (reducing bank erosion) and gravel extraction (reducing bedload).

20. I agree with Dr Keesing (para. 19) that the NCI makes no comment on outstandingness, but as noted in the Joint Witness Statement of 1 October 2020, it is my contention that the NCI provides a holistic assessment of overall river condition over time and therefore has value as part of the Ngaruroro WCO to ensure natural character does not degrade.

21. The points made by Dr Keesing in para. 20 are moot and already addressed in this rebuttal, noting that in my EiC para. 42 and 57 I also comment on the limitations imposed by clarity of water to assess subaqueous features in the river channel (pools, riffles).

22. It is a pity that Dr Keesing's attempts to use aerial photography to assess habitat quality at a large scale have not worked (para. 21). However, his own experience should not, I believe, cloud the Court's judgement on the efficacy and utility of the NCI, which has been demonstrated as effective in this regard in published, peer-reviewed literature (Fuller et al. 2020).

23. To clarify, the removal of floodplain parameters (Keesing, para. 22) from the application of the NCI to the WCO is simply because the floodplain is not being considered as part of the WCO, where the focus is on the active river channel (bank to bank). It would not be appropriate to incorporate assessment of floodplain characteristics, although if the Court wished, these could be readily added. I also note the use of the median NCI score will not be of relevance anymore, as I suggest in this statement (below) that setting a separate limit for each variable of the NCI incorporated into the WCO is more useful in this context.

24. I agree that the number of measurements, and where these are undertaken for the NCI, is very important (Keesing, para. 23) and refer to my EiC (Fuller, para. 42 and 57).

25. I concede that localised changes will not be "averaged", since median values are being used (Keesing, para. 24) and suggest that normalised is a better term used here. However, as above, this is moot because I suggest (below) setting individual limits for each variable of the NCI as more useful in the context of the WCO.

26. Dr Keesing questions the relevance of the NCI in the context of a WCO (para. 25), to which I respond that the purpose of the NCI is monitoring ongoing river condition following the implementation of the WCO to detect any change that may occur in future – and to set a limit on degradation. As discussed in the Joint Witness Statement (1 October 2020), the NCI therefore provides a method of holistic monitoring of river condition as part of the WCO.

27. Dr Keesing (para. 25) also questions the NCI limits proposed in my EiC. Following analysis of fluctuations in the character of the river over the previous decade using measurements from aerial photography, I have suggested a revised approach to setting these. This is discussed later in this statement.

28. I wholeheartedly endorse the suggestion made by Dr Keesing (para. 26) that the Regional Council may like to consider the NCI as a possible monitoring tool. If it were part of the Council's approach to river management, incorporating it in the WCO would be readily achieved (and proposed limits would be readily complied with).

29. In response to the criticism made by Dr Keesing in paragraph 27, some assessments of the Ngaruroro River have now been made to better inform discussion of risks to the condition of the Ngaruroro River and appropriate NCI limits (as mentioned above). These are included following my responses to the statements made by Ian Jowett and Adam Forbes.

30. I agree with Dr Keesing's conclusions that the NCI is a tool to measure broad-scale changes in some geomorphological parameters of the river (para. 28) and that the NCI does not assess the outstandingness of the river (para. 29).

Response to Statement of Evidence of Ian Jowett (24 September 2020)

31. Dr Jowett's assertion in para. 20 (d) that flood control works and channel maintenance would keep the river in its present state is at odds with his assertion in 20 (b) that the magnitude and frequency of (slightly reduced) high flows is sufficient to maintain the diversity of present habitat. The fact that management is required suggests flows in and of themselves are in fact insufficient to maintain habitat diversity.

32. In response to Dr Jowett's suggestion (citing from literature at para. 26) that the movement of fine sediment at flows usually in the range of 3-6 times the median is necessary for flushing algae, I refer the Court to a recently published review paper by Neverman et al. (2018), of which I was a co-author, which critically reviews the effectiveness of 'flushing flows' and the effectiveness of fine sediment abrasion for

algal control. Neverman et al. (2018) argue that “molar action” (when coarse particles, much bigger than fine sediment – i.e. stones etc., collide with periphyton biomass) is a better and more desirable and long-lasting means of removing algae from gravel and cobbles.

33. I also note in reference to Dr Jowett’s statement at para. 27 that the threshold of motion to move sediment on a river bed is not as simple as it may appear. The bed structure, mortaring (degree that fine sediment has acted like cement to hold stones in place), and organisation of stones on the riverbed are all critical in determining the threshold of motion, such that no single value of shear stress can be identified at which sediment of a given size moves.

34. I agree that channel forming flows are larger floods (Jowett, para. 28), which break-up the armour layer of the riverbed (the layer of stones that has become ‘reinforced’ and hard to break up) and cause large scale bed movement, controlling river morphology, and I add that these floods work alongside the sediment supply / regime, since river morphology reflects both discharge regime and sediment flux.

35. I agree that the mean annual flood, approximated as Q2.33 (the flood that occurs every 2.33 years) is often used as the channel-forming flood (Jowett, para. 28), but would caution that this is a little over-simplified since the precise relationship between flood magnitude/frequency and channel form is dependent on channel sensitivity: smaller floods have channel-forming capacity in some systems, whilst in less sensitive rivers much larger floods are required to maintain channel form. This concept has been discussed in floods literature.

36. In response to Dr Jowett’s assertion in para. 43, the maintenance of pools (and adjacent riffles) is in fact much-debated in the scientific literature. There is not a simple relationship as he implies (‘big floods scour pools, absence of large floods fills them in’). The pool-riffle unit is something of an enigma in fluvial geomorphology and in fact large floods may completely reset channel form, infilling some pools and scouring out others. The precise trajectory and relationship between pools, riffles, and floods is dependent on the nature of a specific river system and form.

37. I agree with Dr Jowett’s comment in para. 44 that floods cause sediment movement that can create or disestablish braids, but I note the movement of sediment in a braided river is complex. Published literature indicates that bedload often moves as a series of coherent sheets or waves or pulses during flood events, and it is the stalling of these sheets of gravel that has been linked to the braiding mechanism

(Ashmore, 1991). Nevertheless, I completely agree with Dr. Jowett's assessment of the conditions he identifies as being associated with braiding (para. 45).

38. Dr Jowett refers to a threshold for sediment load at which a river changes from a single-thread to a braided system, providing the banks are erodible (para. 46). However, this appears to miss the concept of the channel continuum in which "hard" thresholds are in fact difficult to identify: in reality the river transitions from single thread, to wandering, to braided. Some literature refers to distinct thresholds but in practice these are difficult to identify with certainty. I include a Figure to illustrate the channel continuum concept, to avoid misunderstanding.

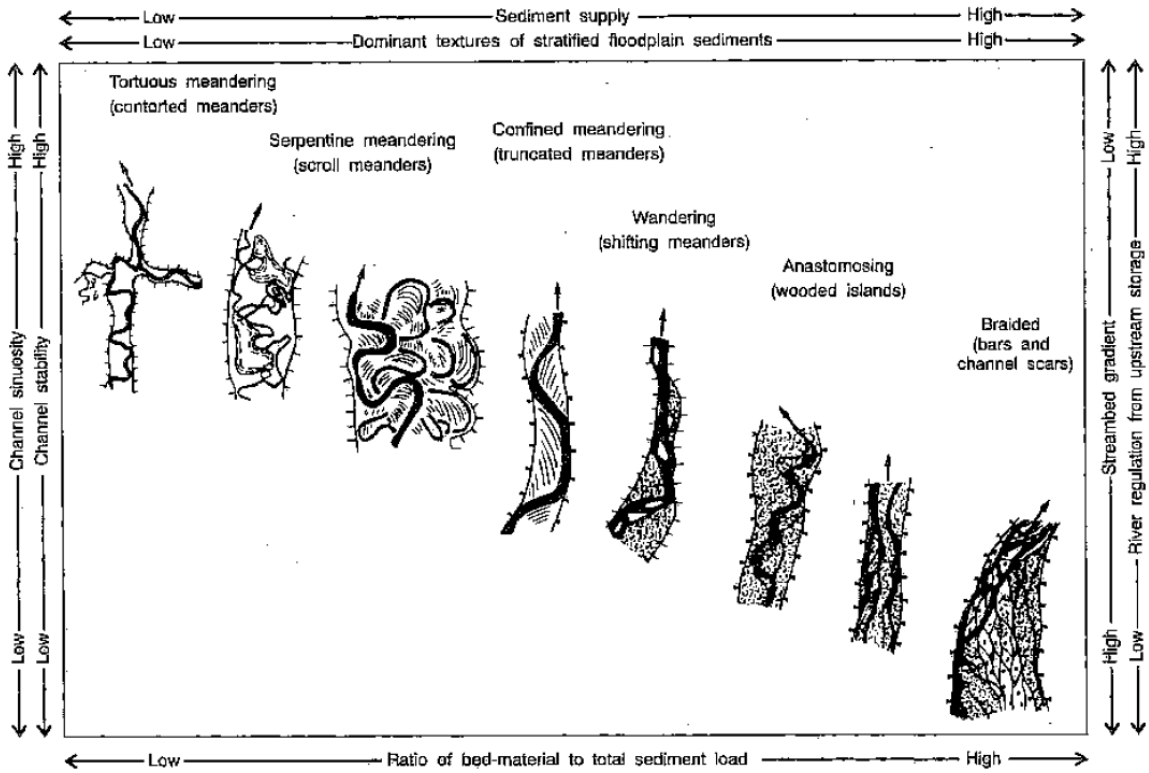

Figure 1: the continuum of alluvial river channel types: source Fig 16.1, Mosley (1992).

39. Dr Jowett refers to the Waitaki River to illustrate how difficult it is in his opinion to alter flows and sediment transport sufficiently to change a river from a braided to a single channel system (para. 47-50). In response to this statement:

    a. Firstly, there is evidence from around the world that describes the transition of braided rivers to single thread rivers in response to flow modification and change in sediment flux. By way of example, I refer the Court to a review of Italian rivers by Surian and Rinaldi (2003). More specifically, Piegay et al. (2009) found 53% of a sample of 1214 km of braided rivers in SE France disappeared in the 200 years prior to their study through dam-related impacts, reservoir construction, channelisation, and embankment (each with implications for flow regime and sediment flux). Gurnell et al (2009) document similar changes from a broader geographical spread across Europe. While I accept that Dr Jowett's own experience suggests it may be

hard to change a river from braided to single thread by altering flow and sediment regimes, this is not consistent with international literature on the subject. I have personally observed this transformation in the Rangitikei River (see Fuller et al. 2020), but recognise that this channel modification also resulted from direct intervention in the channel by engineering to stabilise banks.

b. Secondly, in regard to the Waitaki, the nature and condition of the river has been significantly affected following the modifications described by Dr Jowett (para. 49), who, I believe, downplays the changes that have been observed in this river following flow regulation. The intensity of braiding has decreased. The width of the active channel has decreased. The growth of vegetation within the active channel has increased, such that once mobile and bare (or sparsely vegetated) gravel bars are now immobile vegetated islands. The river is *technically* still classified as braided, but the channel mosaic has been significantly impacted by flow modification and changes in sediment flux. A NIWA Client Report in 1997 cited by Hicks et al. (2006) reported that the pre-regulated riverbed was 2 km wide, narrowing to 0.5 km in the 1990s. The NIWA report refers to a river characterised by temporary islands vegetated by tussock, shifting gravel bars, and channels. The river has since become invaded by exotic vegetation because flows are insufficient to remove vegetation, bars have stabilised, and a central fairway is maintained by de-vegetation. Figure 2 illustrates some of these changes and highlights the vulnerability of New Zealand's braided rivers to such

change. It also illustrates the significance of these changes for river geomorphology and habitat.

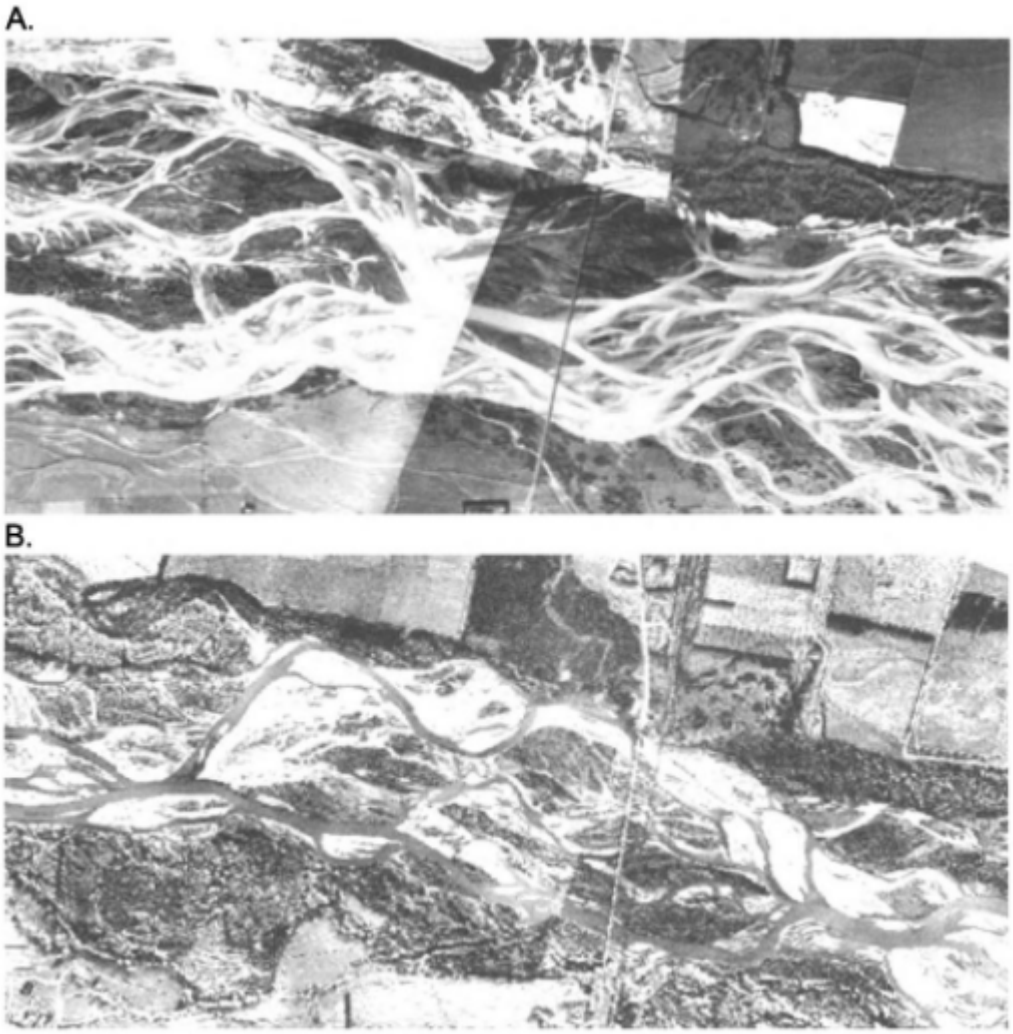

Figure 2: Lower Waitaki River, 5 km upstream from the coast, photographed in 1936 (A) and 2001 (B) when the river discharge was ~150 m^3/s, flow is left to right, frame base spans 3.7 km, scales are identical. Source: Figure 2, Tal et al. (2004).

40. I note Dr Jowett's application of the NCI to Waitaki parameters (para. 54-55), although the location and length of river is not provided. In contrast with the location measured by Dr Jowett, evidence presented above (Hicks et al., 2006) indicates a reach of river far more significantly impacted, which would generate an NCI of 0.25 (75% width reduction). This highlights the importance of clarity regarding the reporting of NCI figures. I note that the difference may be in the additional 15

years between 1997 and 1981 'end dates' of these analyses, during which time further narrowing may well have occurred.

41. Where rivers have not been modified, an NCI of one would be expected, as per Dr Jowett's suggestion in para. 56.

42. It is beyond the scope of my evidence, which focuses on geomorphology, to comment on the comparison made between the Waitaki and Rakaia fish and benthic invertebrate communities (Jowett, para. 57).

43. I agree with Dr Jowett's comment (para. 58) that the NCI is not a predictive tool. It is not intended as such, but as a monitoring tool.

44. I agree with Dr Jowett (para. 59) that the Ngaruroro River is not in its natural state and has been actively managed for flood protection and erosion control. This, however, does not preclude the use of the NCI as a monitoring tool to assess holistic river condition.

45. While I accept that high flow abstractions are a small proportion of channel forming flows (Jowett, para. 60 a), if the Waitaki is being used as an example of why what could happen in the Ngaruroro is of no concern, I have serious reservations. In particular, I doubt that the consequences of changes to the flow regime would be inconsequential for channel geomorphology, because the Waitaki clearly has been significantly affected by modest changes in flow regime. While abstraction does not starve the river of sediment in the same way as flow regulation via dams, gravel extraction and river bank stabilisation may have an equivalent effect of reducing sediment flux through the system. I trust that the Waitaki is not being held as a model to which Dr Jowett and others aspire for the Ngaruroro.

46. I agree with Dr. Jowett's observation (para. 60b) that the upper river is confined and likely not to change width or form. I also recognise that flood works are likely to keep the braided lower river in its present state (Jowett, para. 60c), though I note that not all of the 'lower' river falls within the flood management scheme, and in some cases HBRC's flood management appears to be degrading the character of the river by encroaching into the active riverbed (as below). In any case, this is where the NCI would be of value to monitor future river condition and ensure that the present state is in fact maintained.

47. The assertion made by Dr Jowett in para. 61 cannot actually be determined without monitoring. The Waitaki serves as a caution here: zero change in river type may be *assumed*, but the reality may be quite different.

Response to Supplementary Evidence of Adam Forbes (24 September 2020)

48. I note para. 7-11 where it is asserted that the existing HBRC river management regime is "appropriately managing" the risk to bare gravel areas that I identify in my EiC (Fuller, para. 51). However, aerial photos of the Ngaruroro suggest otherwise

and I note that as part of river management the Regional Council continues to plant willow poles *within* the active channel of the river on bare gravel surfaces, thereby emulating the effect of invasive vegetation and the threat identified in my EiC (Figure 3).

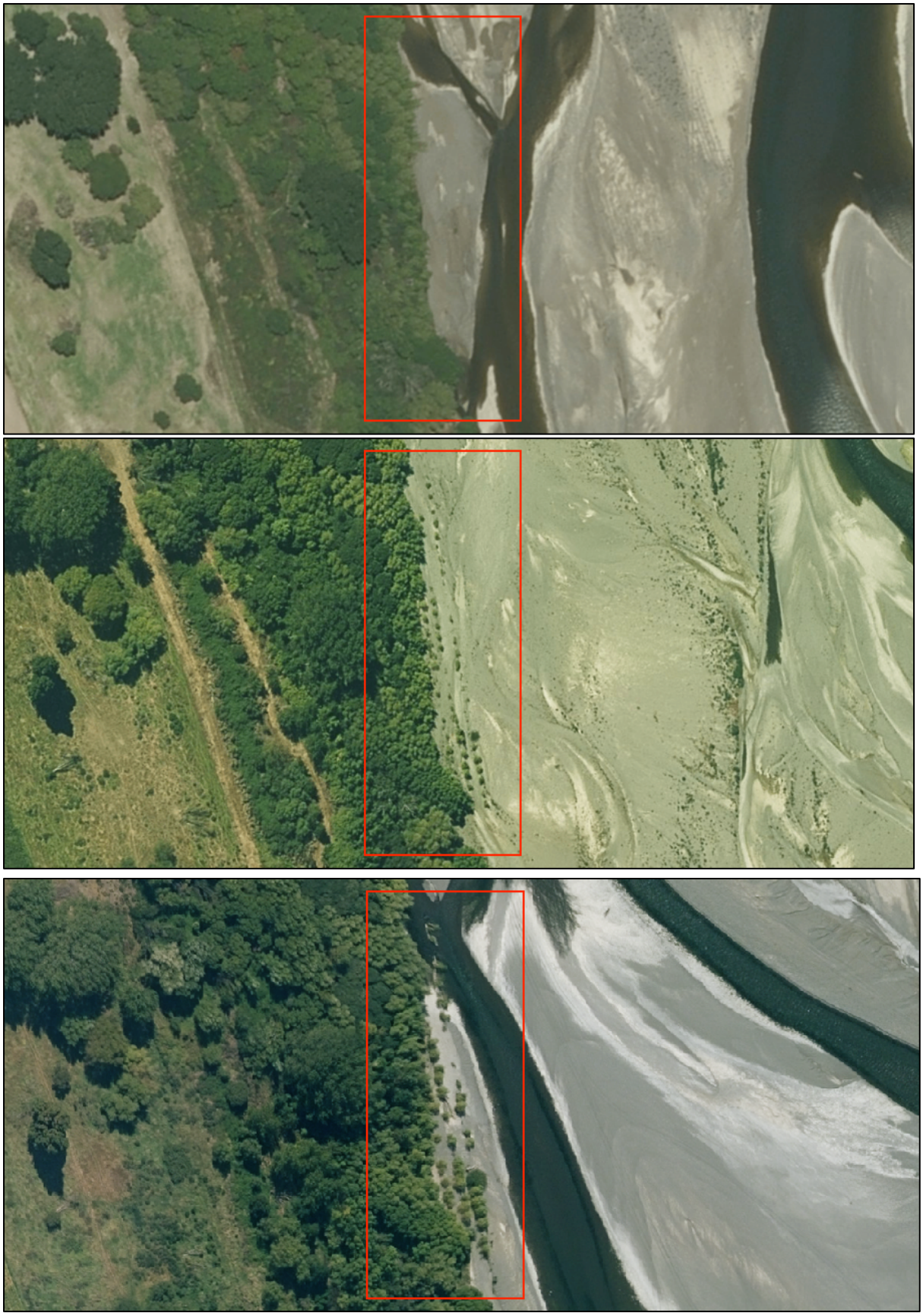

Figure 3: Ngaruroro riverbed just upstream of the Mangatahi Stream confluence, true right bank (https://goo.gl/maps/BvzjSVVpHj2s1Dau7), summer 2010/2011 (top), summer 2014/2015 (middle), and summer 2019/2020, (bottom), illustrating the planting and establishment of willows on a previously unvegetated bar in the active channel of the river.

NCI assessment and appropriate WCO limits

49. In my EiC (para. 47 and 59) I recommended that a reduction in the median NCI score for the lower reaches of the Ngaruroro should not exceed 15% and a reduction in any single component score should not exceed 40% to avoid a decline in natural character. This was a reflection of our best understanding of NCI application.

50. However, I also stated (para. 48 and 60) that analysis of the lower reaches of the Ngaruroro River could be undertaken to ascertain the natural limits of NCI variability in the river and more rigorously set NCI limits for the WCO.

51. This analysis would ensure that the proposed limits are wide enough to allow for the natural fluctuations in variables of character that are associated with a braided river, while still triggering a management response if a variable is reduced by a degree greater than what could be expected within natural fluctuations.

52. This analysis has since been undertaken on the three reaches of the river for which specific protection of natural character is sought through the WCO[1] – that is: Whanawhana to Matapiro Rd, Matapiro Rd to the top of the HBRC flood management scheme, and the top of HBRC flood management scheme to Fernhill Bridge. Justification for this separation is outlined in para. 44 of my EiC.

53. The active channel width, braiding index, and area of unvegetated bar for these reaches of the Ngaruroro River over the last decade have been calculated using aerial photos[2] flown in the summers of 2010/11, 2014/15, and 2019/20. These variables were identified in para. 42 of my EiC as the most appropriate to assess the form of the river.

54. While the area of backwaters was also noted as appropriate for measuring river form in my EiC, as well as the respective areas of riffles, pools, and runs where the resolution of aerial imagery allowed it, a preliminary review of changes in the area of backwaters over the last decade suggests the focus for limits in the WCO should be on the channel width, braiding index, and area of unvegetated bar (noting that ongoing monitoring could still include those other measurements).

55. The results of this analysis, along with the associated NCI values, are presented in the tables below (a larger table, including flows during the survey acquisition periods and hydrographs, is included as an appendix).

[1] i.e. Whananwhana to Fernhill, as noted in clause 9.(2)(a)(i) of the draft WCO in Annex A of the supplementary evidence of Greg Carlyon dated 15 June 2020

[2] Sourced from the LINZ Data Service and Hawke's Bay Regional Council

56. **Table 1:** Active channel width 2014/15 to 2019/20

Reach	2014/15 (m)	2019/20 (m)	NCI
Whanawhana to Matapiro Rd	390	364	0.93
Matapiro Rd to top of HBRC Flood Management Scheme	274	269	0.98
Top of HBRC Flood Management Scheme to Fernhill Bridge	301	301	1.00

57. **Table 2:** Braiding Index 2014/15 to 2019/20

Reach	2014/15	2019/20	NCI
Whanawhana to Matapiro Rd	3.19	2.49	0.78
Matapiro Rd to top of HBRC Flood Management Scheme	1.66	1.91	1.15
Top of HBRC Flood Management Scheme to Fernhill Bridge	2.16	2.46	1.14

58. **Table 3**: Area of unvegetated bars 2014/15 to 2019/20

Reach	2014/15 (ha)	2019/20 (ha)	NCI
Whanawhana to Matapiro Rd	196.07	218.89	1.12
Matapiro Rd to top of HBRC Flood Management Scheme	228.08	220.55	0.97
Top of HBRC Flood Management Scheme to Fernhill Bridge	528.51	503.03	0.95

59. **Table 4:** Active channel width 2010/2011 to 2014/15

Reach	2010/11 (m)	2014/15 (m)	NCI
Whanawhana to Matapiro Rd	379	390	1.03
Matapiro Rd to top of HBRC Flood Protection Scheme	279	274	0.98
Top of HBRC Flood Protection Scheme to Fernhill Bridge	304	301	0.99

60. **Table 5:** Braiding Index 2010/2011 to 2014/15

Reach	2010/11	2014/15	NCI
Whanawhana to Matapiro Rd	5.48	3.19	0.58
Matapiro Rd to top of HBRC Flood Protection Scheme	2.65	1.66	0.63
Top of HBRC Flood Protection Scheme to Fernhill Bridge	4.13	2.16	0.52

61. **Table 6:** Area of unvegetated bars 2010/2011 to 2014/15

Reach	2010/11 (ha)	2014/15 (ha)	NCI
Whanawhana to Matapiro Rd	211.07	196.07	0.93
Matapiro Rd to top of HBRC Flood Protection Scheme	207.19	228.08	1.10
Top of HBRC Flood Protection Scheme to Fernhill Bridge	462.82	528.51	1.14

62. These results suggest that changes in the past 5 years have fluctuated by up to 7% in channel width, ~20% in braiding index (a less precise parameter), and ~12% in the area of unvegetated bar. Similar results were derived for comparison between 2010/11 and 2014/15, although the difference in braiding index is much greater, probably reflecting a more complex network of braids following a much higher flow during the 2010/11 acquisition period: 884.5 m^3/s compared with maxima of 63.7 m^3/s and 11.0 m^3/s around the 2014/15 and 2019/20 acquisition periods respectively (noting that the metadata for more recent surveys is more precise than earlier surveys – see appendix 1). A table of the full analysis, including flows during the survey acquisition periods, is included as appendix 1 to this evidence. Associated hydrographs for image acquisition periods are included in appendices 2-5.

63. Assessment of these parameters and associated NCI values suggests that a reasonable limit to impose upon changes to river condition through the WCO for each of the reaches are in a similar order, i.e. future reductions in the NCI for each variable should not exceed the changes (+/-) identified in Tables 1 to 6. This would account for any fluctuation expected through natural adjustments in the river. It is accepted that braiding index is much more variable than either bar area or channel width and likely more sensitive to natural variability in flow regime, therefore the 'window' for natural fluctuation would be wider and the NCI limit lower than for other variables.

64. In light of this analysis, NCI limits could be inserted into the WCO in the following way:

    a. No resource consent may be granted or rule included in a plan that, either itself or in combination with other consents or rules (including permitted activities) in existence at the time of the decision:

        i. would generate an adverse effect resulting in a natural character index (NCI) score of less than any of the values in the table below for the associated reach and variable as measured against a 2020 reference condition.

Reach	Whanawhana to Matapiro Rd	Matapiro Rd to top of HBRC Flood Management Scheme	Top of HBRC Flood Management Scheme to Fernhill Bridge
Average channel width	0.93	0.98	0.99
Braiding Index	0.78	0.85	0.86
Area of unvegetated bar	0.88	0.90	0.86

65. These limits would be reflective of the maximum fluctuations identified between surveys of the listed reaches over the past decade in Tables 1-6, noting that braiding index limits have been derived solely from the 2014/2015 to 2019/2020 changes (Table 2) to account for the much higher 2010/2011 flows discussed in para. 62. That is maximum changes of:

    a. 7%, 2%, and 1% in the average channel width of the reaches respectively

    b. 22%, 15%, and 14% in the braiding index of the reaches respectively

    c. 12%, 10%, and 14% in the area of unvegetated bar of the reaches respectively

66. In this context (and as alluded to earlier in this EiR), it would be appropriate to exclude the consideration of a median NCI value in limits set through the WCO in this way and simply apply a 'bottom line' approach to each of the variables of natural character.

Limits on abstraction

67. The importance of maintaining flood flows (in particular flows above the FRE3 threshold) and flow variability to protect the morphology of the Ngaruroro River was discussed in para. 52-53 of my EiC. The implications of flow regulation are also discussed in this EiR, in particular in para. 39b and 45.

68. I reiterate the importance of protecting flows to protect the natural character of the Ngaruroro. I consider limits on abstraction, flow variability, and the minimum flow would be beneficial alongside NCI limits and limits on damming to ensure the natural character of the lower Ngaruroro river is protected.

Conclusion: Modern River Management

69. Good practice in river management now recognises the need to provide room for the river to accommodate natural processes of adjustment (e.g. Piegay et al. 2005; Buffin-Belanger et al., 2015; Chone and Biron, 2016). That is, good practice now rarely allows for the further restriction or narrowing of river corridors. This practice is applied internationally and is beginning to be applied in New Zealand (Ramon Strong, Horizons Regional Council, pers. comm.). As a holistic approach to assessing overall river condition, the NCI provides a suitable monitoring tool to ensure narrowing and reduction of geomorphic diversity does not occur in this unique North Island braided river environment. In the event of future changes in HBRC's river management approach to align with best practice elsewhere, the NCI can be used as a tool to assess the success of intended restoration, as well as preservation and conservation (Fuller et al., 2020), including through the WCO.

Prof. Ian Fuller

[27th November 2020]

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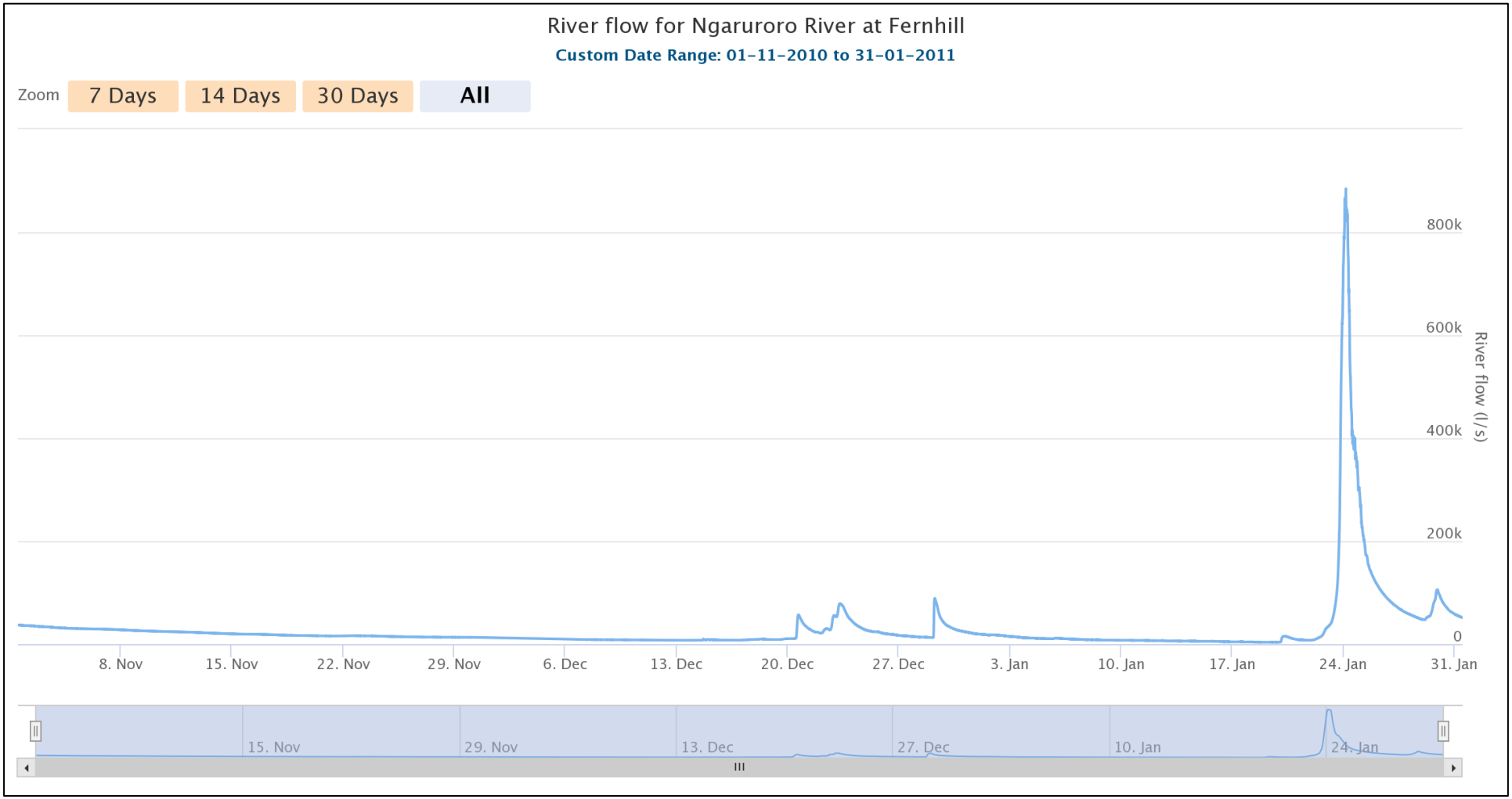
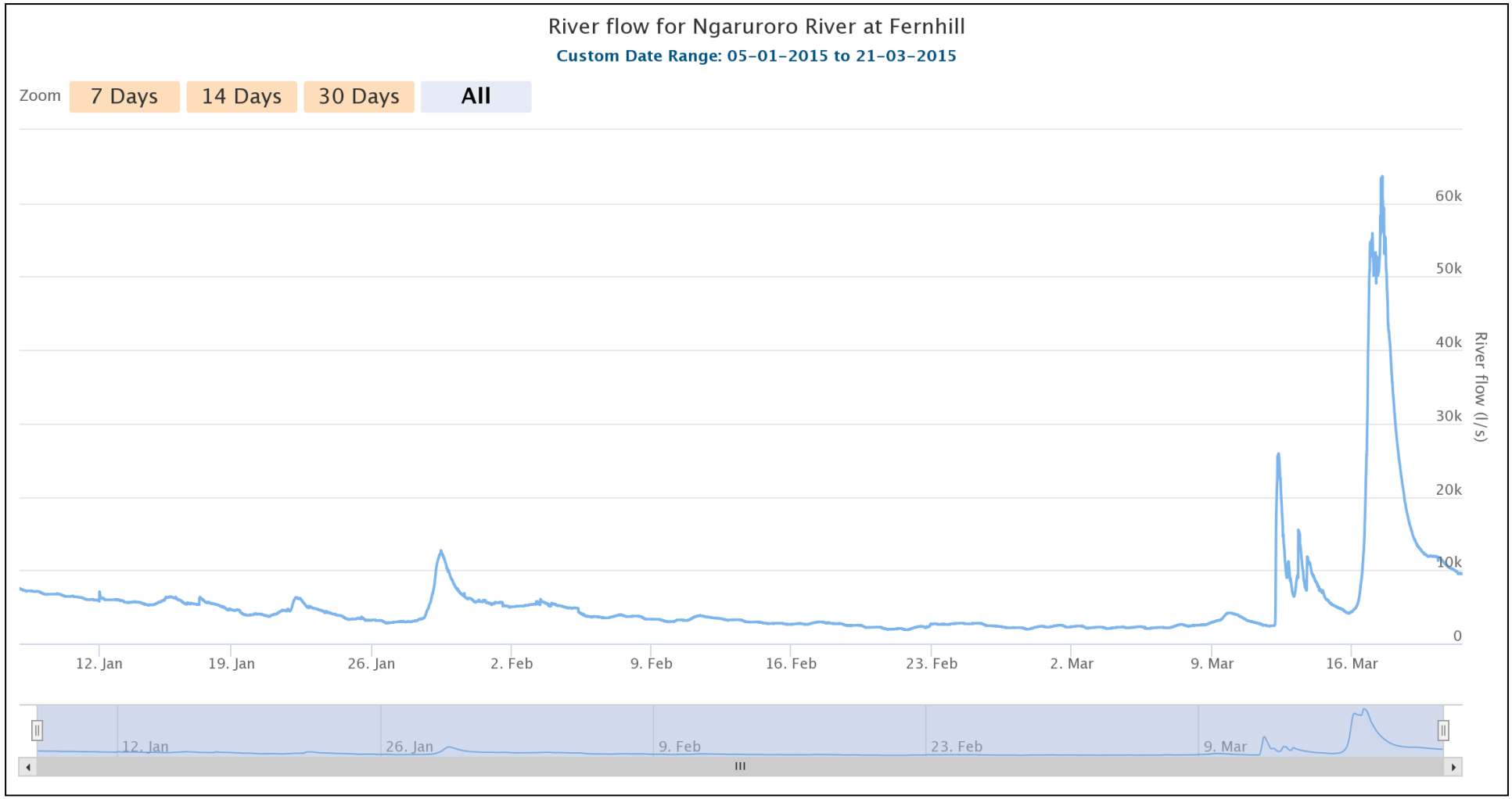
Appendix 1: Channel measurements from the 2010/2011, 2014/2015, and 2019/2020 aerial surveys for each reaches of the lower Ngaruroro River as identified in my EiC. Dates of image acquisition and flows during acquisition are also included. Hydrographs for the image acquisition periods are provided in the following appendices.

Reach	**Whanawhana to Matapiro Rd**			**Matapiro Rd to top of HBRC flood management scheme**			**Top of HBRC flood management scheme to Fernhill Bridge**		
Year	**2010/2011**	**2014/2015**	**2019/2020**	**2010/2011**	**2014/2015**	**2019/2020**	**2010/2011**	**2014/2015**	**2019/2020**
Active channel width (m)	379	390	364	279	274	269	304	301	301
Braiding index (Brice's)	5.48	3.19	2.49	2.65	1.66	1.91	4.13	2.16	2.46
Unvegetated bars (area, ha)	211.07	196.07	218.89	207.19	228.08	220.55	462.82	528.51	503.03
Date of image acquisition	Nov 2010 - Jan 2011	05/01/15, 06/01/15, 11/01/15, 18/02/15, 19/02/15, 28/02/15, 01/03/15, 02/03/15, 21/03/15	05/03/19 - 07/03/19	Nov 2010 - Jan 2011	05/01/15, 06/01/15, 11/01/15, 18/02/15, 19/02/15, 28/02/15, 01/03/15, 02/03/15, 21/03/15	07/03/19,	Nov 2010 - Jan 2011	05/01/15, 06/01/15, 11/01/15, 18/02/15, 19/02/15, 28/02/15, 01/03/15, 02/03/15, 21/03/15	07/03/19, 19/04/19, 06/03/19, 25/01/20
Approx. flow during acquisition (@ Fernhill)	Max 884.5 m^3/s, min 3.3 m^3/s.	2.2 - 10.1 m^3/s	8.2 - 8.7 m^3/s	Max 884.5 m^3/s, min 3.3 m^3/s.	2.2 - 10.1 m^3/s	8.1 - 8.2 m^3/s	Max 884.5 m^3/s, min 3.3 m^3/s.	2.2 - 10.1 m^3/s	3.3 - 8.5 m^3/s

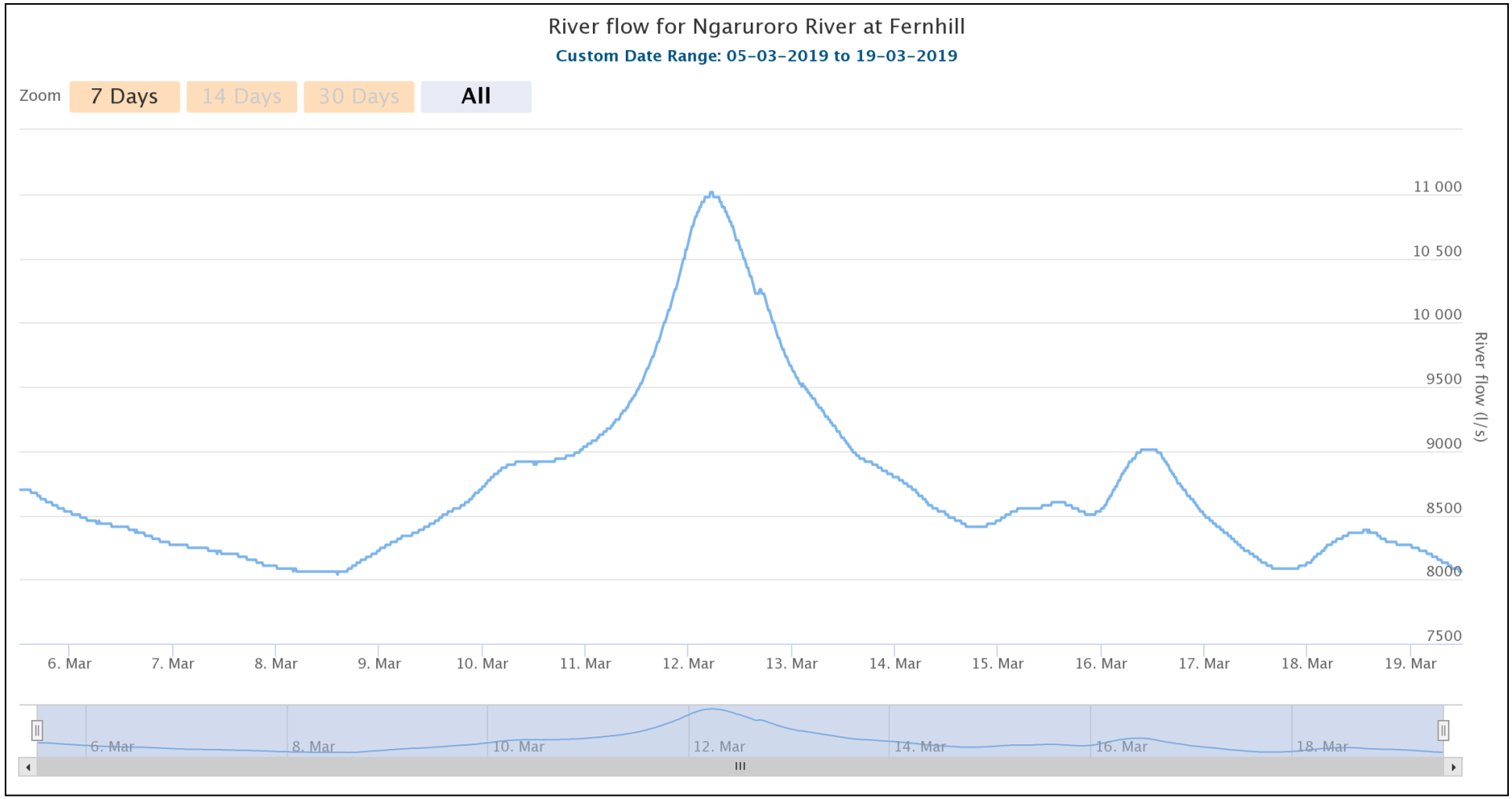
Appendix 2: Ngaruroro River flow hydrograph at Fernhill across the survey period for 2010/2011 aerial photos.



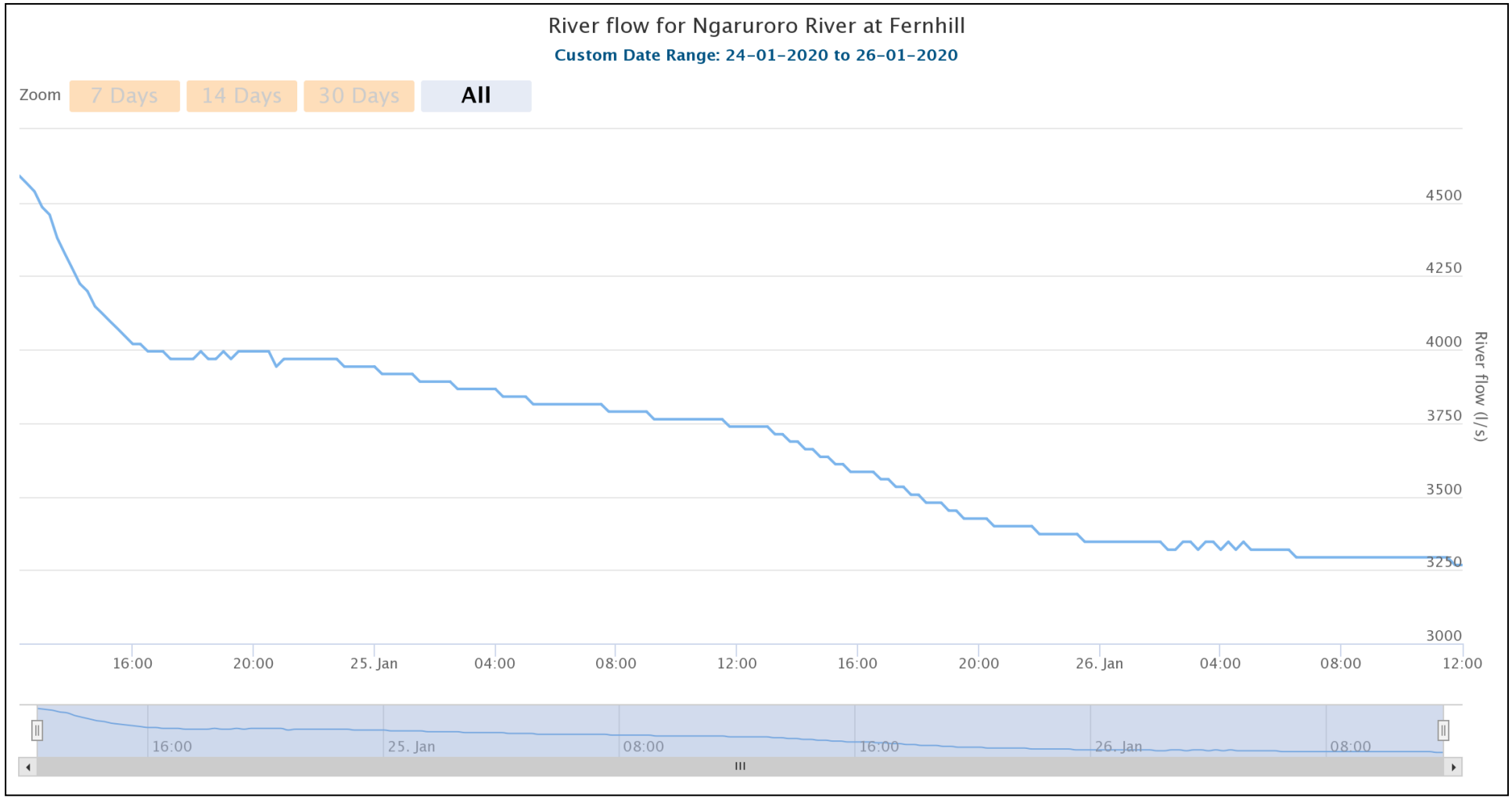
Appendix 3: Ngaruroro River flow hydrograph at Fernhill across the survey period for 2014/2015 aerial photos.



Appendix 4: Ngaruroro River flow hydrograph at Fernhill across the survey period for 2019/2020 aerial photos (image 1 of 2).



Appendix 5: Ngaruroro River flow hydrograph at Fernhill across the survey period for 2019/2020 aerial photos (image 2 of 2).



IN THE ENVIRONMENT COURT

AT AUCKLAND

I MUA I TE KOOTI TAIAO O AOTEAROA

TĀMAKI MAKAURAU ROHE

IN THE MATTER	of submissions under s 209 of the Resource Management Act 1991
BETWEEN	**NGA KAITIAKI O TE AWA O NGARURORO** (ENV-2019-AKL-000270) **CLINTON ELLIS, HEEMI JAMES BIDDLE, MARK ROSS, MATIU NORTHCROFT, NGAHERE WALL as trustees of East Taupo Lands Trust** (ENV-2019-AKL-000273) **WHITEWATER NEW ZEALAND INC.** (ENV-2019-AKL-000277) **ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INC** (ENV-2019-AKL-000278)

(Continued next page)

REPLY EVIDENCE OF THOMAS JAMES KAY ON BEHALF OF ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INCORPORATED

21 DECEMBER 2020

HAWKE'S BAY REGIONAL COUNCIL

(ENV-2019-AKL-000272)

PETER HUGHES MACGREGOR, MATAORA NEVILLE TOATOA, NGAPUOTERANGI HOHEPA (KORO) TE WHAITI, SHERYLE ALLEN, MONA STEWART, TANIA HUATA KUPA, KAHUKURANUI HAKIWAI as trustees of the Owhaoko C Trust

(ENV-2019-AKL-000309)

ANGUS HARTLEY, BARBARA BELL, CYRIL MAKO,, MARK ROSS, RICHARD STEEDMAN, NGAIRE ANN KAUIKASTEVENS, TERRY STEEDMAN as trustees of Owhaoko B & D Lands Trust

(ENV-2019-AKL-000274)

Introduction

1. My name is Thomas James Kay

2. I am a Regional Conservation Manager at Forest & Bird.

3. I was born and grew up in Taradale in Napier, Hawke's Bay.

Qualifications and Experience

4. In 2013 I received a Short Award in Raft Guiding from Tai Poutini Polytechnic and completed a National Certificate in Outdoor Recreation (River Guide) as a Grade III Raft Guide through Skills Active NZ.

5. In 2016 I graduated from Massey University with a Bachelor of Science in Environmental Science.

6. I am currently in the final stages of study at Massey University for a Master of Science in Ecology. My thesis focuses on the further development and application of the 'Habitat Quality Index' (a.k.a. Natural Character Index) as a measure of change in river habitat quality in response to specific events such as flood protection engineering.

7. I am an experienced whitewater kayaker and have kayaked and rafted for recreation, competition, and work on rivers throughout New Zealand, including on the 'Oxbow' (Kuripapango) and 'Lower Gorge' (Kuripapango to Whanawhana) sections of the Ngaruroro River.

8. I am a member of the New Zealand Freshwater Sciences Society, the Engineering New Zealand Rivers Group, and Whitewater NZ.

9. I have worked at Forest & Bird since 2017 in the roles of Regional Manager (2017-2019), Freshwater Advocate (2019-2020), and Regional Conservation Manager (2020-). In my role I am involved in advocating for Forest & Bird's national campaigns; participating in Resource Management Act and other statutory processes; advocating to national, regional and local government; building relationships with other organisations involved in resource management and environmental protection; providing strategic and operational advice to branches; and supporting our communications and legal teams.

Scope of Evidence

10. This evidence is prepared in response to the supplementary evidence of Dr Adam Forbes (24 September 2020).

11. In preparing this evidence I have reviewed:

    - The Statement of Evidence of Professor Ian Fuller (4 September 2020)

- The Statement of Evidence of Dr Adam Forbes (24 September 2020)
- The Evidence in Reply of Professor Ian Fuller (January 2021)

Evidence

12. In the Supplementary Evidence of Dr Adam Forbes (24 September 2020), paragraphs 7-11 assert the existing Hawke's Bay Regional Council (HBRC) river management regime, through the Ngaruroro Ecological Management and Enhancement Plan, is "appropriately managing weed encroachment of bare river gravels in the lower Ngaruroro River…" and the threat to bare gravel areas identified in the Evidence in Chief of Professor Fuller (para. 51) is therefore addressed.

13. However, this assertion and confidence in HBRC's river management regime is undermined by HBRC's actual river management practices.

14. Analysis of the lower reaches of the Ngaruroro River over the last decade (2010-2020) reveals numerous locations where the Council has attempted to plant willow poles within the active channel of the river on unvegetated/bare gravel surfaces, thereby emulating the effect of invasive vegetation and realising the threat identified by Professor Fuller.

15. Examples of this activity are provided in Figures 1-11 of Appendix 1.

16. This does not amount to 'appropriate management' to protect the ecological values of the river and is an obvious threat to natural character and habitat for native birds and fish. The cumulative impact of this activity could amount to a significant reduction in the width of the river corridor over time, reduce the area of unvegetated bar, and reduce the extent of braiding.

17. I wrote to HBRC on 14 August 2020 (on behalf of Forest & Bird) expressing concern with this practice and the threat it poses to the values of the river. A copy of this letter, which included an example of planting in the riverbed, is provided in Appendix 2. Another example of planting was provided to HBRC by email at the time.

18. HBRC responded on 8 September 2020 with a letter (Appendix 3) asserting:

    i. the activity is permitted under Rule 70 of the Regional Resource Management Plan (RRMP),
    ii. the activity is undertaken under the Hawke's Bay Regional Council Environmental Code of Practice for River Control and Waterway Works

(2017) as required by Rule 70 (noting the conditions of Rule 70 actually refer to a 1999 document[1]), and

iii. that planting willows to "reclaim the land" is best practice for river management.

19. Rule 70 of the RRMP states that "planting," when carried out "in accordance with the Hawke's Bay Regional Council Environmental Code of Practice for River Control and Drainage Works, 1999" (Code of Practice), is a permitted activity. I assume this 1999 document is no longer operative because HBRC appears to have updated the Code of Practice[2] and now refers (as per their letter) to the Environmental Code of Practice For River Control and Waterway Works 2017 as the relevant document. Neither of the more recent Codes of Practice provide for planting *in a riverbed* as a permitted activity. Instead, they permit planting only as part of the following activities (emphasis in italics added):

- **Live Edge Protection:** Includes trees planted *on the river berm adjacent to the active river channel and on the river bank*. The trees reduce lateral scour and help confine high velocity flood flows to the main river channel. The species most commonly used are willows (Salix spp.), due to their hardy nature and large fibrous root mass.
- **Pole Planting:** Planting of willow or poplar poles *on river berm areas and banks*.
- **Planting Native and Exotic Plants:** Planting of native shrubs and trees. Planting of exotic shrubs and trees other than willows and poplars for biodiversity, enhancement and flood control purposes.
- **Bank reinstatement:** The *reinstatement of eroded river and waterway banks to their original (pre-flood) state* and profile or improved profile. This may involve using gravel material from within the active river channel, combined with either *live edge protection plantings*, rock revetments or other structural means.

20. I include below (Figure 1) a diagram from the Environmental Code of Practice For River Control and Waterway Works 2017 that defines the active river channel, berms, and stopbanks to provide some clarity as to how these provisions should be interpreted.

[1] HBRC RRMP, Rule 70, condition (e), states "All activities shall be undertaken in accordance with the Hawke's Bay Regional Council Environmental Code of Practice for River Control and Drainage Works, 1999." https://www.hbrc.govt.nz/assets/Document-Library/TANK/TANK-Key-Reports/Proposed-TANK-Plan-Change-9.pdf

[2] In 2003 (https://www.hbrc.govt.nz/assets/Document-Library/Publications-Database/3256-AM-03-12-Enviro-code-practice-RivControl-Drainage-2003.pdf) and 2017 (https://www.hbrc.govt.nz/assets/Document-Library/Reports/Environmental-Science/3256-AM-04-15-Environmental-Code-of-Practice-2017.pdf)

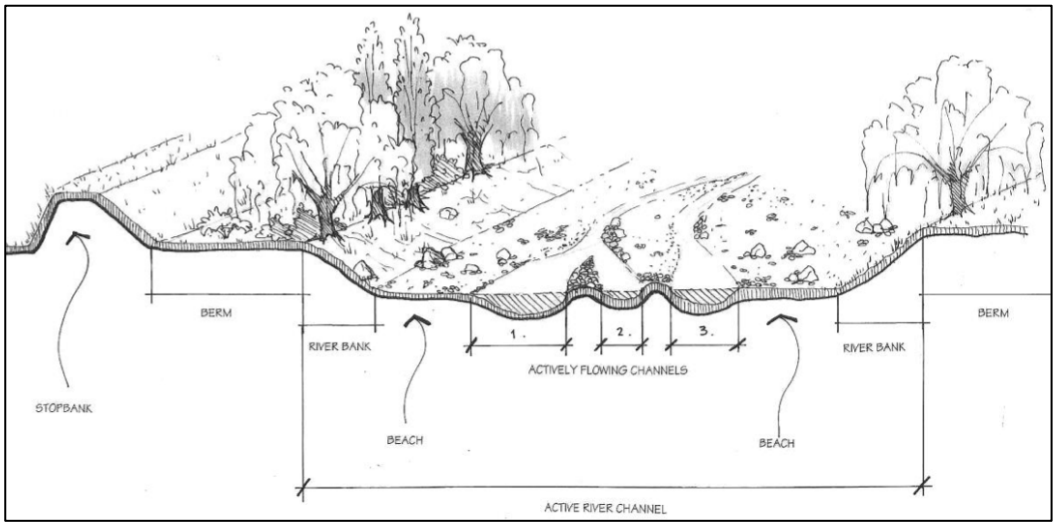


Figure 1: Diagram of the active river channel, berms, and stopbanks, as defined by HBRC's Environmental Code of Practice for River Control and Waterway Works 2017 (taken from Figure 5 of the Code of Practice).[3]

21. Rule 71 of the RRMP states that "the introduction or planting of any plant including any tree in, on, or under the bed of any river, lake or artificial water course, or within 6 metres of the bed" is a discretionary activity requiring resource consent.[4]

22. It needs to be made clear to the court that in all of the cases identified in Appendix 1, the area planted in willows was previously an area of active gravel riverbed. That is, the 'reclamation' being attempted by HBRC was/is not to re-establish dry land where it has been 'lost' to the river through erosion, but to create dry land where there previously was none. It therefore cannot reasonably be considered to be captured under the Environmental Code of Practice's (2017) allowance for "Bank Reinstatement" (para. 19 above). This is clearly illustrated in the changes seen across aerial imagery from the years 1950, 2000, 2010/2011, 2014/2015 and 2019/2020 at each location (noting that a few of the sites are not captured in the 2000 imagery).

23. HBRC, exercising their (previously unchallenged) discretion, clearly consider it a permitted activity.

24. I note that HBRC's plan change 9 (PC9, the TANK plan change) does not propose to amend rules 70 and 71 in regard to their application to the Ngaruroro River[5]. Interestingly, HBRC does not even seek to update Rule 70 condition (e) to reference the 2017, rather than the 1999, Environmental Code of Practice.

[3] https://www.hbrc.govt.nz/assets/Document-Library/Reports/Environmental-Science/3256-AM-04-15-Environmental-Code-of-Practice-2017.pdf
[4] https://www.hbrc.govt.nz/assets/Document-Library/Plans/Regional-Resource-Management-Plan/View-RRMP/New-Chapter-6.pdf
[5] https://www.hbrc.govt.nz/assets/Document-Library/TANK/TANK-Key-Reports/Proposed-TANK-Plan-Change-9.pdf

25. In regard to the assertion this planting in the active bed is 'best practice', I direct the court to paragraph 69 of the evidence in reply of Professor Fuller (as well as the literature he cites, which I have referenced in footnotes below), which clearly states that modern approaches to river management emphasise a need to maintain and/or widen river corridors, rather than narrow them. This allows rivers to naturally adjust to fluctuations in their systems:

> Good practice in river management now recognises the need to provide room for the river to accommodate natural processes of adjustment (e.g. Piegay et al. 2005[6]; Buffin-Belanger et al., 2015[7]; Chone and Biron, 2016[8]). That is, good practice now rarely allows for the further restriction or narrowing of river corridors. This practice is applied internationally and is beginning to be applied in New Zealand (Ramon Strong, Horizons Regional Council, pers. comm.)

26. Channelisation and encroachment of rivers through the construction of stopbanks, river realignment/channelisation, and planting is widely accepted in academic literature as being a severe driver of ecological degradation. It is this sort of activity that has narrowed the very lowest reaches of the Ngaruroro River (i.e. those nearest the coast) so significantly when compared to their 'natural' condition.

27. If a WCO came into effect protecting the lower reaches of the river from further degradation of this sort, including the introduction of limits to changes in the natural character of the river using the Natural Character Index (NCI), HBRC's ability to argue that willow planting in the active riverbed falls within permitted activity provisions would be limited. A WCO would inform regional planning documents, and provide a clear direction to HBRC to protect the river's outstanding values and discontinue this ecologically harmful practice.

Thomas James Kay

[21 December 2020]

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[6] Piégay, H., Darby, S. E., Mosselman, E., & Surian, N. (2005). A review of techniques available for delimiting the erodible river corridor: A sustainable approach to managing bank erosion. *River Research and Applications*, 21, 773–789. https://doi.org/10.1002/rra.881

[7] Buffin-Bélanger, T., Biron, P. M., Larocque, M., Demers, S., Olsen, T., Choné, G., … Eyquem, J. (2015). Freedom space for rivers: An economically viable river management concept in a changing climate. *Geomorphology*, 251, 137–148. https://doi.org/10.1016/j.geomorph.2015.05.013

[8] Choné, G. & Biron, P. M. 2016. Assessing the relationship between river mobility and habitat. *River Research and Applications*, 32, 528–539. DOI https://doi.org/10.1002/rra.2896

APPENDIX 1:

Figure 1: Ngaruroro riverbed, upstream of the Mangatahi Stream confluence, true left bank (https://goo.gl/maps/zUgfoZGMBSkeCTVD6), summer 2010/2011 (top) and summer 2019/2020 (bottom).

Figure 2: Ngaruroro riverbed just upstream of the Mangatahi Stream confluence, true right bank (https://goo.gl/maps/BvzjSVVpHj2s1Dau7), summer 2010/2011 (top), summer 2014/2015 (middle), and summer 2019/2020, (bottom).

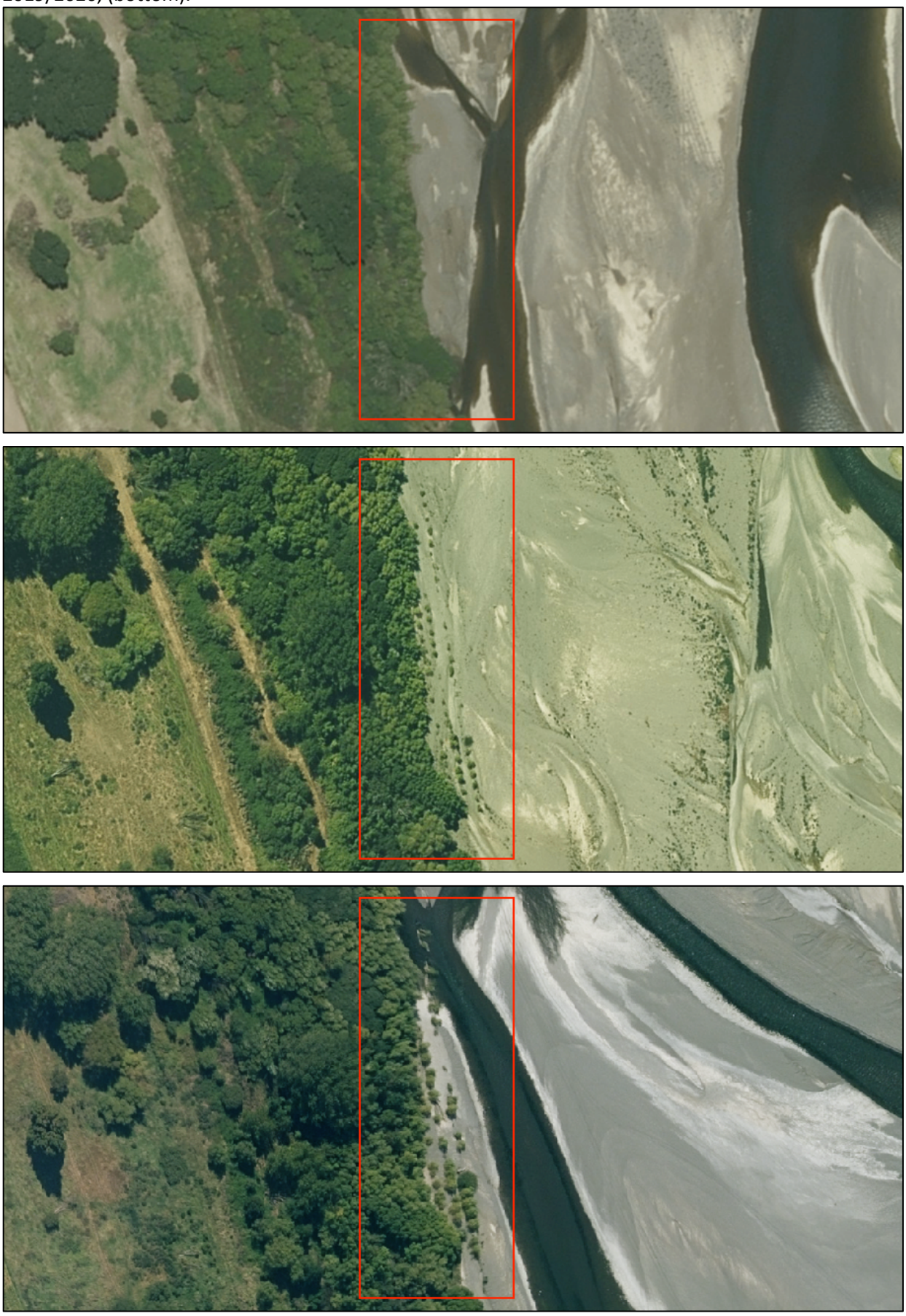

Figure 3: Ngaruroro riverbed at the Mangatahi Stream confluence, true right bank (https://goo.gl/maps/m8cCsoXmKm4Hyqxz8), summer 2010/2011 (left), summer 2014/2015 (middle), and summer 2019/2020, (right).

Figure 4: Ngaruroro riverbed, upstream of Maraekakaho, true left bank (https://goo.gl/maps/SbNXuDKMJaZs8ncN9), summer 2010/2011 (top), summer 2014/2015 (middle), and summer 2019/2020 (bottom). Flow of the river is from left to bottom of image.

Figure 5: Ngaruroro riverbed at Maraekakaho, true left bank (https://goo.gl/maps/NVDutdzqKafcJSfUA), summer 2010/2011 (top) and summer 2019/2020 (bottom). These willows do not appear to have become established. Flow of the river is from left to right.

Figure 6: Ngaruroro riverbed downstream of Maraekakaho (https://goo.gl/maps/q2yGnkGsAFg2EaE67), summer 2010/2011 (top) and summer 2019/2020 (bottom). Flow of the river is from left to right.

Figure 7: Ngaruroro riverbed, upstream of the 'gravel pit', true right bank (https://goo.gl/maps/89vkxPf24KpApzqAA), summer 2010/2011 (top), summer 2014/2015 (middle), and summer 2019/2020 (bottom). Flow of the river is from left to right.

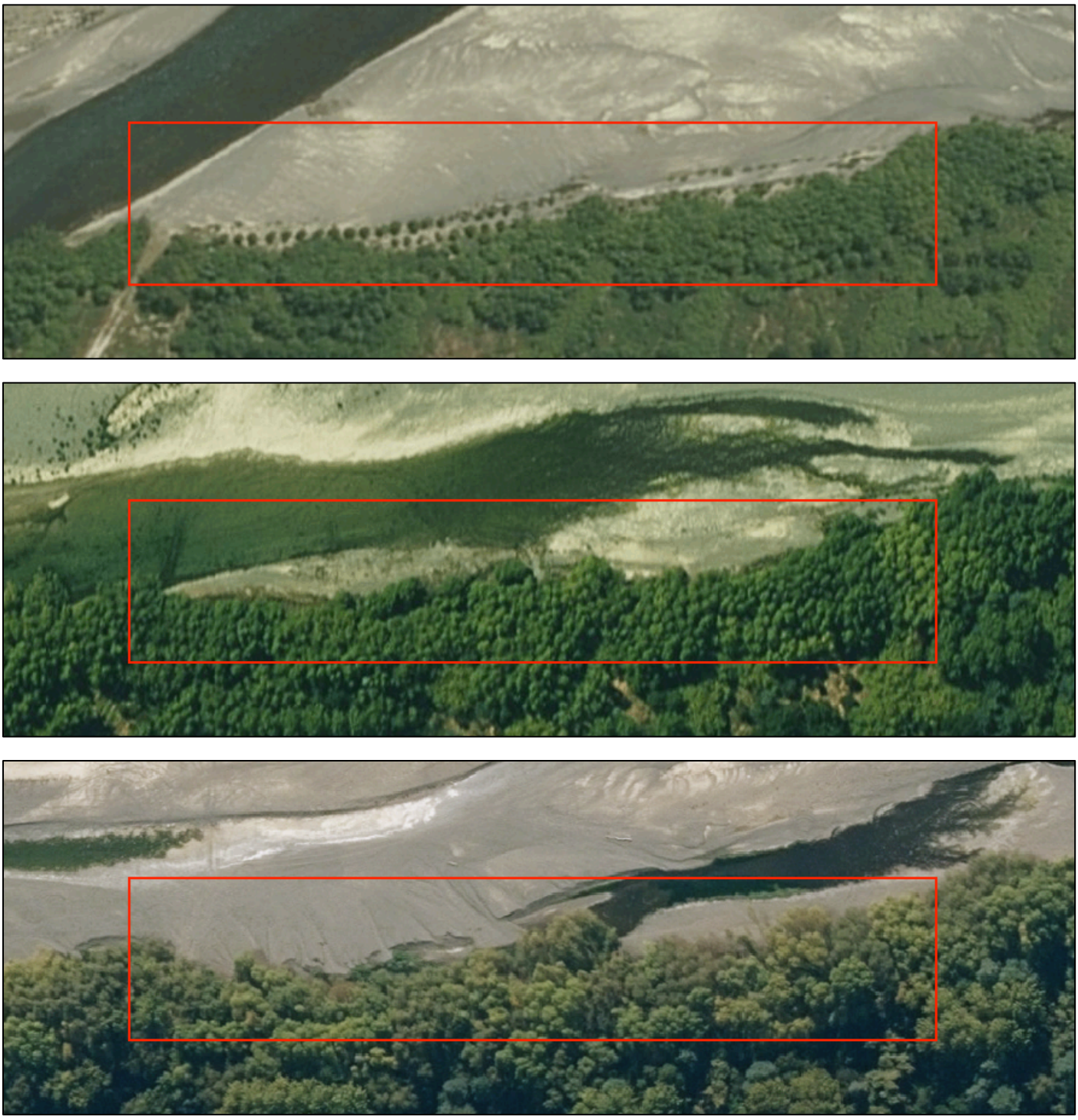

Figure 8: Ngaruroro riverbed near the 'gravel pit' downstream of Maraekakaho (https://goo.gl/maps/n4x3VsdLQPGDL6226), summer 2010/2011 (top) and summer 2019/2020 (bottom). Flow of the river is from bottom to top. Willow planting circled in red. A larger-scale image in presented in Figure 9.

Figure 9: Zoomed view of the Ngaruroro riverbed near the 'gravel pit' downstream of Maraekakaho (https://goo.gl/maps/n4x3VsdLQPGDL6226), summer 2010/2011.

Figure 10: Ngaruroro riverbed, just upstream of the SH50 bridge near Omahu (https://goo.gl/maps/WyZYgg6pdpw9wDpf8), summer 2010/2011 (top), summer 2014/2015 (middle), and summer 2019/2020, (bottom). Flow of the river is from left to right. Willow planting has clearly been undertaken on gravel and the river has continued to flow around it.