In the matter of: Clauses 6 and 8 of Schedule 1 – Resource Management Act 1991 – Submissions on publicly notified plan change and variation – Proposed Plan Change 1 and Variation 1 to Waikato Regional Plan – Waikato and Waipa River Catchments

And: **Wairakei Pastoral Ltd**

Submitter

And: **Waikato Regional Council**

Local Authority

Statement of evidence of Martin William Neale

Block 1 Hearing Topics

Dated: 15 February 2019

SUMMARY AND CONCLUSIONS

1 I agree with the premise that parts of the Waikato and Waipā Rivers are degraded, and that a revised management framework is needed to meet the NPS-FM and the Vision and Strategy. However, I have concerns about the approach of PC1 and the transparency and robustness of the process taken to determine the freshwater objectives.

2 The catchments are generally well described in the PC1 documents, but the Section 42A Report fails to account for one of the key contextual issues for the Waikato River. In most rivers the algal biomass in the water column is limited by the flushing rate, in that water moves through the water body before phytoplankton can respond to changes in nutrient concentrations. In contrast, extensive impoundment of the Waikato River behind hydroelectric dams result in increased journey times of water along the river. Therefore, phytoplankton have more time to respond to increases in nutrient concentrations from human activities. This situation is of great relevance to PC1 as the sensitivity of algal growth to nutrients is greater in the Waikato River than most other rivers in New Zealand.

3 Multiple lines of evidence indicate that the algal growth in the river is more strongly controlled by P than N, including analysis of WRC monitoring data and nutrient manipulation experiments. Based on this body of evidence, I consider it appropriate that efforts to manage algal biomass in the Waikato River should focus most on managing P.

4 The high-level approach in PC1 is to manage the four key contaminants in the river (N, P, sediment and microbial pathogens). However, in practice PC1 focuses on the management of N, which is problematic for several reasons;

4.1 That P is of greater importance than N for managing algal biomass in the river, as described;

4.2 It is based on the concept of a N “load to come”, which is unproven; and

4.3 Management to reduce N will likely have little impact on the other three contaminants.

5 I consider the terminology used in PC1 and the Section 42A Report to be confusing and inconsistent with the NPS-FM. In particular, the numbers in Table 3.11-1 are ‘freshwater objectives’ as described by the NPS-FM, not targets or limits. To be consistent with the NPSFM, I recommend that all references to the numbers in Table 3.11-1 be changed to ‘objective(s)’.

6 The application of some of the NPS-FM attributes is inconsistent. I support the use of the TN and TP attributes in PC1 because of the nutrient sensitivity of the Waikato River. However, they are applied inconsistently across the catchment. Given that nutrients from anywhere in the catchment will affect algal biomass in the Waikato River, it is unexpected that the use of TN and TP attributes is limited to the main stem of the Waikato River only (and not its tributaries and the Waipā catchment). In my opinion, the TN and TP attributes should be applied to the whole catchment to provide a greater probability of achieving the Vision and Strategy.

7 Table 3.11-1 is a cornerstone of PC1 as it sets short-term and long-term water quality objectives for the Waikato and Waipa Rivers and their tributaries, and long-term freshwater objectives for the lakes FMUs. Given this, it is important that the objectives are determined in a transparent and scientifically credible manner.

8 Conceptually, the manner in which the freshwater objectives in Table 3.11-1 have been developed appears logical and credible; the PC1 supporting documents inform us that the current state has been determined from WRC monitoring data; the long-term objectives are determined by a NPS-FM guided process using the NOF methodology and the short-term targets are based on 10% of the difference between these two benchmarks. However, I have several concerns about the assessment of the current state and the derivation of the freshwater objectives contained in Table 3.11-1 that I describe in my evidence and summarise below:

8.1 There is no meaningful description of how the current state of water quality in the catchment was determined. There are inconsistencies in the current state amongst the PC1 supporting documents and I have been unable to replicate the results in the Section 32 Report using the monitoring data supplied by WRC (see **Appendix 2**).

8.2 The five-year period (2010-14) used to describe the current state of water quality in the catchment was a particularly dry period, which included the two of the driest years since 1991. I consider that the use of monitoring data from this five-year period without reference to, or accounting for the unusually dry conditions, may lead to biased assessments of the current state of the river (e.g. **Figure 1**). This bias is likely to lead to an under-estimation of the current state of water quality in the catchment (i.e. water quality at the current time is actually worse than the current state described in the Section 32 report). In addition to the implications for freshwater objectives described in my evidence, Dr Jordan discusses the implication of this issue for the use of water quality models.

8.3 There are consequential changes that arise for the short and long-term freshwater objectives from potential changes in the current state assessments based on the discussion above. Until there is a transparent and robust assessment of the current state, the scale of these changes will not be apparent or measurable.

8.4 Table 3.11-1 contains freshwater objectives for some attributes that are presented to three decimal places and/or below the detection limit used in the laboratory analysis in the WRC monitoring programme. Setting freshwater objectives below detection limits and at unrealistic levels of precision means that the objectives do not meet the 'measurable' or 'achievable' test in the SMART objectives' framework. In this regard, I support the approach of Doole et al (2016), where the summary statistics from most water quality Attributes were reported to two significant figures only.

8.5 Table 3.11-1 also contains a number of objectives for attributes where the median is greater than the maximum or 95th percentile. Given the definition of these measures it is impossible for the median value to be greater than a maximum or 95th percentile. These issues may be a drafting error, but they have not been corrected in the Section 42A Report.

8.6 The footnote to Table 3.11-1 specifies that measurements of black disc sighting distance for the clarity attribute are carried out under baseflow conditions, which conflicts with the advice in the Section 42A Report that monitoring is carried out monthly irrespective of weather conditions. Second, if this is the intent of PC1, it will require that WRC's monitoring programme will have to be expanded to provide for data collection irrespective of weather conditions and flows for most attributes (and as required for the E. coli Attribute in the NOF), whilst also enabling the measurement of black disc sighting under only baseflow conditions.

9 Collectively these issues create substantial uncertainty around the robustness of Table 3.11-1 and the process through which it was developed. I provide an amended version of part of the Table in **Appendix 3**, which I consider takes into account the best available information and is consistent with the 'SMART' framework.

10 Given the issues I describe in my evidence and the uncertainty they create in my opinion Table 3.11-1, which is a key provision in PC1, is not fit for purpose and should not be used in this manner until the issues I have raised have been addressed or clarified.

STATEMENT OF EVIDENCE OF MARTIN WILLIAM NEALE

Block 1 Hearing Topics

1 My name is **Martin William Neale**. I have the qualifications and experience recorded in my curriculum vitae **attached** to this statement of evidence as **Appendix 1**. Key aspects of my recent expert experience relevant to these Hearings include:

1.1 I provided freshwater science and management input to Auckland Council throughout the development, consultation, hearing and Environment Court appeals for the Auckland Unitary Plan.

1.2 I have provided expert evidence on behalf of Auckland Council at the EPA Board of Inquiry hearings for the Puhoi to Warkworth Road of National Significance.

1.3 I managed the Auckland State of the Environment monitoring and applied environmental research programmes. This included the oversight of a range of complex environmental research and monitoring programmes covering air quality, soil science, biodiversity, marine and freshwater, in order to meet Auckland Council's obligations under a number of statutory instruments,

1.4 I provided evidence on freshwater management for the New Zealand Transport Agency in relation to the Mt Messenger bypass at a combined Regional/District council hearing in Taranaki.

1.5 I am an active member of the scientific community, maintaining an honorary lecturer position at the University of Auckland and I have published 17 peer reviewed scientific papers as author or co-author.

2 I have been engaged to prepare this evidence in support of the submissions and further submissions made by Wairakei Pastoral Ltd (**WPL**) on the Proposed Waikato Regional Plan Change 1 (**PC1**) and Variation 1 to Proposed Waikato Regional Plan Change 1 – Waikato and Waipā River Catchments (**Var1**).

3 Relevant to my qualifications and experience, my evidence focuses on the following matters:

3.1 Review of the Collaborative Stakeholder Group (**CSG**) and Technical Leaders Group (**TLG**) background reports, the Section 32 Evaluation Report, and the Section 42A Report.

3.2 Description of the current state of the Waikato and Waipā River catchments.

3.3 The importance of nutrients in managing algal biomass.

3.4 The consistency of PC1 with the National Policy Statement for Freshwater Management 2014 (as amended 2017) (**NPS-FM**).

3.5 The review and development of freshwater objectives in Table 3.11-1 of PC1.

4 My evidence has been prepared in accordance with the Code of Conduct for expert witnesses as set out in Section 7 of the Environment Court of New Zealand Practice Note 2014.

REVIEW OF PLAN CHANGE DOCUMENTS AND SUPPORTING TECHNICAL REPORTS

5 Healthy Rivers: Plan for Change/Wai Ora: He Rautaki Whakapaipai (**HRWO**) was approved by Waikato Regional Council (**WRC**) for public notification on 22 October 2016.

6 WRC has expended considerable and useful effort on the PC1 process. PC1 was supported by numerous technical reports. I have reviewed the information that was presented in the following technical reports, which were referenced by the CSG and WRC in support of HRWO:

6.1 Yalden S & Elliott S. 2015. A methodology for chlorophyll and visual clarity modelling of the Waikato and Waipa Rivers. Report No. HR/TLG/2015-2016/2.3.

6.2 Gibbs M et al. 2014. Waikato River Bioassay Study 2013-14. Report No. HR/TLG/2015-2016/3.1.

6.3 Gibbs M et al. 2015. Factors influencing chlorophyll a concentrations in the Waikato River. Report No. HR/TLG/2015-2016/3.2.

6.4 Anon. 2016. Assessment of Waikato River nutrient limitation: Peer reviewed key findings of WRC and DairyNZ studies. Report No. HR/TLG/2015-2016/3.3.

6.5 Gibbs M & Croker G. 2015. Nutrient reduction bioassays in the Waikato River. Report No. HR/TLG/2015-2016/3.5.

6.6 Technical Leaders Group. 2015. Nutrients and phytoplankton (chlorophyll a) in the Waikato River. Report No. HR/TLG/2015-2016/3.6.

6.7 Verberg P. 2016. Nutrient limitation of algal biomass in the Waikato River. Report No. HR/TLG/2015-2016/3.4.

WATER QUALITY AND ECOSYSTEM HEALTH

7 I agree with the premise that parts of the Waikato and Waipā Rivers are degraded, and that a revised management framework is needed to meet the NPS-FM and the Vision and Strategy.

OVERVIEW OF CATCHMENTS

8 The description of the catchment in the Section 42A Report fails to account for one of the key contextual issues for the Waikato River.

9 In most rivers the algal biomass in the water column is limited by the flushing rate, in that water moves through the water body before phytoplankton can respond to changes in nutrient concentrations.

10 In contrast, the algal biomass for much of the length of the Waikato River is generally nutrient limited. This occurs because of the extensive impoundment of the river behind hydroelectric dams, which increases the journey time of water along the river so that phytoplankton can respond to changes in nutrient concentrations. For example, it has been estimated that the time taken for a mass of water to move from Lake Taupo to the sea has increased from around 5 days to 40 days since the development of the hydroelectric dams on the river (Brown, 2010).

11 This increased residence time and the increase in nutrient concentrations from human activities has greatly increased the ability of the river to support phytoplankton biomass (Vant, 2010). Rutherford et al (2001) estimated that the algal biomass in the river at Lake Karapiro is over three times greater because of the dams.

12 This situation is of great relevance to PC1 as the sensitivity of algal growth to nutrients is greater in the Waikato River than many other rivers.

OVERVIEW OF THE “FOUR CONTAMINANTS”

13 This section of the Section 42A Report provides a simple summary of each of the four contaminants, but it provides an incomplete description of the nitrogen (**N**) cycle. Specifically, it fails to recognise that denitrification is a key step in the cycle and is a process that is highly relevant to PC1. This issue is covered in detail by Mr Williamson and Dr Cresswell in their evidence.

CURRENT STATE

14 I generally agree with the description of the current state of the catchments presented in the Section 42A Report. The findings presented here are consistent with Mr Vant's trend analysis work (Vant, 2018).

15 However, the statement about sediment in paragraph 92 requires reference to the source material, as sediment is not monitored in the river by WRC. The reporting Officers may have confused sediment with clarity and/or turbidity, both of which are monitored by WRC. But sediment is not monitored.

16 The current state analysis in Section 42a report begins to explore some of the nutrient–algal dynamics in the river. The trend analysis found widespread decreasing concentrations of phosphorus (**P**) and chlorophyll a in the Waikato River; whilst at the same time finding widespread increases in N. Notwithstanding, there is some uncertainty around the P data used in the trend report. Vant (2018) suggests that the results imply that phytoplankton growth (as indicated by chlorophyll a concentrations) in the river is less dependent on the availability of N (as compared with P).

17 Furthermore, multiple lines of evidence produced by the TLG indicate that overall, P is the key limiting factor of algal biomass in the Waikato River. Nutrients (indicated by total phosphorus (**TP**) and total nitrogen (**TN**) concentrations) and algal biomass (indicated by chlorophyll a concentration) all increase with distance downstream from Taupo Gates and there is therefore a correlation amongst these three variables. However, at an individual site level, there is a strong positive relationship between TP and chlorophyll a, whereas the relationship between TN and chlorophyll a is weak.

18 These findings are consistent with previous long-term trend analysis of WRC's monitoring data that shows TP and chlorophyll a have decreased, whilst TN has increased, indicating that TP is limiting algal biomass (Verburg, 2016).

19 In addition, bioassays, in which algal response to nutrient manipulations were investigated, have documented much greater changes in algal biomass with P additions or reductions, than N (Gibbs et al., 2014; Gibbs & Croker, 2015).

20 As a result of this body of evidence, I consider it appropriate that efforts to manage algal biomass in the Waikato River should focus more on managing P to achieve the Vision and Strategy. Reducing algal growth through the management of P is important for a number of the objectives in the Vision and Strategy, but is critical to objective k and the ability to swim and take food from the river.

MANAGEMENT OF NITROGEN

21 In contrast to the current state and understanding of the nutrients-algal relationship, PC1 places much greater emphasis on the management of N than any of the other contaminants. This is recognised in the Section 42A Report, where it states “N is subject to particular scrutiny” (paragraph 128) and that only when there is public confidence in farming improvements “that a reduction of the emphasis on N can be suggested” (paragraph 134).

22 This emphasis on N is questionable for several reasons:

22.1 First, the relative importance of N compared with P for managing algal biomass in the river, as described above;

22.2 Second, that the “Officers wish to make it clear that N is not considered to be any more important than the other three constituents” (Section 42A Report, paragraph 131);

22.3 Third, the N focus is partly based on groundwater ‘lag’ times (Section 42A Report, paragraph 82) and the related concept that there is a N “load to come”. The N “load to come” is an extension of the fact that water takes up to 80 years from falling as rain to pass through soils and groundwater before reaching surface waters in the catchment. However, this does not mean that all of the N is carried with the groundwater during this process. There is a difference between the concepts of “lag” and “load to come” and Mr Williamson addresses this issue in detail in his evidence.

23 From a management perspective, the greater emphasis on N is problematic because actions to manage N are highly unlikely to achieve any meaningful reductions in the other three contaminants due to the different delivery pathways to the river.[1] Coupled with the over-stated importance of the N load to come, the focus on N in PC1 may produce little change in any of the other contaminants discharged to the river, whilst coming at a significant economic and social cost to implement (Section 42A Report, paragraph 129). Such an outcome would fail to meet the Vision and Strategy.

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[1] Nitrogen is typically transported through the soil and groundwater, whereas sediment, phosphorus and microbial contaminants are typically transported via surface run off.

SPECIFIC OBJECTIVES

Objectives 1 and 3 and Table 3.11-1

Terminology

24 The terminology used to describe the numbers in Table 3.11-1 was the subject of several submissions as described in paragraph 335 of the Section 42A Report. I consider the terminology used in PC1 and the Section 42A Report to be confusing and inconsistent.

25 The Explanatory Statement in PC1 (page 8) states that terms marked with ^ are defined in the NPS-FM (Ministry for the Environment, 2017a)). Consistent with the NPS-FM definitions, PC1 then begins by referring to the "numeric, long-term freshwater objectives^" in the introduction to Chapter 3.11, which is consistent with the NPS-FM definition:

> "**Freshwater objective**" describes an intended environmental outcome in a freshwater management unit.

26 However, the use of the ^ symbol to indicate NPS-FM terminology is then inconsistently applied throughout PC1. For example, Objective 1 refers to "targets^" (page 27), but the symbol is missing when referring to the "targets" in Table 3.11-1 (page 56). However, I consider that the numbers in Table 3.11-1 are not targets and calling them such is inconsistent with the NPS-FM definitions of targets and limits, for example:

> **"Target"** is a limit which must be met at a defined time in the future. This meaning only applies in the context of over-allocation.
>
> **"Limit"** is the maximum amount of resource use available, which allows a freshwater objective to be met.

27 Therefore, the reference to targets and limits, specifically in relation to Table 3.11-1 in PC1 is inconsistent with the NPS-FM definitions. Further guidance is provided on this issue by the Ministry for the Environment (**MfE**) (Ministry for the Environment 2017b), namely:

> A limit is the maximum amount of resource that is available for use while still enabling a freshwater objective to be met. It is a specific quantifiable amount that links the freshwater objective (the desired state) to use of the freshwater resource.

A quality limit would describe how much of a contaminant (eg, a nutrient) could be discharged into the water by users without exceeding a freshwater objective.

28 To be consistent with the NPS-FM, I recommend that all references to the numbers in Table 3.11-1 should be changed to 'freshwater objective(s)'. This is how I address these numbers throughout the balance of my evidence statement.

SPATIAL EXTENT OF SUB-CATCHMENTS

29 The reporting Officers in the Section 42A Report did not support amending the spatial scale of sub-catchments based on the availability of monitoring information. However, this rationale fails to reflect the purpose of WPL's submission on Sub-catchment 66 (described in paragraphs 502 and 506). The issue is whether it is appropriate to apply NPS-FM lake attributes[2] to a section of the river that is functioning as a river, rather than as a riverine lake.

30 There are several NPS-FM attributes that are intended for use in lake environments and three of these lake attributes (chlorophyll a, TN, and TP) have been used to set the long-term freshwater objectives for the restoration of the Waikato River main stem by 2096.

31 As discussed above, parts of the river have a nutrient-algal relationship that is generally similar to that observed in lakes and therefore I support the use of these attributes in such locations.

32 However, there remains some variability in this relationship and whilst there is a strong positive relationship at the catchment scale, at a site-specific scale, the sites immediately below Lake Taupo (Taupo Gates and Ohaaki) do not show a positive relationship between nutrients and chlorophyll a (Verburg, 2016). That is, an increase in nutrient concentrations at these sites has not been shown to result in an increase in chlorophyll a (e.g. Figure A2 in Verburg, 2016). Indeed, there are such low levels of chlorophyll a, that the vast majority of the data reported for Ohaaki was below the limit of detection for chlorophyll a of 0.003 g/m^3 (Verberg, 2016).

33 This finding indicates that the algal biomass in this section of the river is likely to be limited by flushing rates and is consistent with the description of the river between Huka Falls and Ohakuri as predominantly riverine in appearance (Collier et al. 2010). However, at the Ohakuri Tailrace and most sites downstream of this point,

[2] I use the terms Attribute and Attribute State consistent with their definitions in the NPS-FM thus: "**Attribute**" is a measurable characteristic of fresh water, including physical, chemical and biological properties, which supports particular values; and "**Attribute state**" is the level to which an attribute is to be managed for those attributes specified in Appendix 2.

there is a strong positive relationship between TP and chlorophyll a concentrations, indicating that the river is functioning as a lake below this location.

34 Therefore, from an appearance and an ecological function perspective, the Waikato River can be considered to change from a riverine system to a lacustrine system between the Ohaaki and Ohakuri Tailrace monitoring sites. Analysis of the river in this area indicates that change occurs around Tutukau Bridge and therefore following the logic in PC1, it would be appropriate to manage the river upstream and downstream of this location differently.

35 The logic for this change is consistent with the rationale for not applying the NPS-FM lake attributes to the tributaries of the Waikato River and to the Waipa River catchment (Waikato River Authority, 2016). That is, phytoplankton does not grow in these areas and therefore objectives to control phytoplankton are not presented in PC1. In contrast, the river at Ohakuri Tailrace is considered to have similar ecological relationships as a lacustrine water body and the application of the NPS-FM lake attributes at this site (and downstream) can be considered appropriate to manage algal biomass.

36 However, I do consider that the logic in PC1 about where to apply the lake attributes is flawed. Given that nutrients from anywhere in the catchment will affect algal biomass in the Waikato River, it is unexpected that the use of TN and TP attributes is limited to the main stem of the Waikato River only (and not its tributaries and the Waipā River catchment).

37 It is accepted that not all streams require nutrient management, but streams discharging to lake environments do, particularly when there are sensitive downstream waters (Wilcock et al., 2007). Given this is the situation in the Waikato River catchment, then the appropriate management approach for the river includes the management of nutrients, and that approach should be applied in a consistent manner across the whole catchment including stream tributaries.

38 PC1 currently inconsistently deals with this situation by applying lake attributes to some places that function as a river and not to others. This inconsistency should be remedied in one of two ways :

38.1 By consistently **not** applying lake attributes to parts of the river that are functioning as a river; or

38.2 By consistently applying the lake attributes to all sites in the catchment because all tributaries flow into sensitive downstream environments.

39 In my opinion, the second option of using TN and TP attributes to manage the whole catchment gives a greater probability of achieving the NPS-FM and the Vision and Strategy. Such an approach is consistent with the scientific evidence on managing nutrients in rivers that discharge to nutrient sensitive waters (Wilcock et al, 2007) and it would also provide information on sub-catchments that are contributing high concentrations of these nutrients to inform subsequent prioritisation exercises.

Loads

40 In addition to the catchment-wide use of the TP and TP attributes, I consider the addition of loads to PC1 would also provide for more effective management of nutrients (consistent with the submission by Beef + Lamb New Zealand Limited[3] and others). I disagree with the reporting Officers' rationale for not adopting this approach. To calculate loads, the concentration of nutrient in the river water and the discharge volume is required. Both of these pieces of information are available for all of the monitoring sites; indeed, WRC's trend analysis uses both of these pieces of information (Vant, 2018). I have therefore included a nutrient load current state as a supplementary table to Table 3.11-1 presented in Appendix 3 to my evidence.

FRESHWATER OBJECTIVES (Table 3.11-1)

41 Table 3.11-1 sets short-term and long-term water quality objectives for the Waikato and Waipa Rivers and their tributaries, and long-term freshwater objectives for the lakes Freshwater Management Units (**FMUs**). As such, this table is a critical part of PC1 as it guides the future management of the catchment and provides clear performance criteria against which effectiveness will be assessed. Given this, it is important that the objectives are determined in a transparent and scientifically credible manner.

42 Conceptually, the manner in which the freshwater objectives have been developed appears logical and credible; the PC1 supporting documents inform us that the current state has been determined from WRC monitoring data; the long-term objectives are determined by a NPS-FM guided process using the National Objectives Framework (**NOF**) and the short-term targets are based on 10% of the difference between these two benchmarks.

43 However, I have several concerns about the assessment of the current state and the derivation of the freshwater objectives contained in Table 3.11-1 that I describe below.

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3 Beef + Lamb New Zealand Limited, ID73369, Submission Points: PC1-11158, V1PC1-675, V1PC1-1658.

Current state

44 The process followed to calculate and describe the current state from the monitoring data is not described in any publicly available report.

45 There are descriptions of current state contained in the Section 32 Evaluation Report, which are reproduced from the 'Overview of Collaborative Stakeholders Group's Recommendations for Waikato Regional Plan Change No 1 - Waikato and Waipa River catchments' (**CSG report**) and two of the technical reports used to support PC1 (Doole et al., 2016; Semadeni-Davies et al., 2015).

46 Comparison of the current state statistics amongst these three reports identified several inconsistencies that create uncertainty around the description of current state used in PC1 and subsequently used to inform the freshwater objectives. For example, the Section 32 Report states that the current state for median chlorophyll a at Ohakuri is 3.2 mg/m^3, whereas Doole et al (2016) reports the current state for median chlorophyll a at Ohakuri as 4.9 mg/m^3.

47 Given these inconsistencies, I requested the monitoring data from WRC and calculated the current state statistics from the raw data for the period January 2010 to December 2014 for 11 sites in the Upper Waikato FMU. This is consistent with the brief description of the analysis undertaken for the CSG report described as "5 years of monthly data was used to describe current state (up to 2014)" (CSG report, Section 3.1). I focussed on the Upper Waikato FMU because the current state assessments are of greatest importance in this FMU. This is because the water quality is good at many of these sites and therefore the freshwater objectives in Table 3.11-1 are set at the current state.

48 I found numerous discrepancies between the current state documented in the Section 32 Report, the Doole et al (2016) report and the current state calculated from the monitoring data supplied by WRC. There is not a consistent pattern in the Section 32 Report current state over or under estimating water quality compared with that derived from the monitoring data (some are higher, some are lower). Whilst some minor differences may be expected when analysing a large dataset, there are important differences for several attributes. The Section 42A Report clearly states, "datasets were not edited before being summarised for the s32 report" (paragraph 556).

49 A full presentation of this analysis, identifying all of the differences between the current state described in the Section 32 Report, the Doole et al (2016) report and those calculated directly from the monitoring data is presented in **Appendix 2** of my evidence.

However, I present and discuss some key differences in the text below.

Ammonia

50 Firstly, I address the many differences in the current state for ammonia as some of these may be explained by the declaration in the Section 42A Report that ammonia data has been adjusted for pH and temperature consistent with the NPS-FM NOF methodology.

51 I accept that the NOF ammonia attribute states that results are “based on pH 8 and temperature of 20^{O}c” (Ministry for the Environment 2017) as ammonia toxicity varies with pH and temperature. However, whilst the MfE’s guide to NOF attributes (Ministry for the Environment, 2017c) specifies a method to adjust ammonia results for pH, it states “that a method for converting to standard temperature is not currently available”. The Section 42A Report does not specify the methods used for ammonia adjustment, therefore it is uncertain how the results were adjusted for temperature and therefore I cannot replicate this analysis. Furthermore, I note that WRC do not adjust ammonia results in their routine reporting (e.g. Tulagi, 2015).

52 I have adjusted some of the ammonia results from the monitoring data using the approach specified in the MfE guide to attributes and this does not account for the differences observed between the assessments of current state. I illustrate this issue with two examples:

52.1 The maximum ammonia result in the WRC dataset for the Waikato River at Ohaaki is 0.05 mg/l obtained on 4 August 2010. The pH for the same sample was recorded as 7.1, and using the MfE specified pH adjustment method, results in an adjusted ammonia result of 0.022 mg/l. This observed maximum ammonia concentration after adjustment is nearly double the current state estimate described in the Section 32 Report (0.013 mg/l).

52.2 The maximum ammonia result in the WRC dataset for the Waikato River at Ohakuri is 0.104 mg/l obtained on 3 April 2012. The pH for the same sample was recorded as 7.2, and using the MfE specified pH adjustment method, results in an adjusted ammonia result of 0.047 mg/l. This observed maximum ammonia concentration after adjustment is well over double the current state estimate described in the Section 32 Report (0.017 mg/l).

53 These examples create uncertainty around the current state assessment for ammonia used to inform PC1. This is of particular

importance for the Upper Waikato FMU as the current state for ammonia is also used as the short and long-term freshwater objective for many of the sites (e.g. Pueto Stream, Torepatutahi Stream, Otamakokore Stream and Whirinaki Stream in addition to four of the main stem Waikato River sites).

54 Following the approach used to set freshwater objectives in Table 3.11-1, the short and long-term objectives for ammonia at both sites would be set at the adjusted ammonia concentrations described in paragraph 51 above. This is because the results obtained are both within the band for Attribute State A for ammonia in the NOF (therefore no improvement is required).

Total Phosphorus

55 There are discrepancies amongst the current state for the three main stem Waikato River sites (Ohaaki, Ohakuri & Whakamaru) amongst the three estimates. The current state in the Section 32 Report is lower than that described in Doole et al (2016) for two sites, and that calculated from the WRC monitoring data for all three sites.

56 Again, these differences are important as the freshwater objectives for these three sites are set at the current state specified in the Section 32 Report. If the objectives were set at the current state calculated directly from the monitoring data, they would be 20% (Ohaaki), 18% (Ohakuri) higher than currently described in Table 3.11-1. This is because the results obtained are both within the same Attribute band as the current objective and therefore no improvement is required.

57 The freshwater objective for the third site (Whakamaru) may not change as the current state from the monitoring data would place it in Attribute band C and the objective seeks to achieve Attribute band B for this location (therefore improvement would be required).

58 In addition, I have calculated current state estimates from the monitoring data for Whakamaru that are lower than described in the CSG report (for TN and median nitrate). In this instance, the current state data suggests that the objectives at this location may be set too high.

Nitrate

59 Whilst there are several more discrepancies, the final example I illustrate is for nitrate at Ohaaki. The Section 32 report specifies a current state for the nitrate 95th percentile of 0.062 mg/l. The same statistic for nitrate calculated directly from the monitoring data gives a result of 0.075 mg/l. In addition, Doole et al (2016) states that the same statistic is higher still at 0.08 mg/l, although this report

sensibly reported nitrate results to two decimal places so the difference between the monitoring data and this report may be a rounding issue.

60 Again, these differences are important in terms of the freshwater objectives in Table 3.11-1. All three estimates place the site in NOF Attribute state A for nitrate, therefore, following the convention of setting objectives, the short and long-term objectives would be set at the current state (to maintain the Attribute state A). If that current state was calculated directly from the monitoring data, my analysis indicates it should be set at 0.075 mg/l. No improvement would therefore be required.

Selection of current state data (2010 – 2014)

61 At first glance, it seems perfectly sensible to use monitoring data from the period 2010-14 to provide an assessment of the current state of water quality in the Waikato River catchment. Monitoring data was collected routinely during this period and it was the five-year period that immediately preceded the notification of PC1.

62 Describing a current state using a five-year period provides some ability to reduce the impact of unusual results or short-term highs and lows in monitoring data arising from storm or pollution events (e.g. Section 42A Report, paragraph 339). For example, if a single year's data was used and there was something unusual about that year, the current state estimate may not be representative of the typical conditions in the catchment.

63 However, by coincidence the five-year period used to characterise the current state of water quality in the catchment was a particularly dry period. The mean annual rainfall for the period 1991 to 2014 was 953mm based on the Taupo AWS rain gauge (Cliflo Agent number 1858), whereas the mean annual rainfall for the five-year period 2010 to 2014 was 862mm.

64 In addition to the five-year period being below average, the period also included the two driest years since 1991, with rainfall of only 606mm in 2014 and 645mm in 2013.

65 The amount of rainfall falling on the catchment will affect the flow regime of the river, the transport of contaminants from land to water and in-stream processes and ecology.

66 The importance of flow on water quality measures is widely recognised, such that water quality data are frequently flow-adjusted before state and trend analysis is undertaken (e.g. Vant, 2018).

67 The influence of rainfall on water quality measures can be seen by referring to **Figure 1**. The graph shows the variability in TP in the Pueto Stream based on WRC's monitoring data. The green line represents the current state based on the 2010-14 median. The boxplots indicate that between 1993 and 2015, the majority of the data points and all of the annual median values were greater than the current state estimate. The only two exceptions were the two dry years mentioned previously (2013 and 2014).

68 Furthermore, Vant (2010) discusses that low flows in the Waikato River have potentially reduced algal growth through settling effects and suggests that once flows return to normal, phytoplankton biomass in the hydro-lakes will increase.

69 Therefore, I consider that the use of monitoring data from this five-year period without reference to, or accounting for the unusually dry conditions may lead to biased assessments of the current state of the river. This bias is likely to lead to an under-estimation of the current state of water quality in the catchment. In addition to the implications for freshwater objectives described below, Dr Jordan comments (in his evidence) on the implication of this issue for the use of water quality models.

70 When rainfall and flows return towards average conditions, for example when we enter a period of negative Interdecadal Pacific Oscillations (Brown, 2010), we may see increases in several water quality measures in response to these climatic drivers. The implication for freshwater objectives derived from unusually dry periods is that they may be unachievable, even with substantial land management changes.

71 To avoid such a situation, I recommend that the current state assessments are re-assessed with reference to rainfall variability to reduce any bias that may be introduced by unusually dry or wet periods. An obvious straightforward solution would be to extend the period used to determine current state to ten years, which would reduce the influence of the dry years during the period 2010-14.

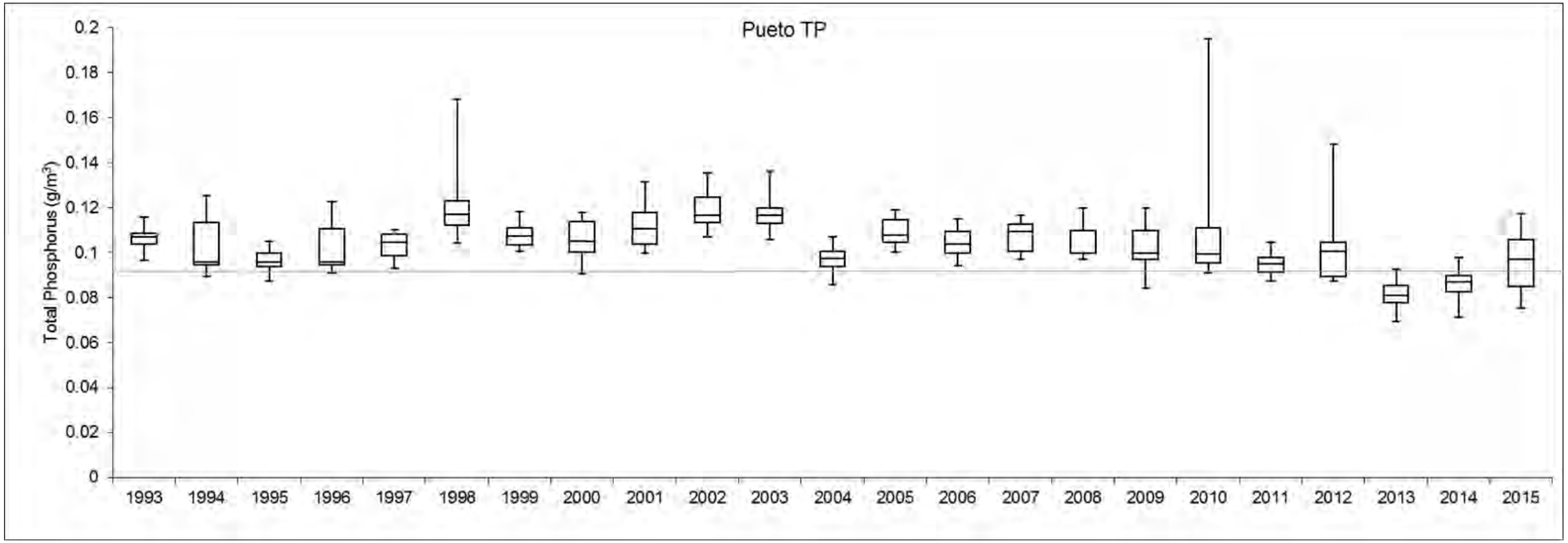

Figure 1; Long term monitoring record for total phosphorus (TP) in the Pueto Stream. The green line is the current state based on monitoring data collected between 2010 and 2014.

Interpretation and implementation issues with Table 3.11-1

72 There are a number of general issues with Table 3.11-1 that raise issues with regards to interpretation and implementation of the freshwater objectives it contains.

Decimal places and detection limits

73 Table 3.11-1 contains freshwater objectives for some attributes that are presented to three decimal places. This implies a level of accuracy and precision that is not attainable.

74 For example, the Section 42A Report refers to a detection limit for ammonia of 0.01 g/m^3 at Hills Laboratories (paragraph 584). Given that the water quality monitoring data for WRC is tested at Hills Laboratories, we can assume this is the detection limit for all the monitoring data that has been used to identify the current state and inform the freshwater objectives.

75 This detection limit means that we have no reliable information of the concentration of ammonia in a sample when the result is below the detection limit. All we know is that the actual concentration of ammonia is below 0.01 g/m^3.

76 However, the current state estimates and freshwater objectives set numerical values below and with more decimal places than the detection limit. I agree with the reporting Officers' statement that more sensitive testing procedures may exist elsewhere (or in the future), however this does not assist with our understanding of the current monitoring data and its subsequent use to set objectives.

77 It is highly likely that some of the results currently recorded, as below the detection limit would return results that are above the description of current state and freshwater objectives if tested with a more sensitive procedure. For example, the true results of an ammonia test result of below 0.01 g/m^3 could be 0.009 g/m^3 (which is greater than the freshwater objective for many of the Upper Waikato FMU locations). I note in their regular state of the environment monitoring reports, WRC report ammonia to two decimal places (e.g. Tulagi, 2015).

78 Similar issues also exist for some of the other attributes, with freshwater objectives for chlorophyll a set below detection limits and nitrate objectives set at 3 decimal figures.

79 I recommend that a "common sense" filter should now be applied to the objectives in Table 3.11-1 taking into account the detection limits, precision and accuracy of such laboratory tests. Setting freshwater objectives below detection limits and at unrealistic levels of precision means that the objectives do not meet the

"measurable" or "achievable" test in the SMART objectives' framework (Specific-Measurable-Achievable-Relevant-Timely).

80 In this regard, I support the approach of Doole et al (2016), where the summary statistics from most water quality attributes were reported to two significant figures.

Medians, maximums and 95th percentiles in Table 3.11-1

81 Medians and percentiles are examples of summary statistics that may be used to describe a population of data points (in this case monitoring data).

82 A median is a measure of "middle" number in a population of data points, with half of the data points above and half below. The median may also be referred to as the 50th percentile.

83 The maximum and the 95th percentile are measures of the upper range of a population of data points[4]. A maximum is obviously the highest observation, whereas the 95th percentile is a measure that is equal or greater than 95 percent of the data (so only 5% of data can be above this number). A 95th percentile is typically used to describe data where there might be unusual, very high numbers that might make a maximum measure less useful.

84 Given the definition of these measures it is impossible for the median value to be greater than a maximum or 95th percentile. In an unusual dataset, it is possible that they will be equal, but the median value can never be greater than the maximum or the 95th percentile.

85 It is therefore concerning that Table 3.11-1 includes a number of objectives for attributes where the median is greater than the maximum or 95th percentile. For example:

85.1 For nitrate, the 80-year median value for Mangaone Stream (Annebrooke Rd Br) is 2.4 mg/l, whereas the 95th percentile is lower at 1.5 mg/l.

85.2 For nitrate, the 80-year median value for Mangamingi Stream (Paraonui Rd Br) is 2.4 mg/l, whereas the 95th percentile is lower at 1.5 mg/l.

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[4] For example, the use of five year reporting periods in PC1 will result in 60 data points for any reporting period (5 years x 12 months). The maximum result during this period is obvious and the 95th percentile will typically be the 4th highest result. Both of these statistics can be heavily influenced by a small number of unusual results and given the five-year reporting period, they could influence the reporting statistic for five years after their collection.

85.3 For ammonia, the 80-year median value for Waitawhiriwhiri Stream (Edgecumbe Street) is 0.24 mg/l, whereas the maximum is lower at 0.05 mg/l.

86 These issues may be drafting errors, but they have not been corrected in the Section 42A Report. If these are the intended objectives for PC1, then it has the effect of making the median objectives for these examples redundant.

Measurements during floods and baseflow

87 As described in paragraph 62 above, water quality data is often summarised over several years to reduce the effects of unusual conditions associated with floods or other unusual events.

88 This approach has been applied to the use of monitoring data in PC1 and in the proposed approach to assess against freshwater objectives (Section 42A Report, paragraphs 339 and 556). Further, it is then used to support the argument for not removing “spikes” from the data (paragraph 556) and for not excluding E. coli data collected during high flow events (paragraph 598).

89 This commentary indicates that the approach to monitoring has been (and will continue to be) monthly data collection irrespective of weather conditions and that any effects of unusual events will be addressed during data analysis and interpretation.

90 This approach conflicts with the direction contained in a footnote to Table 3.11-1 that measurements of black disc sighting distance for the clarity attribute are carried out under baseflow conditions.

91 This conflicting commentary creates two issues. First, in the existing monitoring dataset all the water quality data has been collected on the same day. Clearly this creates an impossible situation, as the data cannot be collected to include high flow events, whilst also being collected at baseflow.

92 Second, if this is the intent of PC1, it will require that WRC’s monitoring programme in the future will have to be expanded to provide for data collection irrespective of weather conditions and flows for most attributes (and as required for the E. coli Attribute in the NOF), whilst also enabling the measurement of black disc sighting under only baseflow conditions.

Amended freshwater objectives

93 There are consequential changes that arise for the short and long-term freshwater objectives based on the discussion above. Until there is a transparent and robust assessment of current state, the scale of these changes will not be fully apparent. However, I

provide an amended version of Table 3.11.1 for eleven sites in the upper Waikato FMU based on the analysis described in the above paragraphs in Appendix 3.

Dr Martin Neale

15 February 2019

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APPENDIX 1

CURRICULUM VITAE | MARTIN NEALE

Director and Lead Scientist

Dr Martin Neale is a founding director and lead scientist at Puhoi Stour. Martin has specialist scientific skills and experience in the application of scientific information to the management of the natural environment.

Martin is an active member of the science community, but he also understands how science can be applied within the environmental management framework in New Zealand to achieve positive outcomes. Martin has led and coordinated a wide range of environmental research and monitoring projects through his roles in regional government, research institutes and more recently, in a commercial consultancy

Qualifications

2004 PhD, Freshwater Ecology, University of Ulster (U.K.)

2000 MSc, Environmental Science, Bournemouth University (U.K.).

1995 BSc (Hons), Biological Sciences, University of Plymouth (U.K.)

Professional positions held

2012 – Present Honorary Lecturer, School of Biological Sciences, University of Auckland

2017 – Present, Director, Puhoi Stour Limited, Auckland.

2016 – 2017 Senior Consultant, MartinJenkins Limited, Auckland.

2015 – 2017 Principal Freshwater Scientist, Golder Associates Limited, Auckland

2013 – 2015 Manager Environmental Science, Research Unit (RIMU), Auckland Council

2007 – 2013 Senior Scientist, Research Unit (RIMU), Auckland Council

2002 – 2007 Freshwater Biologist, Centre for Ecology and Hydrology (U.K.)

Professional distinctions and awards

2013 – 2015 National Objectives Framework expert group (periphyton and invertebrates)

2011 – 2014 National Environmental Monitoring and Reporting expert group member.

2014 – 2015 NPSFM 2014 implementation working group member

2010 to present, Member of Society for Freshwater Science

2007 to present, Member New Zealand Freshwater Science Society

Publications

Total number of *peer reviewed* publications and patents	Journal articles	Books, book chapters, books edited	Conference proceedings	Patents
	17	2	6	0

Selected publications;

Neale, M.W., Storey, R.G. & Rowe, D.K. 2017. Stream Ecological Valuation (SEV): revisions to the method for assessing the ecological functions of New Zealand streams. Australasian Journal of Environment Management. 24, 392-405.

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APPENDIX 2

Comparison table of current state estimates from CSG report, Doole et al (2016) and derived from WRC monitoring data. Differences of 10% and greater between current state estimates are highlighted.

Site/Parameter	Section 32 report (CSG report)	Doole et al (2016)	WRC monitoring data
Waikato River @ Ohaaki			
Chl a (median)	1.5	No data	1.5
Chl a (maximum)	13	No data	13
TN (median)	134	138	134
TP (median)	10	11	12
Nitrate (median)	0.039	0.04	0.039
Nitrate (95th %ile)	0.062	0.08	0.075
Ammonia (median)	0.002	No data	0.005
Ammonia (maximum)	0.013	No data	0.050
E. coli (95th %ile)	70	No data	73
Clarity	3.83	No data	3.53
Waikato River @ Ohakuri			
Chl a (median)	3.2	4.9	3.1
Chl a (maximum)	11	15.6	11
TN (median)	211	215	216
TP (median)	17	18	20
Nitrate (median)	0.084	0.08	0.082
Nitrate (95th %ile)	0.172	0.17	0.172
Ammonia (median)	0.003	No data	0.005
Ammonia (maximum)	0.017	No data	0.104
E. coli (95th %ile)	15	No data	15
Clarity	3.44	2	2.27
Waikato River @ Whakamaru Tailrace			
Chl a (median)	No data	No data	0.007
Chl a (maximum)	No data	No data	0.148

TN (median)	271	271	256
TP (median)	20	20	22
Nitrate (median)	0.101	0.10	0.080
Nitrate (95th %ile)	0.230	0.25	0.238
Ammonia (median)	0.003	No data	0.005
Ammonia (maximum)	0.010	No data	0.029
E. coli (95th %ile)	60	No data	60
Clarity	1.87	No data	1.92
Pueto Stream			
TN (median)	540	No data	500
TP (median)	93	No data	100
Nitrate* (median)	0.450	0.45	0.400
Nitrate* (95th %ile)	0.530	0.54	0.470
Ammonia (median)	0.003	No data	0.005
Ammonia (maximum)	0.009	No data	0.025
E. coli (95th %ile)	92	No data	30
Clarity	1.64	No data	1.72
Torepatutahi Stream			
TN (median)	625	No data	625
TP (median)	96	No data	96
Nitrate* (median)	0.500	0.5	0.500
Nitrate* (95th %ile)	0.800	0.83	0.821
Ammonia (median)	0.002	No data	0.005
Ammonia (maximum)	0.011	No data	0.032
E. coli (95th %ile)	216	No data	168
Clarity	No data	No data	No data
Waiotapu Stream @ Homestead Road Bridge			
TN (median)	1860	No data	1865
TP (median)	No data	No data	101*
Nitrate* (median)	1.285	1.29	1.300
Nitrate* (95th %ile)	1.570	1.67	1.627
Ammonia (median)	0.121	No data	0.315
Ammonia (maximum)	0.190	No data	0.550

E. coli (95th %ile)	281	No data	267*
Clarity	No data	No data	No data
Mangakara Stream			
TN (median)	1580	No data	1580
TP (median)	74	No data	74
Nitrate* (median)	1.300	1.30	1.300
Nitrate* (95th %ile)	1.600	1.68	1.662
Ammonia (median)	0.008	No data	0.019
Ammonia (maximum)	0.063	No data	0.510
E. coli (95th %ile)	1700	No data	1630
Clarity	0.86	No data	0.86
Kawanui Stream			
TN (median)	2990	No data	2990
TP (median)	82	No data	82
Nitrate* (median)	2.600	2.6	2.600
Nitrate* (95th %ile)	3.000	3.1	3.010
Ammonia (median)	0.006	No data	0.016
Ammonia (maximum)	0.083	No data	0.500
E. coli (95th %ile)	2535	No data	1578
Clarity	1.35	1.3	1.23
Waiotapu Stream @ Campbell Bridge Road			
TN (median)	1955	No data	1955
TP (median)	73	No data	73
Nitrate* (median)	0.915	0.92	0.915
Nitrate* (95th %ile)	1.100	1.14	1.131
Ammonia (median)	0.297	No data	0.860
Ammonia (maximum)	0.345	No data	1.100
E. coli (95th %ile)	18	No data	15
Clarity	1.17	1.2	1.16
Otamakokore Stream			
TN (median)	990	No data	990
TP (median)	144	No data	144
Nitrate (median)	0.740	0.74	0.740

Nitrate (95th %ile)	1.190	1.36	1.333
Ammonia (median)	0.006	No data	0.005
Ammonia (maximum)	0.024	No data	0.083
E. coli (95th %ile)	696	No data	437
Clarity	1.10	1.1	1.10
Whirinaki Stream			
TN (median)	810	No data	810
TP (median)	63	No data	63
Nitrate (median)	0.770	0.77	0.770
Nitrate (95th %ile)	0.870	0.89	0.881
Ammonia (median)	0.002	No data	0.005
Ammonia (maximum)	0.012	No data	0.076
E. coli (95th %ile)	98	No data	49
Clarity	2.70	2.7	2.70

Table notes:

1. Nitrate data for tributaries is Total Oxidised Nitrogen (nitrite and nitrate). Nitrate is not monitored by WRC in tributaries.

2. Chlorophyll a data only for Waikato River.

3. Incomplete dataset for Waiotapu Stream @ Homestead (TP monitoring data only from November 2011 onwards and E. coli only February 2013 onwards).

4. All units as per Table 3.11.3 in PC1 (i.e. Chlorophyll a, TN & TP = mg/m^3; nitrate = mg NO_3 – N/L; Ammonia = mg NH_4 – N/L; E. coli = E. coli/100mL; clarity = m)

APPENDIX 3

An updated version of Table 3.11-1 for 11 sites in the Upper Waikato FMU, showing amended freshwater objectives and a supplementary table of nutrient loads for limit and target setting purposes.

Objectives are amended to account for discrepancies in current state and issues associated with precision and accuracy discussed in my evidence.

Table 3.11-1 Short and long-term freshwater objectives

	Site	Attributes																													
		Annual median chlorophyll a (mg/m^3)			Annual maximum chlorophyll a (mg/m^3)			Annual median total nitrogen (mg/m^3)			Annual median total phosphorus (mg/m^3)			Annual median nitrate (mg NO_3-N/L)			Annual 95th percentile nitrate (mg NO_3-N/L)			Annual median ammonia (mg NH_4-N/L)			Annual maximum ammonia (mg NH_4-N/L)			95th percentile E. coli (E. coli/100mL)			Clarity (m)		
		Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year	Current state	Short term	80 year
73	Waikato River (Ohaaki)	NA	NA	NA	NA	NA	NA	134	134	134	12	12	12	0.04	0.04	0.04	0.08	0.08	0.08	0.01	0.01	0.01	0.05	0.02	0.02	73	70	70	3.5	3.5	3.5
66a	Waikato River (Tahorakuri)	NA	NA	NA	NA	NA	NA	200	200	160	28	15	15	0.09	0.09	0.09	0.25	0.20	0.15	0.01	0.01	0.01	0.03	0.02	0.02	102	102	102	ND	3.0	3.5
66b	Waikato River (Ohakuri)	3.1	3.2	3.2	11	11	11	216	206	160	20	20	17	0.08	0.08	0.08	0.17	0.17	0.17	0.01	0.01	0.01	0.10	0.05	0.05	15	15	15	2.3	2.5	3.0
67	Waikato River (Whakamaru)	7	4	3	15	15	15	256	260	200	22	22	20	0.08	0.08	0.08	0.24	0.24	0.24	0.01	0.01	0.01	0.03	0.02	0.02	60	60	60	1.9	2.0	3.0
74	Pueto Stm Broadlands Rd Br	NA	NA	NA	NA	NA	NA	540	540	500	93	85	50	0.45	0.45	0.40	0.47	0.53	0.50	0.01	0.01	0.01	0.03	0.02	0.02	82	90	90	1.6	1.8	3.0
72	Torepatutahi Stm Vaile Rd Br	NA	NA	NA	NA	NA	NA	625	600	500	96	90	50	0.50	0.50	0.45	0.82	0.80	0.80	0.01	0.01	0.01	0.03	0.02	0.02	168	220	200	ND	2.0	3.0
65	Waiotapu Stm Homestead Br Rd	NA	NA	NA	NA	NA	NA	1860	1800	800	101	100	50	1.29	1.26	1.00	1.66	1.60	1.50	0.32	0.11	0.03	0.55	0.20	0.05	266	280	280	ND	2.0	3.0
69	Mangakara Stm (Reporoa) SH5	NA	NA	NA	NA	NA	NA	1580	1550	800	74	70	50	1.30	1.27	1.00	1.66	2.50	1.50	0.02	0.01	0.01	0.51	0.06	0.05	1630	1600	540	0.86	0.9	1.6
62	Kawanui Stm SH5 Br	NA	NA	NA	NA	NA	NA	2990	2500	800	82	80	50	2.60	2.60	2.40	3.01	2.90	1.50	0.02	0.01	0.01	0.50	0.10	0.05	1578	2000	540	1.23	1.4	1.6
58	Waiotapu Stm Campbell Rd Br	NA	NA	NA	NA	NA	NA	1955	1900	800	73	70	50	0.92	0.92	0.92	1.13	1.10	1.10	0.86	0.29	0.24	1.10	0.35	0.05	15	20	20	1.2	1.2	1.6
59	Otamakokore Stm Hossack Rd	NA	NA	NA	NA	NA	NA	990	950	800	144	140	50	0.74	0.74	0.74	1.33	1.30	1.30	0.01	0.01	0.01	0.08	0.03	0.02	437	540	540	1.1	1.2	1.6
56	Whirinaki Stm Corbett Rd	NA	NA	NA	NA	NA	NA	810	800	500	63	60	50	0.77	0.77	0.77	0.88	0.90	0.90	0.01	0.01	0.01	0.076	0.03	0.02	49	100	100	2.7	2.7	3.0

NA – Attribute is not applicable to the sub-catchment

ND – No data for the sub-catchment

Supplementary table to Table 3.11-1 showing nutrient loads for limit and target setting purposes.

	Site	TN load (t/yr)			TP load (t/yr)		
		Current state	Short term	80 year	Current state	Short term	80 year
73	Waikato River (Ohaaki)	760	TBC	TBC	68	TBC	TBC
66a	Waikato River (Tahorakuri)*	1600	TBC	TBC	170	TBC	TBC
66b	Waikato River (Ohakuri)	1200	TBC	TBC	120	TBC	TBC
67	Waikato River (Whakamaru)	1700	TBC	TBC	140	TBC	TBC
74	Pueto Stm Broadlands Rd Br	85	TBC	TBC	15	TBC	TBC
72	Torepatutahi Stm Vaile Rd Br	93	TBC	TBC	17	TBC	TBC
65	Waiotapu Stm Homestead Br Rd	470	TBC	TBC	25	TBC	TBC
69	Mangakara Stm (Reporoa) SH5	36	TBC	TBC	2	TBC	TBC
62	Kawanui Stm SH5 Br	38	TBC	TBC	2	TBC	TBC
58	Waiotapu Stm Campbell Rd Br	110	TBC	TBC	4	TBC	TBC
59	Otamakokore Stm Hossack Rd	35	TBC	TBC	5	TBC	TBC
56	Whirinaki Stm Corbett Rd	7	TBC	TBC	1	TBC	TBC

* Loads for Waikato River (Tahorakuri) based on best available data (i.e. not monitored by WRC).

TBC – to be confirmed in Block 3 evidence when an alternative approach is presented.