in the matter of:	the Resource Management Act 1991
and:	submissions and further submissions in relation to proposed Variation 1 to the proposed Canterbury Land and Water Regional Plan
and:	**Fonterra Co-operative Group Limited** *Submitter*
and:	**DairyNZ** *Submitter*

Statement of evidence of Shirley Ann Hayward (NPSFM and nutrients)

Dated: 29 August 2014

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STATEMENT OF EVIDENCE OF SHIRLEY ANN HAYWARD

INTRODUCTION

1 My full name is Shirley Ann Hayward.

2 I am currently employed as a Water Quality Specialist for DairyNZ.

3 I hold the degrees of Bachelor of Science in Plant and Microbial Sciences and Master of Science in Environmental Science. I am a member of the New Zealand Freshwater Sciences Society.

4 In my current employment with DairyNZ I provide technical expertise on water quality issues relating to impacts of dairy farming, and provide input into various regional policy processes with regional councils. I was co-leader of the science team for the Land Use and Water Quality Hurunui pilot limit-setting project, in which the science team provided technical analysis of catchment water quality, hydrological and ecological issues and options for input into stakeholder and governance group deliberations.

5 I was previously employed by the Canterbury Regional Council for 16 years in a succession of roles including Microbiologist, Groundwater Quality Officer, Environmental Quality Analyst and Surface Water Quality Scientist. Over an 11 year period with Environment Canterbury I was involved with and managed groundwater quality, river and lake water quality and ecological monitoring programmes and investigations and have authored numerous peer reviewed technical reports on groundwater quality, river and lake water quality and aquatic ecosystem health.

6 During my time as a Surface Water Quality Scientist I was the project manager for the coastal lakes water quality monitoring programme and managed several studies relating to water quality and ecology of Te Waihora/Lake Ellesmere. I was also involved with developing a set of recommendations to the panel hearing submissions on the Natural Resources Regional Plan in relation to river and lake management units and indicators and numeric criteria for water quality objectives and discharge standards.

7 I have also been employed as a consultant with Pattle Delamore Partners during 2012/13, in which time I project managed investigations of earthquake impacts on hydrological and ecological functioning of the Wairarapa Stream in Christchurch, and completed a review of regional groundwater quality for the Horizons Regional Council.

8 In preparing my evidence I have reviewed the relevant technical reports relating to groundwater quality, surface water quality and ecology, lake water quality, lake remediation and ecosystem restoration opportunities and the technical overview report.

9 I have also read the evidence of **Mr Willis, Mr Ryan, Mr Cullen** and **Mr Smeaton** and the relevant parts of the section 32 Report and section 42A Report.

SCOPE OF EVIDENCE

10 In my evidence I have been asked to provide:

10.1 A comparison of the outcomes ("attribute states") required by the National Policy Statement for Freshwater Management 2014 (NPS-FM 2014) and the objective and limits contained in Variation 1;

10.2 An evaluation of current water quality compared to the objective and limits in Variation 1 and the NPS-FM 2014 attributes;

10.3 An assessment of Te Waihora/Lake Ellesmere and measures proposed in Variation 1 to achieve the outcomes sought for the lake; and

10.4 An outline of the catchment nitrogen load limit.

11 Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2011. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

KEY CONCLUSIONS

12 A comparison of the water quality objectives and limits proposed in Variation 1 with the attributes set out in the NPS-FM 2014 indicate that Variation 1 currently does not fully apply the all the attributes listed to all water management units. The nutrient related limits proposed in Variation 1 for Te Waihora/Lake Ellesmere do not meet the national bottom-lines values. However, it has been clarified recently that the lake attributes in the NPS-FM 2014 were not intended to apply to lakes such as Te Waihora/Lake Ellesmere and Coopers Lagoon, because these lakes can be classified as

intermittently closing and opening lagoons (ICOLs). Shallow, brackish ICOLs such as Te Waihora/Lake Ellesmere have quite different trophic responses compared to deep freshwater lakes for which the NPS-FM 2014 attributes states were intended.

13 Many uncertainties remain in the predictions of the effects of the regulatory measures proposed in Variation 1. This includes uncertainties of the estimate of the nitrogen load that is ‘yet to come’ from time lags in the catchment. Also, there is uncertainty around how the lake is likely to respond to in-lake and near-lake mitigation measures.

14 Despite these uncertainties, I support the need to carefully manage nitrogen and phosphorus loads to Te Waihora/Lake Ellesmere in order that the broader objectives of Variation 1 and Zone Committee may be successfully achieved in the long term. It is important that it is acknowledged that successful achievement of the zone committee outcomes for Te Waihora/Lake Ellesmere is dependent on a range of in-lake and near-lake interventions.

COMPARISON OF THE WATER QUALITY OBJECTIVES AND LIMITS IN VARIATION 1 TO THE NPS-FM 2014 OUTCOMES

15 The National Policy Statement for Freshwater Management 2014 (NPS-FM 2014) came into effect 1 August 2014. The NPS-FM 2014 now provides a national framework that directs how councils are to go about setting objectives, policies and rules about fresh water in their regional plans. The NPS-FM 2014 provides a set of water quality attributes for which councils must apply appropriate states to all water management units in their region.

16 The attributes applicable to rivers in Appendix 2 of the NPS-FM 2014 are periphyton (chlorophyll a), nitrate, ammonia, and *E. coli*.

17 The attributes applicable to lakes in Appendix 2 of the NPS-FM 2014 include total nitrogen (TN), total phosphorus (TP), phytoplankton (chlorophyll a) (chl. a), ammonia (NH_3N), *E. coli*, and planktonic cyanobacteria.

18 Tables 1 and 2 in Appendix 1 of this statement of evidence combine the relevant NPS-FM 2014 attributes with objectives and limits proposed in Variation 1 for rivers and lakes respectively. The metrics used differ between the two documents, but I have attempted to align similar metrics in the tables. For example, annual median is commonly used metric in the Attributes Tables while Variation 1 specifies annual averages. Both of these metrics describe the central tendency of a dataset and can be considered broadly comparable, providing the dataset is not strongly skewed. Ideally, the development of numeric objectives and limits in plans

will use the same metrics as those in the NPS-FM 2014 or relevant guidelines.

19 Variation 1 also sets out proposed nitrate toxicity limits for all river management units encountered in the Selwyn Te Waihora zone. The nitrate toxicity limits proposed in Variation 1 are consistent with the range of Attribute States in the NPS- FM 2014.

20 Table 11(a) in Variation 1 sets out numeric water quality outcomes which form part of the water quality objectives for Selwyn Te Waihora zone. These outcomes include periphyton and microbial indicators that can be compared to the NPS-FM 2014 Attributes. Appendix 1. The range of periphyton outcomes (chlorophyll a) fall within the various Attribute States in the NPS-FM 2014, although the metrics used differ somewhat.

21 Table 11(a) does not include *E. coli* specifically but does include the Suitability for Recreation Grade (SFRG) for specified popular bathing sites. The SFRG is based on guidelines for primary contact recreation (full immersion) (MfE 2003). The range of grades (good to fair) are equivalent to Attribute States A and B and C. Table 11(b) does not, however, set any microbial indicators for spring-fed plains streams.

22 Ammonia toxicity is not included in the water quality outcomes or limits in Variation 1.

23 It is apparent that the Variation 1 lake limits proposed in Table 11(l) for Te Waihora/Lake Ellesmere are considerably higher (worse) than the national bottom-lines for TN, TP and chl. a. Assuming that annual median and annual average metric are comparable, the TN limit is nearly 5 times higher than the national bottom line while the TP limit is twice as high. The chlorophyll a limit is over 6 times higher than the NPS national bottom-line. The proposed limits for Coopers Lagoon are at the approximate lower boundary for Attribute State B and are well above the national bottom-lines.

24 Table 11(l) do not include values for *E. coli* or ammonia. However the outcomes in Table 11(b) do include Suitability for Recreation Grade (SFRG) specifically for the site at Te Waihora/Ellesmere Domain. The SFRG is based on guidelines for primary contact recreation (full immersion) (MfE 2003). This grade range set for this site is equivalent to Attribute States A and B. Variation 1 does not include *E. coli* or ammonia objectives or limits for other areas of Te Waihora/Lake Ellesmere or Coopers Lagoon.

25 In relation to total nitrogen, a footnote in Appendix 2 of the NPS-FM 2014 states that

> *'Intermittently closing and opening lagoons' (ICOLs) are not included in brackish lakes'*

26 I interpret this to mean that the attributes for annual median of 'Seasonally stratified and brackish lakes' to not apply to ICOLs. Te Waihora/Lake Ellesmere is an ICOL, in that it is a shallow, brackish lagoon with a coastal gravel barrier that is more frequently closed than open (Schallenberg et al, 2010). As with many ICOLs, openings to the sea in Te Waihora/Lake Ellesmere are managed artificially. Te Waihora/Lake Ellesmere is also a polymictic lake (shallow, mixed year round) but the footnote appears ambiguous with regard to brackish *and* polymictic ICOLs. Coopers Lagoon/Muriwai can also be considered an ICOL because it is a coastal lagoon separated from the sea by the same barrier that separates Te Waihora/Lake Ellesmere from the sea. Coopers Lagoon/Muriwai has a piped outlet to the sea that remains closed most of the time.

27 Based on a recent letter from the Ministry for the Environment (MfE) to regional councils, it has been clarified that the lake attributes in Appendix 2 of the NPS-FM 2014 were not intended to apply to ICOLs, and that the MfE is considering making changes to the NPS-FM 2014 to clarify that position. It is noted in the letter that:

> *Initial advice suggests that the attributes for human health and ammonia toxicity as set out in the NPS-FM 2014 are likely to remain unchanged for ICOLs.*

28 From the above letter, it appears that the lake attributes set for TN, TP and phytoplankton (chlorophyll a) are not applicable to ICOLs such as Te Waihora/Lake Ellesmere and Coopers Lagoon. The reasons for this are that different lake types respond differently to eutrophication pressures. In particular, lake depth is a key driver of lake trophic responses. Other characteristics such as lake level fluctuations (e.g., intermittent opening regimes of ICOLs), salinity and light regimes can also influence lake trophic response (production of macrophytes, macroalgae and/or phytoplankton) and consequential effects of other components of the lake ecosystem.

29 For example, chlorophyll a concentrations found in Te Waihora are very high, and in the range that could be expected to create widespread anoxic (absence of dissolved oxygen) conditions in a deeper lake that routinely stratifies. However, Te Waihora/Lake Ellesmere does not stratify, largely because of the frequent wind-induced mixing of the shallow lake waters that maintain an aerated condition. Furthermore, the poor water clarity of the lake caused by frequent resuspension of bed sediments mean the phytoplankton growth is frequently light-limited (Norton et al., 2014). Therefore, Te Waihora/Lake Ellesmere does not routinely generate the massive

algal blooms and scums that occur in other similarly enriched lakes, for example those that occur in the neighbouring and similarly enriched Lake Forsyth/Te Roto O Wairewa (Hayward and Ward 2009).

30 Therefore I consider the trophic lake attributes set out in the NPS-FM 2014 are not applicable to Te Waihora/Lake Ellesmere and Coopers Lagoon.

31 While the NPS-FM 2014 does not include the use of the Trophic Level Index[1] (TLI), applying the TLI equations of Burns et al. (2000) to the national bottom lines for TN, TP and chl. a equates to a TLI_3 of 5.1. This compares to the TLI limit proposed in Variation 1 for Te Waihora/Lake Ellesmere of 6.6 at mid lake and 6 around the lake's margins. The TLI is essentially a logarithmic scale and therefore, attempting to meet the NPS-FM trophic bottom-line attributes would mean a greater than 10-fold reduction in the lake's trophic status.

32 Early modelling by Environment Canterbury during the plan development phase explored the implications of reducing the TLI from 6.8 (2011 average) to 6 at the mid lake site (Norton et al., 2014, Robson, 2014). The Section 32 report concluded that the level of nutrient reduction required to achieve at midlake TLI of 6.0 would result in very significant social disruption from the land use changes required.

33 Furthermore, the section 32 report comments in relation to the Focus Groups and Zone Committee evaluation of Scenario 3 that :

> *The Focus Groups and Zone Committee acknowledged this option more effectively achieved the environmental and cultural outcomes sought, but all found the level of social and economic disruption that would occur to be unacceptable.*

34 Therefore reducing the TLI further to 5.1 is likely to require significant land use changes that reduce N losses.

35 Overall while the water quality objectives and limits proposed in Variation 1 include a number of the attributes listed in the NPS-FM 2014, not all water management units have been assigned values for each of the attributes. In particular, *E. coli*, which is an attribute for the compulsory human health for recreation value is not specified for all water management units. Nor are cyanobacteria (phytoplankton) attributes set for the lakes. While water quality limits proposed for the two lakes include the attributes set out in Appendix 2 of the NPS-FM 2014, the levels set for Te Waihora/Lake

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[1] Trophic level index (TLI) integrates measures of nitrogen, phosphorus, chlorophyll a and water clarity into an index that describes the trophic status of a lake on a scale of 0-7. TLI_3 is a modification that utilises TN, TP and chlorophyll a.

Ellesmere are considerably higher than the national bottom-lines. It is apparent from recent advice from MfE that the lake attributes currently included in the NPS-FM 2014 were not intended to be applicable to ICOLs such as Te Waihora/Lake Ellesmere and Coopers Lagoon.

AN EVALUATION OF CURRENT WATER QUALITY COMPARED TO THE NUTRIENT OBJECTIVES AND LIMITS IN VARIATION AND THE NPS-FM 2014 OUTCOMES

36 I have undertaken an assessment of the nitrate data available for rivers and streams in comparison to the limits proposed in Table 11(k), focussing on those that flows into Te Waihora/Lake Ellesmere. I have also undertaken an assessment of the water quality of Te Waihora/Lake Ellesmere and Coopers Lagoon in relation to the TN, TP and chl. a attributes for lakes in the NPS-FM 2014. These assessments are based on water quality data obtained from Environment Canterbury.

37 Appendix 2 show a series of graphs of annual median nitrate+nitrite nitrogen[2] (NNN) concentrations for the main rivers and streams that flow into Te Waihora/Lake Ellesmere. Each graph includes the limit (annual median) as set out in Table 11(k) for that river type.

38 The data show that spring-fed plain streams have generally high NNN concentrations, which reflect the dominant influence of nitrate rich groundwater inflows, and therefore the NNN limits proposed for these river types are realistic and appropriate. The Selwyn River is classified on Environment Canterbury's planning maps as hill-fed lower from where it emerges from the foothills and travels along the plains to its discharge into Te Waihora/Lake Ellesmere. Appendix 2 show NNN concentrations for two sites on the Selwyn River; Whitecliffs is located just as the river emerges from the foothills, and Coes Ford site is located east of SH1, about 6 km upstream of Te Waihora/Lake Ellesmere. The data shows very low NNN concentrations in the upper site, well below the proposed toxicity limit for hill-fed lower. In contrast, the lower site at Coes Ford has elevated NNN concentrations. The lower Selwyn River (below SH 1) gains significant flows from nitrate rich groundwater, and consequently has nitrate concentrations more similar to spring-fed plains rivers than true hill-fed rivers. The lower Selwyn River would need more than 50% reductions in nitrate concentrations in order for it to comply with the limit set out in the Table 11(k) for hill-fed lower rivers. Despite elevated NNN concentrations, Environment

[2] Nitrate + nitrite nitrogen (NNN) is the standard laboratory parameter for the sum of oxidised nitrogen forms in freshwaters. Because nitrite is readily transformed to nitrate in well oxygenated waters, it is usually a very minor component of NNN concentrations meaning that NNN can be generally equated with concentrations of nitrate nitrogen.

Canterbury's ecosystem health data for the Coes Ford site indicates healthy invertebrate communities (very good invertebrate grade) (Hughey et al. 2013). It is therefore more appropriate that the lower Selwyn River is recognised as more of a groundwater spring-fed influenced reach and the nitrate toxicity limit is set at 6.9 mg/L (annual median) for the lower Selwyn River (below SH1).

39 I have also assessed the data for Te Waihora/Lake Ellesmere and Coopers Lagoon/Muriwai against the limits and targets proposed in Table 11(l) of Variation 1. Graphs of the relevant metric compared to the Variation 1 limits are provided in Appendix 4. The metric used for lake trophic attributes in the NPS-FM 2014 are annual median and maximum (chlorophyll a only). While the metric used for Table 11(l) is based on annual averages. Hence the need for separate graphs to strictly assess the limits and attributes.

40 The graphs illustrate that in both lakes there is considerable year to year variation in concentrations in total N and P, and even greater annual variation in chlorophyll a concentrations. In Te Waihora/Lake Ellesmere, nutrient concentrations *within the lake* are not increasing nor are chlorophyll a concentrations showing long-term increases. However the large variation in chlorophyll a is acutely apparent in recent years, where the highest annual median and maximum concentration occurred in 2009/10, while the lowest concentrations occurred in 2012/13.

41 The chlorophyll a concentrations in Te Waihora/Lake Ellesmere over the 2010/11, 2011/12 and 2012/13 period are the lowest over the 21 year dataset. This is despite a general pattern of increasing nitrate concentrations in the rivers feeding into the lake (see graphs in Appendix 2).

42 Drivers of the trophic response of Te Waihora/Lake Ellesmere are a complex interaction of nutrient inputs, nutrient processes within the lake, variation the light regime, salinity variations, lake levels and discharges during openings (Norton et al., 2014, Gibbs and Norton 2014, Schallenberg et al. 2010). The data shown in Appendix 3 suggest that variations in nitrogen concentrations *within* the lake are not linked in a 1:1 manner to variations in nitrogen inputs to the lake. That is not to say that nitrogen does not have an influence of the trophic condition of the lake. I agree with Norton et al., (2014) that current evidence indicates that control of both nitrogen and phosphorus will be important in reducing the unacceptably high trophic status of the lake. Rather, that there are processes within the lake, particularly denitrification, that result in significant in reductions in nitrogen concentrations compared to inputs (Norton et al 2014, Schallenberg et al, 2010).

43 Despite these uncertainties, I support the need to reduce the loads of nitrogen and phosphorus within Te Waihora/Lake Ellesmere in order that the broader objectives of Variation 1 and Zone Committee may be successfully achieved in the long term.

UNCERTAINTIES IN PREDICTIONS OF WATER QUALITY OUTCOMES

44 With any attempt to predict the effects of land use impacts on environment outcomes, there will be assumptions needed and uncertainties generated. This is unavoidable and cannot be eliminated. The approach taken by Environment Canterbury in attempting to develop a set of linked models that incorporate a wide range of catchment components inevitably results in simplifications and areas of uncertainty (Robson et al., 2014),. In my view, some significant areas of uncertainty remain in their predictions of current land use and associated nitrogen losses. While the land use information used was probably the best that could be currently obtained at the catchment scale, it still remains a rudimentary estimate of land use intensity and consequently nitrogen loss predictions. The uncertainties created at this step in the process carries through several modelling stages through to predictions of groundwater, stream and lake nitrogen concentrations once the full effects of current land uses are seen (measured).

45 In particular, I consider the estimate of the ‘nitrogen load to come’ which is based on these rudimentary estimates of current land use, nitrogen losses and drainage losses associated with land use, is highly uncertain (Hanson, 2014). While I agree that there is likely to be a time lag in the transport of nitrogen from the time it is lost from land to when it enters groundwater (transport through the vadose zone) and subsequent transport through groundwater to ultimately discharge to either the lowland streams, directly to the lake or off-shore. This time lag will vary across the catchment with greater time lags occurring in the upper catchment. However, the estimate of the quantity of nitrogen yet to be measured in receiving environments is subject to considerable uncertainty because of the limited ability to determine recent nitrogen losses at the catchment scale.

46 Furthermore, simplifying assumptions that nitrate concentrations in land surface recharge equate to shallow groundwater nitrate concentrations add a level of conservatism (worst case) to the model predictions of nitrogen concentrations in the various receiving environments (Hanson 2014). This raises the question of whether the anticipated ‘nitrogen loads to come’ are over estimated.

47 Despite the potential considerable uncertainty in the approach taken by Environment Canterbury, I accept that nitrogen concentrations in

the receiving environments are likely to increase, at least in parts of the catchment where significant recent land use intensification has occurred. Improved information about land use and associated nitrogen losses will come in time, particularly as land use consents start to be required on many farms in the catchment.

48 In addition, the development of the matrix of good management practice nitrogen loss numbers will greatly aid in catchment modelling in the future.

49 In summary I acknowledge that the water quality objectives and limits proposed in Variation 1 are the product of Environment Canterbury's best current predictions of water quality outcomes, and I generally support those objectives and limits. However, it is important to acknowledge the need for on-going monitoring, data gathering and refinement of models. A commitment to reviewing and reporting on the outcomes and limits in the plan at regular intervals (say 5 years) will help address some concerns with the current approach.

ADDITIONAL METHODS NEEDED TO ACHIEVE THE DESIRED OUTCOMES FOR TE WAIHORA/LAKE ELLESMERE

50 The broad outcomes sought in the Selwyn Waihora zone implementation plan addendum (ZIP Addendum) for Te Waihora/Lake Ellesmere are a healthy ecosystem that includes establishment of healthy macrophyte beds, improved water clarity, and recreational opportunities are improved.

51 I acknowledge that these outcomes, while ambitious, are desirable for achieving long-held goals for Te Waihora (Hughey and Taylor 2008). Variation 1 sets out specific numeric water quality outcomes and limits that will contribute to achieving these broad outcomes. In particular, Variation 1 includes specific controls on nitrogen in the catchment along with provisions that implicitly control phosphorus losses, in order to achieve an improved trophic status of the lake. It is acknowledged in the section 42 report and by Gibbs and Norton (2014) that reducing current nutrient loads on their own are unlikely to achieve the zone committee outcomes for the lake.

52 Consequently, in order to achieve the outcomes for the lake, a range of other interventions are required in addition to controls on nutrients. Gibbs and Norton (2014) explored at a conceptual level various mitigation options, of which some were included in catchment modelling that formed an essential part of the 'zone committee solution' (Norton, et al, 2014).

53 While I agree with Gibbs and Norton (2014) that the long-term success of strategies to improve the overall health and water quality

will depend on in-lake reductions in nitrogen and phosphorus, other lake interventions are going to be critical to achieving the zone committee and Variation 1 outcomes.

54 Many uncertainties remain around how the lake is likely to respond to in-lake and near-lake mitigation measures, and other implications and costs. However, including in Variation 1 an on-going commitment to developing and where possible implementing appropriate interventions are helpful in the sense of balancing the expectations of the regulatory measures in the plan with the non-regulatory measures in achieving the outcomes.

55 It is encouraging to see in the section 42A report the commitment of Environment Canterbury and its partners to development of mitigation measures and implementation. This includes the investment by Fonterra for programmes that contribute to improved water quality outcomes in the Selwyn Te Waihora zone.

NITROGEN LOAD LIMIT

56 I have been asked to provide an explanation of components of the farm nitrogen load proposed in Table 11(i). I have relied on the section 32 report for the following data: 2011 nitrogen load from farming activities, increase in nitrogen load allowance for farms losing less than 15 kgN/ha/yr, and proposed farming load limit to be achieved by 2022. The additional nitrogen load that was allocated to the Central Plains Water (CPW) Scheme for additional irrigation of 30,000 ha was sourced from spreadsheets provided to CPW at the time of notification of Variation 1 (Susan Goodfellow, pers comm.). From this, I have been able to calculate the nitrogen (N) load reduction that was needed from existing farms, whose current losses were greater than 15 kgN/ha/yr in order to achieve the 2022 limit of 4830 tonnes/year.

57 Table 1 summarises this simple calculation. It is important to note that the 2011 farm load was calculated using updated estimates of nitrogen losses for Canterbury (Lilburne et al., 2013) and the assumption was made during the catchment load modelling that these N loss estimates represented farms operating at good management practice (GMP) (Robson 2014). Therefore the load calculated for 2011 is actually attempting to estimate 2011 land use losses as if all farms were operating at the 2017 expectation for achieving the Good Management Practice Nitrogen and Phosphorus Loss Rates.

58 Based on the breakdown of components in the farming load set in Variation 1, the total N load reduction expected from existing farms that are losing more than 15 kg N/ha/yr is 653 tonnes/year, which is a 14% reduction in N load beyond assumptions about GMP.

Table 1	Tonnes of N/year	% of 2011 load
2011 current land use (assumes GMP)	4529	
Additional load allowed for flexibility of farms below 15 kg/ha/yr	520	11%
Additional load allowed for CPW's new irrigation area	434	10%
Load reduction expected from existing farms losing more than 15 kgN/ha/yr	**-653**	**-14%**
2022 load proposed in Variation 1	4830	

CONCLUSION

59 While the water quality objectives and limits proposed in Variation 1 include some of the attributes listed in Appendix 2 of the NPS-FM 2014, not all water management units have been assigned values for each of the attributes. In particular, *E. coli*, which is an attribute for the compulsory human health for recreation value is not specified for all water management units. Nor are cyanobacteria (phytoplankton) attributes set for the lakes.

60 The water quality limits proposed for the two lakes include attributes set out in Appendix 2 of the NPS-FM 2014 for TN, TP and Chlorophyll a. It is apparent in recent advice from MfE that the lake attributes currently included in the NPS-FM 2014 were not intended to be applicable to ICOLs such as Te Waihora/Lake Ellesmere and Coopers Lagoon. Shallow, brackish ICOls such as Te Waihora/Lake Ellesmere have quite different trophic responses compared to deep= freshwater lakes for which the NPS-FM 2014 attributes states were intended. If the national bottom line attribute states were to be applied to Te Waihora/Lake Ellesmere, this is likely to require vary large nutrient reductions and consequently widespread land use changes.

61 The approach taken by Environment Canterbury in attempting to develop a set of linked models that incorporate a wide range of catchment components inevitably results in simplifications and areas of uncertainty. These areas of uncertainty include the amount of nitrogen that is ‘yet to come’ and nitrate mixing and transport in the shallow groundwater. Despite these uncertainties, I support the need to control nutrients and other contaminants in order to achieve the outcomes sought in Variation 1 and by the Zone Committee.

62 Further uncertainties remain around how the lake is likely to respond to nutrient controls and in-lake mitigation measures. Despite these uncertainties, I support the need to carefully manage nitrogen and phosphorus loads to Te Waihora/Lake Ellesmere in order that the broader objectives of Variation 1 and the Zone Committee may be successfully achieved in the long term. It is important that it is acknowledged that successful achievement of the zone committee outcomes for Te Waihora/Lake Ellesmere is dependent on a range of in-lake and near-lake interventions.

63 A commitment to continual improvements in catchment information (e.g., land use), monitoring of outcomes sought, and refinement of water quality predictions will help address concerns with current areas of uncertainty.

Dated: 29 August 2014

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Shirley Hayward

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APPENDIX 1 – SUMMARY TABLES OF COMPARISON OF NPS-FM 2014 ATTRIBUTES AND VARIATION 1 OBJECTIVE AND LIMITS

Rivers	NPS -FM 2014 Appendix 2 Attribute states			Variation 1 Table 11(a) - freshwater outcomes				
	State A	State B	State C	Alpine - upland	Hill-fed upland	Hill fed -lower	Banks Peninsula	Spring-fed plains
Periphyton (Chlorophyll a) mg chl-a/m^2	Default Class - Exceeded in no more than 8% of samples*1			maximum	maximum	80% of samples over 5 year period	maximum	maximum
	≤50	≤120	≤200	≤50	≤50	≤200	≤120	no value set
	Productive Class - Exceeded in no more than 17% of samples*1							
	≤10	≤25	≤60					
E. coli (*E. coli* /100 ml)	State A	State B	State C	Alpine - upland	Hill-fed upland	Hill fed -lower	Banks Peninsula	Spring-fed plains
	Annual median - relating to secondary contact recreation							
	≤260	≤540	≤1000					
	95th percentile - relating to full immersion activities			95 percentile*2				
	≤260	≤540		≤260 (good) - ≤550 (fair)	≤260 (good)	≤260 (good) - ≤550 (fair)	no value set	no value set
				Table 11(k) - limits for rivers				
Nitrate (toxicity) mg NO_3N/L	State A	State B	State C	Alpine - upland	Hill-fed upland	Hill fed -lower	Banks Peninsula	Spring-fed plains
	Annual median			Annual median				
	≤1.0	≤2.4	≤6.9	≤1	≤1	≤2.4	≤1	≤6.9
	Annual 95th percentile			Annual 95th percentile				
	≤1.5	≤3.5	≤9.8	≤1.5	≤1.5	≤3.5	≤1.5	≤9.8
Ammonia toxicity mg/L (= 1000 x mg/m3)	State A	State B	State C					
	Annual median (based on pH 8 and temperature of 20°C)							
	≤0.03	≤0.24	≤1.3					
	Annual maximum (based on pH 8 and temperature of 20°C)							
	≤0.05	≤0.4	≤2.2					

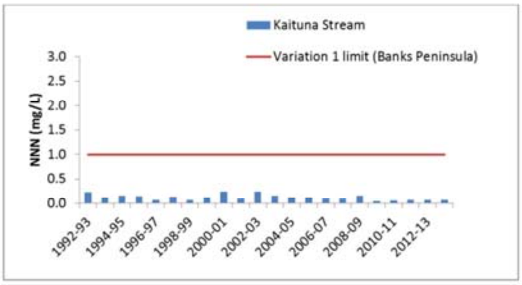
*1 Based on a monthly monitoring regime. The minimum record length for grading a site based on periphyton (chl-a) is 3 years.

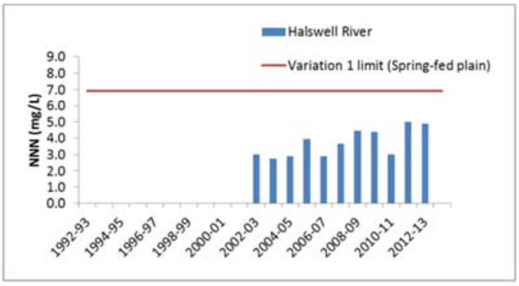
*2 Table 11(b) sets a 'Suitability for recreation grade (SFRG)' of good to fair for Te Waihora/Lake Ellesmere. In combination with a site risk assessment, compliance with SFRG for a particular site is based on the 95th percentile of 5 years *E. coli* data collected weekly during the bathing season. For a grade of 'good' the 95th percentile value needs to be within the range of 131 -260 *E. coli*/100 ml, and for 'Fair' within the range of 261 - 550 *E. coli*/100 ml

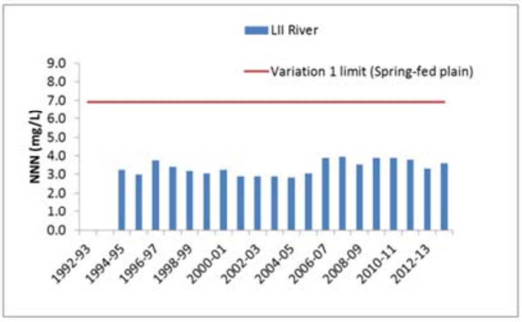
Lakes	**NPS -FM 2014** **Appendix 2 Attribute states**			**Variation 1** **Table (l) - targets**	
Phytoplankton (Chlorophyll a) **(mg/m^3 = mg/L)**	**State A**	**State B**	**State C**	**Te Waihora**	**Coopers Lagoon**
	Annual median			Annual average	
	≤2	≤5	≤12	≤74	≤5
	Annual maximum				
	≤10	≤25	≤60		
Total Nitrogen **mg/L (= 1000 x mg/m^3)**	**State A**	**State B**	**State C**	**Te Waihora**	**Coopers Lagoon**
	Seasonally stratified and brackish lakes - Annual median			Annual average	
	≤0.16	≤0.35	≤0.75	≤3.4	≤0.34
	Polymictic lakes - Annual median				
	0.30	0.50	0.80		
Total phosphorus **mg/L (= 1000 x mg/m^3)**	**State A**	**State B**	**State C**	**Te Waihora**	**Coopers Lagoon**
	Annual median			Annual average	
	≤0.01	≤0.02	≤0.05	≤0.1	≤0.02
				Table 11(b) - freshwater outcomes	
E. coli	**State A**	**State B**	**State C**	**Te Waihora**	**Coopers Lagoon**
	Annual median - relating to secondary contact recreation				
	≤260	≤540	≤1000		
	95^{th} percentile - relating to full immersion activities			95 percentile*[1]	
	≤260	≤540		≤260 (good) - ≤550 (fair)	no value set
Ammonia toxicity **mg/L (= 1000 x mg/m3)**	**State A**	**State B**	**State C**	Not included in Variation 1	
	Annual median (based on pH 8 and temperature of 20°C)				
	≤0.03	≤0.24	≤1.3		
	Annual maximum (based on pH 8 and temperature of 20°C)				
	≤0.05	≤0.4	≤2.2		

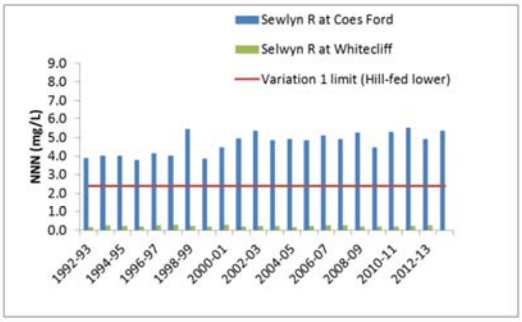
*1 Table 11(b) sets a 'Suitability for recreation grade (SFRG)' of good to fair for Te Waihora/Lake Ellesmere. In combination with a site risk assessment, compliance with SFRG for a particular site is based on the 95^{th} percentile of 5 years *E. coli* data collected weekly during the bathing season. For a grade of 'good' the 95th percentile value needs to be within the range of 131 -260 *E. coli*/100 ml, and for 'Fair' within the range of 261 - 550 *E. coli*/100 ml

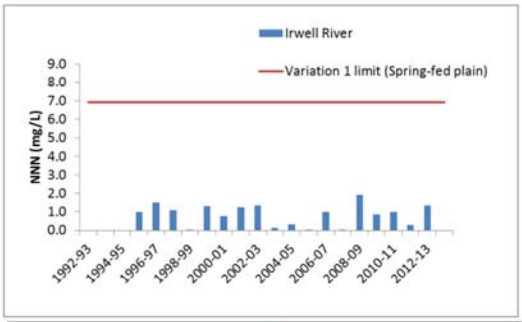
APPENDIX 2 – ANNUAL MEDIAN NITRATE+NITRITE NITROGEN (NNN) CONCENTRATIONS IN RIVERS AND STREAMS THAT FLOW TO TE WAIHORA/LAKE ELLESMERE

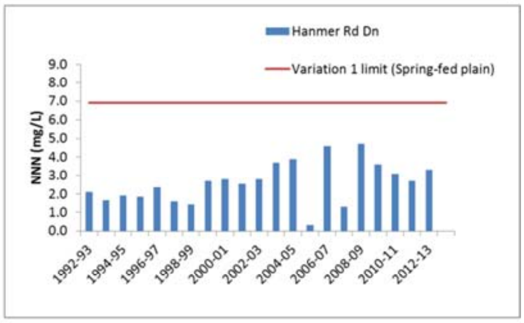


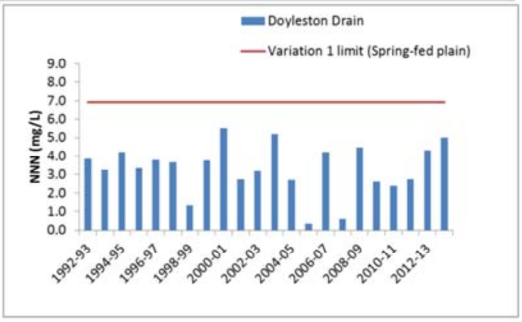


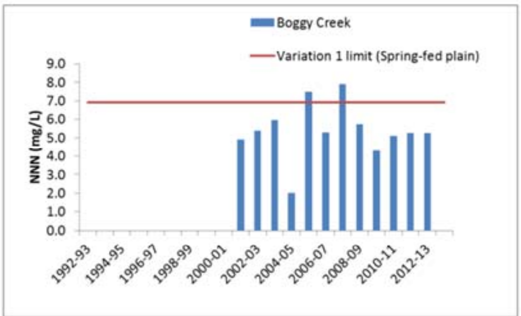


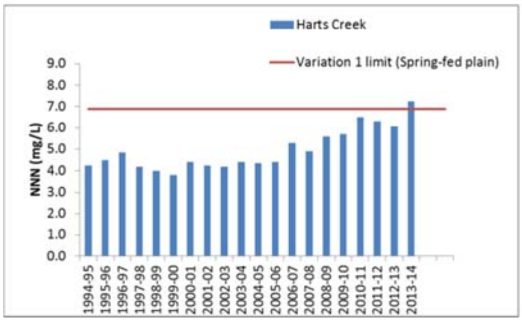


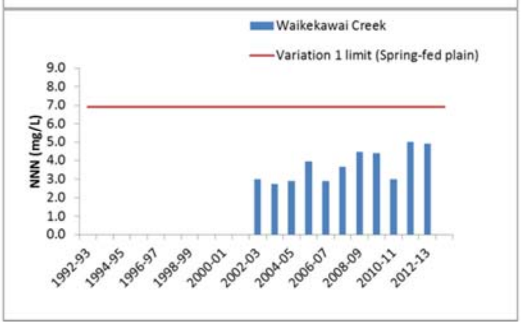




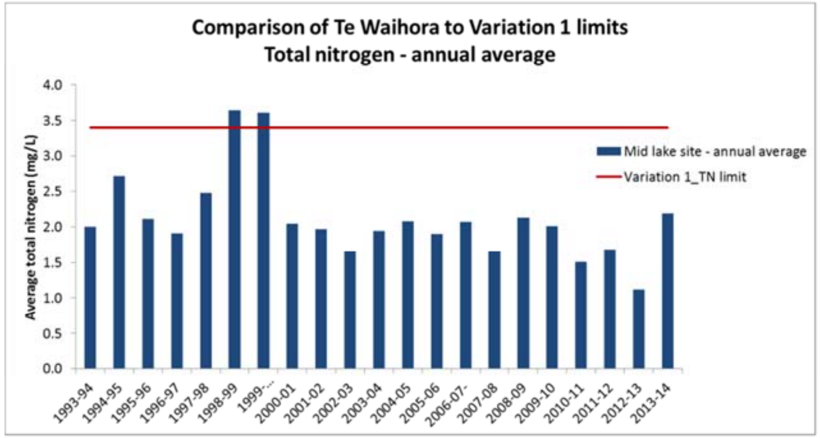


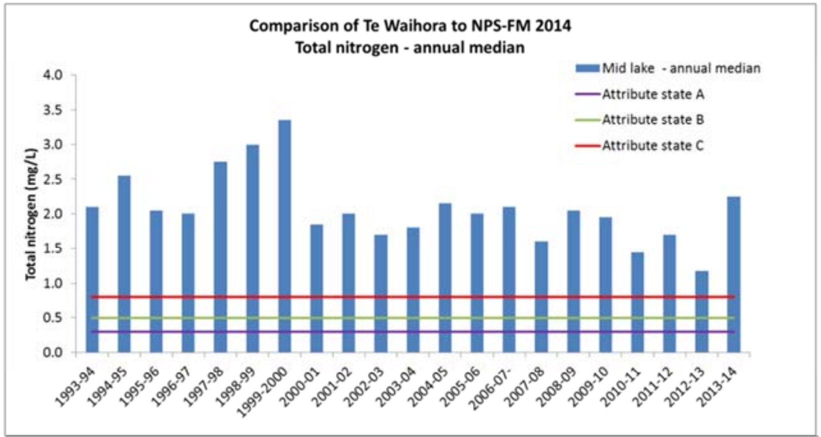


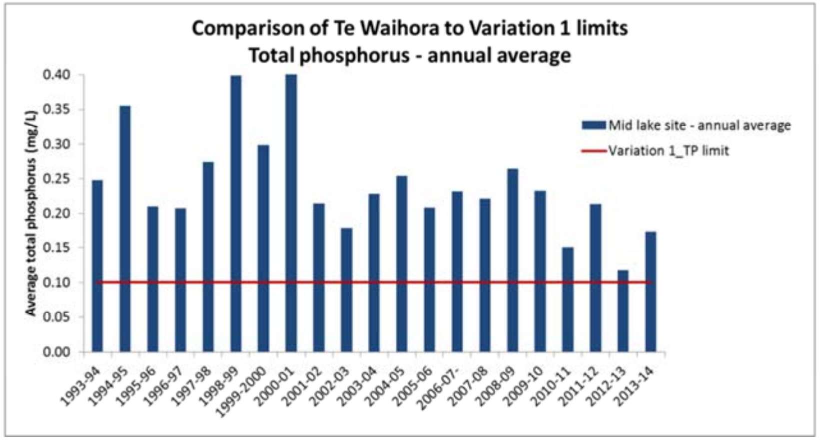


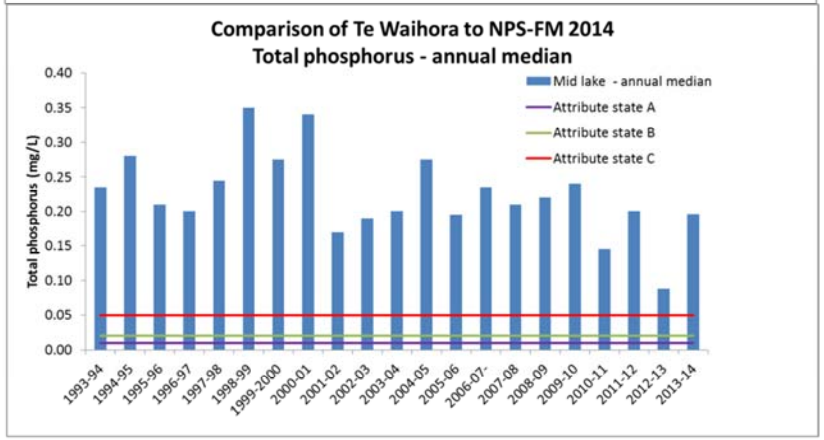


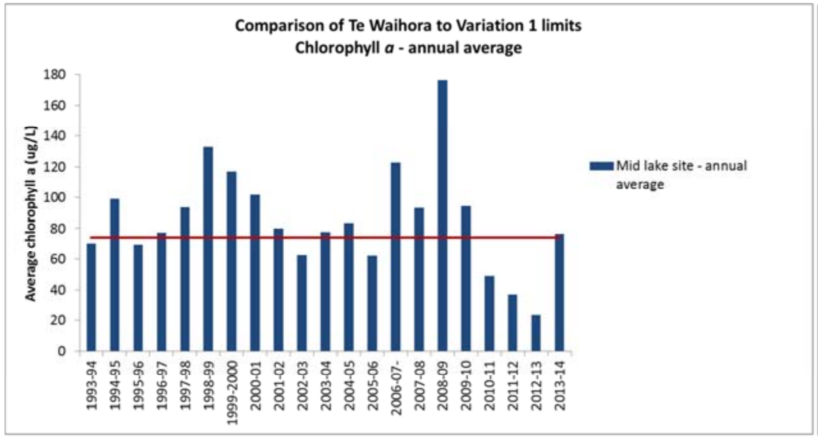
APPENDIX 3 – TE WAIHORA/LAKE ELLESMERE WATER QUALITY

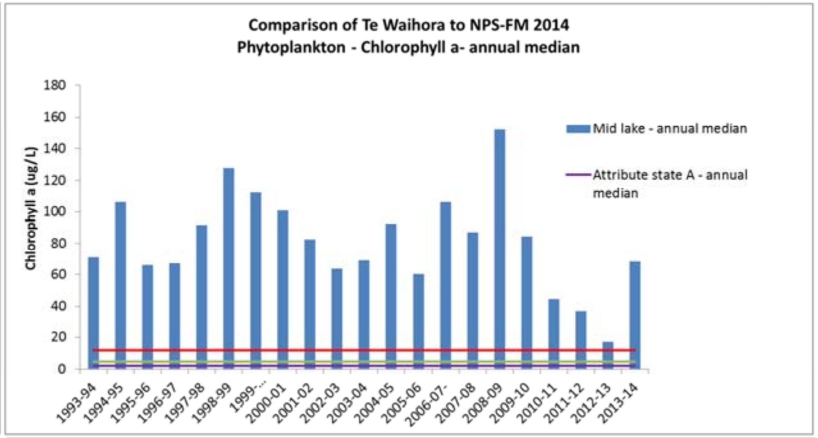


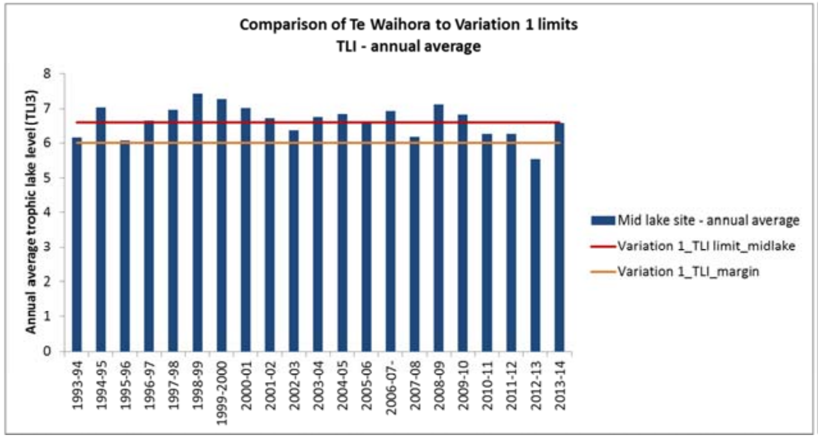


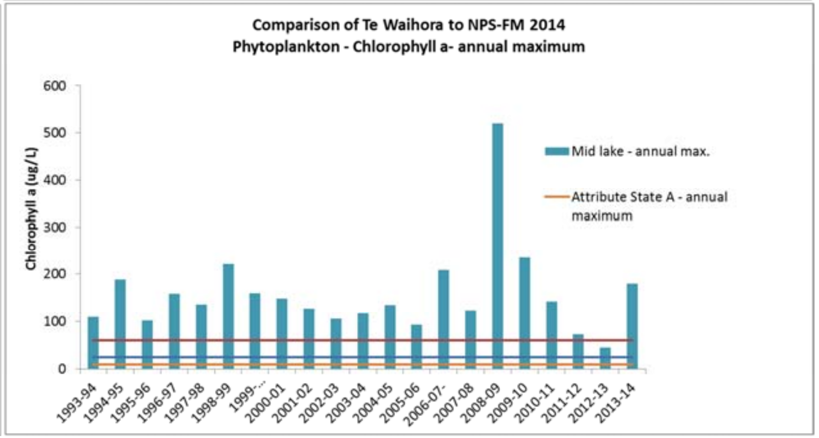




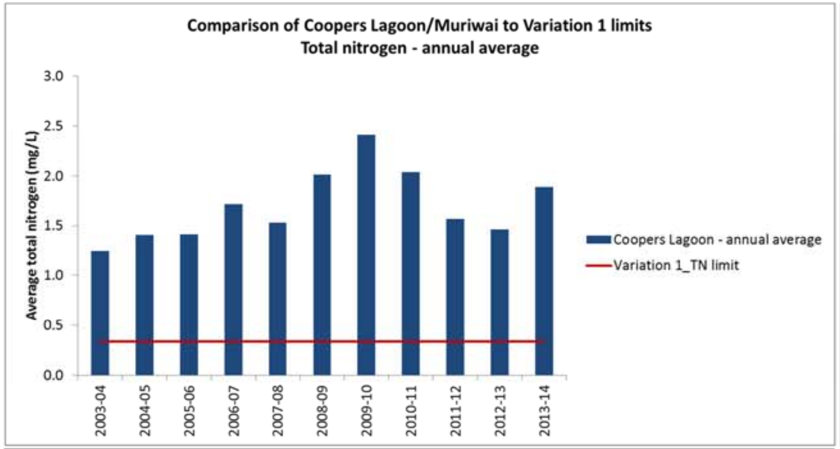

Comparison of Te Waihora to Variation 1 limits
Chlorophyll a - annual average
Average chlorophyll a (ug/L)
Mid lake site - annual average

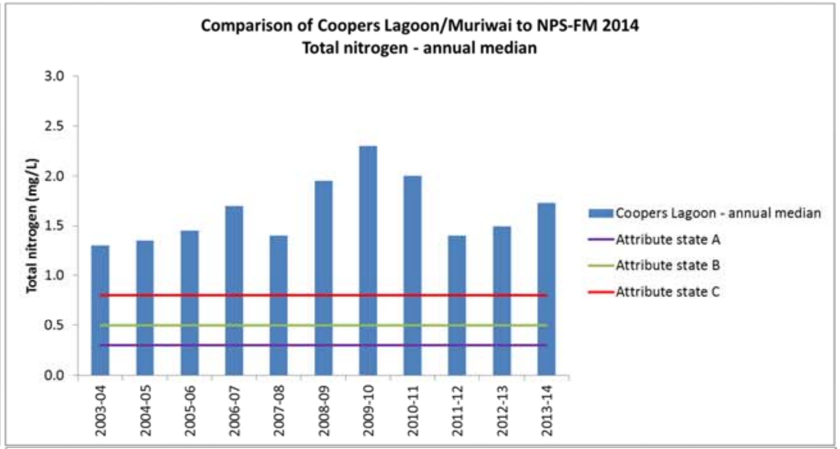

Comparison of Te Waihora to NPS-FM 2014
Phytoplankton - Chlorophyll a- annual median
Chlorophyll a (ug/L)
Mid lake - annual median
Attribute state A - annual median

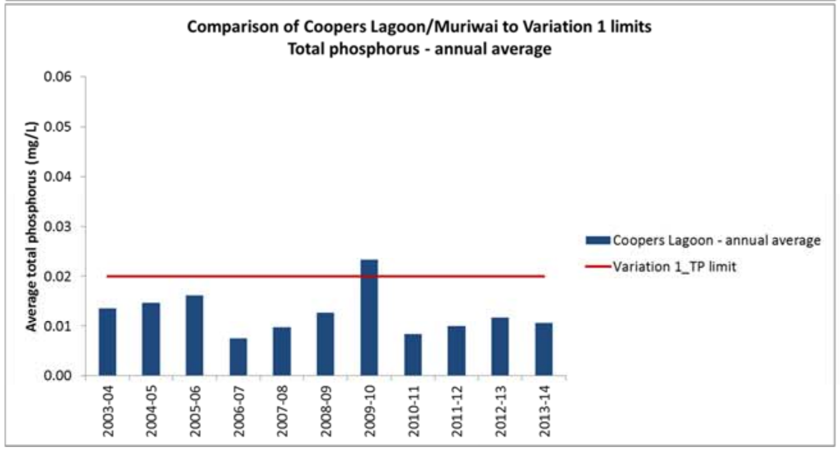

Comparison of Te Waihora to Variation 1 limits
TLI - annual average
Annual average trophic lake level (TLI3)
Mid lake site - annual average
Variation 1_TLI limit_midlake
Variation 1_TLI_margin

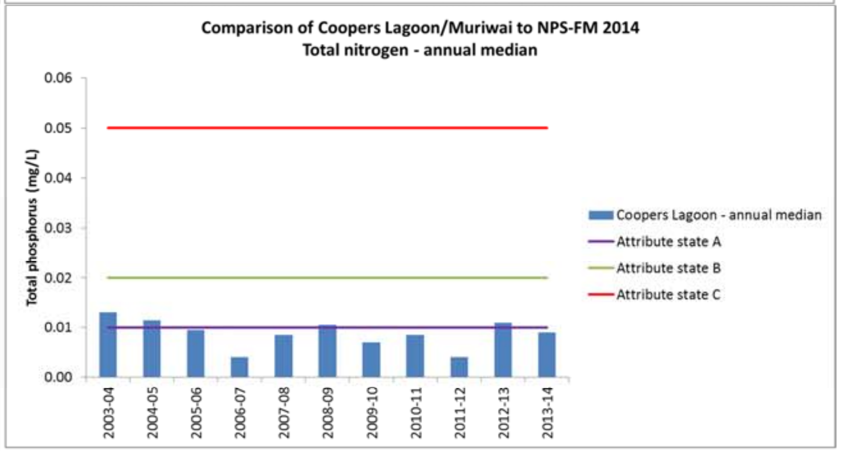

Comparison of Te Waihora to NPS-FM 2014
Phytoplankton - Chlorophyll a- annual maximum
Chlorophyll a (ug/L)
Mid lake - annual max.
Attribute State A - annual maximum

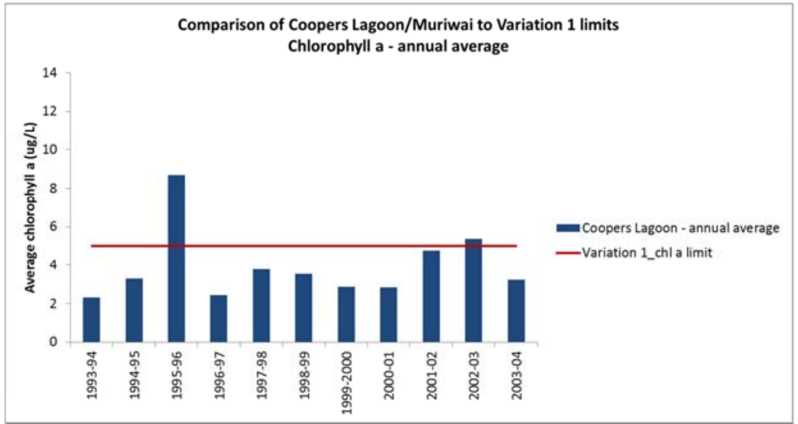
APPENDIX 4 – COOPERS LAGOON / MURIWAI WATER QUALITY

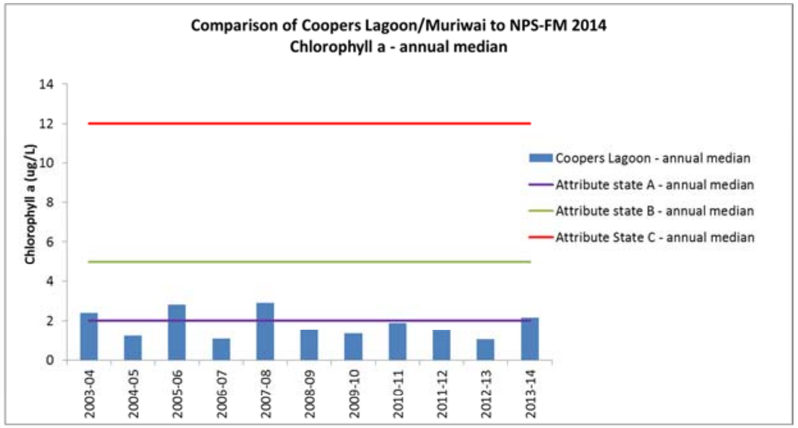


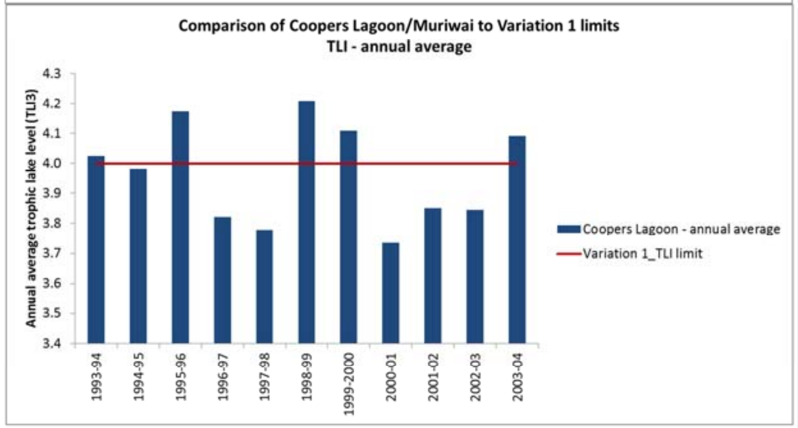


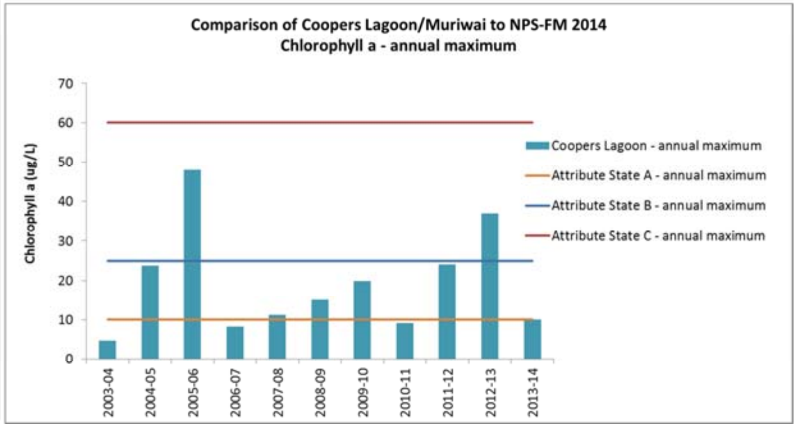





Comparison of Coopers Lagoon/Muriwai to Variation 1 limits
Chlorophyll a - annual average
Average chlorophyll a (ug/L)
Coopers Lagoon - annual average
Variation 1_chl a limit


Comparison of Coopers Lagoon/Muriwai to NPS-FM 2014
Chlorophyll a - annual median
Chlorophyll a (ug/L)
Coopers Lagoon - annual median
Attribute state A - annual median
Attribute state B - annual median
Attribute State C - annual median


Comparison of Coopers Lagoon/Muriwai to Variation 1 limits
TLI - annual average
Annual average trophic lake level (TLI3)
Coopers Lagoon - annual average
Variation 1_TLI limit


Comparison of Coopers Lagoon/Muriwai to NPS-FM 2014
Chlorophyll a - annual maximum
Chlorophyll a (ug/L)
Coopers Lagoon - annual maximum
Attribute State A - annual maximum
Attribute State B - annual maximum
Attribute State C - annual maximum