in the matter of:	a submission on proposed Plan Change 3 to the Land & Water Regional Plan – South Canterbury Coastal Streams
to:	**Canterbury Regional Council**
submitter	**Hunter Downs Development Company Limited**

Statement of evidence of Donna Lee Sutherland

Dated: 25 September 2015

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STATEMENT OF EVIDENCE OF DONNA LEE SUTHERLAND

QUALIFICATIONS AND EXPERIENCE

1 My full name is Donna Lee Sutherland.

2 I am a scientist in Freshwater Ecology at the National Institute of Water and Atmospheric Research (NIWA). For the past 12 years I have worked on New Zealand lake ecosystems focusing on algal and macrophyte response to anthropogenic impacts, freshwater biosecurity, and the taxonomy and ecology of New Zealand and Antarctic algae and New Zealand freshwater macrophytes. Over the past 4 years I have undertaken research on algal nutrient uptake and removal from nutrient enriched waters. I have authored or co-authored 20 scientific publications, numerous presentations and popular articles and over 100 significant commercial consultancy reports.

3 I hold a PhD in Environmental Science (University of Canterbury (*UoC*)), specialising in microalgal physiology, productivity and nutrient removal from wastewater and a Master's of Science (Hons; *UoC*), specialising in cyanobacteria.

4 I am a member of New Zealand Freshwater Sciences Society, Australasian Society for Phycology and Aquatic Botany, the International Applied Phycology Society, and the New Zealand Plant Conservation Network.

5 I have been involved in the following work that is relevant to proposed Plan Change 3 (*PC3*) to the Land & Water Regional Plan – South Canterbury Coastal Streams:

- Appendix 18 to the Overview Report – Sutherland, D.L., Norton, N. (2011) Assessment of augmentation of water flows in Wainono Lagoon. NIWA Client report CHC2011-043.
- Numerous client reports on the ecology of the Upper Waitaki lakes, including Lake Waitaki and the potential effects of increased nutrient loads to the Upper Waitaki aquatic ecology.

SCOPE OF EVIDENCE

6 I have been asked by the Hunter Downs Development Company Limited (*HDDCL*) to prepare evidence on the effects of the proposed flow augmentation into Wainono Lagoon on the water quality and primary productivity in Wainono Lagoon.

7 My evidence includes a discussion of:

7.1 the current state of water quality and primary productivity in Wainono Lagoon;

7.2 the potential effects of increased nutrient loads, under Scenario 2A, on water quality and primary productivity in Wainono Lagoon; and

7.3 the potential effects of flow augmentation on the water quality and primary productivity in Wainono Lagoon.

8 I confirm that I have read the Environment Court's Code of Conduct for expert witnesses and this evidence has been prepared in accordance with that code. I agree to comply with the code's terms. In that regard, I confirm that the statements made in this evidence are within my area of expertise (unless I state otherwise) and I also confirm that I have not omitted to consider material facts which might alter the opinions stated in this evidence.

BACKGROUND TO AUGMENTATION

9 As discussed by **Ms Sarah Dawson**, the provision of augmentation is key part of the South Coastal Canterbury ZIP Addendum 2014 and the wider framework provided by PC3.

10 In simple terms PC3 is intended *inter alia* to enable:

10.1 the development of further irrigation through the Hunter Downs Irrigation and Waihao Downs Irrigation Scheme(s);

10.2 some potential increase in existing low nitrogen properties (the 'flexibility cap');

10.3 a requirement for some properties to reduce their total nitrogen losses (the 'maximum cap'); and

10.4 the augmentation of Wainono Lagoon.

11 Collectively, the Overview Report[1] that accompanied the notified plan change refers to the 'package' as Scenario 2 – with Scenario 2a assuming the irrigation schemes would be built as consented while Scenario 2b explored the merits of flow augmentation.

12 Under the proposed Scenario 2a, the Overview Report predicts total nitrogen and total phosphorus loads to the lagoon to increase by 60% and 13%, respectively. Accordingly, flow augmentation, using water originating from the lower Waitaki River, has been proposed as a part of 2b as a means to provide not only immediate mitigation of the adverse effects on the water quality and primary productivity of Wainono Lagoon

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[1] Norton, N.; Robson, M. (2015) South Canterbury Coastal Streams (SCCS) limit setting process - Predicting consequences of future scenarios: Overview Report. Environment Canterbury.

but also improvement – with an anticipated reduction of the existing trophic level index (*TLI*) to 6.0 or less.

13 My evidence focuses on the role of flow augmentation as a means of providing one of the simplest methods for reducing nutrient concentrations in Wainono Lagoon by dilution with lower nutrient water.

EFFECTS OF FLOW AUGMENTATION ON PHYTOPLANKTON BIOMASS PRODUCTION IN WAINONO LAGOON

14 Before turning specifically to biomass production it is noted that flow augmentation would involve the removal of water from the Waitaki River downstream of Lake Waitaki. Lake Waitaki is currently regarded as being in an oligotrophic state, meaning that the lake have low biological productivity, and have relatively high water quality i.e., low nutrients, highly valued colour and clarity, limited phytoplankton productivity, and no known blooms of nuisance or toxic phytoplankton. Lake Waitaki is part of a chain of glacial fed hydro-lakes regarded as having high aesthetic values due to the fine suspended particles of glacial flour that give these lakes their distinctive milky blue appearance. Oligotrophic state is four orders of magnitude below the current trophic state of Wainono Lagoon.

15 Prior to discussing the lagoon it is useful to note that shallow lakes are typically either turbid and devoid of submerged macrophytes or clear and vegetated. Excessive nutrient loading has caused many lakes to shift towards the turbid, or phytoplankton (free-floating photosynthetic microalgae) dominated, state. Natural events such as alterations in the water level, heavy storms, salinity intrusions, or natural fish kills may also cause a shift between the alternative stable states. Lakes that have undergone eutrophication are typically in a phytoplankton dominated state.

16 Presently, Wainono Lagoon is in a phytoplankton dominated state and is turbid for most of the time. Native milfoils (*Myriophyllum* spp) and *Ruppia* spp. have been recorded in the lagoon previously, but there are no aquatic macrophytes in the lagoon at present. I will discuss the effects on macrophyte re-establishment later in my evidence.

17 Chlorophyll *a* (Chl-*a*), a photosynthetic pigment, is a standard unit of measure used to quantify phytoplankton biomass. Using the monthly water quality monitoring data from Environment Canterbury, the long term (2000 – 2010) mean Chl-*a* in the lagoon was 23.7 mg m^{-3}, although peak biomass has reached as high as 240 mg m^{-3}. To place this in context, Lake Waitaki has a long-term mean Chl-*a* of 1.5 mg m^{-3}, and a maximum peak biomass of 3.3 mg m^{-3}. A visual representation of these Chl-a concentrations is shown in **Figure 1**.

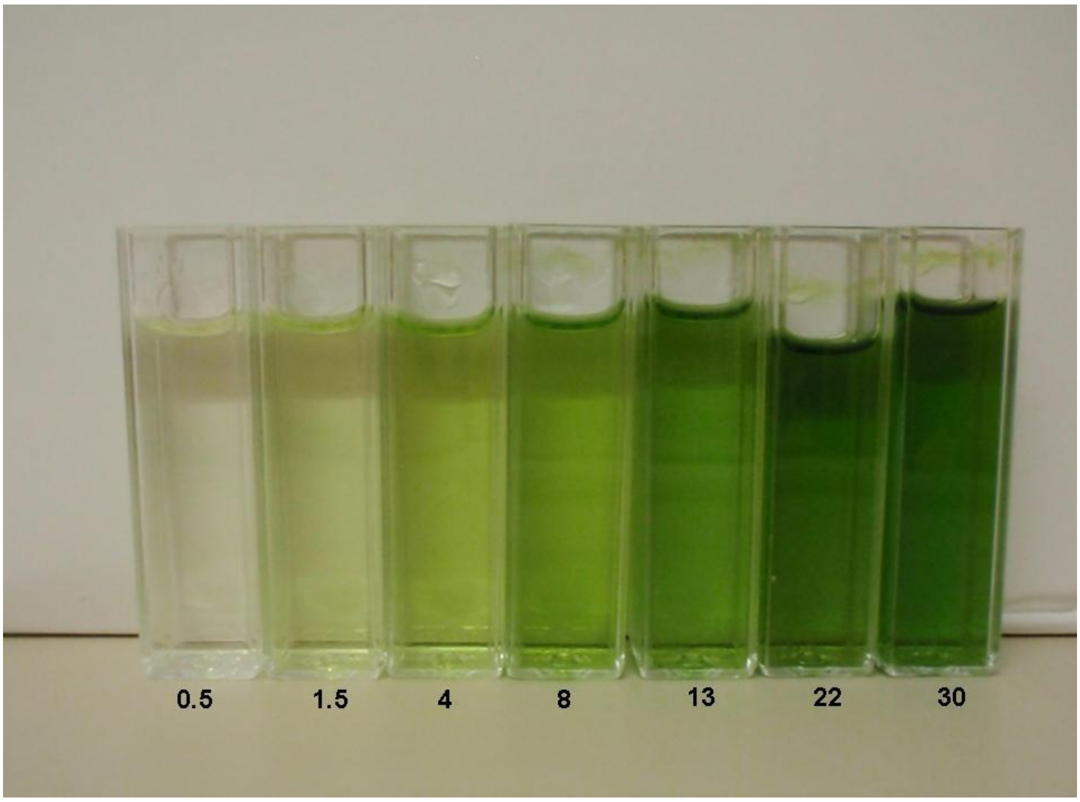

Figure 1: Visual display of extracted Chlorophyll *a* at a range of concentrations (mg m^{-3}). Lake Waitaki currently at 1.5 mg m^{-3} and Wainono Lagoon currently at 23.7 mg m^{-3}.

18 With strong positive relationships between major nutrients and phytoplankton biomass, increased nutrient loads without augmentation are anticipated to further stimulate the growth of phytoplankton in Wainono Lagoon.

19 In this regard, nutrient enrichment mesocosms were undertaken to demonstrate the potential response of the resident phytoplankton community in Wainono Lagoon to increased nutrient loads[2]. The phytoplankton community present at the time of the mesocosm experiments (2007) was most responsive to the addition of dissolved inorganic nitrogen (DIN). Using the results of the mesocosm experiments, Norton et al. (2007) developed a relationship between Chl-*a* and DIN concentration as a means to predict phytoplankton biomass in response to the anticipated nutrient load increases. This relationship predicted an approximate 1.5 fold increase in phytoplankton biomass were further

[2] Norton, N.; Floeder, S.; Drake, D. (2007). Hunter Downs Irrigation Scheme: Assessment of potential effects of increased nutrients on aquatic ecology values in rivers and Wainono Lagoon. NIWA Client Report CHC2007-057

irrigation to occur without augmentation (Scenario 2a). Based on the mean Chl-*a* data reported earlier in my evidence, this would result in an increase in the summer-time Chl-*a* from 23.7 mg m^{-3} to 35.6 mg m^{-3}.

20 A more sophisticated modelling approach was undertaken by Abell et al. (2015), using the coupled hydrodynamic-ecological models DYRESM-CAEDYM and ELCOM-CAEDYM. Based on Scenario 2a, the model predicated a 40% increase in the long-term Chl-*a* biomass, and a 56% increase of the maximum Chl-*a* biomass. This would result in a long-term annual average increase from 23.7 mg m^{-3} to 23.2 mg m^{-3}, while peak Chl-*a* biomass may exceed 370.0 mg m^{-3}.

21 As discussed above, flow augmentation with Lake Waitaki derived water is anticipated to reduce the in-lagoon N and P species concentrations through the simple process of dilution.

22 Dilutions of in-lagoon nutrients is anticipated to reduce phytoplankton biomass - although potential physiological adaptations of the phytoplankton in response to changing environmental parameters make it difficult to accurately predict the degree of reduction in biomass productivity in response to a specific nutrient dilution. A recent study I undertook on wastewater phytoplankton demonstrated that when nutrient loads were diluted by half there was a 15-30% reduction in phytoplankton biomass, depending on season (i.e. the response is not necessarily proportion to the dilution that occurs). This was due to improved physiological performance of the phytoplankton in response to reduced nutrient load, meaning that the phytoplankton were better adapted at utilising available resources.

23 However, of further key relevance, increased inflow into the lagoon from flow augmentation will most likely result in a decrease in residence time. Residence time is the time that a parcel of water remains in the lagoon. Residence time affects the accumulation of phytoplankton biomass, with accumulation decreasing as residence time decreases. Increased inflows will flush the lagoon on a more frequent basis than current, particularly during drier summer months. This will help contribute to reduced biomass accumulation.

24 Overall, if augmentation is to occur it will more than likely need to be managed adaptively (balancing dilution and residence time) to ensure the intended outcomes are met.

EFFECTS OF FLOW AUGMENTATION ON THE TROPHIC LEVEL INDEX IN WAINONO LAGOON

25 The trophic level index (TLI) is a numeric measure of the lake water quality, or the life-supporting capacity per unit volume of a lake[3]. The TLI was developed for New Zealand lakes and is determined using measurements of TN, TP, Chl-*a* and Secchi depth (a measure of water clarity). Measurements of the components of the TLI are typically made monthly over the entire year. TLI is calculated as an annual average from 3 complete years of (preferably at least monthly) data.

26 Wainono lagoon is currently classified as hypertrophic with a mean TLI_3 of 6.5[4]. Hypertrophic is the highest level (the most nutrient-enriched state) under the TLI classification. This means that the waterbody has been excessively enriched with nutrients, which results in high phytoplankton biomass production and frequent blooms. In its present state, Wainono Lagoon exceeds the maximum TLI objective (currently 6.5 compared to TLI ≤ 6.0 anticipated under PC3).

27 Without augmentation, and based on simple mass balance, increased nutrient loads and the associated increase in phytoplankton productivity under Scenario 2a, that I described earlier (i.e. full irrigation development), TLI_3 could be expected to increase by approximately 0.3 units. A similar rise in TLI_3 by 0.28 units was predicted by the coupled modelling approach undertaken by Abel et al. (2015). This would result in TLI_3 increasing from its current value of 6.5 to 6.78 - 6.8. This would lead to a further departure from the TLI objectives for Wainono Lagoon.

28 Under flow augmentation dilution of the nutrient loads to the lagoon with the oligotrophic water derived from the Waitaki River would subsequently lead to dilution of nutrient concentrations within the lagoon. Based on simple mass balance of nutrients, and dis-regarding any decrease in phytoplankton biomass, augmenting inflows by approximately between 952 L s^{-1} and 1270 L s^{-1} would result in the dilution of both TN and TP sufficient enough to lower TLI_3 to $\leq$ 6.

EFFECTS OF FLOW AUGMENTATION ON DISSOLVED OXYGEN CONCENTRATION IN WAINONO LAGOON

29 Dissolved oxygen (DO) concentration is one of the most important variables in aquatic systems. DO is critical for supporting aquatic life and reflects the balance between several physical and biochemical processes.

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[3] Burns, N.M.; Rutherford, J.C.; Clayton, J.S. (1999). A monitoring and classification system for New Zealand lakes and reservoirs. Journal of Lake and Reservoir Management 15(4): 255-271

[4] Due to the very limited Secchi depth data, TLI for Wainono Lagoon has been calculated using TN, TP and Chl-*a* only, hence termed TLI_3.

30 DO concentrations can undergo diurnal cycles. Daytime photosynthesis produces oxygen which is released by the algae into the water column. When phytoplankton biomass is high, production of oxygen exceeds whole-lake consumption (respiration and decomposition), and DO concentration in the water column increases, often reaching super-saturating levels in hypertrophic waterbodies. At night when no oxygen is produced from photosynthesis, whole-lake consumption results in declining DO concentrations, sometimes reaching critical levels. Typically the lowest DO concentrations in a diurnal cycle occur in early morning.

31 DO can be replenished at surface from the atmosphere. Oxygen concentrations in the atmosphere are considerably greater than in water and this difference results in oxygen dissolving into the water. More oxygen dissolves in the water under windy, or turbulent, conditions as the resulting waves increase the surface area thus allowing more diffusion. The amount of oxygen that can dissolve into the water is dependent on water temperature due to the relationship between water temperature and gas saturation.

32 There is limited DO data available for the Wainono Lagoon. ECan have undertaken single spot measurements of DO as part of their monthly monitoring. The long-term (2004-2010) mid-morning median DO saturation was 60%. Based on this monitoring data, DO would frequently breach the 90% minimum specified in the LWRP.

33 It should be noted that time of day can greatly impact on the DO measurements. While mid-morning measurements of those diurnally variable water quality parameters are typically similar to diurnal median value, they do not represent the extreme minimum and maximum concentrations, which biota are more sensitive to.

34 Due to the high phytoplankton biomass in Wainono Lagoon, DO concentrations would most likely reach super-saturation levels (> 100%) midday / early afternoon, particularly during the summer. Oxygen depletion through respiration would see the DO levels in Wainono decline over night, reaching the lowest concentration at dawn. Under bloom conditions this could potentially reach transient critical levels for other biota.

35 Under Scenario 2a, both the minimum and maximum DO concentrations are anticipated to become more extreme as a result of increased phytoplankton biomass and associated bacteria biomass.

36 However under flow augmentation (Scenario 2b), in addition to the potential dilution of biomass and therefore a reduction in respiration (oxygen consumption), waters from the Waitaki River would be saturated in DO which would add positively to the DO balance in Wainono lagoon. The degree of this benefit is not able to be quantified at present with the available data.

EFFECTS OF FLOW AUGMENTATION ON TURBIDITY IN WAINONO LAGOON

37 High turbidity, or low water clarity, is another key feature of the water quality in Wainono Lagoon. Suspended sediment in the water column gives rise to the characteristic brown coloured appearance of the water (**Figure 2**). This is a result of a shallow water column (~ 1m) coupled with frequent wind-driven mixing that results in the re-suspension of fine particulate sediment (**Figure 3**).

38 The long-term (2000 – 2010) median turbidity in Wainono Lagoon was 100 NTU, while the minimum and maximum recorded turbidity during this period was 4 and 2,500 NTU, respectively[5].

[5] Data source Environment Canterbury.

Figure 2. The typical turbid, brown-coloured appearance of the water of Wainono Lagoon.

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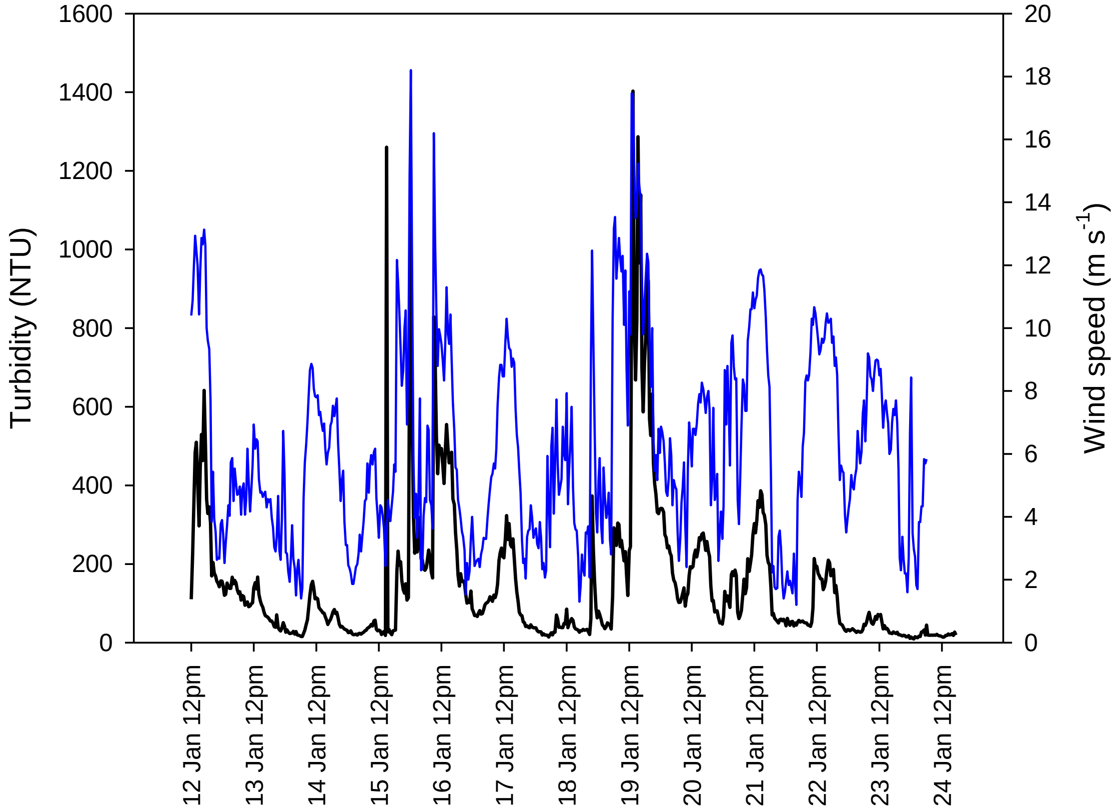

Figure 3: Turbidity (black line) and wind speed (blue line) in Wainono Lagoon. Measurements taken every 30 minutes during a 12 day period in January 2011.

39 While phytoplankton biomass is often associated with turbidity in a waterbody, it is likely to be second to wind-driven re-suspended bed sediment as the primary driver of turbidity in Wainono Lagoon. There is only a very weak positive correlation (R^2 = 0.281) between turbidity and Chl-*a* concentration in the lagoon (**Figure 4**). While increased phytoplankton biomass under the proposed Scenario 2a would further increase turbidity, this is likely to only be detected during extended calm periods when sediment has settled out of the water column.

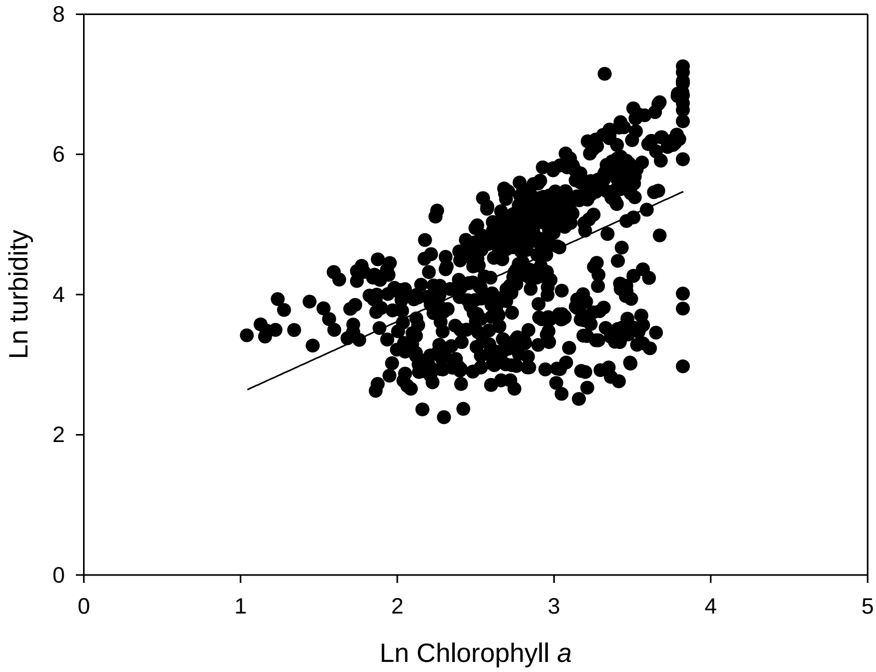

Figure 4: Relationship between log transformed chlorophyll *a* and turbidity in Wainono Lagoon during January 2011, R^2 = 0.281.The Department of Conservation (DoC) has raised concerns regarding turbidity in the Waitaki derived waters for flow augmentation. In particular, concern has been raised over the glacial flow laden waters and its potential effects on smothering macrophytes and inhibiting re-establishment in the lagoon. I will discuss macrophyte re-establishment later in my evidence.

40 Glacial flour suspended sediment in Lake Waitaki originated from either Lake Tekapo or Lake Pukaki. Under typical flow years, this flour has had over 450 days to settle out of the water column (based on the mean residence time of lakes upstream of Lake Waitaki). Glacial flour that is remaining in the water column by the time it reaches Lake Waitaki is unlikely to settle out in Wainono Lagoon nor is it likely to smother any macrophytes in the lagoon. Based on underwater macrophyte surveillance work I have carried out in Lake Waitaki, I have recorded tall vascular macrophytes colonising up to 7 m deep and characean macroalgae up to 14 m deep in the lake.

41 Water originating from Lake Waitaki that is intended for flow augmentation is typically low in turbidity relative to Wainono Lagoon. While suspended glacial flour gives rise to a slight milky blue appearance of the water, median turbidity in the lake is typically < 2NTU[6]. Long-term records of turbidity in the Waitaki River show a slight increase in turbidity

[6] Data source Sutherland, D.; Kelly, G.; McDermott, H. (2013). Waitaki Water Quality 2008-2013. NIWA Client Report CHC2013-117.

after the water leaves the lake. Long-term (1989 – 2014[7]) median and mean turbidity in the Waitaki River at Kurow was 2.4 NTU and 6.5 NTU, respectively. Between 1898 and 2014 turbidity exceeded 6 NTU on 26% of the monitoring occasions, and exceeded the median turbidity of Wainono (100 NTU) < 0.3% of the time (1 occasion). In my opinion, given the very high natural turbidity in Wainono Lagoon relative to Waitaki derived water, a limit of turbidity of 6 NTU is not necessary, although flood flows in the Waitaki River, where turbidity exceeds that of the median turbidity of Wainono, should not be diverted to the lagoon as flood flows typically include sediment run-off from land high in TP.

42 The addition of the lower turbidity waters from the Waitaki River into Wainono Lagoon will most probably result in a dilution of turbidity within the Lagoon. Increased flushing may also help to reduce the suspended sediment in the lagoon over the long term. However, suspended sediment is most likely to still be the main contributor to turbidity in the lagoon and the brown appearance to the water column likely to remain.

EFFECTS OF FLOW AUGMENTATION ON PHYTOPLANKTON COMMUNITY COMPOSITION IN WAINONO LAGOON

43 Community composition of phytoplankton depends on a number of factors including the morphology of the water body, hydrodynamic characteristics, sunlight intensity, temperature, nutrient concentration and the biological characteristics of algae and zooplankton. Of these, the nutrients N and P play a large role in shaping the community structure of phytoplankton. In water with higher concentrations of N and P, the green algae typically become the dominant taxa, while in water with lower concentrations of N cyanobacteria can often become the predominant taxa.

44 At the time of the Norton et al. (2007) mesocosm studies Wainono Lagoon was regarded as being N-limited, suggesting that it would favour species that preferentially grow under N limitation, such as cyanobacteria (the potential for cyanobacteria growth is discussed below). However, the shallow (~ 1 m) Wainono Lagoon is very exposed to wind-driven mixing which typically favours green algae and diatoms at the expense of cyanobacteria. There has been little phytoplankton taxonomy carried out for the Wainono Lagoon and no known records of cyanobacteria blooms. In a one-off sampling occasion, Norton et al (2007) found two species of cyanobacteria, 10 species of diatoms, 7 species of green algae and 2 species of dinoflagellates.

45 Under Scenario 2a, increased N load relative to the P load would result in a change in the N:P ratio thereby favouring species that have a higher N requirement such as green algae, at the expense of cyanobacteria.

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[7] NIWA National River Water Quality Network monitoring data.

46 As Wainono Lagoon is a very dynamic environment, the success of a given species will not only be influenced by the nutrient load but also by many factors such as residence time, amount of seawater intrusion, seasonality, wind-driven mixing events, species competition and presence of grazers. As these factors vary spatially and temporally, it is not possible to make more specific predictions about changes to community composition than the general statements above. However, for context I would not expect wholesale shifts in the types of communities that occur currently, compared to (say) a situation where nutrient loads were doubled to an oligotrophic lake. This is because Wainono lagoon is already hypertrophic and the community composition currently reflects that state, and would likely be similar under a Scenario 2a.

47 However, the increased risk of cyanobacterial bloom formation under Scenario 2a compared to the current state is regarded to be less than minor. As nutrient concentrations within Wainono lagoon are already within the hypertrophic level, nutrients are not regarded as the primary limiting factor to cyanobacterial bloom formation. The over-riding factor controlling cyanobacterial bloom formation in Wainono Lagoon is wind-induced mixing, decreasing its competitive advantage over other species. Cyanobacteria typically have a superior advantage over other algae by forming floating blooms that exclude light to their competitors. While wind-induced mixing will not exclude cyanobacteria growth, blooms are unable to form on the surface and the competitive advantage is lost.

48 Flow augmentation will bring in other algal species originating from Lake Waitaki. During a summer-time monitoring programme of the lake, I recorded over 40 phytoplankton species, with representatives from the groups cyanobacteria, flagellates, green algae, diatoms, desmids, dinoflagellates and golden-brown algae. The addition of other phytoplankton species may help to enhance biodiversity in the lagoon, although even under flow augmentation, the aquatic environment may still be outside the tolerance range of some species. It is possible that wind-blown algal propagules originating from Lake Waitaki have arrived at Wainono Lagoon on many occasions as the algae were not able to establish in the lagoon.

49 DoC has raised concerns over the transfer of the unwanted, invasive diatom, *Didymosphenia geminata* (Didymo) from the Waitaki River to the Wainono Lagoon. Didymo will most probably arrive at the lagoon as a result of flow augmentation. While it is unclear if didymo will establish in the river where augmented water will enter, or if it hasn’t already been introduced at the river site and not been able to establish, it is highly unlikely that didymo will establish in the lagoon. Unsuitable bottom substrate limits the available habitat for the establishment of didymo, while P levels (even with flow augmentation) will be unfavourable for

didymo dominance and stalk formation[8]. Saline intrusion into the lagoon will also aide to an unfavourable environment for didymo growth. Didymo is sensitive to saline and salt water is recommended as a fatal treatment method against didymo.

ADAPTIVE MANAGEMENT AND MONITORING OF FLOW AUGMENTATION INTO WAINONO LAGOON

50 Mass balance calculations and model predictions suggest that flow augmentation into Wainono Lagoon will be sufficient to achieve the TLI objective of 6. However, I acknowledge that some uncertainty exists in the predicted response of phytoplankton, management of the water quality in the Upper Waitaki lakes, inter-annual climatic variability and improvements in on-farm management practices.

51 I consider it likely that this uncertainty could be addressed through the adaptive management of flow augmentation.

52 Such an adaptive management regime would include (but not necessarily be limited to):

52.1 *Provision for monitoring-triggered bloom remediation flow:*

Rationale: In the unlikely event of a nuisance cyanobacteria bloom (detected by monitoring programme), the adaptive management regime would initiate a response process that might include contacting agreed stakeholder representatives for a decision on whether to release a 'lagoon volume exchange' flow ($4m^3/s$ for 5 days = 1.7 million m^3). Decision criteria could include current lagoon level, associated risk of flooding surrounding land, and risk of interference with events such as mahinga kai gathering and game bird hunting season.

52.2 *Provision for flow adaptation based on "lessons learnt' from previous years:*

Rationale: In practise, the best application of augmented flows will be entirely depended on how the system responds at different times of the year. Understanding how the system responds will allow for even better management of the lagoon. For example, the timing of events such as a complete flush of the lagoon have been proposed to occur at the start of spring, however, this may be better timed later in the season to give even more protection to the summer peak growth period..

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[8] Kilroy, C.; Bothwell, M.L. (2011). Environmental control of stalk length in the bloom-forming, freshwater benthic diatom *Didymosphenia geminata*. Journal of Phycology 47: 981-989.

52.3 *Cease augmentation flow during periods of high sediment load in source (Waitaki) water:*

Rationale: Augmentation should cease when the source water is carrying a high suspended sediment load and associated high TP, typically during floods in the lower Waitaki River. The scheme design should provide for efficient augmentation shut-off in the event that monitored turbidity exceeds a pre-defined trigger level in the source water.

53 The volume of augmented flows set out earlier in my evidence is based on average current flow estimates into the lagoon and simple mass balance equations. How the system responds to the augmented flow regime would need to be monitored for reasons discussed above, particularly with respect to the response of phytoplankton. This information would then be used to inform that adaptive management regime. In particular, monitoring would help determine the effectiveness of the augmented flows and could help fine tune the flow regime, if required.

54 Overall, the possible use of an adaptive management regime provides further confidence that augmentation will be effective in achieving the sought outcomes.

OTHER NUTRIENT MITIGATION OPTIONS IN ADDITION TO FLOW AUGMENTATION INTO WAINONO LAGOON

55 Flow augmentation offers the most immediate solution to improving the water quality of Wainono Lagoon and as is clear from the balance of my evidence it appears on the assessments undertaken that there is a good chance that a TLI of 6.0 to be achieved – especially if adaptive management is applied.

56 Given that the PC3 approach is dependent on augmentation delivering the outcomes anticipated (and accepting some of the uncertainties re the exact level of improvement that will occur with a given level of augmentation), it is worth noting that in addition to augmentation there are other options that can be employed on smaller scales to assist with nutrient mitigation both within the catchment and within the immediate lagoon vicinity. Such options can be used as a further compliment to flow augmentation.

57 A number of these low cost technologies utilise natural biological processes to mitigate nutrient enrichment and allow for the recovery of resources. These technologies area positive step forward in ensuring ecological and economic partnerships. Technologies that have the potential to be used for reducing nutrient loads to Wainono Lagoon and its

tributaries (in addition to any improvements that may be made on farm) are described below:

Artificial wetlands

57.1 Natural wetlands have been called the “kidneys of the landscape” because of their ability to store, assimilate, and transform contaminants lost from the land, before they reach waterways[9]. Key processes that occur in wetlands and affect agricultural pollutants are: nitrification (conversion of ammonium and ammonia to nitrate); plant and microbial uptake of soluble N and P and conversion to particulate forms (e.g. algae, dead plant tissue); trapping and storage of particles (e.g. particulate N and P, sediment and faecal microbes); and denitrification (the conversion of nitrate to nitrogen gas (N_2) or nitrous oxide (N_2O) gas that may return to the atmosphere.

57.2 Wetland capacity to remove N, P and *E. coli* is highly variable because it is dependent on hydraulic loading rate, hydraulic efficiency, input concentrations and wetland condition. Treatment efficiency is enhanced by optimising dispersion, flow paths, water depths, residence times and vegetation characteristics[10]. Artificial wetlands have however been used successfully under New Zealand climate conditions for remediation.

Algal turf scrubbers

57.3 An Algal Turf Scrubber (*ATS*) is essentially an artificial stream with an inclined flow-way for attached native periphyton (typically dominated by filamentous green algae) to grow. Water for treatment flows down the ATS in a series of pulses, allowing the algae to readily sequester the nutrients. The periphyton biomass is then harvested at one to two week intervals, depending on the season, which can then be used as an organic slow-release fertiliser.

57.4 An ATS is ideally suited to streams and tributaries that have low flow but high nutrient load. An ATS would ideally be suited for treating inflows at the northern end of Wainono Lagoon, just below Hook Beach Road. A portion of the flow from the Hook River and the northern drainage channel could be diverted to the ATS for treatment. The ATS would readily uptake more nutrients (both N and P), require less land and is cheaper to install than surface flow

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[9] Tanner, C.C., Sukias, J.P.S., Yates, C.R. (2010) New Zealand guidelines: Constructed wetland treatment of tile drainage. NIWA Information Series No. 75.

[10] McKergow, L.A., Tanner, C.C., Monaghan, R.M., Anderson, G. (2007) Stocktake of diffuse pollution attenuation tools for New Zealand pastoral farming systems. Prepared for Pastoral 21 Research Consortium, NIWA Client Report HAM2007-161, Hamilton.

artificial wetlands. Another advantage of an ATS is there is no risk of phosphorus leaching out under anaerobic conditions, as can happen in artificial wetlands.

57.5 To date, ATS have not been trialled in New Zealand, but are used for nutrient scrubbing of agricultural non-point source wastewaters (steams, canals and lakes) throughout South Florida, USA. In these systems, ATS removal capability was found to be roughly two orders of magnitude greater than that of the managed wetlands in the same region. I anticipate they would be effective in the context of Wainono Lagoon.

58 As noted above, the purpose for briefly covering these in my evidence was simply to note that in addition to adaptive management there are further methods that can be used to supplement augmentation should the achievement of the anticipated outcomes need support from other means. In the context of PC3, this means there is an even greater likelihood that the wider anticipated catchment outcomes will be met.

Dated: 25 September 2015

D J Sutherland

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Donna Sutherland