Before the Proposed Queenstown Lakes District Plan Stage 2 Hearings Panel

In the matter of	Proposed District Plan Stage 2 (Lake Hayes catchment (Wakatipu Basin) rezoning request)
For submitter	The Friends of Lake Hayes Society Incorporated

Statement of evidence of Marc Schallenberg for the Friends of Lake Hayes Society Incorporated

Dated July 24, 2018

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1. My name is Marc Schallenberg. I have a PhD in freshwater science and 25 year's professional experience (1 year at the National Institute of Water and Atmospheric Research and 24 years at the University of Otago) specialising in lake science, management and restoration. I have worked on-and-off on issues associated with Lake Hayes since 1995 and last year I wrote a comprehensive scientific review as well as a monitoring and restoration strategy for Lake Hayes (Schallenberg & Schallenberg 2017).

2. I have read and am familiar with the Code of Conduct for Expert Witnesses in the current Environment Court Practice Note (2014), have complied with it in preparing this evidence and will follow the Code when presenting evidence at the hearing.

3. I've been asked by the Friends of Lake Hayes (FOLH) to address the issue of proposed rezoning in the Lake Hayes catchment. I have undertaken an analysis of Otago Regional Council (ORC) water quality monitoring data for Lake Hayes and Mill Creek (the lake's main inflow).

4. I've compared the data with two key sets of water quality limits: (1) the National Policy Statement for Freshwater Management (MfE 2017) and (2) the Otago Regional Council Regional Water Plan (ORC 2016) to determine how the current water qualities of the lake and creek compare to the limits, which have been set in place to protect the freshwater values in Lake Hayes and Mill Creek.

5. This information should be of interest to the commissioners and QLDC because it shows that many of the statutory water quality limits are already exceeded, indicating: (1) that there is no headroom left in this system for further increases in contaminant concentrations and (2) that to meet the statutory limits, contaminant losses from land to water will need to be decreased, in some cases substantially. This has serious implications for aspects of the District Plan Stage 2, as applied to the Lake Hayes catchment.

Key results of my analysis

6. If national and regional water quality limits set to protect the ecology and human values of Mill Creek and Lake Hayes are to be met in the future, substantial reductions in some contaminant concentrations in the creek (nitrate) and the lake (total nitrogen and total phosphorus) will need to be achieved. In addition, levels of other contaminants in Mill Creek must not be allowed to increase (*E. coli*, dissolved reactive phosphorus, and turbidity).

7. Phosphorus losses from the catchment to the lake are poorly understood because the sampling design used by the ORC to monitor Mill Creek misses the majority of phosphorus transfer, which occurs during a few, episodic floods per year. Total phosphorus concentrations in the lake indicate that inputs from the catchment are excessive and need to be reduced.

8. These facts challenge initiatives to further develop the catchment because contaminant transfers from land to water will generally increase with increasing development, population growth, land use intensification, etc.

9. A an overallocation situation similar to this occurred in the Lake Taupo catchment, where a rigorous debate between scientists, stakeholders and regulators resulted in the implementation of a nitrogen cap-and-trade system, which was designed to safeguard the values of Lake Taupo. A similar process (but for nitrogen, phosphorus, sediment and *E. coli*) might be of use

in the Lake Hayes catchment, where contaminant limits set by Central and Regional Governments are being exceeded.

Lake Hayes:

10. The FOLH have been working since 2008 to raise awareness of the poor state of the water quality of Lake Hayes and to encourage the ORC to undertake measures to improve water quality. Figure 1 shows the trophic state of the lake from 2005 to 2016, confirming what the FOLH have been telling the ORC - that the lake is in a poor state.

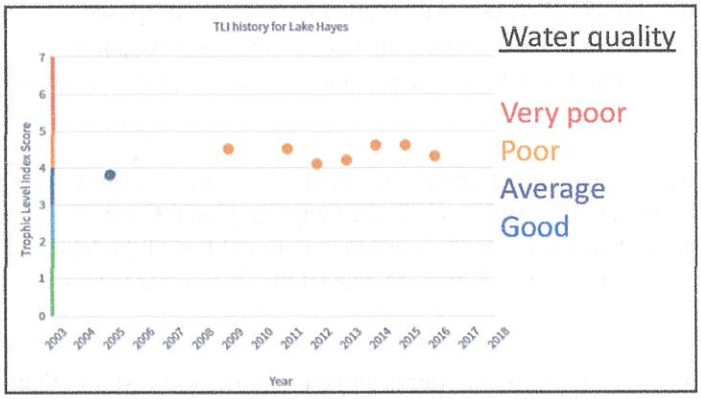

Figure 1. *The trophic state (state of nutrient enrichment including algal blooms) of Lake Hayes derived from ORC data published on the Land Air Water Aotearoa (LAWA) website (accessed July 20, 2018). The data show that the lake has had "poor" water quality since at least 2008, sometimes bordering on "very poor".*

11. The analysis of lake and creek water quality attributes summarised in Table 1 shows that both Lake Hayes and Mill Creek already exceed water quality targets set by Central and Regional Government. In particular, the lake exceeds targets for all three water quality attributes, including the national bottom line for chlorophyll *a* concentration (algal biomass) and it is very close to the national bottom line for phosphorus concentrations. It also exceeds the ORC's limits set for Lake Hayes for nitrogen and phosphorus concentration.

12. Where attributes are at, or exceed, the limits, there is no headroom left to allow further increases in nutrient concentrations in the lake. Where the attributes exceed the limits, the nutrient concentrations and algal biomass will need to be reduced to meet the water quality limits.

13. Previous studies on Lake Hayes by Cook (1973), Mitchell & Burns (1981), Robertson (1988), Caruso (2001), Schallenberg & Schallenberg (2017) and Gibbs (2018) indicated that careful management of contaminant transfers from the catchment to the lake is required to improve the water quality of Lake Hayes. In fact, the ORC's Lake Hayes Management Strategy (ORC 1995) called for an initial 20% reduction in the total phosphorus load to the lake to attempt to improve the condition of the lake. The strategy also stated that 80% of the total annual phosphorus input to the lake was attributable to Mill Creek.

***Table 1**. Summary of current water quality conditions of Lake Hayes and Mill Creek in relation to applicable water quality targets in the National Policy Statement for Freshwater Management (MfE 2017) and the Otago Regional Council's Regional Water Plan (ORC 2016). Red text indicates attributes that are currently very close to, or exceeding, the limits.*

Attribute	National Policy Statement (NPS)		ORC Water Plan (6a)
	Current state	**Proximity to NPS bottom line**	**Proximity to ORC limit**
Lake Hayes			
Total nitrogen	C - moderately impacted	Some headroom exists	Exceeds limit[1] - no headroom; reduction required to meet limit
Total phosphorus	C/D - very close to bottom line; degraded state	No headroom	Far exceeds limit[1] - no headroom; reduction required to meet limit
Chlorophyll *a*	D - high risk of regime shift and persistent degraded state	Reduction required to meet bottom line[2]	N/A
Mill Creek			
Nitrate (ecosystem health)	N/A	N/A	Limit is always exceeded[2] - no headroom exists; substantial reduction required to meet limit
Dissolved reactive phosphate	N/A	N/A	Slightly below limit - minimal headroom exists
Turbidity	N/A	N/A	Slightly below limit - minimal headroom exists
E. coli (recreation)	Near to bottom line (yellow-orange threshold indicating c. 3% infection risk)	Close to bottom line - almost no headroom exists	Close to limit - almost no headroom exists

[1]limit is supposed to have been met by 2012
[2]limit must be met by 2025

14. The ORC's data show that the total phosphorus concentration in Mill Creek has not been declining in recent years (Figure 2), showing a relatively constant median concentration of around 0.025 g/m^3. However, the Otago Regional Council avoids measuring water quality when streams are in flood. However, it is during floods that Mill Creek delivers around 80% of the annual load of phosphorus from the catchment to the lake (Caruso 2000; Chemsearch Ltd., unpubl. data). It is during floods that the effects of land use on total phosphorus, suspended sediment and *E. coli* concentrations in streams are most apparent.

15. Phosphorus is mainly attached to sediment particles and Mr. Hanff has shown photographs of the visual effect of sediment-laden water entering Lake Hayes from Mill Creek during floods. So, the limited ORC data shown in Fig. 2 doesn't reflect the bulk of the phosphorus load to the lake and thus it is unclear whether the total load has been constant, declining or increasing over time. To illustrate the importance of floods on the total phosphorus concentrations in Mill Creek (and on the loads to the lake), I've replotted Figure 2 along with some total phosphorus measurements for Mill Creek measured during flood conditions (Fig. 3; the figure has been re-scaled to show the extreme concentrations).

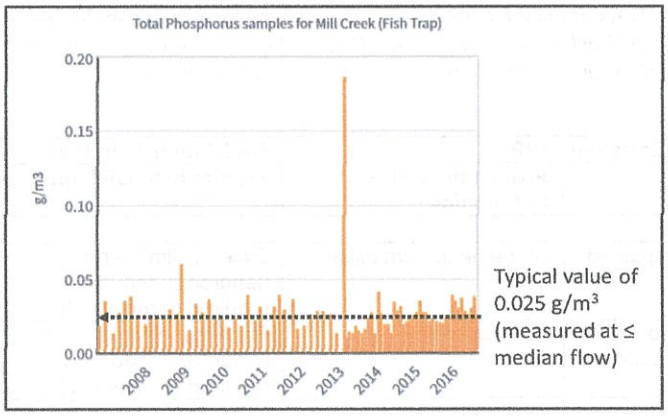

Figure 2. *Total phosphorus concentrations at the Fish Trap in Mill Creek from 2007 to 2016, showing no decline in concentrations measured at or below the median flow of the creek. ORC data from LAWA website (accessed July 20, 2018).*

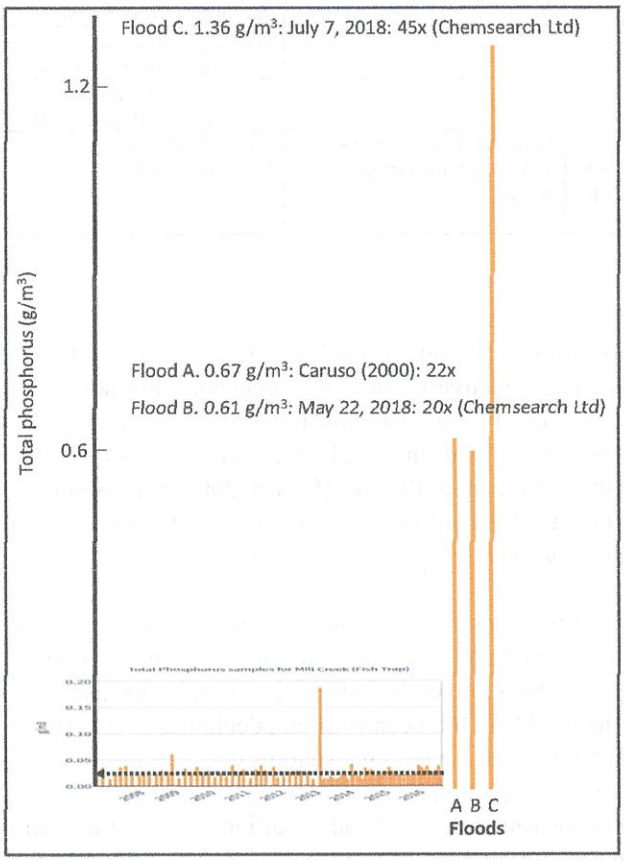

Figure 3. *Total phosphorus concentrations at the Fish Trap in Mill Creek from 2007 to 2016, presented together with measurements taken during three floods. ORC data from LAWA website (accessed July 20, 2018). Flood A and C were measured by Chemsearch Ltd (FOLH unpubl. data) and Flood A was reported in Caruso (2000). Also indicated are the multiples of the ORC median concentration (0.025 g/m³) that is represented by each flood measurement.*

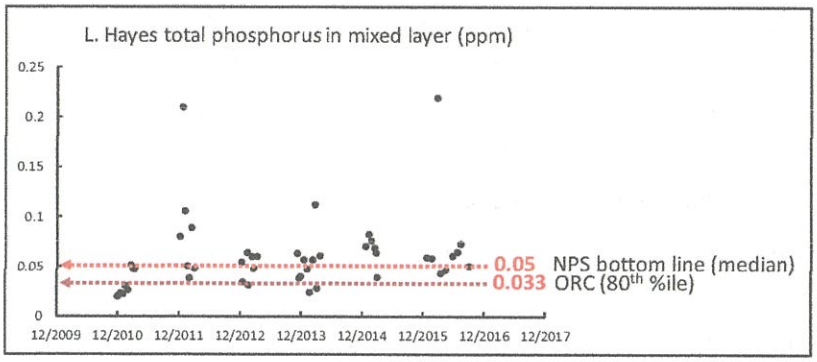

Figure 4. *Total phosphorus concentrations in the surface waters of Lake Hayes (mid-lake site) from 2009 to 2016), showing it approximately meets Central Government's national bottom line (MfE 2017) and fails the ORC's limit for Lake Hayes (ORC 2016; 80% of the measurements in a 5-year period should be below the limit). ORC data.*

16. While the limitations on monitoring mean that it's unclear what the actual phosphorus loads to the lake are, what is clear from Figure 4 is that that total phosphorus concentrations in Lake Hayes have not been declining, are very near the national bottom line (unacceptable concentration; MfE 2017) and exceed the ORC's limit for total phosphorus concentration for Lake Hayes (ORC 2016).

Mill Creek:

17. Table 1 shows that the water quality limit in Mill Creek is currently exceeded for nitrate concentrations and approaches the limit for *E. coli* concentrations. Every nitrate sample from Mill Creek taken from Mill Creek between 2007 and 2016 greatly exceeded the ORC's nitrate limit for the creek (Fig. 5). Nitrate is readily leachable from fertilisers, animal urine, septic tanks and other sources through the generally dry and porous soils of the Mill Creek catchment and, therefore not surprisingly, Table 1 also shows that total nitrogen levels in Lake Hayes exceed the ORC's limit for the lake. Controlling and managing the nitrate losses to the creek and lake in this catchment are substantial challenges. As with phosphorus, nitrogen losses from the catchment are likely to increase with increasing development of the catchment, unless effective mitigations are put in place.

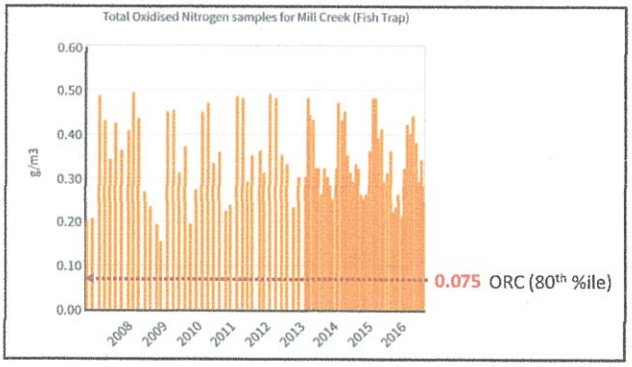

Figure 5. *Nitrate (total oxidised nitrogen) concentrations for Mill Creek from 2007 to 2016, showing the ORC's nitrate limit for Mill Creek (ORC 2016; 80% of the measurements in a 5-year period should be below the limit). ORC data from LAWA website (accessed July 20, 2018).*

References

Caruso BS (2000) Spatial and temporal variability of stream phosphorus in a New Zealand high-country agricultural catchment, *New Zealand Journal of Agricultural Research* 43: 235-249.

Cook RA (1973) The geolimnology and eutrophication of Lake Hayes, Central Otago, New Zealand. Unpublished MSc. Thesis. University of Canterbury. Christchurch.

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ORC (1995) Lake Hayes management strategy. Otago Regional Council. Dunedin.

ORC (2016) Regional Water Plan - Schedule 15: Good quality water. Otago Regional Council. Dunedin.

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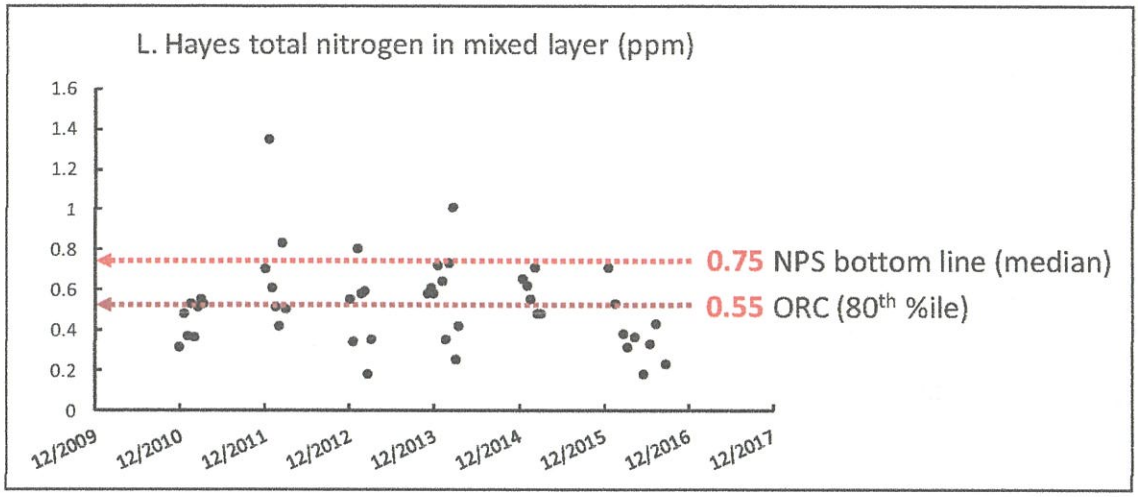
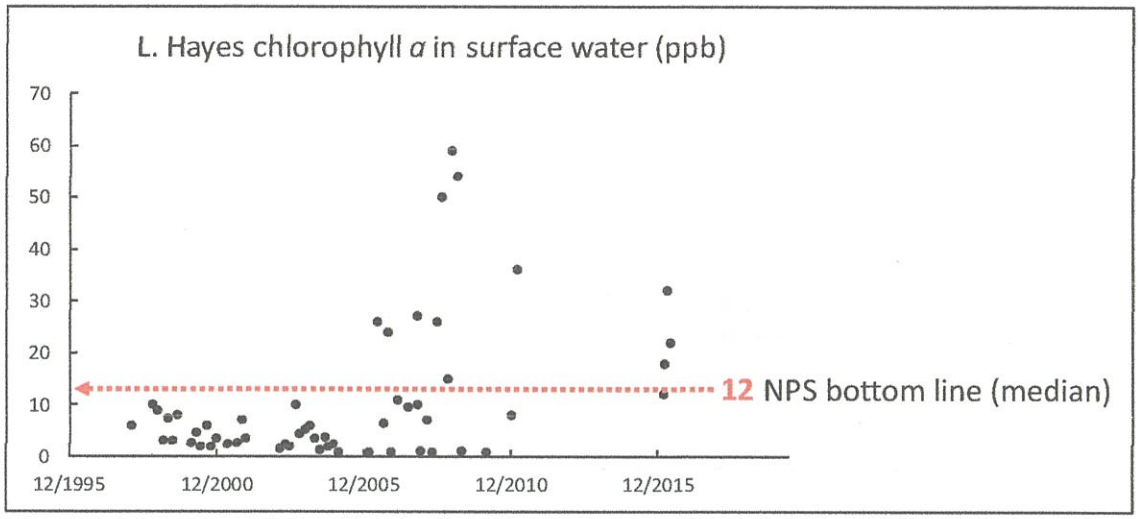
Schallenberg M, Schallenberg L. (2017) Lake Hayes restoration and monitoring plan. Report prepared by Hydrosphere Research Ltd. for the Friends of Lake Hayes. Hydrosphere Research Ltd. Dunedin.

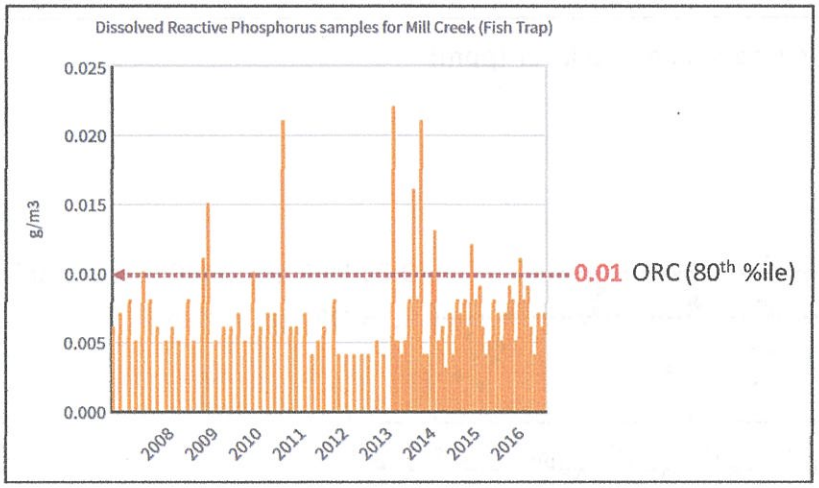
Appendix 1. Supporting information

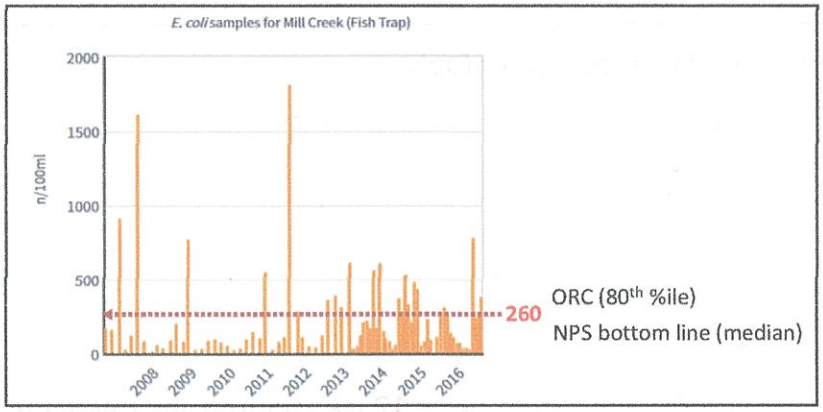
Lake Hayes

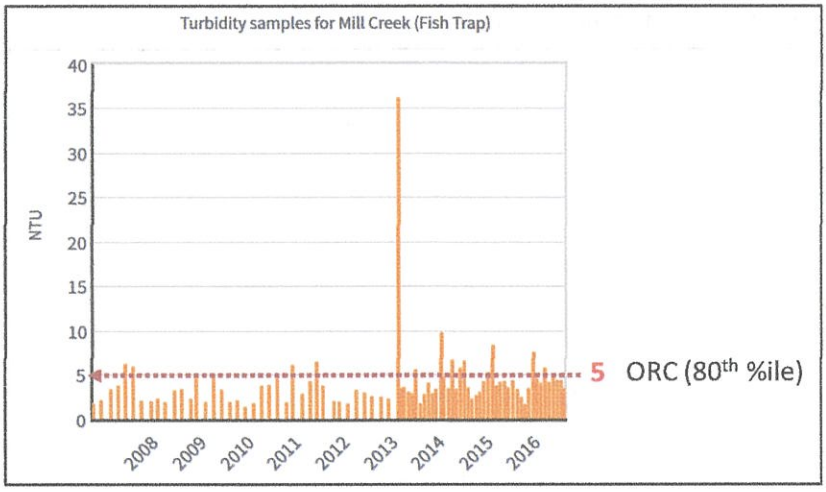




Mill Creek


Dissolved Reactive Phosphorus samples for Mill Creek (Fish Trap)
g/m3
0.025
0.020
0.015
0.010
0.005
0.000
2008
2009
2010
2011
2012
2013
2014
2015
2016
0.01 ORC (80th %ile)


E. coli samples for Mill Creek (Fish Trap)
n/100ml
2000
1500
1000
500
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
260
ORC (80th %ile)
NPS bottom line (median)


Turbidity samples for Mill Creek (Fish Trap)
NTU
40
35
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
5 ORC (80th %ile)