Under The Resource Management Act 1991

In the matter of an application for resource consent to discharge wastewater overflows from Queenstown Lakes District Council's wastewater network

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Statement of Evidence of Dr Dean Antony Olsen

18 October 2019

MEREDITH CONNELL

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Statement of Evidence of Dr Dean Antony Olsen

1 Introduction

Qualification and experience

1.1 My full name is Dr Dean Antony Olsen. I am an Environmental Scientist and Associate Director at Ryder Environmental. I hold the degrees of B.Sc. (Honours I) in Zoology and Ph.D. in Zoology, both from the University of Otago. I am a member of the New Zealand Freshwater Sciences Society.

1.1 I have been working in freshwater ecology since 1995, first as a summer Research Assistant in the Zoology Department, assisting on a wide range of projects in the field and laboratory. I held this role in the summers from 1995 until I began my Ph.D. in 1999. After completing my Ph.D. in 2003, I worked for two years as a Post-Doctoral Research Associate at the University of Vermont in Burlington, Vermont, USA. I have previously held positions as a Freshwater Scientist at the Cawthron Institute in Nelson (2005-2011) and as an Associate Director at Ryder Consulting (2011-2013). Between 2013 and 2015, I was a Water Resource Scientist within the Resource Science team at the Otago Regional Council (**ORC**). During this time, I spent approximately half of my time on water allocation and half on water quality. Between 2015 and 2018, I was Manager of the Resource Science team at the ORC with responsibility for eight staff undertaking scientific investigations in water quality, water quantity, ground water and air quality.

1.2 I have given evidence at a number of hearings, including three before the Environment Court (Arnold hydro-electric power scheme, Wairau hydro-electric power scheme and Lindis minimum flow plan change) and one before a Special Tribunal (variation to the Water Conservation (Kawarau) Order relating to the Nevis River). I have also prepared evidence for a number of resource consent hearings including irrigation schemes, gold mining and regional plans (e.g. Hurunui-Waiau Regional Plan, Plan Change 6A). At these hearings, I have been an expert witness for a range of clients, including farmers, large hydro-electricity companies, Fish & Game Councils (including Otago Fish and Game Council) and the Department of Conservation.

1.3 I have previously undertaken water quality studies in a number of catchments in Otago and elsewhere. These water quality studies have considered a wide range of aspects of water quality, including nutrients, metals, water clarity, sediment and microbiological water quality as well as periphyton[1] and macroinvertebrate assessments.

1.4 I have published thirteen scientific papers in peer-reviewed international journals and one peer-reviewed report in the Department of Conservation Research & Development Series. I have peer-reviewed manuscripts for a wide range of international scientific journals.

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1 Periphyton forms the slimy coating on the surface of stones and other substrates in freshwaters. It is made up of a number of different types of algae, diatoms, cyanobacteria, bacteria and fungi.

Purpose and scope of evidence

1.2 My role and involvement in QLDC's resource consent application to authorise wastewater overflows from its sewerage network has been to prepare a report assessing the ecological potential effects of those wastewater overflows to freshwater environments[2]. This report formed part of the Assessment of Environmental Effects prepared for the application. This report presented the available information on the existing environments where wastewater overflows may occur, including water quality (including microbiological), ecology, and fisheries, and assessed the actual and potential adverse effects of discharges of wastewater to these receiving environments.

1.3 The purpose of my evidence is to:

(a) Describe the existing environments that may receive wastewater overflow discharges including the water quality, ecology and fishery values supported by these waterways;

(b) Outline the ecological assessment methodology I used to assess the risk associated with wastewater discharges to these receiving waters;

(c) Compare the existing water quality in receiving environments to relevant water quality limits, targets and standards;

(d) Summarise the potential effects of wastewater overflows on these freshwater environments;

(e) Summarise the results of the risk assessment conducted for 35 locations within the wastewater network and 12 future sites.

1.4 My evidence is set out to describe:

(a) The existing environments of waterbodies that may be affected by the application including comparison to relevant water quality limits/standards;

(b) Fish and fishery values of waterbodies that may be affected by the application;

(c) Characteristics of wastewater;

(d) General effects of wastewater discharge to freshwater environments;

(e) The risk assessment methodology used to assess the potential ecological effects of wastewater overflow discharges on freshwater environments.

(f) The risk associated with discharges from a number of locations within the current wastewater network as well as some likely future locations;

(g) Responses to submissions received relevant to my evidence;

(h) Responses to matters raised in the s 42A Report.

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2 Olsen (2019). Queenstown Lakes District Wastewater Overflow Discharge Network Consent: Assessment of Ecological Effects. Prepared for Queenstown Lakes District (Appendix C to the AEE)

Expert Witness Code of Conduct

1.5 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2 Executive summary

2.1 Many of the rivers and lakes in the Queenstown Lakes District support high values and have good to excellent water quality. However, both Lake Hayes and its tributary Mill Creek do not meet the water quality targets of the Otago Regional Plan: Water (**RPW**).

2.2 All of these rivers and lakes support populations of sports fish (brown trout, rainbow trout and/or quinnat salmon, perch in Lake Hayes) and a range of native fish species. Lakes Hāwea, Wakatipu and Wanaka and the upper Clutha/Mata-Au support nationally significant trout fisheries while the Hāwea River is recognised as a regionally significant fishery, while Lake Hayes supports a regionally significant fishery for trout and wildlife habitat.

2.3 The high values and current water quality make many of these water bodies vulnerable to adverse effects from overflow discharges of wastewater, although the physical characteristics of each waterbody will affect their sensitivity to such discharges.

2.4 The unpredictable nature of the location, timing, magnitude and duration of the overflow discharges that are the subject of this application along with conditions in the receiving waters at the time make it difficult to undertake quantitative assessments of the potential effects of such discharges. The assessments I have undertaken are based on any discharges being short-lived, given in particular, the conditions included in the application are intended to minimise their volume and duration.

2.5 I assessed the risk of potential overflow discharges from 35 locations within the wastewater network and 12 future sites. These sites are where the wastewater network is in closest proximity to waterbodies. This means that my assessment is conservative as in most places the network is further away from waterbodies and there is a lower risk of overflows reaching water. These assessments included the probability of such discharges entering water and the risks associated with such discharges (considering the sensitivity of receiving environments including the capacity to dilute contaminants as well as the existing state of each waterbody) along with the significance of the values in the receiving environment.

2.6 The application includes conditions of consent that seek to minimise the risk of overflow discharges occurring (e.g. inspection regimes, public education efforts) and minimise the duration (e.g. proposed condition 8). The intent of these conditions is to reduce the risk of the occurrence of overflow discharges and to reduce their magnitude and duration. I expect such conditions to reduce any effects of the application on aquatic ecosystems.

2.7 I consider it unlikely that short-term, unplanned discharges will contribute meaningfully towards the risk of long-term eutrophication of these ecosystems, given their likely infrequency and the mitigation measures proposed in the application.

3 Approach to my assessments

3.1 This application is for unplanned discharges from the wastewater networks owned and operated by QLDC. As explained in the evidence of Messrs Hansby, Baker and Glasner, because these discharges are unplanned, it is not possible to know where and when they might occur, how long they might last, or the volume of wastewater discharged. These unknowns make the typical approach to assessing the effects difficult.

3.2 Instead, I have assessed the risk of adverse ecological effects arising from wastewater overflows to freshwater based on:

(a) The risk of any wastewater overflow entering freshwater; and

(b) The actual and potential effect(s) of wastewater overflows entering freshwater (including the significance of the values affected).

3.3 My evidence is structured to outline:

(a) The environmental context of this application (existing environment and ecological values of receiving environments);

(b) The nature of wastewater discharges and their potential effects on the environment;

(c) Assessment of risk associated with discharges from a number of locations within the current wastewater network as well as some likely future locations.

4 Existing environments

4.1 QLDC's wastewater network spans a number of catchment areas and parts of it are in close proximity to a range of different water bodies: glacial lakes (Hāwea, Hayes, Wakatipu and Wanaka), small streams to large rivers. The existing environments of each of these waterbodies is described in detail in the Ecology Report,[3] but I will summarise them here.

4.2 Given the range of different environment types that may potentially be affected by wastewater overflows, I considered these as groups based on the size and type of waterbody:

(a) Large lakes (Lakes Hāwea, Wakatipu and Wanaka);

(b) Medium lakes (Lake Hayes).

(c) Very large rivers (Clutha/Mata-Au, Kawarau);

3 Olsen (2019), Ibid. p.2

(d) Medium-large rivers (Hāwea, Shotover);

(e) Small-medium rivers (Arrow River, Cardrona River, Luggate Creek, Mill Creek); and

(f) Streams (including Bullock Creek, Horne Creek and various others).

Large lakes (Lakes Hāwea, Wakatipu and Wanaka)

4.3 Lakes Hāwea, Wakatipu and Wanaka are large, deep glacial lakes fed by large alpine rivers renowned for the high quality of their water and are classified as microtrophic.[4] Scenic values have been identified as outstanding in all three lakes, particularly the colour of their water[5] which, in part, results from the high clarity of their water.[6] This high clarity is due, in part, to low nutrient availability, which results in these lakes supporting a low biomass of phytoplankton.

4.4 High water clarity also allows high penetration of ultra-violet radiation into the water, killing bacteria, which results in *E. coli* concentrations typically being very low. However, high *E. coli* readings have occasionally been observed in these lakes, with readings in Lake Wanaka at the Township site and Lake Wakatipu at Frankton Beach exceeding guidelines[7] for contact recreation at times.[6]

4.5 Recent Faecal Source Tracking[8] analyses have attributed elevated readings in Lake Wakatipu at Frankton Arm to ruminant and avian sources, while elevated readings in Queenstown Bay were attributed to human and avian sources.[9]

4.6 The ecological communities of Lakes Hāwea, Wakatipu and Wanaka are similar, although the macrophyte community of Lake Wakatipu is in better condition than Lake Wanaka[10], with two invasive oxygen weeds present in Lake Wanaka (*Elodea canadensis* and *Lagarosiphon major*), while only *Elodea canadensis* is present in Lake Wakatipu.[10] The three lakes support similar macroinvertebrate communities.[11]

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4 Based on the classification of Burns, Bryers & Bowman (2000). Protocol for Monitoring Trophic Levels of New Zealand Lakes and Reservoirs. Prepared for the Ministry for the Environment. Lakes Consulting, Pauanui.

5 Schedule 1A of the RPW, Kawarau WCO.

6 Olsen (2019), Ibid. p.2.

7 Ministry for the Environment & Ministry of Health. 2002. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment, Wellington. 89 p. plus appendices.

8 Faecal Source Tracking is a series of molecular (genetic) test methods that identify the most probable sources of faecal contamination of waterways.

9 ESR (2019a-d). Report on Faecal Source Tracking Analysis – Contact Recreation.

10 Olsen (2019), Ibid. p.2.

11 Biggs BJF & Malthus TJ 1982. Macroinvertebrates associated with various aquatic macrophytes in the backwaters and lakes of the upper Clutha Valley, New Zealand, *New Zealand Journal of Marine and Freshwater Research, 16*:1, 81-88; Stark JD 1993. A survey of macroinvertebrate communities in seventeen South Island lakes. Prepared for the Electricity Corporation of New Zealand. *Cawthron Report No. 229.* 36 p.; Kelly DJ & Hawes I 2005. Changes in macroinvertebrate communities and food web dynamics from invasive macrophytes in Lake Wanaka. *Journal of the North American Benthological Society 24:* 300-320. Thompson & Ryder (2008). Thompson RM & Ryder GR (2008) Effects of hydro-electrically induced water level fluctuations on benthic communities in Lake Hawea, New Zealand, New Zealand Journal of Marine and Freshwater Research, 42:2, 197-206.

4.7 Freshwater mussels (*Echydridella menziesii*) are present in Lakes Hāwea, Wakatipu and Wanaka[12] and are listed as "at risk – declining".[13] Most of the macrophyte species that have been recorded from Lakes Hāwea, Wakatipu and Wanaka are native and not threatened.[14] However, Stark (1993) recorded the quillwort *Isoetes kirkii,* which is classified as 'at risk – declining', from both Lakes Wakatipu and Wanaka,[15] although Kelly & Hawes (2005) recorded *Isoetes alpinus* from Lake Wanaka.[16] *Isoetes alpinus* is classified as not threatened.[14] Stark (1993) also recorded the marsh arrow grass *Triglochin palustris* from Lake Wanaka, which is classified as 'threatened – nationally critical'.[14]

4.8 All three lakes support deep water bryophyte (mosses and liverworts) communities.[17] These communities require very high water clarity and are rare internationally.

Medium Lakes (Lake Hayes)

4.9 Lake Hayes is nutrient-rich (eutrophic) as a result of historic catchment development (including top dressing) and land-use intensification as well as contemporary activities in its catchment, which results in periodic algal blooms and fish kills.

4.10 The macrophyte community of Lake Hayes is dominated by invasive species, with the invasive macrophytes *Elodea canadensis* and *Ranunculus trichophyllus* present.[18]

4.11 Contact recreation is monitored at one site Lake Hayes (Lake Hayes at Mill Creek shallows) and *E. coli* concentrations are generally suitable for contact recreation, although they do exceed guidelines[19] at times.[20] Faecal Source tracking analyses recently done on samples from Lake Hayes have attributed elevated readings to ruminant (sheep and cow) and avian sources.[21]

4.12 Lake Hayes also periodically has blooms of potentially toxic cyanobacteria (e.g. *Anabaena*), which can pose a risk to recreational users and has resulted in

12 Thompson RM & Ryder GI (2002). Study Brief CLU #22 Lake Hawea Supplementary Study – Fisheries and Low Lake Level Ecological Study. Prepared for Contact Energy Ltd. Ryder Consulting Ltd, Dunedin., Goldsmith R, Ludgate B, Stewart B & Ryder GI. 2007. Frankton Marina development – Lake ecological assessment. Prepared for John Edmonds and Associates on behalf of Queenstown Marina Developments Limited. Ryder Consulting, Dunedin.

13 Grainger et al. 2014. Conservation status of New Zealand freshwater invertebrates, 2013. New Zealand threat classification series 8. Department of Conservation, Wellington. 28 p.

14 Based on Lange et al. 2013. Conservation status of New Zealand indigenous vas, 2013. New Zealand threat classification series 22. Department of Conservation, Wellington. 82 p.

15 Stark JD 1993. A survey of macroinvertebrate communities in seventeen South Island lakes. Prepared for the Electricity Corporation of New Zealand. Cawthron Report No. 229. 36 p.

16 Kelly DJ & Hawes I 2005. Changes in macroinvertebrate communities and food web dynamics from invasive macrophytes in Lake Wanaka. *Journal of the North American Benthological Society 24*: 300-320.

17 de Winton, M.D. and Beever, J.E. 2004. Deep-water bryophyte records from New Zealand lakes. *New Zealand Journal of Marine and Freshwater Research 38*: 329–340; Coffey, B.T. and Clayton, J.S. 1988b. Contrasting deep-water macrophyte communities in two highly transparent New Zealand lakes and their possible association with freshwater crayfish, *Paranephrops* spp. *New Zealand Journal of Marine and Freshwater Research 22*: 225-230.

18 Whilst both are invasive exotic species, neither is listed in the Pest Management Strategy for Otago 2009.

19 Ministry for the Environment & Ministry of Health. (2002). Ibid. p.5.

20 Olsen (2019), Ibid. p.2.

21 ESR (2019a-d). Report on Faecal Source Tracking Analysis – Contact Recreation.

health warnings to avoid contact with its waters being issued.[22] Low water clarity, particularly associated with algal blooms, can detract from the scenic value of Lake Hayes at times.

Very large Rivers

4.13 The Clutha/Mata-Au and Kawarau Rivers support significant natural values, as recognised in Schedule 1A of the RPW and the Kawarau Water Conservation Order (**WCO**).

4.14 The Clutha/Mata-Au and Kawarau Rivers have very high water quality, with low nutrients and *E. coli.* The Clutha/Mata-Au has low levels of suspended sediment and high water clarity while the Kawarau has naturally high levels of suspended sediments and low water clarity downstream of the Shotover confluence.

4.15 Both of these rivers flow from large alpine lakes and support highly productive ecosystems close to the lake outlets where seston (organic matter, algae) from the lakes can support dense populations of filter-feeding invertebrates, which can sustain high densities of fish.

Medium-large rivers (Hāwea, Shotover)

4.16 A number of the outstanding characteristics of the Shotover River are recognised in the Kawarau WCO including wild and scenic characteristics, natural characteristics, scientific value and recreational values. The Kawarau WCO also states that water quality is to be managed for contact recreation.[23]

4.17 The Shotover River has very good water quality. Counts of *E. coli* generally indicate a very low level of faecal contamination, although *E. coli* counts occasionally exceed alert (260 cfu/100 mL) and Action (550 cfu/100 mL) levels.[24]

4.18 High sediment loads and low water clarity are a feature of the Shotover River,[25] as recognised by the WCO, with the median water clarity (July 2008-December 2017) of less than 1 m.[24] The low water clarity in the Shotover River does not meet national guidelines for swimming most of the time naturally.[26] However, the high sediment loads in the Shotover are natural and its recognised significance for kayaking, rafting and jetboating indicates that the limited visibility in the Shotover does not affect these activities.

4.19 The Hāwea River generally has very low *E. coli* concentrations, with the long-term median concentration of 1.6 cfu/100 mL and water clarity is generally high, with turbidity ranging from 0.2 to 2 NTU,[27] corresponding to a clarity range of 1.4 to 12.1 m.[24]

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22 https://www.odt.co.nz/regions/queenstown/algal-bloom-due-long-hot-summer

23 Class CR Water (being water managed for contact recreation purposes) – from Schedule 3 of the RMA

24 Olsen (2019), Ibid. p.2

25 Ludgate & Ryder (2008). Otago Regional Council Shotover River proposed gravel extraction, training line and rock revetment construction and winning of Rastus Burn rip rap: Aquatic ecology and water quality assessment. Prepared by Ryder Consulting Ltd.

26 Ministry for the Environment (1992). Water quality guidelines No. 2: Guidelines for the management of water colour and clarity, Ministry for the Environment, Wellington.

27 Nephelometric turbidity units – a measure of the cloudiness of water.

Small-medium rivers (Arrow River, Cardrona River, Luggate Creek, Mill Creek)

4.20 Four small- to moderate-sized rivers flow through or adjacent to urban areas within the Queenstown Lakes District: Arrow River (Arrowtown), Cardrona River (Albert Town), Luggate Creek (Luggate) and Mill Creek (Lake Hayes catchment).

4.21 Water quality in the Arrow River is generally good with low concentrations of ammoniacal nitrogen and DRP and *E. coli*. Nitrate-nitrite nitrogen (NNN)[28] concentrations in the lower Arrow River were elevated during the most recent sampling period available (August 1998-June 2014).[29]

4.22 A recent catchment water quality study found that water quality in the Cardrona River is generally high, with very low levels of ammoniacal nitrogen and dissolved reactive phosphorus.[30] However, concentrations of NNN exceeded the Schedule 15 limit in the lower Cardrona River and were elevated at the Mount Barker monitoring site.[30]

4.23 Concentrations of NNN and ammoniacal nitrogen and turbidity were typically low in Luggate Creek, while concentrations of DRP were relatively high and exceed the Schedule 15 target[31] (0.0152 mg/L cf. 0.01 mg/L).[29] Concentrations of *E. coli* in Luggate Creek have generally been low, although they can exceed guidelines for contact recreation at times, usually in association with high rainfall and high flow events.[29]

4.24 Water quality in Mill Creek, does not meet the Schedule 15 targets for NNN (0.36 mg/L cf. 0.075 mg/L) and *E. coli* (440 cfu/100 mL cf. 260 cfu/100 mL) (Ecology Report, Appendix D – Figures 1 & 4). However, dissolved reactive phosphorus concentrations (0.008 mg/L cf. 0.01 mg/L) and turbidity (4.11 NTU cf. 5.0 NTU) are within the Schedule 15 limit.[29]

Streams (including Bullock Creek, Horne Creek and various others)

4.25 A number of small streams flow through the urban areas of Wanaka and Queenstown including Bullock Creek and Horne Creek. Both Bullock Creek and Horne Creek are recognised as having significant habitat for trout spawning and juvenile rearing, and there is a significant presence of trout in the lower reaches of Horne Creek.[32] Horne Creek is also identified as having unimpeded access through to Lake Wakatipu and being free of weeds.[32]

4.26 There is limited information on the water quality and ecology of these smaller streams. Despite their small size, they may carry contaminants to larger water bodies.

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28 Nitrate (NO_3^-) and nitrite (NO_2^-) are oxidised forms of nitrogen and are among the most common forms of dissolved nitrogen in freshwaters.

29 Olsen (2019), Ibid. p.2

30 Olsen DA (2016) Water quality study - Cardrona River catchment. Otago Regional Council, Dunedin. 54 p.

31 Schedule 15 of the RPW sets out the numerical limits and targets for good water quality in Otago lakes and rivers.

32 Schedule 1A of the RPW.

5 Fish and fisheries

5.1 The fish species found in each of the potential receiving environments are summarised in Table 1. Longfin eels, kōaro, common bully, upland bully, brown trout and rainbow trout are widespread within the upper Clutha/Kawarau catchment and are likely to be present in most of the waterbodies that are potentially affected by this application.

5.2 Clutha flathead galaxias (this species is known as *Galaxias* sp. D, as it has not been formally described) are known to be present in the Cardrona River and may be present in other tributaries of the upper Clutha/Mata-Au. Clutha flathead galaxias are classified as 'nationally critical', the highest threat classification in New Zealand, while longfin eels and kōaro are classified as 'at risk – declining'.[33]

5.3 Brown and rainbow trout are widespread in the upper Clutha/Kawarau catchment and support recreational fisheries, including nationally significant fisheries in the upper Clutha/Mata-Au, Lakes Hāwea, Wakatipu and Wanaka.[34] The Hāwea River is recognised as a regionally significant fishery, while Lake Hayes supports a regionally significant fishery for trout and wildlife habitat.[34] The other rivers considered support locally significant fisheries.

5.4 The three large lakes also support populations of landlocked quinnat salmon that form an important part of the recreational fishery.[34] Most of these fish complete their life-cycle within the lake and the tributary in which they hatched. However, a portion of these fish undertake a seaward migration, out of the large lakes (especially Hāwea) and into the large outlet rivers (Hāwea, Clutha/Mata-Au and Kawarau) with some passing through Clyde and Roxburgh Dams, into the lower Clutha/Mata-Au and, ultimately, the sea.[34] A proportion of these fish contribute to the run of salmon that enter the lower Clutha/Mata-Au from the sea.[34]

5.5 Native fish including longfin eel, kōaro (especially lake tributaries), common bully (lakes tributaries) and upland bully are potentially present in small streams flowing through the urban areas of Wanaka and Queenstown. Clutha flathead galaxias are potentially present in tributaries of upper Clutha River, particularly where trout are absent.

5.6 Many of the small tributary streams of the upper Clutha and Lakes Hāwea, Wakatipu and Wanaka provide habitat for trout spawning and are likely to be recruitment sources for trout populations in larger receiving water bodies.

5.7 Perch (*Perca fluviatilis*) have been recorded from the Lake Hayes catchment, although they are likely to be mainly confined to Lake Hayes.

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[33] Dunn NR, Allibone RM, Closs GP, Crow SK, David BO, Goodman JM, Griffiths M, Jack DC, Ling N, Waters JM, & Rolfe JR 2018. Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24.* Department of Conservation, Wellington. 11 p.

[34] Otago Fish & Game Council 2015. Sports fish and game management plan for Otago Fish and Game region 2015-2025. Otago Fish & Game Council, Dunedin. 98 p.

Table 1 Summary of fish species recorded from potential receiving waters in the Queenstown Lakes District. From records downloaded from the New Zealand Freshwater Fish Database 8 August 2018.

Species	**Longfin eel**	**Kōaro**	**Clutha flathead galaxias**	**Common bully**	**Upland bully**	**Rainbow trout**	**Quinnat salmon**	**Brown trout**	**Perch**
Scientific name	*Anguilla dieffenbachii*	*Galaxias brevipinnis*	*Galaxias* sp. D	*Gobiomorphus cotidianus*	*Gobiomorphus breviceps*	*Onchorhynchus mykiss*	*Onchorhynchus tshawytscha*	*Salmo trutta*	*Perca fluviatilis*
Threat classification*	Declining	Declining	Nationally critical	Not threatened	Not threatened	Introduced and naturalised	Introduced and naturalised	Introduced and naturalised	Introduced and naturalised
Clutha/Mata-Au	X	X		X	X	X	X	X	
Kawarau	X	X		X	X	X	X?	X?	
Hāwea	X	X		X	X	X	X?	X	
Shotover	X	X				X		X	
Arrow		X†				X		X	
Cardrona	X	X	X		X	X		X	
Luggate Creek		X				X		X	
Mill Creek		X		X				X	
Bullock Creek	X?	X?		X?	X?	X?		X?	
Horne Creek	X?	X?		X?	X?	X?		X?	
Lake Hāwea	X	X		X	X	X	X	X	
Lake Wakatipu	X	X		X	X	X	X	X	
Lake Wanaka	X	X		X	X	X	X	X	
Lake Hayes		X		X				X	X

X Means [present/detected].

* From Dunn *et al.* (2018). Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24.*

? Indicates that a species isn't recorded as present in a waterbody in the NZ Freshwater Fish Database, but is likely to be present based on broader distribution patterns and the presence or absence of barriers

† Perch are likely to be limited to Lake Hayes.

6 Characteristics of wastewater

The s 42A Report raises concerns that the characteristics of wastewater overflows are unknown.[35] However, I disagree and consider that the characteristics of wastewater are well-known and can be broken down into four major components that may affect ecological processes and/or communities, being organic matter, suspended solids, nutrients and other components. I describe each of these components below.

Organic matter

6.1 Organic matter is a major constituent of wastewater and comes from human faeces, food waste and soaps.[36] The concentration of organic matter in untreated wastewater is about 200 mg/L,[37] which is much higher than observed in natural waters. In addition, this organic matter will contain a large amount of microbes, which will consume oxygen as they break down organic matter. The magnitude of this effect is quantified as the biochemical oxygen demand (BOD[38]).

Suspended solids

6.2 The term suspended solids refers to particulate matter larger than 2 µm and includes inorganic and organic material. Organic matter is the primary component of the suspended solids in untreated wastewater.

Nutrients

6.3 The major nutrients present in wastewater are nitrogen and phosphorus, which are both released by the breakdown of organic matter. Nitrogen is also present as urea in the urine of humans, which can be converted to ammonia/ammonium ions in water, which is usually rapidly oxidised to nitrate in high-oxygen aquatic environments. Phosphorus is also present in some detergents and these can be a source of phosphorus in wastewater. Typical concentrations of nitrogen and phosphorus in wastewater are 40 mg/L and 15 mg/L, respectively, which is 2-3 orders of magnitude higher than the concentrations in water ways in the Queenstown Lakes District.

Other components

6.4 Wastewater can also contain a range of other contaminants including metals (especially from trade waste), industrial or household chemicals (e.g. surfactants), as well as chemicals that may interfere with the physiology of organisms exposed to them (e.g. endocrine disruptors).

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[35] Section 42A Report, section 4.1.3.

[36] Ministry for the Environment 2003. Sustainable Wastewater Management – A Handbook for Smaller Communities. Ministry for the Environment, Wellington. 133 p. plus appendices.

[37] Ministry for the Environment 2003. Sustainable Wastewater Management – A Handbook for Smaller Communities. Ministry for the Environment, Wellington. 133 p. plus appendices.

[38] Biochemical oxygen demand is a measure of the consumption of oxygen by chemical and biological processes. It is typically measured by incubating a sample at 20°C for 5 days. BOD is computed from the difference between initial and final dissolved oxygen concentrations in the sample.

7 Potential ecological effects of wastewater on freshwaters

7.1 The potential effects of wastewater discharges entering freshwaters are summarised in Table 2.[39] These are potential effects – it does not necessarily mean that every wastewater discharge will have all or any of these effects.

7.2 The magnitude of any potential effect is dependent on a large number of variables including the location of the discharge, the magnitude of the discharge (i.e. volume, duration, concentration), and conditions in the receiving waters at the time of discharge. The risk of adverse ecological effects increases as the volume and duration of the discharge increase. Whilst some effects (e.g. oxygen depletion, sedimentation, contamination with pathogens, odour, scums and foams) will occur within a short period of time of the discharge occurring, other responses develop more slowly (e.g. algal blooms, sewage fungus).

7.3 The assessments I have undertaken are based on such discharges being short-lived (up to 24 hours), given that this application is for unplanned discharges from the wastewater network and many of the conditions included in the consent are intended to minimise the volume and duration of any such discharges. This approach was based on the proposed physical response condition (Condition 8 in the proposed consent conditions attached to the statement of evidence of Mr Collins), which will act to minimise the effect of any discharge(s).

7.4 In rivers, factors that may affect the magnitude of the effect of any potential overflow discharge include flow at the time (which would affect the rate of dispersion, the capacity to dilute any contaminants, the reaeration rate and water quality) and water quality at the time that the discharge occurs. For instance, high *E. coli* and suspended solid concentrations are often associated with high river flow events.

7.5 In lakes, factors such as thermal stratification,[40] the relative temperature of the discharge and the receiving water and weather conditions (wind strength, direction) may affect how the receiving water and discharge mix.

7.6 The unpredictable nature of the location, timing, magnitude and duration of the overflow discharges along with the number of other potential variables identified above (paragraphs 7.2-7.5) makes modelling predictions difficult. Any modelling would have to assume so many worst-case scenario variables that it would unrealistically over represent the effects of almost every overflow event. For this reason I have used a risk assessment methodology, as outlined in the next section of my evidence.

[39] Olsen (2019), Ibid. p.2

[40] Thermal stratification refers to a change in water temperature with depth in the lake, and is due to the change in water's density with temperature.

Table 2 Summary of potential adverse effects of wastewater discharges to freshwaters

Potential effect	Description
Oxygen depletion	High biochemical oxygen demand may cause depletion of oxygen in vicinity of discharge, particularly where limited current/mixing leads to low dispersion. This can lead to oxygen stress in fish and invertebrates.
Sediment:	
Sedimentation	Potential for direct or indirect effects. Direct effects include sedimentation of gill surfaces or smothering of eggs or redds (nests), abrasive damage of skin or respiratory surfaces. Indirect effects may include changes in invertebrate prey resulting from sedimentation of substrate.
Clarity	Suspended sediment (and organic matter) can lead to changes in the clarity and colour of receiving waters.
Growths:	
Fungus	Wastewater contains high levels of organic matter, which can lead to growths of heterotrophic organisms, such as sewage fungus.
Algae	The high concentrations of nutrients (nitrogen and phosphorus) in wastewater can lead to proliferation of filamentous algae.
Pathogens	Wastewater contains human waste, which contains bacteria, protozoa and viruses that can lead to illness in humans and other mammals that ingest contaminated water.
Odour	At high concentrations, wastewater can give water an unpleasant odour.
Scums/foam	Dissolved organic matter, surfactants and oils in wastewater can lead to the formation of scums and foams in receiving waters.
Endocrine disruptors	Wastewater can contain hormones (e.g. from contraceptive pills) or other chemicals that can disrupt the physiology of aquatic organisms.

8 Approach to assessment of risk and effects

8.1 My assessment of the risk of adverse ecological effects arising from wastewater overflows to freshwater consisted of two primary considerations:

(a) The risk of any wastewater overflow entering freshwater; and

(b) The actual and potential effect(s) of wastewater overflows entering freshwater (including the significance of the values affected).

Assessment of risk of wastewater overflows entering freshwater

8.2 The first step was to identify representative points within the network to assess. My colleague Dr Ryder selected 35 points, a mix of pump stations, engineered overflows and pipe bridges, for further evaluation and assessment. These sites were selected to represent components of the wastewater network that were in the closest proximity to receiving environments.

8.3 We also examined areas of future development of wastewater systems in the Queenstown Lakes District. During these assessments, I visited many of the sites personally, while my colleague Dr Greg Ryder visited the remainder, taking photographs and making notes about each location.

8.4 For each identified potential overflow location the risk of wastewater entering surface waterbodies was evaluated, based on the distance to water, presence of surface flow paths and land cover (Table 3).

8.5 Where a clear flow path was identified during the site visit or from aerial photographs , the distance to water was estimated along this path. Such flow paths included roadways and stormwater systems, where these discharged to surface waters. Where no clear pathway was identified, the distance to water was estimated as the shortest straight-line distance to water considering the local topography.

8.6 The landcover of each potential flow path was also considered based on site inspections and aerial photographs. Impervious surfaces (e.g. concrete, asphalt) provide minimal infiltration of wastewater, so could facilitate rapid transport to surface waters, and were therefore were considered to represent a higher risk of wastewater reaching surface waters than vegetated areas (e.g. rank grass) (Table 3). Vegetation that forms low-growing and dense cover (such as grasses) can slow the flow of any discharge and trap particulate matter and allowing it to infiltrate, thereby reducing the amount of contaminants entering water, and so were considered to present a lower risk (Table 3).

8.7 These factors and the resulting level of risk are set out in Table 3. While presented as discrete bands in Table 3, these factors are actually continuous variables and the risk of wastewater entering water from each of the at-risk parts of the network was considered based on the combination of each of these factors. The overall risk was assessed as the combination of the three factors in Table 3. For example, a grassed flow path within 40 m of a waterbody would be assessed as having a moderate risk. The presence of a flow path is a moderate-high risk and the short distance to water represents a high risk of any wastewater overflow reaching water. However, the grass ground cover (low-moderate) reduces this risk, as it is expected to retain particulate matter and promote infiltration of wastewater, resulting in a moderate risk overall.

Table 3 Characteristics used to determine the risk of wastewater entering freshwater in this assessment.

Distance to water	Flow path	Ground cover	Risk
>200 m	No	-	Negligible
>200 m	No	Rank grass, thick vegetation	Low
100-200 m	Possible flow path present	Grass, shrubs with good undergrowth	Low-mod
100-200 m	Flow path present	Sparse grass or trees with little undergrowth	Moderate
40-100 m	Flow path present	Gravel, rock, bare soil	Mod-high
0-40 m	Clear flow path present	Impervious (e.g. concrete, asphalt)	High

Assessment of potential risks

8.8 The risks associated with wastewater overflows on freshwater ecology were based on an assessment of the likely consequences of wastewater overflow to the various types of waterbody (as presented in Section 7).

8.9 This assessment considered the sensitivity of receiving environments (including the capacity to dilute contaminants as well as the existing state of each waterbody) along with the significance of the values in the receiving environment. For rivers, factors considered included the size of the river (flow) as well as water velocities/channel gradient (which affects the aeration rate and sediment deposition rate) as well as existing water quality. In lakes, this assessment considered of the size of the lake (volume), residence time of water, exposure of the area that could potentially be affected by an outflow (considering wind directions, currents), tributary inflows and proximity to the lake outlet.

8.10 Table 4 below sets out my assessment of the likely consequences of short-lived (ie less than 24 hours duration) wastewater discharges and resulting level of risk to waterbodies and their ecosystems.

Table 4 Description of the assessment of the potential effects of wastewater overflows on freshwater ecosystems.

Oxygen	Sediment		Growths		Odour	Scums/foam	Assessed level of effects
	Sedimentation	Clarity	Fungus	Periphyton			
Oxygen levels unchanged	Limited sedimentation	Water clarity not noticeably changed	No sewage fungus evident	Periphyton similar to areas upstream of overflow	No noticeable odour	No scums or foams	Low
Oxygen levels slightly lower than expected but unlikely to cause any ecological effect	Some localised deposits of fine sediment on channel margins and in backwaters (rivers) or thin layer of sediment on macrophytes or natural substrate in vicinity of overflow	Slight reduction in clarity	Very limited fungus growths in vicinity of overflow	Some moderate growths of algal mats or filamentous algae in the vicinity of overflow	Slight odour in vicinity of overflow	Minor scums or foams in immediate vicinity of overflow	Low-mod
Oxygen levels lower than normal which may cause stress for aquatic organisms	Some sedimentation on channel margins and in backwaters (rivers) or layer of sediment on macrophytes or natural substrate in vicinity of overflow	Obvious reduction in water clarity	Some fungus growth evident in vicinity of overflow	Moderate growths of algal mats or filamentous algae in the vicinity of overflow	Noticeable odour in vicinity of overflow	Scums/foams evident in vicinity of overflow	Moderate
Oxygen levels at levels that may cause stress for aquatic organisms and lead to mortality if prolonged	Moderate sedimentation, deposited fine sediment covers much of the surface of natural substrate and macrophytes	Noticeable reduction in water clarity	Substantial fungus growth evident, mostly in vicinity of overflow	Moderate to thick growths of algal mats or filamentous algae mostly in the vicinity of overflow	Strong odour in vicinity of overflow	Conspicuous scums/foams in vicinity of overflow	Mod-high
Oxygen concentrations likely to drop to levels that may lead to the death of aquatic organisms	Severe sedimentation, deposited fine sediment completely covers the surface of natural substrate and may smother macrophytes	Marked reduction in water clarity	Substantial growths of sewage fungus extending well beyond the vicinity of overflow	Thick growths of algal mats or filamentous algae extending well beyond the vicinity of overflow	Strong odour extending beyond the vicinity of overflow	Conspicuous scums or foams evident beyond the vicinity of overflow	High

9 Assessment of risk and potential effects

9.1 The likely effects of overflow discharges on the large and medium lakes (Lake Hayes), the large Rivers (Kawarau, Clutha/Mata-Au) and Medium Rivers (Hāwea and Shotover) are described in section 6.2 of the Ecological Report.[41] In summary, the volumes of these waterbodies are sufficiently large that isolated, short-duration discharges will be quickly diluted and are unlikely to have any measurable ecological effects. However, there could be short-duration localised effects in the immediate vicinity of the discharge, with such potential effects being those outlined in Table 4.

9.2 Small to medium rivers will be more sensitive to overflow discharges. Low levels of nutrients, *E. coli* and suspended sediments in the small- to medium-sized rivers in the Queenstown Lakes District mean that they are expected to be highly sensitive to inputs of nutrients, microbes and sediments in wastewater discharges during periods of low flows (Table 5). However, the risk is expected to be lower during periods of higher flows, when there will be greater dilution with high quality water from the upper catchments. Flows in these rivers are highly seasonal, with the lowest flows occurring in summer and autumn months,[42] meaning that the ecological risks associated with wastewater discharges are expected to be greatest in the summer and autumn months.

9.3 Mill Creek has high levels of nitrogen, *E. coli* and suspended sediments and parts of the bed of Mill Creek has significant cover of fine sediments.[43] As a result, it is not expected to be as ecologically sensitive to wastewater discharges as many other waterways within the QLDC district. However, given that Mill Creek discharges to Lake Hayes, any nutrients or sediment that enters Mill Creek will contribute to nutrient and sediment loads to Lake Hayes, which will contribute to the continuation of poor water quality in Lake Hayes and the associated poor environmental outcomes (such as blooms of cyanobacteria). There may be some attenuation of nitrogen before it enters Lakes Hayes (via processes such as denitrification), but it is not possible to estimate the extent to which this may occur. Any phosphorus or sediments contributed to Mill Creek are expected to enter Lake Hayes.

9.4 However, I note that Condition 11 would ensure that discharges that exceed 24 hours in duration and that have significant adverse ecological effects (as determined by monitoring under Condition 9) will not be authorised by the consent. I discuss this at paragraph 11.4.

Streams and small rivers

9.5 Most small streams in the Queenstown Lakes District are expected to contain low levels of nutrients, *E. coli* and suspended sediments and they are expected to be highly sensitive to wastewater discharges (Table 5). Lower gradient streams are expected to provide habitat for trout spawning and rearing, and those that are close to large lakes are also expected to support kōaro.

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41 Olsen (2019), Ibid. p.2

42 Olsen DA, Lu X & Ravenscroft P 2017. Update of scientific information for the Arrow catchment: 2012-2017. Otago Regional Council, Dunedin. 40 p.; Ravenscroft PR, Lu X, Mohssen M, Augspurger J & Olsen D. 2018. Update of scientific information for the Cardrona catchment: 2011-2017. Otago Regional Council, Dunedin. 47 p. + appendices.

43 Olsen (2019), Ibid. p.2

9.6 A lack of dilution means that any discharge has potential to impart significant effects on local water quality and ecological values while the discharge continues (Table 7). However, infrequent, short-lived wastewater discharges are not expected to have lasting effects on most of the values these streams support. However, as discussed above, Condition 11 would ensure that discharges that exceed 24 hours in duration and that have significant adverse ecological effects (as determined by monitoring under Condition 9) will not be authorised by the consent. I discuss this further at paragraph 11.4.

Table 5 Summary of the assessment of the risks associated with each of the potential effects of wastewater discharges to freshwaters.

Potential effect		Large lakes	Lake Hayes	Streams	Small-medium rivers	Medium-large rivers	Large rivers	Values potentially affected
Oxygen		Low, but high locally	Mod-high	Mod-high	Moderate	Low-moderate	Low	Fish, invertebrates
Sediment	Sedimentation	Low-moderate, but high locally	Mod-high	Mod-high	Moderate	Low-moderate	Low	Fish, invertebrates, macrophytes
	Clarity	Low, but high locally	Low, but high locally	Moderate	Low-moderate	Low	Low	Fish, macrophytes, aesthetics
Growths	Fungus	Low	Low	Moderate	Low-moderate	Low	Low	Fish, invertebrates, macrophytes
	Periphyton/ phytoplankton	Moderate	Moderate	Moderate	Moderate	Low-moderate	Low	Fish, invertebrates, macrophytes
Odour		Moderate	Moderate	Mod-high	Moderate	Moderate	Moderate	Aesthetic
Scums/foam		Moderate	Mod-high	High	Mod-high	Moderate	Low-moderate	Aesthetic

10 Risk assessment for specific locations within the wastewater network

10.1 The results of the risk and effects assessment for 35 locations within the wastewater network and 12 future sites assessed is presented in

10.2 Table *6*. Most of these locations were pump stations but also included engineered overflow points, manholes and pipe crossings.

10.3 Eleven sites were identified as "high risk" of wastewater entering surface waters in the event of a discharge (

10.4 Table *6*, based on the criteria inTable 3). These sites included pump stations at Lake Wanaka, Bullock Creek, Luggate Creek, a roadside drain that enters the Arrow River, a small stream that enters Lake Wakatipu at Sunshine Bay, Lake Wakatipu (Queenstown Bay, Frankton Arm), Lake Hayes, Stone Creek and Buckler Burn (

10.5 Table *6*).

10.6 Thirteen sites with moderate-high risk (based on the criteria inTable 3) were identified in Lake Wanaka, the upper Clutha/Mata-Au, Arrow River, Shotover

River, several sites around Lake Wakatipu (including the Frankton Arm and at Kingston), the Kawarau River, Lake Hayes, and Mill Creek (

10.7 Table ***6***).

10.8 Seven sites were identified as having a "negligible" risk of wastewater entering water (

10.9 Table ***6***) due to their distance from surface waterbodies, a lack of obvious surface flow path, and the presence of surfaces that will reduce the likelihood of wastewater reaching surface waterbodies (see Table 3). Sites assessed as having a negligible risk included at two locations within the lower Cardrona catchment, two sites in Luggate Creek, one location at Bush Creek (Arrow catchment) and two sites at Lake Hawea (

10.10 Table ***6***).

10.11 The 35 sites assessed were those in close proximity to waterbodies, which would have the highest risk to a wastewater overflow entering water. As explained in Mr Hansby's evidence, the QLDC owned and managed wastewater networks are extensive (eg consisting of 421km of pipework). Given the greater distances to waterbodies, the risk of wastewater entering water from most parts of the network would be considerably lower than those components of the network that I considered.

Table 6 Risk assessment associated with potential discharge points from QLDC wastewater infrastructure.

Location Number	Area	Distance to water (m)	Receiving water body/bodies	Description	Probability of waste water entering water (based on criteria in Table 3)	Risk associated with wastewater discharge
1	Wanaka	16	Lake Wanaka	Pump station on Lakeside Road on lake shore.	High	Moderate, but high locally
2	Wanaka	110	Lake Wanaka (Bremner Bay)	Pump station near the end of Waimana Place.	Low-mod	Moderate, but high locally
3	Wanaka	30	Lake Wanaka (Eely Point)	Pump station near Eely Point Access track.	Mod-high	Moderate, but high locally
4	Wanaka	120	Lake Wanaka (Roys Bay)	Pump station on Dungarvon Street. Possible stormwater route or along road.	Mod-high	Moderate, but high locally
5	Wanaka	105	Lake Wanaka (Roys Bay)	Pump station near Edgewater Resort.	Moderate	Moderate, but high locally
6	Wanaka	71	Bullock Creek	Pump station on Dungarvon Street.	High	Mod-high
7	Wanaka	210*	Cardrona River	Pump station on Riverbank Road.	Negligible	Moderate
8	Clutha outlet	70	Clutha River	Pump station at end of Clutha Outlet Road.	Mod-high	Low-mod
9	Albert Town	650	Cardrona River	Pump station on Albert Town-Lake Hāwea Road.	Negligible	Moderate
10	Albert Town	25	Clutha River	Pump station on Wicklow Terrace.	Mod-high	Low-mod
11	Albert Town	120	Clutha River	Pump station on Gunn Road.	Low-mod	Low-mod
12	Albert Town	114	Clutha River	Pump station on Alison Avenue.	Mod-high	Low-mod
13	Albert Town	70	Clutha River	Pump station on Alison Avenue.	Moderate	Low-mod
14	Luggate	400	Luggate Creek	Pump station on Pisa Road.	Negligible	Moderate
15	Luggate	374	Luggate Creek	Pump station on Alice Burn Drive (unformed).	Negligible	Moderate
16	Luggate	110	Luggate Creek	Pump station on Harris Place.	Moderate	Moderate
17	Luggate	15	Luggate Creek	Pump station on river bank near Church Road.	High	Mod-high
18	Arrowtown	42	Arrow River	Pump station on bank near Alexander Place above river.	Mod-high	Mod-high
19	Arrowtown	3	Roadside drain/Arrow River	Pump station near McDonnell Road.	High	Mod-high
20	Arrowtown	425	Bush Creek	Pump station beside Essex Avenue.	Negligible	Moderate
21	Arthur's Point	292	Shotover River	Pump station beside Atley Road.	Low	Low-mod
22	Arthur's Point	8	Shotover River	Pump station beside Oxenbridge Tunnel Road on bank of Shotover River.	Mod-high	Low-mod

23	Queenstown	34	Lake Wakatipu (Queenstown Bay)	Pump station on Marine Parade beside lake shore.	High	Moderate, but high locally

Pump station	Area	Distance to water (m)	Receiving water body/bodies	Description	Probability of waste water entering water	Risk associated with wastewater discharge
24	Queenstown	23/150	Small stream, Lake Wakatipu (Sunshine Bay)	Pump station on track off Glenorchy-Queenstown Road.	High	Moderate, but high locally
25	Queenstown	60	Lake Wakatipu (Frankton Arm)	Pump station on lake shore on Shoreline Road at Frankton Beach.	Mod-high	Moderate, but high locally
26	Queenstown	10	Lake Wakatipu (Frankton Arm)	Sewer main with overflow on lake shore on Allan Cresent at Frankton Beach.	High	Moderate, but high locally
27	Queenstown	25	Lake Wakatipu	Pump station beside Park Street.	High	Moderate, but high locally
28	Queenstown	25	Lake Wakatipu	Pump station on vehicle track off Cedar Drive.	Mod-high	Moderate, but high locally
29	Queenstown	52	Kawarau River	Pump station on vehicle track at end of Riverside Road.	Mod-high	Low-mod
30	Lake Hayes	84	Lake Hayes	Pump station beside access road to Mill Creek shallows.	Mod-high	Mod-high
31	Lake Hayes	13	Lake Hayes	Pump station on shore of Lake Hayes beside access track and carpark off Arrowtown-Lake Hayes Road.	High	Mod-high
32	Lake Hāwea	52	Lake Hāwea	Pump station on Hawea Esplanade Road near shoreline of Lake Hāwea.	Moderate	Moderate, but high locally
33	Lake Hāwea	98	Lake Hāwea	Pump station near Scotts Beach Road near shoreline of Lake Hāwea. No obvious flow path to lake.	Moderate	Moderate, but high locally
34	Lake Hāwea	380	Hāwea River	Pump station near Domain Road.	Negligible	Low-mod
35	Lake Hāwea	990	Lake Hāwea	Pump station on Cemetery Road.	Negligible	Moderate
36	Kingston	36	Lake Wakatipu	PROPOSED - Pump station at lakefront park across from Gloucester Street.	Moderate	Low-moderate, but high locally
37	Kingston	30	Lake Wakatipu	PROPOSED - Pump station at lakefront park across from Cornwall and Oxford Street.	Mod-high	Low-moderate, but high locally
38	Jacks Point	0	Various ephemeral creeks	PROPOSED - pipeline from Jacks Point to Frankton.	Low-mod	Low
39	Lower Shotover	>150	Shotover River	PROPOSED - wastewater network infrastructure for development on low-lying land on true left of the Shotover River	Low	Low-mod
40	Glenorchy	0 (pipe crossing)	Stone Creek	PROPOSED - pipeline from Glenorchy to potential disposal site at Glenorchy airport.	High	Moderate, but high locally

Pump station	Area	Distance to water (m)	Receiving water body/bodies	Description	Probability of waste water entering water	Risk associated with wastewater discharge
41	Glenorchy	0 (pipe crossing)	Buckler Burn	PROPOSED - pipeline from Glenorchy to potential disposal site at Glenorchy airport.	High	Moderate, but high locally
42	Cardrona	15	Cardrona River	PROPOSED - pipeline from Cardrona township to potential disposal site at skifield turn-off.	Low-high	Low-mod
43	Clutha near Wanaka airport	0 (pipe crossing)	Clutha River	PROPOSED - pipeline from Hāwea township to potential disposal site at Wanaka airport.	Low-high	Low
44	Luggate	0 (pipe crossing)	Luggate Creek	PROPOSED - pipeline from Luggate township to potential disposal site at Wanaka airport.	Low-high	Moderate
45	Luggate	0 (pipe crossing)	Dead Horse Creek	PROPOSED - wastewater from developments to east of Luggate township.	Low-high	Mod-high
46	Glendhu Bay	>55	Lake Wanaka (Glendhu Bay)	PROPOSED - Glendhu Bay campground	Moderate	Moderate, but high locally
47	Mill Creek	12	Mill Creek	PROPOSED - Pump station at Millbrook, near 18th hole.	Mod-high	Moderate
			Lake Hayes			Mod-high

11 Consent conditions

11.1 The application contains proposed conditions of consent that seek to minimise the risk of overflow discharges occurring (e.g. inspection regimes, public education efforts) and minimise the duration of such discharges (e.g. proposed condition 8). The intent of these conditions is to reduce the risk of the occurrence of overflow discharges and to reduce their magnitude and duration. I expect such conditions to reduce any effects of the application on aquatic ecosystems.

11.2 To address the uncertainty regarding the potential effects of the application, I have contributed to a draft consent condition that would require visual inspection of any waterbody affected by a wastewater overflow for deposited solids, undesirable growths (sewage fungus, filamentous algae) or dead/distressed aquatic life. If any of these adverse effects were observed, this would trigger more comprehensive monitoring by a qualified aquatic ecologist to assess the effects (if any) of the discharge (Condition 9).

11.3 The purpose of this condition is to gather information on the ecological impacts of any discharges that may occur, and seeks to address the current uncertainty regarding such effects. It also provides a check on the duration of any discharge, as effects such as periphyton proliferation, sewage fungus and macroinvertebrate community changes would take several days to manifest, and therefore would indicate that the discharge had been present for several days. In my view, such a condition will provide an important check to ensure that QLDC's response processes are robust and being implemented effectively to limit the volume and duration of any overflows that occur, thereby limiting the potential magnitude of any ecological effects of any overflow.

11.4 The ecological monitoring condition (Condition 9) contributes to proposed Condition 11 which ensures that discharges that exceed 24 hours in duration and that have significant adverse ecological effects (as determined by monitoring under Condition 9) will not be authorised by the consent. This condition addresses concerns raised in submissions (Section 12) and in the Section 42A report that the application could lead to significant adverse effects in aquatic ecosystems. I am satisfied that Condition 11 along with other consent conditions mean that the consent will not authorise significant effects on aquatic systems.

12 Submissions

12.1 I have read many of the submissions that address the ecological effects of the application. I have identified three major themes in these submissions:

(a) High values and high water quality in receiving waters;

(b) Lack of specific assessments of the effects of discharges;

(c) Eutrophication/cumulative effects.

High values and water quality

12.2 I agree that many of the potential receiving environments support high values and that many have high water quality. For information on specific receiving waters considered, see Section 3 of the assessment of ecological effects[44] and Section 4 of this evidence.

Lack of specific assessments of the effects of discharges

12.3 Some of the submitters raised concerns regarding the lack of specific assessments of the effects of the discharges covered by the consent application. The apparent lack of specific assessments reflects the unplanned nature of the discharges from the wastewater network. It is not possible to predict their frequency, duration or magnitude or what the conditions will be in the receiving environment during any such event.

12.4 As I state at paragraph 7.6, I do not believe it is possible to meaningfully model the potential effects of these discharges given the unpredictable nature of the location, timing, magnitude and duration of the overflow discharges that are the subject of this application and have used the risk assessment methodology outlined above (Section 10).

Eutrophication/cumulative effects

12.5 The unplanned and unpredictable nature of the discharges that would be covered by this consent application also mean that it is not possible to meaningfully model its potential cumulative effects.

[44] Olsen (2019), Ibid. p.2

12.6 I consider it unlikely that short-term, unplanned discharges are likely to contribute meaningfully towards the risk of long-term eutrophication of these ecosystems. This is because of their likely infrequency and the mitigation measures proposed as conditions of consent.

13 Section 42A Report

13.1 The s 42A report raises the concern that the quality, quantity and characteristics of past and therefore future discharges is unknown. This reflects the nature of the discharges for which consent is sought. However, the characteristics of wastewater are outlined in Section 6 of this evidence.

13.2 I have considered the data provided by QLDC on past discharges that have reached water. However, I have concluded that although the characteristics of wastewater are well-known, given the unplanned nature of these discharges and the resulting uncertainty regarding the location, duration and volume of any such future discharges, these data provide no guarantee of the nature of future potential discharges.

13.3 The s 42A report identifies that there is uncertainty of effects, as the application includes only a risk assessment. As highlighted in Section 7, a risk assessment was undertaken given the unpredictable nature of the discharges for which consent is sought. Dr Michael Greer's evidence and report[45] acknowledge that the approaches taken were appropriate given the unpredictable nature of the discharges for which consent is sought. The monitoring condition (Condition 9) seeks to provide information on the magnitude of ecological effects of any discharges that reach water (if any) and the unauthorised discharge condition (condition 11) sets limits as to the scope of effects authorised under this consent.

13.4 One of the key issues identified in the s 42A report was the potential for adverse effects that are significant. As I state at paragraph 7.6, modelling the <u>potential</u> effect of discharges would have to assume so many worst-case scenario variables that it would unrealistically over represent the effects of almost every overflow event. As Dr Greer states at paragraph 4.8 of his evidence *"This is not to say that significant adverse effects will occur, rather that they cannot be discounted"*. Proposed Condition 11 addresses this concern by ensuring that discharges that exceed 24 hours in duration and that have significant adverse ecological effects (as determined by monitoring under Condition 9) will not be authorised by the consent.

13.5 Section 7.4 of the s 42A report states that the submission by the Otago Fish & Game Council identifies some of the potentially affected water bodies support regionally or nationally significant fisheries. The significance of these fisheries was identified in the Ecology report, along with an assessment of the potential effects on fish populations (including sports fish) in these waterbodies.

13.6 The s 42A report states that downstream/cross-boundary effects were not considered. Water bodies in the Wanaka, Hāwea or Luggate area ultimately discharge to the Clutha/Mata-Au, while water bodies in the Queenstown/Wakatipu area ultimately discharge to the Kawarau River. I

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[45] Greer (2019). Queenstown Lakes Wastewater Overflow Discharges – Final Review. Prepared for Otago Regional Council by Aquanet Consulting Ltd. 8 August 2019.

assessed the potential effect of direct discharges to the Clutha/Mata-Au and Kawarau, which will be more direct, and therefore greater, than any effect of an indirect discharge (i.e. a discharge to a tributary of these rivers). Given the very large size of these rivers, I remain of the view that any effect of the unplanned discharges covered by this consent would be undetectable after full mixing. However, as stated above (paragraph 12.6), it is not possible to meaningfully model the potential cumulative effects of this consent on water quality due to the unplanned and unpredictable nature of the discharges that would be covered by this consent application.

14 Conclusions

14.1 Many of the rivers and lakes in the Queenstown Lakes District support high values and have good to excellent water quality. The primary exceptions to this are Lake Hayes and its tributary Mill Creek, both of which do not meet water quality targets. All of these rivers and lakes support populations of sports fish (brown trout, rainbow trout and/or quinnat salmon, perch in Lake Hayes) and a range of native fish species. Lakes Hāwea, Wakatipu and Wanaka and the upper Clutha/Mata-Au support nationally significant trout fisheries while the Hāwea River is recognised as a regionally significant fishery, while Lake Hayes supports a regionally significant fishery for trout and wildlife habitat.

14.2 The high values and current water quality make many of these water bodies vulnerable to adverse effects from overflow discharges of wastewater, although the physical characteristics of each waterbody will affect their sensitivity to such discharges.

14.3 The unpredictable nature of the location, timing, magnitude and duration of the overflow discharges that are the subject of this application along with conditions in the receiving waters at the time make it difficult to undertake quantitative assessments of the potential effects of such discharges. The assessments I have undertaken are based on any discharges being short-lived, given in particular, the conditions included in the application are intended to minimise their volume and duration.

14.4 I assessed the risk of potential overflow discharges from 35 locations within the wastewater network and 12 future sites that my colleagues and I considered were at highest risk of a discharge reaching water due to their proximity to waterbodies. These assessments included the probability of such discharges entering water and the risks associated with such discharges (considering the sensitivity of receiving environments including the capacity to dilute contaminants as well as the existing state of each waterbody) along with the significance of the values in the receiving environment.

14.5 The application contains proposed conditions of consent that seek to minimise the risk of overflow discharges occurring (e.g. inspection regimes, public education efforts) and minimise the duration (e.g. proposed condition 8). The intent of these conditions is to reduce the risk of the occurrence of overflow discharges and to reduce their magnitude and duration. I expect such conditions to reduce any effects of the application on aquatic ecosystems.

14.6 I consider it unlikely that short-term, unplanned discharges will contribute meaningfully towards the risk of long-term eutrophication of these ecosystems, given their likely infrequency and the mitigation measures proposed in the application.

Dr Dean Antony Olsen

18 October 2019