BEFORE A HEARINGS PANEL OF THE GREATER WELLINGTON REGIONAL COUNCIL

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| UNDER | the Resource Management Act 1991 ("the Act") |
| IN THE MATTER OF | Resource Consent Applications to Greater Wellington Regional Council pursuant to section 88 of the Act to discharge contaminants to land, air and water |
| BY | South Wairarapa District Council |
| FOR | the proposed staged upgrade and operation of the Featherston Wastewater Treatment Plant |

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# BRIEF OF EVIDENCE OF KEITH DAVID HAMILL ON BEHALF OF SOUTH WAIRARAPA DISTRICT COUNCIL

## ECOLOGY

## DATED 29 MARCH 2019

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## EVIDENCE OF KEITH DAVID HAMILL ON BEHALF OF SOUTH WAIRARAPA DISTRICT COUNCIL

### QUALIFICATIONS AND RELEVANT EXPERIENCE

1. My full name is Keith David Hamill. I am an Environmental Scientist and Director at River Lake Limited. River Lake Limited is a consultancy that provides research and environmental science advice for understanding and managing rivers, lakes and estuaries. My technical speciality is in water quality and aquatic ecology.
2. I hold a Bachelor of Science degree (Geography) from the University of Auckland (1992) and a Master of Science (1st Class Hons) in Ecology and Resource & Environmental Planning from the University of Waikato (1995).
3. I have 24 years' experience in the area of resource management and environmental science. I have previously worked as a Principal Environmental Scientist at Opus International Consultants Limited, in the United Kingdom as a Senior Environmental Scientist for a consultancy called WRc, and as an Environmental Scientist at Southland Regional Council for six years.
4. I have been responsible for designing and implementing state of the environment monitoring programmes, undertaking environmental investigations, and developing environmental policy in New Zealand and Europe.
5. I have been involved in numerous projects in which I have assessed the effects of wastewater treatment plant discharges of streams, lakes and estuaries, including: Milton, Whitianga, Porangahau, Rotoiti, Rotorua and Palmerston North. I have also provided early (2013) reports to Greater Wellington Regional Council (GWRC) that have contributed to setting limits (for lakes) in the proposed regional plan.

## CODE OF CONDUCT

6. I have read the Code of Conduct for Expert Witnesses in section 7 of the Environment Court's Practice Note (2014). I agree to comply with that Code of Conduct. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is my own opinion and is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions which I express.

## MY ROLE IN THE PROJECT

7. My role in Featherston Wastewater Treatment Plant (WWTP) consent has been assessing the potential effects of the current and proposed future discharges on freshwater ecology in the receiving environments.

8. In particular, I have:

   *a.* Reviewed past monitoring assessing the current effects of the discharge during summer and autumn (i.e. Coffey 2010, Coffey 2013, Forbes 2013);

   *b.* Undertaken a mixing study and monitoring of effect of the current discharge on aquatic ecology during spring (October and November 2016) (Hamill 2017a).

   *c.* Analysed results of aquatic macroinvertebrate monitoring undertaken in April 2018.

   *d.* Prepared a summary report on the expected effects on the stream of the current and future discharges that contributed to the AEE (Hamill 2017b).

   *e.* Provided responses to Section 92 Request for Further information (Hamill 2017c).

9. In addition, since the application was notified I have provided advice to the Applicant's team on some particular issues raised by the GW officers and Dr Olivier Aussiel, have further addressed those issues and

participated in a series of caucusing meetings with Olivier Ausseil (Aquanet Consulting) and Emma Hammond (Mott MacDonald) which resulted in a joint memo dated 1 November 2018.

## SCOPE OF EVIDENCE

10. The purpose of my evidence is to describe the current effects of the Featherston WWTP discharge on aquatic ecology and water quality, and the potential effects (including improvements) at each stage of the proposed upgrade/land treatment.

11. My evidence will address the following:

(a) An overview of the current ecological values of the streams;

(b) Summary of past monitoring and investigations;

(c) Effects of the current and future discharges on aquatic ecology;

(d) Mitigation and management of actual or potential adverse effects (conditions)

(e) Response to submissions and the section 42A report.

(f) Conclusions

12. The assessment presented in my reports and evidence relies on results of past ecological surveys, ecological surveys that I have undertaken, water quality analysis and modelling by Craig Campbell and Emma Hammond (Mott MacDonald), modelled discharge volumes by Katie Beecroft and modelled stream flows by Greg Butcher. My evidence on water quality effects overlaps with that of Emma Hammond. I have assumed that the land application will occur in a way so as to avoid leaching of nutrients, and particularly phosphorus, to the streams. I note that there are conditions proposed to provide assurance on that point. This potential effect is addressed by others.

## GUIDELINE VALUES

13. This section discusses guideline values used for assessing measurements of periphyton cover, periphyton biomass and aquatic macroinvertebrates.

### Periphyton

14. Periphyton is an essential part of a healthy river ecosystem, but when it proliferates it can become a nuisance from an amenity perspective and can alter the habitat for aquatic macroinvertebrates and increase fluctuations in DO. The degree to which periphyton proliferates in a river is determined by a number of factors. Flood and fresh events are one of the most important controlling variables; they remove periphyton from river and effectively reset the system.

15. Periphyton biomass is generally expressed in terms of chlorophyll-*a* or Ash Free Dry Mass (AFDM). The NZ periphyton guideline (Biggs 2000) set guidelines to maintain 'trout habitat and angling' as a peak biomass of <35 g AFDM/$m^2$ which corresponded[1] to <200 mg chlorophyll *a*/$m^2$ for diatoms/cyanobacteria dominated communities, and <120 mg chlorophyll *a*/$m^2$ for filamentous dominated communities.

16. The Objectives Framework within the National Policy Statement for Freshwater Management (NPS-FM). Sets attribute states and National Bottom Lines for periphyton biomass. The National Bottom Line is set as 200 mg chlorophyll-*a*/$m^2$ to be exceeded no more than 8% of samples[2]. These were adopted as objectives in the.

17. The Proposed Natural Resources Plan (PNRP) sets "Aquatic Health and Mahinga Kai Objectives" for Periphyton biomass in "all rivers" as ≤120 mg chlorophyll-*a*/$m^2$ to be exceeded no more than 8% of samples. For rivers classed as "significant" on the basis of high macroinvertebrate community health the Periphyton biomass objective is ≥50 mg chlorophyll-*a*/$m^2$.

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[1] Was converted on an assumed *Cladophora* sp. dominated community (p. 100 Biggs 2000).
[2] This is the 'default class' and assumes monthly sampling over several years.

18. Guidelines for periphyton cover to protect aesthetic /recreational values are periphyton cover <30% long and <60% of streambed covered by diatoms or cyanobacteria >0.3mm thick (Biggs 2000). Matheson et al. (2012) proposed an alternative index of cover called the Periphyton Weighted Composite Cover (Peri WCC)[3]. They proposed an aesthetic nuisance guideline of >30% Peri WCC.

19. The Periphyton Sliminess Index (PSI) more closely corresponds to periphyton biomass and macroinvertebrate diversity and condition than does PeriWCC. There are no guideline values set for PSI but it has been used to augment periphyton biomass measures.

**Macroinvertebrates**

20. The structure and composition of macroinvertebrate communities is a commonly used indicator of river condition. The presence and abundance data of invertebrate taxa can be summarised in different ways to assess ecological condition. Common indices are taxa richness, EPT abundance[4], Macroinvertebrate Community Index (MCI) and the Quantitative Macroinvertebrate Community Index (QMCI). Thresholds have been developed for the MCI and QMCI (Table 1).

21. For lowland streams such as Donald Creek, the Proposed Natural Resources Plan (PNRP) sets “Aquatic Health and Mahinga Kai Objectives” for macroinvertebrates in “all rivers” as an MCI score ≥100. For rivers classed as “significant” on the basis of high macroinvertebrate community health the MCI objective is ≥120.

**Table 1**: Quality thresholds for interpretation of the MCI & QMCI (Stark 1998)

| Quality Class | Stark (1998) descriptions | MCI | QMCI |
|---|---|---|---|
| Excellent | Clean water | > 120 | > 6.0 |
| Good | Doubtful quality or possible mild pollution | 100 – 120 | 5.0 - 6.0 |
| Fair | Probable moderate pollution | 80 – 100 | 4.0 - 5.0 |
| Poor | Probable severe pollution | < 80 | < 4.0 |

[3] Peri WCC is calculated as %filamentous cover + (%mat cover/2).
[4] EPT refers to the orders Ephemeroptera, Plecoptera and Trichoptera. The index excludes the pollution tolerant *Oxyethira* sp. and *Paroxyethira* sp

## OVERVIEW OF SITE

22. Featherston WWTP discharges treated wastewater to Donald Creek. Donald Creek enters the Otauira Stream (Abbot Creek) about 2.5 km downstream of the discharge, and Otauira Stream flows another 2.6 km before entering the northern end of Lake Wairarapa. Most of Donald Creek flows through pasture but at the site of the discharge and for several hundred metres downstream the stream passes through a remnant of protected bush.

23. A small tributary (Longwood water race) enters Donald Creek from the true left about 430m downstream of the discharge. Groundwater inputs and tributaries continue to augment Donald Creek before it enters Otauira Stream, with increases flow by about 67% during summer low flow (e.g. 54 L/s to 90 L/s)[5]. The stream width increases from about 4m near the discharge to 7m at the sample site 650m downstream, and the median water depth is about 0.25m at median flow.

24. The flow in Donald Creek and Otauira Stream is very seasonal. Donald Creek's annual median flow is 258 L/s while the median flow in the months January to March is about 75 L/s and the mean annual low flow about 42 L/s (Butcher 2016, Butcher 2018). This results in considerably less dilution during the summer, with the current discharge regularly contributing more than 20% of the stream flow (less than 5 times dilution) (Figure 1). This in turn contributes to a dramatic seasonal difference in the current effects of the discharge. Otauira Stream is often dry during summer at the site upstream of Donald Creek confluence.

25. The size of substrate reduces from upstream to downstream - large gravel comprises 28% of the substrate at the upstream sites but is absent from the 650m downstream site. Sand was observed moving along the stream bed during median flows and scouring by sand is likely to be limiting periphyton biomass at flows above median. This is consistent with findings from Kilroy et al (2016) who found that periphyton biomass

[5] Concurrent gaugings by G Butcher.

was only weakly linked to dissolved nutrient concentrations at sites/times when sand is often mobilised.

26. The stream has low macrophyte cover in the shaded sections, about 8-16% cover upstream of the discharge and about 15-30% cover at the downstream site. The dominant macrophyte was the sprawling emergent *Apium nodifolrum* (Hamill 2017a, Coffey 2013).

27. Upstream of the discharge, periphyton biomass and cover were consistently within guideline values to maintain aesthetic values and 'trout habitat and angling' (equivalent to PNRP objectives for "All Rivers"), and probably within guidelines for benthic biodiversity (equivalent to PNRP objectives for "Significant Rivers").

28. Aquatic macroinvertebrates are commonly used to assess the health of streams by summarising the presence/ relative abundance of taxa using the Macroinvertebrate Community Index (MCI) and the Quantitative Macroinvertebrate Community Index (QMCI). Sampling of Donald Creek upstream of the Featherston WWTP discharge has found MCI and QMCI scores indicative of 'poor' to 'fair' ecological condition (MCI scores of 70 to 98, QMCI scores of 2.7 to 4.6) (Figure 2 and Figure 3). No sample from upstream sample sites has met the PNRP objectives for "All Rivers".

29. Sampling of Otauira Stream at sites upstream of the confluence with Donald Creek found MCI scores indicative of 'fair' ecological condition (range 95 to 98) but QMCI scores indicative of 'poor' ecological condition (range 2.1 to 3.0) (Hamill 2017a).

30. Donald Creek and Otauira Stream support populations of large longfin eel and common bully. I also found rainbow trout, shortfin eel and inanga in Otauira Stream. Good habitat is provided for fish where the stream passes through the bush remnant downstream of the discharge; riparian cover and woody debris in the stream creates diverse habitat and hydraulic regimes. In addition to the fish species I found, the NZ Freshwater Fish Database also records the presence of giant kōkopu,

common smelt, Cran's bully and brown trout in the Otauira Stream catchment.

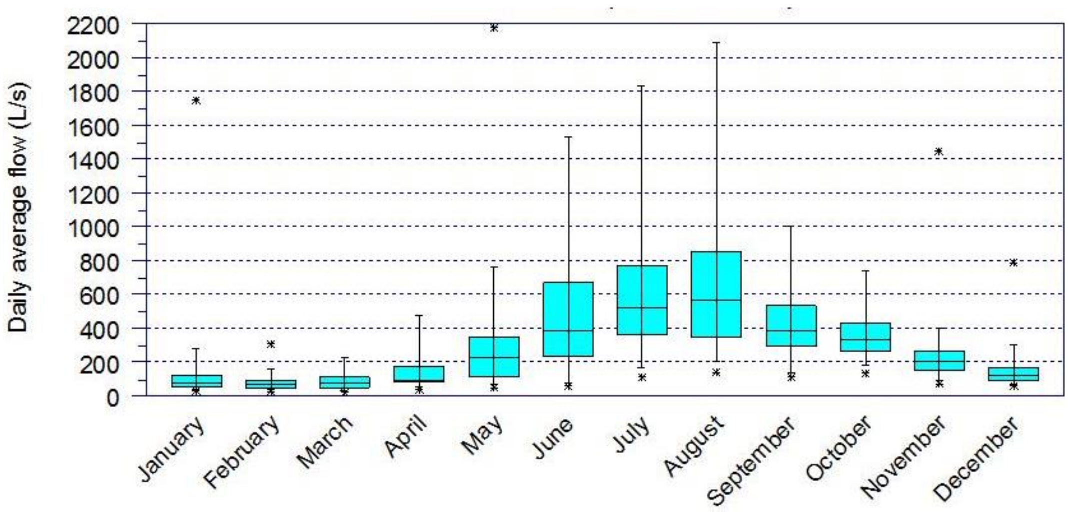


**Figure 1**: Seasonal variation in flow in Donald Creek (2005-2016). The graph shows the median, 50%ile (within the box), 95 %ile error bars and extreme values.

## EFFECTS OF THE CURRENT DISCHARGE

31. Ecological monitoring to assess the effects of the discharge has been undertaken on three occasions during summer low flow, twice during spring and once during autumn near median flows.

32. Ecological surveys have found that the Featherston WWTP discharge has significant impacts on Donald Creek downstream of the discharge during the summer/autumn low flows, relatively minor impacts during the spring (median flows) and minor effects during spring during median flows about two weeks after a flood event. The seasonal differences largely reflect differences in the stream flow regime.

33. Surveys undertaken in late summer of 2010 and 2013 during low flow found that the discharge caused a substantial reduction of all macroinvertebrate metrics (e.g. Figure 2 and Figure 3). Periphyton cover was also elevated at the Donald Creek downstream sites but not as much as expected given the concentration of dissolved nutrients at the time (Figure 4, Hamill 2017b). This may be due to shading and the deposition

of planktonic algae from the oxidation ponds as a scum on substrate. During these summer surveys the effluent caused a noticeable plume of turbid, coloured water, and a small amount of heterotrophic growth (5% cover) was present on the streambed (Coffey 2010, Coffey 2013).

34. The spring surveys on 11 October 2016 and 1 November 2016 found the effect of the discharge to be detectable, but mild compared to those observed during late summer, despite there being relatively low (ca. 10 times) dilution at the time[6]. There was some increase in periphyton cover and biomass but these were within guideline values to maintain aesthetic values and 'trout habitat and angling' (Figure 4, Figure 5). The macroinvertebrate community had slightly lower MCI scores at the two downstream sites (a statistically significant difference up to 7% lower), and no consistent upstream to downstream difference in QMCI scores (Figure 2 and Figure 3).

35. In contrast to observations during late summer, spring surveys found no conspicuous change in water colour or clarity from the discharge, and there were no visible heterotrophic growths present in the stream. Effects on these variables at the time of sampling appeared to be minor or less than minor.

36. This seasonal difference in the effect of the discharge is likely to reflect seasonal differences in stream flow (and dilution), effluent quality and water temperature. The flow in Donald Creek is highly seasonal with a distinct low flow period from about December to April (inclusive). The flow in Donald Creek at the time of the summer survey on 13 April 2010 and 4 March 2013 was 98 L/s and 50 L/s respectively, providing considerably less dilution than during winter and spring. The higher flow also causes movement of sand on the stream bed which will contribute to scouring of periphyton. Some aspects of effluent quality are also worse during summer, with algae proliferation within the ponds

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[6] Both sample occasions occurs during a period of receding flows with time since the last three times median flow event being 20 days and 40 days for the October and November sampling respectively. These are reasonably periods of stable flows in which to assess effects and particularly during spring.

affecting the colour and turbidity of the discharge as found by Forbes (2013). Seasonal algae proliferation within the ponds will also cause more extreme dissolved oxygen fluctuations within the effluent. Furthermore, warmer water during summer months can accentuate stress on stream biota, particularly with relation to impacts from ammonia or low dissolved oxygen (Davies-Colley et al. 2013).

37. A survey undertaken during a period median flow in autumn (28 April 2018) found no impact of the discharge on periphyton cover or biomass (Figure 4 and 5), little effect on MCI scores 60m downstream of the discharge, but a decline in QMCI (Figure 2 and Figure 3). The results from the site 650m downstream of the discharge needs to be treated with some caution because cattle pug the stream edge and, on this sample occasion, a highly turbid discharge was occurring from Longwood Water Race and obscured the stream bed from sight. Although Donald Creek was flowing at just below median flow, Otauira Stream was dry so no sample could be collected from upstream of the confluence (Figure 6).

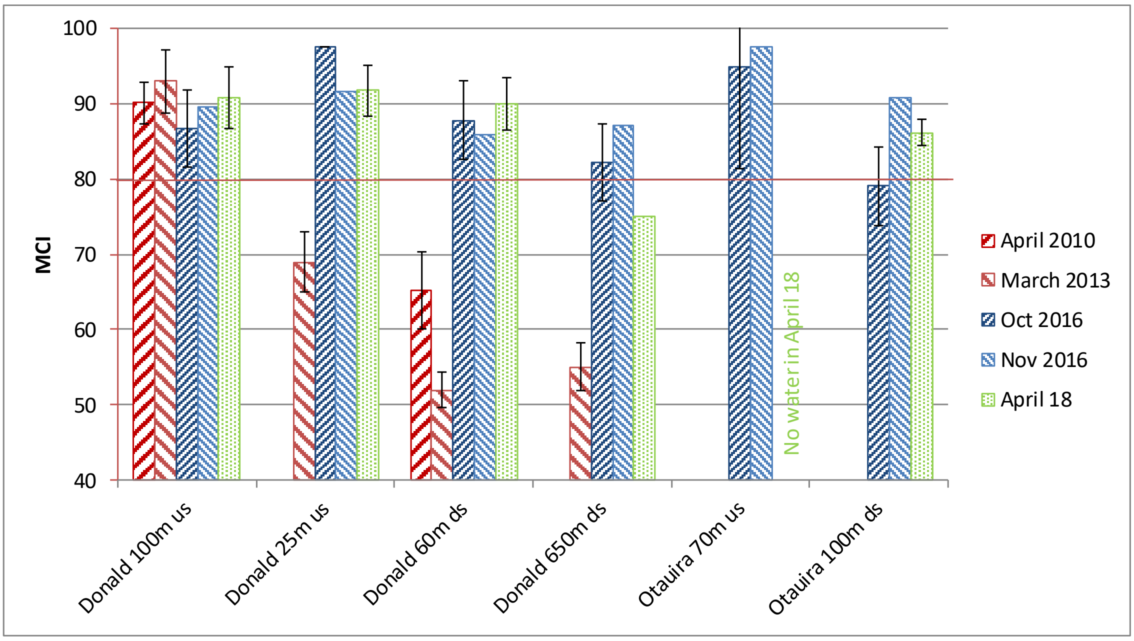


**Figure 2**: MCI scores in Donald Creek and Otauira Stream. Error bars are standard deviation. An MCI score of 80 represents a boundary between 'fair' and 'poor'.

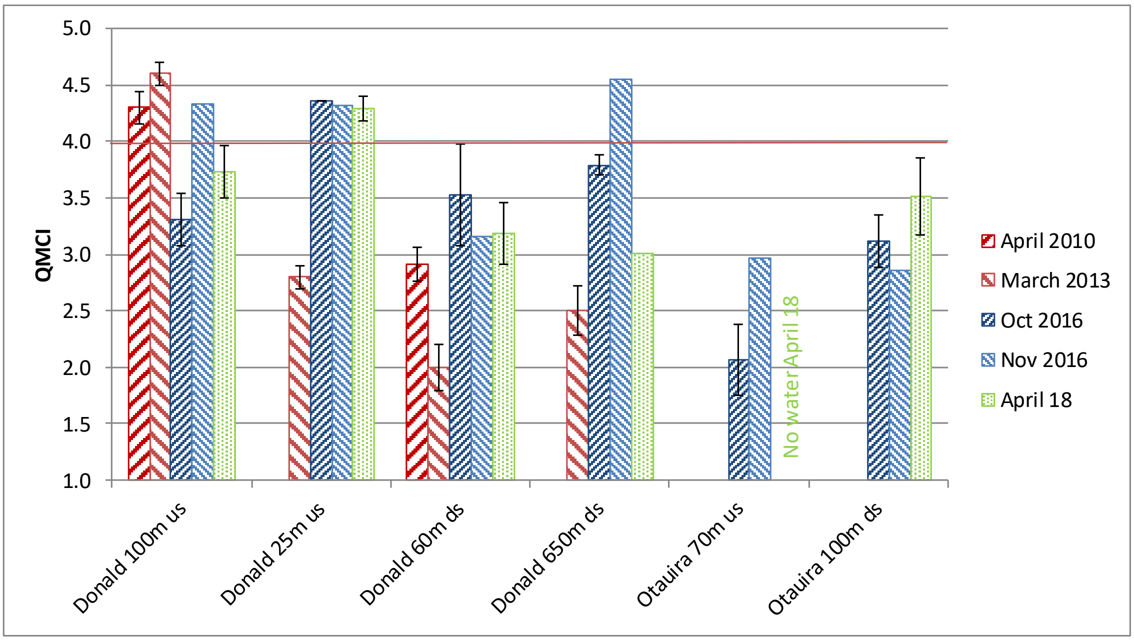


**Figure 3**: QMCI in Donald Creek and Otauira Stream. Error bars are one standard deviation. A QMCI score of 4.0 represents a boundary between 'fair' and 'poor'.

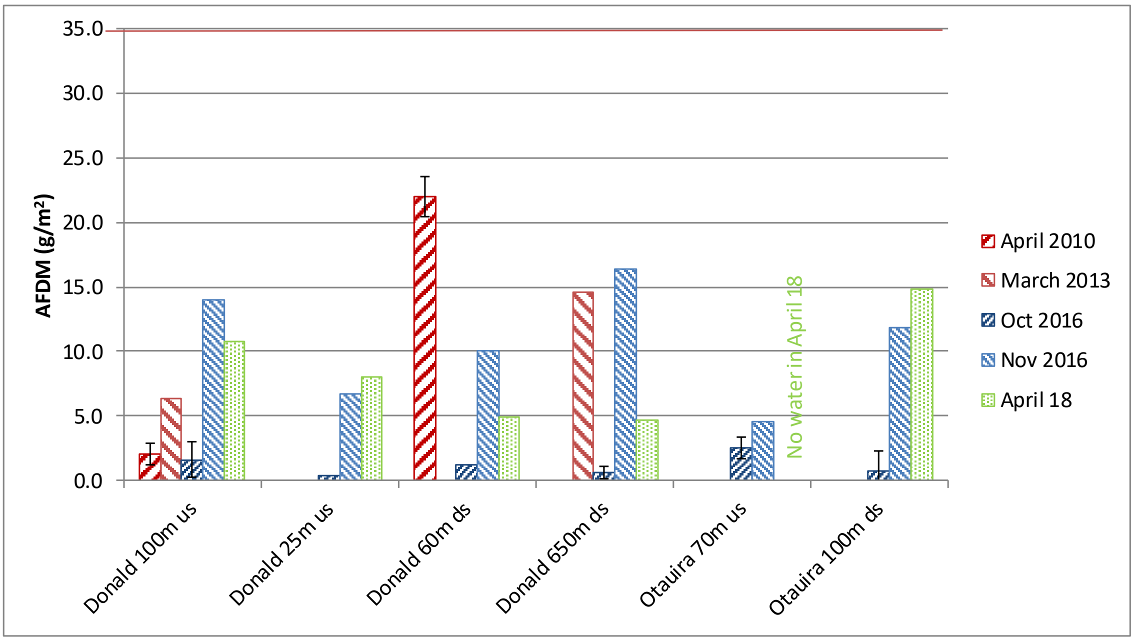


**Figure 4**: Periphyton biomass (as AFDM) in Donald Creek and Otauira Stream. Error bars are standard deviation. The AFDM guideline to maintain trout habitat and angling' is 35 g/m$^2$ (Biggs 2000).

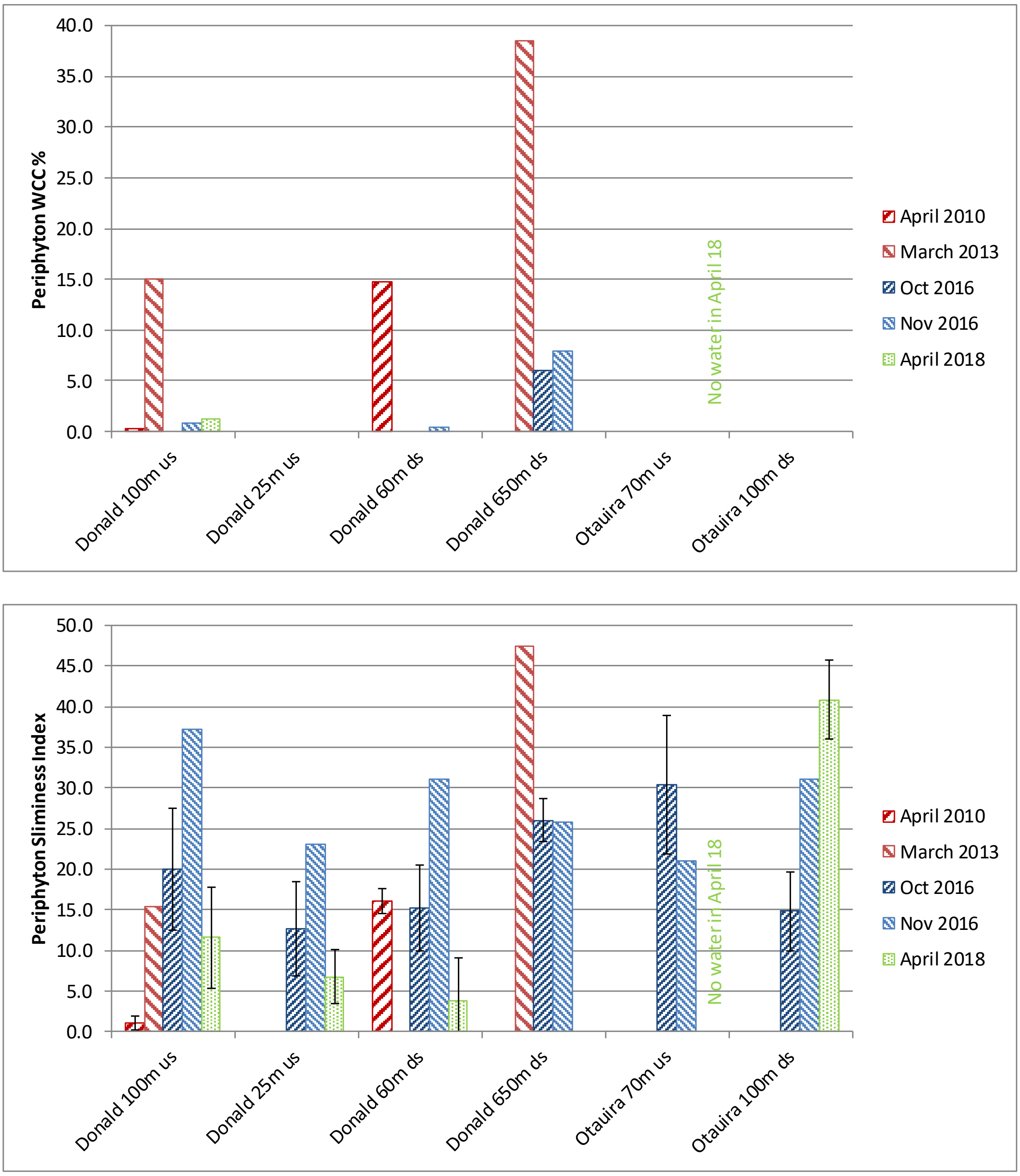


**Figure 5**: Periphyton cover as Periphyton Weighted Composite Cover (top) and Periphyton Sliminess Index (bottom) in Donald Creek and Otauira Stream. Error bars are one standard deviation.

**Figure 6**: Facing upstream towards the confluence of Donald Creek (true right), and Otauira Stream (true left). Top photo taken 1 November 2016 when flow in Donald Creek was 259 L/s. Bottom photo taken 28 April 2018, when flow in Donald Creek was 230 L/s.

38. In summary:

a. The Donald Creek and Otauira Stream provide good quality habitat that supports abundant native fish.

b. The aquatic macroinvertebrate community in Donald Creek and Otauira Stream is typical of 'fair' (moderate) ecological condition at sites upstream of the discharge and confluence respectively.

c. The current discharge is causing a significant adverse effect on the aquatic macroinvertebrate community in Donald Creek during summer. This effect probably extends into Otauira Stream during summer.

d. During spring, the effects of the current discharge on Donald Creek are apparent, but much more mild, compared to summer. Spring effects in Otauira Stream were even less apparent. This reflects the much higher stream flows during spring.

## EFFECTS OF PROPOSED FUTURE DISCHARGES

### Approach

39. In order to assess the effects for different stages of upgrade I drew on multiple lines of evidence; these included: the observed effects of the current discharge in different seasons and flows, comparison of modelled water quality with guideline values, and the amount of dilution provided by the stream when discharges occur and flow when discharges occur.

40. In order to assess whether ecological effects are overall 'significant', I have considered the downstream extent of the effect, the magnitude of effect, its likely frequency, and duration. Effects are more significant when they are result in large changes (e.g. loss of species from the community) are apparent in a range of metrics, and cascade through the ecosystem (e.g. affecting macroinvertebrates and fish). Similarly, effects are more significant when they occur for long periods of time/frequently or are persistent.

41. An important aspect of land treatment is not just stopping discharges to the stream but reducing the volume of discharge and load to a stream when it does occur. I have also considered recovery periods. That is,

how long after a sustained period of discharge it will take the aquatic system to recover.

42. Another important aspect is reducing the frequency, duration and volume of the discharge generally and particular at times of low stream flow. Emma Hammond describes these improvements in her evidence. From stage 1B and increasing at 2A there will be a significant reduction in all of these parameters (volume, load, frequency and duration.)

43. Contrary to statements in the Reporting Officers report (page 43), each treatment stage results in effluent being discharged to Donald Creek on fewer occasions, and when it is discharged it has an overall lesser volume, a smaller contaminant load, and more hydraulic dilution of the effluent. I have used a dilution threshold of 15 times to illustrate the changes in dilution for different stages. For Stage 2A during winter, about 15 times dilution (discharge <7% of stream flow) is needed for the downstream ammonia concentration to be less than 0.5 mg/L (assuming median effluent concentrations). Table 2 shows the percentage of days when a discharge occurs that results in less than 15 times dilution for each upgrade stage. There is a significant reduction of such occurrences at stage 1B (77% reduces to 20%), with further reductions in future stages.

**Table 2**: Percent of days when the discharge results in less than 15 times dilution for each upgrade stage.

| Month | Current | 1A | 1B | 2A | 2B |
|---|---|---|---|---|---|
| Jan | 94% | 94% | 0% | 0% | 0% |
| Feb | 90% | 90% | 2% | 0% | 0% |
| Mar | 88% | 88% | 1% | 0% | 0% |
| Apr | 85% | 85% | 10% | 0% | 0% |
| May | 79% | 79% | 20% | 4% | 0% |
| Jun | 59% | 59% | 62% | 35% | 0% |
| Jul | 55% | 55% | 54% | 25% | 0% |
| Aug | 50% | 50% | 49% | 18% | 0% |
| Sep | 63% | 63% | 15% | 2% | 0% |
| Oct | 71% | 71% | 19% | 5% | 0% |
| Nov | 95% | 95% | 1% | 0% | 0% |
| Dec | 89% | 89% | 1% | 0% | 0% |
| **TOTAL** | **77%** | **77%** | **20%** | **7%** | **0%** |

44. The Proposed Natural Resources Plan (PNRP) Policy 71 sets proposed standards for discharges[7], including, that the effects of point source discharges shall cause a decrease in the Quantitative Macroinvertebrate Community Index (QMCI) of not more than 20%. I discussed the extent that the current and future discharge would meet this standard in a memo response to a Section 92 Further Information Request (Hamill 2017b). In this memo I note that from an ecological perspective the QMCI it is just one of several useful metrics and that a percent change in QMCI should be interpreted in a wider context before deciding if it corresponds to a significant adverse effect on aquatic life (e.g. absolute value of the QMCI, abundance of sensitive species, frequency and duration of the occurrence). This is illustrated by the fact that a greater than 20% change in QMCI was measured between the two upstream sites in the summer of 2013 and spring 2016. This amount of variability is not uncommon between sites with apparently similar habitat and no difference in water quality. An overall picture requires multiple metrics and measurements.

**Total ammonia**

45. One characteristic of the discharge is that most of the dissolved nitrogen is in the form of total ammoniacal nitrogen (total ammonia). In high concentrations total ammonia can be toxic to aquatic life. Total ammonia becomes more toxic with increasing pH and to a lesser extent, temperature. Guideline values are generally expressed assuming pH 8 and a temperature of 20°C, but should be adjusted for actual pH to allow an accurate comparison with measurements.

46. The National Policy Statement for Freshwater Management (NPS-FM) establishes a national bottom-line for total ammonia of 1.3 mg/L and 2.2 mg/L expressed as an annual median and annual maximum respectively.

[7] These have not yet been finalised and may change.

47. The ANZECC (2000) guidelines sets a guideline trigger value for total ammonia of 0.9 mg/L. This was considered appropriate for protecting against chronic effects in slight-moderately disturbed systems (95 percent species protection). It was recommended that the guideline was halved to 0.45 mg/L when particularly sensitive macroinvertebrates need protecting, e.g. the fingernail clam *Sphaerium novaeslandiae*, or freshwater mussel (kākahi).

48. Ammonia guidelines were updated by Hickey (2014) to account for new information on mussels and to inform the bottom-lines sets in the NPS-FM. Dr Hickey provided further interpretation of the updated guidance in a memo to Olivier Ausseil and myself (Hickey 2018), particularly in relation to appropriate values to use for protection of sensitive species such as amphipods (*Paracalliope* sp.), fingernail clam (*sphaeriids*) and kākahi (freshwater mussel).

49. The total ammonium thresholds derived by NIWA (2014) were:

    a. 90% protection level: No Observed Effects Concentration (NOEC) and Threshold Effects Concentration (TEC) of 0.54 mg/L and 0.92 mg/L respectively.

    b. 95% protection level: NOEC and TEC of 0.24 and 0.39 mg/L respectively. The NOEC is to apply to median values and the TEC to 95 percentile values.

50. The toxicity of total ammonia reduces with decreasing pH and guidelines are typically adjusted to reflect either the actual pH at the time of sampling or the $95^{th}$ percentile of the annual pH (e.g. MfE 2014). Donald Creek has a 95-percentile pH of 7.9, at pH 7.9 and 20°C the NIWA (2014) protection levels are:

    a. 90% protection level: median and $95^{th}$ percentile values of 0.62 mg/L and 1.05 mg/L respectively.

    b. 95% protection level: median and $95^{th}$ percentile values of 0.27 and 0.46 mg/L respectively.

51. The average pH in Donald Creek is 7.3, at this pH the 95$^{th}$ protection level for total ammonia is 0.5 mg/L and 0.84 mg/L for median and 95th percentile values respectively. Using the 95$^{th}$ percentile pH adjusting guideline values is precautionary and, on most occasions, the relevant guideline values will be higher.

52. The toxicity of total ammonia to invertebrates decreases with decreasing water temperature[8]. This is a relevant consideration for this application because during Stage 1B 90% of occasions when total ammonia exceeds 0.46mg/L are in the period May to October, during which time the 90$^{th}$ percentile water temperature is 14$^{o}$C (average 12$^{o}$C). Similarly, during Stage 2A 90% of occasions when total ammonia exceeds 0.46 mg/L are in the period June to September, during which time the 90$^{th}$ percentile water temperature is 13$^{o}$C (average 11$^{o}$C).

53. USEPA (1999) developed a relationship for temperature dependence of chronic toxicity of total ammonia on invertebrates as a slope of -0.028 at temperatures above 7$^{o}$C. This equated to chronic criterion guidelines being 1.43 times higher at 14$^{o}$C compared to 20$^{o}$C. Applying this ratio to the 95$^{th}$ percentile protection level described above results in total ammonia of **0.39 mg/L** and **0.66 mg/L** respectively at pH 7.9 and 14$^{o}$C.

54. NIWA (2014) noted that: *"[the 90th percentile guideline values] are protective of the native fingernail clam…"*, although long term exposure at these levels is equated to 21% mortality compared to the control.

55. The 90% protection guideline values result in some effects on North American juvenile mussels. These are not resident in New Zealand but provide a surrogate for NZ freshwater mussel (kākahi) (Hickey 2014). The most sensitive freshwater mussel species tested for total ammonium had a NOEC of 0.24 mg/L and a TEC of 0.54 mg/L (based on chronic effects on growth). This is similar to the 95% protection level of 0.24 and

[8] The ANZECC guidelines do not adjust total ammonia guidelines for temperature because the changes are relatively small compared to pH and because the effect of temperature on total ammonia toxicity in fish is weak and inconsistent. However, invertebrates show a strong and consistent response within the temperature ranges relevant to Donald Creek. The most sensitive species of concern in Donald Creek are chronic sub-lethal effects on invertebrates.

0.39 mg/L for median and 95 percentile values respectively. Long term exposure to the NOEC value may have some chronic effects (e.g. on growth), and applying the 0.24 mg/L threshold to a 95-percentile value would be more protective (Hickey 2018).

56. Kākahi are likely to be NZs most sensitive aquatic species. Kākahi are common in Lake Wairarapa but surveys and searches of Otauira Stream and Donald Creek have not found them either upstream or downstream of the WWTP discharge. I cannot rule out total ammonia from the current discharge having an influence on kākahi presence downstream of the discharge, however, in my view the absence of kākahi in Donald Creek is more like to be due to other factors such as habitat or hydrology. The current total ammonia concentrations caused by the discharge are not sufficiently high to affect dispersal of kākahi to upstream sites. Freshwater mussel disperses when in the glochidia stage. This is an early life-stage which requires the glochidia to parasitise a host fish species for a period of about 20-days prior to being released as juvenile mussels. The glochidia life stage of kākahi has been tested for sensitivity to total ammonia and NPS bottom-line values are likely to provide good protection (the NOEC value for total ammonia was 6.0 mg/L). Current total ammonia measured in the discharge meet the NPS-FM bottom line values.

57. The updated guidelines are inherently precautionary and use No Observable Effect Concentration (NOEC) and the Threshold Effect Concentration (TEC) which in many cases are likely to be result in more conservative guideline values compared with the sensitivity of field monitoring approaches (e.g. reduced species diversity) (Hickey 2018). This situation is observed in Donald Creek. For example, in November 2016 the total ammonia concentration downstream of the discharge was 0.51 mg/L (slightly above the long-term medium). This is borderline for protecting sensitive invertebrate species like the fingernail clam if occurring long term. Nevertheless, fingernail clam was more abundant at the 650m downstream site than upstream. This does not rule out the possibility of high total ammonia currently affecting the fingernail clam

community, and occasional total ammonia has been high (e.g. 3.1 mg/L in December 2016), but it does suggest that the effects during winter and spring conditions are less than those caused by habitat variability.

58. Water quality modelling was undertaken by Mott MacDonald (2017) to estimate total ammonium in Donald Creek with each scenario. This indicates that total ammonia downstream will achieve the 90$^{th}$ protection level by Stage 1B and 2A, and achieve the 95$^{th}$ protection level by Stage 2B. This modelling was very conservative because it did not account for high discharge flows generally occurring at times of high stream flow, and it did not account for improved treatment that comes from improved retention times after I&I work.

59. To more accurately predict future total ammonia downstream of the discharge I modelled total ammonia based on mass load calculations using daily time-steps of flow and dilution over 11 years (2005 -2016). Total ammonia concentrations for use in the mass load calculation were derived using Monte Carlo sampling of a Pert distribution fitted to historical seasonal data from Donald Creek and the effluent. I used the same assumptions about the effects of I&I as Mott McDonald (2017), i.e. adjusted for less dilution but did not account for improved treatment that comes from improved retention times after I&I work (see Appendix 1).

60. The updated model results are shown in Table 3 and compared with guideline protection levels. This shows that total ammonia downstream of the discharge will be well within 90$^{th}$ percentile guidelines after Stage 1B, within 95$^{th}$ percentile guidelines by Stage 2A after adjusting for temperature and within 95$^{th}$ percentile guidelines by Stage 2B. Note that by Stage 2B the downstream 95$^{th}$ percentile for total ammonia is very similar to upstream. This analysis allows for a precautionary approach in adjusting for pH and a very conservative approach in modelling effect after I&I (Stage 2A and Stage 2B). Overall, this analysis shows that the effect of total ammonia is likely to be less than discussed in the caucusing report, with Stage 2A have a low risk of either acute or chronic

effects being apparent on sensitive species of fingernail clam or freshwater mussel.

**Table 3:** Total ammoniacal nitrogen predicted by daily time step Monte Carlo model for period 2005-2018 and NIWA (2014) protection level adjusted for stream pH and temperature.

| Scenario | Median (mg/L) | Mean (mg/L) | $95^{th}$ %ile (mg/L) | Protection Level achieved |
|---|---|---|---|---|
| *$95^{th}$ % protection level pH 7.9 and 20°C* | *0.27* | | *0.46* | |
| *$95^{th}$ % protection level pH 7.9 and 14°C* | *0.39* | | *0.66* | |
| **Time Step Model** | | | | |
| Scenario 1A | 0.496 | 0.605 | 1.41 | $80^{th}$ |
| Scenario 1B | 0.064 | 0.189 | 0.69 | $90^{th}$ |
| Scenario 2A | 0.042 | 0.141 | 0.57 | $90^{th}$ / $95^{th}$ at 14°C |
| Scenario 2B1 | 0.022 | 0.037 | 0.07 | $95^{th}$ /$99^{th}$ at 14°C |

**Stage 1A**

61. Stage 1A consists of only minor treatment pond improvements and irrigation to 8 ha of land. This will reduce the average summer discharge volume/load by 28%. The treatment will provide small improvements for the stream but overall the discharge is likely to still result in substantial effects on aquatic life during the summer. I understand that this stage is scheduled to be implemented at the same time as Stage 1B.

**Stage 1B**

62. Stage 1B is proposed for year two after commencement. It will expand the irrigation area to include a further 70 ha allowing for irrigation of approximately 45% of the average annual wastewater discharge volume. At this stage the majority of discharges occur in winter months.

63. Stage 1B will result in a large reduction in discharge volume and a consequent significant improvement in stream water quality – particularly during periods of summer/autumn low flow. Discharges will occur for about 80% of the time during winter (June to Dec inclusive). Overall about half (46%) will occur during flood events (flows > two times median flow). Discharges with low dilution (<15 times) will occur on 20%

of occasions (Table 2), and 71% of these occasions will occur when the river is above median flow and 25% when the river is in flood (>two times median flow).

64. Implementation of Stage 1B will result in the most substantial and noticeable improvements in stream water quality and ecology of any of the stages. It is during summer /autumn low flows that the worst effects on the stream currently occur and these will be mostly avoided with implementation of Stage 1B (discharges will occur 22% of the time in summer but with greater than 20 times dilution for >91% of these occasions).

65. After implementation of this stage the discharge will cause either no effect or only minor effects on the stream during most of the summer. In some years a discharge is likely to occur with less than 10 times dilution available for up to a week during April or May (and up to two weeks with less than 20 times dilution). At these times there is likely to be stimulation of periphyton growth and there may be noticeable reductions in water clarity (corresponding to increases in suspended sediment). These relatively short periods of discharge are likely to cause changes in the aquatic macroinvertebrate community composition (e.g. QMCI). However, the effects will be small and of short durations compared to effects of the current discharge during summer, with rapid recovery of the macroinvertebrate community. Current effects caused by deposition of material on the stream bed will be avoided because of the higher stream flows and short duration between flood events typical in April and May.

66. Implementation of Stage 1B will also reduce winter discharges to 80% of the time, but the discharge will have more than 10 times dilution for 85% of the time.

67. When winter discharges are occurring the effects during base flow conditions are likely to be similar to the effects found during ecological surveys in October and November 2016, i.e. the periphyton community showing a small increase in cover and biomass but no exceedance of

guideline values for protecting habitat, and the macroinvertebrate community showing a small decline in MCI scores. Some sites may show a >20% change in QMCI but, as found during 2016 sampling, this is unlikely to be consistent through space or time. The change in QMCI on these occasions is likely to be driven by an increase in the abundance of tolerant species rather than a decrease in the abundance of sensitive species like mayfly. Effects will be of short duration. These correspond to moderate to minor effects.

68. Currently the effects of the discharge during spring (September and October) are minor to moderate. With implementation of Stage 1B these effects will considerably reduce to the smaller load discharged and higher dilution. The Officers 42A Report page 21 (section 9.1) states that during Stage 1B "*the effects on aquatic life will be more than minor in the opinion of Dr Ausseil and possibly significantly adverse for 4-6 weeks per year…*" In my view, this statement is misleading in terms of the magnitude, certainty and duration of possible effects during Stage 1B. There is a risk of ecological effects during Stage 1B, probably up to a moderate magnitude, but they are of short duration and infrequent occurrences so that the overall effect is unlikely to be significant.

**Stage 2A**

69. For Stage 2A the infiltration and inflow (I&I) into the pipe sewage reticulation network is reduced by upgrading of the pipe network. The area of irrigation is further increased allowing for irrigation of approximately 68% of the average annual waste water discharge. During this stage almost all effluent discharged to Donald Creek occurs during winter.

70. Stage 2A will further reduce discharge volumes, particularly during winter and autumn. Discharges with low dilution (<15 times) will occur on 7% of occasions. About half (54%) of the discharges will occur during flood events greater than two times median flow.

71. Implementation of Stage 2A will extend the period of no discharge, and consequently no effects, to 87% of the time (mostly spring to autumn).

There will be more than 20 times dilution for more than 97% of the time. This will almost eliminate summer /autumn low flow impacts on ecology. In my opinion the QMCI at the downstream sites is likely to be within 20% of the upstream sites almost all the time. Variability in QMCI between sites will be very similar to natural variability.

72. A decline in QMCI may still be apparent in years with extended periods of winter low flow. In my view, and considering the results of spring sampling, the magnitude of QMCI change is likely to be less than 20% and the overall ecological effects of the discharge during Stage 2A will likely be minor.

73. As discussed in the caucusing report, the effects of Stage 2A on aquatic life is generally minor or less, but there is a possibility of short periods of time when the effects on the macroinvertebrate community may be more than minor. These are most likely to occur in autumn (and to a much lesser extent in spring) as autumn rain starts to limit the volume of effluent able to be discharged to land but has not sufficiently raised the baseflow in the stream. We estimated in the caucusing report that this might occur for a period of up to two to three weeks, but this is a near worst-case scenario that will not occur annually and rarely occur twice in the same year. By way of context, modelling of this Stage 2A shows the longest period of time with less than 20 times dilution was for nine days commencing 19 April 2014, this was after a flood which has the effect of partially 'resetting' periphyton and invertebrate communities. In my view, the overall effect[9] of the discharge on aquatic life during Stage 2A will be minor.

74. I agree with the conclusion of Dr Ausseil that Stage 2A is unlikely to constitute a significant adverse effect on aquatic life (section 8.4) and I support undertaking monitoring during Stage 1B and 2A to better quantify any effects.

[9] Considering the likely magnitude, duration, frequency and persistence of any effect.

**Stage 2B**

75. For Stage 2B a large deferred storage pond is constructed to buffer flows and to provide additional storage and oxidation of the effluent. The buffering allows for approximately 94% of the average annual wastewater discharge volume to be irrigated. During this stage discharge to Donald Creek occurs infrequently and is predicted to occur 91% when Donald Creek's flow exceeds two times the median flow and at no times when there would be less than 15% dilution.

76. Stage 2B work will enable effluent flows to be buffered. This will eliminate effluent discharges during summer and substantially reduce the discharges during winter (to 7% of the time). When discharges do occur during the winter months, they will be managed so as to occur when there is always have more than 20 times hydraulic dilution. Most (91%) of the discharges will occur during flood events greater than two times median flow.

77. On the rare occasions, when discharges occur during low flow periods, an effect may still be measurable in the periphyton and aquatic macroinvertebrate community. However, these effects will be much less than what was observed during the spring surveys because of the reduced duration and volume of discharge. Overall the effects of the discharge on stream ecology after implementation of Stage 2B are expected to be negligible.

**Summary of effects**

The effect of the discharge on aquatic life is summarised in Table 4 for each upgrade stage. I note that the overall effect of the proposal as compared to the existing environment (with the discharge) is significantly positive and the largest, most noticeable benefits will occur at stages 1B and 2A.

**Table 4**: Summary of effects of the discharge

| Effect | Existing | Stage1B | Stage 2A | Stage 2B |
|---|---|---|---|---|
| **Deposition** | Substantial deposition observed during summer. | Small amount possible on for short duration in autumn but likely minor effect. | Negligible | none |
| **Ammonia** | Chronic effects on sensitive sp. during summer. | Possible chronic effects for short duration on FW clam and Kākahi. | Low risk of chronic effects on most sensitive species. Overall minor | Negligible |
| **Periphyton** | More periphyton d/s, but generally within guidelines. Moderate effect but probably not significant. | Increased biomass d/s for short duration in autumn. Likely within guideline values. | Minor or less. | Negligible |
| **Invertebrates** | Substantial effect during summer/autumn low flow.<br><br>Moderate effects during spring. | Moderate effect on invertebrate composition for short duration during autumn. Overall minor. | Possible effect on invertebrate composition for short duration during autumn. Overall minor. | Negligible |
| **Fish** | Likely a reduced food quality during summer low flow. Effects not apparent in spring sampling. | Expect Negligible | Negligible.<br><br>Net benefit if riparian planting occurs | Negligible.<br><br>Net benefit if riparian planting occurs |

## RESPONSE TO SECTION 42A REPORT

### Significance of the Otauira Stream and Donald Creek

78. There is ambiguity in the Proposed Natural Resources Plan (PNRP) as to whether Donald Creek and the lower Otauira Stream (Abbots Creek) are classed as a ‘significant river’ or not. Schedule F1 lists “Abbotts Creek” (and tributaries) as having ‘*high macroinvertebrate community health*” and “*habitat for indigenous threatened/at risk fish species*” (page 367 of the PNRP). In contrast, PNRP map 13a (Schedule F) shows that Abbots Creek/Otauira Stream listed as ‘*high macroinvertebrate community*

*health*' from upstream of its confluence with Donald Creek only. This mapping does not appear to be a mistake because Map13b shows Abbots Creek/Otauira Stream as significant for habitat and indigenous fish species along its full length. The Reporting Officer expresses a view that the words in the Schedule F table should be given preference over the maps. Others will comment on the validity of this view from a planning and legal perspective, and I will provide comment from a technical perspective.

79. In my view, the information in PNRP Map 13a is more appropriate and for the purposed of Table 3.4 in Objective 25, Donald Creek (and the lowland section of Otauira Stream) should fit under the category of '*all rivers*'. The reason for this is two-fold. Firstly, these stream sections do not currently meet the Objective 25 criteria of MCI score ≥120. On all sample occasions the background MCI score in streams has been less than 100. Even with widespread landuse change it is questionable whether this criterion would be met during summer/autumns low flows (the period of time when the PNRP specifies macroinvertebrate assessments).

80. Secondly, it is possible that both the tables in Schedule F1 and the maps are correct for the purpose of determining '*significant*' as applied in PNRP chapter 3, Table 3.4. This is because Abbots Creek, as shown on NZ topo map, only starts upstream of Featherston, and the section downstream of Featherston is called Otauira Stream, i.e. different names are applied to different sections of the same waterway. Thus, a strict reading of the tables in Schedule F1 would only apply the macroinvertebrate significant classification to the sections of Abbots Creek upstream of Featherston.

**Officer's Summary of Effects**

81. Page 28 of the Officers Report, Section 9.3.4 summarises potential effects of the discharge at each stage in a table and stated that "*It is important to note here that this table relates to the effects from the proposal in the context of the actual effects occurring on the*

*environment all of the time (i.e. in line with Section 107 of the Act), which considers effects at any time (day or night, summer or winter).*" This statement is incorrect. The description of effects in the table or those summarised in the joint caucusing statement, do not describe actual effects that occur all of the time. They describe potential effects and often they are describing effects that might occur some of the time. I have already referred to this issue in relation to autumn and spring effects for Stage 1B.

**RESPONSE TO EVIDENCE BY Dr AUSSIEL**

82. On page 23, Section 7.16, Dr Ausseil states that: "*Ecological effects are not expected to be more than minor in summer, but adverse effects on periphyton, and macroinvertebrates cannot be discounted during the remainder of the year, as follows…*". He goes on to make a number of statements regarding Donald Creek that, in my view, require clarification.

83. He states that: "(c i) *Significant increases in periphyton growth are likely to occur when flow conditions are sufficiently stable (noting flow does not need to be particularly low, just stable), particularly in spring and autumn*". Actual observations and sampling of the river during do not fully support this statement. While phosphorus loads from the WWTP discharge do generally (not always) result in high periphyton biomass downstream the biomass is within guideline values. The movement of sand at flows above about median flow appears to be one mechanism limiting periphyton cover in the stream despite high nutrient concentrations.

84. He states that: "c (ii) *Deposition of particulate organic matter from the discharge is similarly likely to occur when flow conditions are sufficiently stable*". Based on my observations deposition of organic matter does not occur when flows are above about median flow. No organic matter deposition was observed on the stream bed during the 1 November 2016 survey despite flows ranging from about 190 L/s to 330

L/s over the previous 20 days. At these flows, typical during spring/summer, the stream water velocity appears to be too high to allow for significant deposition. I also note that from Stage 1B the discharge volumes/loads during the shoulder seasons will be much lower than what currently occurs, which further reduces the risk of deposition and other effects.

85. Evidence by Dr Ausseil, on advice from the reporting Officer, assumed that Donald Creek and Otauira Stream were classed as 'significant' rivers. This influenced his assessment of effects as summarised in Table 3 of his evidence. Instead, Donald Creek and Otauira Stream should be considered in the "All Rivers" class for biological reasons and geographical reasons described above. The apparent mis-classification of Donald Creek particularly affected the assessment for Periphyton. Donald Creek is likely to meet the Objective 25 criteria for periphyton by Stage 1B.

86. The summary in Table 3 of Dr Ausseil's evidence was used by the Reporting Officer (page 60) to assess whether the proposal will safeguard ecosystem health. This assessment will need to be revised if, in the Commissioner's view, Donald Creek and Otauira Stream should be classed as "all rivers" for the purpose of Objective 25 of the PNRP.

## CONCLUSION

87. Ecological surveys have found that the Featherston WWTP has a significant effect on water quality and the aquatic macroinvertebrate community of Donald Creek during the summer; however, the effect during spring sampling was relatively minor to moderate. The difference in the effect of the discharge in spring compared to summer reflects seasonal differences in stream flow, dilution, effluent quality and water temperature.

88. The effects of the discharge will reduce with implementing each stage of upgrade. However, the most noticeable improvements in stream water quality and ecology will occur with implementation of Stage 1B.

This is because of the large reduction in discharge volume during summer, but also during low flow periods in spring and autumn. At stage 2A there may still be effects on invertebrate composition for short durations during autumn, but this will only likely be apparent in some years and, in my view, the overall effects on aquatic life in Donald Creek and Otauira Stream will be minor. With implementation of Stage 2B the ecological effects on the streams will be negligible.

89. In terms of section 107 of the RMA, I am of the view that from Stage 1B onwards (or at latest from Stage 2A) the discharge will be acceptable and not give rise to significant adverse effects on aquatic life.

90. In terms of section 5 of the Act, in my opinion the proposal will safeguard the life supporting capacity of Donald Creek and Otauira Stream, probably from Stage 1B onwards and more certainly from Stage 2A.

91. In terms of section 6 of the Act, in my opinion the proposal will protect significant habitats of indigenous fauna.

92. So far as they relate to aquatic ecology, I support the conditions of consent as proposed by the Applicant. I have suggested the addition of a requirement for the Consent Holder to carry out riparian planting of Donald Creek within the boundaries of its site. In my view, this will particularly benefit aquatic macroinvertebrates and fish and provide further mitigation of the residual minor effects of the discharge.

Signed:

Keith Hamill

29 March 2019

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## APPENDIX 1: Time step Monte Carlo model of total ammonia at each stage

Past modelling of total ammonia assumed no correlation between effluent volume and stream flow, when in fact high effluent discharge flows generally occurring at times of high stream flow. To more accurately predict future total ammonia downstream, total ammonia was modelled based on mass load calculations using daily time-steps of flow and dilution over 11 years (2005 -2016). Total ammonia concentrations for use in the mass load calculation were derived using Monte Carlo sampling of a Pert distribution fitted seasonal data from Donald Creek and the effluent from the period 2005 to 2018. For scenarios after I&I programme (i.e. Stage 2A and 2B), we assumed an increase in total ammonia concentrations in the effluent of 1.1 times in the summer and 1.5 times in the winter as per. The modelling by Mott McDonald (2017). This is a conservative assumption that adjusted for less dilution post I&I work but does not account for improved treatment that comes from improved retention times after I&I work.

Monte Carlo analysis was done using the software RISKAMP. Pert distribution of total ammonia in the stream and effluent we defined using the minimum, medium and maximum values from sampling over the period 2005 to 2018 (see Table A and B below). A lambda value of 4 was used for effluent distribution and a lambda value of 8 was used for the stream distribution – this reflected the skewed nature of total ammonia concentrations in the stream.

Table A: Donald Creek upstream water quality statistics by season for period 2005-2018

| Season | Dec - Feb | Mar - May | Jun - Aug | Sep - Nov |
|---|---|---|---|---|
| N | 27 | 23 | 26 | 24 |
| Mean | 0.02 | 0.037 | 0.023 | 0.026 |
| Median | 0.01 | 0.01 | 0.02 | 0.005 |
| 5% | 0.005 | 0.005 | 0.005 | 0.005 |
| 25% | 0.005 | 0.005 | 0.005 | 0.005 |
| 75% | 0.033 | 0.048 | 0.027 | 0.031 |
| 95% | 0.05 | 0.159 | 0.063 | 0.109 |
| Max | 0.09 | 0.29 | 0.15 | 0.2 |

Table B: Featherston effluent water quality statistics by season for period 2005-2018

| Season | Dec - Feb | Mar - May | Jun - Aug | Sep - Nov |
|---|---|---|---|---|
| N | 21 | 22 | 24 | 18 |
| Mean | 3.50 | 6.04 | 4.27 | 6.11 |
| Median | 3.79 | 5.22 | 4.18 | 6.32 |
| 5% | 0.34 | 0.57 | 0.94 | 2.28 |
| 25% | 2.40 | 3.11 | 2.64 | 4.02 |
| 75% | 4.4 | 7.4 | 5.6 | 7.3 |
| 95% | 6.8 | 14.8 | 9.3 | 10.4 |
| Min | 0.044 | 0.32 | 0.38 | 2.05 |
| Max | 6.9 | 15.6 | 11.4 | 10.9 |