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Featherston Wastewater Treatment Plant: Effects on stream ecology

Prepared for:

South Wairarapa District Council

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Date: 31 January 2017
Status: Final
Reference: wk-1070

Cover photo: Fyke net in Otauira Stream.

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1 Introduction

1.1 Background

Featherston Wastewater Treatment Plant (WWTP) discharges treated wastewater to Donald Creek. Donald Creek enters the Otauira Stream about 2.5km downstream of the discharge, and Otauira Stream flows another 2.6 km before entering the northern end of Lake Wairarapa. The South Wairarapa District Council (SWDC) is undertaking a programme to upgrade the WWTP to partial land disposal but there is likely to still be a discharge to Donald Creek for a period of time and under wet conditions that typically occur during winter.

This report assesses the potential effects of the discharge and future stages of the upgrade; it builds on ecological surveys assessing the effects of the discharge during base flow conditions in summer (Coffey 2010, Coffey 2013, Forbes 2013) and spring (Hamill 2017). It uses the results of water quality analysis by Craig Campbell and the modelling of the discharge by K. Beecroft.

1.2 Stages of upgrade

The Project proposes a staged approach to upgrading the treatment system for Featherston WWTP; the Stages are:

Stage 1A: Minor treatment pond improvements and irrigation to land starts with an area 8Ha of land allowing for approximately 5% of the average annual wastewater discharge volume and 28% of the average summer discharge volume to be irrigated.

Stage 1B: Irrigation area expanded 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.

Stage 2A: The infiltration and inflow (I&I) into the pipe sewage reticulation network is reduced by upgrading of the pipe network, resulting in a reduction of approximately 35% of inflow into the system in winter and 20% of the flow in summer. 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.

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 73% of the time when the flow exceeds three times the median flow.

Each stage results in less effluent discharged to Donald Creek, a lower proportion of time the effluent is discharged and more dilution when discharges do occur (Table 1.1 and Figure 1.1). Stage 1A is similar to the current situation. Stage 1B will result in a large reduction in discharge volume and a consequent improvement in stream water quality – particularly during summer. Discharges will occur for about 22% of the time in summer and 80% of the time during winter (June to Dec inclusive). During peak summer (December to March inclusive) discharges will occur about 3.3% of days. When discharges do occur,

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they will have more than 20 times dilution[1] about 91% of the time during summer and about 50% of the time during winter. Almost half (46%) of the discharges will occur during flood events greater than two times median flow.

Stage 2A will reduce average discharge volumes to the stream by a further 40% to 65% (winter and summer respectively) to 16 L/s and 1.2 L/s and . Discharges during peak summer will reduce to 1.5% of the time. However at times of discharge (mostly during winter months now) the improvements in stream water quality will be limited because the reduced effluent volume from the I & I work will be balanced by higher concentrations of contaminants in the effluent (see water quality modelling Mott MacDonald, 2017). About 54% of the discharges will occur during flood events greater than two times median flow.

Stage 2B work will enable effluent flows to be buffered. This will eliminate effluent discharges during summer and substantially reduce the discharges during winter. When discharges do occur during the winter months, they can be managed 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.

In preparing this assessment I have assumed that the land application will occur in a way so as to avoid leaching nutrients, and particularly phosphorus, to the streams.

Table 1.1: Changes in the effluent discharge to Donald Creek at different stages of the upgrade. Each stage results in less effluent discharged to Donald Creek and more dilution when discharges do occur. Winter was June to Nov (inclusive). For stage 2A and 2B 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).

Statistic	**Season**	**Donald Creek**	**Discharge Stage 1A**	**Discharge Stage 1B**	**Discharge Stage 2A**	**Discharge Stage 2B option1**
Average (L/s)	summer	159.8	17.4	3.4	1.2	0
	winter	537.9	35.4	26.5	16.0	3.5
% time discharging	summer		97.6	21.8	12.8	0
	winter		100.0	80.3	68.7	7.6
% time discharging with < 20x dilution	summer		92.5	8.9	2.3	0
	winter		82.0	49.4	24.6	0
% time discharging with < 10x dilution	summer		71.1	3.5	0.5	0
	winter		36.0	15.7	4.3	0

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[1] This refers to the hydraulic dilution (stream flow / effluent flow). The actual dilution will differ depending on the concentration of contaminant upstream, for contaminants with a very low upstream concentration (e.g. ammonia), there will be very little difference between hydraulic dilution and the actual dilution.

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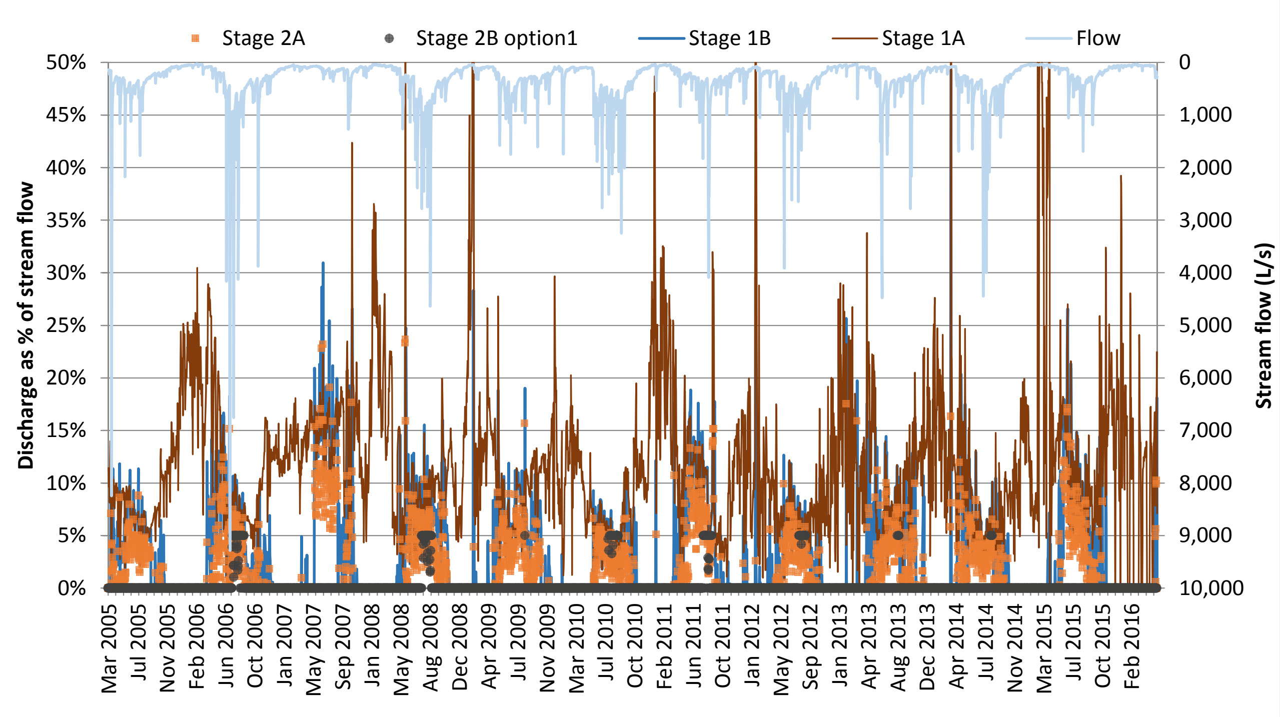

Figure 1.1: Modelled discharge as a % of stream flow. Axis truncated at 50% but Stage 2A maximum was 116% of stream flow. 5% of stream flow corresponds to a hydraulic dilution of 20 times.

2 Effects of the current discharge on stream ecology

2.1 Stream habitat and flow

Featherston WWTP discharges treated wastewater to Donald Creek. Donald Creek enters the Otauira Stream (Abbot Creek) about 2.5km 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 meters downstream the stream passes through a remnant of protected bush.

A small tributary (Longburn 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 Otauria Stream. The stream width increases from about 4m near the discharge to 7m at the sample site 650m downstream, while the median water depth in runs remains about 0.25m along this reach (spring base flow conditions).

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. 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 2017, Coffey 2013).

Donald Creek and Otauira Stream support populations of large longfin eel and common bully. Rainbow trout and inanga have also been caught in the streams. Good habitat is provided for fish where the stream passes through the bush remnant by riparian cover, and woody debris in the stream creating a diversity of hydraulic regimes.

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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). Past sampling of Donald Creek has found upstream site with MCI and QMCI scores indicative of 'poor' to 'fair' ecological condition (MCI scores of 70 to 98, QMCI scores of 2.7to 4.6) (Figure 2.1).

Past sampling of Otauira Stream (Abbot Creek) has 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 2016).

The flow in Donald Creek is very seasonal. The annual median flow is 241 L/s while the median flow in the months January to March is about 75 L/s (Butcher 2016). This results in considerably less dilution during the summer, with the discharge regularly contributing more than 20% of the stream flow (less than 5 times dilution) (Figure 1.1 and Table 1.1). This in turn contributes to a dramatic seasonal difference in the current effects of the discharge.

2.2 Effects of the discharge

Ecological monitoring to assess the effects of the discharge has been undertaken on three occasions during summer and twice during spring.

Ecological surveys of Donald Creek were undertaken at two sites in April 2010 and five sites in March 2013 to assess the effects of the WWTP (Coffey 2010, Coffey 2013). Shading by trees was thought to mask the full effect of the nutrient enrichment so additional sites were sampled in 2013. Some willows were removed after the 2013 sampling to make the stream more open. Sampling during March 2013 occurred during a period of extreme low flows so probably reflect a near 'worse case' scenario.

Forbes (2013) monitored water quality and periphyton in Donald Creek about monthly between November 2012 and April 2013. This consisted of water quality samples and visual assessments of periphyton cover and analysis of periphyton relative abundance. Sites were located about just upstream, about 60m downstream and about 160m downstream.

Hamill (2017) undertook ecological surveys of Donald Creek and Otauria Stream in October and November 2016. The surveys assessed periphyton, aquatic macroinvertebrates, fish and water quality. The stream flow and discharge at the time of the surveys was typical for late spring conditions and the last large flood had occurred about four weeks prior to the October survey. At the time of both surveys the hydraulic dilution factor provided by the stream for the effluent was about 11.5 times.

2.2.1 Macroinvertebrate community

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, Macroinvertebrate Community Index (MCI) and the Quantitative Macroinvertebrate Community Index (QMCI).

The MCI and QMCI reflect the sensitivity of the macroinvertebrate community to pollution and habitat change, with higher scores indicating higher water quality. Generally accepted water quality classes for different MCI and QMCI scores and soft-bottomed version are shown in Table 2.1.

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Table 2.1: Suggested quality thresholds for interpretation of the MCI & QMCI from Stark (1998).

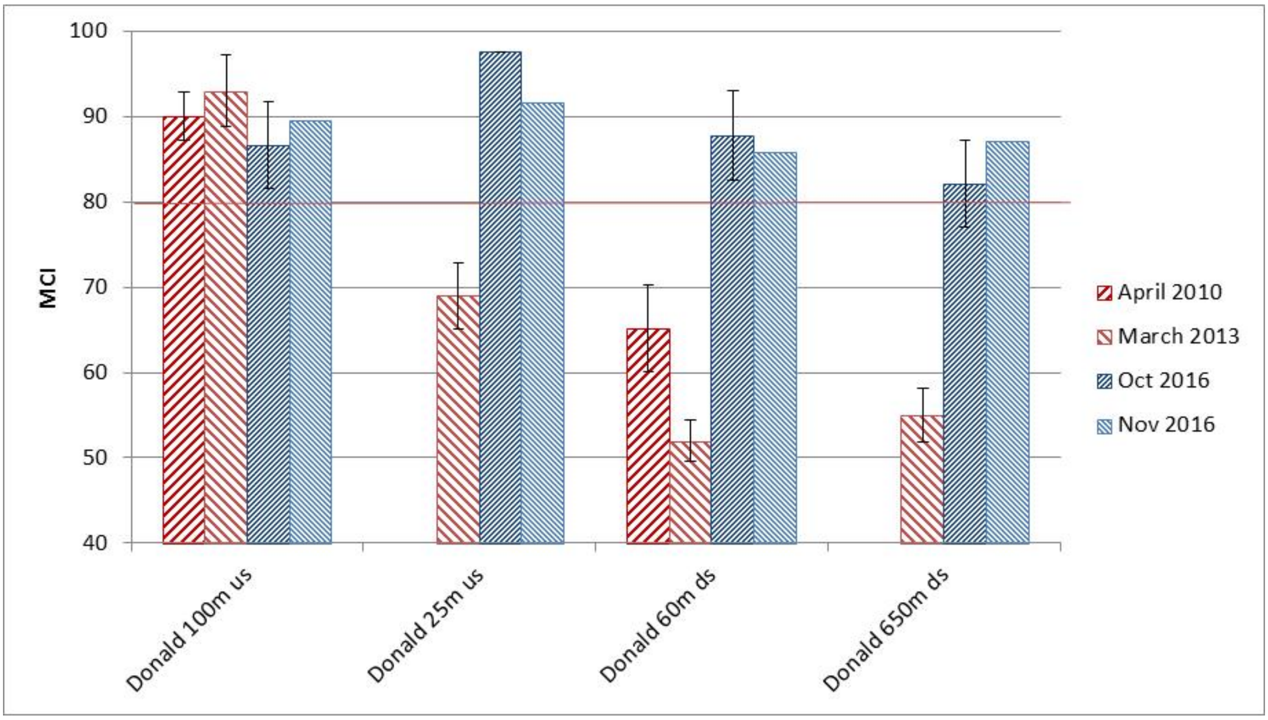
Quality Class	Description	MCI	QMCI
Excellent	Clean water	> 120	> 6.0
Good	Doubtful quality or possible mild pollution	100 – 120	5.0 - 6.0
Fair	Probable moderate pollution	80 – 100	4.0 – 5.0
Poor	Probable severe pollution	< 80	< 4.0

Sampling during late summer found statistically significant deterioration of all measured macroinvertebrate metrics downstream of the discharge. The declines in MCI and QMCI were substantial and corresponded to the almost complete loss from the community of some sensitive taxa such as mayfly (Figure 2.1).

The deterioration in aquatic macroinvertebrate community was in part explained by the deposition of fine organic matter on the stream bed from the oxidation ponds. Sites immediately downstream of the discharge had planktonic algae from the oxidation ponds as a scum on substrate and moss. Planktonic green algae and Daphnia (indicative of an oxidation pond discharge) were common in the samples (Coffey 2010, Coffey 2013).

The two surveys during late spring 2016 (October and November) found the effect of the discharge to be relatively mild compared to those observed during late summer. The macroinvertebrate community had slightly lower MCI scores at the two downstream sites (statistically significant but on 7% lower), and no consistent upstream to downstream difference in QMCI scores. No organic ‘scums’ were observed on the stream bed. Some of the decline in MCI at the 650m downstream site was likely to be due to pressures in addition to the WWTP discharge including smaller substrate size, localised sediment input and direct disturbance by cattle in the stream (Figure 2.1, Hamill 2017).

Otauira Stream upstream of the confluence with Donald Creek had macroinvertebrate communities indicative of ‘fair’ water quality based on MCI scores (95 – 98), but QMCI scores indicated poorer conditions (2.1 – 3.0). MCI scores were 7% lower downstream of the confluence, but other indices had an inconsistent pattern, and in October 2016 the QMCI was significantly higher at the downstream site (Hamill 2017).



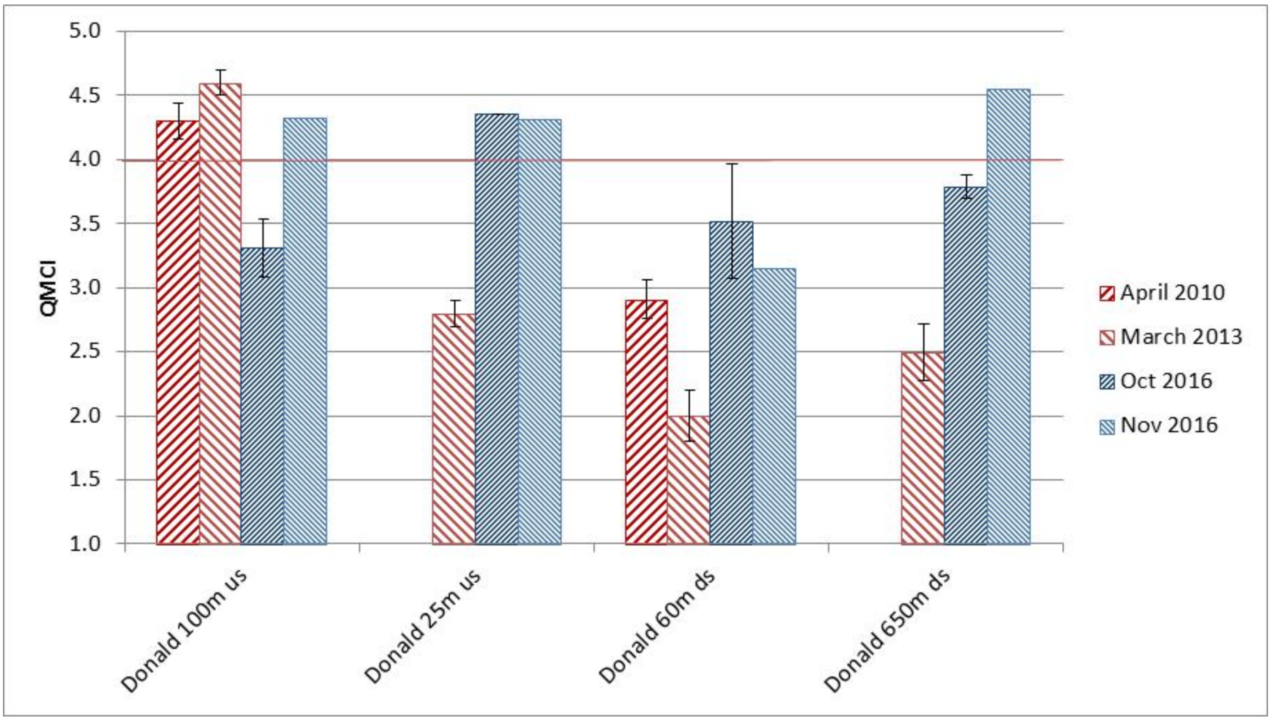


Figure 2.1: Median MCI and QMCI scores for Donald Creek for surveys in April 2010, March 201, October 2016 and November 2016 (Coffey 2010, 2013, Hamill 2017). The error bars show one standard deviation of replicate samples. The red horizontal line indicates scores indicative of ‘poor’ water quality /habitat.

2.2.2 Periphyton and heterotrophic growths

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 dissolved oxygen.

The NZ periphyton guideline (Biggs 2000) has set guidelines to maintain 'trout habitat and angling' based on biomass and the percent cover of the stream bed. Peak biomass was set at <35 g AFDM/m^2 (Ash Free Dry Mass), or if measured as chlorophyll-*a*, <200 mg chl-*a*/m^2 for diatom / cyanobacteria dominated communities, and <120 mg chl-*a*/ m^2 for filamentous algae dominated communities.

Guidelines for periphyton cover to maintain aesthetic values are periphyton cover <30% long and <60% of streambed covered by diatoms or cyanobacteria >0.3mm thick (Biggs 2000). These guidelines are commonly simplified by using the index Periphyton Weighted Composite Cover (PeriWCC) and an aesthetic nuisance guideline of PeriWCC 30% (Matheson et al. 2012).

Sampling during April 2010 and March 2013 found periphyton cover and biomass was significantly higher downstream of the discharge, particularly at unshaded sites (Figure 2.2, and 2.3). Periphyton cover as measured by PeriWCC was in 2010 0.3% upstream and 15% downstream, and in 2013 15% upstream and 38% downstream.

Forbes (2013) sampled periphyton monthly and found all sites were clear of periphyton during November 2012 and that the amount of periphyton cover increased during the summer - particularly at the downstream sites. During April, 'sludge' (medium mats) covered about 10% of the bed and coarse filamentous green algae covered almost 20% of the bed at the 160 downstream site. The highest periphyton biomass was recorded -at the 160m downstream site during February 2013 at 138 mg chlorophyll-*a*/m^2 and 42 g AFDM/m^2. This was the only occasion where the periphyton exceeded the periphyton guidelines for protection of trout habitat (Biggs 2000).

The October and November 2016 survey found a small increase in cover of filamentous algae (e.g. PeriWCC in November 1% upstream and 8% downstream). There was little or no difference in periphyton biomass between upstream and downstream as measured by AFDM but there was an increase in November based on chlorophyll-*a* measurements (i.e. 45 mg/m^2 upstream and 110 mg/m^2 downstream). The downstream sites were still within guideline values for protection of trout habitat (Figure 2.2, Figure 2.3).

Some heterotrophic growths were found in Donald Creek (ca.5% cover) during both 2010 and 2013 summer surveys, but none were present at the time of the surveys in October and November 2016.

In Otauira Stream the periphyton cover and biomass was higher upstream of the confluence with Donald Creek in October 2016, this was surprising given the difference in nutrient concentrations but may have reflected low grazing pressure by invertebrate (e.g. snails and mayfly) at this site. During November periphyton cover and biomass was higher downstream of the confluence, but remained low and well within guidelines for maintaining trout habitat (i.e. chlorophyll-*a* was 48 mg/m^2, AFDM 12 g/m^2 and PeriWCC was 0%).

The amount of periphyton in Donald Creek is less than would be expected given the high concentration of dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) in the stream. Biggs (2000) developed a simple periphyton growth model to estimate periphyton biomass based on days of accrual, and either DIN of DRP (depending which is most limiting). Prior to the October and November surveys there had been respectively 17 days and 38 days accrual since the last flood greater than three times median flow. At the time of both surveys DRP was potentially more limiting than DIN. The model predicted dramatically more periphyton than was found in the survey of any upstream of downstream sites. This suggests that the periphyton biomass is being limited by factors other than nutrients or shading. Sand was observed moving along the stream bed and scouring by sand a moderate flows (e.g. above median) may be limiting the periphyton biomass.

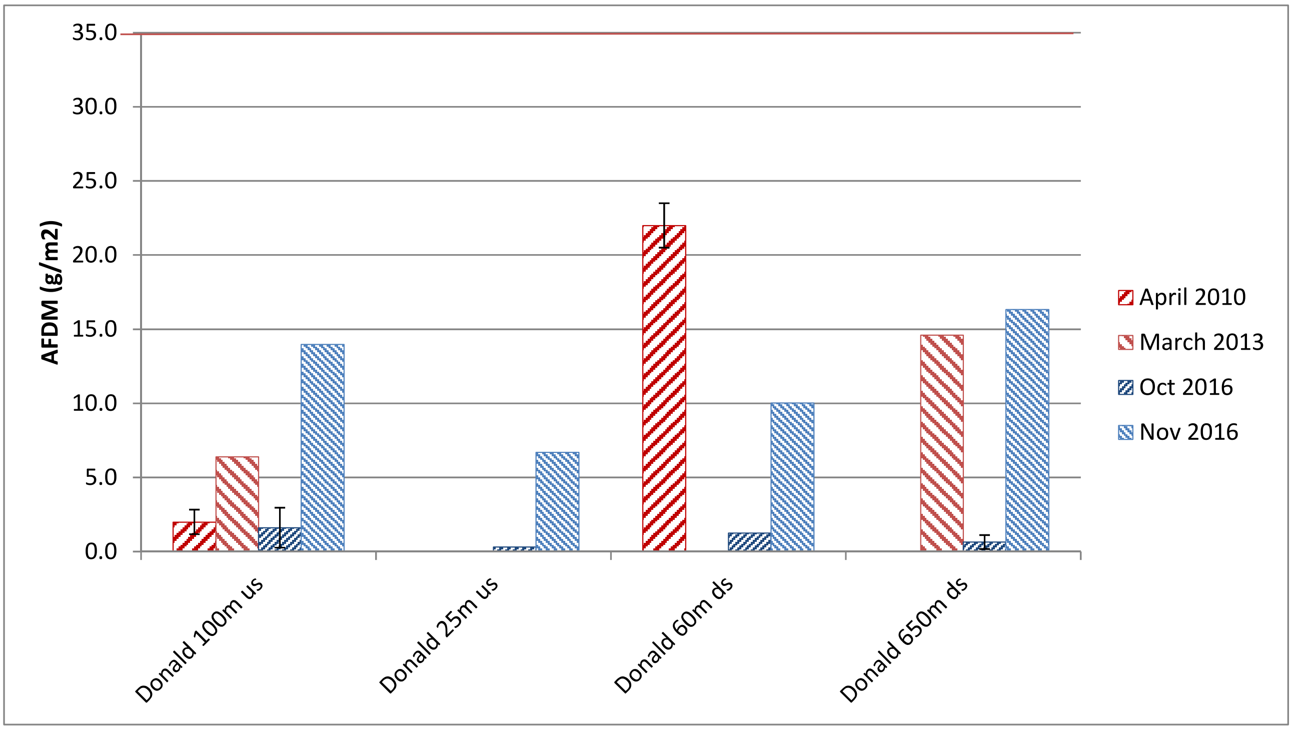


Figure 2.2: Periphyton biomass in Donald Creek measured as Ash Free Dry Mass. The AFDM for October 2016 was estimated from chlorophyll-*a* samples. The guideline for protection of trout habitat is 35 g/m^2 (Biggs 2000). In March 2013 no periphyton was found at the 25m upstream site due to heavy shading, and none at the 60m downstream site due to deposition of phytoplankton.

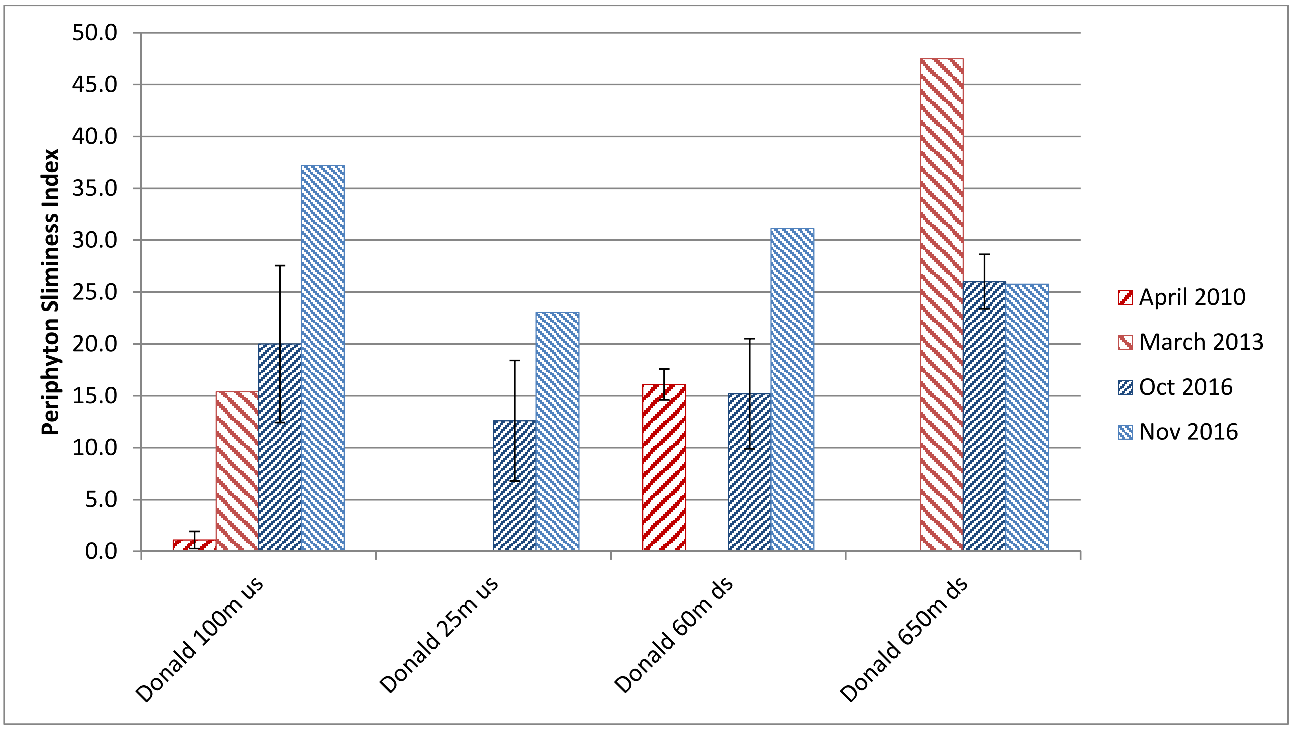


Figure 2.3: Periphyton cover as measured by the Periphyton Sliminess Index. In March 2013 no periphyton was found at the 25m upstream site due to heavy shading, and none at the 60m downstream site due to deposition of phytoplankton.

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2.2.3 Water Quality

2.2.3.1 Clarity, colour and foam

Surveys undertaken during the summer observed foam in Donald Creek as a result of the discharge (Coffey 2010, Coffey 2013), but the surveys undertaken in October and November 2016 found similar amounts of foam at sites upstream and downstream of the discharge. The foam observed during spring was attributed to the breakdown of macrophytes within the stream.

During the summer surveys a conspicuous change in colour and clarity was observed as a result of the discharge (Coffey 2010, Coffey 2013). Forbes (2013) found downstream sites had substantially lower water clarity and higher turbidity, except for the November 2012 sample where the change in turbidity was relatively small. During the summer fine sediment was observed to accumulate on the streambed downstream of the discharge (Forbes 2013). In contrast to summer surveys, the October and November 2016 survey found no obvious change in colour or clarity (Hamill 2017).

2.2.3.2 Nutrients

Nitrogen and phosphorus and major nutrient required for periphyton growth. Rier and Steven (2006) found nutrient saturation at dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) concentrations of 0.31 mg/L and 0.038 mg/L respectively; while peak growth rates occurred at DIN and DRP concentrations of 0.086 mg/L and 0.016 mg/L respectively. This is consistent with other studies that have found little growth limitation at DRP concentrations above 0.02 to 0.08 mg/L (Hill and Fanta 2008, Bothwell 1989). Kilroy et al. (2012) found that periphyton biomass in rivers from the Manawatu region did not exceed guideline values if mean soluble inorganic nitrogen was < 0.1 mg/L. The periphyton model developed by Biggs (2000) predicts that DIN and DRP concentrations of 0.1 mg/L and 0.01 mg/L will maintain periphyton within the 200 mg/m^2 chlorophyll *a* guideline value for accrual periods of up to 27 days.

During November 2016, Donald Creek upstream of the discharge had high concentrations of nitrogen (DIN 1.0 mg/L) and moderate to low concentrations of phosphorus (DRP of 0.011 mg/L) (similar to the longer term winter median of 0.98 mg/L and 0.011 mg/L for DIN and DRP respectively). The discharge added further N and P, increasing downstream concentrations to 1.5 mg/L and 0.12 mg/L for DIN and DRP respectively (similar to the longer term winter median of 1.6 mg/L and 0.094 mg/L for DIN and DRP respectively). Upstream of the discharge periphyton biomass is likely to be at least partially controlled by low P concentrations but DIN is too high to exert any significant control on periphyton growth. Downstream of the discharge the concentration of dissolved N and P was sufficiently high to not exert any control on periphyton growth (see discussion in Hamill 2017).

Nutrient concentrations in Otauira Stream were low upstream of the confluence with Donald Creek (0.08 mg/L and 0.005 mg/L for DIN and DRP respectively) and relatively high downstream (1.0 mg/L and 0.028 mg/L for DIN and DRP respectively) – although still considerably less than Donald Creek. The low nutrient concentrations upstream of the confluent will reduce periphyton growth rates, but the concentrations downstream are likely to exert only a small amount of control on periphyton growth.

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2.2.3.3 Total ammonia

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. It becomes more toxic with increasing temperature and pH. 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.

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 (or use 0.35 mg/L) when particularly sensitive macroinvertebrates need protecting, e.g. the fingernail clam *Sphaerium novaeslandiae*, or freshwater mussel (kākahi).

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. Hickey (2014) expressed guidelines as based on the No Observable Effect Concentration (NOEC) and the Threshold Effect Concentration (TEC) these were intended to be compared with median and 95 percentile data respectively. Hickey (2014) noted that: *"[the 90th percentile guideline values] are protective of the native fingernail clam, though some effects are indicated for the North American juvenile mussels, which are not resident in New Zealand."* These 90th percentile guideline values were 0.54 mg/L and 0.92 mg/L for the NOEC (compare with median) and TEC (compare with 95 percentile) respectively. Freshwater mussel are currently not found in the stream either upstream of downstream of the discharge, however the more stringent Hickey (2014) 95th percentile guideline values would be more appropriate to use in the long term to allow the future potential for kākahi to recruit into the stream.

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[2].

At the time of the survey 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 were 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 is very 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.

The monitoring data and modelling by Mott MacDonald 2017) predicts that in some years Donald Creek has spikes in total ammonia to above the value in the national bottom-line. When these spikes occur they are likely to reduce the abundance of sensitive species such as the fingernail clam and probably causes impacts on some mayfly species (e.g. *Deleatidium* mayfly has a NOEC of 1.79 mg/L). It is doubtful whether this level of total ammonia will have any impact on the population of longfin eel because large numbers of eel have been observed within the oxidation pond itself.

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[2] Assuming a pH of 8 and temperature of 20°C.

2.2.4 Summary of current effects

Ecological surveys have found that the Featherston WWTP discharge has significant impacts on Donald Creek during the summer/autumn but relatively minor impacts during the spring (and presumably winter). This largely reflects seasonal differences in stream flow.

Previous surveys undertaken in late summer of 2010 and 2013 found that the discharge caused a reduction of all macroinvertebrate metrics. Periphyton cover was also elevated at the downstream sites but not as much as expected – possibly due to shading and the deposition of planktonic algae from the oxidation ponds as a scum on substrate[3]. 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, 2013).

The October and November surveys found the effect of the discharge to be detectable, but relatively mild compared to those observed during late summer. There was some increase in periphyton cover and biomass but these were within guideline values to maintain aesthetic values and 'trout habitat and angling' (Biggs 2000). 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.

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.

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 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).

3 Future effects with upgrade

3.1 Stage 1B

In order to reduce the ecological effects of the Featherston WWTP on Donald Creek, it is a high priority to reduce discharges during summer and periods of low flow periods. A substantial reduction in summer discharges occurs with Stage 1B. Implementation of this stage will reduce the frequency of summer discharges from the current 98% of the time to 22% of the time, and there will be more than 20 times dilution for more than 91% of the time, and more than 10 times dilution for 96% of the time.

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[3] Some willows were killed in 2013 which appeared to reduce the effect of shading by 2016. Unlike the previous surveys, the 2016 survey found some emergent macrophyte cover at all sites.

The vast majority of times when the discharges will have less than 20 times dilution will occur during April or May. Almost half (46%) of the discharges will occur during flood events (>2 times median flow).

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[4]. At these times there is likely to be stimulation of periphyton growth and there may be noticeable reductions in water clarity. These relatively short periods of discharge are likely to cause changes in the aquatic macroinvertebrate community composition, but the effect will be small compared to effects of the current discharge during summer because there will be insufficient time for significant deposition of material on the stream bed. The effects will also be short term as stream flows increase during May.

Implementation of Stage 1B will also reduce winter discharges; discharges will occur 80% of the time instead of all of the time, but the discharge will have more than 10 times dilution for 85% of the time. When winter discharges are occurring then 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. These are moderate to minor effects.

3.2 Stage 2A

Implementation of Stage 2A will extend the period of no summer discharge, and consequently no effects, to 87% of the time. There will be more than 20 times dilution for more than 97% of the time, and more than 10 times dilution for 99% of the time during summer. This will almost eliminate summer impacts. When this scenario was modelled, the longest period of time with less than 20 times dilution was for nine days commencing 19 April 2014, this was on the back of a flood when stream flows were also high. In this case the effect of the discharge on periphyton would be limited by the scouring that occurs in the stream bed at high flows.

Winter discharges will reduce but still occur two thirds of the time. The winter discharge will have more than 10 times dilution for 95% of the time – similar to the dilution occurring during the November 2016 survey.

3.3 Stage 2B

Implementation of Stage 2B will eliminate summer discharges; in particular it will stop the discharges during April and May that still occasionally occurred under the previous stages. Discharges during winter will also substantially reduce so that they occur only 8% of the time and always when there more than 20 times hydraulic dilution available. Most (91%) of the discharges that do occur will be during flood events greater than two times median flow.

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

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[4] Discharges with less than 20 times dilution modelled to occur up to two weeks at a time during April or May.

3.3.1 Total ammonia on sensitive species

The water quality modelling has predicted that the annual median ammonia will dramatically reduce after Stage 1B to be well within guidelines to protect sensitive fingernail clam. However, the annual 95 percentile may not be within 0.9 mg/L limit to protect fingernail clam until implementation of Stage 2B.

Currently fingernail clam were only found in the stream during the spring survey. After Stage 1B they are likely to persist in the stream throughout the year, but occasional spikes may temporarily reduce their abundance. The model is conservative in its predictions, but even if accurate detecting the impact is likely to require multiple, carefully designed surveys. This is because the fingernail clam appears to occur at low abundance in Donald Creek upstream of the discharge and often has a patch distribution.

It is unlikely that total ammonia will adversely affect less sensitive invertebrate species such as mayfly after implementation of Stage 1B.

4 Conclusions

Ecological surveys have found that the Featherson 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 is likely to reflect seasonal differences in stream flow, dilution, effluent quality and water temperature.

It is recommended that the staging timing of upgrade give priority to reducing the effects of the discharge during summer and periods of low flow. In particular priority should be given to implementing Stage 1B as soon as practical.

An adaptive management approach could be taken to determining the timing of stages beyond Stage 1B, with stages brought forward if the remaining winter discharges are found to be causing significant adverse effects on water quality and aquatic ecology.

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