ECOLOGICAL ASSESSMENT OF THE COMPLIANCE POINT FOR THE TAIPA WASTEWATER TREATMENT PLANT DISCHARGE, TAIPA

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ECOLOGICAL ASSESSMENT OF THE COMPLIANCE POINT FOR THE TAIPA WASTEWATER TREATMENT PLANT DISCHARGE, TAIPA

The existing compliance point for the Taipa WWTP discharge, Parapara Stream catchment.

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1. INTRODUCTION

Far North District Council (FNDC) commissioned Wildland Consultants to undertake an ecological assessment of the existing compliance point for the discharge from the Taipa Wastewater Treatment Plant (WWTP). The compliance point is located *c*.1 km downstream of where Taipa WWTP discharges into a tributary of the Parapara Stream. The resource consent requires that FNDC complies with specific ammonia limits at the compliance point.

The current compliance limit for ammonia is 1.8 mg/L. This limit is usually breached over summer because there is very little mixing within the drain during dry conditions; at these times, the ammonia concentration at the compliance point is similar is to that of the discharge from the treatment plant (10 to 20 g/m^3).

The resource consent has expired and FNDC is in the process of obtaining a replacement. This provides an opportunity to assess whether the current compliance point is appropriate. This report provides:

- An assessment of the habitat quality at the current compliance point (Northland Regional Council Sample Site 5941). This assessment will determine whether aquatic habitat at the ammonia compliance point is capable of supporting fauna that the ammonia limits imposed on the resource consent are intended to protect.
- An assessment of an alternative compliance point in the receiving catchment.
- A recommendation on whether the existing or alternative compliance point should be selected for future monitoring of ammonia limits.

2. METHODS

Field surveys were undertaken on 25 July 2014 during winter high-flow conditions and on 20 February 2015 during summer low-flow conditions. Aquatic habitats were described for the following sites (mapped in Figure 1):

- Site 1: the discharge flow path;
- Site 2: the receiving drain immediately upstream of its confluence with the discharge flow path;
- Site 3: the receiving drain immediately downstream of its confluence with the discharge
- Site 4: the stream into which the receiving drain flows, *c*.650 m downstream of the compliance point at the Parapara Road bridge.

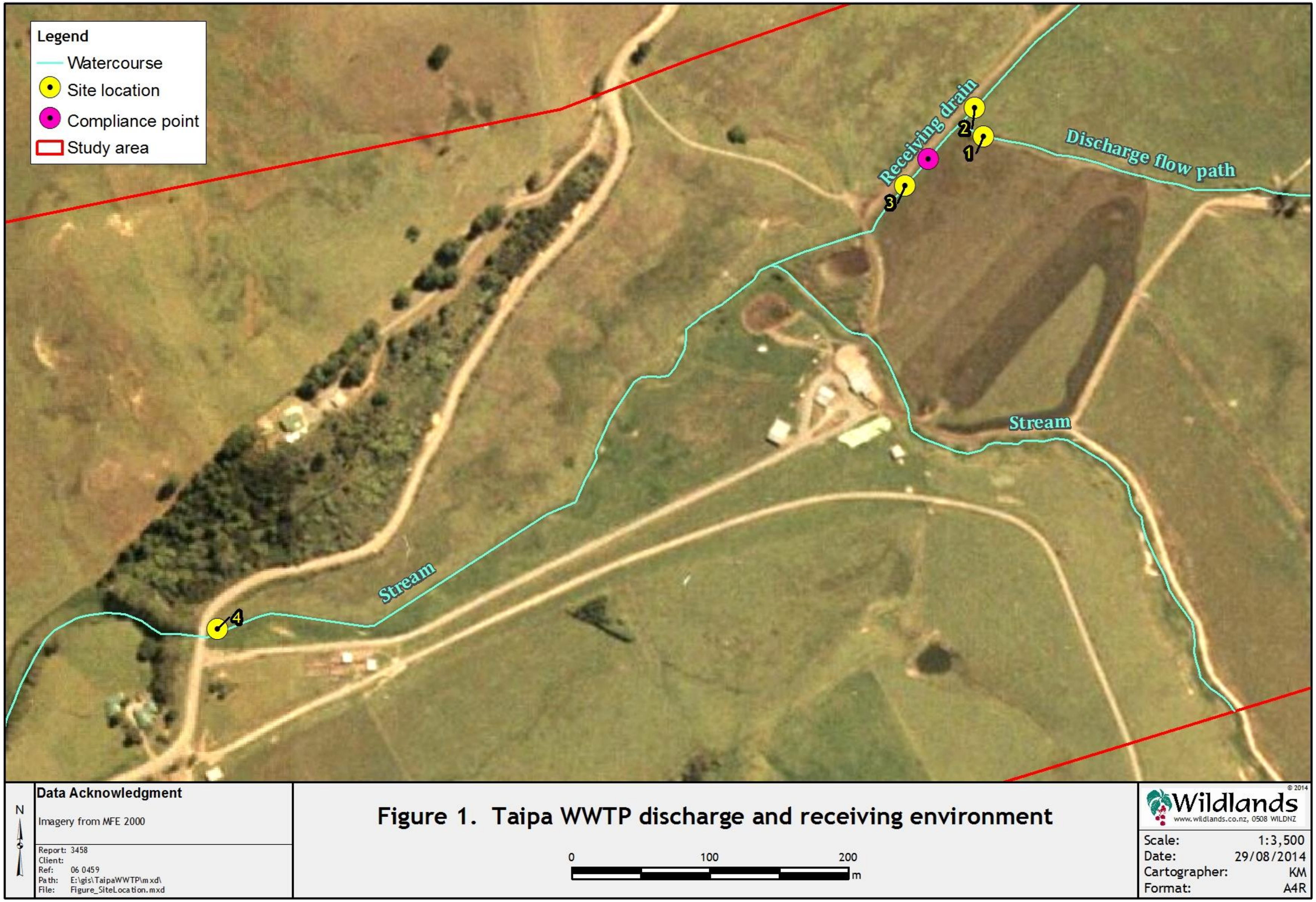

Figure 1. Taipa WWTP discharge and receiving environment

During the winter and summer assessments, four Gee minnow traps baited with bread and marmite were deployed at Site 4 and checked after three hours. Captured fish were identified and released. During the summer assessment, Gee minnow traps were also deployed further upstream; three in the discharge flow path and three in the reach immediately below the confluence. Kick-netting was also undertaken at all study sites to assess fish populations, as low water levels during the summer survey made the setting of traps difficult A large whitebait net was set in the stream channel, and fish were moved into the net by walking down the stream channel towards it. Kick-netting covered 4-5 m of stream length at a time, and representative habitats at each site such as runs, riffles, and pools were included. All fish captured by kick-netting were identified and released.

Macroinvertebrates were also sampled at all sites in summer using standard New Zealand macroinvertebrate sampling protocols: a pole kicknet with a 0.5 mm mesh (c.f. Stark *et al.* 2001). Samples were preserved in ethanol for later analysis. Macroinvertebrates were identified to the level required for the Macroinvertebrate Community Index (MCI) as per Boothroyd and Stark (2000) and Stark *et al.* (2001).

3. AQUATIC HABITATS

3.1 Discharge flow path (Site 1)

The discharge flow path flows in a westerly direction until it reaches its confluence with a farm drain. This reach is fenced to exclude livestock, and is partly shaded by steep banks, overhanging rank grass and macrophytes in the stream channel.

3.1.1 July 2014

On 25 July 2014, the discharge flow path comprised runs, riffles, and pools with slow to moderate water flow. Average wetted width was *c.*1 m, and water depth was 0.2-0.8 m (Appendix 1: Plate 1). The substrate was fine mud and silt. Where the adjacent stream banks were steep, short sections were undercut. The exotic macrophyte water pepper (*Persicaria hydropiper*) was common, forming dense patches along the channel edges. The discharge flow path supported an abundant population of inanga (*Galaxias maculatus*) (Appendix 1: Plate 2) and common bully (*Gobiomorphus cotidianus*) (Appendix 1: Plate 3), with up to seven inanga and 12 common bullies caught within each 4-5 m reach. One large longfin eel (*Anguilla dieffenbachii*), *c.*1.5 m in length, was caught several metres upstream of the confluence within the farm drain (Appendix 1: Plate 4).

3.1.2 February 2015

On 20 February 2015, the channel comprised runs and pools with very little flow. Wetted width was 0.5-1 m, and water depth was 0.1-0.6 m. The substrate was fine mud and silts, and the entire channel was densely choked by water pepper (Appendix 1: Plate 5). Kick-netting was difficult due to the abundance of water pepper and minimal water flows, and no fish were caught by this method. One shortfin eel (*Anguilla australis*) *c.*0.3 m long was caught in a Gee minnow trap set in a pool under an overhanging pampas (*Cortaderia selloana*). The MCI score for soft-bottomed streams was 74.1, indicative of poor water quality, or “probable severe pollution” (Stark and Maxted 2004).

3.2 Drain upstream of confluence with discharge (Site 2)

Immediately upstream of its confluence with the discharge flow path, the drain runs parallel to a cattle race. The drain is unfenced on its true right (the side with the race).

3.2.1 July 2014

On 25 July 2014, the channel immediately upstream of the confluence with the discharge flow path had low to moderate flow and included runs and riffles. Wetted width was 1-2 m, with a water depth of 0.2-0.6 m (Appendix 1: Plate 6). The channel was partly shaded by patches of water pepper. This section of the drain provided habitat for inanga and common bully. Fewer fish were caught than in the discharge flow path, which may be due to the absence of pools. Eels (*Anguilla* sp.) are also likely to be present, at least during higher winter and spring flows.

3.2.2 February 2015

On 20 February 2015, surface water in the drain above the confluence was restricted to a few shallow pools 2-5 cm deep. The channel bed was choked with dense growth of water pepper (Appendix 1: Plate 7). No fish were recorded and macroinvertebrates were not sampled.

3.3 Drain downstream of confluence with discharge (Site 3)

This reach also runs parallel to the cattle race, and is also unfenced on its true right (the side with the race).

3.3.1 July 2014

On 25 July 2014, the channel had slow to moderate flow and included pools and riffles. Wetted width was 1-2 m with a water depth of 0.3-1.0 m (Appendix 1: Plate 8). Water pepper covered 0.5-1.0 m of the width of the stream channel.

This section of drain also provided habitat for inanga and common bully. Numbers caught were higher than those for above the confluence, but less than for the discharge flow path. Eels are also likely to be present.

3.3.2 February 2015

On 20 February 2015, the channel had very low flow and included runs and pools. Wetted width was 1-2 m with a water depth of 0.1-1.0 m. Water pepper covered the entire channel except for the deepest pools (Appendix 1: Plate 9). Gambusia (mosquitofish; *Gambusia affinis*) were abundant in the pools, and inanga were present in the pools in low numbers. One inanga was caught in one of the three Gee minnow traps. The MCI score was 80.0, indicative of fair water quality, or “probable moderate pollution”.

3.4 Stream by the Parapara Road bridge (Site 4)

3.4.1 July 2014

On 25 July 2014, the stream included runs, riffles, and pools (Appendix 1: Plate 10). Flow was detectable in the shallow runs and riffles, but not in the pools. Upstream of the bridge, where the stream flows through pasture, wetted width was 1-3 m, water depth was 0.3-1.0 m, and water pepper covered 0.5-1.0 m of the stream width. Under the Parapara Road bridge and further downstream, livestock are excluded from both banks. The stream is shaded by overhanging vegetation and steep banks, and there are several pools of unknown depth.

The stream at this location supported an abundant population of inanga, and common bully. All Gee minnow traps caught numerous inanga (Appendix 1: Plate 11), and eels are also likely to be present. This stream is likely to also act as a migration pathway for other species of fish such as banded kokopu (*Galaxias fasciatus*) whose larvae hatch in freshwater, are swept out to sea with the downstream current and tide, and return to rivers and streams in spring.

3.4.2 February 2015

On 20 February 2015, the stream included shallow runs and pools with low flow. Wetted width was 1-3 m, water depth was 0.2-1.0 m, and except for the deepest pools. water pepper covered the entire channel (Appendix 1: Plate 12). Inanga, mosquitofish, and koi carp (*Cyprinus carpio*) were present in the pool under the Parapara Road bridge. The MCI score was 50.5, the lowest of the three MCI sites, and indicative of poor water quality, or “probable severe pollution”.

4. ECOLOGICAL VALUES OF THE RECEIVING ENVIRONMENTS

The Taipa WWTP discharge empties into a drain and stream that flow through a highly modified catchment. In addition to the wastewater discharge, run-off of stock effluent into the waterways, grazing along the banks of the watercourses, and a lack of overhead shade are likely to contribute to poor water quality in the receiving environment. Overall, the ecological values of the receiving watercourses, relative to other streams in the Far North District, are low.

The aquatic habitats of the receiving environment are subject to pronounced seasonal change. During the wetter winter months, the discharge is diluted in the receiving environment by the combined flows of other drains and streams. Under these conditions the discharge flow path, the receiving drain, and the stream further down in the catchment support populations of at least three indigenous fish species: common bully, inanga, and longfin eel. Other species, such as banded kokopu, are also likely to either be resident, or migrate through these reaches as they move between the sea and headwater streams. Two of these fish species, inanga and longfin eel, are classified as “At Risk-Declining” (Goodman *et al.* 2014). These species are still widespread, but numbers are in decline nationally due to factors such as overfishing, habitat degradation and loss, and migration barriers. The Parapara Stream and its tributaries therefore provide habitat, at least during the wetter winter months, for at least two indigenous freshwater fish species of conservation concern. During the drier summer months, when the discharge accounts for most, if not all, of the flow in the receiving drain and stream, water quality is fair or poor and fish populations are much reduced. Whilst two indigenous fish species, inanga and shortfin eel, persist in the receiving environment during summer low flows, few were seen or caught during the February survey. Based on the MCI scores for the three sites sampled in February 2015, water quality, and associated aquatic habitat values, decline from the compliance point in a downstream direction. This is likely to be attributable to grazing of the banks of the watercourse by cattle, and potential input of effluent from a dairy shed oxidation pond.

5. EFFECTS OF AMMONIA ON THE RECEIVING ENVIRONMENT

The ammonia concentrations at the compliance point can be similar to the discharge from the treatment plant, reaching 10-20 g/m^3 (10-20 mg/L) during dry conditions. In February 2015, ammonia concentrations ranged from 17-20 g/m^3 (17-20 mg/L) for the discharge flow path, and 8-13 g/m^3 (8-13 mg/L) at the compliance point (below the confluence with the drain that was dry at the time of survey). Full monitoring results for February 2015 are provided in Appendix 2. High concentrations of ammonia at the compliance point is expected, as little or no mixing of the discharge occurs until it reaches confluences with flowing streams further down the catchment (Figure 1).

Ammonia concentrations for the compliance point, for the period April 2009-March 2010, averaged 1.1 mg/L. In comparison, ammonia concentrations of up to 0.4 mg/L are common for lowland streams which pass through agricultural land (Richardson 1997). A dairy shed oxidation pond is located *c*.200 m downstream of the compliance point and when effluent is being discharged from the pond, ammonia concentrations are likely to be much higher in the stream as effluent ammonia can frequently exceed 360 mg/L (Hickey and Vickers 1994). Below the dairy shed oxidation pond, aquatic life in the watercourse may be limited by ammonia toxicity from both the discharge from the wastewater treatment plant and the dairy oxidation ponds.

Background levels of ammonia are also monitored at the settlement of Parapara, upstream of where the discharge tributary meets the Parapara Stream. Trends and peaks in ammonia concentration appear to be closely correlated with concentration at the compliance point (Figure 2). However, the similarity in trends between the compliance point and the Parapara Stream upstream of the discharge, are likely to be caused ammonia being concentrated during low flow conditions throughout the catchment. Upstream at Parapara, this may possibly be caused by inflows from septic tanks within the settlement. Whilst the discharge is a significant source of ammonia, the Parapara Stream receives ammonia from multiple sources other than the wastewater treatment plant.

Richardson (1997) tested the acute toxicity of ammonia to seven New Zealand freshwater fish species, including the three species confirmed as present at the compliance point by this study. The LC50 (lethal concentration to kill 50% of study animals) for 96 and 24 hours exposure are given in Table 1 below.

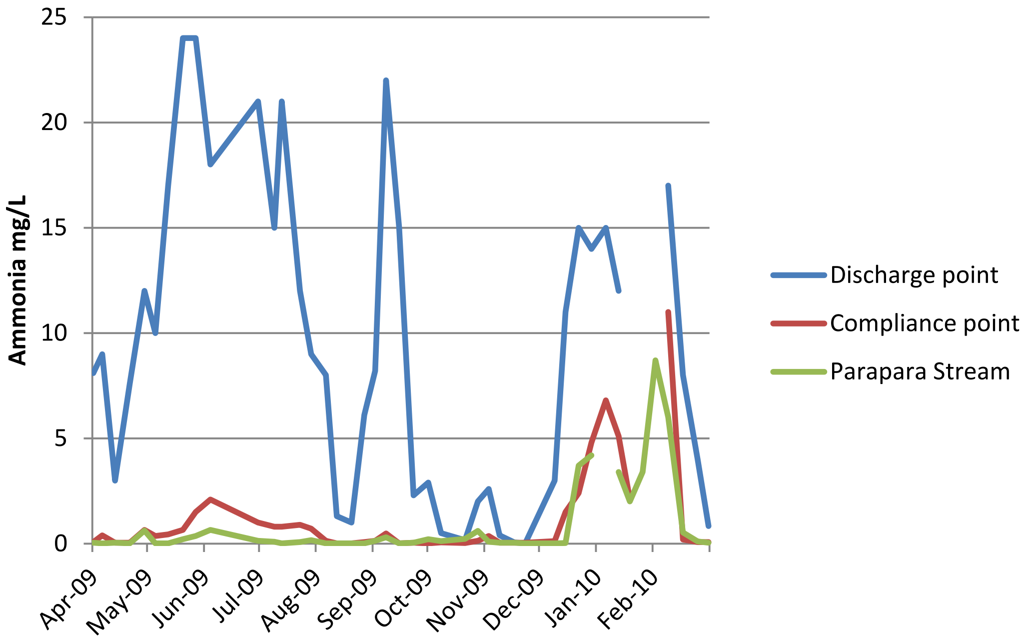

Figure 2: Ammonia concentrations (mg/L) for the discharge point, compliance point, and upstream where the Parapara Stream flows through the settlement of Parapara, April 2009-March 2010.

Table 1: Lethal concentration of ammonia (mg/L) for three freshwater fish species present at the compliance point. Data sourced from Richardson (1997).

Species	Ammonia LC_{50} 96 Hours	Ammonia LC_{50} 24 Hours
Inanga (juvenile)	1.47	1.70
Common bully (juvenile)	0.86	1.28
Common bully (adult)	-	>1.31
Longfin eel (juvenile)	>1.80	>1.80
Shortfin eel (juvenile)	2.35	>5.1

Ammonia concentrations in lowland streams can fluctuate dramatically over short time periods due to changes in pH, temperature, and the input of ammoniacal nitrogen, and lethal doses for exposure periods of as little as one hour may be critical for determining which species can persist in a stream (Richardson 1997). Richardson (1997) stated that no lethal or sub-lethal effects occurred for any New Zealand fish species after exposure for one hour to ammonia concentrations of *c*.2 mg/L. This can be regarded as the ideal maximum concentration for ammonia, because it would result in no adverse effects on freshwater fish.

During the winter months, water volumes within the receiving environment are much higher, and consequently, there is more mixing of the discharge with the receiving waters. Minor peaks in ammonia can occur, with concentrations frequently between 1-2 mg/L (refer to Figure 2, June-July 2009), but these peaks are below the levels at which lethal or sub-lethal effects would be expected (Richardson 1997). It is probable that fish, including inanga, common bully, and eels, are present at the compliance point during high flows when the ammonia concentration is normally less than 2 mg/L (e.g. April-December 2009 monitoring data).

Ammonia concentrations in excess of 10 mg/L, coupled with stagnant or low flow conditions, are likely to explain the marked decrease in the abundance of inanga, and the absence of common bully (refer to Table 1), during low summer flows. It is unknown whether the fish present during the wetter winter months die during low-flow peaks in the concentration of ammonia, or move to more suitable habitats downstream. However, based on MCI scores, water quality was at its lowest *c*.650 m downstream of the compliance point, where the receiving stream passes under the Parapara Road bridge. Therefore opportunities for fish to survive adverse conditions at the compliance point, by moving elsewhere in the catchment, may be limited.

Although beyond the scope of this study, the toxic effects of ammonia on macroinvertebrates should be acknowledged, given their critical role in aquatic ecosystems. For instance, Hickey and Vickers (1994) tested the toxicity of ammonia on nine indigenous macroinvertebrate species, the four most sensitive of which yielded a final acute value of 0.15mg/L. This level is lower than the current compliance limit of 0.18mg/L and significantly lower than the lethal doses of ammonia for eels, inanga, and common bully.

6. ASSESSMENT OF THE COMPLIANCE POINT

The existing compliance point provides habitat during higher winter flows for several indigenous freshwater fish species, two of which are listed as "At Risk-Declining". Indigenous fish species are also present at the compliance site during low summer flows, albeit in much lower numbers. Therefore the aquatic habitat at the ammonia compliance point supports fauna that the ammonia limits imposed on the resource consent are intended to protect. Furthermore, the compliance point had the best MCI score (and therefore potentially the best quality fauna habitat) of the three sampled sites.

During the wetter winter months, flow in the receiving drain increases substantially when it meets a tributary *c*.160 downstream of the compliance point. However, two dairy shed oxidation ponds are located on the stream banks near the confluence. An alternative compliance point here or further downstream at the Parapara Road bridge would mean that the compliance data would be confounded by inputs from this tributary and dairy shed effluent.

The existing compliance point should be retained. However it should be acknowledged that, during low flow conditions, little or no dilution of the discharge occurs upstream of Parapara Road. Any site that allows for dilution of the discharge at all times would receive pollutants from multiple sources other than the wastewater treatment plant.

7. OPPORTUNITIES FOR ENHANCEMENT OF AQUATIC HABITATS

7.1 Overview

The ecological values of aquatic habitat at the compliance point are likely to be limited by several factors, including low-flow peaks in ammonia concentrations, limited habitat diversity, lack of shade and associated peaks in water temperature, lack of woody debris, and grazing of the edges of the watercourses by cattle. Any restoration works undertaken to address these factors are likely to benefit fish and macroinvertebrate populations in the receiving environment.

7.2 Construction of wetlands to reduce ammonia concentrations

The discharge flow path, immediately upstream of the compliance point, flows across a wide valley floor (Appendix 1: Plate 5). At this location, there is the opportunity to create additional treatment wetlands, and these could be constructed within the bounds of the existing riparian margin from which livestock are excluded. Earthmoving machinery could be used to construct a series of bunded wetlands so that the wetted width, which is as little as 0.5 m during low flows, is increased to 3-5 m. If the bunds were created so that they formed wetlands 0.3-0.5 m deep, these wetlands could be planted with indigenous reeds (e.g. raupo (*Typha orientalis*) and sedges (*Carex* species)). Planting would not need to occur across all of the wetland area, but instead be limited to introducing the desired species into the system, and then allow for natural spread to achieve dense wetland vegetation. During low-flow conditions, when ammonia levels peak, filtering of the discharge through these wetlands could reduce ammonia concentrations at the compliance point. This option could be implemented for approximately $12,000 GST exclusive[1].

7.3 Exclusion of livestock from the receiving drain

Livestock have access to the true-right bank of the receiving drain (the north-western side), both upstream and downstream of its confluence with the discharge. Fencing to exclude livestock from the true-right bank would not only reduce grazing and trampling of the water margins, but also allow the growth of a dense vegetated buffer between the drain and the adjacent cattle race. This will reduce the movement of effluent into the drain via overland flow, particularly during the wetter, winter months. Construction of a permanent post and batten fence would cost approximately $1,700[2] GST exclusive for the drain below the discharge confluence, and $3,570[3] GST exclusive for the drain upstream of the discharge confluence (as far as the bend in the race).

[1] Costs include wetland design, project oversight, digger transport plus two days on site, plants and planting. No costs have been allocated for fence repair or construction (if required).
[2] 100 m at $17 per metre.
[3] 210 m at $17 per metre.

7.4 Restoration of a riparian buffer alongside the receiving drain

Without any planting, the fenced drain will develop a dense sward of grasses that will provide significant filtering of overland flow. As the retention of dense ground-tier vegetation is important for improving water quality at this site, any planting strategy must avoid the development of a dense canopy, with suppression of vegetation in the ground-tier. Two alternative planting strategies could therefore be implemented at this site; planting of specimen trees at intervals along the drain, or planting of a dense riparian buffer along all of the water margins, with ground-tier species comprising the majority of the plants on the immediate stream banks.

Planting specimen trees at intervals along the fenced drain is the lower cost option. Establishment costs can be reduced by planting large grade trees, which, whilst having a higher initial cost, should establish without the need for ongoing maintenance. Establishment of specimen trees would achieve some shading of the water, whist retaining a dense cover of grasses for filtration of overland flow, create more open water habitat through the localized suppression of aquatic macrophytes, and provide a source of leaf litter and woody debris, which is important for macroinvertebrates. Greater shading of the watercourse, with the same number of trees, will be achieved if the trees are planted on the true-right bank, as these will shade the watercourse from the afternoon sun. A suggested plant schedule is provided in Table 2 below.

Table 2: Plant schedule for specimen trees on riparian margins of watercourses.

Species	Common Name	Spacing	Grade
Alectryon excelsus	Titoki	10 m	PB95
Dacrycarpus dacrydioides	Kahikatea	10 m	PB95
Podocarpus totara	Totara	10 m	PB95
Vitex lucens	Puriri	10 m	PB95

Establishment of specimen trees along the true-right bank of the receiving drain would cost approximately $3,200[1] GST exclusive for the reach between the discharge flow path and where it passes under the race via a culvert.

Alternatively, a dense buffer of indigenous species could be established along both banks. Larger-growing tree species would be planted 2-5 m back from the water edge, with a dense sward of ground-cover species planted on the immediate banks (0-3 m from the water edge). This would be the most preferred restoration strategy as it would increase stream shading, retain ground-tier vegetation to filter overland flow, and increase habitat quality and heterogeneity along all of the reach. A suggested plant schedule is provided in Table 3 below.

[1] $1,700 for fencing and 10 trees at $150 each, including trees, freight, and planting labour.

Table 3: Plant schedule for restoration of an indigenous riparian buffer.

Species	Common Name	Spacing (m)	Grade	%
Alectryon excelsus[1]	Titoki	5	PB8	1
Carex lessoniana[2]	Rautahi	0.75	0.5L	30
Carex virgata[2]	Purei	0.75	0.5L	10
Cordyline australis	Ti kouka	1	0.5L	10
Dacrycarpus dacrydioides[1]	Kahikatea	5	PB8	2.5
Kunzea robusta[3]	Kanuka	1	0.5L	10
Leptospermum scoparium	Manuka	1	0.5L	20
Phormium tenax	Harakeke, flax	1	0.5L	12
Podocarpus totara[1,3]	Totara	5	PB8	2.5
Vitex lucens[1,3]	Puriri	5	PB8	2

[1] Not within 2 m of the water edge.
[2] Only plant within 3 m of water edge.
[3] Only plant in well-drained soils.

Establishment of an indigenous riparian buffer would cost approximately $13,700[1] GST exclusive for an area of 6,000 m^2 (100 m × 6 m, 3 metres either side of the drain).

7.5 Addition of woody debris

Woody debris plays an important role in stream ecology, but is generally lacking in agricultural streams due to deforestation. Whilst restoration of vegetated riparian buffers can restore a source of woody debris, it can take hundreds of years before this is incorporated into stream habitats. The incorporation of woody debris into streams at the onset of a stream restoration project can rapidly lead to increases in habitat complexity, slow water flow, and increase water storage. Woody debris is particularly important for inanga in small streams, as it impedes flow, creating the deeper, slower-flowing pools preferred by this species (Richardson and Taylor 2002). Addition of woody debris is therefore likely to be particularly beneficial for the inanga population in this stream, and may increase persistence of this species during lower flow conditions of the dryer, summer months. Woody debris could be placed at intervals of *c*.5 m along the drain below the discharge confluence. Each log should be dug into the adjacent bank at one end to make it secure, with the log either spanning the width of the drain, or projecting in a downstream direction at an angle of *c*.45° from the bank. Post installation, each log should be checked to ensure it doesn't create a weir-like drop that may impede upstream migration. The cost of installing woody debris in the receiving drain, from the confluence of the discharge to where it passes under the race, is approximately $2,500[2] GST exclusive.

[1] $1,700 for fencing and $12,000 for site preparation, plants, planting, post-planting maintenance until canopy closure (3-5 years).
[2] $200 for twelve 1.8 m ponga logs and $2,200 for installation.

8. CONCLUSIONS

Aquatic habitats of the Taipa WWTP discharge and its receiving environment were surveyed during high flow conditions in July 2014 and low flow conditions in February 2015. During high winter flows, one longfin eel was found in the discharge flow path, and populations of common bully and inanga occurred in the discharge flow path and in the receiving drain, both upstream and downstream of its confluence with the discharge flow path. During low summer flows, one shortfin eel was present in the discharge flow path, and the receiving drain downstream from its confluence with the discharge flow path provided habitat for inanga. The MCI scores for summer low flows indicated that all of the sampled sites were polluted, and that the degree of pollution increased between the compliance point (Site 3) to where the stream passes under Parapara Road (Site 4).

All of the fish species confirmed as present in the receiving environment are susceptible to ammonia toxicity at levels much less than the ammonia concentrations of the discharge during low flow conditions (10-20 mg/L). To ensure the freshwater fish species present at the compliance site are unaffected by the discharge, the ammonia concentrations, post-mixing with the drain, would need to be less than 2 mg/L. The greater abundance of inanga in July 2014, and the presence of common bully, is likely to be attributed to reduced ammonia concentrations during the high flow conditions. However the volume of flow in itself, which influences the availability of open water habitat, is also likely to affect fish populations to some degree.

Potential alternative ammonia compliance points in the receiving environment were assessed. An ideal compliance point would have the following characteristics: permanent flow, populations of species sensitive to ammonia toxicity, and only receiving ammonia from the WWTP discharge. No alternative site met all of these requirements. Any compliance point located further downstream would be subject to fluctuations in ammonia concentrations sourced from the WWTP, the adjacent dairy farm, and dairy oxidation ponds.

The existing ammonia compliance point should be retained, with monitoring of ammonia levels to occur during the wetter winter months. This is when the receiving environment is known to have sufficient flows to dilute the ammonia in the WWTP discharge.

Restoration of aquatic habitats would substantially improve the ecological values of the site. The highest priority action is the exclusion of livestock from the true-right bank of the drain below the discharge. This would increase filtering of overland flow, with resulting improvements in water quality and the ecological value of aquatic habitats. Additional gains could be made through riparian plantings and the addition of woody debris. The construction of vegetated wetlands within the lower discharge flow path should be considered to help reduce the magnitude of ammonia peaks during low summer flows and enhance ecological values at the compliance point.

ACKNOWLEDGMENTS

Ruben Wylie (FNDC) provided client liaison.

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APPENDIX 1

SITE PHOTOGRAPHS

Plate 1: The discharge flow path during winter high-flow conditions. The channel is partly shaded by macrophytes, overhanging grasses, and, further upstream, by steep banks. 25 July 2014.

Plate 2: Inanga caught in the discharge flow path. 25 July 2014.

Plate 3: Common bully caught in the discharge flow path. 25 July 2014.

Plate 4: Adult longfin eel caught in the discharge flow path. 25 July 2014.

Plate 5: The discharge flow path during summer low-flow conditions, viewed looking upstream from near its confluence with the drain. The channel is densely covered with water pepper. 25 July 2014.

Plate 6: Drain immediately upstream of its confluence with the discharge flow path during high-flow conditions. Woody debris and pools are absent from this reach. 25 July 2014.

Plate 7: Drain immediately upstream of its confluence with the discharge flow path during low-flow conditions. 20 February 2015.

Plate 8: Drain immediately downstream of its confluence with the discharge flow path during high-flow conditions. 25 July 2014.

Plate 9: Drain immediately downstream of its confluence with the discharge flow path during low-flow conditions. 20 February 2014.

Plate 10: Stream immediately upstream of Parapara Road bridge. 25 July 2014.

Plate 11: Inanga caught in one Gee minnow trap set by Parapara Road bridge. 25 July 2014.

Plate 12: Stream immediately above the Parapara Road bridge during low-flow conditions. 20 February 2015.

MACROINVERTEBRATE RESULTS

Taipa WWTP 20-2-15	MCI-sb Score	Upstream of Road Bridge	Below Discharge Confluence	Discharge Flow Path
Ephemeroptera				
Deleatidium	5.6		1	
Plecoptera				
Trichoptera				
Oxyethira	1.2	1		
Pycnocentrodes	3.8		4	
Odonata				
Xanthocnemis	1.2	1		1
Hemiptera				
Anisops	2.2		3	
Coleoptera				
Hydrophilidae	8.0		1	
Staphylinidae	6.2			2
Diptera				
Ceratopogonidae	6.2		1	
Chironomus	3.4		6	15
Culicidae	1.2			1
Muscidae	1.6		1	
Orthocladiinae	3.2		2	3
Psychodidae	6.1		2	8
Tanypodinae	6.5		1	
Tanytarsini	4.5		31	45
COLLEMBOLA	5.3			2
Crustacea				
Copepoda	2.4			4
Isopoda	4.5			2
Ostracoda	1.9			1
Paratya	3.6	3		
Talitridae	5.5			1
ACARINA	5.2	4		4
MOLLUSCA				
Potamopyrgus	2.1		3	
OLIGOHAETA	3.8	1808	1232	1088
HIRUDINEA	1.2	18	14	10
PLATYHELMINTHES	0.9	112		
NEMATODA	3.1	2		
NEMERTEA	1.8		1	
Number of Taxa		8	15	15
Total individuals		1949	1303	1187
EPT Taxa		1	2	0
EPT individuals		1	5	0
MCI Value		67.5	69.3	70.7
MCI-sb Value		50.5	80.0	74.1
Galaxiidae (fish)			1	

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