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Biomonitoring of the Haehanga Stream in relation to discharges from the Remediation (NZ) Limited composting site at Uruti, January 2018

Introduction

Remediation (NZ) Ltd operates a composting facility in the Haehanga Valley, Uruti. Raw materials are trucked to the site for composting, on a purpose built composting pad for a period of 35-40 days. Synthetic hydrocarbon contaminated drilling muds and cuttings are also received on site. They are piled up and the liquids are allowed to drain, then blended with green waste and other organic matter. Composted material is transported off site by trucks to Remediation (NZ) Ltd's worm farming operations at Waitara Road and Pennington Road.

This survey was the only survey scheduled for the 2017-2018 monitoring year. At the time of this survey, there were two composting pads. The south-west pad (referred to as composting pad 1 in this report) is where the synthetic muds are blended with green waste and other organic matter. A second pad northeast of the original composting pad, which became operational in the summer of 2005, is referred to as composting pad 2.

Both composting pads are bunded, with all surface stormwater and leachate contained and directed to treatment ponds. Water from the settling pond is recycled back to the composting material when required to maintain a moist composting environment. The runoff from composting pad 1 is treated in a series of ponds. Between each pond, there is a baffle that skims off any floating hydrocarbons as the leachate passes through. The treated liquid in the final pond, located just upstream of site 5 (HHG000115), is then irrigated to pasture. This irrigation system was installed prior to the November 2005 biological survey.

Prior to February 2008, no discharges of stormwater or leachate directly entered the Haehanga Stream or its tributaries. However, after that date, the site has been permitted to discharge treated stormwater and compost leachate to the unnamed tributary of the Haehanga Stream. This comes from composting pad 2, where leachate is pumped up to the top of a seven-tier wetland, which was constructed in late 2007. Under dry conditions, the wetland water from the bottom pond of the wetland is reticulated back to the upper tier of the wetland. Under high flow conditions the wetland discharges to a tributary of the Haehanga Stream.

In addition to this discharge from the wetland, there is some potential for seepage from the composting pads and irrigation area to enter groundwater, and for stormwater runoff to escape the collection system, and thus gravitate toward the surface watercourses at the site.

A baseline survey of five sites was conducted in October 2002 in relation to the composting operation (Dunning, 2003). At the time of this earlier survey, only composting pad 1 was operational, and sites were established for both the existing and proposed composting pads. Unnamed tributaries of the Haehanga Stream flow adjacent to (and down gradient of) both composting pads and flow into the Haehanga Stream downstream of the composting areas (Figure 1). Since this baseline survey, significant changes have occurred on site, leading to sampling sites being moved, or sampling at some sites to be discontinued. Any changes to sampling sites made prior to the current survey have been discussed in previous reports, referenced below.

The current biological survey was conducted to monitor the effects of discharges from the composting site to the Haehanga Stream and tributaries in relation to composting areas (pads 1 & 2), the irrigation of treated liquid to land, and the discharge of treated stormwater and leachate to the unnamed tributary. During the May 2012 survey an additional site was included (HHG000150), at the downstream extent of the irrigation area. This site is now referred to as site 6, with HHG000112 now referred to as site 5. This constitutes a change, as HHG000112 was previously referred to as site 6.

Methods

This survey, completed on 16 January 2018 was preceded by a particularly dry start to the summer, resulting in significantly reduced flows in the Haehanga catchment. Consequently, invertebrate samples were not collected from sites T2 and T3 in the unnamed tributary. Sampling techniques were also impacted, due to reduced riffle habitat.

Two different sampling techniques were used to collect streambed macroinvertebrates in this survey. The 'vegetation sweep' sampling technique was used at sites 1, 2, 5 and 7 and the Council's standard 'streambed kick' sampling technique was used at site 6 (Table 1). The 'streambed kick' and 'vegetation sweep' techniques are very similar to Protocol C1 (hard-bottomed, semi-quantitative) and C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Two of the sites surveyed were previously established in the baseline survey (sites 1 and 2) (Dunning, 2003).

Table 1 Biomonitoring sites in the Haehanga Stream catchment

Site	Site Code	Location	Sampling Method
1	HHG000093	Upstream of extended irrigation area	Vegetation sweep
2	HHG000100	Downstream of extended irrigation area	Vegetation sweep
T2	HHG000098	Upstream of wetland discharge point	Not sampled
T3	HHG000103	Downstream of wetland discharge point	Not sampled
5	HHG000115	25 m downstream of last pond and swale collection area	Vegetation sweep
6	HHG000150	30 m downstream of lower irrigation area	Streambed Kick
7	HHG000190	50 metres upstream of State Highway 3 bridge	Vegetation sweep

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001).

Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams (MCI). Recently, a similar scoring system has been developed for macroinvertebrate taxa found in soft bottomed streams (Stark and Maxted, 2004, 2007) (SBMCI). The SBMCI has been used in a number of biomonitoring reports since its inception, and results to date suggest that it is not as effective at assessing the impacts of organic pollution as the MCI. For example, results from the February 2008 Mangati survey found a relatively unchanged SBMCI score at a site that had thick growths of sewage fungus (Jansma, 2008c). Therefore, this index is considered less appropriate for the assessment of macroinvertebrate communities possibly affected by industrial discharges. Any subsequent reference to MCI refers to the MCI.

Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1 and 0.1 in hard bottomed and soft bottomed streams respectively. The sensitivity scores for certain taxa found in hard bottomed streams have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. Communities that are more 'sensitive' inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_S$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

HHG000190 ~1900m DS

HHG000150 ~ 675m DS

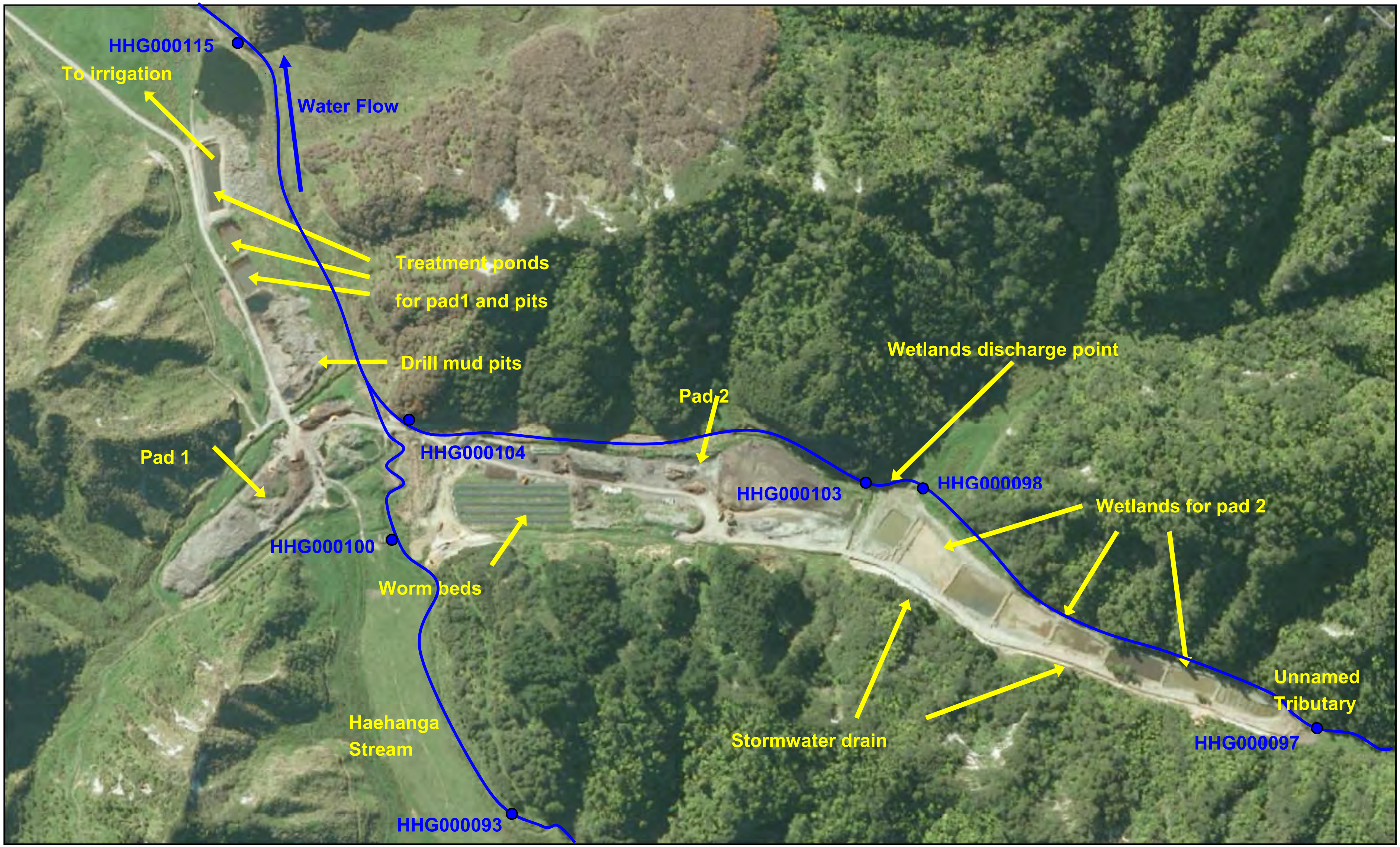

Figure 1 Location of biomonitoring sites in the Haehanga Stream catchment

Sub-samples of algal and detrital material taken from the macroinvertebrate samples, were scanned under 40-400x magnification to determine the presence or absence of any mats, plumes or dense growths of bacteria, fungi or protozoa ("undesirable biological growths") at a microscopic level. The presence of masses of these organisms is an indicator of organic enrichment within a stream.

Results and Discussion

During the present survey, water temperatures in the Haehanga Stream catchment ranged from 23.1°C to 28.2°C. Such warm temperatures have been recorded previously, with the January 2015 survey recording a temperature of 28.3°C, which is outside the upper thermal tolerances of some macroinvertebrate taxa, including some occasionally recorded in the Haehanga Stream catchment (Quinn et al, 1994)). Previous surveys have been undertaken earlier in the year, in an effort to survey at a time of higher flow in the Haehanga Stream. However, due to a very dry spring and early summer, the current survey was delayed in the hope that rains would return and flows would recover. A rain event occurred ten days prior to this survey, but was not sufficient to restore groundwater levels to the point where there was improved flow in the Haehanga Stream. As a result, the current survey was undertaken in very low flows, with sampling of the unnamed tributary precluded by these low flows. These low flows also resulted in limited sampling habitat at the mainstem sites, and consequently a relatively small sample was collected at these sites.

At sites 1 and 2, the Haehanga Stream was observed to be running clear but with a yellow tannin colour. At sites 5 and 6 the yellow tannin colouration was still apparent, but the stream had become cloudy while at site 7 the stream was observed to be brown and cloudy. The Haehanga Stream is frequently observed to be cloudy, with associated yellow to brown discolouration. Usually the cloudiness and discolouration is primarily caused through tannins and suspended solids entering via groundwater and tributary inflows, rather than a point source discharge from the wormfarm. However, at times tannins are also provided through the wetland discharge, which can also result in some discolouration. During the current survey, the wetland was observed to not be discharging, although discharge records indicate a discharge of 120 litres/minute was occurring six days prior, and a discharge of 80 litres/minute was occurring the day after this survey.

With the exception of site 1, the substrate at all sites was generally a mix of silt, sand and gravels, with some wood. The streambed at site 1 was covered in macrophytes, with an underlying bed of silt. All mainstem sites supported aquatic vegetation, with such growth observed at the edges of the stream at site 6, and throughout the stream at the other four sites. Although no samples were collected at sites T2 and T3, both sites supported aquatic vegetation, with small beds growing on the streambed. There was a relatively low algal biomass in the Haehanga Stream during this survey, with sites 2, 5 and 7 supporting only thin films of algae, and sites 1 and 6 supporting patches of algal filaments.

No undesirable heterotrophic growths were recorded at any of the seven sites in this survey.

Unlike the December 2015 survey, which noted dead eels on the stream bed and the January 2015 survey, which observed hydrocarbons being released from the streambed at site 7, no concerning observations were made while completing the current survey.

Macroinvertebrate communities

A moderate number of macroinvertebrate surveys have been conducted at these sites. Monitoring has been conducted in other small lowland hill country streams in Taranaki surveyed at similar altitudes (TRC, 1999 (statistics updated 2016)) and these have been compared with the current results in Table 2. Table 2 gives summary statistics for the sites, while Table 3 provides a complete taxa list for the current survey.

Table 2 Number of taxa, MCI and SQMCI$_s$ values recorded in the Haehanga Stream catchment together with a summary of results from control sites in other small lowland hill country streams (LOWL) between 25-49 MASL, in Taranaki (TRC, 1999) (Updated to October 2017).

Site	No. of previous surveys	Numbers of taxa			MCI values			SQMCIs values		
		Median	Range	Current	Median	Range	Current	Median	Range	Current
LOWL*	25	22	17-30	-	78	68-109	-	4.0	2.7-7.2	-
1	13	21	17-27	17	71	68-78	62	3.9	2.7-4.2	2.6
2	21	19	17-23	15	75	62-99	68	4.0	2.7-5.7	4.1
5	20	19	6-28	18	74	53-88	73	2.9	1.1-4.1	3.7
6	7	19	6-24	9	73	60-88	60	2.9	1.0-3.1	3.4
7	16	21	12-30	17	71	59-82	71	3.3	1.3-4.3	4.3
T2	10	23	18-30	-	87	79-104	-	5.2	4.6-7.2	-
T3	10	27	23-32	-	84	78-93	-	4.5	3.5-5.4	-

*SQMCI$_s$ median and range based on only 24 samples

The current survey results for the Haehanga mainstem are also presented in Figure 2 and Figure 3, with these figures providing a catchment perspective.

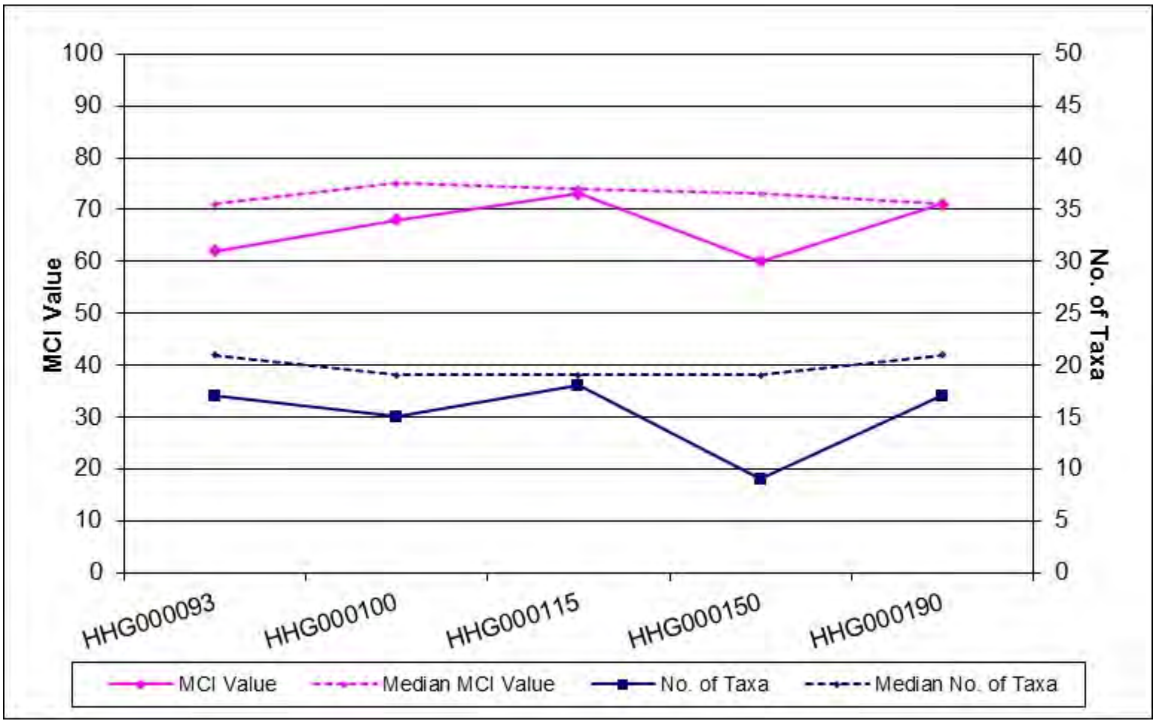

Figure 2 Number of taxa and MCI scores recorded at the Haehanga Stream sites during the current survey, compared with the respective medians for these sites.

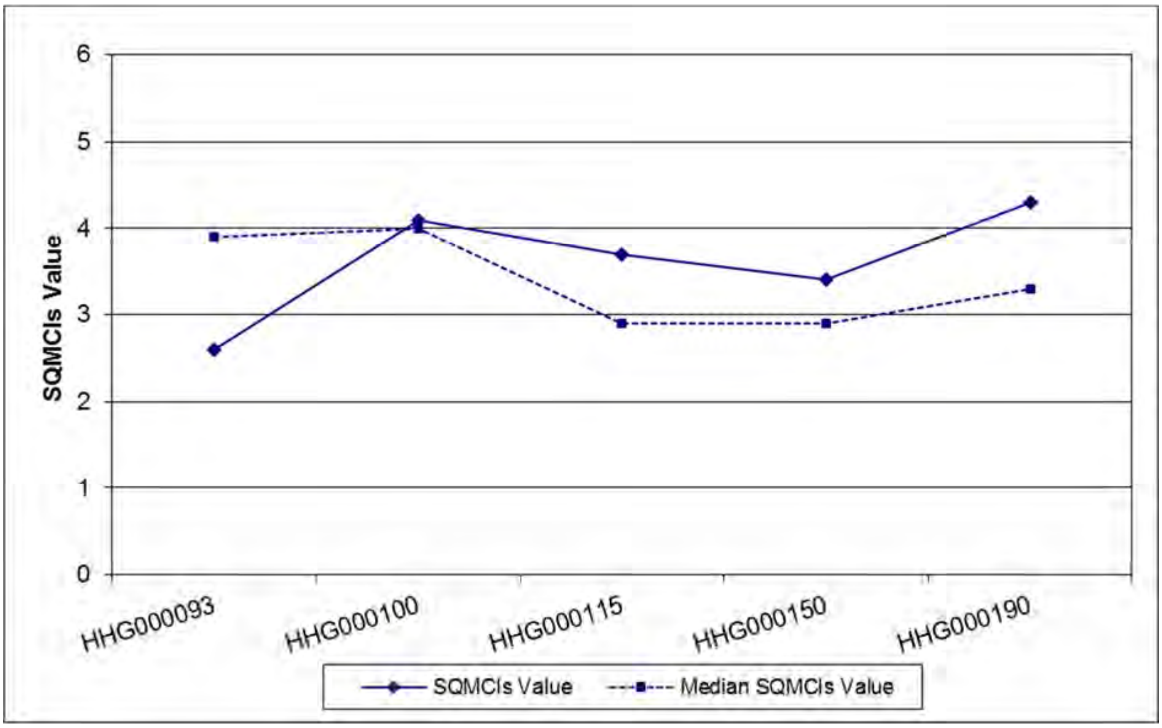

Figure 3 SQMCI$_S$ scores recorded at the Haehanga Stream sites during the current survey, compared with the respective medians for these sites.

Site 1 – Upstream of expanded irrigation area

This site, sampled intermittently since 2002, was re-introduced to the monitoring programme in 2010, prior to the irrigation of wastewater onto land between sites 1 and 2. Irrigation on this land has since occurred, consequently site 1 becomes the upstream control site, and site 2 becomes an impact site.

A relatively low taxa richness was recorded at this site (17), which was four taxa less than the median, and the lowest richness recorded at this site to date, equal to that recorded in the two previous surveys (Figure 4). The low taxa richness recorded in the current survey may be related to the low flows that preceded this survey, coupled with the extensive macrophyte beds. These conditions can lead to warm water temperatures and low dissolved oxygen levels, which can lead to a reduction in taxa richness, with only the more resilient species remaining.

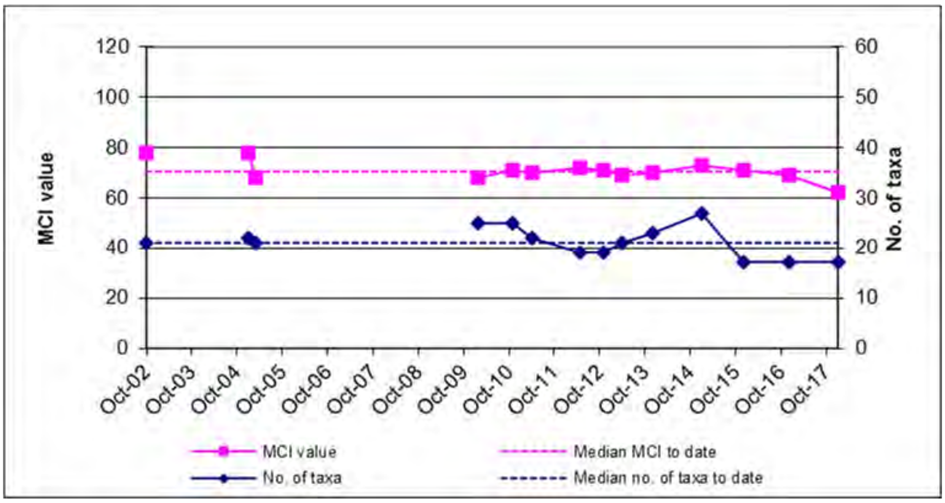

Figure 4 Taxa numbers and MCI recorded to date at site 1

Table 3 Macroinvertebrate fauna of the Haehanga Stream catchment, sampled in relation to Remediation (NZ) Ltd on 16 January 2018.

Taxa List	Site Number	MCI score	1	2	5	6	7
	Site Code HHG000:		093	100	115	150	190
	Sample Number FWB180:		16	17	18	19	20
ANNELIDA	Oligochaeta	1	R	C	-	VA	R
HIRUDINEA	Hirudinea	3	C	R	-	-	-
MOLLUSCA	*Physa*	3	A	A	A	C	C
	Potamopyrgus	4	XA	XA	XA	XA	A
	Sphaeriidae	3	R	-	-	-	-
CRUSTACEA	Cladocera	5	-	-	-	-	VA
	Ostracoda	1	XA	A	VA	A	A
	Paracalliope	5	R	VA	VA	-	C
EPHEMEROPTERA	*Deleatidium*	8	-	-	R	-	-
ODONATA	*Xanthocnemis*	4	VA	VA	A	-	VA
HEMIPTERA	*Anisops*	5	R	R	A	-	VA
	Microvelia	3	R	C	R	-	R
	Saldula	5	-	R	-	-	-
	Sigara	3	R	C	C	-	R
COLEOPTERA	Dytiscidae	5	-	-	R	-	-
	Hydrophilidae	5	-	R	-	R	-
TRICHOPTERA	*Oxyethira*	2	-	-	R	-	-
	Paroxyethira	2	R	-	-	-	-
	Triplectides	5	-	VA	A	-	A
DIPTERA	Hexatomini	5	-	-	-	R	-
	Paralimnophila	6	-	-	-	-	R
	Chironomus	1	A	R	C	R	C
	Corynoneura	3	-	-	R	-	-
	Orthocladiinae	2	C	-	A	A	A
	Polypedilum	3	-	R	-	-	-
	Tanypodinae	5	C	-	A	R	C
	Culicidae	3	R	-	-	-	-
	Paradixa	4	-	-	R	-	R
	Empididae	3	-	-	R	-	R
	Stratiomyidae	5	R	-	-	-	-
		No of taxa	17	15	18	9	17
		MCI	62	68	73	60	71
		SQMCIs	2.6	4.1	3.7	3.4	4.3
		EPT (taxa)	0	1	2	0	1
		%EPT (taxa)	0	7	11	0	6

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

The community comprised a relatively high proportion of tolerant taxa (76%) which resulted in a 'poor' MCI score of 62 units. This is the lowest score recorded at this site to date and is nine units less than the median score (Table 2, Figure 4). Although this is a 'poor' score (TRC, 2015), it is a reflection of the very low and slow to still flows and vegetation habitat sampled, and is relatively consistent with that recorded at this site in recent years. This score is significantly less than the median MCI score for other similar lowland streams (Stark, 1998), indicating that the invertebrate community at this site was in poorer health than similar streams at this altitude.

The community was dominated by two extremely abundant 'tolerant' taxa, (snail (*Potamopyrgus*) and ostracod seed shrimps). Other dominant 'tolerant' taxa included *Physa* snails, damselfly larvae (*Xanthocnemis*) and *Chironomus* bloodworms. No 'sensitive' taxa were abundant at this site in the current survey. The dominance of 'tolerant' taxa resulted in a low $SQMCI_S$ score of 2.6 units, which is also the lowest record at this site to date (Table 2). It was also significantly lower than the median for this site and other sites in similar small lowland streams (Stark, 1997) (Table 2).

Overall, this indicates that the water quality of the Haehanga Stream prior to it flowing into the Remediation NZ composting site was of below average quality, and that the community was strongly influenced by the low and slow flows, and the shallow gradient of this stream.

Site 2 – Downstream of extended irrigation area

At site 2 in the Haehanga Stream, upstream of all composting areas, 15 macroinvertebrate taxa were recorded. This was two taxa fewer than that recorded in the previous survey and four taxa less than the median for this site (Table 2). The community was dominated by four 'tolerant' taxa, (snails (*Physa* and *Potamopyrgus*) ostracod seed shrimp and damselfly larvae (*Xanthocnemis*)), and two very abundant 'moderately sensitive' taxa, (*Paracalliope* amphipods and *Triplectides* caddisfly) (Table 3).

The MCI value of 68 units reflected a low proportion of sensitive taxa in the community at this site (33%). This score is more than thirty units less than that recorded in the previous survey, but not significantly different to the median score for this site, and is within the range of previous results (Stark 1998) (Table 2, Figure 3). The $SQMCI_S$ value at this site (4.1) was similar to the median value, and similar to that recorded in the previous survey, and reflecting the overall numerical dominance of the 'extremely abundant' *Potamopyrgus* snails.

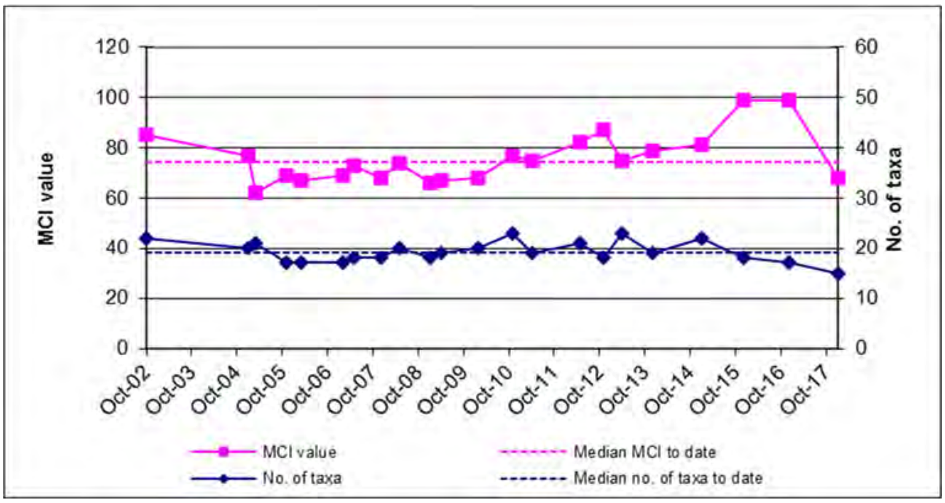

Figure 5 Taxa numbers and MCI recorded to date at site 2

Although this suggests that water quality at this site has deteriorated from the previous survey, it should be noted that the sampling technique differed to the two previous surveys. Historically, this site was sampled using the vegetation sweep technique, as it was in the current survey. However, the December 2015 and 2016 surveys used the kick sample technique, due to a lack of macrophyte habitat. The vegetation sweep technique samples habitat that tends to support more 'tolerant' taxa and therefore produces lower MCI and $SQMCI_S$ scores. This also explains the similarity in MCI score between sites 1 and 2.

Overall, it is apparent that the primary influence on the community at this site is the variation in habitat, and the change in sampling technique. The fact that two 'moderately sensitive' taxa were recorded as 'very abundant' is supportive of the conclusion of reasonable preceding water quality with no discernible impacts from the irrigation of wastewater to land between sites 1 and 2.

Site 5 – downstream of all pond discharges

At site 5 in the Haehanga Stream, 25 m downstream of all wastewater ponds, 18 taxa were recorded, one taxon less the median of the twenty previous surveys, but eight taxa fewer than that recorded in the previous survey (Table 2, Figure 3). This reduced richness may be a reflection of the change in sampling technique from the previous survey, which employed the streambed kick methodology. Five 'tolerant' taxa (snails (*Physa* and *Potamopyrgus*), ostracod seed shrimps, damselfly larvae (*Xanthocnemis*) and orthoclad midge larvae) and four 'moderately sensitive' taxa (*Paracalliope* amphipods, backswimmer (*Anisops*), caddisfly larvae (*Triplectides*) and tanypod midge larvae) (Table 3). The numerical dominance of 'extremely abundant' 'tolerant' *Potamopyrgus* snails resulted in the $SQMCI_S$ score of 3.7 units, a statistically insignificant 0.8 unit higher than the median for this site, and similar to that recorded at site 2. The MCI score (73) was very similar to the median score for this site, but fifteen units less than that recorded in the previous survey, which recorded the highest MCI score for this site to date. It was however, five units higher than that recorded at site 2 upstream in the current survey, despite an equivalent proportion of 'sensitive' taxa in the community (33%) (Table 2).

Some previous surveys have recorded changes in abundance of individual taxa, which can be interpreted as being an indication of organic enrichment of the stream. Such changes included *Chironomus* bloodworms becoming abundant at this site. The results from the current survey indicate that *Chironomus* bloodworms were present at the time of the survey, but only as common (five to nineteen individuals). In total, significant changes in abundance were recorded for only three taxa, including an increase in two 'sensitive' taxa. Overall, this community appears to be in average community health, but indicative of 'poor' water quality.

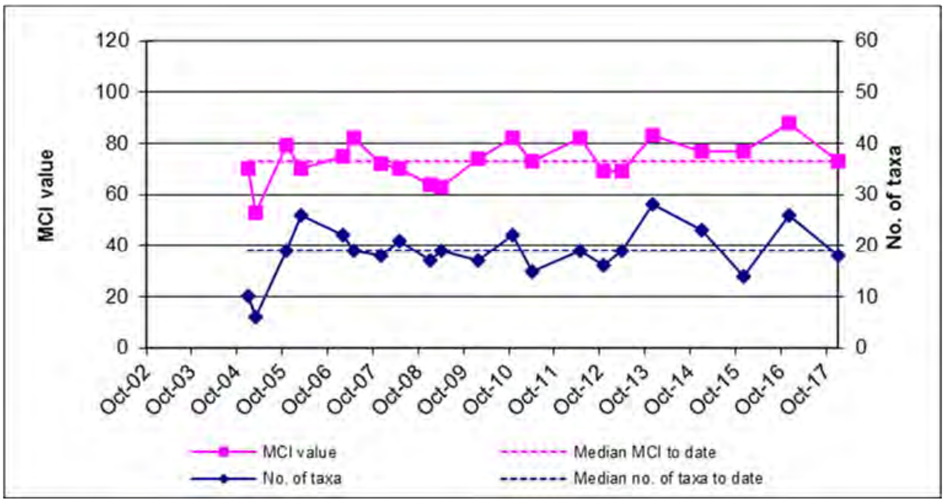

Figure 6 Number of taxa and MCI scores recorded to date at Site 5

Site 6 – Downstream of effluent irrigation area

A richness of nine taxa was recorded at this site, located downstream of the effluent irrigation area (Table 2, Figure 7). This represents a reduction on that recorded in the previous survey when sixteen taxa were recorded, which is considered a direct reflection of the habitat limitation caused by low flows and algal growth on the streambed (Photo 1).

The community was dominated by four 'tolerant' taxa (very abundant oligochaete worms, extremely abundant *Potamopyrgus* snails, ostracod seed shrimps and orthoclad midge larvae). Although this also represents a deterioration from the previous survey, it is also likely to be related to the habitat conditions present at the time of sampling.

The community consisted mainly of 'tolerant' taxa (67%), resulting in an MCI score of 60 units. This score is significantly lower than the median for this site, 28 units lower than that recorded in the previous survey, and equal to the previous minimum score recorded at this site (Table 2, Figure 2). Although this indicates that the community during the current survey was in well below average health, it does not necessarily indicate that this can be attributed to the monitored activities. The current result is indicative of 'poor' water quality (TRC, 2017).

Photo 1 Haehanga Stream at site 6, 16 January 2018

The $SQMCI_S$ score was heavily influenced by the extremely abundant *Potamopyrgus* snails. This resulted in a $SQMCI_S$ score of 3.4 units, slightly higher than the median for this site. Although this is the second lowest $SQMCI_S$ score recorded in the current survey, it does not differ from what is usually recorded at this site, and is significantly better than that recorded in the previous two surveys (1.0 unit).

Previous surveys, had noted $SQMCI_S$ scores at this site that were lower than could be expected. It was concluded that there may be a subtle deterioration in water quality at this site, but habitat differences also needed to be taken into account. This is because this site has habitat that differed to the other Haehanga Stream sites, as it was a true riffle, in that it was shallow flow tumbling over coarse and fine gravel, as opposed to deeper flow moving over macrophyte or submerged wood.

Overall, the results indicate that the community at this site was in average to below average health. Although the MCI score was equal to that recorded in the 2015 survey which coincided with the discovery of a number of dead eels immediately downstream of this site, the $SQMCI_S$ score was significantly higher. This indicates that the lower than average MCI score is related to the low flows and high algal biomass observed at the time.

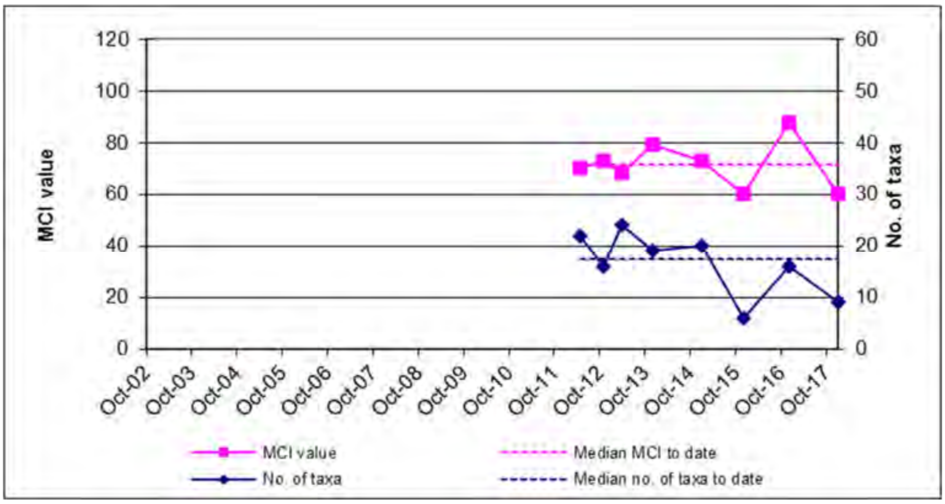

Figure 7 Number of taxa and MCI scores recorded to date at Site 6

Site 7 – Downstream of all site activities

This site exhibited below-average taxa richness (17), four taxa fewer than the median, and seven more than the previous survey undertaken at this site. The 'poor' MCI score of 71 was due to the community comprising 65% 'tolerant' taxa, of which three were abundant (snail (*Potamopyrgus*), ostracod seed shrimp and orthoclad midge larvae) and one was very abundant (damselfly larvae (*Xanthocnemis*). Two 'moderately sensitive' taxa were also recorded in abundance (water fleas (Cladocera) and backswimmers (*Anisops*), suggesting moderate preceding water quality.

The MCI score of 71 was seven units less than that recorded in the previous survey, a statistically insignificant result (Stark, 1998), but equal to the median score for this site (Table 2, Figure 8). The numerical dominance of the two abundant 'moderately sensitive' taxa resulted in a $SQMCI_S$ of 4.3 units, 1.0 unit higher than the median for this site and 0.8 unit higher than that recorded in the previous survey. This result was equal to the previous maximum $SQMCI_S$ recorded at this site.

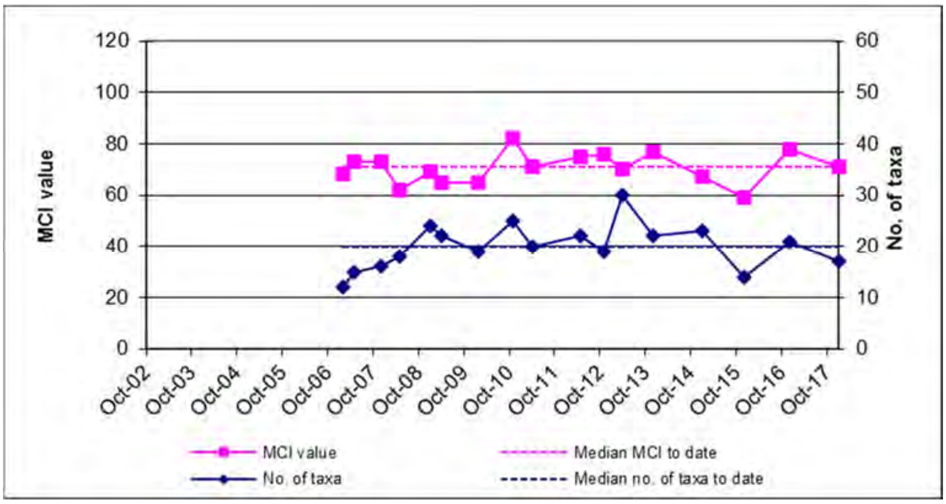

Figure 8 Number of taxa and MCI scores recorded to date at Site 7

When compared with site 6 upstream, the MCI score was significantly higher, as was the $SQMCI_S$ score (Stark, 1998). This improvement was due mainly to an increase in the number of more sensitive taxa, and some significant changes in abundance of a number of taxa. There were seven significant differences in individual taxon abundance recorded between sites 6 and 7, with the majority of these differences reflecting the change in habitat and sampling methodology. Site 6 was a small shallow riffle sampled by kick sampling, while the habitat at site 7 (pool) was sampled using the macrophyte sweep method. This is illustrated in the taxa results, with a number of still or slow water taxa being recorded at site 7. The average MCI and above average $SQMCI_S$ scores indicate that this community was also in average health and appeared to have recovered from the December 2015 survey.

During some previous surveys, concern was raised regarding an extreme abundance of *Chironomus* bloodworm larvae at this site. Such abundance usually only occurs where there is a significant organic discharge, which the *Chironomus* bloodworm larvae feed upon. It was noted that should this result be repeated in subsequent surveys, further investigation would be required. Dissolved oxygen readings were subsequently taken in the stream, and this found that there may be periods of low dissolved oxygen, especially when weed beds are well established, such as in summer. This is natural, and related to the shallow gradient of the stream, and can be exacerbated during low flows. It is likely that the sporadic abundance of *Chironomus* is related to the low dissolved oxygen concentrations within the stream, rather than the discharge of organic wastes upstream. *Chironomus* was recorded as 'common' at this site in the current survey.

Site T2 – upstream of the wetland discharge

Site T2 was not sampled in the current survey due to low flows and insufficient habitat. Figure 9 presents the data collected at this site to date.

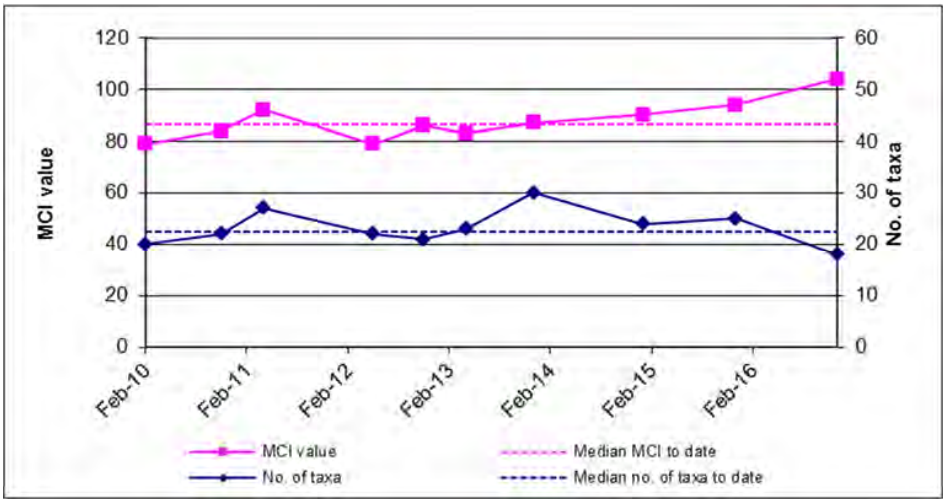

Figure 9 Taxa numbers and MCI recorded to date at site T2

Site T3 – downstream of the wetland discharge point

Site T3 was not sampled in the current survey due to low flows and insufficient habitat. Figure 10 presents the data collected at this site to date.

Some previous water quality results indicate that unionised ammonia concentrations in the unnamed tributary have at times been toxic enough to reduce the abundance of, or eliminate entirely, some of the sensitive species usually found in this stream. Results of sampling undertaken in the year prior to this survey show that two of the five samples contained concentrations of unionised ammonia above the toxicity threshold of 0.025 g/m^3. This shows management of the unionised ammonia concentrations has deteriorated since the previous monitoring survey. Should unionised ammonia concentrations continue to exceed the toxicity threshold on occasion, an additional macroinvertebrate survey at this time might be warranted. At the very least, the water quality monitoring will need to continue to assist with the interpretation of macroinvertebrate results.

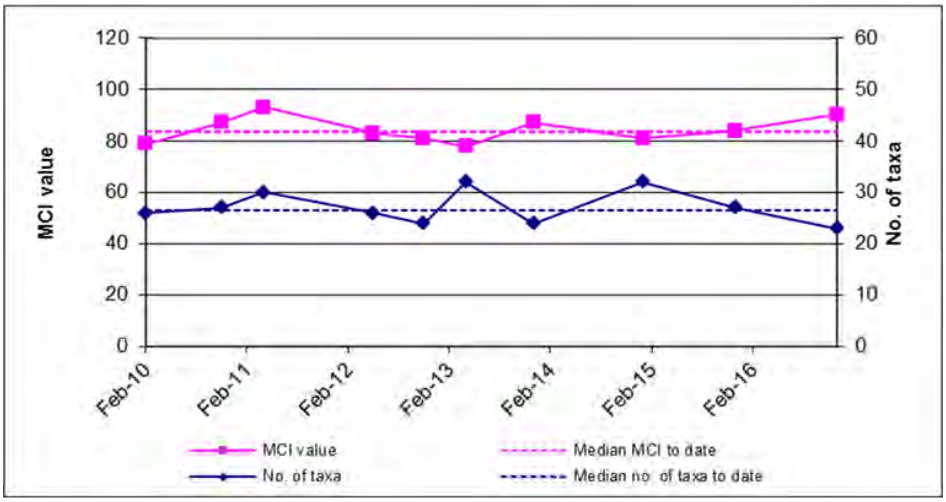

Figure 10 Taxa numbers and MCI recorded to date at site T3

Conclusions

The Council's standard 'streambed kick' and 'vegetation sweep' techniques were used at five established sites to collect streambed macroinvertebrates from the Haehanga Stream catchment in order to assess whether the Remediation (NZ) Ltd composting areas had had any adverse effects on the macroinvertebrate communities of these streams. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ scores for each site. Due to a very dry spring and early summer, flows in the catchment were very low. As a result, sampling of the unnamed tributary was precluded by these low flows. These low flows also resulted in limited sampling habitat at the mainstem sites, and consequently a relatively small sample was collected at these sites, and in some cases, sampling methodology changed from that typically performed at these sites. It should be noted that where community health is discussed below, it is done so with reference to what would be expected in such low flow, habitat restricted conditions.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

The macroinvertebrate survey conducted on 16 January 2018 observed flows in the Haehanga catchment observed to be very low, with no discernible flow at some sites. The water had a yellow tannin colouration at the head of the catchment, deteriorating to brown and cloudy at the most downstream site. The habitat limitation caused by the low flows resulted in reduced community richnesses at all sites, especially at site 6, where only nine taxa were recorded. This habitat limitation, coupled with a change in sampling method at some sites also contributed to reduced community health, as all sites recorded MCI scores lower than their respective medians and that recorded in the previous survey. Overall, this survey found that macroinvertebrate communities of the mainstem sites were of average to below average health. Undesirable heterotrophic growths were not recorded at any of the seven sites in this survey.

The two sites in the unnamed tributary were not sampled in the current survey. However, some previous water quality results indicate that unionised ammonia concentrations in the unnamed tributary have at times been toxic enough to reduce the abundance of, or eliminate entirely, some of the sensitive species usually found in this stream. Results of sampling undertaken in the year prior to this survey show that two of the five samples contained concentrations of unionised ammonia above the toxicity threshold of 0.025 g/m^3. This shows management of the unionised ammonia concentrations has deteriorated since the previous monitoring survey. Should unionised ammonia concentrations continue to exceed the toxicity threshold on occasion, an additional macroinvertebrate survey at this time might be warranted. At the very least, the water quality monitoring will need to continue to assist with the interpretation of macroinvertebrate results.

In general, the communities in the Haehanga Stream sites had relatively low proportions of sensitive taxa. Low numbers of sensitive taxa are expected in small, silty bottomed streams such as the Haehanga Stream and the numbers of taxa were generally similar to other lowland hill country streams surveyed at similar altitude. The community richness at site 6 and 7 was lower than that recorded in the previous survey, but higher than that recorded in 2015, when significant deterioration was recorded. MCI values recorded in the Haehanga Stream varied in a downstream direction, somewhat a-typical for this survey, which normally records a reducing MCI scores in a downstream direction. The lowest MCI score in the current survey was recorded at site 6 (60 units) and the highest at site 5 (73 units). With the exception of site 7, all sites recorded below average scores, significantly so for site 6.

Site 5 has exhibited poorer macroinvertebrate communities in the past compared to other sites upstream. This has suggested some level of impact from the composting operation, although the extent of adverse effects has been difficult to determine due to poor habitat quality. During the current survey, the MCI score for site 5 was one unit less than the median score for this site, but higher than that recorded at any other site in this survey. This indicates that the significant improvement recorded in the previous survey may still be present, but is suppressed by the low flow conditions. The $SQMCI_S$ score recorded at site 5 was reduced compared with that recorded at site 2. In addition, the results from the current survey indicate that *Chironomus* bloodworms were present, but only as a rarity. This suggests some deterioration from that recorded at site 2, but overall, the communities at site 5 were in average to above average health.

Unlike the other sites, the sample from site 6 was collected from a riffle with coarse and fine gravels, using the 'streambed kick' sampling technique. However, during the current survey this riffle had very little flow, and was subject to severe filamentous algal growth. This resulted in a low taxa richness of 6 taxa, ten fewer than in the previous survey. Furthermore, it resulted in an MCI score of 60 units, indicative of 'poor' water quality, and equal to the lowest recorded at this site of the eight surveys conducted there. This represents a significant deterioration from the previous survey, and a lesser deterioration from that recorded at site 5 upstream. It was also significantly less than the median for control sites in other lowland streams at a similar altitude. Although this MCI score was equal to that recorded in the 2015 survey, which coincided with the discovery of a number of dead eels near to this site, the $SQMCI_S$ score at this site was significantly higher than that recorded in 2015, and was also the highest recorded at this site to date. This supports the conclusion that the lower than average MCI score is related to the low flows and high algal biomass observed at the time.

The surveys undertaken at this site sampled habitat that differed to the other Haehanga Stream sites, as it was a true riffle, with shallow flow tumbling over coarse and fine gravel, as opposed to deeper flow moving over macrophyte or submerged wood. This habitat difference can explain some of the differences in the taxa recorded and the increased abundance of worms. The current survey indicates that the water quality preceding this survey had been average to below average, with the main influence on the community being the low flows.

The lowest site (site 7) was sampled for the seventeenth time in this survey. There was an improvement in MCI score, and the $SQMCI_S$ score was higher than that recorded at site 6. When compared with historical data, the community at site 7 was in average to above average health, and not indicative of a deterioration in water quality. The $SQMCI_S$ score for this site (4.3) was equal to the highest recorded previously, but taxa richness (17) was lower than the long-term average. This also indicates that the community was in average to above average health.

During certain previous surveys, *Chironomus* bloodworms have been recorded as abundant at various sites. Abundance of this taxon is usually an indication of an organic discharge, although low dissolved oxygen in the stream can also allow this taxon to dominate the community, especially when this is associated with low flows. It may be then that the sporadic appearance of *Chironomus* in abundance is at least in part related to the dissolved oxygen concentrations. Dissolved oxygen concentrations in the Haehanga have been found to be depressed at times, and during the warmer months, when there is more aquatic weed growth, dissolved oxygen may be significantly depleted at night. This is a natural occurrence in some streams that are slow flowing and weedy. Any macroinvertebrate surveys undertaken when such conditions exist could potentially record a community with fewer sensitive species, and a more abundant population of *Chironomus*. During the current survey, *Chironomus* was recorded as rare at sites 2 and 6, common at sites 5 and 7 and abundant at site 1, the control site. This possibly suggests a slight increase in the organic enrichment of the stream, but the abundance at the control site indicates that it is more likely a reflection of the very low flows, and as a consequence, low dissolved oxygen concentrations. It is understood that the issue of high chlorides at site 6 has been identified and is being addressed, and so water quality will hopefully improve with time. This would be further contributed to through any on-going works to the leachate and stormwater treatment system, and improved management of the riparian margin. Any works that improve water quality are also likely to lead to an improvement in freshwater macroinvertebrate communities below the discharges, and should continue to be encouraged.

This was the only macroinvertebrate programme scheduled for the 2017-18 period. It is recommended that this level of monitoring continue, but that a provisional macroinvertebrate survey be retained in the programme, to be implemented should water quality monitoring indicate an issue.

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To	Nathan Crook, Job Manager
From	Bart Jansma, Environmental Scientist
Report No	BJ309
Document	2066234
Date	7 June 2018

Fish Survey of the Haehanga Stream in relation to discharges from the Remediation (NZ) Limited composting site at Uruti, January 2018

Introduction

Remediation (NZ) Ltd operates a composting facility in the Haehanga Valley, Uruti (previously owned by Perry Environmental Ltd who was preceded by Global Vermiculture Ltd). Raw materials are trucked to the site for composting, on a purpose built composting pad for a period of 35-40 days. Synthetic hydrocarbon contaminated drilling muds and cuttings are also received on site. They are piled up and the liquids are allowed to drain, then blended with green waste and other organic matter. Composted material is transported off site by trucks to Remediation (NZ) Ltd's worm farming operations at Waitara Road and Pennington Road.

This survey is the fifth fish survey undertaken in the Haehanga Stream, in relation to this site. It was included for the first time in the 13-14 monitoring period as a replacement for the late summer macroinvertebrate programme, as flow rates have been slowly reducing over time, inhibiting macroinvertebrate sample collection. On this occasion, the fish survey was undertaken concurrent with the spring/early summer macroinvertebrate survey. Results from previous surveys are detailed in the references.

Fish surveys are useful long-term indicators of ecosystem health, as most fish live longer than a year, and as such may reflect chronic impacts from the composting site, should there be any. The first few surveys will provide results, which can be compared to those from subsequent surveys. This will allow the fish community to be assessed at that point in time, and over time, it will also allow an assessment of any change in community health. Fish communities can be influenced by operations at the composting site, principally related to the discharge of wastewater from the site (and the quality thereof), but also by changes in instream habitat. The banks of the Haehanga Stream are highly unstable and support little in the way of riparian vegetation (with the exception of rank grass). As a result, there is significant bank slumping in areas. Should the stream be fenced and planted in a way that adequately protects the banks and stream channel, it is likely that the fish community would improve.

Methods

In this survey, three sites were surveyed in the Haehanga Stream. Site 1 was located upstream of all composting and waste disposal activities, site 2 was located immediately downstream of the lower irrigation area, while site 3 was located just upstream of State Highway 3. Details of the sites surveyed are given in Table 1 and the locations of the sites surveyed in relation to the site are shown in Figure 1.

The fish populations were sampled using fyke nets (Photo 1) and gee minnow traps. At each site, five gee minnow traps were set, and baited with Marmite. They were set overnight, among macrophytes or alongside woody debris. Two fyke nets were also set at each site, a standard mesh (25mm) net and a fine mesh (13mm). The standard mesh net was set downstream, in attempt to intercept any large eels moving up from downstream. Both fyke nets were baited with fish food pellets. These nets were also set overnight. All fish caught were identified, counted and measured, and any eels longer than 300mm were weighed, using electronic scales that measured to the nearest 20 grams. All nets and traps were deployed on the afternoon of 16 January 2018, and retrieved midmorning the following day.

In addition to the nets and traps set in the Haehanga Stream, gee minnow traps were also set in the unnamed tributary. Two traps were set both upstream and downstream of the wetland discharge. This is the second time this tributary was surveyed, and was done to gain some understanding of what may inhabit this area of the catchment.

Table 1 Sampling sites surveyed in the Haehanga Stream in relation to the Remediation NZ composting operations

Site	Site code	Stream Name	Location
1	HHG000093	Haehanga Stream	Upstream of all composting and waste water irrigation areas
2	HHG000150	Haehanga Stream	30 meters downstream of Remediation NZ irrigation area
3	HHG000190	Haehanga Stream	50 metres upstream of State Highway 3 bridge
T1	HHG000098	Unnamed Tributary	5 meters upstream of wetland discharge
T2	HHG000103	Unnamed Tributary	40 meters downstream of wetland discharge

Figure 1 Location of the three Haehanga Stream and two unnamed tributary sampling sites in relation to composting and wastewater irrigation areas.

Photo 1 A fyke net and gee minnow trap, set at site 1, Haehanga Stream. 16 January 2018

Results and Discussion

The fish-monitoring component of the compliance monitoring programme is usually scheduled for December, to target the higher flows typically present in early summer. However, due to a very dry spring and early summer, the current survey was delayed in the hope that rains would return and flows would recover. A rain event occurred ten days prior to this survey, but was not sufficient to restore groundwater levels to the point where there was improved flow in the Haehanga Stream. As a result, the current survey was undertaken in very low flows, with no discernible flow at site 1, and very little flow present at sites 2 and 3.

All sites contained moderate fish habitat, with deep pools, and macrophyte beds both on the bed and on the edge. The substrate of the surveyed pools comprised primarily of thick silt, with some large logs present at site 3. All sites had at least some undercut banks, but there was no overhanging vegetation at any site, other than long grass. The water appearance of the Haehanga Stream was clear and yellow at site 1 and brown and cloudy at sites 2 and 3.

The unnamed tributary also had very little to no flow, with the pools containing clear and uncoloured water.

Water temperatures recorded during the macroinvertebrate survey, conducted on the same day, ranged from 23.1 to 28.2 ˚C, which is particularly warm, well above the thermal preference, and near to the maximum thermal tolerance of a number of native fish species (Richardson, Boubee and West, 1994)).

A previous (December 2015) survey observed seven dead eels at, and downstream of site 2. In addition, a macroinvertebrate sample collected upstream of site 2 on the same day smelt of hydrocarbons, and there was a hydrocarbon sheen noted on the surface. This follows on from the observations made during the December 2014 survey, when hydrocarbons were released from the sediment at site 3. No such observations were made during the current survey.

It is worth noting that the macroinvertebrate survey undertaken on the first day of the fish survey found that macroinvertebrate communities of five mainstem sites were in average to below average health. This was attributed primarily to the low flow causing habitat limitation, coupled with a change in sampling method at some sites.

The full results of the fish survey are shown in Table 2 and Table 3.

Table 2 Results of the current fish survey and a summary of previous surveys undertaken in the Haehanga Stream in relation to Remediation NZ's composting operations.

	Site:	Site 1			Site 2			Site 3		
	Net/Trap type:	Previous results (4 surveys)	Fyke net	Gee minnow trap	Previous results (4 surveys)	Fyke net	Gee minnow trap	Previous results (4 surveys)	Fyke net	Gee minnow trap
	Sampling effort (minutes):		**2790**	**6900**		**2410**	**6025**		**2670**	**6675**
Longfin eel (*Anguilla dieffenbachii*)	Number	3-7	1	-	1-17	2	-	1-8	3	-
	Length range (mm)	478-1045	413	-	365-1050	484-570	-	431-930	738-825	-
	Weight range (kg)	0.24-3.31	0.16	-	0.10-3.425	0.29-0.46	-	0.18-2.61	1.17-1.44	-
Shortfin eel (*Anguilla australis*)	Number	0-1	1	-	4-17	10	1	2-3	6	-
	Length range (mm)	195-600	683	-	196-850	257-789	239	510-790	449-822	-
	Weight range (kg)	0.44	0.61	-	0.02-0.98	0.13-1.01	-	0.26-1.57	0.18-1.23	-
Inanga (*Galaxias maculatus*)	Number	-	-	-	1-11	-	-	0-6	-	-
	Length range (mm)	-	-	-	86-123	-	-	-	-	-
Redfin bully (*Gobiomorphus huttoni*)	Number	-	-	-	-	-	-	0-1	-	-
	Length range (mm)	-	-	-	-	-	-	70	-	-
Total number of species		**2**	**2**		**3**	**2**		**4**	**2**	
Total number of fish		**-**	**2**		**-**	**13**		**-**	**9**	

Table 3 Results of the current fish survey and a summary of previous surveys undertaken in the unnamed tributary of the Haehanga Stream in relation to Remediation NZ's composting operations

Site:		T1		T2	
Net/Trap type:		Previous results (1 survey)	Gee minnow trap	Previous results (0 surveys)	Gee minnow trap
Sampling effort (minutes):			2700		2700
Banded Kokopu (*Galaxias fasciatus*)	Number	1	-	-	-
	Length range (mm)	130	-	-	-
Total number of species		**1**	**0**	-	**0**
Total number of fish		-	**0**	-	**0**

Site 1

This site recorded just two species, being longfin and shortfin eel. This is consistent with that recorded in previous surveys. It is likely that this is related in part to the reduced flow that can occur at this site, resulting in reduced habitat. As in some previous surveys, there was little to know flow at this site. Fish passage may also be influencing the number of species present at this site, as the barriers to fish passage observed downstream may have prevented fish migrating upstream to this site. This has serious implications for inanga, as this species is a short-lived species, and migrates downstream annually to spawn, with juveniles migrating upstream during the whitebait season.

Overall, two fish were recorded at this site, which is a reduction from that recorded previously. This is likely a reflection of the extended period of lower flows preceding this survey, which may have prompted fish to emigrate from this reach. In addition, the lack of flow will have reduced the extent that the bait odour travelled downstream, reducing the attraction of fish to the nets.

This site is intended as a control site with which to compare the downstream results. Due to the lack of fish passage, it cannot be considered a true control site. In addition, if a culvert does not provide for the passage of fish, it is non-compliant and must be remediated. Some remedial works have been undertaken since the previous survey was completed. However, further remedial work is required, so it is once again recommended that the site operator is made aware of these barriers to fish passage, and required to take steps to remediate them. The barriers are discussed in more detail below.

Site 2

This site, located immediately downstream of the lowest irrigation area, contained an equivalent species richness (2) but the highest abundance (13) of the three sites surveyed. No inanga were recorded at this site during this survey, although this species has been recorded at this site in three of the four previous surveys completed. Natural variation will occur in inanga populations from year to year, as they recruit annually, and are therefore subject to numerous other factors. That no inanga were recorded (compared with a maximum of eleven in 2014) is not necessarily cause for concern, as it is likely that the low flows resulted in lower numbers, either through emigration, predation or low dissolved oxygen levels. There may have also been predation within the nets, especially with the number of large eels caught also.

Thirteen eels were captured, of which two were longfin eels, none of which were particularly large, with the largest being 570mm and 0.46kg. This is a reduction from the number of eels recorded in the previous survey, which recorded eighteen eels. Unlike in the more recent surveys, there was little difference in size class distribution, similar to that recorded in the 2013-2014 survey, which was also undertaken in low flows (Figure 2). There were more smaller eels recorded at this site than in the previous survey, which is likely related to the smaller number of large eels, and a consequent reduction in predation within the nets.

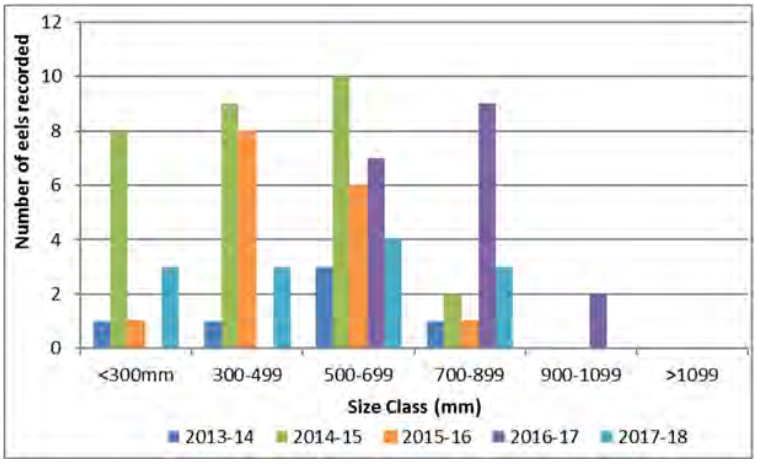

Figure 2 Size class distribution of all eels recorded at site 2 over the four surveys completed to date

It is apparent that site 2 still had a much higher abundance than that recorded upstream at site 1. This suggests that the access culvert immediately upstream of this site may still be posing a barrier to fish passage (Photo 2). Some remedial works had been undertaken in the past, with gravel being used to build up the bed level at the outlet of the first pool downstream of the culvert prior to the 2016-2017 survey. While this was an appropriate approach, as it lifted the water level and resolved the perched nature of the culverts, the material used was too fine and had already begun scouring away. During the current survey, it was apparent that the material had indeed washed away, and the culverts were again perched. Remedial works are therefore once again required.

Photo 2 The access culvert immediately upstream of site 2, December 2015 (left), December 2016 (middle) and January 2018 (right).

Site 3

Located just upstream of State Highway 3, this site provides some perspective, providing an indication as to the extent of influence from the upstream composting activities. This site contained some of the best habitat, with large logs, deep water and undercut banks. These three habitat features are frequently used by nocturnal fish as daytime cover.

Nine fish were recorded at this site, similar to that recorded in the previous survey. Inanga and redfin bully were absent despite being recorded in one or more previous surveys. Three longfin eels and six shortfin eels were recorded, although there was a lack of small individuals, which seems typical for this site (Table 2). This site recorded the same species richness (two) as site 1, with a similar ratio of longfin to shortfin eels. It is possible that predation within the nets contributed to the low species richness lack of small eels, as suggested in previous reports. Overall, these results reflected the low flows present at the time of this survey, and represented little change from that recorded in the previous survey.

Unnamed tributary

This tributary was surveyed for the second time in this survey, with the current survey being the first occasion when both sites TI and T2 were trapped. It should be noted that previous macroinvertebrate surveys have incidentally recorded fish, including banded kokopu and longfin eel, with larger unidentified eels observed below the wetland discharge. Unfortunately, no fish were recorded at either site in the current survey, which is a reflection of the relatively low intensity trapping, but also the low flows present at the time. In the previous (2016-2017) survey, one banded kokopu was captured (Photo 3), being an individual 130mm in length, likely to be between two and three years old (Hopkins, 1979). Banded kokopu are considered a regionally distinctive species in Taranaki, and as such, their presence in this unnamed tributary shows the significant values such small streams can have.

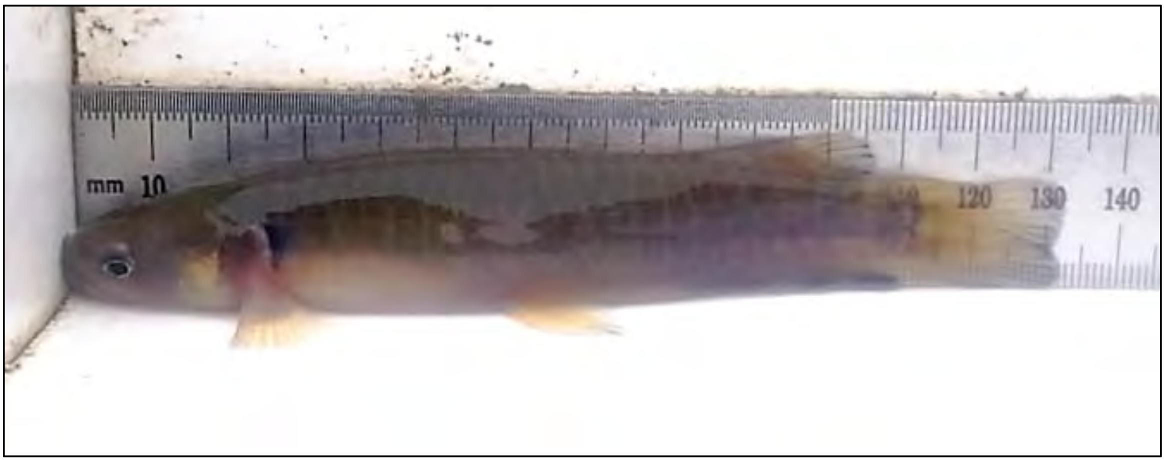

Photo 3 Banded kokopu (*Galaxias fasciatus*) captured in the unnamed tributary upstream of the wetland discharge, December 2016.

Size class distribution

Assessing the size class distribution of fish populations can provide a useful perspective on fish recruitment, and the long-term health of the community. For example, if recruitment were restricted, then there would be a lack of young fish. However, it can be influenced by other activities such as people feeding eels, or commercial eeling operations. It is therefore recommended that no such activities take place on the consent holder's property. It should also be noted that good numbers of fish are needed to support strong conclusions, and therefore only the size class distribution of eels (as opposed to other species) is discussed.

Figure 3Figure 4 shows that a lower number of eels were recorded in the current survey than in the 2015-2016 survey, but similar to that recorded in the 2015-16 survey. The size class distribution was quite different however, with no size category clearly dominating the community. This differs to the previous surveys, which have recorded the most eels in the 500 to 700 mm size class. The most abundant size category in the current survey (albeit by only two eels) was the 700-899 mm size category.

This difference in the number of eels and the size class distribution can be attributed to the reduced flow conditions during the current survey. This lower flow meant that the bait scent was not carried as far downstream, with fish attracted from a smaller area than during higher flows. This will have contributed to the reduced number of large eels in the nets, reducing the likelihood of predation in the nets. This allowed for an increased survival of smaller eels.

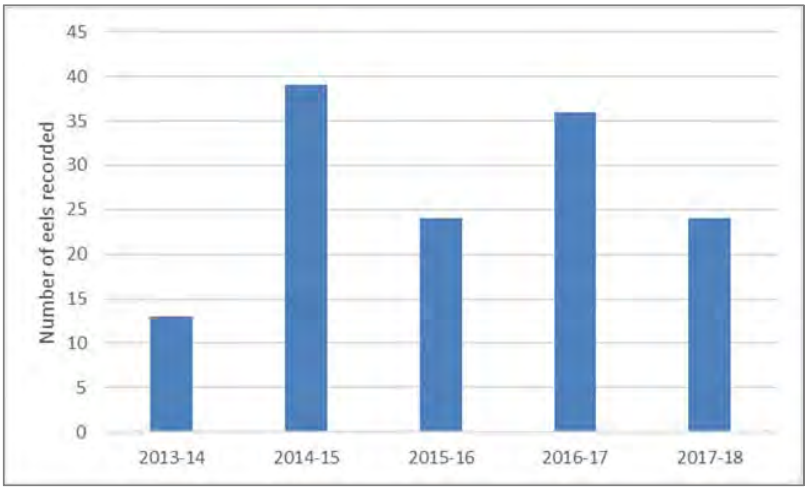

Figure 3 The total number of eels recorded per survey

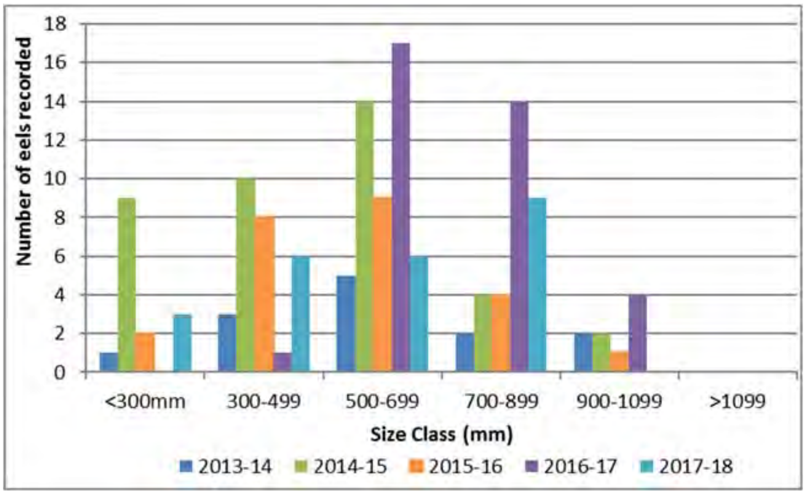

Figure 4 The size class distribution of all eels captured at all sites over the three surveys undertaken to date.

The presence of large eels (coupled with the higher numbers recorded in the previous survey) is a positive result, as it suggests some recovery from the impacts of commercial eeling, which is understood to have occurred just prior to the 2013-14 survey. However, this recovery will not yet be complete. The community will take some time to recover from the impacts of commercial eeling, as commercial eeling methods (fyke netting) are so efficient that 75% of the eels in a fished area can be caught in a single night. As a result, it can take a decade or more for the eel's population at such a site to recover (PCE, 2013). It should be noted that the sampling methodology is less likely to record eels smaller than 150mm, compared with larger eels.

Fish condition

The composting activities undertaken alongside the Haehanga Stream have the potential to release a range of substances to the stream, including some that have toxic effects on the fauna of the stream. The degree of toxicity can range from acute, resulting in quick death, to chronic, where repeated exposure over time may result in the fauna becoming unwell, and/or leaving the area. Eels captured in this survey were measured and weighed. This data is used to gauge the physical condition of the fish, which can be a useful indication of fish health. If fish at one site were in poorer condition than others in the same stream, then it would be expected that the sick fish of the same length would be lighter.

Figure 5 shows that all of the longfin eels recorded in the current survey were in better condition than would be expected. Shortfin eel showed a similar result, although one eel was found to be underweight by 26%. The four eels captured at site 3 were all well in excess of the expected weight, a result consistent with that recorded in the previous two surveys. This indicates that the longfin eel communities were in better physical condition than would be expected, while the shortfin eel communities were in average physical condition. This is despite the low flows and likely stressful conditions that preceded this survey, reflecting their relatively robust nature. This overall average condition is similar to that that recorded in the 2013-14 and 2014-15 surveys, but not as high as recorded in the previous two surveys, when most fish were heavier that that predicted by Jellyman *et al* (2013). The trend lines in Figure 5 used the equation from table 1 for longfin eel and table 3 for shortfin eel found in Jellyman *et al* (2013).

Overall, these fish condition results suggest that fish condition is better in early summer than late summer, including at site 2. This is consistent with the higher and cooler early summer flow conditions providing for improved habitat and food supply. The results from site 2 suggest that the eel community was in poorer health than the previous survey, although the eels were still of average condition i.e. not underweight. This suggests that the activities at the composting facility had not affected this community.

In addition to length and weight measurements, each fish was inspected for obvious physical damage or abnormalities. No such features were noted.

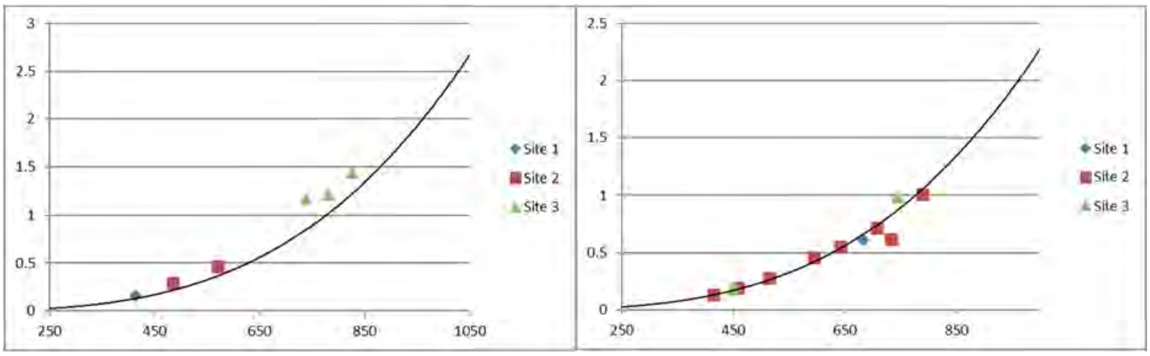

Figure 5 Longfin eel condition (left) and shortfin eel condition (right) in the Haehanga Stream, 14/15 December 2016. Weight (Kg) is on the y-axis, length (mm) on the x-axis. The trend line is the predicted weight, using equations from Jellyman *et al* 2013.

Fish Passage

During this and previous surveys, three access culverts were inspected, and assessed for fish passage. The locations of these culverts are summarised in Table 4. It was noted that each of the three culverts impeded fish passage in some way.

Culvert 1, on the Haehanga Stream near the composting pads, had a very shallow flow (Photo 4), which would inhibit most swimmers including inanga. The outlet of this culvert is usually too steep and water speeds too swift, and only suitable for climbing species. The low flows during the current survey reduced passage by reducing depth. Furthermore, the large rocks added to the streambed had moved, further reducing water depth. This culvert is in need of remediation.

Culvert 2 has two pipes, one that takes low flow, and a higher one that only flows during higher flows. Both culverts were perched, although the lower culvert only by a matter of approximately 20 mm. However, the lower culvert appeared subject to blockage (Photo 4). Although kokopu and eels have been recorded upstream of this culvert, these species are good climbing species and highly adept at negotiating barriers that swimming species cannot pass. This culvert will still reduce the passage of climbing species, while completely preventing the passage of swimming species.

Culvert 3, a double culvert under the main access track, was again perched (Photo 2), due to the remedial works completed prior to the 2016-2017 survey having washed away. This was predicted in the previous report (Jansma, 2017), and as a result, remedial works are once again required.

It is important that the site operator is made aware that these culverts generally need ongoing maintenance, and that the provision of fish passage is a requirement that must be met at all times.

Table 4 Culverts assessed for fish passage during the current fish survey

Culvert number	Location	NZTM GPS reference
1	Haehanga Stream, near composting pads	1732285-5685087
2	Unnamed tributary, immediately upstream of Haehanga Stream	1732291-5685098
3	Haehanga Stream, at downstream extent of irrigation area	1731707-5685778

Photo 4 Culvert 1
Top left: December 2015
Top right: December 2016
Bottom left: January 2018

Photo 5 Culvert 2
Top left: December 2015
Top right: December 2016
Bottom left: January 2018
Bottom right: Interior, January 2018

Summary and conclusions

On 16 and 17 January 2018, three sites were surveyed for freshwater fish in the Haehanga Stream in relation to the composting activities undertaken by Remediation NZ Ltd. Site 1 was located upstream of the site, site 2 located immediately downstream of the lowest extent of the irrigation area, and site 3 was located just upstream of State Highway 3. The survey method involved deploying baited fine and coarse mesh fyke nets and gee minnow traps at each site overnight. This survey also including trapping of the unnamed tributary that receives the wetland discharge, with two gee minnow traps set both upstream and downstream of the discharge. All nets and traps were recovered the following morning, with all fish identified, counted and measured, with eels greater than 300mm weighed.

This survey is usually scheduled for December, to target the higher flows typically present in early summer. However, due to a very dry spring and early summer, the current survey was delayed in the hope that rains would return and flows would recover. A rain event occurred ten days prior to this survey, but was not sufficient to restore groundwater levels to the point where there was improved flow in the Haehanga Stream. As a result, the current survey was undertaken in very low flows, with no discernible flow at site 1, and very little flow present at sites 2 and 3.

All sites contained moderate fish habitat, with deep pools, and good cover. It should be noted that water temperatures in this stream may occasionally exceed the thermal preference, and maximum thermal tolerance of a number of native fish species, with a water temperature of 28.2˚C recorded during the current survey. Due to the reduced flow conditions, which resulted in less flow past the nets and traps and reduced distribution of bait odour downstream, fish abundance and number of species recorded was lower than that recorded in the previous survey. Over all sites, twenty-four fish were recorded across two species. Unfortunately no fish were recorded in the unnamed tributary, where a banded kokopu was recorded in the previous survey.

Unlike in the 2015-2016 survey, when seven dead eels were observed at and downstream of site 2, there were no observations made that posed any concern. There was some discolouration noted at sites 2 and 3, but no obvious hydrocarbon contamination of the Haehanga Stream like that recorded in the 2014-2015 and 2015-2016 surveys. The degree of discolouration at sites 2 and 3 was minor, and likely a reflection of a lack of flushing due to the low flows. Upstream, the water was coloured yellow by dissolved tannins.

It is worth noting that the macroinvertebrate survey undertaken on the first day of the fish survey found that macroinvertebrate communities of five mainstem sites were in average to below average health. This was attributed primarily to the low flow causing habitat limitation, coupled with a change in sampling method at some sites.

The site that would be expected to experience the greatest impacts should there be any is site 2. At this site, two species were recorded, as was the highest abundance (13 fish) of the survey. Inanga were not present, despite being present in the previous survey. Natural variation will occur in inanga populations from year to year, as they recruit annually, and are therefore subject to numerous other factors. It should also be noted that there may be predation within the nets, as noted in the previous survey, when larger eels had clearly ingested smaller eels. It is very possible that smaller fish such as inanga has also been predated upon, although this was not obvious when handling the eels.

Site 3, further downstream also recorded two species, which is equal to that recorded in the previous survey. Inanga were absent, but have been recorded at this site previously.

Eels were recorded at all three sites, with the largest longfin eel being recorded at site 3. This individual was 825 mm long, and weighed 1.44 kg. The size class distribution of the eels was quite different to that recorded in the previous surveys, with no size class clearly dominating the community. This is probably a reflection of the reduced flow conditions during the current survey. This lower flow meant that the bait scent was not carried as far downstream, with fish attracted from a smaller area than during higher flows. This will have contributed to the reduced number of large eels in the nets, reducing the likelihood of predation in the nets. This allowed for an increased survival of smaller eels. It is likely that the community is still impacted by the commercial eeling that is understood to have occurred just prior to the 2013-14 survey. It is expected it will take over decade for the community to recover from this. The physical condition of the eels showed that most of the eels captured at all three sites were in average condition, although the condition of the longfin eels was better than would be expected. This is despite the low flows and likely stressful conditions that preceded this survey, reflecting their relatively robust nature. Overall, these fish condition results suggest that fish condition is better in early summer than late summer, including at site 2. This is consistent with the higher and cooler early summer flow conditions providing for improved habitat and food supply. The results from site 2 suggest that the eel community was in poorer health than the previous survey, although the eels were still of average condition i.e. not underweight. This suggests that the activities at the composting facility had not affected this community. No observed fish exhibited any obvious physical damage or abnormalities during the current survey.

Three access culverts were assessed for fish passage during this survey, and all were found to present a barrier to fish passage at most if not all flows. Even in higher flows, it is likely that these culverts severely restrict the passage of swimming species such as inanga. The culvert located immediately above site 2 was perched, as the remedial works completed prior to the previous survey had scoured away. Remedial works are required on this culvert, and on the remaining two culverts, which have been identified as a barrier for a number of years.

In summary, the results of the current survey do not indicate that the composting activities and wastewater irrigation undertaken by Remediation NZ Ltd, alongside the Haehanga Stream, have had a deleterious impact on the fish communities of this stream. This is consistent with the findings of the macroinvertebrate survey, completed on the same day. However, the impact on fish passage caused by the three access culverts is likely to have contributed to the reduced species richness at site 1. It is important that the site operator is made aware that these culverts generally need ongoing maintenance, and that the provision of fish passage is a requirement that must be met at all times.

Although originally planned for early summer, this survey was delayed until mid-summer in the hope that flows would recover from the extended period of dry weather that occurred in late 2017. It is recommended that this survey continues to be scheduled for early summer, and that surveys continue on an annual basis. In addition, it is recommended consideration be given to installing continuous water temperature monitoring equipment over the summer months, to improve the understanding of how water temperature changes in the Haehanga Stream. It is also recommended that the company be reminded of their responsibilities regarding the provision for fish passage.

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