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# Ecological Survey of Donald Creek to meet Conditions 21 to 24 of Consent WAR 970080 that permit the discharge of contaminants to water from the Featherston Wastewater Treatment Plant

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## 1.0 Executive Summary

The wastewater treatment plant at Featherston comprises two oxidation ponds that discharge treated wastewater into Donald (Boar) Creek.

This discharge is authorised by Consent WAR 970080, Conditions 21, 22, 23 and 24 of which, prescribe the detail of an ecological survey that was required to determine the effect of the discharge on the aquatic ecosystem of Donald Creek.

Coffey (2010) conducted a preliminary assessment of effects for the discharge but considered a wider range of sampling sites was required to adequately interpret the effects of the discharge in Donald Creek.

This report describes a total of five sampling sites (25m long creek reaches) that account for differences in physical habitat quality upstream and downstream of the discharge.

At the time of this survey (04 March 2013) there were two discharges from the Featherston oxidation ponds entering the Donald Creek. The first (upstream) discharge had been "polished" by a constructed wetland. The second (downstream) discharge was a direct discharge to the creek from the second oxidation pond.

Valid comparisons of the effect of water quality on instream community structure could be made at un-shaded sampling sites upstream and downstream of the oxidation pond discharges and at shaded sampling sites upstream and downstream of the oxidation pond discharges.

The oxidation pond discharges to Donald Creek were associated with a conspicuous change in water clarity due to high chlorophyll concentration in the oxidation ponds and increased embeddedness of the gravel substrate in Donald Creek due to suspended solids discharged from the oxidation ponds.

There was a low cover (c. 5%) of heterotrophic growths (sewage fungus complex) an 800 m reach of Donald Creek downstream of the discharges from the Featherston Oxidation Ponds.

Periphyton cover and biomass were higher at the un-shaded downstream sampling site relative to the un-shaded upstream control site but periphyton scores were similar at these two sites. Periphyton and vascular aquatic macrophytes were not a feature of the shaded sampling sites upstream or downstream of the oxidation pond discharges.

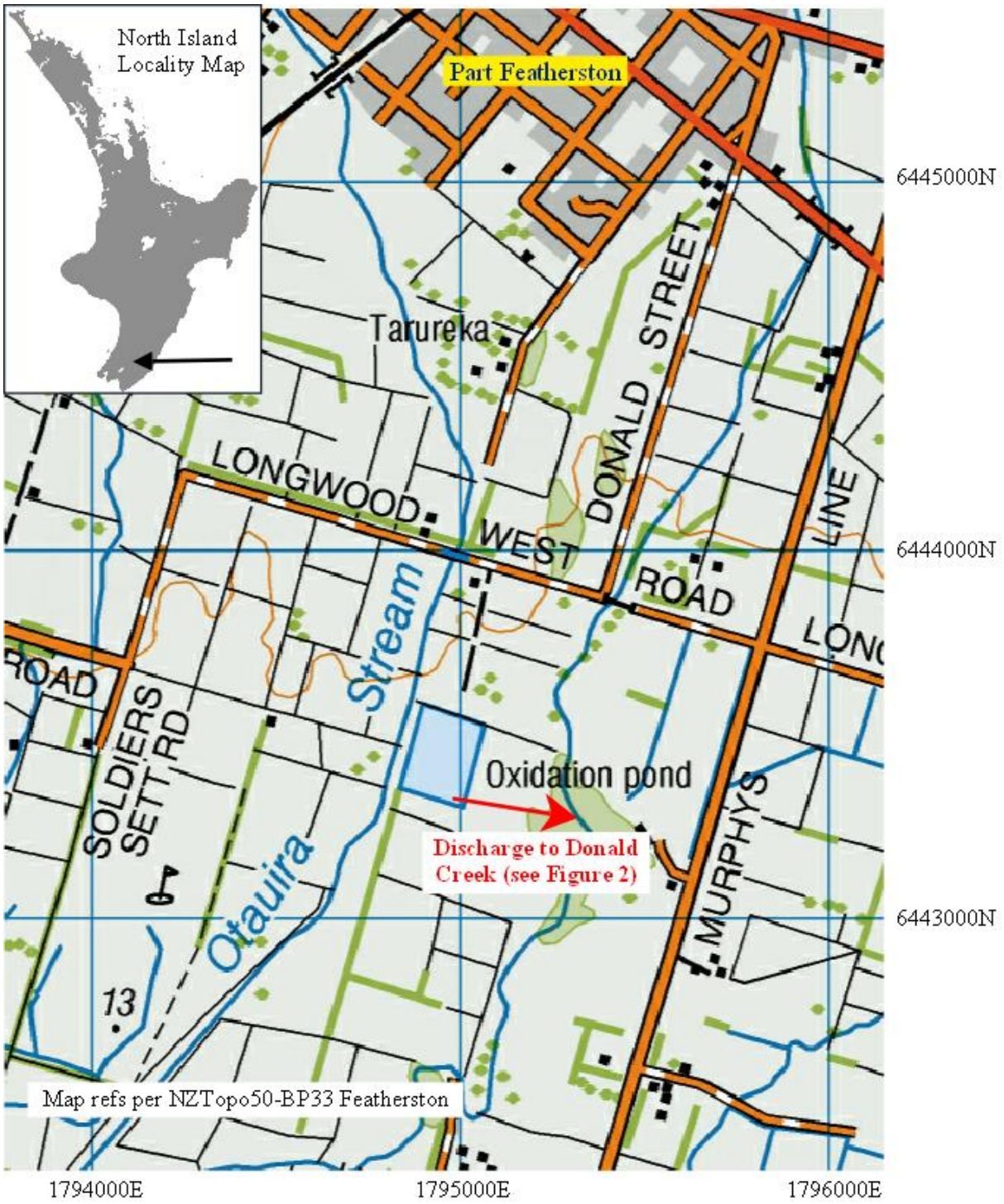
All of the metrics used to assess macroinvertebrate community structure indicated significantly compromised water quality downstream of the discharges from the Featherston oxidation ponds relative to an upstream control site, particularly downstream of the "un-polished discharge direct from the oxidation ponds.

Whilst there was some recovery of metrics of instream community structure at an unshaded control site 800 m downstream of the oxidation pond discharges, they all remained significantly reduced relative to the unshaded control site upstream of the oxidation pond discharges.

## 2.0 Introduction and Background

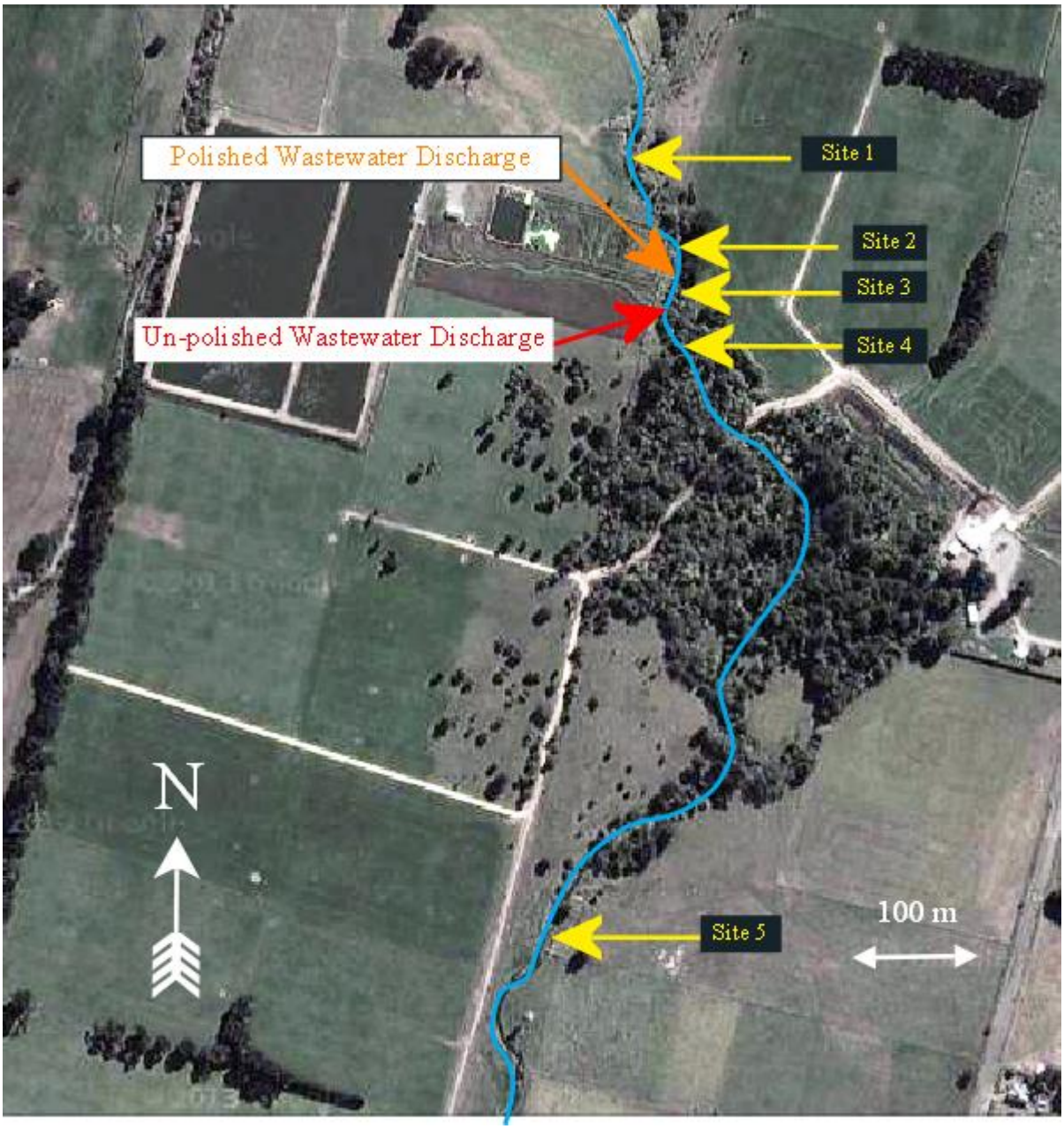
Wastewater from Featherston[1] was treated in two oxidation ponds that were two km south of the town centre and that were accessed from Longford West Road (see Figures 1 and 2).

*Figure 1: Locality of Featherston Oxidation ponds, Donald Creek and Otauira Stream.*




[1] The population of Featherston was 2,340 in the 2006 Census.

*Figure 2: Sampling Sites 1 to 5 in Donald Creek refer to 25m long reaches of the Creek that were sampled on the 4th March 2013.*




Treated effluent from these two oxidation ponds discharged into Donald (Boar) Creek on the eastern boundary of the oxidation ponds. Some 1.5 km south west of the oxidation ponds, Donald Creek discharged into the Otauira Stream (see Figure 1). The Otauira Stream discharged into Lake Wairarapa a further 2 km south west of its confluence with Donald Creek.

At the time of this survey (04/03/2013), a proportion of the oxidation pond discharge was being diverted into Donald Creek via a constructed wetland (the polished wastewater discharge shown in Figure 2) and the remainder was being discharged directly into Donald Creek (the un-polished discharge shown in Figure 2).

To the north of the discharge from the oxidation ponds and 350 m south of the discharge from the oxidation ponds, Donald Creek flowed through open farmland. However, for 350 m downstream of the discharge from the oxidation ponds, Donald Creek flowed through a dense willow swamp.

The discharge of treated wastewater to Donald Creek is authorised by Consent (Discharge Permit) No. WAR 970080.

Conditions 21, 22, 23 and 24 of Consent WAR 970080 (see Appendix A) prescribe the detail of an ecological survey that was required to determine the effect of the discharge on the aquatic ecosystem of Donald Creek.

The prescriptive sampling sites specified in Appendix A did not account for the upstream control site being in an un-shaded section of the Creek whereas the downstream treated site was in a heavily shaded section of the Creek.

On this basis, Coffey (2010) recommended that any subsequent / repeat survey of Donald Creek to determine the effect of the discharge from the Featherston Oxidation Ponds should include two additional sampling sites. These should be in an unshaded reach of riffles upstream and downstream of the currently prescribed sampling sites.

In contrast to the survey reported by Coffey (2010,) this survey describes a total of five sampling sites (5 x 25 m long reaches of the Creek) where Sites 1 and 5are in unshaded reaches of the Creek upstream and downstream of the willow cover and Sites 2 and 4 are upstream and downstream of the oxidation pond discharge in the shaded reach of Donald Creek.

Site 2 is an additional site between the "polished" and the "unpolished" oxidation pond discharges to Donald Creek.

## 3.0 Methods and Approach

### 3.1 Instream Habitat Quality

Stream habitat, as affected by instream and topographical features, is a major determinant of aquatic community potential. Both the quality and quantity of available habitat affect the structure and composition of resident macroinvertebrate communities.

The effects of habitat differences can be minimised by sampling similar habitats at all sites being compared. However, when sites are not physically comparable (for example, a native forest head water stream site as opposed to a downstream site in an agricultural catchment), habitat characterisation is particularly important for the proper interpretation of biosurvey results. In this instance, the eleven habitat characteristics recommended by Edgar et. al., (1994) were used to score habitat quality (see Appendix B).

### 3.2 Inspection for Heterotrophic growths

Instream growths of heterotrophic organisms (bacteria and/or fungi) occur in response to high inputs of readily degradable dissolved organic compounds (i.e., low molecular weight organic compounds such as short-chain organic acids, sugars and alcohols) that may be associated with discharges of inadequately treated effluent from milk factories and domestic wastewater treatment plants for example. These growths, commonly referred to as "sewage fungus", are unacceptable in recreational waters (Ministry for the Environment 1992).

Larger stones, bedrock, woody debris and macrophytes offer stable attachment sites for sewage fungus and summer temperatures in New Zealand streams are conducive to the rapid growth of sewage fungus.

Sewage fungus is normally identifiable in the field as a white to light grey mat with the appearance of "cotton wool". However, it is advisable to return samples to the laboratory for microscopic examination as sewage fungus can be mistaken for growths of stalked diatoms such as *Gomphonema* and *Didymosphenia*. The most common associate of sewage fungus is generally the filamentous bacterium *Sphaerotilus natans*.

An inspection of the streambed below the point of discharge (for a distance extending 100 m downstream of the discharge) was made for the presence of any nuisance heterotrophic or periphyton growths (as required by Condition 21 of Consent WAR 970080 – see Appendix A). Selected samples were returned to the laboratory for microscopic examination.

### 3.3 Description of Periphyton Communities

Periphyton was described upstream and downstream of the Featherston oxidation pond discharge to Donald Creek as required by Conditions 21 and 22 of Consent WAR 970080 (see Appendix A).

The periphyton survey included:

- An assessment of the percentage cover of both filamentous algae and algal mats (to nearest 5%) at five rather than 10 points across each of four transects encompassing both riffle and run habitat and extending across the width of the creek at each sampling site;

  Although RAM-1 quadrat method for assessing periphyton cover (Biggs & Kilroy 2000) recommended assessing cover at 10 points across each of four transects, in this instance the creek was only 1 – 2 m wide and this would involve an overlap of area assessed with a 15 to 20 cm quadrat. Hence, in common with RAM-2 point method for % cover (Biggs & Kilroy 2000), cover was assessed at 5 points across each of four transects encompassing both riffle and run habitat and extending across the width of the creek at each sampling site.
- Collection of a composite periphyton sample from riffle and run habitat (a composite of scraping from 10 rocks. 5 from a riffle and 5 from a run) across each sampling site using method QM-1a from the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000); and
- Analysis of periphyton samples for community composition and abundance using the Biggs & Kilroy (2000) relative abundance method and ash free dry weight.

### 3.4 Description of Aquatic Macrophytes

Therefore the cover of submerged macrophytes was described using the methodology recommended by Collier et al. (2007).

This involved the assessment of cover for submerged and emergent macrophytes across the same 4 transects at which periphyton cover was assessed.

### 3.5 Macroinvertebrate Community Structure

Macroinvertebrate Community Structure was described upstream and downstream of the Featherston oxidation pond discharge to Donald Creek as required by Conditions 21 and 23 of Consent WAR 970080 (see Appendix A).

The macroinvertebrate survey followed Protocols C3 and P3 from the Ministry for the Environment's report on protocols for sampling macroinvertebrates in wadeable streams (Stark et at. 2001).

The macroinvertebrate survey included:

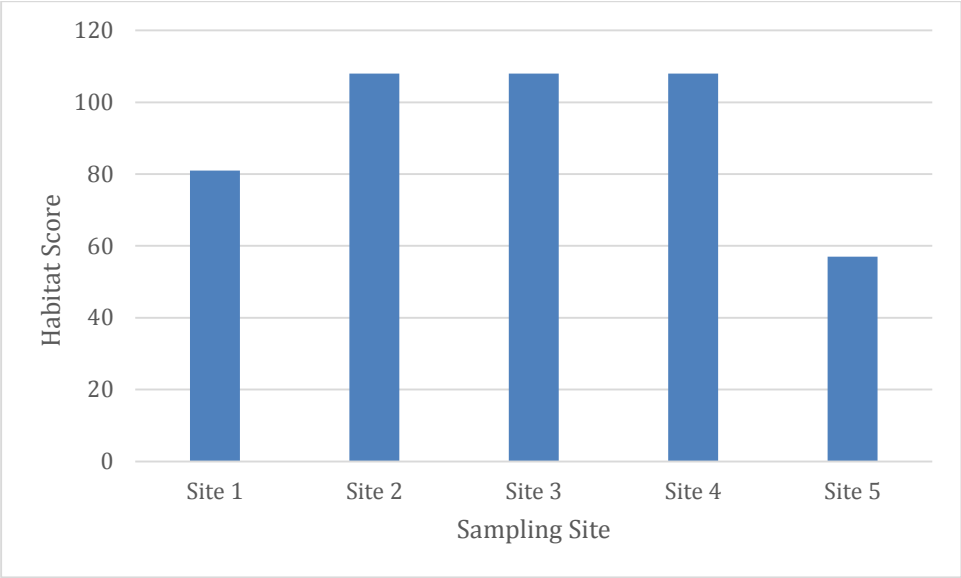
- Collection of 5 replicate 0.1 $m^2$ Surber samples at random within a 20 m section of riffle habitat at each sampling site;
- Full count of the macroinvertebrate taxa within each replicate sample to the taxonomic resolution level specified for use of the Macroinvertebrate Community Index (MCI); and
- Enumeration of the results as average Taxa Richness, average Macroinvertebrate Community Index (MCI), average Quantitative Macroinvertebrate Community Index (QMCI), Percent Ephemeroptera, Plecoptera Trichoptera taxa (% EPT taxa) and Percent Ephemeroptera, Plecoptera Trichoptera Individuals (%EPT Individuals).

## 4.0 Results and Discussion

### 4.1 Instream Habitat Quality

An assessment of physical habitat conditions upstream and downstream of the oxidation pond discharge is tabulated in Appendix B and summarised in Figures 3

*Figure 3: Total Physical Habitat Scores for Sampling Sites Upstream (U.S.) and Downstream (D.S.) of the Featherston Oxidation Ponds to Donald Creek, March 2013.*




Reaches of the Creek under the willow canopy (Sites 2, 3 and 4) scored more highly than the upstream and downstream sites (Sites 1 and 5) due to the presence of a constructive riparian zone.

The un-shaded Sampling Site 1 scored more highly than the unshaded downstream Sampling Site 5 on the basis of channel structure, substrate / cover, and embeddedness were better at the upstream site because the oxidation pond discharge was associated with a significant input of silt, chlorophyll and nutrients to the stream (see Appendix B).

At the time of this survey (04.03.2013,) flow from the Featherston oxidation ponds were similar to flow at the upstream sampling site in Donald Creek and there were therefore, substantially higher flows at the downstream sampling sites relative to the upstream control site.

### 4.2 Inspection for Heterotrophic growths

Visually obvious growths of sewage fungus was present on c. 5% of stable submerged substrate (gravel, wood and submerged willow roots) throughout the three sampling reached downstream of the "un-polished" oxidation pond discharge to Donald Creek (at Sites 3,4 and 5).

The filamentous bacterium *Sphaerotilus natans* (a principle component of sewage fungus) was present in samples that were dissected microscopically to assess the floristic composition of periphyton at Sampling Sites 3, 4 and 5 (see Section 4.3 and Appendix C1).

### 4.3 Description of Periphyton Communities

The floristic composition of five periphyton samples from Transect 1 (riffle habitat) and five periphyton samples from Transect 3 (run habitat) both upstream and downstream of the oxidation pond discharge are tabulated in Appendix C1.

The green filamentous alga *Stigeoclonium tenue* dominated periphyton cover at Site 1 upstream of the oxidation pond discharge in Donald Creek as of March 2013 (see Appendix C1).

The diatom *Fragilaria vaucheriae* dominated periphyton at the downstream Sampling Site 5 (see Appendix C1).

Periphyton cover scores and biomass (Ash Free Dry matter per $m^2$) are tabulated in Appendix C2 and summarised in Figures 4 and 5.

Periphyton cover / biomass was very low or non-existent at Sampling Sites 2, 3 and 4 in Donald Creek (see Appendix C1).

*Figure 4: Average Periphyton Scores at Sampling Sites Upstream and Downstream of the Featherston Oxidation Ponds to Donald Creek, March 2013.*

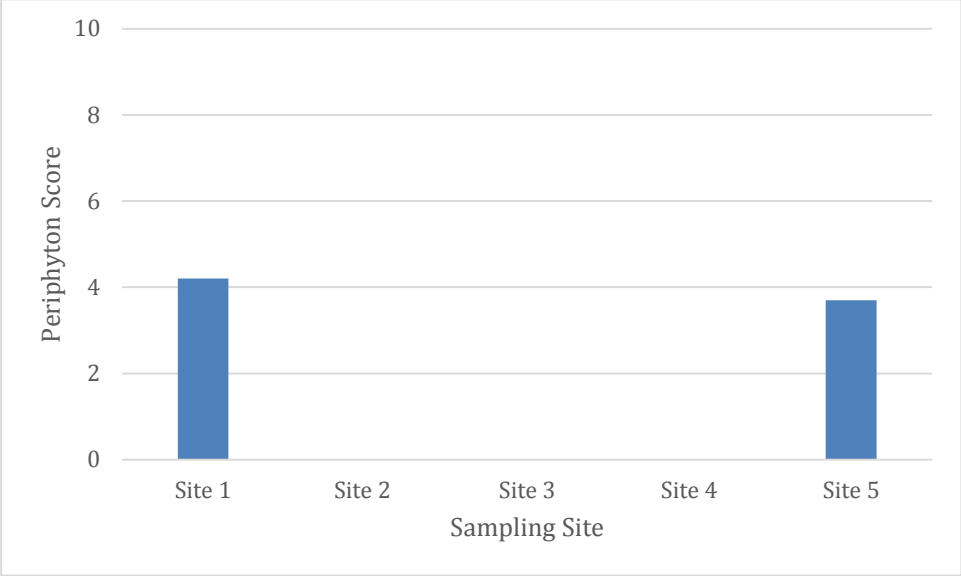



*Figure 5: Average Periphyton Biomass at Sampling Sites Upstream and Downstream of the Featherston Oxidation Ponds to Donald Creek, March 2013.*

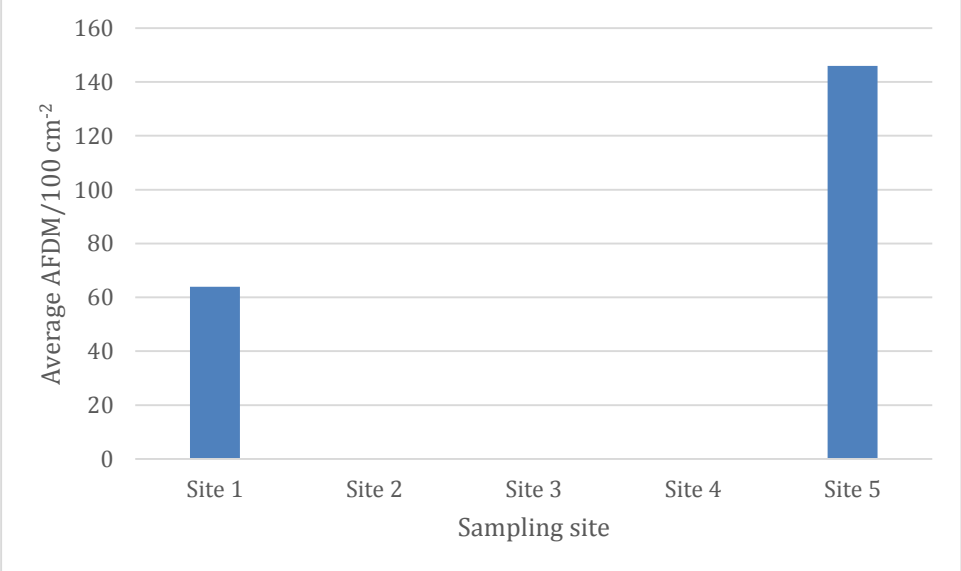



Table 1 provides an interpretation of periphyton scores (after Biggs and Kilroy, 2000) and on this basis; Figure 4 represents a change from slight to moderate levels of nutrient enrichment.

*Table 1: Interpretation of Periphyton scores (after Biggs and Kilroy, 2000).*

| |
|---|
| Score: 0 to 1.9<br>There are mainly long filamentous green algae at the site indicating that there is moderate to high enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments. |
| Score: 2 to 3.9<br>These communities suggest a moderate level of enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments. |
| Score: 4 to 5.9<br>These communities suggest slight enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone, recent volcanic rocks (central North Island), limestone or marble in their catchments. Clean stones can result from recent abrasion by flood flows or intense grazing by invertebrates/insects that live in the gravels. |
| Score: 6 to 7.9<br>These communities are generally composed of species that are able to grow under moderate to low nutrient conditions. These communities also usually grow back first after a flood has removed previous growths, but may be out-grown by filamentous algae if nutrient levels are sufficiently high. |
| Score: 8 to 10<br>These communities usually signify low concentrations of nutrients and/or intensive grazing by invertebrates/insects that live among the gravels. |

Periphyton cover was highest at Site 5 downstream of the oxidation pond discharge and exceeded the "nuisance value of 30% cover of filaments > 2cm long as proposed by Biggs and Kilroy 2000 for aesthetics / recreation and trout habitat and angling (see Appendix C2).

There was also a marked increase in the biomass of periphyton between the un-shaded upstream and downstream sampling sites in Donald Creek (see Figure 5).

However ,there was very little difference in periphyton scores between Sites 1 and 5 and it appeared likely that light limitation (because of the willow canopy and turbid water with high phytoplankton concentrations downstream of Site 2) masked the full potential effects of nutrient enrichment on periphyton growth at the un-shaded downstream site (Site 5).

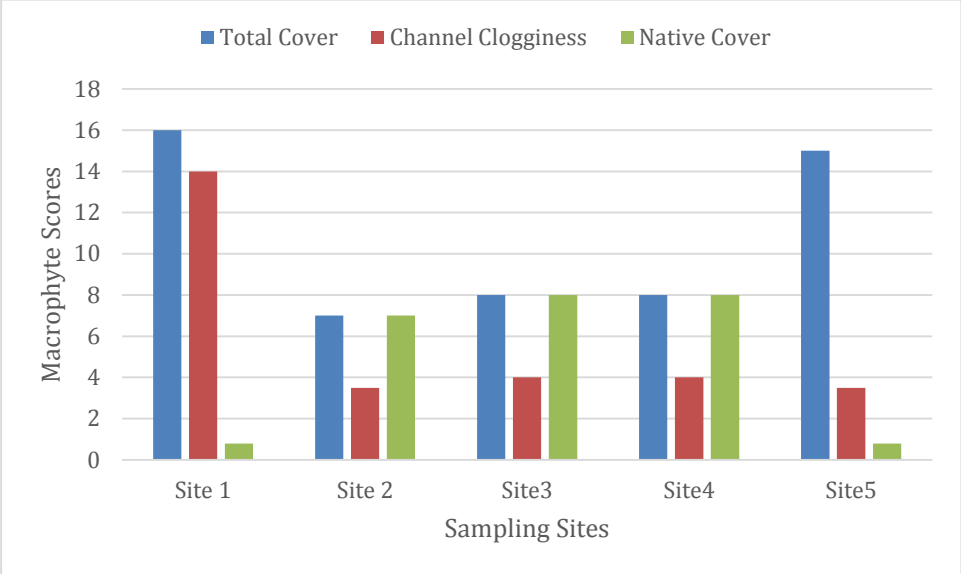
### 4.4 Description of Aquatic Macrophytes

Survey sheets for aquatic macrophytes are attached in Appendix C3 and are summarized in Figure 6.

There was a low (15- 16%) cover of aquatic macrophytes at the upstream site and downstream un-shaded sites (dominated by the submerged macrophyte *Elodea canadensis* and the sprawling emergent *Apium nodiflorum*) but there were no vascular aquatic macrophytes at Sites 2, 3 or 4, which were under a canopy of willow trees *(Salix spp*.) and blackberry (*Rubus fruiticosa*).

However, a native submerged moss (*Drepanocladus adnuncus*) and a native stonewort (*Nitella hookeri*) occurred under shaded conditions at Sites 2, 3 and 4 (see Appendix C3).

*Figure 6: the Total Cover, Channel Clogginess and Native Cover for macrophytes at Sampling Sites 1 to 5 in Donald Creek, March 2013.*




### 4.5 Macroinvertebrate Community Structure

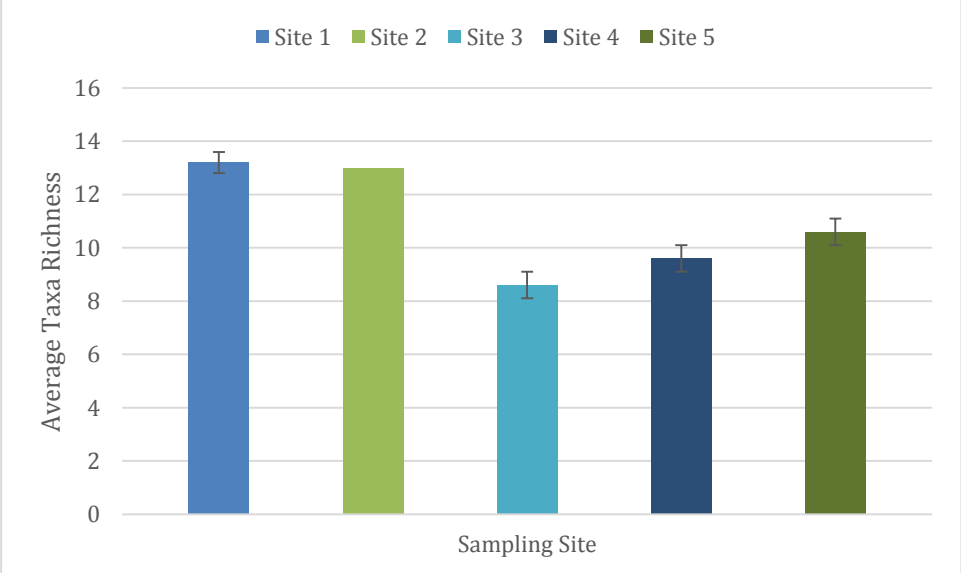
Metrics of macroinvertebrate community structure upstream and downstream of the discharge from the Featherston oxidation ponds are tabulated in Appendix D and summarised in Figures 7 to 13.

Error bars in Figures 7 to 13 are ± standard deviation of the mean estimate (where n = 5).

In Tables 2 to 8 (T-Test statistics), NSD = no significant difference in mean values; SD = significant difference in mean values (for 95% CI).

Average taxa richness for invertebrates (see Appendix D and Figure 7) reflects the "health" of instream communities and generally increases with increasing water quality, habitat diversity and / or habitat suitability.

*Figure 7: Average Taxa Richness at Sampling Sites 1 to 5 in Donald Creek, May 2013.*




There was no significant difference in average taxa richness upstream and downstream of the "polished" pond discharge (Sites 1 and 2) but there was a significant decrease of taxa richness upstream and downstream of the "un-polished" pond discharge to Donald Creek (see Figure 7 and Table 2).

*Table 2: Probability values for "two tailed" heteroscedastic T-Test for Average Taxa Richness, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 35% (N.S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 3 | | | 2% (S.D.) | 0% (S.D.) |
| Site 4 | | | 0% (S.D.) | 0% (S.D.) |

Average taxa richness remained significantly reduced at Site 5 relative to Site 1 (see Figure 7 and Table 2).

The average density of macroinvertebrates (see Figure 8 and Table 3) sampled with a 0.3 m x 0.3 m Surber Sampler upstream of the oxidation pond discharge was significantly lower at Sampling Sites 3, 4 and 5 relative to Sampling Site 1 (see Figure 8 and Table 2).

*Figure 8: Average density of macroinvertebrates per 0.09 $m^{-2}$ at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

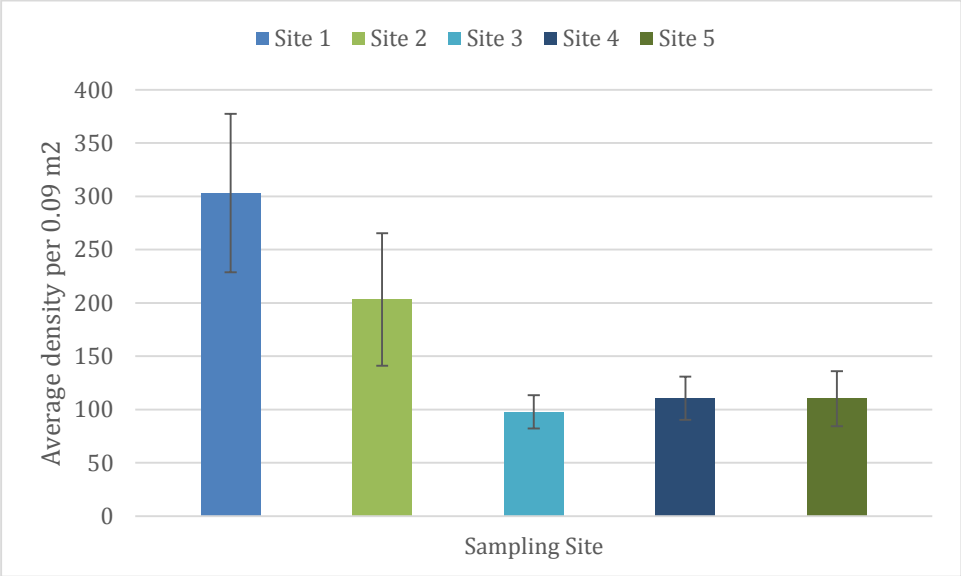



*Table 3: Probability values for "two tailed" heteroscedastic T-Test for Average Density, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 5% (N.S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | 1% (S.D.) | 1% (S.D.) | 1% (S.D.) |
| Site 3 | | | 30% | 39% (N.S.D.) |
| Site 4 | | | | 98% (N.S.D.) |

The calculated Macroinvertebrate Community Index (MCI see Appendix B, Figure 9 and Table 4) and Quantitative Macroinvertebrate Community Index (QMCI see Appendix B, Figure 10 and Table 5) rely on prior allocation of scores (tolerance values range from 0 to 10) to freshwater macroinvertebrates based upon their pollution tolerances (see Appendix D). Taxa that are characteristic of pristine conditions score more highly than taxa that may be found in "polluted" conditions.

The MCI and QMCI have been developed as a means of detecting organic pollution in communities inhabiting rock or gravel riffles.

Both the average MCI and the average QMCI were significantly lower downstream of the Featherston oxidation pond discharge relative to the sampling site upstream of the Featherston oxidation pond discharge (see Figures 9 and 10, and Table 2).

An MCI value of 80 to 100 and a QMCI value of 4 to 5 at the upstream sampling site indicated probable moderate pollution (Stark, 1998). An MCI value of less than 80 and a QMCI value of less than 4 at the downstream sampling sites indicated probable sever pollution (Stark, 1998).

*Figure 9: Average Macroinvertebrate Community Index (MCI) at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

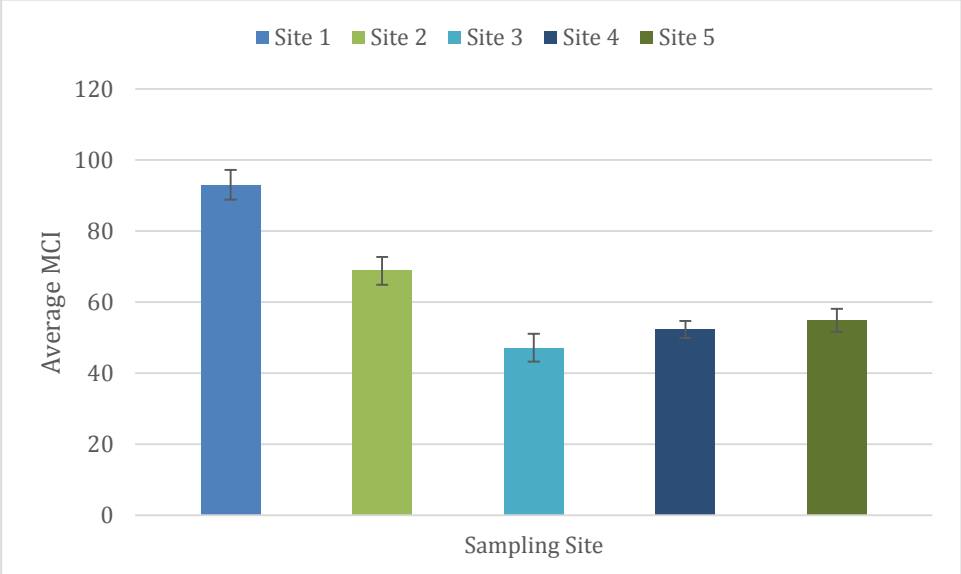



*Table 4: Probability values for "two tailed" heteroscedastic T-Test for Average MCI, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 3 | | | 4% (S.D.) | 1% (S.D.) |
| Site 4 | | | | 18% (N.S.D.) |

*Figure 10: Average Quantitative Macroinvertebrate Community Index (QMCI) at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

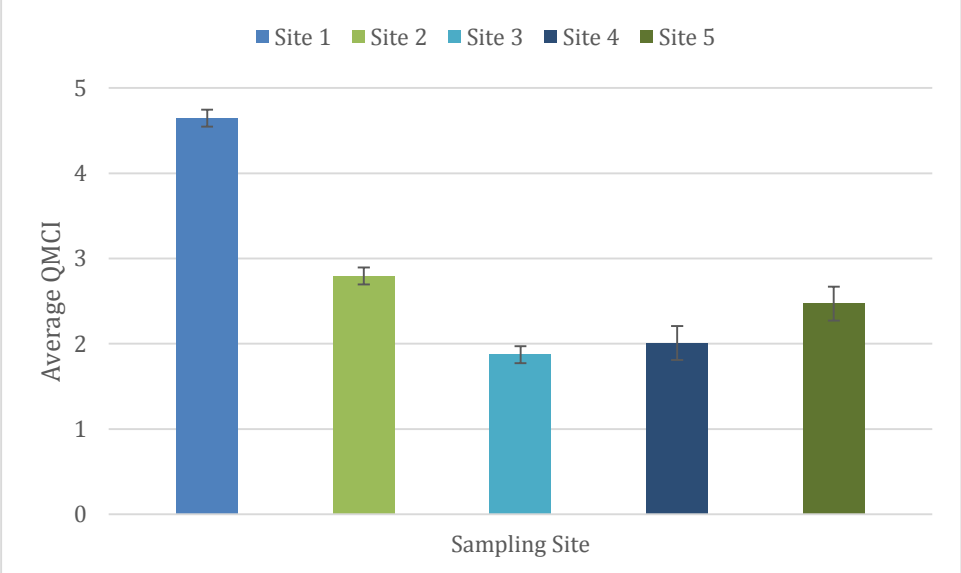



*Table 5: Probability values for "two tailed" heteroscedastic T-Test for Average QMCI, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | 0% (S.D.) | 0% (S.D.) | 2% (S.D.) |
| Site 3 | | | 12% (N.S.D.) | 0% (S.D.) |
| Site 4 | | | | 1% (S.D.) |

On the basis of both MCI and QMCI, the "un-polished" discharge from the oxidation ponds had a more significant adverse effect on instream community structure in Donald Creek than the "polished" discharge from the oxidation ponds (see Figures 9 and 10).

The EPT (Ephemeroptera, Plecoptera Trichoptera) Index (see Figure 11 and Table 6) is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera that are present at a sampling site and generally increases with increasing water quality. This value summarises taxa richness within the insect orders that are generally considered to be pollution sensitive.

*Figure 11: Average Ephemeroptera, Plecoptera, Trichoptera (EPT) Index at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

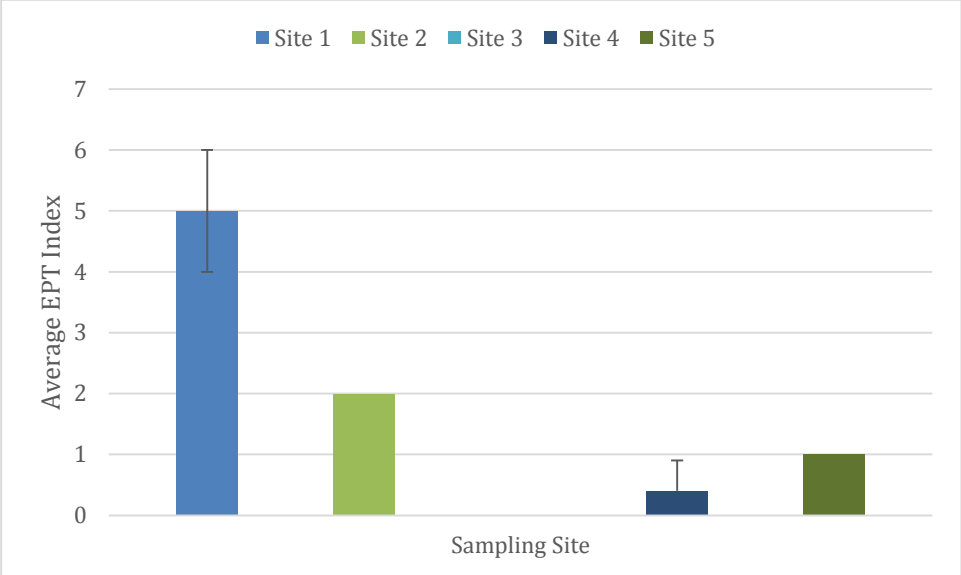



*Table 6: Probability values for "two tailed" heteroscedastic T-Test for Average EPT Index, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | (S.D.) | 0% (S.D.) | (S.D.) |
| Site 3 | | | (S.D.) | (S.D.) |
| Site 4 | | | | 4% (S.D.) |

As of March 2013, there was a significantly reduced EPT Index downstream of the "Polished" oxidation pond discharge relative to the upstream control site (see Figure 11 and Table 6 and no EPT taxa were present at Site 3 (downstream of the "un-polished discharge from the oxidation ponds).

The average percent EPT Taxa is generally highest in unimpaired, pristine sites little affected by eutrophication or nutrient enrichment. It was significantly higher upstream of the Featherston oxidation pond discharge to Donald Creek relative to downstream sampling sites (see Figure 12 and Table 7).

"Very Good" instream habitat for aquatic macroinvertebrates is associated with greater than 60% EPT Taxa: "Poor" instream habitat is associated with less than 10% EPT Taxa and "Moderate" instream habitat is associated with 10 to 60% EPT Taxa (Milne and Perrie, 2006). On this basis, the upstream sampling site was of moderate quality and the downstream site was on the borderline between poor and moderate quality (see Figure 12).

The average percent of EPT individuals was significantly higher upstream of the oxidation pond discharge relative to the downstream treated sampling site (see Figure 13 and Table 8.

*Figure 12: Average Percent Ephemeroptera, Plecoptera, Trichoptera Taxa (%EPT Taxa) at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

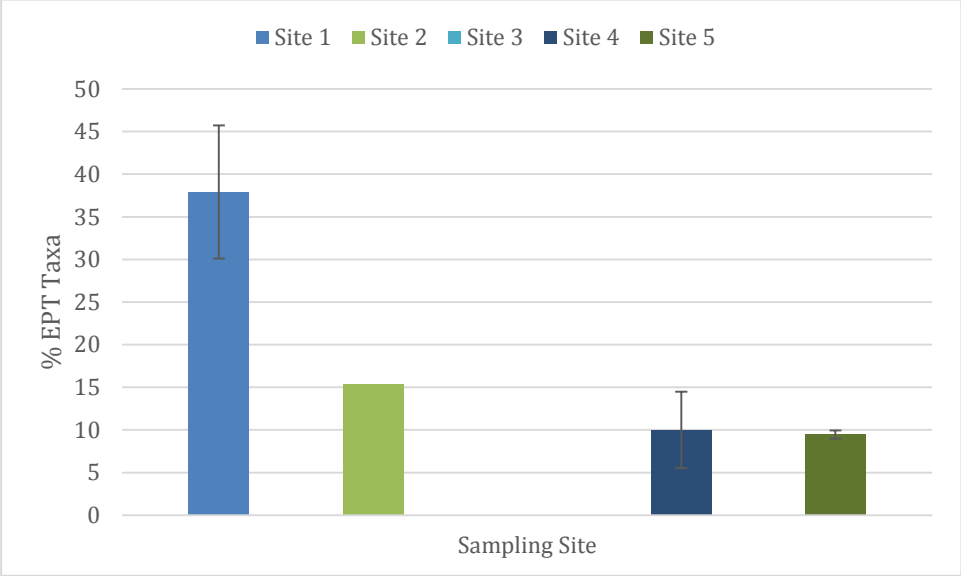



*Table 7: Probability values for "two tailed" heteroscedastic T-Test for Average % EPT Taxa, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 2 | | 0% (S.D.) | 0% (S.D.) | 0% (S.D.) |
| Site 3 | | | 0% (S.D.) | 0% (S.D.) |
| Site 4 | | | | 6% (N.S.D) |

*Figure 13: Average Percent Ephemeroptera, Plecoptera, Trichoptera Individuals (%EPT Individuals) at Sampling Sites 1 to 5 in Donald Creek, May 2013.*

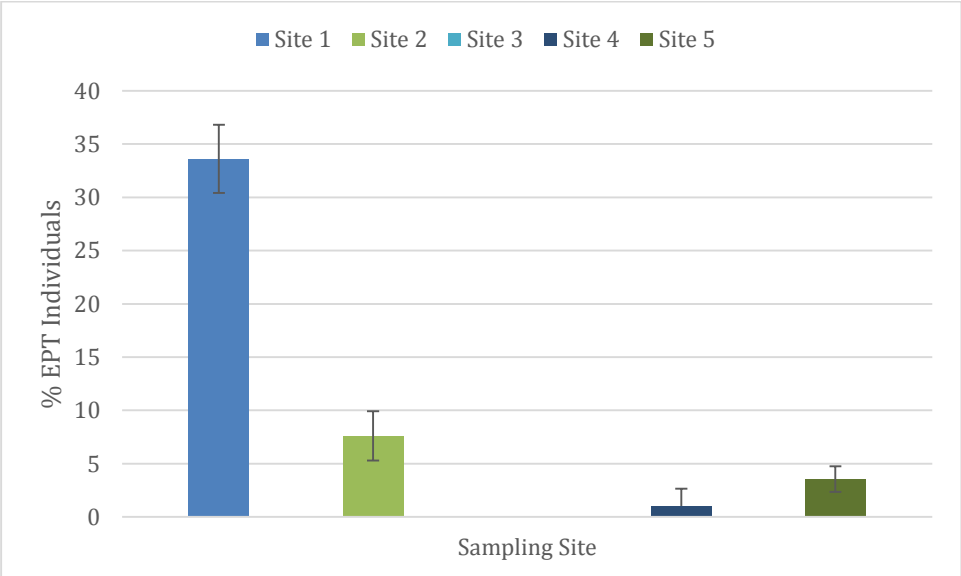



*Table 8: Probability values for "two tailed" heteroscedastic T-Test for Average % EPT Individuals, 04/03/13.*

| | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|
| Site 1 | 0% | 0% | 0% | 0% |
| Site 2 | | 0% | 0% | 1% |
| Site 3 | | | 19% | 0% |
| Site 4 | | | | 2% |

## 5.0 Findings and Conclusions

At the time of this survey, valid comparisons of the effect of water quality on instream community structure could be made at un-shaded sampling sites upstream and downstream of the oxidation pond discharges and at shaded sampling sites upstream and downstream of the oxidation pond discharges.

The oxidation pond discharges to Donald Creek were associated with a conspicuous change in water clarity due to high chlorophyll concentration in the oxidation ponds and increased embeddedness of the gravel substrate in Donald Creek due to suspended solids discharged from the oxidation ponds.

There was a low cover (c. 5%) of heterotrophic growths (sewage fungus complex) an 800 m reach of Donald Creek downstream of the discharges from the Featherston Oxidation Ponds.

Periphyton cover and biomass were higher at the un-shaded downstream sampling site relative to the un-shaded upstream control site but periphyton scores were similar at these two sites. Periphyton and vascular aquatic macrophytes were not a feature of the shaded sampling sites upstream or downstream of the oxidation pond discharges.

All of the metrics used to assess macroinvertebrate community structure indicated significantly compromised water quality downstream of the discharges from the Featherston oxidation ponds relative to an upstream control site, particularly downstream of the "un-polished discharge direct from the oxidation ponds.

Whilst there was some recovery of metrics of instream community structure at an unshaded control site 800 m downstream of the oxidation pond discharges, they all remained significantly reduced relative to the unshaded control site upstream of the oxidation pond discharges.

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Appendix A:

Consent No. WAR 970080
Category:

Discharge permit - water [2625]
Discharge permit -land [23139]
Discharge permit - air [20869]

Pursuant to sections 104, 104B, 105, 107 and 108, and subject to all the relevant provisions of the Resource Management Act 1991 and any regulations made thereunder, a consent in respect of a natural resource is hereby granted to:

| | |
|---|---|
| Name | South Wairarapa District Council |
| Address | PO Box 6. Martinborough |
| Duration of consent | Effective: 25 August 2009 Expires: 25 August 2012 |
| Purpose for which right is granted | To discharge contaminants to water, land, and air associated with the operation of the Featherston wastewater treatment plant |
| Location | Longwood West Road, Featherston, at or about map reference NZMS 260: S27: 2705187.6005162 |
| Legal description of land | Part Section 258 Featherston Suburban, Part Section 330 Featherston Suburban, I Part Section 331 Featherston Suburban |
| Conditions | 1 – 37 as attached |

For and on behalf of WELLINGTON REGIONAL COUNCIL

Manger, Environmental Regulation
Date: 24/9/09

Relevant Conditions

21. Once in either 2010 or 2011, during the period 31 January to 30 April inclusive and following at least a two week period without a significant flood event, an appropriately experienced and qualified freshwater ecologist shall carry out a quantitative ecological survey of the Donalds Creek upstream and downstream of the point of discharge for the purpose of determining the effect of the discharge on the aquatic ecosystem of the creek. The survey shall comprise as a minimum:

    A. An inspection of the streambed below the point of discharge (for a distance extending 100 m downstream of the discharge) for the presence of any nuisance heterotrophic or periphyton growths; and

    B. One upstream and one downstream periphyton and macroinvertebrate sampling site in the general locations outlined below (and agreed with Wellington Regional Council prior to sampling) that, where possible, share similar habitat features in terms of substrate, flow, depth and width:

        (i) Immediately upstream of the discharge, at or about Map Reference NZMS 260 S27 :053.051; and

        (ii) Approximately 100 m downstream of the discharge, at or about Map Reference NZMS 260 S27:053-050.

22. The periphyton survey shall include:

- An assessment of the percentage cover of both filamentous algae and algal mats (to nearest 5%) at 10 points across each of four transects encompassing both riffle and run habitat and extending across the width of the creek at each sampling site;

- Collection of a composite periphyton sample from riffle and run habitat (a composite of scraping from 10 rocks. 5 from a riffle and 5 from a run) across each sampling site using method QM-1a from the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000); and
- Analysis of periphyton samples for community composition and abundance using the Biggs & Kilroy (2000) relative abundance method, ash free dry weight and chlorophyll a.

23. The macroinvertebrate survey shall follow Protocols C3 and P3 from the Ministry for the Environment's report on protocols for sampling macroinvertebrates in wadeable streams (Stark et at. 2001). This shall involve:

- Collection of 5 replicate 0.1 $m^2$ Surber samples at random within a 20 m section of riffle habitat at each sampling site;
- Full count of the macroinvertebrate taxa within each replicate sample to the taxonomic resolution level specified for use of the Macroinvertebrate Community Index (MCI); and
- Enumeration of the results as taxa richness, MCI, QMCI, %EPT taxa and %EPT Individuals.

24. The results of the ecological survey shall be reported in writing to Manager Environmental Regulation, Wellington Regional Council by 1 June of the year in which the survey was undertaken.

Appendix B: Stream Habitat Assessment

Stream / River Name: Donald Creek (see Figures 1 and 2 for locality of sampling sites)

Date: 04.03.2013 Evaluators Name: BTC

| | *score* | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|---|
| Q1. Land use pattern beyond the immediate riparian zone | | | | | | |
| Undisturbed native forest | *40* | | | | | |
| Disturbed native forest | *30* | | | | | |
| Undisturbed exotic forest | *30* | | | | | |
| Disturbed exotic forest | *20* | | | | | |
| Mixture of shrub and pasture | *10* | | | | | |
| Intensive pastoral farming | *5* | 5 | 5 | 5 | 5 | 5 |
| Horticultural / Urban | *1* | | | | | |
| Q2. Width of riparian zone from stream edge to field/forest | | | | | | |
| Riparian zone > 30 m wide | *30* | | | | | |
| Riparian zone varying from 5-30 m | *20* | | 20 | 20 | 20 | |
| Riparian zone 1 - 5 m | *5* | 5 | | | | 5 |
| Riparian zone absent | *1* | | | | | |
| Q3 Completeness of riparian zone | | | | | | |
| Riparian zone intact without breaks in vegetation | *30* | | 30 | 30 | 30 | |
| Breaks occurring at intervals of > 50 m | *20* | | | | | |
| Breaks frequent with some gullies and scars | *5* | 5 | | | | 5 |
| Deeply scarred with gullies all along its length | *1* | | | | | |
| Q4 Stream-side cover | | | | | | |
| Dominant vegetation is shrub | *20* | | | | | |
| Dominant vegetation is of tree form | *10* | | 10 | 10 | 10 | |
| Dominant vegetation is grass | *5* | 5 | | | | 5 |
| Over 50% of the stream bank has no vegetation | *1* | | | | | |
| Q5 Bank stability | | | | | | |
| Bank stable. No evidence of erosion or bank failure. Side slopes generally < 30% | *20* | | | | | |
| Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. | *10* | 10 | 10 | 10 | 10 | 10 |
| Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. | *5* | | | | | |
| Unstable. Many eroded areas. Side slopes > 60% common. "Raw areas" frequent along straight sections and banks. | *1* | | | | | |
| Q6. Channel structure. | | | | | | |
| Little or no enlargement of islands or point bars, and/or no channelisation. | *20* | | | | | |
| Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present | *10* | | | | | |
| Moderate deposition of new gravel, coarse sand on old & new bars; pools part filled with silt; and/or embankments both sides. | *5* | 5 | | | | 5 |
| Heavy deposits of fine material, increased bar development; most pools filled with sediment; . and/or extensive channelisation | *1* | | 1 | 1 | 1 | |

| | *score* | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|---|
| Q7 Pool/riffle; Run/bend ratio (av. distance between riffles OR bends divided by the average stream width. | | | | | | |
| Ratio of 5-7. Variety of habitat. Deep riffles & pools | *20* | | | | | |
| 7-15. Adequate depth in pools and riffles. Bends provide habitat. | *10* | | | | | |
| 15-20. Occasional riffle or bend. Bottom contours provide some habitat. | *5* | 5 | | | | 5 |
| > 25. Essentially a straight stream. Generally all flat water or shallow riffles. Poor habitat. | *1* | | 1 | 1 | 1 | |
| Q8. Bottom substrate/available cover. | | | | | | |
| Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat | *20* | | | | | |
| 30-50% rubble, gravel or other stable habitat. Adequate habitat. | *10* | 10 | | | | 10 |
| 10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. | *5* | | 5 | 5 | 5 | |
| Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. | *1* | | | | | |
| Q9 Embeddedness. | | | | | | |
| Gravel, cobble, and boulder particles are between 0 and 25% surrounded by fine sediment. | *20* | | | | | |
| Gravel, cobble, and boulder particles are between 25 and 50% surrounded by fine sediment. | *10* | 10 | | | | |
| Gravel, cobble, and boulder particles are between 50 and 75% surrounded by fine sediment. | *5* | | | | | 5 |
| Gravel, cobble, and boulder particles are between 75 and 100% surrounded by fine sediment. | *1* | | 1 | 1 | 1 | |
| Q10. Periphyton Cover. | | | | | | |
| Periphyton not visible on hand held stones | *25* | | | | | |
| Visible on bed covering few surfaces, < 20% cove | *15* | | 15 | 15 | 15 | |
| Visible on bed covering many surfaces, 20-50% c | *10* | | | | | |
| Visible on bed covering most surfaces, 50-80% co | *5* | 5 | | | | |
| Visible as complete cover of bed, 80-100% cover | *1* | | | | | 1 |
| Q11 Macrophyte Abundance | | | | | | |
| Macrophytes absent | *20* | | | | | |
| Submerged and/or Emergent macrophytes present | *10* | | 10 | 10 | 10 | |
| Submerged macrophytes abundant | *5* | | | | | |
| Emergent macrophytes abundant | *1* | 1 | | | | 1 |
| Site Score | | 66 | 108 | 108 | 108 | 57 |

Appendix C1: Periphyton Database - Relative Abundance of Taxa.

| d | dominant | p | present as sub-dominant |
|---|---|---|---|

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| Assorted Diatoms | p | | | | p |
| *Chroodactyton sp.* | p | | | | p |
| *Cladophora glomerata* | | | | | p |
| *Cladophora sp.* | p | | | | p |
| *Cocconeis placentula* | p | | | | p |
| *Cymbella kappii* | p | | | | p |
| *Encyonema sp* | p | | | | |
| *Epithemia sorex,* | p | | | | |
| *Fragilaria vaucheriae* | p | | | | d |
| *Gomphonema spp.* | p | | | | p |
| *Melosira varians* | p | | | | |
| *Microspora sp.* | p | | | | p |
| *Mougeotia sp.* | p | | | | |
| *Navicula spp.* | p | | | | p |
| *Nitzchia spp.* | p | | | | p |
| *Nostoc sp.* | p | | | | p |
| *Oedogonium spp.* | p | | | | p |
| *Oscillatoria spp.* | p | | | | p |
| *Phormidium spp.* | p | | | | |
| *Rhizoclonium sp.* | p | | | | |
| *Sphaerotilus natans** | | | p | p | p |
| *Spirogyra sp.* | p | | | | p |
| *Stigeoclonium tenue* | d | | | | |
| *Synedra ulna* | p | | | | p |
| *Tabellaria flocculosa* | | | | | p |
| *Tribonema sp.* | | | | | p |
| *Ulothrix zonata* | p | | | | p |
| *Vaucheria sp* | p | | | | p |

** a member of the "sewage gungus complex" that it technically a heterotrophic bacterium* rather than an autotrophic component of the periphyton community.

Appendix C2: Periphyton Cover and Biomass Database (after Biggs and Kilroy, 2000).

Site 1 Date: 04.03.2013

Periphyton Cover on Individual Stones / Samples

| | | | Stone / Sample Number: | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Riffle | | | | | | | | | | Run | | | | | | | | | |
| | | Periphyton | Transect 1 | | | | | Transect 2 | | | | | Transect 3 | | | | | Transect 4 | | | | |
| | | Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thin mat/film: | green | 7 | | | | | | | | | | | | | | | | | | | | |
| (under 0.5 mm thick) | light brown | 10 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | black/dark brown | 10 | 5 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 5 |
| Medium mat: | green | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 |
| (0.5-3 mm thick) | light brown | 7 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 5 | 0 |
| | black/dark brown | 9 | 5 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thick mat: | green/ light brown | 4 | | | | | | | | | | | | | | | | | | | | |
| (over 3 mm thick) | black/dark brown | 7 | | | | | | | | | | | | | | | | | | | | |
| Filaments, short | green | 5 | 0 | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 10 | 0 | 5 | 0 | 0 | 0 |
| (under 2 cm long) | brown/reddish | 5 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| Filaments, long | green | 1 | 25 | 50 | 0 | 0 | 70 | 25 | 0 | 0 | 0 | 50 | 5 | 0 | 0 | 10 | 25 | 0 | 0 | 0 | 15 | 25 |
| (over 2 cm long) | brown/reddish | 4 | | | | | | | | | | | | | | | | | | | | |
| (a) Total % Periphyton on stone surface | | | 35 | 60 | 5 | 15 | 75 | 25 | 20 | 10 | 0 | 60 | 15 | 10 | 10 | 20 | 35 | 15 | 5 | 5 | 20 | 30 |
| (b) List of: | | | 50 | 50 | 25 | 50 | 25 | 25 | 100 | 50 | 0 | 70 | 100 | 45 | 50 | 35 | 25 | 50 | 25 | 25 | 35 | 50 |
| percentage cover x score | | | 45 | 50 | | 70 | 70 | | 90 | | | 50 | 5 | 25 | | 10 | | 50 | | | 15 | 25 |
| for that type of periphyton | | | 25 | | | | | | | | | | | | | | | | | | | |
| (c) Sum of all multiplied % scores | | | 120 | 100 | 25 | 120 | 95 | 25 | 190 | 50 | 0 | 120 | 105 | 70 | 50 | 45 | 25 | 100 | 25 | 25 | 50 | 75 |
| (d) Average score per stone/sample [(c) / (a)] | | | 3.4 | 1.7 | 5.0 | 8.0 | 1.3 | 1.0 | 9.5 | 5.0 | 0.0 | 2.0 | 7.0 | 7.0 | 5.0 | 2.3 | 0.7 | 6.7 | 5.0 | 5.0 | 2.5 | 2.5 |
| (e) Total of all average scores in line (d) | | | 80.5 | | | | | | | | | | | | | | | | | | | |
| (f) Total average periphyton score [d/sample#] | | | 4.2 | | | | | | | | | | | | | | | | | | | |

| | | Stone / Sample Number: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transect 1 | | | | | Transect 3 | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 11 | 12 | 13 | 14 | 15 |
| Ash Free Dry Mass (AFDM) | mg | 135 | | | | | 97 | | | | |
| stone surface area sampled* | $cm^{-2}$ | 22 | 32 | 39 | 44 | 51 | 48 | 23 | 38 | 24 | 41 |
| Ash Free Dry Mass (AFDM) | $mg/100cm^{-2}$ | 72 | | | | | 56 | | | | |

average of 64 $mg/100cm^{-2}$

*Stone surface area (cm2) = 1.59 + 0.811 (xy + yz + xz) where x, y and z are the lengths of the three main axes of the stones in centimetres.
Formula has been adjusted to only include the area of the stone normally protruding into the water on which the periphyton can colonise (~ 65 % of total).

Appendix C2: Periphyton Cover and Biomass Database (after Biggs and Kilroy, 2000).

Site 2 Date: 04.03.2013

| Periphyton Cover on Individual Stones | | | Stone / Sample Number: | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Riffle | | | | | | | | | | Run | | | | | | | | |
| | | Periphyton | Transect 1 | | | | | Transect 2 | | | | | Transect 3 | | | | | Transect 4 | | | | |
| | | Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thin mat/film: | green | 7 | | | | | | | | | | | | | | | | | | | | |
| (under 0.5 mm thick) | light brown | 10 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 10 | | | | | | | | | | | | | | | | | | | | |
| Medium mat: | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (0.5-3 mm thick) | light brown | 7 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 9 | | | | | | | | | | | | | | | | | | | | |
| Thick mat: | green/ light brown | 4 | | | | | | | | | | | | | | | | | | | | |
| (over 3 mm thick) | black/dark brown | 7 | | | | | | | | | | | | | | | | | | | | |
| Filaments, short | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (under 2 cm long) | brown/reddish | 5 | | | | | | | | | | | | | | | | | | | | |
| Filaments, long | green | 1 | | | | | | | | | | | | | | | | | | | | |
| (over 2 cm long) | brown/reddish | 4 | | | | | | | | | | | | | | | | | | | | |
| (a) Total % Periphyton on stone surface | | | | | | | | | | | | | | | | | | | | | | |
| (b) List of: percentage cover x score for that type of periphyton | | | | | | | | | | | | | | | | | | | | | | |
| (c) Sum of all multiplied % scores | | | | | | | | | | | | | | | | | | | | | | |
| (d) Average score per stone/sample [(c) / (a)] | | | | | | | | | | | | | | | | | | | | | | |
| (e) Total of all average scores in line (d) | | | | | | | | | | | | | | | | | | | | | | |
| (f) Total average periphyton score [d/sample#] | | | | | | | | | | | | | | | | | | | | | | |

No attached periphyton under heavily shaded conditions

Planktonic algae from ovidation ponds present in water column and forming scum at water level and on mosses

Appendix C2: Periphyton Cover and Biomass Database (after Biggs and Kilroy, 2000).

Site 3 Date: 04.03.2013

| Periphyton Cover on Individual Stones | | | Stone Number: | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Periphyton | Transect 1 | | | | | Transect 2 | | | | | Transect 3 | | | | | Transect 4 | | | | |
| | | Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thin mat/film: | green | 7 | | | | | | | | | | | | | | | | | | | | |
| (under 0.5 mm thick) | light brown | 10 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 10 | | | | | | | | | | | | | | | | | | | | |
| Medium mat: | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (0.5-3 mm thick) | light brown | 7 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 9 | | | | | | | | | | | | | | | | | | | | |
| Thick mat: | green/ light brown | 4 | | | | | | | | | | | | | | | | | | | | |
| (over 3 mm thick) | black/dark brown | 7 | | | | | | | | | | | | | | | | | | | | |
| Filaments, short | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (under 2 cm long) | brown/reddish | 5 | | | | | | | | | | | | | | | | | | | | |
| Filaments, long | green | 1 | | | | | | | | | | | | | | | | | | | | |
| (over 2 cm long) | brown/reddish | 4 | | | | | | | | | | | | | | | | | | | | |
| (a) Total % Periphyton on stone surface | | | | | | | | | | | | | | | | | | | | | | |
| (b) List of: percentage cover x score for that type of periphyton | | | | | | | | | | | | | | | | | | | | | | |
| (c) Sum of all multiplied % scores | | | | | | | | | | | | | | | | | | | | | | |
| (d) Average score per stone/sample [(c) / (a)] | | | | | | | | | | | | | | | | | | | | | | |
| (e) Total of all average scores in line (d) | | | | | | | | | | | | | | | | | | | | | | |
| (f) Total average periphyton score [d/sample#] | | | | | | | | | | | | | | | | | | | | | | |

No attached periphyton under heavily shaded conditions

Planktonic algae from ovidation ponds present in water column and forming scum at water level and on mosses

Appendix C2: Periphyton Cover and Biomass Database (after Biggs and Kilroy, 2000).

Site 4 Date: 04.03.2013

| Periphyton Cover on Individual Stones / Samples | | | Stone / Sample Number: | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Riffle | | | | | | | | | | Run | | | | | | | | |
| | | Periphyton | Transect 1 | | | | | Transect 2 | | | | | Transect 3 | | | | | Transect 4 | | | | |
| | | Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thin mat/film: | green | 7 | | | | | | | | | | | | | | | | | | | | |
| (under 0.5 mm thick) | light brown | 10 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 10 | | | | | | | | | | | | | | | | | | | | |
| Medium mat: | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (0.5-3 mm thick) | light brown | 7 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 9 | | | | | | | | | | | | | | | | | | | | |
| Thick mat: | green/ light brown | 4 | | | | | | | | | | | | | | | | | | | | |
| (over 3 mm thick) | black/dark brown | 7 | | | | | | | | | | | | | | | | | | | | |
| Filaments, short | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (under 2 cm long) | brown/reddish | 5 | | | | | | | | | | | | | | | | | | | | |
| Filaments, long | green | 1 | | | | | | | | | | | | | | | | | | | | |
| (over 2 cm long) | brown/reddish | 4 | | | | | | | | | | | | | | | | | | | | |
| (a) Total % Periphyton on stone surface | | | | | | | | | | | | | | | | | | | | | | |
| (b) List of: percentage cover x score for that type of periphyton | | | | | | | | | | | | | | | | | | | | | | |
| (c) Sum of all multiplied % scores | | | | | | | | | | | | | | | | | | | | | | |
| (d) Average score per stone/sample [(c) / (a)] | | | | | | | | | | | | | | | | | | | | | | |
| (e) Total of all average scores in line (d) | | | | | | | | | | | | | | | | | | | | | | |
| (f) Total average periphyton score [d/sample#] | | | | | | | | | | | | | | | | | | | | | | |

No attached periphyton under heavily shaded conditions

Planktonic algae from ovidation ponds present in water column and forming scum at water level and on mosses

Appendix C2: Periphyton Cover and Biomass Database (after Biggs and Kilroy, 2000).

Site 5 Date: 04.03.2013

Periphyton Cover on Individual Stones / Samples

| | | | Stone / Sample Number: | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Riffle | | | | | | | | | | Run | | | | | | | | | |
| | | Periphyton | Transect 1 | | | | | Transect 2 | | | | | Transect 3 | | | | | Transect 4 | | | | |
| | | Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thin mat/film: | green | 7 | | | | | | | | | | | | | | | | | | | | |
| (under 0.5 mm thick) | light brown | 10 | | | | | | | | | | | | | | | | | | | | |
| | black/dark brown | 10 | | | | | | | | | | | | | | | | | | | | |
| Medium mat: | green | 5 | 0 | 0 | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 50 | 0 |
| (0.5-3 mm thick) | light brown | 7 | 0 | 10 | 0 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 75 | 40 | 80 | 0 | 25 | 0 | 60 |
| | black/dark brown | 9 | 0 | 0 | 0 | 0 | 0 | 20 | 10 | 0 | 0 | 0 | 25 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 |
| Thick mat: | green/ light brown | 4 | | | | | | | | | | | | | | | | | | | | |
| (over 3 mm thick) | black/dark brown | 7 | | | | | | | | | | | | | | | | | | | | |
| Filaments, short | green | 5 | | | | | | | | | | | | | | | | | | | | |
| (under 2 cm long) | brown/reddish | 5 | | | | | | | | | | | | | | | | | | | | |
| Filaments, long | green | 1 | 100 | 80 | 0 | 60 | 80 | 60 | 50 | 10 | 100 | 100 | 25 | 0 | 0 | 25 | 30 | 20 | 10 | 0 | 0 | 25 |
| (over 2 cm long) | brown/reddish | 4 | | | | | | | | | | | | | | | | | | | | |
| (a) Total % Periphyton on stone surface | | | 100 | 90 | 10 | 80 | 100 | 80 | 70 | 10 | 100 | 100 | 100 | 10 | 0 | 100 | 90 | 100 | 10 | 25 | 70 | 85 |
| (b) List of: | | | 100 | 70 | 50 | 140 | 140 | 180 | 50 | 10 | 100 | 100 | 250 | 90 | | 525 | 100 | 560 | 10 | 175 | 250 | 420 |
| percentage cover x score | | | | 80 | | 60 | 80 | 60 | 90 | | | | 225 | | | 25 | 280 | 20 | | | 180 | |
| for that type of periphyton | | | | | | | | | 50 | | | | 25 | | | | 30 | | | | | |
| (c) Sum of all multiplied % scores | | | 100 | 150 | 50 | 200 | 220 | 240 | 190 | 10 | 100 | 100 | 500 | 90 | 0 | 550 | 410 | 580 | 10 | 175 | 430 | 420 |
| (d) Average score per stone/sample [(c) / (a)] | | | 1.0 | 1.7 | 5.0 | 2.5 | 2.2 | 3.0 | 2.7 | 1.0 | 1.0 | 1.0 | 5.0 | 9.0 | 0.0 | 5.5 | 4.6 | 5.8 | 1.0 | 7.0 | 6.1 | 4.9 |
| (e) Total of all average scores in line (d) | | | 70.0 | | | | | | | | | | | | | | | | | | | |
| (f) Total average periphyton score [d/sample#] | | | 3.7 | | | | | | | | | | | | | | | | | | | |

| | | Stone / Sample Number: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transect 1 | | | | | Transect 3 | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 11 | 12 | 13 | 14 | 15 |
| Ash Free Dry Mass (AFDM) | mg | 209 | | | | | 313 | | | | |
| stone surface area sampled* | $cm^{-2}$ | 30 | 25 | 43 | 53 | 34 | 34 | 29 | 55 | 28 | 30 |
| Ash Free Dry Mass (AFDM) | $mg/100cm^{-2}$ | 113 | | | | | 178 | | | | |

average of 146 $mg/100cm^{-2}$

*Stone surface area (cm2) = 1.59 + 0.811 (xy + yz + xz) where x, y and z are the lengths of the three main axes of the stones in centimetres.

Formula has been adjusted to only include the area of the stone normally protruding into the water on which the periphyton can colonise (~ 65 % of total).

Appendix C3: Stream Survey Sheet 4: Macrophyte Cover and Scores.

| Client / Job Code: SWDC Featherston WWTP. | | | | | | | Date: 04 March 2013 | | | Assessed by: BTC |
|---|---|---|---|---|---|---|---|---|---|---|
| Site 1 | | | | | | | | | | |
| | | | Vegetation Cover (% Wetted Area of Channel) | | | | | | | |
| | | | | Submerged Plants | | | | | Emergent Plants | |
| Transect | Wetted Width (m) | Channel Width (m) | Overall Cover | Total Cover | Surface reaching | | Sub-Surface | | Total Cover | Taxa |
| | | | | | sub-total | Taxa | sub-total | Taxa | | |
| 1 | 1.9 | 2.5 | 15 | 5 | 0 | | 5 | Ec (5%) | 10 | An (10%) |
| 2 | 1.2 | 2.1 | 20 | 10 | 5 | Ec (5%) | 5 | Ec (3%)<br>Nh (2%) | 10 | An (5%)<br>Rc (3%)<br>Gr (2%) |
| 3 | 0.7 | 1.9 | 10 | 0 | 0 | | 0 | | 10 | An (10%) |
| 4 | 1.4 | 2.5 | 15 | 0 | 0 | | 0 | | 15 | An (10%)<br>Gr (5%) |
| 5 | 1.6 | 2.3 | 20 | 10 | 0 | | 10 | Ec (8%)<br>Nh (2%) | 10 | Gr (5%)<br>An (5%) |
| Totals | | | 80 | 25 | 5 | | 20 | | 55 | |

Site 1 Macrophyte Total Cover (%) 16
Site 1 Macrophyte Channel Clogginess (%) 14
Site 1 Macrophyte Native Cover (%) 0.8

Ec = *Elodea canadensis*
Nh = *Nitella hookeri*
An = *Apium nodiflorum*
Rc = *Rubus fruticosa*
Gr = Assorted grasses
Da=*Drepanocladus adnuncu* s (moss)

Appendix C3: Stream Survey Sheet 4: Macrophyte Cover and Scores.

| Client / Job Code: SWDC Featherston WWTP. | | | | | | | Date: 04 March 2013 | | | Assessed by: BTC |
|---|---|---|---|---|---|---|---|---|---|---|
| Site 2 | | | | | | | | | | |
| | | | Vegetation Cover (% Wetted Area of Channel) | | | | | | | |
| | | | | Submerged Plants | | | | | Emergent Plants | |
| | | | | | Surface reaching | | Sub-Surface | | Total | |
| Transect | Wetted Width (m) | Channel Width (m) | Overall Cover | Total Cover | sub-total | Taxa | sub-total | Taxa | Cover | Taxa |
| 1 | 1.9 | 3.3 | 5 | 5 | 0 | | 5 | Da (3%) | closed | |
| | | | | | | | | Nh (2%) | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 2 | 2.2 | 3.1 | 0 | 0 | 0 | | 0 | | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 3 | 2.3 | 2.9 | 0 | 0 | 0 | | 0 | | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 4 | 1.8 | 2.8 | 20 | 20 | 0 | | 20 | Da (15%) | closed | |
| | | | | | | | | Nh (5%) | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 5 | 2.4 | 3.1 | 10 | 10 | 0 | | 10 | Nh (10%) | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| Totals | | | 35 | 35 | 0 | | 35 | | 0 | |

Site 2 Macrophyte Total Cover (%) 7
Site 2 Macrophyte Channel Clogginess (%) 3.5
Site 2 Macrophyte Native Cover (%) 7

Ec = *Elodea canadensis*
Nh = *Nitella hookeri*
An = *Apium nodiflorum*
Rc = *Rubus fruticosa*
Gr = Assorted grasses
Da=*Drepanocladus adnuncu* s (moss)

Appendix C3: Stream Survey Sheet 4: Macrophyte Cover and Scores.

| Client / Job Code: SWDC Featherston WWTP. | Date: 04 March 2013 | Assessed by: BTC |
|---|---|---|

Site 3

| Transect | Wetted Width (m) | Channel Width (m) | Vegetation Cover (% Wetted Area of Channel) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Overall Cover | Total Cover | Submerged Plants | | | | Emergent Plants | |
| | | | | | Surface reaching | | Sub-Surface | | Total | |
| | | | | | sub-total | Taxa | sub-total | Taxa | Cover | Taxa |
| 1 | 1.9 | 1 | 0 | 0 | | | 0 | | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 2 | 2.6 | 2.1 | 10 | 10 | | | 10 | Da (3%) | closed | |
| | | | | | | | | Nh (2%) | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 3 | 3.3 | 2.6 | 10 | 10 | | | 10 | Da (8%) | closed | |
| | | | | | | | | Nh (2%) | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 4 | 2.5 | 1.9 | 10 | 10 | | | 10 | Da (10%) | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 5 | 2.7 | 2.4 | 10 | 10 | | | 10 | Da (5%) | closed | |
| | | | | | | | | Nh (5%) | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| Totals | | | 40 | 40 | 0 | | 40 | | 0 | |

Site 3 Macrophyte Total Cover (%) 8

Site 3 Macrophyte Channel Clogginess (%) 4

Site 3 Macrophyte Native Cover (%) 8

Ec = *Elodea canadensis*
Nh = *Nitella hookeri*
An = *Apium nodiflorum*
Rc = *Rubus fruticosa*
Gr = Assorted grasses
Da=*Drepanocladus adnuncu* s (moss)

Appendix C3: Stream Survey Sheet 4: Macrophyte Cover and Scores.

| Client / Job Code: SWDC Featherston WWTP. | | | | | | | Date: 04 March 2013 | | Assessed by: BTC | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site 4 | | | | | | | | | | |
| | | | Vegetation Cover (% Wetted Area of Channel) | | | | | | | |
| | | | | Submerged Plants | | | | | Emergent Plants | |
| Transect | Wetted Width (m) | Channel Width (m) | | Total Cover | Surface reaching sub-total | Surface reaching Taxa | Sub-Surface sub-total | Sub-Surface Taxa | Total Cover | Taxa |
| 1 | 1.9 | 2.3 | 5 | 5 | 0 | | 5 | Da (5%) | closed willow / blackberry canopy | |
| 2 | 1.9 | 2.2 | 5 | 5 | | | 5 | Da (3%)<br>Nh (2%) | closed willow / blackberry canopy | |
| 3 | 1.7 | 1.9 | 15 | 15 | 0 | | 15 | Da (15%) | closed willow / blackberry canopy | |
| 4 | 2.0 | 2.3 | 10 | 10 | 0 | | 10 | Da (5%)<br>Nh (5%) | closed willow / blackberry canopy | |
| 5 | 1.6 | 2.1 | 5 | 5 | 0 | | 5 | Da (3%)<br>Nh (2%) | closed willow / blackberry canopy | |
| Totals | | | 40 | 40 | 0 | | 40 | | 0 | |

| | |
|---|---|
| Site 4 Macrophyte Total Cover (%) | 8 |
| Site 4 Macrophyte Channel Clogginess (%) | 4 |
| Site 4 Macrophyte Native Cover (%) | 8 |

Ec = *Elodea canadensis*
Nh = *Nitella hookeri*
An = *Apium nodiflorum*
Rc = *Rubus fruticosa*
Gr = Assorted grasses
Da=*Drepanocladus adnuncu* s (moss)

Appendix C3: Stream Survey Sheet 4: Macrophyte Cover and Scores.

| Client / Job Code: SWDC Featherston WWTP. | | | | | | | Date: 04 March 2013 | | Assessed by: BTC | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site 5 | | | | | | | | | | |
| | | | Vegetation Cover (% Wetted Area of Channel) | | | | | | | |
| | | | | Submerged Plants | | | | | Emergent Plants | |
| Transect | Wetted Width (m) | Channel Width (m) | Overall Cover | Total Cover | Surface reaching | | Sub-Surface | | Total Cover | Taxa |
| | | | | | sub-total | Taxa | sub-total | Taxa | | |
| 1 | 1.2 | 2.3 | 20 | 10 | 0 | | 10 | Ec (10%) | closed | An (10%) |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 2 | 1.4 | 2.4 | 15 | 10 | 5 | Ec (5%) | 5 | Ec (3%) | closed | An (2%) |
| | | | | | | | | Nh (2%) | willow / | Rc (2%) |
| | | | | | | | | | blackberry | Gr (1%) |
| | | | | | | | | | canopy | |
| 3 | 1.3 | 2.4 | 10 | 0 | 0 | | 0 | | closed | An (10%) |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 4 | 1.4 | 2.2 | 5 | 5 | 0 | | 5 | Ec (5%) | closed | |
| | | | | | | | | | willow / | |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| 5 | 1.3 | 2.1 | 25 | 5 | 0 | | 5 | Ec (3%) | closed | Gr (15%) |
| | | | | | | | | Nh (2%) | willow / | An (5%) |
| | | | | | | | | | blackberry | |
| | | | | | | | | | canopy | |
| Totals | | | 75 | 30 | 5 | | 25 | | 0 | |

Site 5 Macrophyte Total Cover (%) 15
Site 5 Macrophyte Channel Clogginess (%) 3.5
Site 5 Macrophyte Native Cover (%) 0.8

Ec = *Elodea canadensis*
Nh = *Nitella hookeri*
An = *Apium nodiflorum*
Rc = *Rubus fruticosa*
Gr = Assorted grasses
Da=*Drepanocladus adnuncu* s (moss)

Appendix D: Laboratory Analysis of Macroinvertebrate Samples.

Client / Job Code: Featherston WWTP  Date: 04.03.2013

| *Stream Type* | | hard-bottomed | | | | | | hard-bottomed | | | | | | hard-bottomed | | | | | | hard-bottomed | | | | | | hard-bottomed | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HB | Site 1 | | | | | | Site 2 | | | | | | Site 3 | | | | | | Site 4 | | | | | | Site 5 | | | | |
| TAXA | *MCI* | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 |
| ANNELIDA (laboratory counts) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oligochaeta | *1* | 3 | 6 | 2 | 8 | 0 | | 8 | 12 | 7 | 13 | 11 | | 17 | 14 | 12 | 15 | 22 | | 15 | 14 | 20 | 47 | 15 | | 12 | 18 | 24 | 9 | 22 |
| Hirudinea | *3* | 0 | 0 | 0 | 1 | 0 | | 0 | 1 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| MOLLUSCA (laboratory counts) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Physa sp.* | *3* | 0 | 0 | 1 | 0 | 5 | | 8 | 9 | 8 | 7 | 22 | | 12 | 6 | 8 | 8 | 13 | | 16 | 12 | 22 | 13 | 12 | | 13 | 26 | 21 | 7 | 15 |
| *Potamopyrgus antipodarum* | *4* | 45 | 62 | 33 | 32 | 44 | | 12 | 18 | 9 | 13 | 19 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| CRUSTACEA (laboratory counts) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Amphipoda | *5* | 0 | 4 | 0 | 5 | 0 | | 4 | 5 | 4 | 6 | 4 | | 0 | 0 | 0 | 0 | 0 | | 7 | 11 | 6 | 12 | 12 | | 17 | 15 | 22 | 21 | 34 |
| *Daphnia sp.* | | 0 | 0 | 0 | 0 | 0 | | 7 | 14 | 9 | 18 | 20 | | 3 | 5 | 7 | 6 | 8 | | 6 | 4 | 7 | 3 | 4 | | 2 | 5 | 1 | 2 | 7 |
| Ostracods | *3* | 0 | 0 | 0 | 0 | 0 | | 2 | 4 | 3 | 5 | 8 | | 17 | 21 | 13 | 21 | 17 | | 10 | 16 | 11 | 11 | 11 | | 5 | 7 | 18 | 8 | 13 |
| *Paranephrops planifrons* | *5* | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| INSECT LARVAE (counts) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EPHEMEROPTERA (mayflies) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Deleatidium* | *8* | 4 | 10 | 6 | 3 | 3 | | 0 | 0 | 0 | 1 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Mauiulus luma* | *5* | 51 | 64 | 29 | 38 | 39 | | 3 | 7 | 2 | 0 | 12 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Zephlebia sp.* | *7* | 0 | 2 | 0 | 1 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| TRICHOPTERA (caddisflies) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aoteapsyche colonica* | *4* | 35 | 64 | 37 | 44 | 45 | | 10 | 13 | 6 | 9 | 17 | | 0 | 0 | 0 | 0 | 0 | | 4 | 2 | 0 | 0 | 0 | | 3 | 6 | 3 | 2 | 6 |
| *Costachorema sp.* | *7* | 0 | 4 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Hudsonema amabilis* | *6* | 0 | 0 | 0 | 0 | 3 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Hydrobiosis parumbripennis* | *5* | 0 | 0 | 2 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Pycnocentrodes sp.* | *5* | 3 | 0 | 0 | 9 | 5 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Triplectides obseleta* | *5* | 0 | 2 | 0 | 0 | 4 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| HEMIPTERA (water bugs) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Microvelia macgregori* | *5* | 0 | 0 | 0 | 1 | 0 | | 0 | 0 | 0 | 0 | 2 | | 0 | 1 | 0 | 1 | 1 | | 0 | 0 | 0 | 0 | 1 | | 0 | 1 | 0 | 0 | 0 |
| COLEOPTERA (beetles) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Elmidae* | *6* | 103 | 130 | 69 | 98 | 150 | | 18 | 42 | 23 | 33 | 37 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 2 | 0 | 2 |
| *MEGALOPTERA (dobsonflies)* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Archichauloides diversus* | *7* | 1 | 0 | 1 | 2 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| DIPTERA (two winged flies) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aphrophila neozelandica* | *5* | 3 | 0 | 2 | 0 | 2 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| *Austrosiumulium austrolense* | *3* | 5 | 0 | 0 | 0 | 0 | | 28 | 55 | 21 | 38 | 51 | | 11 | 9 | 9 | 7 | 12 | | 2 | 9 | 2 | 2 | 1 | | 2 | 0 | 0 | 2 | 0 |

Appendix D: Laboratory Analysis of Macroinvertebrate Samples.

| | | Site 1 | | | | | | Site 2 | | | | | | Site 3 | | | | | | Site 4 | | | | | | Site 5 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TAXA | *MCI* | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | | #1 | #2 | #3 | #4 | #5 | |
| *Chironomidae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chironomus* | *1* | 22 | 42 | 18 | 41 | 33 | | 36 | 64 | 24 | 40 | 46 | | 21 | 31 | 16 | 16 | 11 | | 27 | 31 | 22 | 23 | 12 | | 24 | 20 | 20 | 12 | 19 | |
| *Chironomus* A | *1* | 0 | 0 | 0 | 0 | 0 | | 16 | 26 | 12 | 15 | 12 | | 12 | 19 | 7 | 8 | 14 | | 13 | 23 | 11 | 12 | 10 | | 16 | 13 | 14 | 4 | 14 | |
| *Orthocladiinae* | *2* | 5 | 0 | 0 | 0 | 6 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 2 | 1 | 6 | 4 | 4 | |
| *Tanypodinae* | *5* | 0 | 10 | 0 | 0 | 4 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | |
| *Culex pervigilans* | *3* | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 3 | 2 | 0 | | 6 | 8 | 4 | 7 | 13 | | 9 | 8 | 7 | 4 | 1 | | 0 | 2 | 0 | 2 | 0 | |
| *Limonia nigrescens* | *6* | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | |
| Muscidae | *3* | 0 | 0 | 0 | 0 | 0 | | 2 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 1 | 0 | 0 | 0 | 0 | |
| *Paralimnophila skusei* | *6* | 3 | 0 | 0 | 3 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | |
| *Zelandoptipula sp* | *6* | 0 | 1 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | |

SUMMARY STATS: MACROINVERTEBRATES

| | Site 1 | | | | | | | Site 2 | | | | | | | Site 3 | | | | | | | Site 4 | | | | | | | Site 5 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | #2 | #3 | #4 | #5 | ave. | S.D. | #1 | #2 | #3 | #4 | #5 | ave. | S.D. | #1 | #2 | #3 | #4 | #5 | ave. | S.D. | #1 | #2 | #3 | #4 | #5 | ave. | S.D. | #1 | #2 | #3 | #4 | #5 | ave. | S.D. |
| Taxa Richness | 13 | 13 | 13 | 14 | 13 | 13 | 0.4 | 13 | 13 | 13 | 13 | 13 | 13 | 0 | 8 | 9 | 8 | 9 | 9 | 8.6 | 0.5 | 10 | 10 | 9 | 9 | 10 | 9.6 | 0.5 | 11 | 11 | 10 | 11 | 10 | 10.6 | 0.55 |
| # inverts | 283 | 401 | 202 | 286 | 343 | 303 | 74 | 154 | 270 | 131 | 200 | 261 | 203 | 62 | 99 | 114 | 76 | 89 | 111 | 98 | 16 | 109 | 130 | 108 | 127 | 79 | 111 | 20 | 97 | 114 | 131 | 73 | 136 | 110 | 25.8 |
| MCI | 88 | 98 | 92 | 96 | 91 | 93 | 4.2 | 65 | 72 | 65 | 73 | 68 | 69 | 3.9 | 43 | 50 | 43 | 50 | 50 | 47 | 3.9 | 53 | 53 | 50 | 50 | 56 | 52 | 2.4 | 52 | 56 | 58 | 51 | 58 | 54.8 | 3.15 |
| QMCI | 4.7 | 4.6 | 4.7 | 4.4 | 4.7 | 4.6 | 0.1 | 2.7 | 2.8 | 2.9 | 2.7 | 2.9 | 2.8 | 0.1 | 1.9 | 1.8 | 1.8 | 1.9 | 2 | 1.9 | 0.1 | 2 | 2 | 1.9 | 1.8 | 2.2 | 2 | 0.2 | 2.2 | 2.3 | 2.5 | 2.8 | 2.6 | 2.47 | 0.22 |
| EPT Index | 4 | 6 | 4 | 5 | 6 | 5 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0.4 | 0.5 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| %EPT Taxa | 31 | 46 | 31 | 36 | 46 | 38 | 7.8 | 15 | 15 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 | 0 | 0 | 0 | 4 | 5.5 | 9.1 | 9.1 | 10 | 9.1 | 10 | 9.45 | 0.5 |
| %PT Individuals | 33 | 36 | 37 | 33 | 29 | 34 | 3.2 | 8.4 | 7.4 | 6.1 | 5 | 11 | 7.6 | 2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.7 | 1.5 | 0 | 0 | 0 | 1 | 1.6 | 3.1 | 5.3 | 2.3 | 2.7 | 4.4 | 3.56 | 1.24 |