Baseline Environmental Monitoring, Program 2: Macroinvertebrate Assessment – Exploration Permit # 51985 at Puhipuhi, Northland

Prepared for

Evolution Mining NZ Pty Ltd

May 2016

PATTLE DELAMORE PARTNERS LTD
Level 4, PDP House
235 Broadway, Newmarket, Auckland 1023
PO Box 9528, Auckland 1149, New Zealand

Tel +64 9 **523 6900** Fax +64 9 **523 6901**
Website **http://www.pdp.co.nz**
Auckland Tauranga Wellington Christchurch

solutions for your environment

Quality Control Sheet

TITLE	Baseline Environmental Monitoring, Program 2: Macroinvertebrate Assessment – Exploration Permit # 51985 at Puhipuhi, Northland
CLIENT	Evolution Mining NZ Pty Ltd
VERSION	Final
ISSUE DATE	27 May 2016
JOB REFERENCE	A02982802
SOURCE FILE(S)	A02982802R001_for formatting.docx

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE Patrick Lees

Reviewed by

SIGNATURE

Mary Beech

Approved by

Steve Pearce

Limitations:

This report has been prepared by PDP on the specific instructions of Evolution Mining NZ Pty Ltd for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Executive Summary

Ecological monitoring (including macroinvertebrate sampling, habitat assessments, and water quality sampling) was undertaken at eleven sites within and downstream of the Evolution Mining NZ Pty Ltd exploration tenement boundary.

Sites in the upper catchment near to the headwaters of the streams generally had the highest quality and diversity of macroinvertebrates and the highest quality of habitat. Sites in the mid – lower Puhipuhi catchment generally had lower quality macroinvertebrate communities and a lower quality of habitat. Assessment of the water quality data for heavy metals, nutrients and field parameters indicates that there were no consistent relationships between increases in heavy metal concentrations, nutrient concentrations and the diversity and abundance of macroinvertebrate taxa.

The differences in the quality and composition of the macroinvertebrate community are likely attributed to differences in the surrounding land use and instream habitat characteristics (e.g., a change from faster flowing diverse depth/ velocity combinations to slower flowing stream reaches with very little diversity in stream depth) rather than from the effects of historical mining activity.

Table of Contents

Table of Tables

Appendices

1.0 Introduction

1.1 Project Background and Objectives

Pattle Delamore Partners Ltd (PDP) has been engaged by Evolution Mining NZ Pty Ltd (ENZ) to provide baseline data and assessment at Puhipuhi, Northland.

The purpose of this report is to determine a baseline condition of the macroinvertebrate communities and instream, riparian and bankside habitat within the tenement area and to compare macroinvertebrate communities with relevant water quality data.

Further baseline environmental monitoring was commissioned by ENZ and undertaken by PDP in March 2016 and is presented in;

- Program 1: Groundwater Sampling (PDP, 2016);
- Program 2: Surface Water Sampling and Stream Sediment;
- Program 3: Hydrology and hydrogeology assessment; and
- Program 4: Environmental management strategy.

Relevant water quality data collected in Program 2 has been incorporated into this report.

1.2 Scope and Tasks

This report presents results obtained by quantitative macroinvertebrate sampling and an in-field qualitative habitat assessment. The report includes details of;

- Sampling locations;
- Sampling results (both macroinvertebrate and in-field habitat assessment);
- Discussion of the macroinvertebrate community; and
- Discussion of water quality results, collected in Program 2, relevant to the macroinvertebrate community.

2.0 Site Descriptions

A detailed description of the Puhipuhi catchment, topography, climate and rainfall is available in;

- Program 1: Groundwater Sampling (PDP, 2016); and
- Program 3 Hydrological and Hydrogeological Assessment (PDP, 2016).

2.1 Macroinvertebrate sampling and in-field habitat assessment locations

Macroinvertebrate and habitat sampling locations were selected by PDP with consideration of historical sampling sites (i.e., Hoggins and Brooks, 1973) and the 2013 Northland Regional Council (NRC) sampling sites. Additionally, it was important to align the macroinvertebrate and habitat sites to sampling sites in Program 2 (e.g., sediment, water quality and biota tissue analysis) and Program 3. Sites requiring access over private property were approached in the first instance by ENZ to gain landowners permission to access rivers and streams crossing their property. Initial site inspection/ reconnaissance was completed by ENZ to gain basic access and logistical information on the sample site before the sampling was conducted. The final sampling program included 11 sites, seven from within and four "downstream" of the exploration tenement boundary (Table 1). Site localities are presented in Figure 1 and Figure 2.

Table 1: Puhipuhi Baseline Monitoring Sites

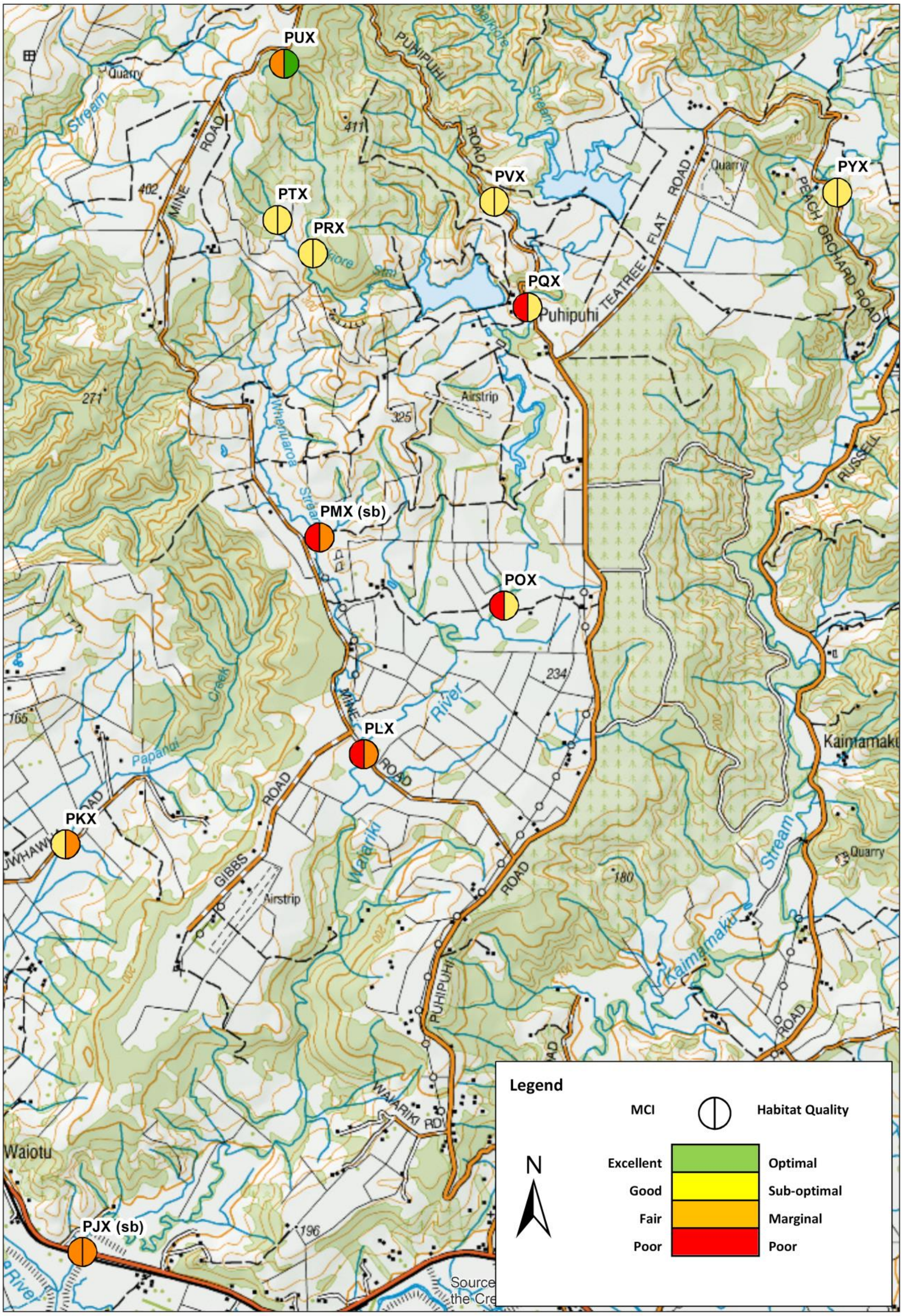
Site ID		Site Name	Monitoring
Upstream	PUX	Wiakiore Stream DoC reserve	Water quality, habitat, macroinvertebrates
↓	PYX	Kaimamaku Stream at Peach Orchard Road	Water quality, habitat, macroinvertebrates
	PVX	Tributary of Pukekaikiore Stream upstream of Puhipuhi Road	Water quality, habitat, macroinvertebrates
	PTX	Tributary of Waikiore Stream	Water quality, habitat, macroinvertebrates
	PRX	Waikiore Stream	Water quality, habitat, macroinvertebrates
	PQX	Pukekaikiore Stream at Puhipuhi Road	Water quality, habitat, macroinvertebrates
	PMX	Whenuaroa Stream via Paper Road	Water quality, habitat, macroinvertebrates
	POX	Waiariki River	Water quality, habitat, macroinvertebrates
	PLX	Waiariki River at Mine Road	Water quality, habitat, macroinvertebrates
	PKX	Papanui Creek at Umuwhawha Road	Water quality, habitat, macroinvertebrates
Downstream	PJX	Waiariki River at SH1	Water quality, habitat, macroinvertebrates

3.0 Methods

3.1 Ecological Sampling Procedures

In brief, macroinvertebrate samples were collected quantitatively using a surber sampler (Surber, 1937) or long-handled D-net (kick net), as per Protocols C3 and C4 in Stark *et al* (2001). These protocols outline separate methods for sampling both hard bottomed (surber sampler) and soft bottomed streams (kick net sampling). Soft bottomed streams (Sb) are those that are dominated by ≥ 50 % sand (0.063 – 2 mm) and silt (< 0.063 mm). Hard bottomed streams (Hb)

A02982802 PUHIPUHI ECOLOGY



SOURCE:
1. TOPOGRAPHICAL INFORMATION SUPPLIED BY LINZ.

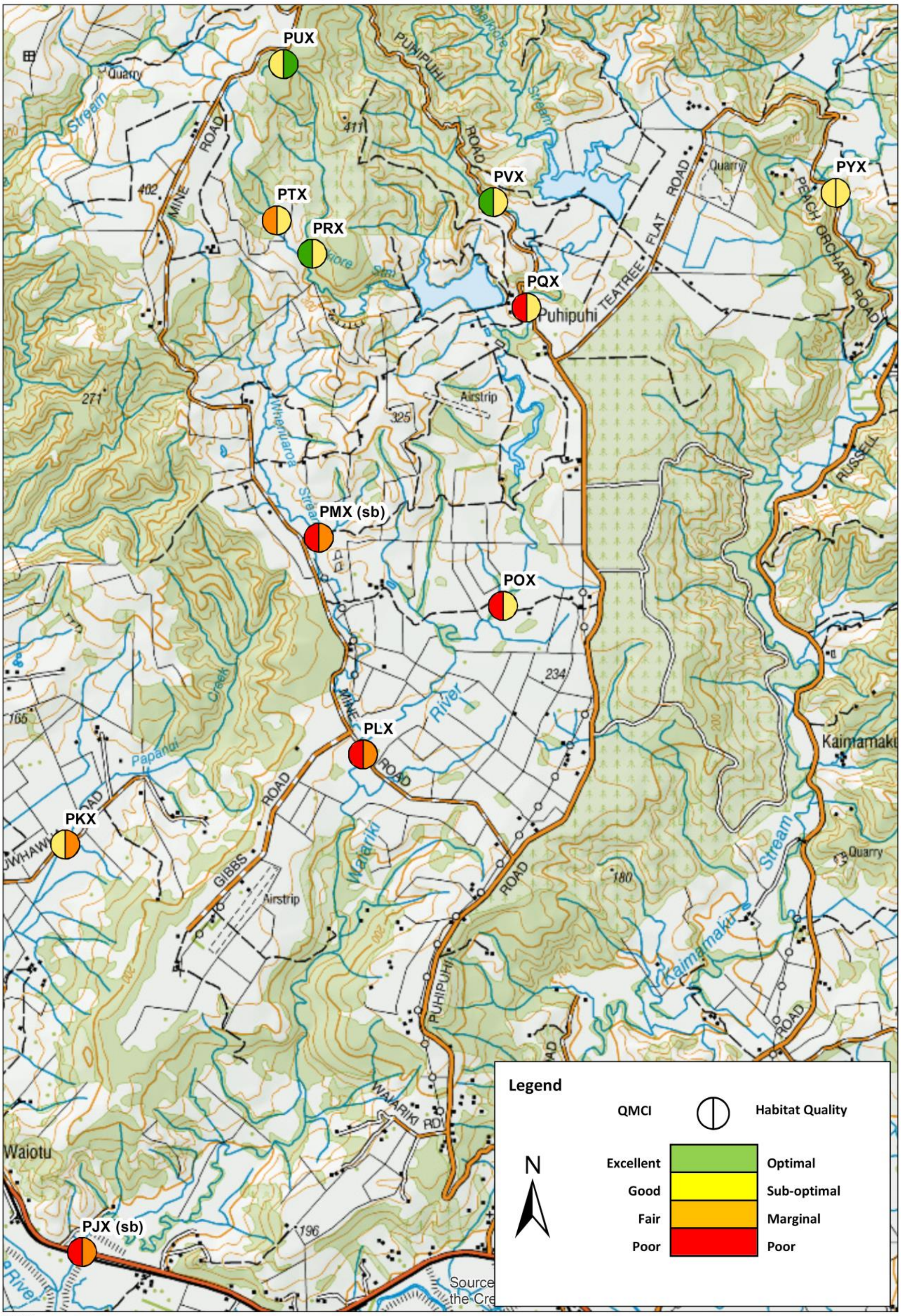
0 250 500 1,000 M

FIGURE 1 : Site locations, Macroinvertebrate Community Index and Habitat Quality

A02982802_Ecology_health_metrics_20160506.mxd

PATTLE DELAMORE PARTNERS LTD

A02982802 PUHIPUHI ECOLOGY



SOURCE:
1. TOPOGRAPHICAL INFORMATION SUPPLIED BY LINZ.

0 250 500 1,000 M

FIGURE 2 : Site locations, Quantitative Macroinvertebrate Community Index and Habitat Quality

A02982802_Ecology_health_QMCI_20160506.mxd

PATTLE DELAMORE PARTNERS LTD

are those with the substrate made up of < 50 % sands and silts with any combination of larger particle sizes dominating the substrate. The proportion of habitat and the effort of sampling remained consistent between sites and replicate types (i.e., between surber and kick net). The type and amount of habitat sampled was recorded on field assessment forms. Four replicates were collected at each site with each replicate being cleaned through a 500 *u*m sieve and preserved individually in 70 % denatured ethanol for later processing and analysis.

Macroinvertebrate samples were sent to Stark Environmental Limited for identification. A full count and identification to genera was undertaken (as per Protocol P3 in Stark *et al.*, 2001). Identification to genera allows common macroinvertebrate community metrics to be calculated (Section 3.4 and Table 2).

3.2 Habitat Assessment

Qualitative habitat assessments were conducted over a 30 m to 50 m survey reach at each of the eleven sites using field habitat assessment forms for hard and soft bottomed streams (adapted from those developed by Collier and Kelly, 2005). The habitat assessment characterises the instream, riparian and bankside habitat, and landscape features to assess a site on a four point scale (i.e. optimal, sub-optimal, marginal and poor condition).

The habitat assessment involves scoring nine or ten parameters, for soft bottomed or hard bottomed streams respectively, on a scale of 20 to 1 (20 representing the best habitat). The parameters include abiotic and biotic variables and instream, riparian, and landscape features (Appendix A; Example of Qualitative Habitat Assessment field form). Habitat parameter scores are combined to provide a total habitat score which is useful for comparing sites and reporting (Collier and Kelly, 2005). PDP have assigned the total habitat scores to descriptive bandings. For both hard and soft bottomed sites the bandings are: >151 = optimal habitat, 101 – 150 = sub-optimal habitat, 51 – 100 = marginal habitat, and 9 – 50 = poor habitat.

Field assessments were completed by both members of the field team to limit the subjectivity of the observations and maintain consistent interpretation between users throughout the assessment.

3.3 Analysis of the Macroinvertebrate Data

A variety of commonly used metrics (NRC 2011, NIWA 2013, Stark & Maxted 2007) were used to assess the relative health of the macroinvertebrate communities at each site:

- The total number of invertebrates;
- number of taxa;
- percent of Ephemeroptera, Plecoptera, Trichoptera (%EPT);

- Macroinvertebrate Community Index (MCI); and
- Quantitative Macroinvertebrate Community Index (QMCI).

The individual metric are described in Table 2.

Table 2: Macroinvertebrate Metrics

Metric	Definition
Taxa Richness	Indicates the number of different taxonomic groups present in a sample. Streams supporting a high number of different taxa generally indicate healthy communities.
%EPT taxa	Measures the number of macroinvertebrate taxa belonging to Ephemeroptera, Plecoptera and Trichoptera orders as a percent of taxa richness (excluding the pollution tolerant genera *Oxyethiria* and *Paroxyethira*[1]).
%EPT abundance	The abundance of sensitive Ephemeroptera, Plecoptera and Trichoptera (excluding the pollution tolerant genera *Oxyethiria* and *Paroxyethira*[1]) as a percentage of the total abundance of macroinvertebrates in a sample.
MCI	This index allocates macroinvertebrate taxa a score between 1 (pollution tolerant) and 10 (pollution intolerant) depending on each taxon's tolerance to organic enrichment and is based on presence/absence data. Interpretation of MCI values is as follows: >120 = Excellent, 100-120 = Good, 80-100 = Fair and <80 = poor. Stark and Maxted (2007) developed a soft bottomed variant of the MCI that is to be used in soft bottomed streams.
QMCI	This utilizes the same macroinvertebrate taxa score's as MCI. The QMCI gives an average score per taxon and is more sensitive to changes in abundance or sample size. Stark (1998) provided an interpretation of QMCI values as follows: >6 = Excellent, 5-6 = Good, 4-5 = Fair and < 4 = Poor. Stark and Maxted (2007) developed a soft bottomed variant of the QMCI that is to be used in soft bottomed streams.

3.4 Water quality

Water quality samples were collected at all sites to assess the concentrations of heavy metals, alkali metals, alkalinity and nutrient species within the Puhipuhi catchment. The full methodology and trend analysis for this water quality sampling is available in Program 2: Surface Water Sampling and Stream Sediment

[1] Both *Oxyethira* and *Paraoxyethira* are common *Hydroptilidae* caddisfly taxa that are able to withstand habitats with increased nutrient enrichment, algae bio mass and low shade. Their removal from the percent EPT taxa calculation enables this metric to represent the proportion of EPT taxa that are sensitive to pollution and degraded environments.

report. In-field spot water quality parameters (temperature, conductivity, dissolved oxygen, ORP, turbidity and pH) were measured at each ecological monitoring site using calibrated field meters.

4.0 Results and Discussion

4.1 Qualitative Habitat assessment

The qualitative habitat assessment scores are summarised in Table 3, the site habitat parameter scores are in Appendix A; Table 1 A, and any trends are described below.

Habitat quality was generally highest in the upper reaches of the catchment and decreased downstream through the catchment (Figure 1). The higher quality sites were characterised by:

- good fencing between stream and the surrounding land uses,
- riparian zone of continuous native vegetation (Sites PUX and PRX) or a mixture of native and non-native (Sites PTX, PVX and PYX) canopy and sub-canopy trees,
- dense ground cover with stable riparian and bankside zones;
- greater diversity of velocity and depth combinations,
- varied substrate types (e.g., wood, gravels, cobbles), with no single dominant substrate type, and
- diverse sources and quantity of food inputs (e.g., woody debris, periphyton and macrophytes).

Low quality habitat sites were located within the lower gradient sections of the catchment, where land use was dominated by dairying and cropping. The lower

quality sites (especially PMX, PKX, and PLX) were seldom buffered from the surrounding land use by dense continuous riparian and bankside vegetation (e.g., bankside vegetation was limited to rank pasture grasses, weeds and sporadic sub-canopy trees). Site PJX has overall low habitat quality, but was well buffered from the surrounding land uses by dense and a continuous combination of native and non-native canopy trees, with a well-developed under story consisting of rank grasses and blackberry.

Low habitat quality sites in the Puhipuhi exploration tenement were characterised by:

- river banks had many actively eroding areas with high erosion potential during high flows;
- high levels of deposited fine sediment, especially in pools;

- substrates were dominated by fine (< 4 mm), unstable gravels;
- little diversity of depth and velocity, with slow and deep water dominating the survey reaches;
- low habitat diversity with limited snags, submerged logs, cobbles or boulders;
- little stable habitat to provide refuge during high flow events; and
- periphyton growth was restricted to areas were cobbles and gravels were present. However, epiphytic periphyton was common where marginal and submergent macrophytes were present.

Table 3: Qualitative habitat assessment results

	Site	Score	Banding
Upstream	PUX	152.5	Optimal
	PYX	113.5	Sub-optimal
	PVX	101	Sub-optimal
	PTX	106.5	Sub-optimal
	PRX	139	Sub-optimal
	PQX	107.5	Sub-optimal
	PMX(sb)	69	Marginal
	POX	105	Sub-optimal
	PLX	83	Marginal
Downstream	PKK	81.5	Marginal
	PJX(sb)	75.5	Marginal

Notes:
1. *Sb = soft bottom habitat assessment completed at these sites only*

4.2 Macroinvertebrate Health and Indices

The presence and relative abundance of macroinvertebrates as measured at the sites, together with calculated metrics of macroinvertebrate community structure are provided in Appendix C and summarised in Table 4. Results were generated by pooling the replicate samples together at each site.

4.2.1 Community Composition

Taxonomic richness (number of taxa found at a site) ranged from 14 at sites PUX, PVX and POX through to 25 at sites PYX, PMX, and PKX (Table 4). The most abundant taxa overall were the common freshwater snail (*Potamopyrgus antipodarum*), the riffle beetle (*Elmidae*), black fly larva (*Austrosimulium sp*), toe biter (*Archichauliodes sp*) and the common mayfly (*Deleatidium sp*). Overall 70 taxa were identified from all sites. The greatest site abundance of macroinvertebrates was observed at Sites PKX, PMX and PJX. The lowest abundance in macroinvertebrates was observed at Sites PUX and PVX (Table 4).

Macroinvertebrates from mayfly, stonefly and caddisfly orders (EPT) are generally the most sensitive macroinvertebrates within the water body. Low EPT usually coincides with low MCI and low habitat health, and vice versa. The percent abundance of EPT taxa with the removal of *Hydroptilidae sp* (%EPT abundance) was lowest at Site PLX, followed by Sites PMX, POX and PUX (Table 4 and Appendix B; Figure 3 B); Sites PLX, PMX and POX all had MCI values indicating "poor" quality. The highest %EPT was at site PVX, followed by PYX, PTX and PRX (Table 4, Appendix B; Figure 3 B). All four of these sites are in the upper catchment near to the headwaters of the streams, and are characterised by diverse velocity/ depth regimes and increased substrate complexity. This combination of habitats is likely to see greater abundance and diversity in EPT taxa.

4.2.2 Macroinvertebrate Community Index (MCI) and Quantitative Community Index (QMCI)

MCI values were generally higher indicating "good" quality at sites in the upper catchment at sites PRX, PTX and PVX, and closer to the stream headwaters at sites PYX and PKX (Table 4, Figure 1 and Appendix B; Figure 1 B). Sites with high MCI scores are dominated by mayflies and caddisflies, with fewer snails and non-biting midge species (e.g., Chironomids).

Site PMX scored the lowest MCI value followed by Sites POX, PQX and PLX (Table 4). All four sites had MCI values that indicate "poor" quality. These sites were predominantly further down the tenement catchment in lower gradient stream reaches, and were dominated by non-biting midges (e.g., Chironomids), snails, worms, and crustaceans.

QMCI values generally followed a similar pattern to that of the MCI values. Higher QMCI values were calculated at sites near the headwaters and in the upper catchment, while sites within the lower gradient catchment predominantly had low QMCI values (Table 4, Figure 2 and Appendix B; Figure 2 B).

The mismatch between MCI and QMCI grades at some sites (Table 4) reflects the differences in sensitivity of the two metrics used. The MCI metric responds only to the number and sensitivity of different taxa found in a sample and will increase when there are high numbers of rare but sensitive taxa, whereas QMCI responds to the numerical composition of a sample. As a result QMCI is less influenced by the presence of sensitive taxa in low numbers. The QMCI metric is therefore best suited for use when subtle changes in community composition need to be assessed.

In summary MCI scores decline with increasing distance from the headwaters. This gradient reflects the qualitative habitat assessment reported in Section 4.1, which also indicates that habitat is degraded in the lower catchment areas. A clear exception to this is site PUX which has a relatively low MCI score, but

"optimal" habitat assessment. Habitat at this site was dominated by a high degree of organic matter in the form of leaf packs and little hard substrate. These conditions are not favourable to many species and the community at this site has a low abundance and taxa richness, but is dominated by one species of a sensitive beetle (*Scirtidae sp*). The QMCI score for this site is a better representation of the community (Table 4).

Table 4: Macroinvertebrate metrics results

	PUX	PYX	PVX	PTX	PRX	PQX	PMX (sb[1])	POX	PLX	PKX	PJX (sb[1])
	Upstream →										Downstream
Number of taxa	14	25	14	24	17	20	25	14	17	25	15
Number of individuals	54	336	56	321	73	227	544	184	397	629	481
MCI	Fair 96	Good 106	Good 107	Good 116	Good 118	Poor 75	Poor 66	Poor 70	Poor 76	Good 109	Fair 89
QMCI	Good 5.91	Good 5.60	Fair 6.27	Fair 4.25	Excellent 6.43	Poor 3.03	Poor 2.44	Poor 2.65	Poor 3.45	Good 5.56	Poor 2.72
%EPTtaxa[2]	7	44	29	54	47	10	12	14	18	44	33
%EPT abundance[2]	2	28	34	27	25	20	2	2	1	21	10

Notes: Each sites replicates (n=4) have been pooled together to give a by site metric result

1) *Sb = soft bottom metrics have been calculated as per Stark and Maxted (2007)*

2) *Hydroptilidae has been removed, see footnote on page 4.*

4.3 Water quality effects on macroinvertebrate community composition

A comprehensive suite of water quality parameters including heavy metals, alkali metals, alkalinity and nitrogen species were sampled throughout the Puhipuhi catchment by PDP in April 2016. For full sampling methodology and a detailed description of any trends and analysis see Program 2: Water Quality and Sediment report.

Water quality and heavy metal laboratory results have been tabulated and are available in Appendix D; results have been assessed against the Australia and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZECC, 2000) 95% protection level. The 95% protection level assumes that sites are located within a slightly disturbed system (via anthropological disturbance e.g., agriculture and minor urban development). Only results that are matched with macroinvertebrate sites have been presented. For full data set and analysis see Program 2: Water Quality and Sediment report.

4.3.1 Effects of heavy metals on the benthic macroinvertebrate community

As macroinvertebrates inhabit stream ecosystems year round the composition of the macroinvertebrate community is an excellent indicator of the effects of heavy metals may have on the ecology and wider environment. The presence or absence of groups which are sensitive or tolerant to contaminants, such as EPT taxa and Chironomids are particularly useful. However, there is little agreement as to what indicator is best used when it comes to identifying any effects on the benthic community from unnatural increases in heavy metals (Hickey and Clements, 1998 and Hickey, 2000). Generally, streams that are highly impacted by metal pollution have overall lower taxa richness, reduced abundance of mayfly species (which are sensitive to metal contaminants), and are dominated by non-biting midges (Chironomids) which are tolerant to metal contaminants (Hickey and Clements, 1998).

Overall, the water quality results show that only dissolved zinc (Zn) and dissolved copper (Cu) exceeded the ANZECC 95 % protection level at three sites; PVX, PRX and PQX (Appendix C; Table 1 C). All heavy metals above the laboratory analytical detection limit reduced longitudinally downstream throughout the Puhipuhi catchment, only Zn was still detectable at Site PJX (Appendix C; Table 1 C). Further analysis of surface water heavy metal concentrations will be presented in the Program 2: Surface Water and Sediment Quality report.

The heavy metal results were plotted alongside the pooled replicate sample results for macroinvertebrate taxa richness, EPT abundance; mayfly and Chironomid taxa richness and abundance for each site (Appendix C; Figure 1 C – 6 C). To help visualise any response in the macroinvertebrate community, only heavy metals with concentrations above the laboratory detection limit were plotted (i.e., arsenic (As), Cu, lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn)).

Results show that taxonomic richness was generally greatest at sites with heavy metal concentrations less than the ANZECC 95 % protection level. Increased heavy metal concentrations (greater than the ANZECC 95 % protection level) occurred at sites PVX and PRX, coincided with lower taxonomic richness compared to sites with similar habitat health, for example sites PTX and PKX (Figure 1). However this is not consistent between sites and taxonomic richness fluctuates throughout the catchment irrespective of heavy metal concentrations. Further, sites PRX and PQX have elevated heavy metal concentrations and greater taxonomic richness than sites further downstream that have little to no detectable heavy metal concentrations (Appendix C; Figure 1 C).

%EPT abundance (i.e., the number of individuals in the mayfly, stonefly and caddisfly orders) was generally lowest at sites with lower habitat health (Section 5.2.3). There appears to be no relationship between increased heavy metal concentrations and the %EPT abundance at a site. All sites that were dominated

by EPT taxa were in the upper Puhipuhi catchment where heavy metal concentrations were at their highest (Appendix C; Figure 2 C).

The diversity of mayflies, or mayfly taxa, at sites is generally greatest in the upper catchment sites (PVX, PTX, PRX, and PYX) and declines longitudinally down the catchment. The sites PVX and PRX, with the highest heavy metal concentrations, have relatively low diversity of mayflies compared with other sites of the same habitat quality (Figure 1). The decrease in mayfly taxa at these two sites could be associated with heavy metal contamination. However the more general decline in mayfly taxa at sites also reflects the decline in habitat quality longitudinally through the catchment.

The number of identified Chironomid taxa fluctuated throughout the entire Puhipuhi catchment; all sites had at least one Chironomid taxa identified with a maximum of four taxa being identified at Site PUX and Site PQX. Chironomid abundance was greatest at sites in the upper catchment, however, the greatest abundance was observed at sites that had lower concentrations of heavy metals (e.g., Site PUX and PTX). As Chironomids are more tolerant of water bodies with higher concentrations of heavy metals (Hickey and Clements, 1999) it would be expected that abundances would increase at these sites. However, it appears that Chironomids were more abundant at sites that had high diversity and density of benthic periphyton (diatoms and algae) and woody debris, which are both major food sources for Chironomid larva (Armitage *et al.*, 1995) (Appendix C; Figure 5 C and 6 C).

The current dataset for dissolved heavy metals, of one sample per site, is too short to accurately describe the ambient conditions the macroinvertebrate community is exposed to. Comparison with the sediment quality results may be able to elucidate this association more accurately.

4.3.2 Nutrient Species in the Puhipuhi catchment

Dissolved reactive phosphorus (DRP), ammoniacal nitrogen and nitrate nitrogen (nitrate-n) occur naturally in the environment, and in one form or another are essential for plant growth. Ammoniacal nitrogen is a by-product of the metabolism of organic material by bacteria. Whilst nitrate-n occurs naturally through the nitrogen cycle and via agricultural and urban runoff, industrial wastewaters and groundwater inputs (Hickey 2013).

The water quality sampling results show that concentrations of ammonia-n or nitrate-n did not exceed the guideline values (ANZECC, 2000, and Hickey, 2013), at any of the sites in the upper Puhipuhi catchment (Table 5). Ammonia-n ranged from <0.01 – 0.37 mg/L and Ammonium-n ranged from <0.01 – 0.40 mg/L. Site PMX recorded the highest concentration of ammonia-n (0.37 mg/L) and ammonium-n (0.4 mg/L) (Table 5). Increases in both ammonia-n and ammonium-n appear to be greatest at sites that are bordered by high intensity land uses, and

sites with little to no riparian vegetation. Nitrate-n concentrations ranged from <0.02 – 0.81 mg/L, and were highest at Site PTX, before reducing at Sites PRX and PQX. Similarly to ammonia-n and ammonium-n, nitrate-n concentrations increased at sites where agricultural impacts were greatest.

Table 5: Water quality nutrient results

Sample Site Location		Ammonia-n (as N)	Ammonium Ion (as N)	Nitrate (as N)	DRP
Upstream		mg/L	mg/L	mg/L	mg/L
	PUX	0.25	0.27	< 0.02	<0.05
	PYX	< 0.01	< 0.01	0.14	<0.05
	PVX	< 0.01	< 0.01	0.12	<0.05
	PTX	< 0.01	< 0.01	0.81	<0.05
	PRX	< 0.01	< 0.01	0.41	<0.05
	PQX	0.05	0.05	0.20	<0.05
	PMX	0.37	0.40	0.37	<0.05
	POX	0.04	0.05	0.42	<0.05
	PLX	0.03	0.03	0.47	<0.05
	PKX	< 0.01	< 0.01	0.29	<0.05
Downstream	PJX	0.03	0.03	0.57	<0.05
ANZECC (2000)		0.90			
Hickey (2013)[1] (95% protection)				2.40	

Note:
Hickey (2013) updated the nitrate-N guidelines derived in ANZECC (2000), the update includes additional data from new acute and chronic studies which have been undertaken.

Both ammoniacal-n and nitrate-n have the potential to be major environmental stressors to sensitive benthic macroinvertebrate taxa (especially mayfly and stonefly species). The low concentrations recorded in the water quality sampling indicate that is unlikely that nitrogen is adversely affecting macroinvertebrate communities. It is more likely that habitat quality is the key factor affecting macroinvertebrate community composition.

Filterable reactive phosphorus, or dissolved reactive phosphorus (DRP) was less than the laboratory analytical detection limit (0.05 mg/L) at all sites, and is therefore not expected to have an effect on the macroinvertebrate community.

4.3.3 Spot water quality parameters and macroinvertebrate community

Spot water quality measurements were collected using a calibrated YSI ProOdo multi probe. Measurements were collected on three occasions by two different field teams, the first and second sampling occasions were undertaken in mid to late March (10 – 13 March 2016) with the third being undertaken in early April (12 – 13 April 2016). The summary results have been tabulated and compared against ANZECC guideline values in Table 6.

The ANZECC guideline value for dissolved oxygen is set at 80% Disolved Oxygen (DO) for the protection of aquatic ecosystems, below this value aquatic

ecosystems will become stressed. Only one site did not reach the guideline value (Site PJX DO% = 74.1) and one site was just over the guideline value (Site PUX DO% = 80.4%). All other sites had satisfactory DO % values ranging from 87.1 – 102.8 % (Table 6).

Recorded temperatures ranged from 15.9 to 20.0 ° C, and were generally highest at sites with little to no riparian shading and slow/ sluggish water velocity. Water temperatures above 20 °C are not uncommon in the Northland region (NRC, 2011) and unshaded sites may approach the critical 25 °C upper limit for many fish and macroinvertebrates.

Table 6: Summary spot water quality results

Site		Temp	Conductivity	DO	DO	pH	ORP	Turbidity
		° C	µS/cm	(mg/L)	%		mV	NTU
Upstream	PUX	16.1	68.8	8.0	80.4	**6.1**	187.0	2.7
	PYX	19.6	54.7	9.2	94.7	6.5	162.6	4.5
	PVX	16.6	68.2	8.5	87.1	**4.7**	374.5	3.2
	PTX	16.0	64.9	9.6	97.7	**6.1**	191.1	**6.9**
	PRX	16.9	66.3	9.1	96.7	**5.2**	311.5	**6.6**
	PQX	19.5	60.9	9.3	101.3	**6.2**	213.4	4.5
	PMX	18.9	72.5	8.0	88.1	**5.9**	187.1	5.0
	POX	19.4	61.2	8.2	90.4	**6.4**	205.8	3.3
	PLX	20.0	64.9	9.2	102.8	**6.1**	183.5	3.4
Downstream	PKX	15.9	73.9	9.9	98.9	6.6	186.3	4.9
	PJX	18.3	69.5	7.3	**74.1**	**6.1**	159.8	4.2
ANZECC (2000)				6	80	6.5 – 8.5		< 5.6 (lowland streams)

Notes:

2. ***Bold** values do not meet the ANZECC guideline value*
3. ***All sites had n = 3 number of samples except PQX and PTX which had 2, and PKX (pH and ORP only) had a single sample***
4. *Spot water quality measurements record a measurement at a single point in time and as such are not representative of the full diurnal pattern. However, the data that is collected do allow comparison of the range of daytime measurements within the Puhipuhi catchment. Continuous monitoring (via in-situ loggers) would be required to determine the extent of any low observed concentrations/ values and thus the potential effect on aquatic life.*

Field pH measurements tended to be slightly acidic, at site PVX, through to circum-neutral at site POX. Many New Zealand macroinvertebrates are capable of withstanding low pH (Harding *et* al 2000); however, acidification of waters can lead to the reduction of periphyton biomass. A change in periphyton diversity

and abundance can potentially lead to a change in the macroinvertebrate community, as different types of macroinvertebrates will become dominant as food sources may change (Harding *et* al 2000). Small variations in daily pH are expected (likewise for DO %) and can be attributed to plant photosynthesis and respiration. However, within the Puhipuhi catchment pH does not appear to have a significant effect on the macroinvertebrate community (Table 4 and Appendix B; Figures 1 B to 3B).

5.0 Summary

Ecological monitoring was undertaken at eleven sites within and downstream of the ENZ exploration tenement boundary and consisting of quantitative macroinvertebrate and qualitative habitat sampling. Additionally, water quality samples were collected from each site.

Overall, sites in the upper catchment near the headwaters of the streams had higher quality macroinvertebrate communities which were dominated by sensitive EPT taxa but included sensitive dipteran fly larvae and beetle taxa. Sites in the lower gradient areas of the catchment had macroinvertebrate communities of lower quality which are dominated by pollution tolerant snails, worms, non-biting midges, and fly larva.

Macroinvertebrate community health, assessed using the macroinvertebrate community index (MCI), generally reflected the habitat quality assessed at sites. Sites with the healthiest macroinvertebrate community were found at sites with dense and continuous riparian vegetation, stable banks, and a high variety of depth and flow combinations in the form of riffles, runs, drops, and pools.

Assessment of water quality data for heavy metals indicates that there were no consistent relationships between increases in heavy metal concentrations and the diversity and abundance of macroinvertebrate taxa. Sites that recorded elevated heavy metal concentrations (e.g., arsenic, copper and zinc) also had high diversity and abundance of sensitive mayfly species and combined EPT taxa compared with other sites where low concentrations of heavy metals were recorded.

The changes in the quality and composition of the macroinvertebrate community is likely attributed to changes in the surrounding land use and instream habitat characteristics (e.g., a change from faster flowing diverse depth/ velocity combinations to slower flowing stream reaches with very little diversity in stream depth) rather than from any historical mining activity. Changes in habitat quality (both instream and adjacent to the water body) can have a significant effect on the community structure of macroinvertebrates. If the changes in habitat health are persistent and/ or permanent these can potentially shift the macroinvertebrate community from a diverse and sensitive population to one

with little diversity and dominated by species that are more tolerant of degraded water and habitat conditions.

The findings in this report need to be further assessed against analysis of metals in sediments conducted by PDP. This will allow further examination of the likely causes/ reasons for the observed changes in macroinvertebrate health within the Puhipuhi catchment.

6.0 References

Armitage, P.D., Cranston, P.S., and Pinder, L.C.V. 1995. The Chironomidae: Biology and ecology of non-biting midges. Chapman and Hall. ISBN 0 412 45260 X.

Collier, K., Kelly, J. 2005. Regional Guidelines for Ecological Assessments of Freshwater Environments: Macroinvertebrate Sampling in Wadeable Streams. Environment Waikato Technical Report TR2005/02.

DP Gray & JS Harding (2012) Acid Mine Drainage Index (AMDI): a benthic invertebrate biotic index for assessing coal mining impacts in New Zealand streams, New Zealand Journal of Marine and Freshwater Research, 46:3, 335-352, DOI: 10.1080/00288330.2012.663764

Harding, JS., Young, RG., Hayes, JW., Shearer, KS., and Stark, JD. 1999. Changes in agricultural intensity and river health along a river continuum. Freshwater Biology. 42, 345-357.

Harding, JS., Quinn, JM., and Hickey, CW. 2000. Effects of mining and production forestry. *In:* Collier, KJ., Winterbourn, MJ. eds. New Zealand stream invertebrates: ecology and implications for management. New Zealand Limnological Society, Christchurch, pp 230-259.

Hickey, CW. 2013. Updating nitrate toxicity effects on freshwater aquatic species. Prepared for Ministry of Building, Innovation and Employment: Funded by Envirolink. NIWA client report No: HAM2013-009.

Hickey, CW., and Clements, WH. 1998. Effects of heavy metals on benthic macroinvertebrate communities in New Zealand streams. Environmental Toxicology and Chemistry. Vol 17, No 11, 2338-2346.

Hoggins, F.E., Brooks, R.R. 1973. Natural dispersion of mercury from Puhipuhi, Northland, New Zealand. New Zealand Journal of Marine and Freshwater Research, 7:1-2, 125-132.

Unwin, M.J., Larned, S.T. 2013. Statistical models, indicators and trend analyses for reporting national-scale river water quality (NEMAR Phase 3). Prepared for the Ministry for the Environment. 46pp

NRC. 2011. River water quality and ecology in Northland: State and Trends 2007 – 2011. Northland Regional Council.

Stark, J.D., Boothroyd, I.K.G, Harding, J.S.; Maxted, J.R.; Scarsbrook, M.R. 2001. Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark, J.D., Maxted, J.R. 2007. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166.

Surber, EW. 1937. Rainbow trout and bottom fauna production in one mile of stream. Transactions of the American Fisheries Society 66: 193–202.

Appendix A: Habitat Field Assessment

Table 1 A. Qualitative habitat scores

	PUX	PVX	PTX	PRX	PYX	PQX	POX	PMX	PLX	PKK	PJX
Riparian vegetation width	20	15	13.5	16.5	14.5	8.5	18	11	13	11	13
Vegetative zone protection	18	11	8	16.5	19	11.5	14.5	7	8	7	8
Stability	14.5	13	14	14	16	9.5	17.5	12	11	4.5	11
Frequency of riffles (Hb only)	15	9	13	12	8	13	7	-	4	8	-
Channel alteration	19	13	15	20	18	13	15	7	13	13	13
Sediment deposition	15	9	14	19	9	13	11	3	8	12	8
Velocity/depth Regimes (Hb only)	18	10	10	14	8	15	7	-	8	8	-
Abundance and diversity of Habitat	19	14	10	16	13	15	8	3	11	10	11
Periphyton	14	7	9	11	8	9	7	7	7	8	7
Channel sinuosity (Sb only)	-	-	-	-	-	-	-	12	-	-	4
Pool variability (Sb only)	-	-	-	-	-	-	-	7	-	-	8
Total score (maximum score = 180)	152.5	101	106.5	139	113.5	107.5	105	69	83	81.5	75.5

Wadeable Hard-Bottomed Streams

Qualitative Habitat Assessment Field Data Sheet

<table>
<tr><td colspan="2">STREAM NAME:</td><td colspan="3">SITE NUMBER:</td></tr>
<tr><td colspan="2">SAMPLE NUMBER: ASSESSOR:</td><td colspan="3">DATE:</td></tr>
<tr><th>Habitat Parameter</th><th colspan="4">Category</th></tr>
<tr><th></th><th>Optimal</th><th>Suboptimal</th><th>Marginal</th><th>Poor</th></tr>
<tr><td>1. Riparian Vegetative Zone Width (score each bank; determine left or right side by facing downstream)</td><td>• Bankside vegetation buffer is >10m
• Continuous and dense</td><td>• Bankside vegetation buffer is <10m
• Mostly continuous</td><td>• Pathways present and/or stock access to stream
• Mostly healed over</td><td>• Breaks frequent
• Human activity obvious</td></tr>
<tr><td>Left bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Right bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Mean LB&RB_____</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2. Vegetative Protection
(score each bank; determine left or right side by facing downstream</td><td>• Bank surfaces and immediate riparian zones covered by native vegetation
• Trees, understorey shrubs, or non-woody plants present
• Vegetative disruption minimal</td><td>• Bank surfaces covered mainly by native vegetation
• Disruption evident
• Banks may be covered by exotic forestry</td><td>• Bank surfaces covered by a mixture of grasses/shrubs, blackberry, willow and introduced trees
• Vegetation disruption obvious
• Bare soil/closely cropped vegetation common</td><td>• Bank surfaces covered by grasses and shrubs
• Disruption of streambank vegetation very high
• Grass heavily grazed
• Significant stock damage to the bank</td></tr>
<tr><td>Left bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Right bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Mean LB&RB_____</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3. Bank Stability (score each bank; determine left of right side by facing downstream</td><td>• Banks stable
• Erosion/bank failure absent or minimal
• <5% of bank affected</td><td>• Moderately stable
• Infrequent, small areas of erosion mostly healed over
• 5-30% of bank eroded</td><td>• Moderately unstable
• 30-60% of bank in reach has areas of erosion
• High erosion potential during floods</td><td>• Unstable
• Many eroded areas
• 60-100% of bank has erosional scars</td></tr>
<tr><td>Left bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Right bank</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
<tr><td>Mean LB&RB_____</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4. Frequency of Riffles</td><td>• Riffles relatively frequent
• Distance between riffles divided by width of stream = 5-7
• Variety of habitat is key</td><td>• Occurrence of riffles infrequent
• Distance between riffles divided by width of stream = 7-15</td><td>• Occassional riffle or run
• Bottom contours provide some habitat
• Distance between riffles divided by width of stream = 15-25</td><td>• Generally flat water, shallow riffles
• Poor habitat
• Distance between riffles divided by width of stream = >25</td></tr>
<tr><td>SCORE ___</td><td>20 19 18 17 16</td><td>15 14 13 12 11</td><td>10 9 8 7 6</td><td>5 4 3 2 1</td></tr>
</table>

SUBTOTAL : ____________

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Alteration	• Changes to channel/dredging absent or minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments or shoring structures present on both banks • 40 to 80% of reach channelised and disrupted	• Banks shored with gabion or cement • >80% of the stream reach channelised and disrupted. • Instream habitat altered or absent
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Sediment Deposition (out of channel and in channel)	• Little/no islands or point bars present • <20% of the bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of the bottom affected • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old and new bars • 50-80% of the bottom affected • Sediment deposits at obstructions, constrictions, and bends	• Heavy deposits of fine material • Increased bar development • >80% of the bottom changing frequently • Pools almost absent due to sediment deposition
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Veloctity/Depth Regimes	• 4 velocity/depth regimes present • Slow/deep, Slow/shallow, Fast/shallow, Fast/deep	• 3 of 4 velocity/depth regimes present • If fast/shallow is missing then score lower	• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing score low	• Dominated by 1 velocity/depth regime • Usually slow/deep
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance and Diversity of Habitat	• >50% substrate favourable for invertebrate colonisation and wide variety of woody debris, riffles, root mats • Snags/ submerged logs/ undercut banks/ cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
10. Periphyton	• Periphyton not visible on hand held stones • Stable substrate • Surfaces rough to touch	• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch	• Periphyton visible • <20% cover of available substrate	• Periphyton obvious and prolific • >20% cover of available substrate
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Total Score ____	NB: Use only means of LB and RB values			

Wadeable Soft-Bottomed Streams

Qualitative Habitat Assessment Field Data Sheet

STREAM NAME:		**SITE NUMBER:**
SAMPLE NUMBER:	**ASSESSOR:**	**DATE:**

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Riparian Vegetative Zone Width (score each bank; determine left or right side by facing downstream)	• Bankside vegetation buffer is >10m • Continuous and dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock access to stream • Mostly healed over	• Breaks frequent • Human activity obvious
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
2. Vegetative Protection (score each bank; determine left or right side by facing downstream)	• Bank surfaces and immediate riparian zones covered by native vegetation • Trees, understorey shrubs, or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by a mixture of grasses/shrubs, blackberry, willow and introduced trees • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses and shrubs • Disruption of streambank vegetation very high • Grass heavily grazed • Significant stock damage to the bank
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
3. Bank Stability (score each bank; determine left of right side by facing downstream	• Banks stable • Erosion/bank failure absent or minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
4. **Channel sinuousity**	• Bends increase stream length 3-4 times longer than if it was in a straight line	• Bends increase the stream length 2-3 times longer than if it was in a straight line	• Bends increase the stream length 1-2 times longer than if it was in a straight line	• Channel straight
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

SUBTOTAL : _____________

Soft bottomed continued

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Alteration	• Changes to channel/dredging absent or minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments or shoring structures present on both banks • 40 to 80% of reach channelised and disrupted	• Banks shored with gabion or cement • >80% of the stream reach channelised and disrupted. • Instream habitat altered or absent
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Sediment Deposition	• Little/no islands or point bars present • <20% of the bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of the bottom affected; • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old and new bars • 50-80% of the bottom affected • Sediment deposits at obstructions, constrictions, and bends	• Heavy deposits of fine material • Increased bar development • >80% of the bottom changing frequently • Pools almost absent due to sediment deposition
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Pool Variability	• Pools evenly mixed • Large/shallow, Large/deep, Small/shallow, Small/deep	• Majority of pools large/deep • Very few shallow pools	• Prevalence shallow pools	• Majority of pools small/shallow
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance and Diversity of Habitat	• >50% substrate favourable for invertebrate colonisation and wide variety of woody debris, riffles, root mats • Snags/ submerged logs/ undercut banks/ cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc) or fine sediments	• Periphyton not visible on substrates but obvious to touch	• Periphyton visible • <20% cover of available substrates	• Periphyton obvious and prolific • >20% cover of available substrates
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Total Score ____	NB: Use only means of LB and RB values			

Appendix B: Macroinvertebrate Community Results

Table 1 b: Macroinvertebrate laboratory results

Job No. A02982802				PUX					PVX					PTX					PRX					PYX				
				Tuesday, 12 April 2016					Tuesday, 12 April 2016					Wednesday, 13 April 2016					Wednesday, 13 April 2016					Tuesday, 12 April 2016				
	MCI	MCI-sb	AMDI			littoral	littoral																					
	score	Score	Score	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total
Mayflies (Ephemeoptera)																												
Acanthophlebia	7	9.6	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
Ameletopsis	10	10	6	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Austroclima	9	6.5	4	-	-	-	-	-	-	-	-	-	-	3	1	-	-	4	-	-	-	-	-	-	-	-	-	-
Coloburiscus	3	8.1	8	-	-	-	-	-	-	-	-	-	-	2	1	-	-	3	-	-	-	-	-	3	-	2	3	8
Deleatidium	8	5.6	6	-	-	-	-	-	-	-	3	6	9	16	-	1	1	18	-	-	6	-	6	8	1	13	6	28
Ichthybotus	8	9.2	10	-	-	-	-	-	-	-	-	-	-	-	1	2	-	3	-	-	-	-	-	-	-	-	-	-
Neozephlebia	7	7.6	3	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	3	-	3	-	-	-	1	1
Nesameletus	9	8.6	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zephlebia	7	8.8	9	-	-	-	-	-	-	-	-	-	-	2	6	3	14	25	2	-	-	-	2	-	-	-	-	-
Stoneflies (Plecoptera)																												
Acroperla	5	5.1	.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1	-	1	-	-	-	-	-
Zelandoperla	10	8.9	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Dobsonflies																												
Archichauliodes	7		2	-	-	-	-	-	4	2	4	7	17	5	2	3	4	14	-	3	18	5	26	6	1	3	8	18
Damselflies																												
Anisoptera juveniles	6	6	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Austrolestes	6	0.7	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xanthocnemis	5	1.2	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Bugs																												
Anisops	5	2.2	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microvelia	5	4.6	.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-	1	-	-	-	1	1
Sigara	5	2.4	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beetles																												
Antiporus	5	3.5	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elmidae	6	7.2	0	-	-	-	-	-	-	1	-	-	1	2	2	-	4	8	-	-	5	3	8	76	18	51	26	171
Enochrus	5	2.6	.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Hydraenidae	8	6.7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liodessus	5	4.9	.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirtidae	8	6.4	1	-	3	1	21	25	-	-	-	-	-	-	-	-	-	-	-	-	4	1	5	-	-	-	-	-
True Flies (Diptra)																												
Aphrophila	5	5.6	8	-	-	-	-	-	-	-	-	-	-	6	-	-	1	7	-	-	-	-	-	-	2	4	15	21
Austrosimulium	3	3.9	5	-	-	-	-	-	-	-	-	-	-	2	1	-	1	4	-	-	1	-	1	4	1	4	6	15
Ceratopogonidae	3	6.2	5	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephydridiae	4	1.4	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriopterini	9	7.5	3	1	1	-	-	2	1	2	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harrisius	6	4.7	.	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobodiamesa	5	7.7	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maoridiamesa	3	4.9	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Molophilus	5	6.3	.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	2	3.2	0	-	-	-	3	3	-	1	-	2	3	24	21	5	20	70	1	-	3	-	4	-	-	-	-	-
Paradixa	4	8.5	.	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-						-	-	-	-	-
Polypedilum	3	8	0	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psychodidae	1	6.1	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanypodinae	5	6.5	0	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanytarsus	3	-	0	1	3	-	4	8	-	3	-	-	3	3	-	-	-	3	-	-	-	-	-	-	-	-	2	2
Caddisflies (Trichoptera)																												
Alloecentrella	9	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Helicopsyche	10	8.6	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Hudsonema	6	6.5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiosis	5	6.7	2	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	-	-	-	-	1	-	-	1
Hydropsyche - Aoteapsyche	4	6	5	-	-	-	-	-	-	-	-	-	-	4	2	-	7	13	-	-	-	-	-	19	-	2	25	46
Hydropsyche - Orthopsyche	9	7.5	5	-	-	-	-	-	-	-	-	-	-	9	-	1	-	10	1	1	-	-	2	-	-	-	-	-
Neurochorema	6	6	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2
Oecetis	6	6.8	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Olinga	9	7.9	10	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	-	-	-	1	-	-	1	2
Polyplectropus	8	8.1	1	-	-	-	-	-	1	3	2	2	8	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-
Psilochorema	8	7.8	4	1	-	-	-	1	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	1	1
Pycnocentria	7	6.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnocentrodes	5	3.8	7	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	1	1	-	-	-	1
Triplectides	5	5.7	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyethira	2	1.2	6	-	1	-	-	1	2	-	1	1	4	1	-	-	2	3	-	-	-	-	-	1	1	-	-	2
Moths																												
Hygraula	4	1.3	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Collembola	6	5.3	.	-	-	-	-	-	-	-	-	-	-	4	-	-	1	5	-	-	-	-	-	-	-	-	2	2
Crustacea																												
Copepoda	5	2.4	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ostracoda	3	1.9	4	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mites	5	5.2	.	1	1	-	3	5	-	1	-	-	1	6	-	-	-	6	-	-	-	4	4	-	1	-	1	2
Oribatidae	5	-	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	4	-	-	-	-	-
Worms	1	3.8	1	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-
Leeches																												
Placobdelloides	3	1.2	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flatworms	3	6.7	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proboscis worms	3	-	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snails			.																									
Ferrrissia	3	2.4	.	-	-	-	-	-	-	-	-	-	-	34	70	6	3	113	-	-	-	-	-	-	-	-	5	5
Lymnaeidae	3	1.2	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Physa	3	0.1	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamopyrgus	4	2.1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Sphaeriidae	3	2.9	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of taxa				5	6	2	8	14	6	8	5	7	14	21	11	7	15	24	4	6	10	5	17	11	8	8	20	25
Number of individuals				7	10	2	35	54	10	14	11	21	56	128	108	21	64	321	7	8	44	14	73	122	26	80	108	336
MCI[1]				112	100	140	90	96	133	113	136	94	107	112	104	126	109	116	115	130	110	140	118	109	103	115	103	106
QMCI				4.86	5.20	7.00	6.26	5.91	6.30	5.93	7.18	6.00	6.27	4.73	3.30	4.90	4.66	4.25	5.71	6.63	6.39	6.43	6.36	5.70	5.69	6.09	5.09	5.60
%EPTtaxa				20.0	16.7	0.0	0.0	14.3	50.0	12.5	60.0	57.1	35.7	57.1	45.5	57.1	53.3	58.3	50.0	50.0	40.0	20.0	47.1	72.7	37.5	50.0	35.0	48.0
%EPTtaxa (excl. Hydroptilidae)				20.0	0.0	0.0	0.0	14.3	33.3	12.5	40.0	42.9	28.6	52.4	45.5	57.1	46.7	54.2	50.0	50.0	40.0	20.0	47.1	63.6	25.0	50.0	35.0	44.0
%EPT abundance				14.3	10.0	0.0	0.0	3.7	40.0	21.4	54.5	47.6	41.1	32.8	10.2	33.3	46.9	28.0	42.9	37.5	25.0	7.1	24.7	29.5	11.5	22.5	35.2	28.3
%EPT abundance (excl. Hydroptilidae)				14.3	0.0	0.0	0.0	3.7	20.0	21.4	45.5	42.9	33.9	32.0	10.2	33.3	43.8	27.1	42.9	37.5	25.0	7.1	24.7	28.7	7.7	22.5	35.2	27.7
AMDI score				10	19	2	6	19	23	7	25	28	26	48	41	39	47	52	21	19	19	8	31	46	33	47	40	47

Table 1 b: Macroinvertebrate laboratory results

Job No. A02982802				PQX					POX				
				Tuesday, 12 April 2016					Wednesday, 13 April 2016				
	MCI	MCI-sb	AMDI							Littoral	Littoral		
	score	Score	Score	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total
Mayflies (Ephemeoptera)													
Acanthophlebia	7	9.6	.	-	-	-	-	-	-	-	-	-	-
Ameletopsis	10	10	6	-	-	-	-	-	-	-	-	-	-
Austroclima	9	6.5	4	-	-	-	-	-	-	-	-	-	-
Coloburiscus	3	8.1	8	-	-	-	-	-	-	-	-	-	-
Deleatidium	8	5.6	6	-	-	-	-	-	-	-	-	-	-
Ichthybotus	8	9.2	10	-	-	-	-	-	-	-	-	-	-
Neozephlebia	7	7.6	3	-	-	-	-	-	-	-	-	-	-
Nesameletus	9	8.6	9	-	-	-	-	-	-	-	-	-	-
Zephlebia	7	8.8	9	-	-	-	-	-	-	-	-	-	-
Stoneflies (Plecoptera)													
Acroperla	5	5.1	.	-	-	-	-	-	-	-	-	-	-
Zelandoperla	10	8.9	4	-	-	-	-	-	-	-	-	-	-
Dobsonflies													
Archichauliodes	7		2	4	1	3	-	8	1	-	-	-	1
Damselflies													
Anisoptera juveniles	6	6	.	-	-	-	-	-	-	-	-	-	-
Austrolestes	6	0.7	.	-	-	-	-	-	-	-	-	-	-
Xanthocnemis	5	1.2	.	-	-	-	-	-	-	-	-	-	-
Water Bugs													
Anisops	5	2.2	.	2	1	-	-	3	-	-	-	-	-
Microvelia	5	4.6	.	-	1	-	-	1	-	-	-	-	-
Sigara	5	2.4	.	-	-	-	-	-	-	-	-	-	-
Beetles													
Antiporus	5	3.5	.	-	-	-	-	-	-	-	-	-	-
Elmidae	6	7.2	0	-	1	-	1	2	-	-	-	-	-
Enochrus	5	2.6	.	-	-	-	-	-	-	-	-	-	-
Hydraenidae	8	6.7	5	-	-	-	-	-	-	-	-	-	-
Liodessus	5	4.9	.	-	-	-	-	-	-	-	-	-	-
Scirtidae	8	6.4	1	-	-	-	-	-	-	-	-	-	-
True Flies (Diptra)													
Aphrophila	5	5.6	8	2	-	1	-	3	-	-	-	-	-
Austrosimulium	3	3.9	5	2	-	2	1	5	-	11	-	-	11
Ceratopogonidae	3	6.2	5	-	-	-	-	-	-	-	-	-	-
Ephydridiae	4	1.4	.	-	-	1	-	1	-	-	-	-	-
Eriopterini	9	7.5	3	-	-	-	-	-	-	-	-	-	-
Harrisius	6	4.7	.	-	-	-	-	-	-	-	-	-	-
Lobodiamesa	5	7.7	.	1	-	-	-	1	-	-	-	-	-
Maoridiamesa	3	4.9	0	3	-	-	-	3	-	-	-	-	-
Molophilus	5	6.3	.	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	2	3.2	0	13	4	4	1	22	3	-	-	2	5
Paradixa	4	8.5	.	-	-	-	-	-	-	-	-	-	-
Polypedilum	3	8	0	1	-	-	-	1	-	-	-	-	-
Psychodidae	1	6.1	.	-	-	-	-	-	-	-	-	-	-
Tanypodinae	5	6.5	0	-	-	-	-	-	-	-	-	-	-
Tanytarsus	3	-	0	-	-	-	-	-	-	-	-	-	-
Caddisflies (Trichoptera)													
Alloecentrella	9	-	3	-	-	-	-	-	-	-	-	-	-
Helicopsyche	10	8.6	8	-	-	-	-	-	-	-	-	-	-
Hudsonema	6	6.5	6	-	-	-	-	-	-	-	1	-	1
Hydrobiosis	5	6.7	2	-	1	3	-	4	-	-	-	-	-
Hydropsyche - Aoteapsyche	4	6	5	26	-	15	-	41	3	-	-	-	3
Hydropsyche - Orthopsyche	9	7.5	5	-	-	-	-	-	-	-	-	-	-
Neurochorema	6	6	.	-	-	-	-	-	-	-	-	-	-
Oecetis	6	6.8	.	-	-	-	-	-	-	-	-	-	-
Olinga	9	7.9	10	-	-	-	-	-	-	-	-	-	-
Polyplectropus	8	8.1	1	-	-	-	-	-	-	-	-	-	-
Psilochorema	8	7.8	4	-	-	-	-	-	-	-	-	-	-
Pycnocentria	7	6.8	2	-	-	-	-	-	-	-	-	-	-
Pycnocentrodes	5	3.8	7	-	-	-	-	-	-	-	-	-	-
Triplectides	5	5.7	0	-	-	-	-	-	-	-	-	-	-
Oxyethira	2	1.2	6	-	9	17	2	28	4	3	1	1	9
Moths													
Hygraula	4	1.3	.	-	-	-	-	-	-	-	-	-	-
Collembola	6	5.3	.	-	-	-	-	-	-	-	-	-	-
Crustacea													
Copepoda	5	2.4	.	-	-	-	-	-	-	-	-	-	-
Ostracoda	3	1.9	4	-	2	-	-	2	1	-	-	-	1
Mites	5	5.2	.	-	-	-	-	-	-	3	-	-	3
Oribatidae	5	-	.	-	-	-	-	-	-	-	-	-	-
Worms	1	3.8	1	1	16	1	6	24	9	2	1	22	34
Leeches													
Placobdelloides	3	1.2	.	-	-	-	-	-	-	-	-	-	-
Flatworms	3	6.7	.	-	8	2	-	10	-	4	2	-	6
Proboscis worms	3	-	.	1	39	20	2	62	-	-	-	-	-
Snails			.										
Ferrrissia	3	2.4	.	-	-	-	-	-	-	-	-	-	-
Lymnaeidae	3	1.2	.	-	1	-	-	1	-	35	4	-	39
Physa	3	0.1	.	-	-	-	-	-	1	46	14	1	62
Potamopyrgus	4	2.1	10	-	-	-	-	-	-	1	-	-	1
Sphaeriidae	3	2.9	.	-	4	-	1	5	-	7	1	-	8
Number of taxa				11	13	11	7	20	7	9	7	4	14
Number of individuals				56	88	69	14	227	22	112	24	26	184
MCI[1]				75	74	71	57	75	63	60	60	40	70
QMCI				3.66	2.64	3.19	2.14	3.03	2.18	3.00	3.00	1.19	2.65
%EPTtaxa				9.1	15.4	27.3	14.3	15.0	28.6	11.1	28.6	25.0	21.4
%EPTtaxa (excl. Hydroptilidae)				9.1	7.7	18.2	0.0	10.0	14.3	0.0	14.3	0.0	14.3
%EPT abundance				46.4	11.4	50.7	14.3	32.2	31.8	2.7	8.3	3.8	7.1
%EPT abundance (excl. Hydroptilidae)				46.4	1.1	26.1	0.0	19.8	13.6	0.0	4.2	0.0	2.2
AMDI score				20	13	27	14	21	22	23	16	11	32

Job No. A02982802	PMX (Sb)					PLX				
	Wednesday, 13 April 2016					Tuesday, 12 April 2016				
	littoral	littoral	littoral	littoral						
	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total
Mayflies (Ephemeoptera)										
Acanthophlebia	-	-	-	-	-	-	-	-	-	-
Ameletopsis	-	-	-	-	-	-	-	-	-	-
Austroclima	-	-	-	-	-	-	-	-	-	-
Coloburiscus	-	-	-	-	-	-	-	-	-	-
Deleatidium	-	-	-	-	-	-	-	-	-	-
Ichthybotus	-	-	-	-	-	-	-	-	-	-
Neozephlebia	-	-	-	-	-	-	-	-	-	-
Nesameletus	-	-	-	-	-	-	-	-	-	-
Zephlebia	-	-	-	-	-	1	-	-	-	1
Stoneflies (Plecoptera)										
Acroperla	-	-	-	-	-	-	-	-	-	-
Zelandoperla	-	-	-	-	-	-	-	-	-	-
Dobsonflies										
Archichauliodes	-	-	-	-	-	-	1	-	1	2
Damselflies										
Anisoptera juveniles	3	-	-	-	3	-	-	-	-	-
Austrolestes	-	1	-	-	1	-	-	-	-	-
Xanthocnemis	18	7	34	36	95	-	-	-	-	-
Water Bugs										
Anisops	5	3	-	3	11	-	-	-	-	-
Microvelia	-	-	-	-		-	-	-	-	-
Sigara	2	10	1	9	22	-	-	-	-	-
Beetles										
Antiporus	-	-	-	-	-	-	-	-	-	-
Elmidae	-	-	-	-	-	17	4	10	2	33
Enochrus	-	-	-	2	2	-	-	-	-	-
Hydraenidae	-	-	-	-	-	-	-	-	-	-
Liodessus	-	-	-	1	1	-	-	-	-	-
Scirtidae	-	-	-	-	-	-	-	-	-	-
True Flies (Diptra)										
Aphrophila	-	-	-	-	-	-	-	-	-	-
Austrosimulium	2	-	-	-	2	28	35	45	11	119
Ceratopogonidae	-	-	-	-	-	-	-	-	-	-
Ephydridiae	-	-	-	-	-	-	-	-	-	-
Eriopterini	-	-	-	-	-	-	-	-	-	-
Harrisius	-	-	-	-	-	-	-	-	-	-
Lobodiamesa	-	-	-	-	-	-	-	-	-	-
Maoridiamesa	-	-	-	-	-	-	-	-	-	-
Molophilus	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	1	-	-	-	1	1	-	-	-	1
Paradixa	-	-	-	-	-	-	-	-	-	-
Polypedilum	-	-	-	-	-	-	-	-	-	-
Psychodidae	-	-	1	-	1	-	-	-	-	-
Tanypodinae	1	-	-	-	1	-	-	-	-	-
Tanytarsus	-	-	-	-	-	-	-	-	-	-
Caddisflies (Trichoptera)										
Alloecentrella	-	-	-	-	-	-	-	-	-	-
Helicopsyche	-	-	-	-	-	-	-	-	-	-
Hudsonema	-	-	-	-	-	-	-	-	-	-
Hydrobiosis	-	-	-	-	-	-	-	-	-	-
Hydropsyche - Aoteapsyche	1	-	-	-	1	-	1	-	-	1
Hydropsyche - Orthopsyche	-	-	-	-	-	-	-	-	-	-
Neurochorema	-	-	-	-	-	-	-	-	-	-
Oecetis	-	-	-	-	-	-	-	-	-	-
Olinga	-	-	-	-	-	-	-	-	-	-
Polyplectropus	5	1	1	1	8	-	-	-	-	-
Psilochorema	-	-	-	-	-	-	-	-	-	-
Pycnocentria	-	-	-	-	-	-	-	-	-	-
Pycnocentrodes	-	-	-	-	-	-	-	-	2	2
Triplectides	-	-	-	1	1	-	-	-	-	-
Oxyethira	8	-	1	-	9	3	1	1	3	8
Moths										
Hygraula	-	-	-	-	-	-	-	-	4	4
Collembola	-	-	-	-	-	-	-	-	-	-
Crustacea										
Copepoda	1	-	-	-	1	-	-	-	-	-
Ostracoda	-	-	-	31	31	-	-	-	-	-
Mites	-	-	-	-	-	1	-	-	-	1
Oribatidae	-	-	-	-	-	-	-	-	-	-
Worms	2	2	-	-	4	4	9	6	10	29
Leeches										
Placobdelloides	-	-	-	1	1	-	-	-	-	-
Flatworms	22	5	25	22	74	1	10	2	-	13
Proboscis worms	25	3	5	7	40	6	8	3	6	23
Snails										
Ferrrissia	-	-	-	-	-	-	-	-	-	-
Lymnaeidae	1	-	4	-	5	4	1	-	2	7
Physa	7	2	16	10	35	11	2	-	12	25
Potamopyrgus	70	30	71	12	183	62	31	6	25	124
Sphaeriidae	-	-	-	11	11	2	-	1	1	4
Number of taxa	17	10	10	14	25	13	11	8	12	17
Number of individuals	174	64	159	147	544	141	103	74	79	397
MCI[1]	67	55	58	60	66	69	71	63	73	76
QMCI	2.50	2.38	2.40	2.46	2.44	3.76	3.28	3.31	3.25	3.45
%EPTtaxa	17.6	10.0	20.0	14.3	16.0	15.4	18.2	12.5	16.7	23.5
%EPTtaxa (excl. Hydroptilidae)	11.8	10.0	10.0	14.3	12.0	7.7	9.1	0.0	8.3	17.6
%EPT abundance	8.0	1.6	1.3	1.4	3.5	2.8	1.9	1.4	6.3	3.0
%EPT abundance (excl. Hydroptilidae)	3.4	1.6	0.6	1.4	1.8	0.7	1.0	0.0	2.5	1.0
AMDI score	20	12	17	12	18	27	27	25	28	33

Job No. A02982802	PKX					PJX (Sb)				
	Tuesday, 12 April 2016					Tuesday, 12 April 2016				
						littoral	littoral	littoral	littoral	
	R1	R2	R3	R4	Site total	R1	R2	R3	R4	Site total
Mayflies (Ephemeoptera)										
Acanthophlebia	1	-	-	-	1	-	-	-	-	-
Ameletopsis	-	-	-	1	1	-	-	-	-	-
Austroclima	-	-	-	-	-	-	-	-	1	1
Coloburiscus	-	-	8	-	8	-	-	-	-	-
Deleatidium	8	11	75	11	105	-	-	-	-	-
Ichthybotus	-	-	-	-	-	-	-	-	-	-
Neozephlebia	-	-	-	-	-	-	-	-	-	-
Nesameletus	-	-	1	-	1	-	-	-	-	-
Zephlebia	-	1	2	1	4	1	-	5	32	38
Stoneflies (Plecoptera)										
Acroperla	-	-	-	-	-	-	-	-	-	-
Zelandoperla	-	-	-	-	-	-	-	-	-	-
Dobsonflies										
Archichauliodes	10	-	71	19	100	-	-	-	-	-
Damselflies										
Anisoptera juveniles	-	-	-	-	-	-	-	-	-	-
Austrolestes	-	-	-	-	-	-	-	-	-	-
Xanthocnemis	-	-	-	-	-	10	3	-	-	13
Water Bugs										
Anisops	-	-	-	-	-	-	-	-	-	-
Microvelia	-	-	-	-	-	1	-	-	-	1
Sigara	-	-	-	-	-	-	13	-	-	13
Beetles										
Antiporus	-	-	-	-	-	1	-	-	-	1
Elmidae	39	24	36	66	165	-	-	-	-	-
Enochrus	-	-	-	-	-	-	-	-	-	-
Hydraenidae	-	-	9	-	9	-	-	-	-	-
Liodessus	-	-	-	-	-	-	-	-	-	-
Scirtidae	-	-	-	-	-	-	-	-	-	-
True Flies (Diptra)										
Aphrophila	1	-	-	-	1	-	-	-	-	-
Austrosimulium	16	9	129	9	163	-	-	-	-	-
Ceratopogonidae	-	-	-	-	-	-	-	-	-	-
Ephydridiae	-	-	-	-	-	-	-	-	-	-
Eriopterini	-	2	5	4	11	-	-	-	-	-
Harrisius	-	-	-	-	-	-	-	-	-	-
Lobodiamesa	-	-	-	-	-	-	-	-	-	-
Maoridiamesa	-	-	-	-	-	-	-	-	-	-
Molophilus	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	-	-	-	-	-	1	-	-	-	1
Paradixa	-	-	-	-	-	-	-	-	-	-
Polypedilum	-	-	-	-	-	-	-	-	1	1
Psychodidae	-	-	-	-	-	-	-	-	-	-
Tanypodinae	-	-	1	-	1	3	-	-	-	3
Tanytarsus	-	-	-	-	-	-	-	-	-	-
Caddisflies (Trichoptera)										
Alloecentrella	-	-	-	-	-	-	-	-	-	-
Helicopsyche	-	-	-	-	-	-	-	-	-	-
Hudsonema	-	-	-	-	-	-	-	-	-	-
Hydrobiosis	-	-	-	-	-	-	-	-	-	-
Hydropsyche - Aoteapsyche	-	-	2	-	2	-	-	-	-	-
Hydropsyche - Orthopsyche	-	-	-	-	-	-	-	-	-	-
Neurochorema	-	-	-	-	-	-	-	-	2	2
Oecetis	-	-	-	1	1	-	-	-	-	-
Olinga	-	-	-	-	-	-	-	-	-	-
Polyplectropus	-	-	-	-	-	-	-	-	-	-
Psilochorema	-	-	-	-	-	-	-	-	-	-
Pycnocentria	-	-	3	1	4	-	-	3	-	3
Pycnocentrodes	-	-	1	-	1	-	-	-	-	-
Triplectides	-	-	1	1	2	-	-	3	-	3
Oxyethira	-	-	-	-	-	-	-	-	-	-
Moths										
Hygraula	-	-	-	-	-	-	-	-	-	-
Collembola	-	-	-	-	-	-	-	-	-	-
Crustacea										
Copepoda	-	-	-	-	-	-	-	-	-	-
Ostracoda	-	-	-	-	-	-	-	-	-	-
Mites	-	2	-	-	2	-	-	-	-	-
Oribatidae	-	-	-	-	-	-	-	-	-	-
Worms	-	1	-	2	3	-	-	-	-	-
Leeches										
Placobdelloides	-	-	-	-	-	-	-	-	-	-
Flatworms	-	-	1	1	2	-	-	-	-	-
Proboscis worms	-	-	4	12	16	-	-	-	-	-
Snails										
Ferrrissia	-	-	2	3	5	-	-	-	-	-
Lymnaeidae	-	-	-	-	-	2	-	-	-	2
Physa	-	-	-	-	-	-	3	-	-	3
Potamopyrgus	2	-	9	9	20	40	278	74	4	396
Sphaeriidae	-	-	-	1	1	-	-	-	-	-
Number of taxa	7	7	18	16	25	8	4	4	5	15
Number of individuals	77	50	360	142	629	59	297	85	40	481
MCI[1]	114	111	110	106	109	78	29	117	126	89
QMCI	5.66	5.90	5.46	5.66	5.56	2.34	2.08	2.79	7.91	2.72
%EPTtaxa	28.6	28.6	44.4	37.5	44.0	12.5	0.0	75.0	60.0	33.3
%EPTtaxa (excl. Hydroptilidae)	28.6	28.6	44.4	37.5	44.0	12.5	0.0	75.0	60.0	33.3
%EPT abundance	11.7	24.0	25.8	11.3	20.7	1.7	0.0	12.9	87.5	9.8
%EPT abundance (excl. Hydroptilidae)	11.7	24.0	25.8	11.3	20.7	1.7	0.0	12.9	87.5	9.8
AMDI score	37	29	50	33	48	21	15	32	32	20

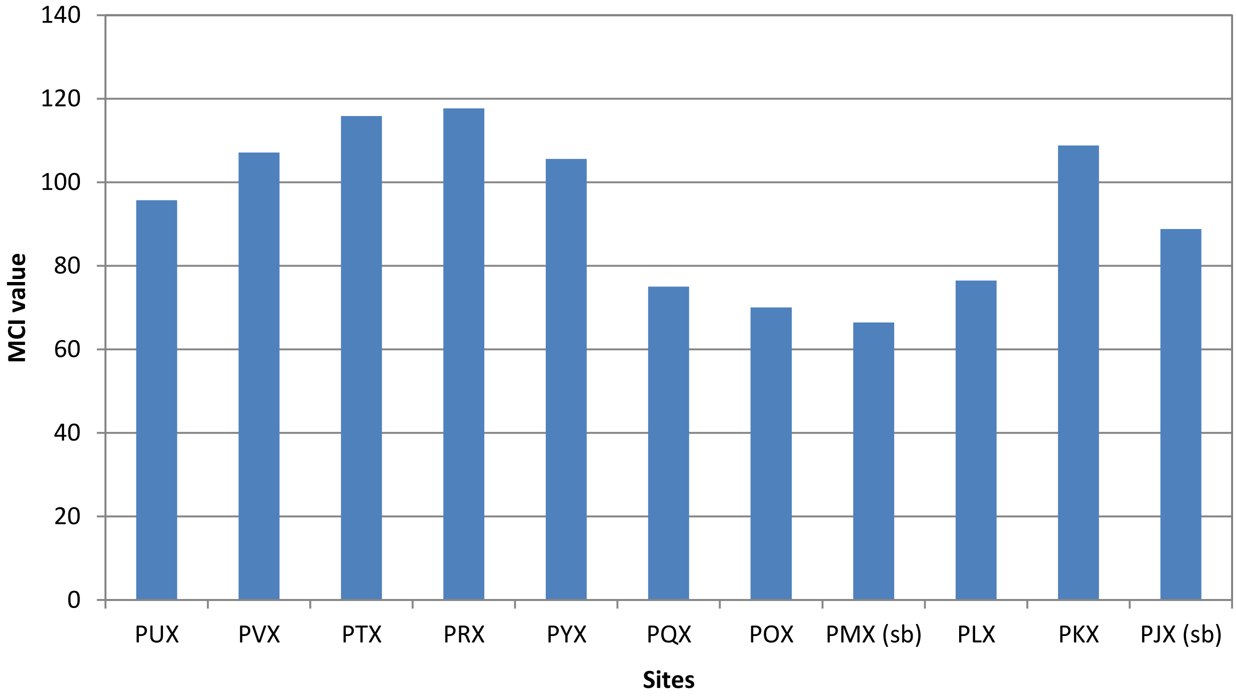


Figure 1 B: Macroinvertebrate community index (MCI) at sites within the Puhipuhi exploration tenement

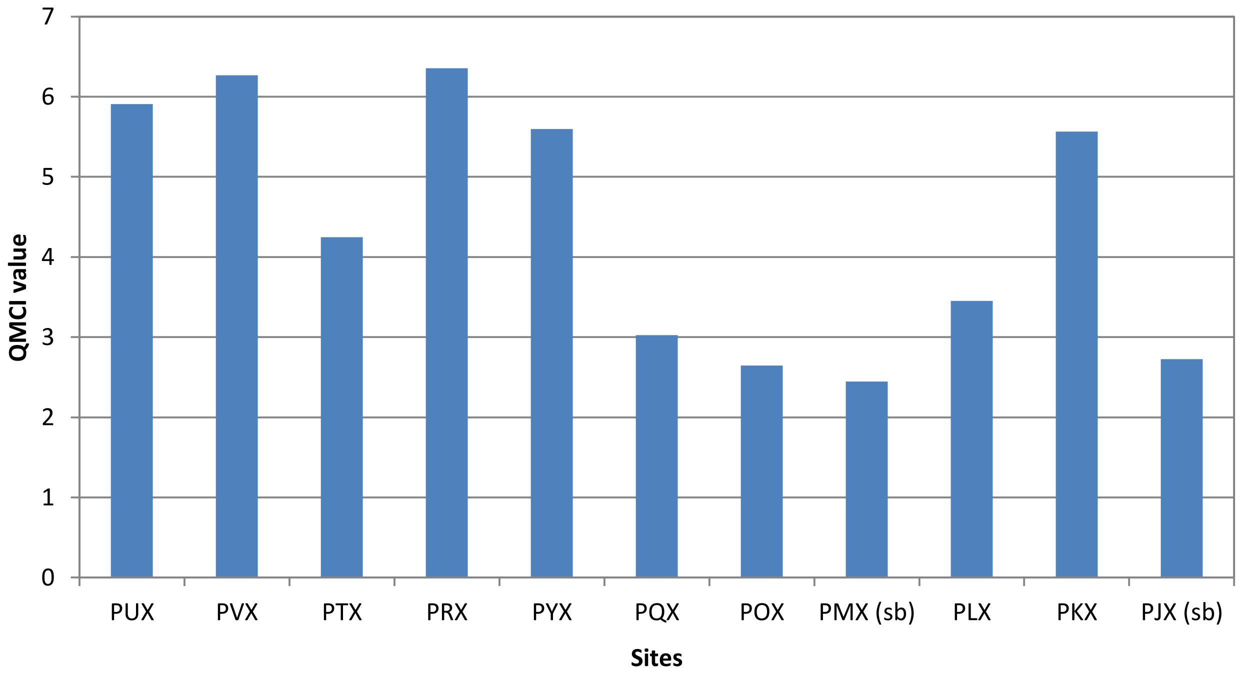


Figure 2 B: Quantitative community index (QMCI) at sites within the Puhipuhi exploration tenement

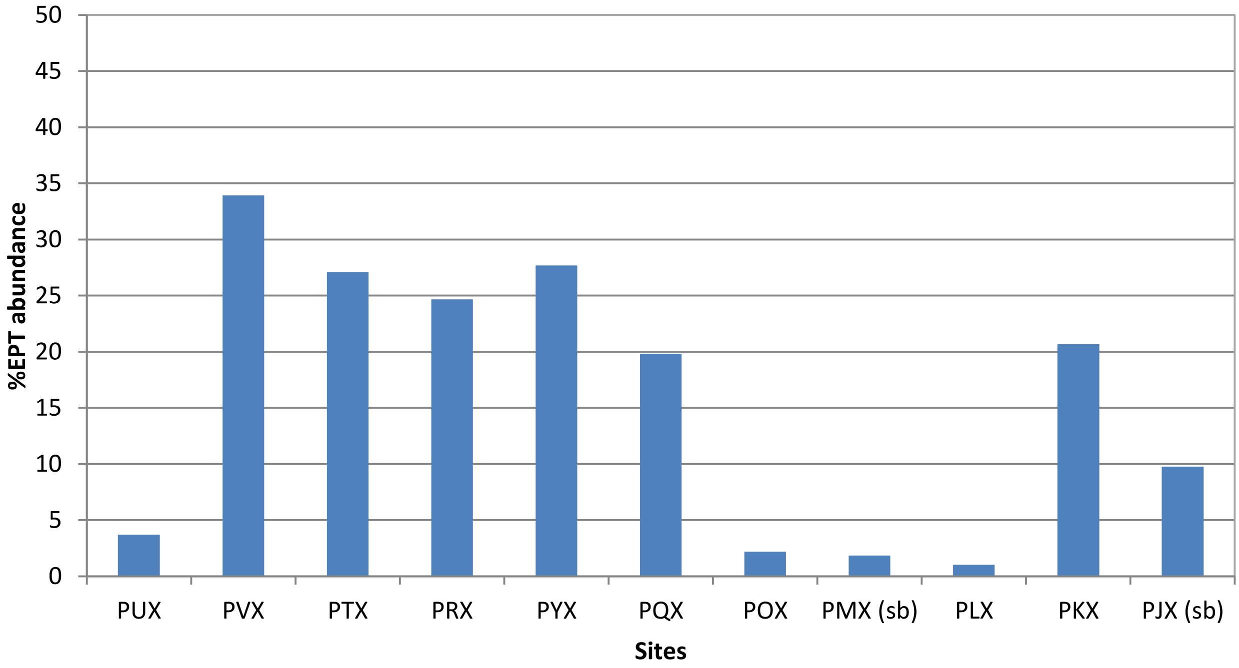


Figure 3 B: Percent abundance of mayfly, stonefly and caddisfly excluding the pollution tolerant *Hydroptilidae* taxa (%EPT) at sites within the Puhipuhi exploration tenement.

Appendix C: Heavy Metal concentrations and Macroinvertebrate Community Composition

Table 1 C: Heavy metal concentrations at sites within the Puhipuhi catchment

Sample ID		**PUW-1**	**PVW-1**	**PTW-1**	**PRW-1**	**PYW-1**	**PQW-1**	**POW01**	**PMW01**	**PLW01**	**PKW01**	**PJW01**	**ANZECC Water Quality Guidelines 95% Protection**
Sample Site Location		PUX	PVX	PTX	PRX	PYX	PQX	POX	PMX	PLX	PKX	PJX	
Eurofins Laboratory ID		M16-Ap02214	M16-Ap02216	M16-Ap02212	M16-Ap02208	M16-Ap02220	M16-Ap02206	M16-Ap02202	M16-Ap02197	M16-Ap02194	M16-Ap02192	M16-Ap02190	
Sampling Date		13-Mar-16	11-Mar-16	12-Mar-16	12-Mar-16	10-Mar-16	11-Mar-16	11-Mar-16	11-Mar-16	10-Mar-16	10-Mar-16	10-Mar-16	
Sampling time (approximate)		09:30	15:45	09:00	15:45	16:00	13:30	07:45	16:00	14:30	11:45	08:00	Freshwater
Total Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Dissolved Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002
Total Copper	mg/L	0.003	0.006	< 0.001	0.002	< 0.001	0.002	0.002	< 0.001	0.002	< 0.001	0.001	-
Dissolved Copper	mg/L	< 0.001	**0.006**	< 0.001	**0.002**	< 0.001	**0.002**	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0014
Total Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Dissolved Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.0034
Total Zinc	mg/L	0.007	0.018	0.007	0.013	0.006	0.009	0.008	0.009	0.008	0.006	0.006	-
Dissolved Zinc	mg/L	0.006	**0.017**	0.006	**0.011**	0.005	**0.009**	0.007	0.007	0.007	0.006	0.005	0.008 [2]
Total Arsenic	mg/L	0.002	0.003	0.003	0.007	0.002	0.002	0.001	< 0.001	< 0.001	0.002	< 0.001	-
Dissolved Arsenic	mg/L	0.001	0.002	0.002	0.006	0.002	0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	0.013 [1]
Total Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Dissolved Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0034
Total Mercury[3]	mg/L	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.001
Dissolved Mercury[3]	mg/L	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-
Dissolved Mercury[4]	ng/L	236	4.78	41.9		1.95	23.8	15.5	18.1	12.6	7.31	8.73	
Dissolved Mercury	mg/L	0.000236	0.00000478	0.0000419		0.00000195	0.0000238	0.0000155	0.0000181	0.0000126	0.00000731	0.00000873	
Total Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-
Dissolved Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.37 [2]
Total Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Dissolved Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001 [2]
Total Manganese	mg/L	*0.3*	*0.16*	0.014	0.072	0.007	0.031	0.025	0.029	0.021	0.029	0.024	-
Dissolved Manganese	mg/L	0.31	0.16	0.012	0.063	0.006	0.031	0.024	0.027	0.018	0.029	0.022	1.9 [2]
Total Nickel	mg/L	0.004	0.003	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	-
Dissolved Nickel	mg/L	0.003	0.002	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.011

Notes:
***Bold** values do not meet the ANZECC guideline value for 95 % protection for aquatic organisms.*
1. Trigger value is for AsV.
2. Trigger value may not protect key test species from chronic toxicity.
3. Mercury determined by ICP-MS (with a detection limit of 0.00001 mg/L or 100 ng/L)
4. Mercury determined by purge and trap CV-AFS (with a detection limit of 0.000 000 5 mg/L or 0.5 ng/L)

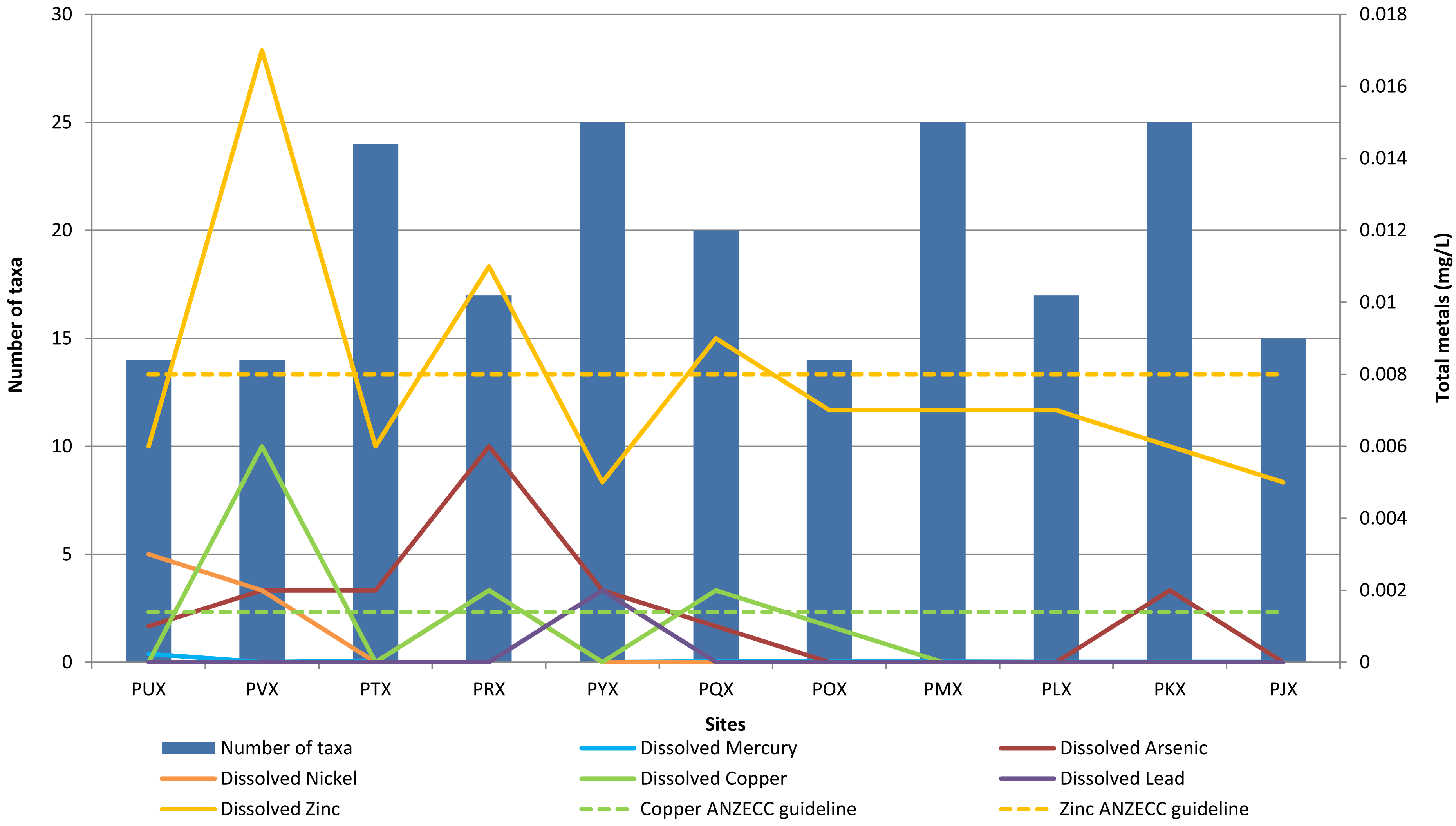


Figure 1 C: Macroinvertebrate taxonomic richness and heavy metal concentrations at sites within the Puhipuhi catchment

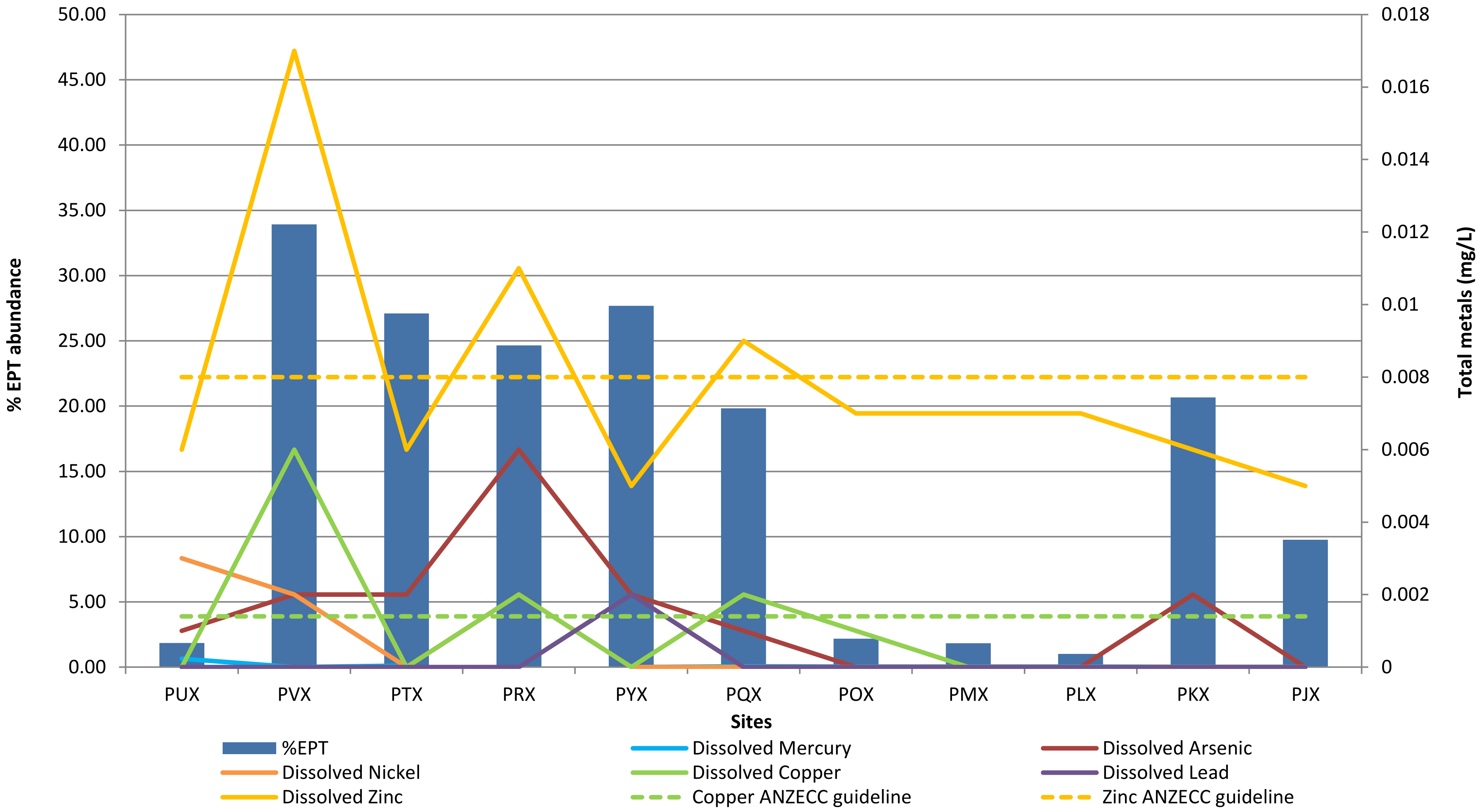


Figure 2 C: Percent abundance of mayfly, stonefly and caddisfly excluding the pollution tolerant Hydroptilidae taxa and heavy metal concentrations at sites within the Puhipuhi catchment

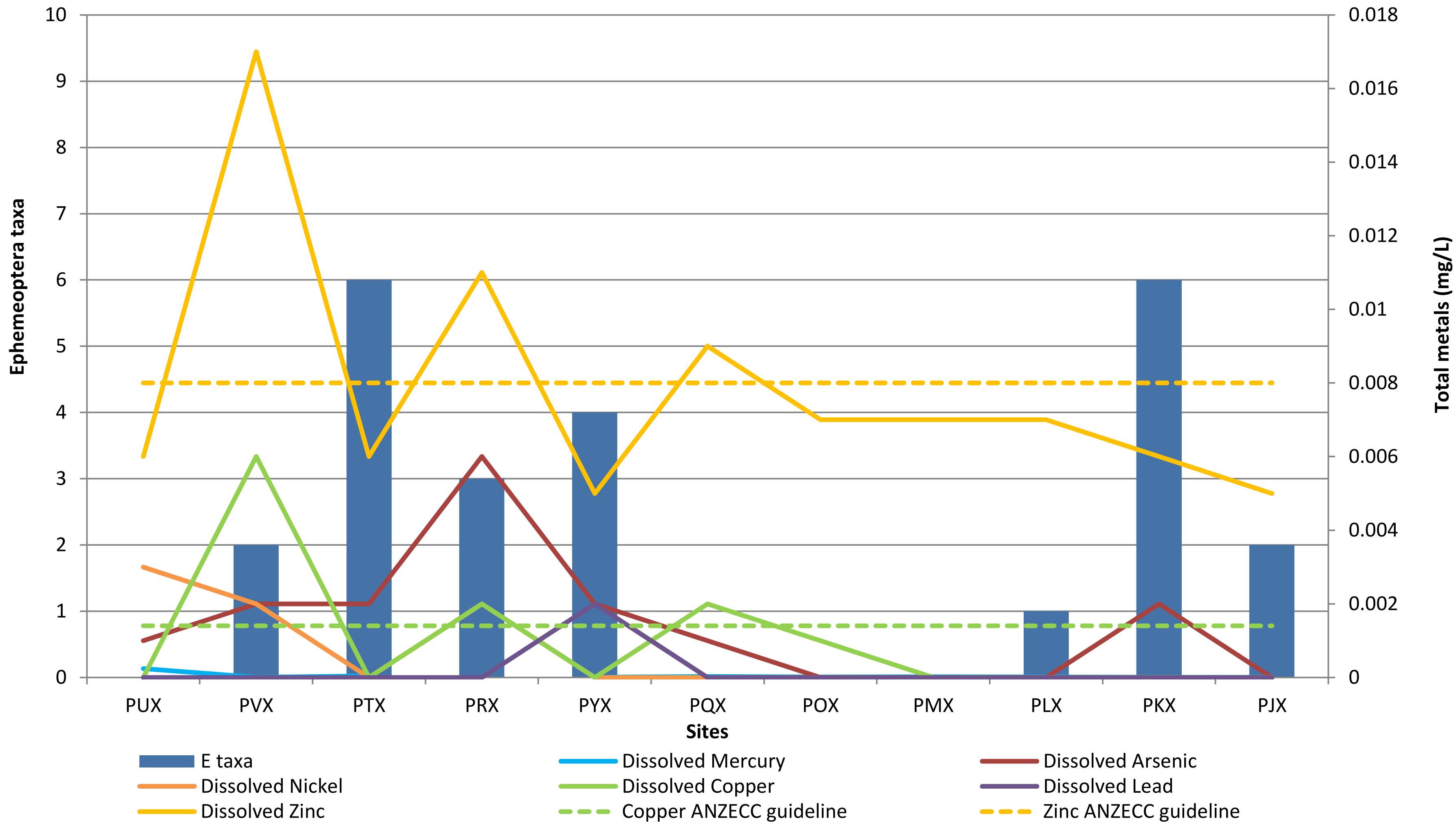


Figure 3 C: Number of mayfly taxa and heavy metal concentrations at sites within the Puhipuhi catchment

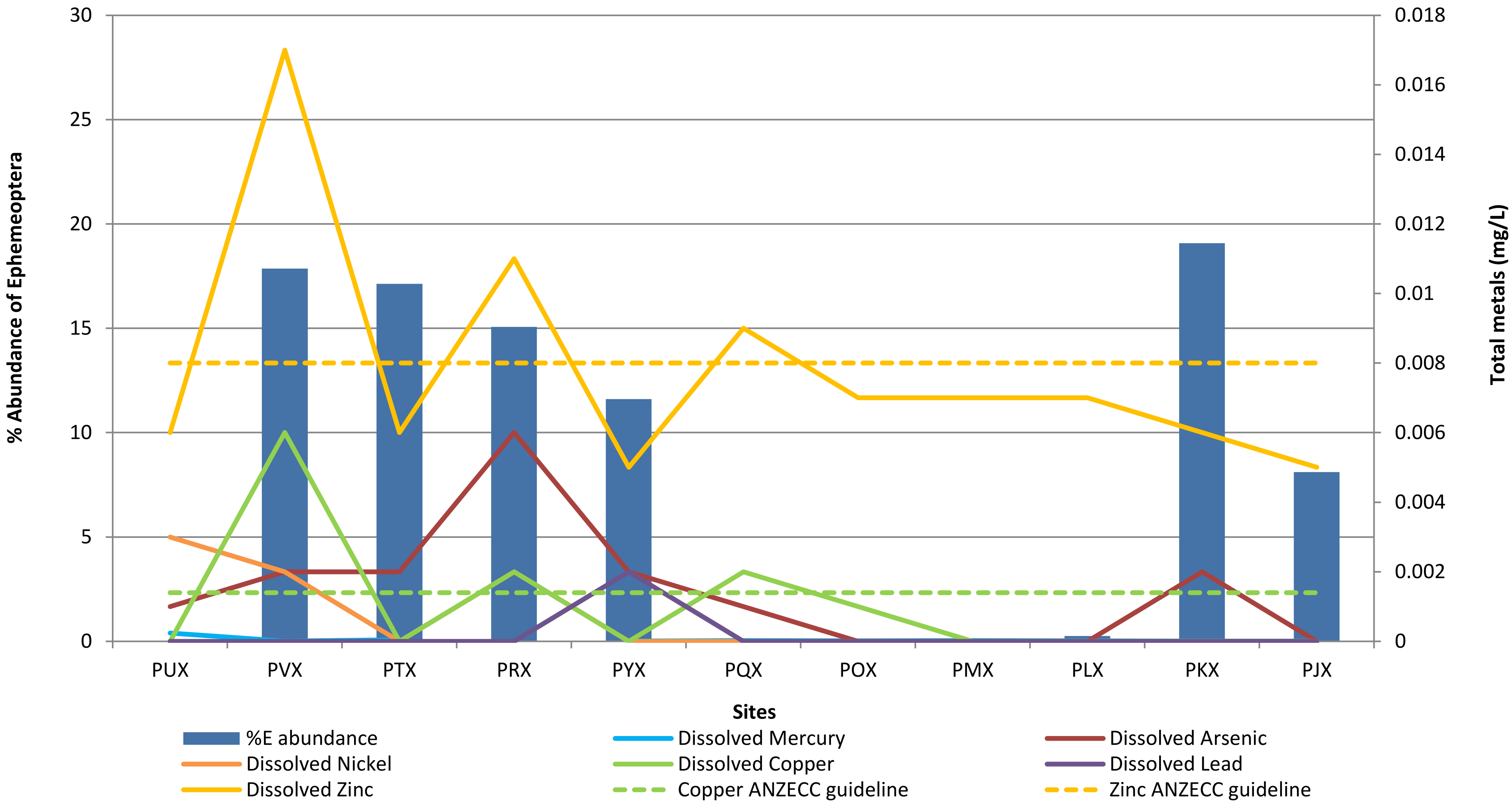


Figure 4 C: Percent abundance of mayfly and heavy metal concentrations at sites within the Puhipuhi catchment

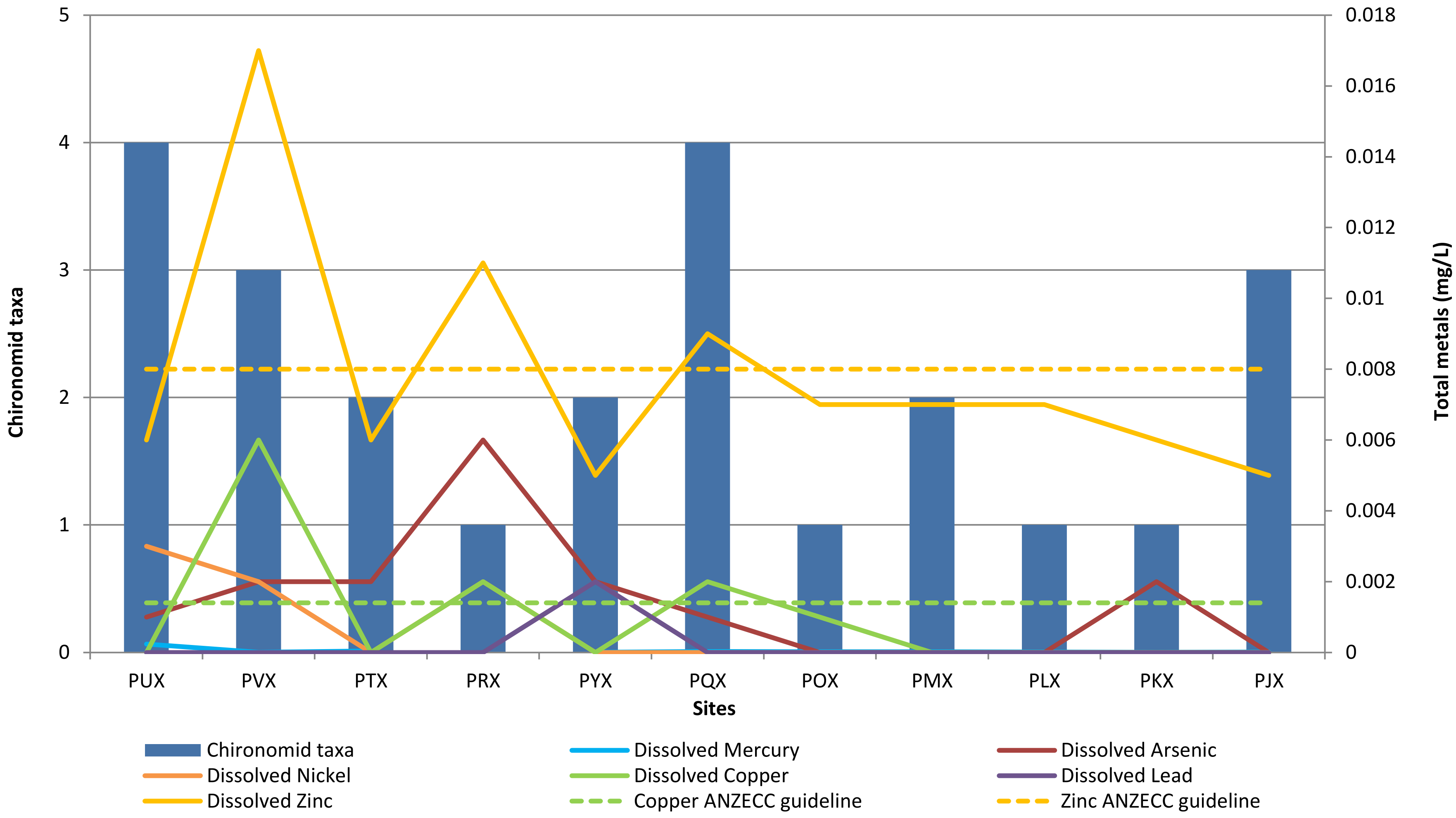


Figure 5 C: Number of Chironomid taxa and heavy metal concentrations within the Puhipuhi catchment

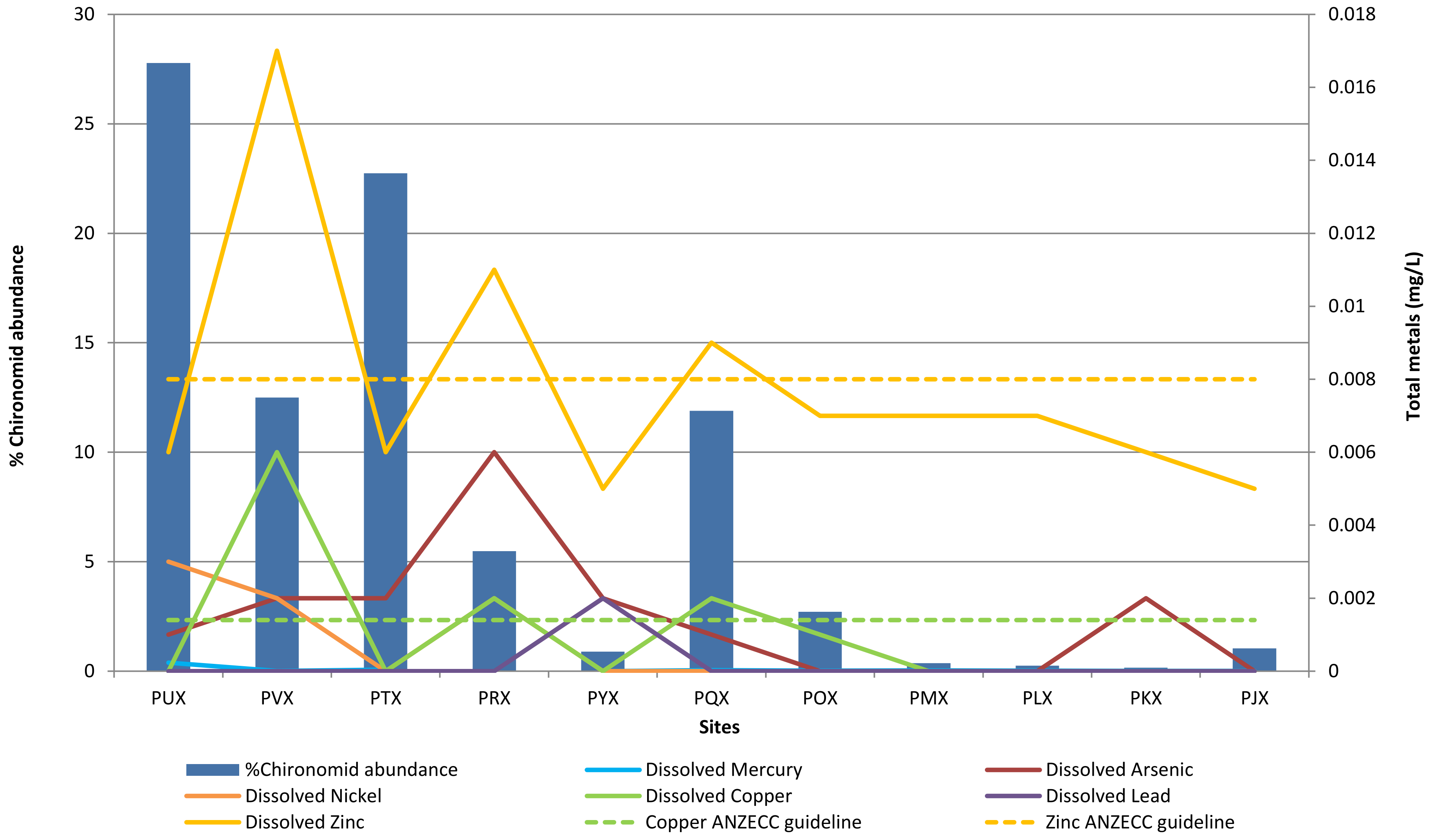


Figure 6 C: Percent abundance of mayfly and heavy metal concentrations at sites within the Puhipuhi catchment