The macroinvertebrates and algae of the Waiokotore and Potae Streams and Mangatera River, Ruahine Ranges

Department of Conservation
Te Papa Atawhai

The macroinvertebrates and algae of the Waiokotore and Potae Streams and Mangatera River, Ruahine Ranges

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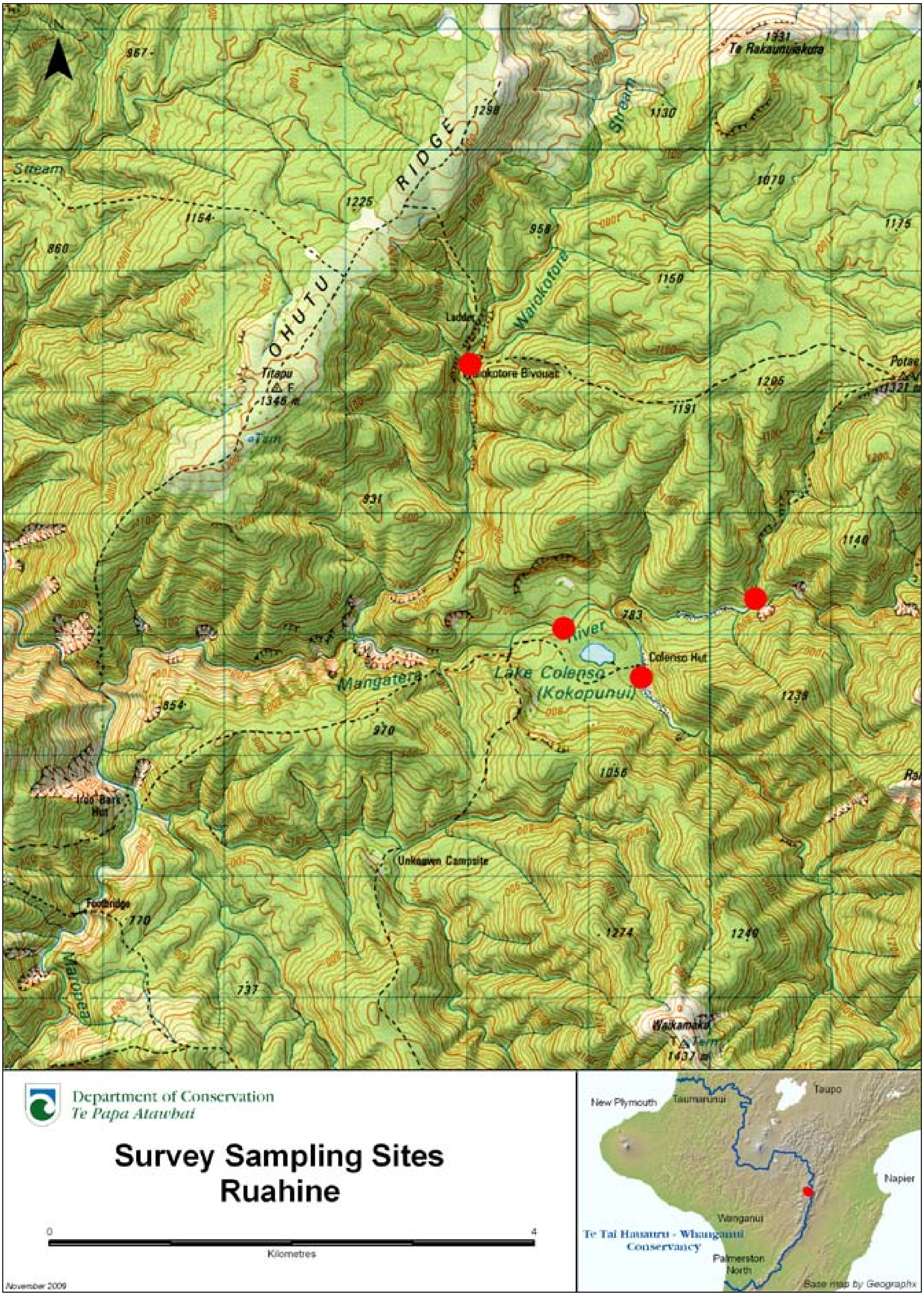
Introduction

Some of the headwater streams and rivers of the Rangitikei River that originate in the Ruahine Ranges have populations of the threatened blue duck/whio (*Hymenolaimus malacorhynchos*). This duck species is restricted mainly to fast-flowing and turbulent rivers and streams in forested hill country and mountains. Numbers have declined significantly since European settlement due to land use change and introduced predators (Heather & Robertson, 1996). Blue duck dabble, dive and up-end in swift white water to feed on aquatic invertebrates which make up most of their diet. They eat mostly caddisfly larvae, but also mayfly, stonefly, and chironomid larvae that they find on the downstream sides of stones and boulders. Occasionally they take emerging adult insects on the surface as well as some algae and fruit (Heather & Robertson, 1996).

While predators are likely the main determinant of breeding success of whio, their food supply is also vitally important. There is concern to what the impacts of the invasive algae, *Didymosphenia geminata* would be on duck populations. There is the potential that this algae, if introduced to the blue duck rivers of the Ruahine Ranges, would alter the benthic macroinvertebrate community and thus impact on the blue duck diet.

This survey provides a snapshot of the macroinvertebrate and algal communities of four sites on headwater streams of the Rangitikei River catchment within the Ruahine Forest Park. These sites were in streams known to have populations of whio. Should *Didymosphenia geminata* ever become established, this data will provide an indication of previous conditions.

FIGURE 1: THE FOUR SITES ON THE WAIOKOTORE STREAM, POTAE STREAM, AND MANGATERA RIVER SURVEYED FOR MACROINVERTEBRATES AND ALGAE ON FEBRUARY 25 AND 26, 2009.



Methods

The four sites were selected as they were in close-proximity and had resident blue ducks (Figure: 1). A helicopter was used to access the area.

In-stream and riparian characteristics were assessed using the Qualitative Habitat Assessment Procedure developed by Environment Waikato (Collier & Kelly 2005). This procedure is derived from the revised USEPA Rapid Bioassessment Protocol and modified to suit local stream conditions. To assess stream habitat, the observer estimates the condition of each characteristic over at least a 100 m reach. Two data sheets are completed at each site, a Field Assessment Cover Form and a Habitat Assessment Field Data Sheet (see Appendix).

The Field Assessment Cover Form describes general watershed and in-stream characteristics. The coordinates of the sampling site were determined using NZMS 260 topographic maps and a Garmin Etrex Vista GPS unit. Stream wetted width was measured at five transects and water depths at the points where invertebrate samples were taken. Water velocity was estimated using a velocity head rod at the same points where depths were measured. Spot measures of temperature, specific conductivity, pH and dissolved oxygen were recorded with Extech ExStik II handheld meters. Other parameters such as the nature of the stream-bottom substrata and in-stream plant cover were estimated visually.

The Habitat Assessment Field Data Sheet comes in two variants, one for hard-bottomed and another for soft-bottomed streams. In this survey all sites were hard-bottomed. This form involves nine in-stream and riparian characteristics that the observer rates from optimal to poor on a 20 point scale (Table: 1, Collier & Kelly 2005). These are then summed to derive an overall score for the assessed site. The theoretical maximum possible score indicating optimal habitat is 180 while the minimum possible score indicating very poor habitat is 9.

TABLE 1: THE NINE IN-STREAM AND RIPARIAN CHARACTERISTICS INCLUDED ON THE HABITAT ASSESSMENT FIELD DATA SHEET FOR HARD-BOTTOMED STREAMS (ADAPTED FROM COLLIER & KELLY, 2005).

CHARACTERISTIC	ASSESSES	IMPORTANCE
1. Riparian vegetative zone width	Assesses the extent of natural vegetation from the edge of the stream bank out through the riparian zone.	The vegetative zone is a buffer to pollutants entering a stream from runoff, controls erosion, provides habitat and organic matter input and provides shade. Generally, the wider, the better.
2. Vegetative Protection	Evaluates the amount and type of vegetative protection present on the bank and near-stream part of the riparian zone.	The root systems of plants growing on stream banks help hold soil in place and reduce the potential for bank erosion.
3. Bank stability	Assesses the erosion or potential erosion of stream banks.	Eroded banks indicate a problem of sediment movement and deposition.

CHARACTERISTIC	ASSESSES	IMPORTANCE
4. Frequency of riffles or bends	Measures the sequence or frequency of riffles.	Riffles are a source of high-quality habitat and diverse fauna. Generally, a high frequency of riffles enhances the diversity of the stream community.
5. Channel alteration	A measure of large-scale changes in the shape of the stream channel.	Many streams have been straightened, deepened and channelized. Such streams have reduced habitat heterogeneity.
6. Sediment deposition	Measures sediment accumulation and changes to the stream bottom resulting from deposition.	Sediment deposition results from the large-scale movement of sediment. High levels of deposition are symptomatic of and unstable habitat that may be unsuitable for many organisms.
7. Velocity/Depth regimes	Assesses the diversity of flow environments.	The most diverse hard-bottomed streams have slow-deep, slow-shallow, fast-deep and fast-shallow flow environments. Greater habitat diversity generally equals greater taxonomic diversity.
8. Abundance and diversity of habitat	Assesses the relative quantity and variety of natural instream features.	The more diverse the range of microhabitats (e.g. cobble, large rocks, logs, branches, leaf packs) the greater the diversity of aquatic organisms.
9. Periphyton growth	Assesses the presence/absence of periphyton growth on the stream bed.	Lower algal biomass is preferable to high levels which can smoother the stream bed.

Benthic macroinvertebrates were sampled by taking five Surber samples (0.1 m^2 area, 500 µm mesh size) from within riffles at each site. Samples were preserved in iso-propyl alcohol and washed through a 500 µm sieve prior to sorting and identification. Macroinvertebrates were identified to the lowest possible level using Smith & Ward (2005) and Winterbourn, Gregson & Dolphin (2006). Chironomids were identified to sub-family where possible. Several macroinvertebrate metrics were calculated. The Macroinvertebrate Community Index (MCI) and its quantitative variant (QMCI) are biotic indices commonly used in New Zealand to assess organic enrichment in stony riffles in streams and rivers (Boothroyd & Stark, 2000). The Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) orders (EPT) are considered to be the most sensitive to declines in water and habitat quality in stony-bottomed streams and rivers. The percentage of EPT individuals and taxa are used to indicate the relative dominance of these insect orders. EPT animals tend to be found in greater numbers in less degraded streams. Hydroptilid trichoptera were excluded from the EPT calculations as they are algal piercers and thrive in high-algae environments and as such are often found in great numbers in degraded streams.

Periphyton was sampled by taking scrapings from four cm diameter circles from four rocks using scalpels. Rocks from close to the invertebrate sampling points were randomly selected. All the samples at each site were pooled. The periphyton samples were frozen as soon as possible and sent to NIWA for chlorophyll-*a*, ash-free dry weight (AFDW) and relative abundance analysis using the methodologies described in Biggs & Kilroy (2000).

Results

PHYSICOCHEMICAL

The sampling sites were all hard-bottomed dominated by gravel, cobble and boulder size substrate (see Appendix for size classes). Organic material and in-stream plant cover was minimal (Table: 2). It should be noted however that the Waiokotore Stream site had riffles with some moss cover that were sampled for macroinvertebrates (Figure: 2). At the macroinvertebrate sampling sites the streams were shallow, swift and highly oxygenated. All sites were within the Ruahine Forest Park and surrounded in native forest. The Mangatera River at Colenso Hut site was within a wide flood channel covered in exotic lupin shrubs.

TABLE 2: THE PHYSCIOCHEMICAL PARAMETERS OF FOUR STREAM SITES SAMPLED IN THE RUAHINE RANGES, FEBRUARY 2009.

	WAIOKOTORE STREAM (AT WAIOKOTORE BIVOUAC) (FIG. 2 & 3)	POTAE STREAM (MIGHT ACTUALLY BE A TRIBUTARY OF POTAE STREAM) (FIG. 4 & 5)	MANGATERA RIVER (DOWNSTREAM OF POTAE STREAM CONFLUENCE) (FIG. 6 & 7)	MANGATERA RIVER (AT COLENSO HUT) (FIG. 8 & 9)
Sampling date & time	25 Feb 2009, 8.40 am	25 Feb 2009, 4.40 pm	26 Feb 2009, 12.20 pm	26 Feb 2009, 10 am
Coordinates	E: 2778018, N: 6168233	E: 2780372, N: 6166298	E: 2778792, N: 6166053	E: 2779432, N: 6165648
Altitude	780 m	750 m	680 m	710 m
Stream-bottom substrata	Compaction: mostly a loose assortment with little overlap. Embeddedness: 51-75%	Compaction: moderately packed with some overlap. Embeddedness: <5%	Compaction: moderately packed with some overlap. Embeddedness: <5%	Compaction: no packing/ loose assortment easily moved. Embeddedness: <5%
Substratum size	Boulder 15% Cobble 35% Gravel 25% Sand 25% Silt trace	Boulder 20% Cobble 30% Gravel 40% Sand 10% Silt trace	Boulder 60% Cobble 30% Gravel 9% Sand 1%	Boulder 5% Cobble 30% Gravel 60% Sand 5%
Organic material (% cover)	Large wood: <5% Coarse detritus: <5% Fine organic deposits: <5%	Large wood: <5% Coarse detritus: <5% Fine organic deposits: <5%	Large wood: <5% Coarse detritus: <5% Fine organic deposits: 26-50%	Large wood: <5% Coarse detritus: <5% Fine organic deposits: <5%
Instream plant cover (% of stream bed)	Filamentous algae: <5% Macrophytes: <5% Mosses/Liverworts: <5%	Filamentous algae: <5% Macrophytes: <5% Mosses/Liverworts: <5%	Filamentous algae: <5% Macrophytes: <5% Mosses/Liverworts: <5%	Filamentous algae: <5% Macrophytes: <5% Mosses/Liverworts: <5%
Temperature	9.6 °C	12.4 °C	14 °C	10.8 °C
pH	9.15	9.26	8.32	8.7
Conductivity	226 μS/cm	220 μS/cm	150.2 μS/cm	90.2 μS/cm
Dissolved oxygen	97.8%, 11.08 mg/L	88.3%, 9.3 mg/L	96.6%, 9.65 mg/L	95.6%, 10.29 mg/L
Stream width (m)	Mean: 8.6, Range: 5.3 – 11.1	Mean: 1.6 Range: 1.35 – 2.1	Mean: 5.14 Range: 4.1 – 7.2	Mean: 7.18 Range: 5.3 – 9.1

	WAIOKOTORE STREAM (AT WAIOKOTORE BIVOUAC) (FIG. 2 & 3)	POTAE STREAM (MIGHT ACTUALLY BE A TRIBUTARY OF POTAE STREAM) (FIG. 4 & 5)	MANGATERA RIVER (DOWNSTREAM OF POTAE STREAM CONFLUENCE) (FIG. 6 & 7)	MANGATERA RIVER (AT COLENSO HUT) (FIG. 8 & 9)
Depths (m)	Mean: 0.28 Range: 0.19 – 0.46	Mean: 0.16 Range: 0.15 – 0.18	Mean: 0.27 Range: 0.14 – 0.39	Mean: 0.16 Range: 0.09 – 0.24
Velocity (m/s)	Mean: 0.61 Range: 0.44 – 0.99	Mean: 0.57 Range: 0.31 – 0.77	Mean: 0.88 Range: 0.70 – 1.1	Mean: 0.68 Range: 0.44 – 0.89
Riparian character:	Within the Ruahine Forest Park. Native beech forest and shrubs partly shade the channel. The study reach is in a steep sided canyon.	Within the Ruahine Forest Park. Native beech forest and shrubs significantly shade the channel.	Within the Ruahine Forest Park with native beech forest and shrubs. Open canopy.	Within the Ruahine Forest Park with native beech forest and shrubs. Lupin covers the banks immediately next to the channel.

FIGURE 2: THE WAIOKOTORE STREAM HAD SOME SWIFTLY FLOWING PATCHES OF MOSS-COVERED SUBSTRATE.

FIGURE 3: THE WAIOKOTORE STREAM WAS SURROUNDED IN NATIVE VEGETATION.

FIGURE 4: THE POTAE STREAM SITE WAS THE SMALLEST STREAM SAMPLED. THIS MAY HAVE BEEN A TRIBUTARY OF THE ACTUAL POTAE STREAM.

FIGURE 5: THE POTAE STREAM SITE JUST UPSTREAM OF THE CONFLUENCE OF WHAT MAY BE THE ACTUAL POTAE STREAM.

FIGURE 6: THE MANGATERA RIVER SITE DOWNSTREAM OF THE CONFLUENCE WITH POTAE STREAM. THE FLOW WAS VERY SWIFT HERE.

FIGURE 7: AT THE MANGATERA RIVER SITE DOWNSTREAM OF THE CONFLUENCE WITH POTAE STREAM, LARGE LIMESTONE BOULDERS CAUSED THE FORMATION OF DEBRIS DAMS.

FIGURE 8: THE MANGATERA RIVER SITE AT COLENSO HUT HAS A WIDE FLOOD CHANNEL COVERED PREDOMINANTLY IN LUPIN.

FIGURE 9: FACING DOWNSTREAM AT THE MANGATERA RIVER AT COLENSO HUT SITE. THE HUT CAN BE SEEN IN THE MID-RIGHT OF THE PHOTO.

Overall, the Qualitative Habitat Assessment scored the four sampled sites highly considering the maximum score is 180. The streams had high quality riparian conditions and high in-stream habitat diversity (Table: 3).

TABLE 3: QUALITATIVE HABITAT ASSESSMENT RESULTS OF FOUR STREAM SITES SAMPLED IN THE RUAHINE RANGES, FEBRUARY 2009 (MAXIMUM SCORE = 20, MINIMUM SCORE = 1).

	WAIOKOTORE STREAM (AT WAIOKOTORE BIVOUAC)	POTAE STREAM (MIGHT ACTUALLY BE A TRIBUTARY OF POTAE STREAM)	MANGATERA RIVER (DOWNSTREAM OF POTAE STREAM CONFLUENCE)	MANGATERA RIVER (AT COLENSO HUT)
1. Riparian vegetative zone width	20	20	20	20
2. Vegetative protection	20	20	20	10
3. Bank stability	19	19	15	10
4. Frequency of riffles	18	19	20	18
5. Channel alteration	20	20	20	20
6. Sediment deposition	14	19	18	14
7. Velocity & depth regimes	17	14	19	10
8. Abundance and diversity of habitat	15	18	19	16
9. Periphyton	10	9	14	14
Total	**153**	**158**	**165**	**132**

MACROINVERTEBRATES

The Waiokotore Stream site had a higher density of macroinvertebrate than the other sites and also a greater number of taxa (Table: 4). Some samples from this site were from moss-covered substrate and these tended to contain large numbers of macroinvertebrates. The MCI and QMCI scores of all four sites indicated "clean water". All sites were above the minimum QMCI score of 6 stated in the Proposed One Plan for this sub-catchment of the Rangitikei River. At all the sampled sites, except the Waiokotore Stream, the EPT orders comprised greater than 90% of all individuals captured (Table: 4).

TABLE 4: MEAN MACROINVERTEBRATE METRICS OF FOUR STREAM SITES SAMPLED IN THE RUAHINE RANGES, FEBRUARY 2009 (N = 5). S.D. = STANDARD DEVIATION.

	WAIOKOTORE STREAM (AT WAIOKOTORE BIVOUAC)	POTAE STREAM (MIGHT ACTUALLY BE A TRIBUTARY OF POTAE STREAM)	MANGATERA RIVER (DOWNSTREAM OF POTAE STREAM CONFLUENCE)	MANGATERA RIVER (AT COLENSO HUT)
Total individuals (per 0.1 m2)	1195.6, (S.D. 1010.1) (Range: 325 – 2796)	337.2, (S.D. 257.5) (Range: 49 – 624)	231.4, (S.D. 146.7) (Range: 28 – 418)	281.6, (S.D. 57.4) (Range: 194 – 336)
Total taxa (per 0.1 m2)	24.6, (S.D. 3.8) (Range: 21 – 29)	19.6, (S.D. 9.1) (Range: 6 – 30)	13.8, (S.D. 1.9) (Range: 11 – 16)	17.8, (S.D. 3.3) (Range: 14 – 21)
MCI	122.4, (S.D. 8.6) (Range: 116.2 – 137.1)	152.6, (S.D. 13.3) (Range: 141.3 – 172.5)	144.3, (S.D. 7.4) (Range: 136.4 – 153.8)	135.9, (S.D. 6.4) (Range: 124.8 – 140)
QMCI	6.1 (S.D. 1.2) (Range: 4.4 – 7.2)	8.1, (S.D. 0.2) (Range: 7.9 – 8.4)	8.3, (S.D. 0.2) (Range: 8.0 – 8.6)	8.2, (S.D. 0.3) (Range: 7.8 – 8.7)
% EPT individuals	68.3, (S.D. 17.4) (Range: 37.9 – 81.8)	91, (S.D. 5.3) (Range: 87.8 – 95.9)	91.3, (S.D. 4.1) (Range: 85.7 – 95.6)	93.6, (S.D. 3.5) (Range: 90.2 – 98.9)
% EPT taxa	60.0, (S.D. 5.5) (Range: 53.6 – 66.7)	65.9, (S.D. 9.1) (Range: 59.1 – 81.3)	68.4, (S.D. 10) (Range: 60 – 84.6)	68.3, (S.D. 7.2) (Range: 61.9 – 78.6)

Samples from the Waiokotore Stream had high numbers of the cased caddisflies, *Confluens hamiltoni* and *Zelolessica cheira* which are taxa often associated with moss-covered substrates in swiftly flowing streams. This was also the only site to have significant numbers of Chironomidae larvae, predominantly Orthocladiinae (Table: 5). Potae Stream (possibly a tributary of the actual Potae Stream) was the smallest stream sampled, and was dominated by EPT taxa, especially the cased caddis *Beraeoptera roria* (Table 5). The two sites on the Mangatera River were dominated numerically by the mayfly *Deleatidium sp.* and stonefly *Zelandoperla sp.* (Table: 5).

TABLE 5: MACROINVERTEBRATE RAW DATA AND TAXON MEANS FROM FOUR STREAM SITES SAMPLED IN THE RUAHINE RANGES, FEBRUARY 2009.

	TAXON	WAI A	WAI B	WAI C	WAI D	WAI E	MEAN	POT A	POT B	POT C	POT D	POT E	MEAN	MDS A	MDS B	MDS C	MDS D	MDS E	MEAN	MC A	MC B	MC C	MC D	MC E	MEAN
Ephemeroptera	*Austroclima sepia*	104	48	156	1	0	61.8	3	1	2	0	6	2.4	0	0	0	0	0	0	0	0	0	0	0	0
	Coloburiscus humeralis	8	0	0	4	7	3.8	22	3	14	0	29	13.6	0	0	0	1	0	0.2	0	0	0	0	1	0.2
	Deleatidium sp.	34	8	8	76	44	34	58	19	80	7	45	41.8	66	90	182	126	7	94.2	76	155	191	147	166	147
	Nesameletus ornatus	0	0	0	0	0	0	1	0	0	0	0	0.2	8	2	5	5	0	4	22	1	12	22	15	14.4
Plecoptera	*Austroperla cryene*	4	0	8	2	4	3.6	1	4	7	0	2	2.8	5	4	32	15	1	11.4	6	4	3	11	13	7.4
	Megaleptoperla sp.	8	0	8	16	5	7.4	3	3	5	0	4	3	3	2	7	4	0	3.2	1	7	4	2	6	4
	Taraperla pseudocyrene	73	32	80	1	0	37.2	0	0	2	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
	Zelandobius confusus-group	0	20	0	0	0	4	0	0	4	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0.2
	Zelandoperla sp.	2	12	112	9	29	32.8	6	1	11	9	8	7	46	89	98	80	5	63.6	19	111	16	20	35	40.2
	Stenoperla prasina	0	0	0	1	0	0.2	1	0	1	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Aoteapsyche sp.	0	8	8	0	0	3.2	0	0	0	0	0	0	1	7	0	21	0	5.8	2	2	1	2	3	2
	Alloecentrella magnicornis	1	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Beraeoptera roria	43	8	16	48	150	53	383	26	370	22	224	205	13	11	35	18	5	16.4	38	7	54	26	27	30.4
	Confluens hamiltoni	134	132	264	1	13	108.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Costachorema callistum	0	0	0	0	0	0	0	0	2	0	0	0.4	0	2	0	0	1	0.6	1	0	0	0	0	0.2
	Costachorema hecton	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	TAXON	WAI A	WAI B	WAI C	WAI D	WAI E	MEAN	POT A	POT B	POT C	POT D	POT E	MEAN	MDS A	MDS B	MDS C	MDS D	MDS E	MEAN	MC A	MC B	MC C	MC D	MC E	MEAN
	Helicopsyche sp.	0	0	0	0	0	0	7	4	22	5	24	12.4	0	0	0	0	0	0	0	0	0	0	0	0
	Hudsonema alienum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.2
	Hydrobiosis falcis	10	12	16	1	3	8.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydrobiosis umbripennis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	1
	Hydrobiosis parumbripennis	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0.8	0	0	2	0	2	0.8
	Hydrobiosis soror	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2
	Olinga feredayi	0	0	0	5	0	1	0	1	6	0	0	1.4	8	7	21	23	0	11.8	9	3	8	7	21	9.6
	Orthopsyche sp.	0	0	0	0	2	0.4	10	4	7	0	9	6	0	0	0	0	0	0	0	0	0	0	0	0
	Oxyethira albiceps	3	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Plectrocnemia maclachlani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0.6
	Psilochorema leptoharpax	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0.4	2	1	9	0	5	3.4
	Psilochorema macroharpax	1	0	0	6	2	1.8	1	1	3	0	4	1.8	1	0	0	1	0	0.4	0	0	0	0	0	0
	Zelolessica cheira	206	104	256	0	2	113.6	1	1	5	0	0	1.4	0	0	0	0	4	0.8	0	0	0	0	0	0
	Pycnocentria evecta	23	100	16	0	0	27.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pycnocentria funerea	60	76	72	49	16	54.6	4	7	35	0	18	12.8	0	0	0	0	0	0	0	0	0	0	0	0
	Pycnocentrodes sp.	368	240	36	16	5	133	2	0	4	0	5	2.2	2	0	2	0	1	1	1	0	1	5	0	1.4
Diptera	*Aphrophila* sp.	1	0	0	2	3	1.2	3	0	3	0	5	2.2	1	0	4	3	0	1.6	3	0	1	4	2	2

	TAXON	WAI A	WAI B	WAI C	WAI D	WAI E	MEAN	POT A	POT B	POT C	POT D	POT E	MEAN	MDS A	MDS B	MDS C	MDS D	MDS E	MEAN	MC A	MC B	MC C	MC D	MC E	MEAN
	Austrosimulium sp.	0	0	0	1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.4
	Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2
	Diamesinae - *Maoridiamesa* sp.	10	16	76	2	13	23.4	2	0	0	0	0	0.4	0	0	0	0	0	0	0	0	1	0	0	0.2
	Empididae	19	8	28	0	0	11	0	0	1	0	0	0.2	0	0	0	0	0	0	1	0	0	0	0	0.2
	Ephydridae	1	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Eriopterini	0	0	0	0	0	0	4	3	1	0	1	1.8	0	0	0	0	0	0	1	0	0	1	4	1.2
	Eriopterini - *Molophilus* sp.	0	0	0	0	0	0	1	0	1	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
	Hexatomini	0	0	0	1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Muscidae	0	4	8	4	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.2
	Orthocladiinae	99	184	1476	10	27	359.2	0	0	6	0	4	2	0	0	4	2	1	1.4	0	0	8	1	0	1.8
	Peritheates sp.	0	0	0	0	0	0	0	0	0	5	2	1.4	0	0	0	0	0	0	0	0	0	0	0	0
	Psychodidae	0	0	0	1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironominae - *Polypedilum* sp.	0	0	0	0	2	0.4	3	0	1	0	2	1.2	0	0	2	0	0	0.4	5	1	3	4	7	4
	Chironominae - Tanytarsini	61	28	4	3	0	19.2	2	0	1	0	0	0.6	0	0	0	0	1	0.2	0	0	0	0	1	0.2
	Tabanidae	0	0	0	1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	1	0	8	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tipulidae - unknown sp.	0	0	0	0	0	0	1	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	91	48	120	36	10	61	3	5	11	0	2	4.2	16	7	19	8	1	10.2	5	1	5	3	9	4.6
	Hydraenidae	22	4	8	16	8	11.6	2	7	12	0	2	4.6	1	0	2	1	0	0.8	0	0	0	0	3	0.6
	Ptilodactylidae	4	0	0	0	0	0.8	0	0	1	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0

	TAXON	WAI A	WAI B	WAI C	WAI D	WAI E	MEAN	POT A	POT B	POT C	POT D	POT E	MEAN	MDS A	MDS B	MDS C	MDS D	MDS E	MEAN	MC A	MC B	MC C	MC D	MC E	MEAN
Megaloptera	*Archichauliodes diversus*	6	0	0	11	1	3.6	0	0	0	0	1	0.2	1	3	3	2	1	2	0	0	12	0	1	2.6
Mollusca	*Potamopyrgus antipodarum*	0	0	0	0	0	0	0	0	5	0	1	1.2	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta		1	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematomorpha (horsehair/ Gordian worms)		0	0	0	0	0	0	0	0	1	0	0	0.2	0	0	0	1	0	0.2	0	0	0	0	0	0
Nematode		0	16	8	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.2
Acari		0	0	0	0	0	0	0	0	0	1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0

WAI = Waiokotore Stream
POT = Potae Stream
MDS = Mangatera River downstream of Potae confluence
MC = Mangatera River at Colenso Hut.

ALGAE

Ash-free dry weight and chlorophyll-*a* concentrations were much higher at the Waiokotore Stream compared to the other three sites (Table: 6). The moss content of the algal sample at this site contributed to these high values. This was also the only site to have chlorophyll-*a* levels higher than the suggested maximum of the Proposed One Plan (0.012 mg/cm^2) for this Rangitikei River sub-catchment, again because of the moss content. This site also had a higher number of taxa and was the only site where green filamentous and cyanobacteria taxa were found (Table: 6 & 7).

At all sites the algal community was dominated by diatoms and at Potae Stream and the two Mangatera River sites, diatoms were the only algal group present in samples (Table: 7). The Waiokotore Stream sample was of special interest to NIWA who have kept the sample as reference material. It has an interesting mixture of species (e.g. two species of *Cocconeis*), is relatively diverse and has a couple of diatom species that could not be definitely identified without acid-cleaning the sample (pers. com. Cathy Kilroy, NIWA).

TABLE 6: ALGAL METRICS OF FOUR STEAM SITES SAMPLED IN THE RUAHINE RANGES, FEBRUARY 2009.

	WAIOKOTORE STREAM (AT WAIOKOTORE BIVOUAC)	POTAE STREAM (MIGHT ACTUALLY BE A TRIBUTARY OF POTAE STREAM)	MANGATERA RIVER (DOWNSTREAM OF POTAE STREAM CONFLUENCE)	MANGATERA RIVER (AT COLENSO HUT)
Ash-free dry weight (mg/cm^2)	5.13	0.35	0.25	0.24
Chlorophyll *a* (mg/cm^2)	0.02934	0.00166	0.00080	0.00030
Total taxa (per sample)	17	9	8	9

TABLE 7. THE RELATIVE ABUNDANCES OF ALGAL TAXA AT FOUR STREAM SITES IN THE RUAHINE RANGES, FEBRUARY 2009.

	TAXON	WAIOKOTORE STREAM	POTAE STREAM	MANGATERA RIVER (DOWNSTREAM OF POTAE CONFLUENCE)	MANGATERA RIVER (AT COLENSO HUT)
Green filaments	*Spirogyra* spp.	1			
Green (Non filamentous)	Little green balls	3			
Diatoms	cf. *Achnanthes lanceolata*				1
	Cocconeis pediculus	2			
	Cocconeis placentula	3	1	2	1
	Cymbella kappii	4			
	Diatoma tenuis	2			
	Diatomella sp.				
	Diatoma vulgaris				
	Encyonema minutum	3	4	2	3
	Epithemia turgida	4	1		
	Epithemia sorex				
	Eunotia cf. *incisa*				1
	Fragilaria vaucheriae			1	
	Gomphoneis minuta var. *cassieae*	6	3	8	5
	Gomphonema spp. 20um (small)		2	5	8
	Navicula cf. *cryptocephala*			1	
	Navicula cf. *gregaria*		2		
	Navicula lanceolata				2
	Navicula (small 15-20)				2

	TAXON	WAIOKOTORE STREAM	POTAE STREAM	MANGATERA RIVER (DOWNSTREAM OF POTAE CONFLUENCE)	MANGATERA RIVER (AT COLENSO HUT)
	Navicula cf. *margilithi*	8	8		
	Nitzschia dissipata				
	Nitzschia cf. *gracilis*				
	Nitzschia linearis		3		
	Nitzschia (fine)		1		
	Nitzschia (small skinny)	3			
	Nitzschia (small)	2			
	Rhoicosphenia abbreviata	3			
	Rhopalodia novae-zealandiae				
	Rhopalodia musculus	2			
	Rossithidium linearis	3		2	1
	Synedra ulna var. *biceps*	2			
	Synedra ulna var. *ramesi*				
Cyanobacteria	*Nostoc* spp.	5			
	Phormidium spp.				
	cf. *Lyngbya*				
Comments		**Detritus and green plant parts**	**Detritus, not much algae**	**Detritus**	**Detritus, not much algae plant parts**

Relative abundance interpretation scores: 1 = rare
2 = rare-occasional
3 = occasional
4 = occasional-common
5 = common
6 = common-abundant
7 = abundant
8 = dominant.

Conclusions

- As one would expect of headwater streams within the Ruahine Ranges, the study streams had high quality riparian conditions (e.g. native forest) although exotic lupins had colonised the wide flood channel of the Mangatera River at Colenso Hut site.
- The water at all sites was highly oxygenated, swift and shallow with a stony stream bed. The Environment Waikato Qualitative Habitat Assessment scored all sites highly.
- All sites had a macroinvertebrate community indicative of high habitat and water quality. MCI and QMCI scores indicated 'clean water' and all sites were dominated by the sensitive EPT (mayflies, stoneflies, caddisflies) invertebrates. The Waiokotore Stream site had the highest densities of invertebrates and the greatest number of taxa. This was likely related to the moss-covered substrate of this site providing a more complex habitat and food source than the smooth rocks sampled at other sites.
- Algal biomass was low at all sites except Waiokotore Stream where the high moss content of samples contributed to higher ash-free dry mass and chlorophyll-*a* levels. All sites were dominated by diatoms as is often the case in streams draining forested catchments with no artificial nutrient inputs.
- Overall, the four sites sampled in the Ruahine Forest Park could be considered to be pristine and not significantly different in terms of macroinvertebrates and algae than they were prior to human settlement.
- All sites have abundant macroinvertebrate food and swift-flowing feeding habitat for whio.

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Appendix

ENVIRONMENT WAIKATO FIELD ASSESSMENT COVER FORM

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

STREAM NAME: | **ASSESSOR:**

SITE NUMBER: | **SAMPLE NUMBER:** | **DATE:** | **TIME (NZST):**

GPS COORDINATES: Downstream end of reach - Easting – Northing –
Upstream end of reach - Easting – Northing –

CHANNEL AND RIPARIAN FEATURES

Canopy Cover:
❍ Open ❍ Partly shaded ❍ Significantly shaded

Fencing:
❍ None or ineffective
❍ One side or partial
❍ Complete both sides

Dominant Riparian Vegetation:
❍ Crops etc ❍ Retired vege.
❍ Pasture ❍ Native shrub
❍ Exotic trees ❍ Native trees

INSTREAM HYDRAULIC CONDITIONS
Estimated or measured reach average:

Stream width (active channel) ________ m
Stream width (water) ________ m
Stream depth ________ m
Surface velocity ________ m/sec

WATER QUALITY
Temperature: ________ °C Conductivity: ______ µS/cm @ 25°C
Dissolved Oxygen: ______ % ______ mg/L
Turbidity: ❍ Clear ❍ Slightly turbid ❍ Highly turbid ❍ Stained ❍ Other ________

STREAM-BOTTOM SUBSTRATA

Compaction (inorganic substrata):
❍ assorted sizes tightly packed &/or overlapping
❍ moderately packed with some overlap
❍ mostly a loose assortment with little overlap
❍ no packing / loose assortment easily moved.

Embeddedness:
(% gravel-boulder particles covered by fine sediment)
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

% surficial inorganic substratum size composition (should sum to 100%)

Substratum type	Dimension (middle axis)	Percentage
Bedrock	-	
Boulder	> 256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	

ORGANIC MATERIAL (% cover)
Large wood (>10 cm diameter):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%
Coarse Detritus (small wood, sticks, leaves etc >1 mm):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%
Fine (<1 mm) **Organic Deposits** (edges and backwaters):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

INSTREAM PLANT COVER (% of streambed area)
Filamentous Algae (>2mm long) & Mats (>3 mm thick):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%
Macrophytes:
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%
Mosses/Liverworts:
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

HABITAT TYPES SAMPLED (% of effort; each column should sum to 100%)

Stones: ______ %
Wood: ______ %
Macrophytes: ______ %
Edges: ______ %

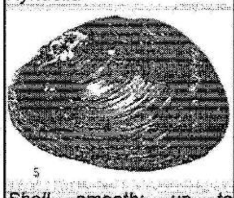
Riffles: ______ %
Runs: ______ %

COMMENTS

NO. INVERTEBRATES RETURNED:
Koura: ______ Shrimps: ______
Crabs: ______ Mussels: ______
Others (specify) ________

Species of mussel (tick)

Hyridella



Shell smooth; up to 100mm long; variable shell shape

Cucumerunio

Nodules and ridges on upper part of shell; up to 90mm long

QUALITATIVE HABITAT ASSESSMENT FIELD DATA SHEET

Wadeable Hard-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. Frequency of Riffles	• Riffles relatively frequent • Distance between riffles divided by width of stream = 5-7 • Variety of habitat is key	• Occurrence of riffles infrequent • Distance between riffles divided by width of stream = 7-15	• Occassional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by width of stream = 15-25	• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by width of stream = >25
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

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			