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Regional Guidelines for Ecological Assessments of Freshwater Environments

Aquatic Plant Cover in Wadeable Streams

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Environment Waikato
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1 Introduction

Environment Waikato is currently developing a series of guidelines to assist those involved in assessment and monitoring of freshwater ecosystems in the Region. The guidelines are intended to establish a regionally consistent set of approaches for sample collection, analysis and reporting, and to set a minimum level of effort that workers are welcome to exceed. We recognise that each study will have its own set of questions and requirements, and that variations to any guidelines or recommended methods may be necessary to address specific questions. These guidelines should not constrain the scope of work that is carried out but should be used to ensure that, where appropriate, the approaches applied are consistent with recommended methods and meet or exceed the minimum level of effort. This set of guidelines describes the procedures used in Environment Waikato's Regional Ecological Monitoring of Streams (REMS) programme to monitor cover by aquatic plants (typically algae and rooted macrophytes).

Macrophytes can be particularly important as habitat over spring-summer in streams dominated by fine sediments where other stable substrates are uncommon, but few invertebrates eat macrophytes directly (with the exception of the koura *Paranephrops* and the moth larva *Hygraula nitens*). Algae growing on stones, wood, macrophytes or any other stable surfaces can be an important food source for invertebrates, especially in more open streams. Some invertebrates pierce the cells of algal filaments and suck out their contents (e.g., *Oxyethira albiceps*), whereas other invertebrates can scrape (e.g., *Potamopyrgus antipodarum*) or sweep (leptophlebiid mayflies) algae such as diatoms from substrate surfaces. Although some plant cover increases habitat diversity (especially where streambeds are dominated by fine sediments) and can provide food, too much can cause ecological problems by impeding water flow, trapping more fine sediments, smoothering benthic habitats, and causing wide fluctuations in dissolved oxygen and pH due to plant respiration and photosynthesis.

The REMS programme assesses the ecological condition of streams for State of the Environment (SOE) monitoring purposes (see Collier & Kelly 2005). As part of this, assessments of instream plant cover are conducted to help describe the condition of the monitoring reach and interpret patterns in invertebrate community metrics at the time of sampling in summer. Cover of the entire sampling reach is assessed for submerged mosses/liverworts (bryophytes), macrophytes, and filamentous algae (>2 mm long) and algal mats (>3 mm thick) using a visual assessment of percent cover or five cover classes, as described in the Field Assessment Cover Form (see Appendix 1 in Collier & Kelly 2005). In addition, the Qualitative Habitat Assessment Field Data Sheets include a field on periphyton cover.

An expanded algal assessment protocol for the REMS network was introduced for streams dominated by stony substrates in 2002 using an adaptation of Rapid Assessment Method 2 (RAM-2) from the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000). Environment Waikato's initial application of this method involved selecting five stones per reach, but this was altered in 2005 to bring the method in line with the RAM-2 approach of selecting five stones at each of several transects (although some modifications to the RAM-2 method exist; see Section 2).

A new rapid macrophyte assessment protocol (RMAP), developed for Environment Waikato by NIWA, was introduced to the REMS programme in 2004 (see Section 3). Both the modified RAM-2 method and the RMAP allow indices to be calculated, as well as providing information that assists with the interpretation of patterns in invertebrate community structure. Indices include nutrient enrichment (periphyton), proliferation (periphyton and macrophytes) and naturalness (macrophytes). Some of these indices are currently considered experimental until further testing of the relationships with ecological condition is conducted.

The methods as applied in Environment Waikato's REMS programme are described below, along with examples of their application. From 2007, periphyton and macrophyte assessments were done in all streams irrespective of dominant substrate types. These methods should be used in association with reach-scale cover assessments (e.g., as described in the REMS Field Assessment Cover Form) to enable comparisons with the transect methods which capture more detailed information at a few locations within the reach. These are rapid assessment approaches, and are therefore recommended for broadscale surveys such as SOE monitoring, but may not be appropriate for targeted assessments aimed at addressing specific questions, such as compliance monitoring where more detailed analyses may be required (e.g., chlorophyll *a* concentration, biomass in replicate samples). They can be used for wadeable streams with adequate water clarity, but are not suitable for non-wadeable streams and rivers.

Both macrophyte and periphyton assessments for the REMS programme are carried out over January to March. Rivers should not be surveyed for aquatic plants if visibility is insufficient to enable a reliable assessment. In slightly-moderately turbid streams, a viewer may assist with assessments. Surveys should be conducted at baseflow as water levels much higher than this could affect assessments of macrophyte height and may lead to inclusion of terrestrial grasses in assessments by inexperienced observers. A standown period of 2 weeks is applied by Environment Waikato once floodflows exceed a level considered likely to mobilise bed sediments at representative flow monitoring sites. This standown period is intended to allow some recovery of macroinvertebrate communities, but may not be sufficient to enable recovery of macrophytes. Some factors that may constrain macrophyte growth at certain sites are recorded on the Field Assessment Cover Form (e.g., shade, turbidity), but additional constraining factors should also be noted (e.g., evidence of macrophyte removal or recent drain clearance, artificial bed substrates).

2 Periphyton cover rapid assessment

As noted earlier, the periphyton protocol is based on the RAM-2 approach described by Biggs & Kilroy (2000). The main points of difference in the approach used by Environment Waikato are:

- we use five transects along 50-100 m long reaches instead of the four transects in the original method to keep consistency with the macrophyte protocol (Section 3).

- the substrates assessed along a transect include not only sediments but also wood and macrophytes where they occur at sampling points in all types of stream.

- we do not distinguish different types/colours of "thin" (<0.5 mm thick) periphyton mats or films as we found the colour of thin algal coverings difficult to distinguish from the background rock colour. For the indices we use, it is not necessary to discriminate the colour of short filaments as they have the same enrichment indicator score (Biggs & Kilroy 2000; Table 1).

2.1 Protocol

The purpose of this protocol is to describe the procedures used in Environment Waikato's regional stream monitoring programme and to enable consultants conducting similar studies to employ complementary methodologies.

- Select five evenly-spaced transects along the sampling reach (50-100 m long). Do not start at 0 m because this point has been selected to define the bottom of the reach and may be biased in some way (e.g., tributary confluence, availability of a post or tree to attach tape).

- Working from the downstream end of the sample reach, move across each transect and randomly remove or assess substrates within a 10 cm diameter circle centred on sampling points at 10%, 30%, 50%, 70% and 90% across the wetted width.

- Assess periphyton on whatever substrate occurs at the sampling point – periphyton adheres to surfaces so if in doubt give the substrate a gentle shake to remove non-adhering material such as detritus or flocculants. In stony streams, aim for stones bigger than around 4 cm across. Place stones on a white tray or similar. If stones are not available, make an *in-situ* assessment on large substrate elements (e.g., boulder, bedrock) or finer sediments (a viewer may be useful), or remove a scoop of sediment from the stream. A tea strainer is recommended by Biggs & Kilroy (2000) for removing scoops of fine sediments.

- If inorganic sediments are not available around the sampling point but macrophytes or wood occur there, make an assessment of periphyton cover on the habitat that is available in an area of around 10 cm diameter.

- Record average percentage cover of upper surfaces at the 5 points across each transect by the different periphyton categories described in Table 1 (see Appendix 1 for data sheet). If cover is patchy for some categories (e.g., nodules which are classified under mats), make an estimate of the average amount of surface area covered as if they all occurred together. Include senescing algae and record it as the colour that it most likely was (look at fresh algal growths nearby for clues); if the original colour isn't apparent record the colour you see.

- Repeat the process at the remaining transects.

- Calculate the mean percent cover for each transect and then the average for all transects for each periphyton thickness and colour category to provide an average for the reach. Calculate indices as described in Section 2.2.

As a general rule, if the periphyton is <0.5 mm thick but can be scraped by a fingernail, we consider it to be "thin". If it feels rough or only slightly slippery and is too thin to be scraped by a fingernail we record it as not present. Sometimes mineral particles will be removed by a fingernail scrape from soft rocks and can be mistaken for periphyton. If the particles feel gritty they are probably mineral, although scrapes from soft clay rocks can feel slippery. The length of filaments is best determined by covering the rock with water. A field identification sheet is provided to assist with colour and biomass assessments in the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000).

For convenience, the periphyton data sheet (Appendix 1) also provides fields to record cover by bryophytes (mosses and liverworts) and iron bacterial growths. These are not algae and so are not used in the calculation of the indices below, although prolific iron bacteria may have implications for aesthetics and ecology. Iron bacteria form orange-coloured growths that resemble jelly-like slime and filaments where there are high concentrations of dissolved iron in the water. We do not record iron-flocs as they don't adhere to stones, or orange precipitates (not slimy) which may form in association with iron bacteria because they are not organic.

Table 1: Enrichment indicator scores for different thickness and colour categories for periphyton. NA = not applicable

Thickness category	Colour category	Enrichment indicator score
Thin mat/film (<0.5 mm thick)	NA	9
Medium mat (0.5-3 mm thick)	Green	5
	Light brown	7
	Black/dark brown	9
Thick mat (>3 mm thick)	Green/light brown	4
	Black/dark brown	7
Short filaments (<2 cm long)	Green	5
	Brown/reddish	5
Long filaments (>2 cm long)	Green	1
	Brown/reddish	4

2.2 Indices

2.2.1 Nutrient enrichment index

The Stream Periphyton Monitoring Manual provides indicator scores for various periphyton biomass and colour categories to reflect enrichment (Table 1). Biggs & Kilroy (2000) indicate that the scores provided were preliminary, but there has been no subsequent work that suggests they should be modified (B. Biggs, NIWA, personal communication). As we do not discriminate colour of thin periphyton films/mats, we give this category a score of 9 to reflect the average of all scores in that biomass category.

The **Periphyton Enrichment Index (PEI)** is adapted from Biggs & Kilroy (2000) to provide values from 0 to 90 with higher scores reflecting higher enrichment):

$$\textbf{PEI} = 100 - [\{\sum(\text{mean \% cover} * \text{Indicator score}) / \text{total \% cover}\}] * 10$$

The maximum possible score is 90 because we have taken the average indicator score of 9 for thin periphyton films (i.e., there is no score of 10). The PEI was originally developed for stony streams so caution needs to be exercised in interpreting this index if the substrates assessed were sandy or wood and macrophytes. The PEI is not recommended if a large proportion of the periphyton recorded is senescing and the original colour is not apparent.

2.2.2 Biomass indices

Calculate a **Periphyton Filamentous Index (PFI)** as percent of total cover by long filaments, and **Periphyton Mat Index (PMI)** as percent cover by thick mats. The periphyton guidelines (Biggs 2000) recommend an upper level 30% cover by long filamentous algae or 60% cover by thick mats of diatoms and cyanobacteria for aesthetic and recreational purposes. These thresholds were originally developed for stony streams and should be applied to these streams as cover of the visible streambed.

Calculate a **Periphyton Proliferation Index (PPI)** as a percent of total cover by long filaments and thick mats. This index is more strongly related to some macroinvertebrate metrics (notably %EPT*; see below) that reflect stream condition than the PFI or the PMI individually, and may be therefore be more useful for evaluating ecological relationships.

Calculate a **Periphyton Slimyness Index (PSI**) using the following formula based on percent cover for each thickness category (i.e., all colour categories combined):

PSI = {(%Thin/mat film) + (%Short filaments * 2) + (%Medium mat * 3) + (%Long filaments * 4) + (%Thick mat * 5)} / 5

The PSI is more strongly related to some metrics reflecting macroinvertebrate diversity as well as condition (no. of total taxa and EPT* taxa, MCI; see below) than the other periphyton indices, and may be therefore be more useful for assessing biodiversity relationships (the periphyton guidelines do not provide a periphyton cover threshold for benthic biodiversity).

The rank order of PEI, PSI, PMI and PPI values at 79 sites sampled in 2006 was highly intercorrelated (r_S = 0.51 to 0.80, P <0.001). PFI was generally less strongly correlated with other indices (r_S = -0.05 to 0.59). The invertebrate condition metrics %EPT* and MCI were negatively correlated with PEI, PMI, PSI and PPI (r_S = -0.30 to -0.43, P <0.01) (EPT* = Ephemeroptera + Plecoptera + Trichoptera excluding Hydroptilidae; MCI = Macroinvertebrate Community Index). EPT* taxa richness was significantly correlated with all periphyton indices, but most strongly with PEI, PPI and PSI (P <0.01). PFI was also significantly correlated with MCI (r_S = -0.25, P < 0.05). PPI values >30 were generally associated with %EPT* <25% and MCI values <90, although there were relatively few sampling sites in 2006 with periphyton proliferations exceeding this index level.

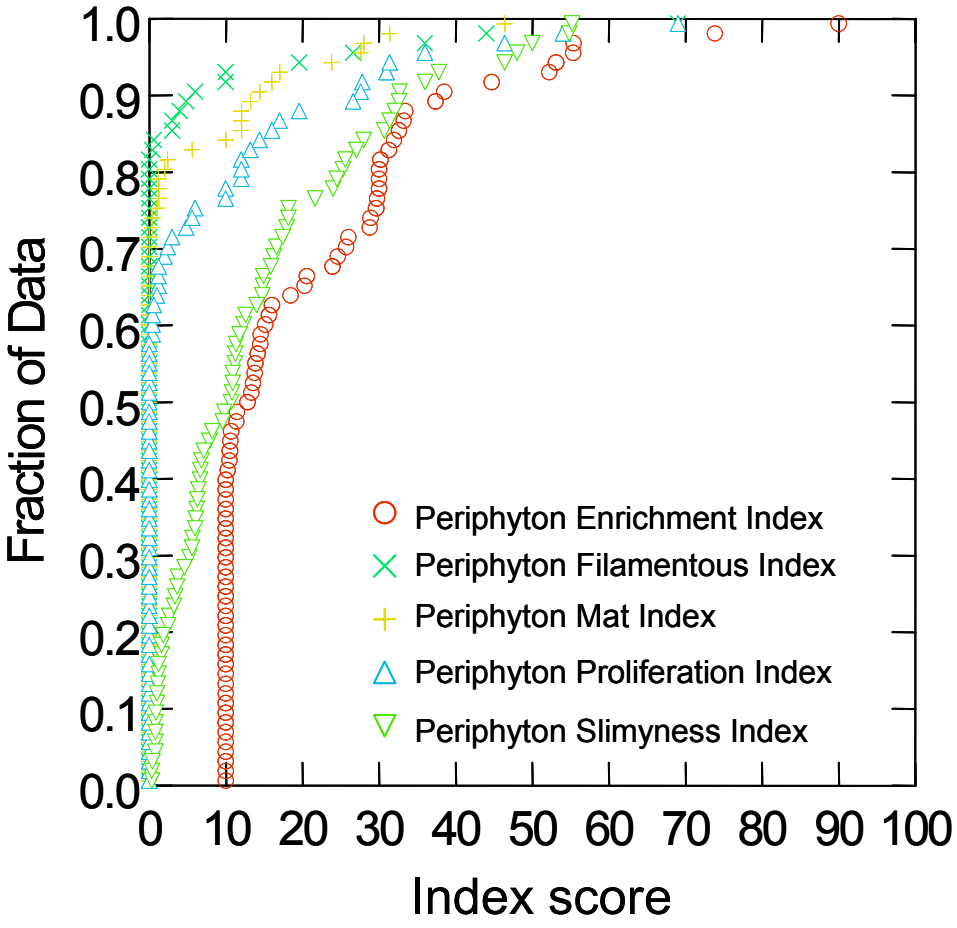


Figure 1: Distribution of periphyton indices for 79 stream sites sampled in summer 2006.

2.3 Example

Figure 2 shows the first of five transects established 20 m upstream of the downstream end of a 100 m stream reach. The substrate across this transect is a mixture of sand and stones with patches of filamentous green algae present, as well as macrophytes (see Section 3.3). Periphyton cover is assessed at 5 evenly-spaced points across each transect (total of 25 points per site). Stones are removed from the water for assessment; where fine sediment or organic material is present, cover is assessed in situ using a viewer where necessary or from scooped up material. Periphyton cover assessed at this transect and four other hypothetical transects upstream is shown in Table 2.

For the example shown in Table 2, these indices equate to:

PEI = 100 – ∑{(300 / 72) *10} = 58

PFI = 32 + 0 = 32

PMI = 10 + 1 = 11

PPI = 11 + 32 = 43

PSI = {(18) + (5 * 2) + (6 * 3) + (32 * 4) + (11 * 5)} / 5 = 46

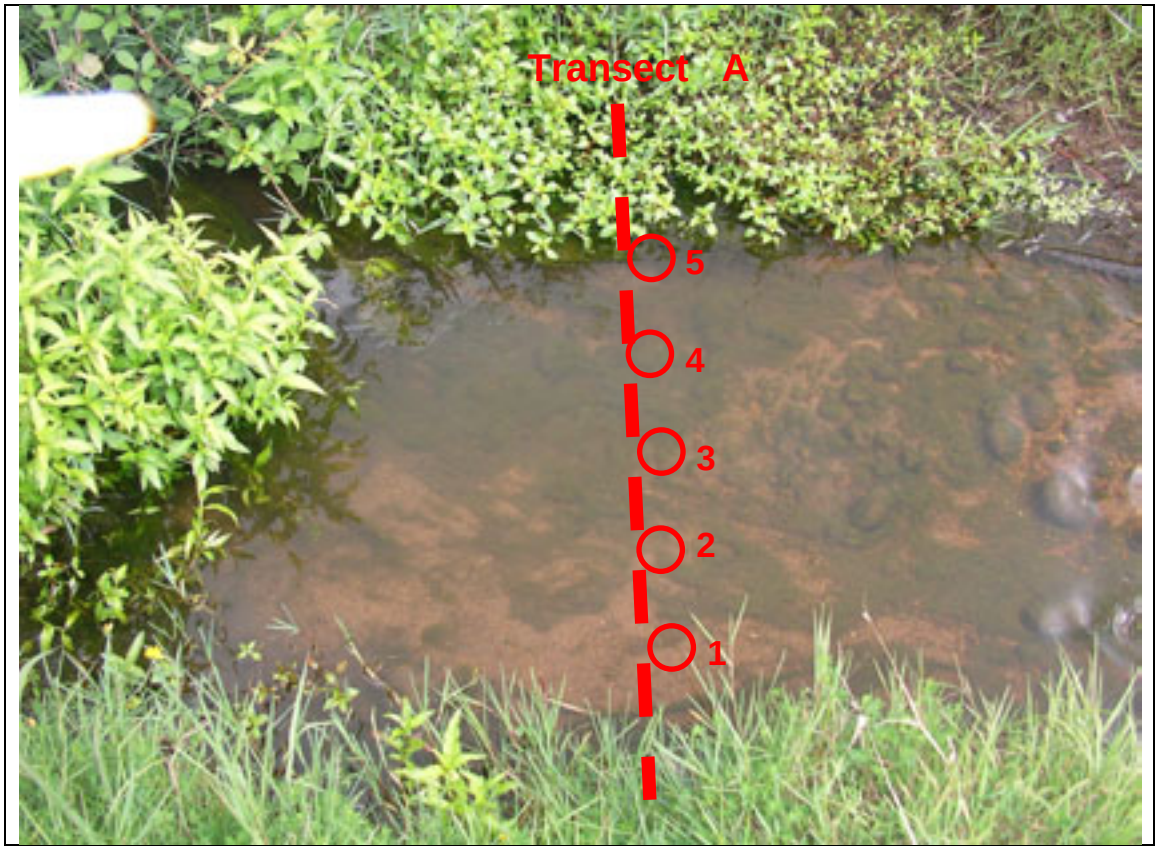


Figure 2: Hypothetical transect (one of five) for assessing periphyton cover in a wadeable stream.

Table 2: Results of a hypothetical assessment of periphyton cover based on an adaptation of RAM-2 (Biggs & Kilroy 2000) at five transects (A-E) on a wadeable stream.

Thickness category	Colour category	Indicator score	A	B	C	D	E	Mean cover	Score x Cover
Thin mat/film (<0.5 mm thick)	NA	9	0	0	20	0	70	18	162
Medium mat (0.5-3 mm thick)	Green	5	0	0	20	0	0	4	20
	Light brown	7	0	0	10	0	0	2	14
	Black/dark brown	9	0	0	0	0	0	0	0
Thick mat (>3 mm thick)	Green/light brown	4	0	0	0	50	0	10	40
	Black/dark brown	7	0	0	0	0	5	1	7
Short filaments (≤2 cm long)	Green	5	10	0	0	10	0	4	20
	Brown/reddish	5	0	0	0	0	5	1	5
Long filaments (>2 cm long)	Green	1	60	100	0	0	0	32	32
	Brown/reddish	4	0	0	0	0	0	0	0
TOTAL			70	100	50	60	80	72	300

3 Macrophyte cover rapid assessment

This protocol is designed to give only a general picture of reach-scale cover and composition by rooted macrophytes – only 5-10% of 50-100 m reaches is assessed. It assesses macrophytes growing in or emerging from the wetted channel only; floating macrophytes are not used in the calculation of indices because their impact on 'clogginess' is minimal and a high density of floating plants would skew measures of total cover and %native cover. Generally free-floating macrophytes only accumulate on top of surface reaching submerged vegetation or amongst emergent plants, although they can build up enough to completely smother slower flowing streams. Include senescing or dying macrophytes in estimates of cover if they can be identified (although surveys should be done before the onset macrophyte senescence).

The protocol requires some training or experience in macrophyte identification; an annual refresher is recommended. If an unknown plant is found and it is of interest or it represents more than 5% of the cover present, a sample (preferably including flowers) should be retained for identification or a photo should be taken. Plants allocated to the "other" category should not exceed 5% without further identification.

3.1 Protocol

- Select five evenly-spaced transects along the sampling reach (50-100 m long). Do not start at 0 m because this point has been selected to define the bottom of the reach and may be biased in some way (e.g., tributary confluence, availability of a post or tree to attach tape).

- Facing upstream, estimate aquatic vegetation cover from a plan view (i.e., looking down) occupying a 1 m wide belt upstream of the transect and across the entire wetted width of the stream, and record this figure (see Appendix 2 for datasheet).

- Divide the 1 m swathe into emergent macrophytes and submerged macrophytes. Emergent macrophytes are those with parts clearly rising above the water. Submerged macrophytes are those that occur beneath the water surface or extend to the surface. Write down total submerged and total emergent percent cover in appropriate columns on the datasheet. The sum of percent emergent and submerged cover should add up to the total cover figure if floating species are not present.

- Identify emergent species using the guide in Appendix 3, and allocate a percent cover to each. The total of these should add up to the total emergent cover.

- Divide the submerged macrophytes into "Below surface" and "Surface reaching". "Below surface" is defined as anything growing beneath the top of the water. "Surface reaching" is defined as breaking the surface of the water column. Write down percent cover for each – the sum of these should add up to the total submerged figure.

- Identify surface-reaching submerged species using the identification guide in Appendix 3, and allocate a percent cover to each. Enter these figures in the appropriate column. Repeat for below-surface submerged species. The total of these should add up to the total submerged cover.

- Repeat the process at the remaining transects. Remember you are looking at a plan view so if emergent macrophytes are growing at the edge but cover the whole stream it is 100% cover. If a species has two forms (e.g., some is surface reaching and some is below surface) record this separately in the appropriate column.

- Calculate indices as described below.

3.2 Indices

The macrophyte indices described below reflect the extent of cover over the bottom (**MTC**) and through the water column (**MCC**), as well as the naturalness (**MNC**) of the rooted macrophyte community.

Macrophyte Total Cover (MTC) = {∑(%emergent + %submerged)} / 5

Macrophyte Channel Clogginess (MCC) = {∑ (%emergent + %surface-reaching) + (% below surface * 0.5)} / 5

Macrophyte Native Cover (MNC) = (∑% native species) / 5

Although the **MTC** and **MCC** indices had similar distributions in the sites sampled in 2006 (see Figure 3) and their rank order was highly correlated (r_s = 0.99), a stream could conceivably have a high **MTC** score and a low **MCC** score. For example, if 100% of all transects are covered by "below surface" macrophytes **MTC** will be 100 but **MCC** will be 50. For the 2006 dataset, both **MTC** and **MCC** were significantly (P <0.001) inversely related to the invertebrate indices EPT* taxa richness (r_s = –0.664 and –0.620, respectively), and %EPT* (r_s = –0.724 and –0.694, respectively). %EPT* and MCI tended to be relatively low (<25% and 101, respectively) at sites where **MTC** and **MCC** values exceeded 30.

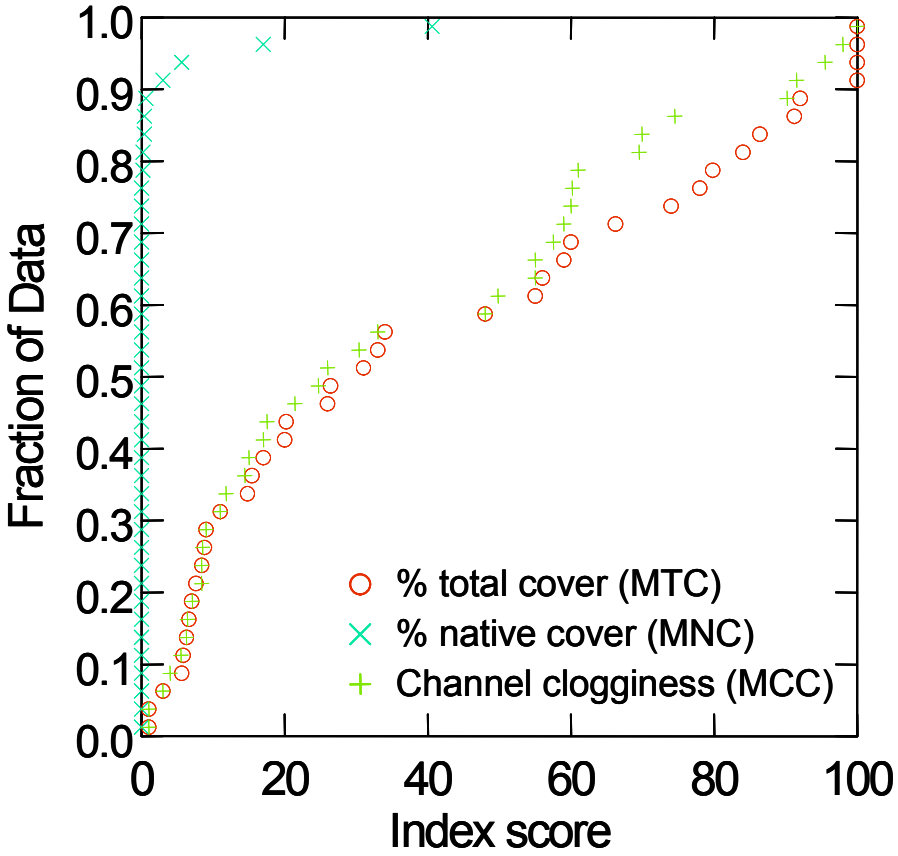


Figure 3: Distribution of data for three macrophyte indices at 47 Waikato sites in summer 2006.

3.3 Example

In Figure 4 below, the rectangle indicates the 1 m wide band upstream of one of five evenly-spaced transects in which macrophyte cover is assessed. Macrophytes cover around 35% of the area (plan view). The dashed lines show emergent macrophytes which are estimated to cover around 25% of the area looking down. These comprise

around 12% starwort, 10% *Persicaria hydropi*per, and 3% *Ludwigia palustris*. Submerged macrophytes, indicated by the dotted line, cover around 10% of the area, and all are classed as surface-reaching. These comprise 5% *Ludwigia* and 5% *Persicaria*. None of these species are native. Macrophyte cover assessed at this transect and four hypothetical transects upstream is shown in Table 3.

For the example shown in Table 3 below these indices equate to:

MTC = (35 + 100 + 60 + 20 + 70) / 5 = 57

MCC = {(135 + 105) + (45 * 0.5)} / 5 = 53

MNC = (5 + 10 + 15 + 10 + 5) / 5 = 9

Figure 4: Hypothetical transect (one of five) for assessing macrophyte cover in a wadeable stream.

Table 3: Results of a hypothetical assessment of macrophyte cover at five transects (A-E) on a wadeable stream

(see Appendix 3 for species codes – those underlined are native species). No floating macrophytes were present.

Transect	Vegetation cover (% wetted area)							
			Submerged plants				Emergent plants	
	Total cover	Total submerged	Surface-reaching		Below surface			
			Sub-total	Species	Sub-total	Species	Total emergent	Species
A	35%	10%	10%	Lp 5% Ph 5%	0	-	25%	St 12% Ph 10% Lp 3%
B	100%	20%	10%	Ed 5% Pk 5%	10%	Nh 10%	80%	Ph 70% Ps 10%
C	60%	60%	50%	Ed 50%	10%	Pk 10%	0%	-
D	20%	15%	0	-	15%	Nh 15%	5%	St 5%
E	70%	45%	35%	Ed 25% Lp 2% Ps 5% Other 3%	10%	Pk 10%	25%	Mp 5% Lp 3% Mg 15% Other 2%

References

Biggs, B.J.F. 2000. New Zealand periphyton guideline. Detecting, monitoring and managing enrichment of streams. Prepared by NIWA for the Ministry for the Environment.

Biggs, B. J. F.; Kilroy, C. 2000. Stream periphyton monitoring manual. Published by NIWA for the Ministry for the Environment.

Collier, K.J.; Kelly, J. 2005. Regional Guidelines for Ecological Assessments of Freshwater Environments: Macroinvertebrate Sampling in Wadeable Streams. Environment Waikato Technical Report TR05/02. (http://www.ew.govt.nz/publications/technicalreports/tr0502.htm), Environment Waikato, Hamilton.

Appendix 1: Datasheet for periphyton rapid assessment.

Bryophytes and iron bacterial growths are recorded here for convenience (NA = not applicable)

Stream:_____ **Located number:**_____

Sample Number:_____ **Date**:_____

Thickness category	Colour category	A	B	C	D	E	Mean cover
Thin mat/film (<0.5 mm thick)	NA						
Medium mat (0.5-3 mm thick)	Green						
	Light brown						
	Black/dark brown						
Thick mat (>3 mm thick)	Green/light brown						
	Black/dark brown						
Short filaments (≤2 mm long)	Green						
	Brown/reddish						
Long filaments (>2 cm long)	Green						
	Brown/reddish						
Submerged bryophytes	NA						
Iron bacteria growths	NA						

Appendix 2: Datasheet for macrophyte rapid assessment.

Channel and wetted widths are recorded here for convenience but are not used in the calculation of indices.

Stream:_____ **Located number:**_____ **Sample Number**:_____

Date:_____

Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1										
2										
3										
4										
5										

SUBMERGED SPECIES

Native spp.
Introduced spp.

- Cd - *Ceratophyllum demersum* - HORNWORT
- Ec - *Elodea Canadensis* - CANADIAN PONDWEED
- Ed - *Egeria densa*
- Lm - *Lagarosiphon major*
- Mp - *Myriophyllum propinquum*
- Mt - *Myriophyllum triphyllum*
- Nh - *Nitella hookeri/cristata*
- Pk - *Potamogeton crispus* - CURLED PONDWEED
- Po - *Potamogeton ochreatus* - BLUNT PONDWEED
- Rt – *Ranunculus tricophyllus* – WATER BUTTERCUP
- St - *Callitriche stagnalis* - STARWORT

EMERGENT SPECIES

- An - *Apium nodiflorum* - WATER CELERY
- Gm - *Glyceria maxima* - REED SWEET GRASS
- Gr - Other grass spp
- Lp - *Ludwigia palustris* - WATER PURSLANE
- Mg - *Mimulus guttatus* - MONKEY MUSK
- Ma - *Myriophyllum aquaticum* - PARROTS FEATHER
- Na - *Nasturtium officinale/microphyllum* - WATERCRESS
- Ph - *Persicaria hydropiper* - WATER PEPPER
- Ps - *Persicaria decipiens* - SWAMP WILLOW WEED
- Ve - *Veronica anagallis-aquatica/Americana* - WATER SPEEDWELL
- Ml - *Myosotis laxa – WATER FORGET-ME-NOT*

Appendix 3: Pictorial guide to some macrophyte species found in Waikato streams and rivers.

Stems leafy– oxygen weeds

Lagarosiphon major (Lm)
EXOTIC

Leaves not in whorls
Usually bend downwards

SUBMERGED SPECIES

Canadian pondweed *(Ec)*
Elodea canadensis
EXOTIC

Leaves in whorls of 3
Usually < 1 cm long
Much smaller than *Egeria*

Leaves in whorls of 4+
Usually > 1 cm long
White flowers

Egeria densa (Eg)
EXOTIC

Stems single cells – charophytes

Branches in whorls
Green or black
Easily crushed

Nitella hookeri/cristata (Nh)
NATIVE

Starwort (St)
Callitriche stagnalis
EXOTIC (a smaller-leaved native species can occur in clear spring waters)

SUBMERGED SPECIES

Leaves alternate

Leaves crimped, red veined, short
Stems flattened

Curled pondweed (Pk)
Potamogeton crispus
EXOTIC

Leaves flat, veins not red, leaves long
Stems round

Blunt pondweed (Po)
Potamogeton ochreatus
NATIVE

Water buttercup (Rt)
Ranunculus trichophyllus
EXOTIC

Erect or creeping stems,
often rooted at nodes
Leaves divided with threadlike stems

Leaves divided

Leaves toothed
Rough to touch
No roots

Hornwort (Cd)
Ceratophyllum demersum
EXOTIC

Leaves divided

EMERGENTSPECIES

Water celery (An)

Apium nodiflorum

EXOTIC

Leaflets toothed
Carroty smell

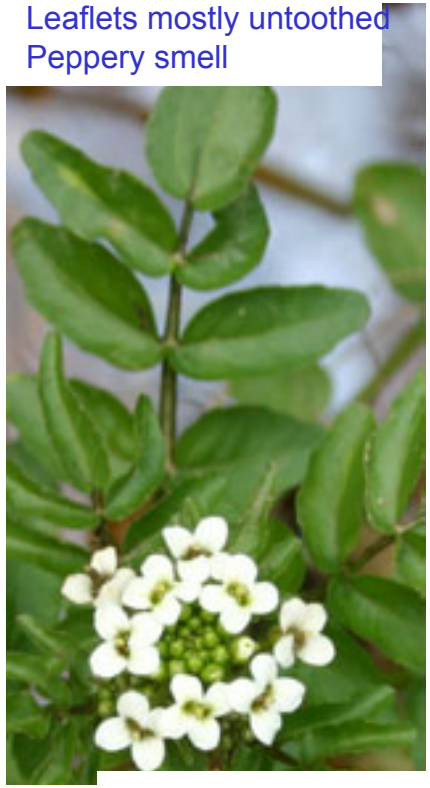
Leaves feathery
Pale green
EXOTIC

Parrot's feather (Ma)

Myriophyllum aquaticum

See other sheet for native species

Leaflets mostly untoothed
Peppery smell



Water cress (Na)

Nasturtium officinale

EXOTIC

Leaves basal, grass-like

Leaves over 1 cm across
Plants ~ 1m tall
Leaf tips keeled

Reed sweet grass (Gm)

Glyceria maxima EXOTIC

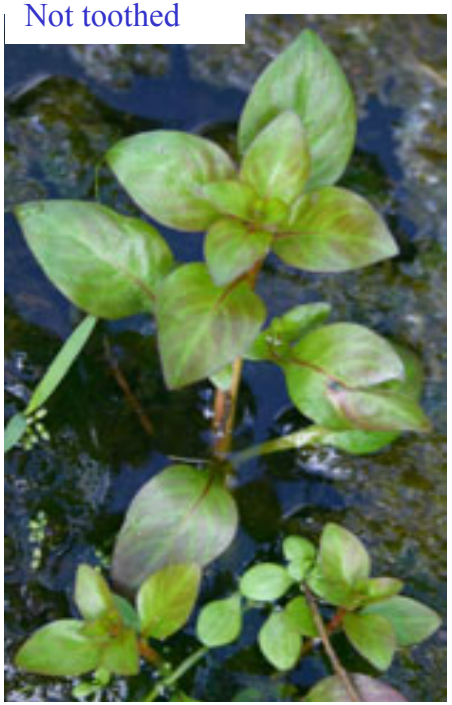
Usually in clear waters where can be submerged

Water forget-me-not (Ml)

Myosotis laxa EXOTIC

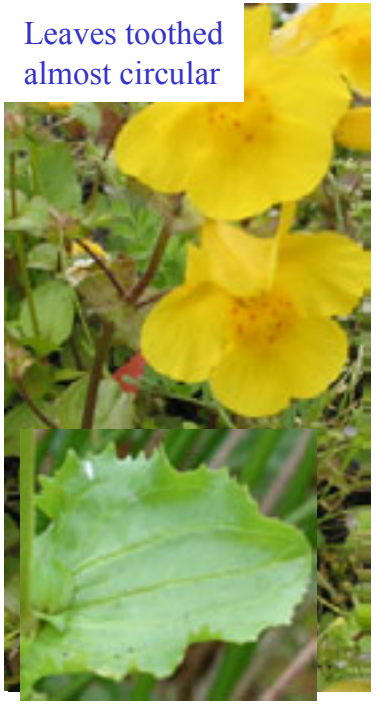
Leaves undivided opposite

Not toothed



Water purslane (Lp)
(can also be submerged)
Ludwigia palustris – EXOTIC

Leaves toothed
almost circular



Monkey musk (Mg)
Mimulus guttatus - EXOTIC

EMERGENT SPECIES

Water speedwell (Ve)
Veronica americana
EXOTIC

Leaves toothed
lance-shaped

Leaves undivided alternate

Leaves wrinkled
Veins obvious

Water pepper (Ph)
Persicaria hydropiper
EXOTIC

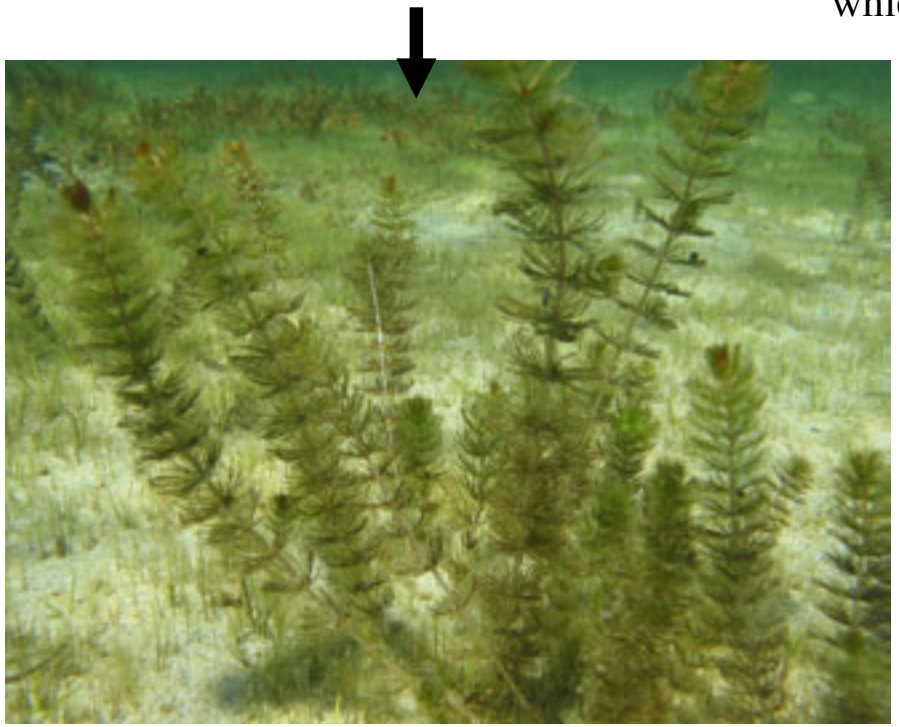
Leaves smooth
Veins not obvious

Swamp willow weed (Ps)
Persicaria decipiens - NATIVE

Native *Myriophyllum* species

Myriophyllum triphyllum – submerged

- More compact plant than *aquaticum* with leaves having shorter attachments to stem. Also more compact than *propinquum*. Relatively rare within the Waikato region. Greener in colour than *aquaticum*



Myriophyllum propinquum – submerged

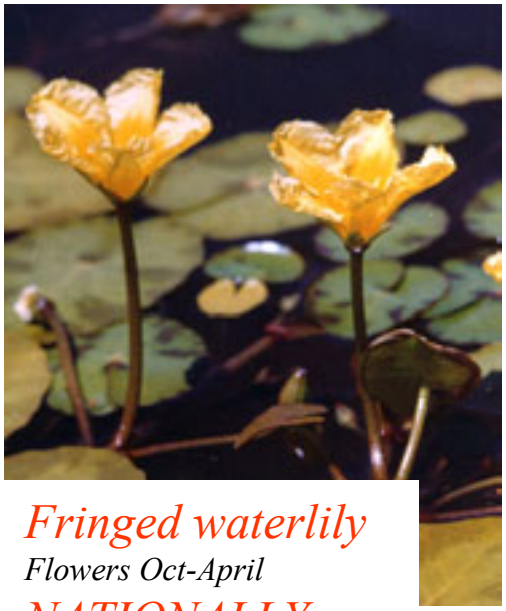
More compact plant than *aquaticum* with leaves having shorter attachments to stem. Relatively rare within the Waikato region but has been seen in Coromandel. Greener in colour than *aquaticum*. Purple green leaves which are pointed at tips

Appendix 4: Pictorial guide to some macrophyte species that are considered biosecurity threats and may be found in Waikato streams and rivers (report these to the Biosecurity officer).

NASTIES – KEEP AN EYE OUT FOR – REPORT SIGHTINGS!!

Water poppy
Flowers Nov-April
NATIONALLY BANNED

Marshwort
Flowers Nov-April
NATIONALLY BANNED



Fringed waterlily
Flowers Oct-April
NATIONALLY BANNED

Water hyacinth
NOTIFIABLE ORGANISM

Salvinia
NOTIFIABLE ORGANISM

NASTIES – KEEP AN EYE OUT FOR – REPORT SIGHTINGS!!

Yellow flag
Flowers Oct-Dec
NATIONALLY BANNED
Present in Lower Waikato

Purple loosestrife
Flowers during summer
NATIONALLY BANNED

Arrowhead
Flowers Oct-April
NATIONALLY BANNED

Sagittaria
Flowers Nov-March
NATIONALLY BANNED

Senegal tea
Flowers Nov-April
NATIONALLY BANNED

Alligator weed
NATIONALLY BANNED