A guide to monitoring the ecological quality of ponds and canals using PSYM

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MONITORING THE QUALITY OF STILL WATERS USING PSYM

1. Introduction

PSYM, the Predictive SYstem for Multimetrics, (pronounced sim) has been developed to provide a method for assessing the biological quality of still waters in England and Wales.

The method uses a number of aquatic plant and invertebrate measures (known as metrics)[1], which are combined together to give a single value which represents the waterbody's overall quality status.

Using the method involves the following steps:

1. Simple environmental data are gathered for each waterbody from map or field evidence (area, grid reference, geology etc.).
2. Biological surveys of the plant and animal communities are undertaken and net samples are processed.
3. The biological and environmental data are entered into the PSYM computer programme which:
   (i) uses the environmental data to predict which plants and animals should be present in the waterbody if it is undegraded,
   (ii) takes the real plant and animal lists and calculates a number of metrics[1].

Finally the programme compares the predicted plant and animal metrics with the real survey metrics to see how similar they are (i.e. how near the waterbody currently is to its ideal/undegraded state). The metric scores are then combined to provide a single value which summarises the overall ecological quality of the waterbody. Where appropriate, individual metric scores can also be examined to help diagnose the causes of any observed degradation (e.g. eutrophication, metal contamination).

2. Background

2.1 Why was the method developed?

Historically, the Environment Agency and other statutory bodies have undertaken relatively little monitoring of still waters (lakes, ponds, canals, ditches etc.). The absence of a standardised assessment method was a major barrier to the assessment of these waterbodies.

The PSYM methodology provides a standard assessment method for still waters which enables a variety of organisations involved in waterbody management to consider water quality in a broad national context. It provides the Environment Agency with a means to assess still water quality for General Quality Assessment (GQA) and other reporting purposes, and can be used in partnership with others such as DEFRA or English Nature. The method also enables public or private sector NGOs (e.g. consultants, community groups) to improve general standards of assessment in waterbody management plans or environmental impact assessments, and provides a means of assessing management techniques.

2.2 About PSYM

PSYM is a waterbody quality assessment methodology which essentially combines the predictive approach of RIVPACS[2] with multimetric-based methods used for ecological quality assessment in the United States.

In multimetric assessments, a range of variables (metrics) each related to degradation is used to assess water quality giving a broad-based assessment of quality. The values from individual metrics are combined to give a single measure which aims to represent the overall ecological quality of the waterbody. Combining this with predictive techniques gives a powerful method for comparing waterbodies of any type with their undegraded counterpart.

The PSYM methodology directly parallels the approach defined in the EU Water Framework Directive. This includes requirements for (i) comparisons with minimally impacted baseline conditions, and for (ii) assessments to be based on multiple parameters related to degradation.

2.3 Which waterbodies can be monitored using the method?

The PSYM approach is potentially applicable to all still waterbody types (e.g. lakes, ponds, temporary ponds, canals). However, to apply the method, specific data need to be collected from each waterbody type. These data are used both to (i) develop equations which can be used to predict the species which should occur at an undegraded site and (ii) to identify which biotic measures (e.g. species richness, ASPT) are the most effective at tracking degradation in that waterbody type.

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[1]Metrics are variables such as species richness or rarity which can be used to help identify how damaged a waterbody's community is. They have been shown to have a strong monotonic relationship with degradation.

[2]RIVPACS. The River InVertebrate Prediction And Classification System, developed by the Institute of Freshwater Ecology and Environment Agency (Wright et al. 1984, Wright 1995).

So far, the method has been developed for use on two still waterbody types (i) canals (ii) ponds[3] and small lakes (up to about 5 ha in area). An extension of the method for temporary ponds is currently being developed independently by PCTPR with support from the Freshwater Biological Association. Methods have not, so far, been developed for assessing the quality of large lakes, ditches or brackish waters.

The baseline dataset used to develop the metrics for ponds was based on survey data from sites with broad coverage of England and Wales from a wide range of altitudes (0-550m), and land types (representative coverage of ITE land classes), so the resulting model is suitable for sites across England and Wales.

2.4 Why assess water quality using both plants and invertebrates?

Ideally, PSYM should use information from both the plant and animal communities present in a waterbody. This is because, together, plants and animal groups span a complementary range of sensitivities to potential degradation factors. Plants are, for example, particularly sensitive to waterbody nutrient status, whereas animals typically exhibit greater oxygen sensitivity.

Matrix analysis suggests that in most waterbodies, the most effective *plant* group to use for assessment is likely to be either diatoms or macrophytes. The most effective *animal* groups are likely to be macroinvertebrates and/or potentially fish in large permanent waters. Combining a plant and animal group from these assemblages gives a range of taxa which span a number of trophic levels, occupy a variety of waterbody habitats (e.g. can be found in the littoral zone and open water) and are long-lived, so that they can provide a temporally and spatially integrated measure of the current ecosystem state. Invertebrate, diatom and macrophyte assemblages are also relatively species-rich groups, ensuring that a good cross section of waterbody biodiversity is included in the quality assessment.

In ponds, macroinvertebrates and macrophytes have been chosen as the most practical and effective taxa for quality assessment. In canals, the choice was macroinvertebrates and diatoms, although the method has so far only been developed for macroinvertebrates. Macrophytes were assessed as being less suitable for canal assessment because the high turbidity and artificial banks which characterise most navigated canals often means that very few higher plant species are present, regardless of overall water quality.

2.5 Do you have to use both plant and invertebrates for PSYM pond assessments?

Although PSYM pond quality assessments should be made using both plant and invertebrate assemblages, a partial assessment can be made using just one assemblage if necessary. If this is the case, macroinvertebrates are likely to be the best single choice of organisms for assessing overall waterbody quality. Macrophytes, however, have the advantage of being very quick to survey and can be used, if necessary, as a rapid bio-assessment method.

2.6 How are the plant and invertebrate metrics chosen?

Metrics are biological measures (such as taxa richness) which vary with anthropogenic degradation and can, therefore, be used to measure the extent of ecosystem degradation. The concept underlying multimetric assessment is that by using a number of different measures and summing these together, an overall assessment of environmental degradation can be made. For canals, at present, only an invertebrate option is available.

Metrics are chosen by correlating known degradation gradients (nutrient levels, heavy metal levels, presence of road runoff etc.) with a wide list of *possible* test metrics e.g. family richness, number of exotic species, EPT (number of Ephemeroptera, Plecoptera and Trichoptera families). The ‘test’ list is narrowed-down to a list of viable metrics by looking at the significance of relationships between each potential metric and anthropogenic degradation gradients. For invertebrates, metrics are chosen at the highest taxonomic level i.e. family or order level rather than species-level to reduce effort (although species level information can be derived from the samples if needed for conservation work). In practice, there were generally at least equally strong correlations between family-level macroinvertebrate metrics and degradation as there were between species-level metrics and degradation. This enables family-level macroinvertebrate data to be used for quality assessments in both ponds and canals. Plant metrics are generally based on species level information.

[3] Waterbodies between 1m^2 and 2 ha in area which usually retain water throughout the year (Collinson *et al*,. 1994). Includes both man-made and natural waterbodies.

Analyses have shown that the most effective metrics for assessing environmental degradation in ponds and canals are:

Ponds

Invertebrates

- Average score per taxon (ASPT)
- Number of dragonfly (Odonata) and alderfly (Megaloptera) families (F_OM)
- Number of beetle (Coleoptera) families (F_COL)

Plants:

- Number of submerged and emergent plant species (SM_NTX)
- Trophic ranking score for aquatic and emergent plants (TRS_ALL)
- Number of uncommon plant species ((PL_NUS)

Canals

Invertebrates

- Average score per taxon (ASPT)
- Number of Ephemeroptera, Plecoptera and Trichoptera families (F_EPT)
- Number of beetle families (F_COL)
- Number of invertebrate families (INV_NFA)

Note that in canals methods for assessing the chosen plant group (diatoms) have not yet been developed.

In order to calculate predictions for these metrics the PSYM model predicts which taxa will be found at a site. An example of a predicted and observed taxa list is given in the following table.

Predicted and observed taxa lists for pond plants and macroinvertebrates for Asham Meads field pond, Oxfordshire.

Species	Predicted (probability of occurrence)	Observed	Species	Predicted (probability of occurrence)	Observed
Wetland plants			*Macroinvertebrates*		
Agrostis stolonifera	0.76	✓	Lymnaeidae	1.00	✓
Juncus effusus	0.75	✓	Planorbidae	1.00	✓
Epilobium hirsutum	0.66	✓	Glossiphoniidae	1.00	✓
Solanum dulcamara	0.64	✓	Coenagrionidae	1.00	
Juncus articulatus	0.61	✓	Corixidae	1.00	✓
Alisma plantago-aquatica	0.58	✓	Haliplidae	1.00	✓
Glyceria fluitans	0.54	✓	Dytiscidae	1.00	✓
Typha latifolia	0.52		Hydrophilidae	1.00	✓
Lycopus europaeus	0.52		Notonectidae	0.80	✓
Mentha aquatica	0.50	✓	Baetidae	0.78	✓
Juncus inflexus	0.48	✓	Asellidae	0.76	✓
Galium palustre	0.43	✓	Libellulidae	0.75	
Sparganium erectum	0.42		Gerridae	0.64	✓
Eloeocharis palustris	0.39	✓	Leptoceridae	0.61	
Deschampsia caespitosa	0.38	✓	Sialidae	0.61	
Myosotis scorpioides	0.30	✓	Hydraenidae	0.58	✓
			Limnephilidae	0.56	✓
Aquatic plants			Aeshnidae	0.53	
Lemna minor	0.67	✓	Crangonyctidae	0.49	✓
Callitriche spp.	0.52	✓	Caenidae	0.45	✓
Chara spp.	0.44		Planariidae	0.42	
Potamogeton natans	0.32	✓	Erpobdellidae	0.39	
			Hydrobiidae	0.32	

2.7 Which physical and chemical variables are used in the predictions?

As in RIVPACS, the PSYM method assesses quality by comparing actual and predicted quality scores for each waterbody. The predictions of unimpaired waterbody quality are made using physico-chemical data gathered from the waterbody.

In *ponds* the main predictors of unimpaired community type fall into nine major variable categories. Of these, three are relatively invariant (e.g. grid reference, altitude, base geology) which need only be assessed once. The remaining six categories of variables require on-site field measurement when each assessment is made. These are area, pH, shade, grazing, presence of an inflow and emergent plant cover. In *canals*, the main predictive variables are grid reference, altitude, alkalinity, substrate and boat traffic.

2.8 How are metrics scored?

When a waterbody is assessed, each individual metric is calculated and compared to the computer predicted score for that metric. The relationship between observed and expected is presented as a percentage of similarity, and then transformed to a 4 point scale e.g. 0, 1, 2 and 3 where 0 represents poor quality, and 3 represents good quality (i.e. no deviation from expected). All metric scores are then summed to give an overall quality index, which is presented as a percentage of the maximum score and, potentially, forms the basis of General Quality Assessment (GQA) categorisation of a site.

2.9 Diagnosis

The main objective of the PSYM method is to assess the overall condition of freshwater ecosystems. The system does not, in itself, diagnose the cause, or causes, of degradation. Indeed it is considered inappropriate for a general quality assessment method to be biased towards the evaluation of a single impact. However, there is considerable potential for data which are collected using the scheme to be re-interpreted to diagnose the causes of degradation. Individual metrics can indicate aspects of water quality and the raw data can be reanalysed to give pollution indices, such as trophic scores or acidification indices.

3. Assessing pond quality using Pond PSYM

3.1 Introduction

Pond PSYM has currently been developed for use in the Summer season (June, July, August), and is based on assessments of both macroinvertebrate and macrophyte assemblages.

3.2 Sites which can be included

Pond PSYM can be used on ponds and small lakes up to about 5 ha in area in England and Wales. The method can, in theory be used to assess the quality of seasonal ponds, but in practice it 'over-predicts' for ponds which are highly seasonal (i.e. which dry hard every year), and is best restricted to ponds which are either permanent, or semi-seasonal (i.e. which dry occasionally in very hot years). An extension of the method is currently being developed for use with fully temporary ponds.

3.3 Field data collection

The environmental data which need to be collected from each pond to use Pond PSYM include:

(i) *locational and other data* used for data processing. This includes: site name and code, county and nearest town, six or eight figure grid reference as necessary to identify the site, survey date, surveyor, site description.

(ii) *predictive variables* used in the pond PSYM programme to predict the undegraded biota for the pond. This includes: map-based locational information (six figure grid reference, altitude), together with site data describing shade, the presence of an inflow, cover of emergent plants, pond base geology and pH.

Collecting predictive variable data

The methods used to collect the main predictive variable data are briefly outlined below.

Grid reference: six figure reference, taken from 1:50,000 or 1:25,000 OS maps, input into the model as Easting and Northing (100 km cell reference followed by 3 figures).

Altitude: in metres above sea level, taken from 1:50,000 or 1:25,000 OS maps.

pH: measured either (i) in the field in a bucket of water taken from a representative area of the pond, or (ii) using a water sample collected in the field and analysed later in the laboratory. For laboratory analysed samples, use acid washed bottles stored in a cool place after collection (e.g. cold box) and analyse within one day of collection.

Pond area: this is the area lying within the outer edge of the pond (see 3.4 below). The pond dimensions can be measured using a tape, or by careful pacing. A small sketch can help to make this estimate. For large ponds it can be easier to use an OS map outline, with the dimensions checked in the field. Note that for the predictions, area data are used as log values so, particularly for large ponds, estimates do not need to be highly accurate.

Pond overhung: the percentage of the pond area which is *directly overhung* (e.g. by trees, scrub etc.).

% of pond edge grazed by livestock: the percentage of the perimeter of the pond to which livestock have active access. Note that if cattle, sheep, horses etc. are not grazing at the time of the survey, their presence can be detected by other features such as poaching of the ground.

Pond base: the rock type underlying the pond (beneath the sediment). This can often be assessed directly in the field, or be determined using a geology map. In the field, push the handle of the pond net through the sediment into the base. Exact measurement is not necessary, only broad categorization into one of three percentage categories: 1= 0%-32%, 2=33%-66%, 3=67%-100%.

Inflow: whether or not the pond has a surface inflow. This can be a direct or indirect inflow from a river, stream, ditch, spring or seepage. The inflow can be *dry* at the time of the survey.

Emergent plant cover: the percentage of the pond covered by emergent plant species. The term 'emergent plant species' includes all species listed as emergents on the wetland plant recording sheet. It includes these species regardless of their habit at the time of the survey (e.g. some emergent species may be growing predominantly under water at the time of the survey). It does not include any other species e.g. terrestrial species or plants specifically defined as 'submerged' or 'floating-leaved' plant species on the wetland plant recording sheet.

Estimates of the percentage cover of emergent plants should be made for the whole area within the outer edge of the pond, not the current water area. The cover of sparsely growing stands of plants (e.g. occasional bulrush plants with much open water between), should be estimated as if they were growing closely together. The easiest way of doing this is to imagine all emergent plants pushed together on one side of the pond, with an estimate then made of what proportion of the pond this covers.

At present it is recommended that for those variables for which field estimates are made (pH, area, overhanging trees, grazing, base type and emergent plant cover) the objective of measurement should be to obtain estimates that are within

5-10% of the long term mean. It is expected that further work will be undertaken to refine understanding of the effects of variation in measurements in the future.

3.4 Defining the outer edge of the pond

Identifying the 'outer edge' of the pond is important for many of the physico-chemical survey assessments and for undertaking the plant survey. In all cases, the definition of pond 'outer edge' is 'the upper level at which water stands in winter'.

In practice, the outer edge is usually readily discernible from one or more site characteristics. The best of these is usually the distribution and/or morphology of wetland plants. For example, it may be marked by a fringe of soft rush (*Juncus effusus)* or by thick bundles of fine roots growing out of the trunks of willows etc. Alternatively, the line can often be seen as a 'water mark' on surrounding trees or walls and is sometimes evident as a break of slope. The outer boundary of the pond will usually, of course, be dry at the time of the survey.

3.5 Plant survey methodology

The aim of plant recording is to make a complete list of wetland plants present within the outer edge of the pond. The field recording sheet gives a definitive list of the plant species regarded as 'wetland'. Terrestrial plants and wetland plants growing outside the outer edge of the pond are not recorded. The wetland plant recording sheet includes *submerged* macrophytes, *floating-leaved* species and *emergent* macrophytes, and these groups are used separately in analysis.

Pond macrophytes are surveyed by walking or wading the entire perimeter of the dry and shallow water areas of the waterbody. Deeper water areas are sampled either using a pond net or by grapnel thrown from shallow water or from a boat.

Most wetland plants are readily identifiable using a hand lens. However, with a few species (especially fine-leaved *Potamogeton* and *Callitriche* spp.) it may be necessary to remove a small amount of plant material for later microscopic examination and confirmation.

Record macrophyte species found on the attached wetland plant recording sheet.

3.6 Invertebrate survey methodology

The pond invertebrate survey methods used for PSYM are based on standard three minute hand-net sampling methods developed for the National Pond Survey (Pond Action, 1998).

The NPS invertebrate survey techniques were developed 'post-RIVPACS' in 1989-90, and were designed to be closely compatible with the original RIVPACS sampling methods, whilst allowing for differences between river and pond habitat types. The main differences between pond and river sampling methods are that:

- RIVPACS allocates sampling time on an area basis (i.e. more time is spent sampling extensive habitats). In pond PSYM, time is allocated according to mesohabitat types (i.e. if six main habitat types are identified time is divided equally amongst these). This change was made to allow for the fact that many ponds have extensive biologically uniform areas of open water and silt, and narrow but highly diverse marginal zones.
- In Pond PSYM the 3 minute survey subsamples are taken around the entire pond site whereas in RIVPACS samples are collected from an area that can be covered comfortably in three minutes: typically a river length of 5-20 m.

3.7 Selecting mesohabitats for invertebrate surveys

All the main mesohabitats in the pond are sampled so that as many invertebrate species are collected from the site as possible. Examples of typical mesohabitats are: stands of *Carex* (sedge); gravel- or muddy-bottomed shallows; areas overhung by willows, including water-bound tree-roots; stands of *Elodea*, or other submerged aquatics; flooded marginal grasses; and inflow areas. As a rough guide, the average pond might contain 3-8 mesohabitats, depending on its size and complexity. It is important that vegetation *structure*, as well as plant species composition, is considered when selecting mesohabitats: it is better to identify habitats consisting of e.g. soft floating leaves, stiff emergent stems, etc. than to make each different plant species a separate habitat. Mesohabitats are identified during the initial walk around the pond examining vegetation stands and other relevant features (this can be combined with the initial plant survey stage).

Invertebrate sampling method

(i) The three-minute sampling time is divided equally between the number of mesohabitats recorded: e.g. for six mesohabitats, each will be sampled for 30 seconds. Where a mesohabitat is extensive or covers several widely-separated areas of the pond, the sampling time allotted to that mesohabitat is *further divided* in order to represent it adequately (e.g. into 6 x 5 second sub-samples).

(ii) Each mesohabitat is netted vigorously to collect macroinvertebrates. Stony or sandy substrates are lightly 'kick-sampled' to disturb and capture macroinvertebrate inhabitants. N.B. deep accumulations of soft sediment are avoided, since these areas typically support few species and collecting large amounts of mud makes later sorting extremely difficult. Similarly, large accumulations of plant material, root masses, and the like should not be taken away in the sample: the idea is to dislodge and capture the animals without collecting an unmanageable sample.

The sample is placed in the labelled bucket for later sorting in the laboratory. Note: the three-minute sampling time refers solely to 'net-in-the-water' time, and does not include time moving between adjacent netting areas around the pond.

(iii) Amphibians or fish caught whilst sampling are noted on the recording sheet and returned to the pond.

Additional invertebrate sampling

A further 1 minute (total time, *not* net-in-the-water time) is spent searching for animals which may otherwise be missed in the 3-minute sample. Areas which might be searched include the water surface (for whirligig beetles, pond skaters etc.) and under stones and logs (for limpets, snails, leeches, flatworms etc.). Additional species found are added to the main 3-minute sample.

3.8 Processing invertebrate samples

Invertebrate sorting and identification methods follow the standard laboratory techniques. Invertebrate samples are identified to *family* level for most groups and class level for oligochaetes.

Record findings in the columns on the field sheet as follows. If present and so included in ASPT calculation, record in the “ASPT” column, if a dragonfly or alderfly family also record in the “OM” column, or if a Coleoptera family in the “Cole.” column.

3.9 Data processing and analysis

Biotic data are used by pond PSYM to calculate three plant metrics and three invertebrate metrics:

Plants:

- Number of submerged and emergent plant species (PL_NTX)
- Trophic ranking score for aquatic and emergent plants (TRS_ALL)
- Number of uncommon plant species (PL_NUS)

Invertebrates:

- Average score per taxon (ASPT)
- Number of dragonfly (Odonata) and alderfly (Megaloptera[4]) families (F_OM)
- Number of beetle (Coleoptera) families (F_COL).

Calculating the pond metrics from taxon lists

1. Number of submerged and emergent plant species

This is simply the sum of the number of submerged plant taxa plus number of emergent plant taxa observed at the site. The terms ‘submerged’ and ‘emergent’ taxa refer only to the species listed in these groups on the field sheet - not to plants of any species which happen to be submerged below water or growing round the edge of the pond at the time of the survey.

The calculation does *not* include the number of floating-leaved species present. This is because the pond data suggest that the number of floating-leaved plants occurring at a site does not decline significantly with increasing degradation. The metric is therefore improved by omitting this plant group.

[4] Note that there is only one family of Megaloptera in the UK (the Sialidae) and that the metric F_OM is concerned with the combined total of Odonata and Megaloptera, not the occurrence of the family Megaloptera alone.

2. Trophic Ranking Score (TRS)

TRS is a measure of the average trophic rank for the pond. This is calculated by assigning each plant species with a trophic score based on its affinity to waters of a particular nutrient status. The trophic scores used in the present study were based on work undertaken on lakes by Palmer (1989). Plant scores in this system vary between 2.5 (dystrophic i.e. very nutrient poor conditions) and 10 (eutrophic, i.e. nutrient rich conditions).

Unfortunately, not all plants have trophic scores. This situation has arisen because the current TRS values for standing waters (Palmer *et al.*, 1992) are based only on analysis of lake data, and many plant species which are common in ponds occurred at too low a frequency in lakes to give them a score. Nigel Holmes's Mean Trophic Ranking method, which was developed for assessing the nutrient status of running water communities, cannot be used in the current analysis because trophic values for some plant species can vary between still and running waters (N. Holmes *pers. comm.*).

The TRS value for a site is calculated as follows:
(i) The trophic scores from each plant species present at the site are summed together.
(ii) The summed score is divided by the total number of plant species which have a trophic ranking score (NOTE not the total number of plants at the site) to give the TRS.

3. Uncommon species index

Uncommon species are those which have a rarity score of 2 or more. The number of these species is simply summed to give the number of uncommon species.

Uncommon species refers to species which can be described as 'local', 'nationally scarce' or 'Red Data Book'. Descriptions of these categories are given below.

Status[5]	Rarity score	Definition
Common	1	Recorded from >700 10x10 km grid squares in Britain
Local	2	Recorded from between 101 and 700 grid squares in Britain
Nationally Scarce	4	Nationally Scarce. Recorded from 15-100 grid squares in Britain
At risk	8	Red Data Book: Category "At risk"
Vulnerable	16	Red Data Book: Category "Vulnerable"
Endangered	32	Red Data Book: Categories " Endangered" or "Highly Endangered"

The rarity score for each species is given on the plant recording sheet so the number of species with a rarity score of 2 or more can be easily calculated.

4. Average Score Per Taxon (ASPT)

ASPT is calculated, as in RIVPACS, by summing the BMWP[6] scores for all taxa present at the site and dividing by the total number of BMWP taxa present.

5. Number of dragonfly and alderfly families

This metric is the sum of the number of Odonata and Megaloptera families which occur at the site.

6. Number of beetle families

This metric is the sum of the number of Coleoptera families present at the site. The metric has a relationship with bank quality as well as water quality.

[5]The rarity status values for Scarce and RDB species are based on existing definitions derived from the Red Data Books and other authorities. The definition of 'local' has been used to define species which are not uniformly common and widespread in Britain: with plants this refers specifically to species recorded from between 101 and 700 10 x 10 km squares (approximately 25% of all 10 km in England, Wales and Scotland).

[6] BMWP (Biological Monitoring Working Party) scores assigned to taxa defined by Maitland (1977), so each is allocated a value from 1 to 10 depending on its known tolerance to organic pollution, a higher score indicates lower tolerance.

4. Assessing canal quality using Canal PSYM

4.1 Introduction

Canal PSYM has currently been developed for use in the Spring season (March, April, May), and is based on a macroinvertebrate assessment only[7]. Two canal PSYM models have been developed in response to the potential problem of obtaining bottom samples. The basic model uses combined edge and bottom samples, but where this is not possible, a second model can be used for which only edge samples are taken.

4.2 Sites which can be included

Canal PSYM can be used to assess the quality of any section of canal, including both reinforced and natural bank sections. The term canal, does not however include major navigations (i.e. canalised rivers), such as the Lee Navigation and Stort Navigation, since these were excluded from the canal survey as many sections are essentially riverine in character.

4.3 Field sheet data collection

Field data collected from each canal site include:

(i) *locational and other data* used simply to identify the site and enable the site to be re-found for monitoring purposes. These data include information on: site name and collection code, canal name, nearest town, six or eight figure grid reference (depending on the degree of accuracy needed to locate the site precisely), survey date, surveyor, description of site.

(ii) *predictive variables* used in the PSYM programme to predict the minimally impaired biota for the canal. This includes map- or desk-based information (grid reference, altitude, number of boats) and field-based measurements (alkalinity, canal substrate).

Field variables

The environmental data which need to be collected from each site to use Canal PSYM depend on whether (i) only edge samples are taken or (ii) combined edge and bottom samples are used. For (i) Northing, altitude, turbidity, substrate and boat traffic are required. For (ii) Easting, Northing, altitude, alkalinity, substrate and boat traffic are needed. Details are as follows.

Easting: 100 km cell reference followed by 4 figures, from 1:25,000 OS maps.

Northing: 100 km cell reference followed by 4 figures, from 1:25,000 OS maps.

Altitude: in metres above sea level, taken from 1:50,000 or 1:25,000 OS maps.

Turbidity*:* Secchi depth in cm.

Total Alkalinity: measured as meq l^{-1}. Analysed in the laboratory from a water sample collected in the field.

Canal substrate: a field estimate of the percentage of the canal sediment composition that is sand. Sediment composition often varies across the canal, with the edge area usually coarser than the bottom substrate in deeper water. Where this is the case, two substrate measurements should be made, one in shallow water and one in deep water and the average calculated.

Number of boats: measured in thousands of boat movements per annum. These data can be provided by British Waterways (or other canal authority as appropriate).

4.4 Invertebrate sampling

Canals are steep-sided and relatively deep waterbodies, so the area-related hand-net sampling methodologies appropriate for rivers (e.g. typical RIVPACS sampling) cannot be directly applied to canals. In particular: (i) hand-net methods are difficult to apply to the deepest open-water areas of canals, (ii) most invertebrate species are concentrated in a narrow band at the canal edge, so that an area-based sampling method can considerably under-sample invertebrate diversity.

The sampling technique used to collect invertebrate samples for this was developed as a hybrid between the 'three-minute hand-net sample' currently used for sampling shallow rivers, and the 'one-minute hand-net sample + dredge hauls' method recommended for sampling deep rivers. The method will also be used by CEH in future canal surveys.

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[7]Ideally PSYM should also include a plant-based assessment, however this has not yet been developed. In canals, diatoms have been identified as the most suitable plant assemblage for assessing quality, since macrophytes often occur in very low abundance where water is at all turbid and banks are reinforced.

The method comprises:

1. A one-minute search.
2. A two-minute semi-continuous hand-net sampling of the canal margin, shallows and any emergent plant habitats present. This sample typically covers a bank length of 5m to 15m.
3. Four net hauls from deeper bottom sediments along a canal length of approximately 10 m, elutriated on site to wash out the bulk of muds and fine sands. These should be taken at c. 3m intervals along the canal sampling length.

Two directly compatible field techniques can be employed to gather the four bottom sediment sample hauls from deeper areas, the choice depending on canal depth and accessibility:
(i) where canals are shallow enough to wade, bottom samples can be collected using a hand-net haul (c.3m length) taken perpendicular to the bank, (ii) where canals are too deep to use a hand net, bottom samples are collected using a Naturalist's dredge with a hand net sub-sample filling ca. one quarter of the pond net then taken from this dredged material. It is recommended that the bank and bottom samples are kept separate, since this makes the samples easier to sort in the laboratory.

4.5 Processing samples

Invertebrate sorting and identification methods follow the standard laboratory techniques used for processing invertebrate samples. Invertebrate samples are identified to *family* level for most groups and class level for oligochaetes.

Record findings in the columns on the field sheet as follows. If present and so included in ASPT calculation, record in the "ASPT" column, if a dragonfly or alderfly family also record in the "OM" column, or if a Coleoptera family in the "Cole." column.

4.6 Data processing and analysis

Invertebrate family data are used by PSYM to calculate four metrics:

- Average score per taxon (ASPT)
- Number of Ephemeroptera, Plecoptera and Trichoptera families (F_EPT)
- Number of beetle (Coleoptera) families (F_COL)
- Number of invertebrate families (INV_NFA)

4.7 Data interpretation and diagnosis

In analyses it was shown that ASPT and EPT scores both correlated strongly with a wide variety of water quality parameters, including heavy metals, suspended solids and chemical water quality (i.e. the overall chemical quality class based on suspended solids, BOD and ammonia concentrations). These metrics, however, showed few relationships with bank degradation variables.

In contrast, invertebrate family richness, and particularly beetle, bug and snail richness, showed strong relationships with bank structure and boat traffic, but very few relationships with water quality attributes.

These differences in degradation sensitivity make it possible to assess both water quality and bank effects separately. Thus where the main aim of canal assessments is to investigate water quality, then metrics based on ASPT and EPT taxa will be most effective. If boat traffic and hard bank structure effects are of concern, then parameters based on taxon richness or bug and beetle species or family richness can be combined into the final integrity index, i.e.:

A. Canal water quality assessment = ASPT + EPT.

B. Canal bank quality assessment = No. Coleoptera families + No. invertebrate families.

Total canal ecological quality = A + B.

Calculating the canal metrics from taxon lists

1. Average score per taxon (ASPT)

ASPT is calculated by summing the BMWP scores for all taxa present at the site and dividing by the total number of BMWP taxa present.

2. Number of Ephemeroptera, Plecoptera and Trichoptera families (F_EPT)

The sum of the number of Ephemeroptera, Plecoptera and Trichoptera families recorded in the sample.

3. Number of Coleoptera families (F_COL)

This metric is simply the sum of the number of Coleoptera families present at the site.

4. Number of invertebrate families (INV_NFA)

The number of all invertebrate taxa recorded on the survey form.

5. References and additional reading

Maitland, P.S. (1977). *A coded checklist of animals occurring in fresh water in the British Isles*. Institute of Terrestrial Ecology, Edinburgh.

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Pond Action (1998). *A guide to the methods of the National Pond Survey*. Pond Action, Oxford.

Preston, C.D., D.A. Pearman and T.D. Dines (Eds) (2002) *New Atlas of the British and Irish Flora*, Oxford University Press, Oxford.

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Wright, J.F., D. Moss, P.D. Armitage and M.T. Furse (1984). A preliminary classification of running-water sites in Great Britain based on macro-invertebrate species and the prediction of community type using environmental data. *Freshwater Biology*, **14**, 221-256.

More detailed information describing the PSYM methodology is given in the following reports:

Williams, P., J. Biggs, L. Dodds, M. Whitfield, A. Corfield and G. Fox (1996). *Biological techniques of still water quality assessment. Phase 1 Scoping Study*. Environment Agency R&D Technical Report E7. Environment Agency, Bristol.

Williams, P., J. Biggs, M. Whitfield, A. Corfield, G. Fox and K. Adare (1998). *Biological techniques of still water quality assessment. Phase 2. Method development.* Environment Agency R&D Technical Report E56. Environment Agency, Bristol.

Biggs, J., P. Williams, M. Whitfield, G. Fox and P. Nicolet (2000). *Biological techniques of still water quality assessment. Phase 3. Method development.* Environment Agency R&D Technical Report E110. Environment Agency, Bristol.

Pond PSYM Fieldsheet

Site and sample details

Site name ______________________ Code No. _______________ Grid ref. ( )

Recording format: (SU)345 678 *or* (41)345 678

Location ______________________

Site access details ______________________

Survey date ______________________ Surveyor ______________________

Notes ______________________

Environmental data

Altitude (m)		pH	
Shade: % pond overhung		% emergent plant cover	
Inflow (absent = 0, present = 1)		Pond area (m^2)	
% of pond margin grazed			

Sketch of pond

Pond base: categorise into one of three groups: 1=0%-32%, 2=33%-66%, 3=67%-100%

Clay/silt		Sand, gravel, cobbles		Bed rock	
Peat		Other			

MACROINVERTEBRATE LIST

Group 1 taxa (BMWP:10)	ASPT	OM	Cole.
Siphlonuridae			
Heptageniidae			
Leptophlebiidae			
Ephemerellidae			
Potamanthidae			
Ephemeridae			
Taeniopterygidae			
Leuctridae			
Capniidae			
Perlodidae			
Perlidae			
Chloroperlidae			
Aphelocheiridae			
Phryganeidae			
Molannidae			
Beraeidae			
Odontoceridae			
Leptoceridae			
Goeridae			
Lepidostomatidae			
Brachycentridae			
Sericostomatidae			
No. of taxa			

Group 2 taxa (BMWP:8)	ASPT	OM	Cole.
Astacidae			
Lestidae			
Calopterygidae (Agriidae)			
Gomphidae			
Cordulegasteridae			
Aeshnidae			
Corduliidae			
Libellulidae			
Philopotamidae			
Psychomyiidae			
No. of taxa			

Group 3 taxa (BMWP:7)	ASPT	OM	Cole.
Caenidae			
Nemouridae			
Rhyacophilidae (Glossomatidae)			
Polycentropodidae			
Limnephilidae			
No. of taxa			

Group 4 taxa (BMWP:6)	ASPT	OM	Cole.
Neritidae			
Viviparidae			
Ancylidae (Acroloxidae)			
Hydroptilidae			
Unionidae			
Corophiidae			
Gammaridae (Crangonyctidae)			
Platycnemididae			
Coenagriidae			
No. of taxa			

Group 5 taxa (BMWP:5)	ASPT	OM	Cole.
Planariidae (Dugesiidae)			
Dendrocoelidae			
Mesovelidae			
Hydrometridae			
Gerridae			
Nepidae			
Naucoridae			
Notonectidae			
Pleidae			
Corixidae			
Haliplidae			
Hygrobiidae			
Dytiscidae (Noteridae)			
Gyrinidae			
Hydrophilidae (Hydraenidae)			
Dryopidae			
Elmidae			
Hydropsychidae			
Tipulidae			
Simuliidae			
No. of taxa			

Group 6 taxa (BMWP:4)	ASPT	OM	Cole.
Baetidae			
Sialidae			
Piscicolidae			
No. of taxa			

Group 7 taxa (BMWP:3)	ASPT	OM	Cole.
Valvatidae			
Hydrobiidae (Bithyniidae)			
Lymnaeidae			
Physidae			
Planorbidae			
Sphaeriidae			
Glossiphoniidae			
Hirudinidae			
Erpobdellidae			
Asellidae			
No. of taxa			

Group 8 taxa (BMWP:2)	ASPT	OM	Cole.
Chironomidae			
No. of taxa			

Group 9 taxa (BMWP:1)	ASPT	OM	Cole.
Oligochaeta			
No. of taxa			

	ASPT	OM	Cole.
TOTAL NO. OF TAXA			
TOTAL BMWP SCORE			
ASPT			
NO. OF OM TAXA			
NO. COLEOPT. TAXA			

Plant recording sheet (score through each species present) RS = Rarity Score, TRS = Trophic Ranking Score

RS	TRS	Emergent plants
1		Achillea ptarmica
1		Acorus calamus
1		Agrostis canina
1	*LP*	Agrostis stolonifera
32		Alisma gramineum
2		Alisma lanceolatum
1	9	Alisma plantago-aquatica
2		Alopecurus aequalis
4		Alopecurus borealis
1		Alopecurus geniculatus
2		Anagallis tenella
2		Andromeda polifolia
1		Angelica archangelica
1		Angelica sylvestris
2		Apium graveolens
1	10	Apium nodiflorum
32		Apium repens
2		Baldellia ranunculoides
2	10	Berula erecta
2		Bidens cernua
1		Bidens connata
1		Bidens frondosa
2		Bidens tripartita
2		Blysmus compressus
2		Bolboschoenus maritimus
2*		Butomus umbellatus
2		Calamagrostis canescens
2		Calamagrostis epigejos
8		Calamagrostis purpurea
8		Calamagrostis stricta
16		Calamogrostis scotica
1		Calla palustris
1	7	Caltha palustris
1		Cardamine amara
1		Cardamine pratensis
2		Carex acuta
1	10	Carex acutiformis
4		Carex appropinquata
2		Carex aquatilis
2		Carex curta
2		Carex diandra
1		Carex disticha
1		Carex echinata
2	10	Carex elata
4		Carex elongata
1		Carex flacca
1		Carex hostiana
2		Carex laevigata
2	4	Carex lasiocarpa
2	4	Carex limosa
1	5	Carex nigra
1		Carex oedocarpa
1		Carex otrubae
1		Carex panicea
2	10	Carex paniculata
1		Carex pendula
2	10	Carex pseudocyperus
1		Carex pulicaris
1	10	Carex riparia
1	5.3	Carex rostrata
2		Carex spicata
2		Carex vesicaria
1		Carex viridula
16		Carex vulpina
1		Carex sp.
2		Catabrosa aquatica
4		Cicuta virosa
2		Cirsium dissectum
1		Cirsium palustre
2		Cladium mariscus
1		Conium maculatum
1		Crassula helmsii
1		Crepis paludosa
16		Cyperus fuscus
4*		Cyperus longus
2		Dactylorhiza sp (undet.)
32		Damasonium alisma
1		Deschampsia cespitosa
2		Drosera anglica
1		Drosera binata
1		Drosera capensis
2		Drosera intermedia
1		Drosera rotundifolia
16		Dryopteris cristata
2		Eleocharis acicularis
8		Eleocharis austriaca
2		Eleocharis multicaulis
1	*LP*	Eleocharis palustris
2		Eleocharis quinqueflora
2		Eleocharis uniglumis
2		Epilobium alsinifolium
2		Epilobium anagallidifolium
1		Epilobium brunnescens
1		Epilobium ciliatum

RS	TRS	
1		Epilobium hirsutum
1		Epilobium obscurum
1		Epilobium palustre
1		Epilobium parviflorum
2		Epilobium tetragonum
2		Epipactis palustris
1	*LP*	Equisetum fluviatile
1		Equisetum palustre
1		Erica tetralix
1	2.5	Eriophorum angustifolium
16		Eriophorum gracile
2		Eriophorum latifolium
1		Eriophorum vaginatum
1		Eupatorium cannabinum
1		Filipendula ulmaria
2		Galium boreale
8		Galium constrictum
1		Galium palustre
2		Galium uliginosum
1		Geum rivale
2		Glyceria declinata
1	*LP*	Glyceria fluitans
1	10	Glyceria maxima
2		Glyceria notata
1		Gnaphalium uliginosum
1	*LP*	Hydrocotyle vulgaris
2		Hypericum elodes
1		Hypericum tetrapterum
4		Hypericum undulatum
2		Impatiens capensis
1		Impatiens glandulifera
4*		Impatiens noli-tangere
1	*LP*	Iris pseudacorus
1		Isolepis setacea
1		Juncus acutiflorus
1		Juncus articulatus
1		Juncus bufonius agg.
1	5.3	Juncus bulbosus
2		Juncus compressus
1		Juncus conglomeratus
1	*LP*	Juncus effusus
2		Juncus foliosus
1		Juncus inflexus
32		Juncus pygmaeus
2		Juncus subnodulosus
4		Lathyrus palustris
32		Leersia oryzoides
32		Liparis loeselii
1		Lotus pedunculatus
1		Luzula luzuloides
2		Luzula sylvatica
1		Lychnis flos-cuculi
1		Lycopus europaeus
1		Lysimachia nummularia
1		Lysimachia terrestris
4		Lysimachia thyrsiflora
2		Lysimachia vulgaris
16		Lythrum hyssopifolium
2		Lythrum portula
1		Lythrum salicaria
1	7.3	Mentha aquatica
16		Mentha pulegium
1	5.3	Menyanthes trifoliata
1		Mimulus guttatus
1		Mimulus luteus
16		Minuartia stricta
1		Molinia caerulea
1		Montia fontana
1	7.7	Myosotis laxa
1	9	Myosotis scorpioides
1		Myosotis secunda
4		Myosotis stolonifera
1		Myosotis sp (undet.).
2		Myosoton aquaticum
1		Myrica gale
1		Narthecium ossifragum
2		Oenanthe aquatica
1		Oenanthe crocata
2		Oenanthe fistulosa
2		Oenanthe lachenalii
2		Oenanthe pimpinelloides
4		Oenanthe silaifolia
2		Osmunda regalis
2		Parnassia palustris
1		Pedicularis palustris
1	10	Persicaria hydropiper
1		Persicaria maculosa
2		Persicaria minor
4		Persicaria mitis
1		Petasites hybridus
1		Petasites japonicus
4		Peucedanum palustre
1	8.5	Phalaris arundinacea

RS	TRS	
1	7.3	Phragmites australis
4	5.5	Pilularia globulifera
2		Pinguicula lusitanica
1		Pinguicula vulgaris
1		Potentilla erecta
1	5.3	Potentilla palustris
1		Pulicaria dysenterica
16		Pulicaria vulgaris
1		Ranunculus ficaria
1	*LP*	Ranunculus flammula
2	10	Ranunculus hederaceus
2*		Ranunculus lingua
2		Ranunculus omiophyllus
32		Ranunculus ophioglossifolius
32		Ranunculus reptans
1	10	Ranunculus sceleratus
2		Rhynchospora alba
4		Rhynchospora fusca
2		Rorippa amphibia
8		Rorripa islandica
2	10	Rorippa microphylla
1	10	Rorippa nasturtium-aquaticum
1	10	Rorippa (undet.).
1		Rorippa palustris
2	10	Rumex hydrolapathum
2		Rumex maritimus
2		Rumex palustris
1		Sagina procumbens
1		Sagittaria rigida
2		Samolus valerandi
2	7.7	Schoenoplectus lacustris
32		Schoenoplectus pungens
2		Schoenoplectus tabernaemontani
32		Schoenoplectus triqueter
16		Schoenus ferrugineus
2		Schoenus nigricans
16		Scorzonera humilis
1		Scrophularia auriculata
1		Scutellaria galericulata
1		Senecio aquaticus
1		Senecio fluviatilis
32		Senecio paludosus
4		Sium latifolium
1	10	Solanum dulcamara
4		Sonchus palustris
1	8.5	Sparganium erectum
1		Stachys palustris
2		Stellaria palustris
1		Stellaria uliginosa
1		Symphytum officinale
16		Teucrium scordium
2		Thalictrum flavum
4		Thelypteris palustris
2		Tofieldia pusilla
1		Trichophorum cespitosum
1		Triglochin palustre
2	10	Typha angustifolia
1	8.5	Typha latifolia
2		Valeriana dioica
1		Vallisneria spiralis
1		Veronica anagallis-aquatica
1	10	Veronica beccabunga
2		Veronica catenata
1	5.5	Veronica scutellata
1		Veronica sp. (undet.)
1		Viola palustris
32		Viola persicifolia
1		Unknown exotic

Floating-leaved plants		
1		Azolla filiculoides
2		Hydrocharis morsus-ranae
1		Hydrocotyle ranunculoides
2		Lemna gibba
1	9	Lemna minor
1		Lemna minuta
1	10	Lemna trisulca
4		Luronium natans
1		Nuphar advena
2	8.5	Nuphar lutea
4	7	Nuphar pumila
2*	6.7	Nymphaea alba
1		Nymphaea sp. (exotic)
4*		Nymphoides peltata
1	9	Persicaria amphibia
1	*LP*	Potamogeton natans
1	3.7	Potamogeton polygonifolius
2		Riccia fluitans
2		Ricciocarpus natans
2		Spirodela polyrhiza
4		Wolffia arrhiza

* = uncommon species often introduced to sites (see Preston *et al.* 2002 for details), if so score species as 1.

RS	TRS	Submerged plants
2	6.3	Apium inundatum
1		Aponogeton distachyos
1		Cabomba caroliniana
2		Callitriche brutia
1	6.3	Callitriche hamulata
2	8.5	Callitriche hermaphroditica
2		Callitriche obtusangula
2		Callitriche platycarpa
1	7.3	Callitriche stagnalis
4		Callitriche truncata
1		C. stagnalis/platycarpa agg.
1		C. hamulata/brutia agg.
1		Callitriche sp. (undet.)
2	10	Ceratophyllum demersum
2		Ceratophyllum submersum
2	7.3	Chara sp.
1		Egeria densa
4	7	Elatine hexandra
4		Elatine hydropiper
2		Eleogiton fluitans
1		Elodea callitrichoides
1	7.3	Elodea canadensis
1	10	Elodea nuttallii
8		Eriocaulon aquaticum
1	6.3	Fontinalis antipyretica
2		Groenlandia densa
2	7.7	Hippuris vulgaris
2		Hottonia palustris
4		Isoetes echinospora
2	5	Isoetes lacustris
1		Lagarosiphon major
2	6.7	Littorella uniflora
2	5	Lobelia dortmanna
8		Ludwigia palustris
1	6.7	Myriophyllum alterniflorum
1		Myriophyllum aquaticum
2	9	Myriophyllum spicatum
4		Myriophyllum verticillatum
4		Najas flexilis
2	6.7	Nitella sp.
2		Oenanthe fluviatilis
16		Potamogeton acutifolius
2	5.5	Potamogeton alpinus
2	7.3	Potamogeton berchtoldii
4		Potamogeton coloratus
4		Potamogeton compressus
1	10	Potamogeton crispus
16		Potamogeton epihydrus
4	10	Potamogeton filiformis
2	10	Potamogeton friesii
2	7	Potamogeton gramineus
2	10	Potamogeton lucens
8		Potamogeton nodosus
2	8	Potamogeton obtusifolius
1	10	Potamogeton pectinatus
2	7.3	Potamogeton perfoliatus
2	8.5	Potamogeton praelongus
2	9	Potamogeton pusillus
8		Potamogeton rutilus
4	10	Potamogeton trichoides
2	10	Ranunculus aquatilis
2	10	Ranunculus baudotii
2	10	Ranunculus circinatus
2		Ranunculus fluitans
2	7	Ranunculus peltatus
2	8.5	Ranunculus penicillatus
2	8.5	Ranunculus trichophyllus
16		Ranunculus tripartitus
1		Ranunculus sp. (undet.)
1		Sagittaria latifolia
1		Sagittaria sagittifolia
2		Sagittaria subulata
2	4	Sparganium angustifolium
1	10	Sparganium emersum
2		Sparganium natans
1	2.5	Sphagnum sp.
4*		Stratiotes aloides
2	4	Subularia aquatica
		Tolypella sp.
2		Utricularia australis
2	4	Utricularia intermedia
2	4	Utricularia minor
2	5	Utricularia vulgaris
1		Vallisneria spiralis
2	10	Zannichellia palustris

	Number of emergent & submerged species
	Number of uncommon species (with a rarity score of 2 or more)
	Trophic Ranking Score

LP = species exhibiting little nutrient preference

Canal PSYM Fieldsheet

Site and sample details

Site name ______________________ **Code no.** ________ **Grid ref.(______)** ______________

Recording format: (SU)3450 6780 *or* (41)3450 6780

Easting ______________________ **Northing** ______________________

Canal ______________________ **Location** ______________________

Survey date ____________ **Surveyors** ____________ **Which bank sampled** ____________

Environmental data

(a)(b) **Altitude (m):** [ ]

(a) **Turbidity (Secchi depth in cm):** [ ]

(a)(b) **% sand in substrate:** [ ]

(b) **Alkalinity (meq l^{-1}):** [ ]

(a)(b) **Boat traffic:**
(1000's of movements per year) [ ]

(a) required if edge samples only taken
(b) required for combined edge and bottom samples

Macroinvertebrate list

Group 1 taxa (BMWP:10)	ASPT	EPT	Cole.
Siphlonuridae			
Heptageniidae			
Leptophlebiidae			
Ephemerellidae			
Potamanthidae			
Ephemeridae			
Taeniopterygidae			
Leuctridae			
Capniidae			
Perlodidae			
Perlidae			
Chloroperlidae			
Aphelocheiridae			
Phryganeidae			
Molannidae			
Beraeidae			
Odontoceridae			
Leptoceridae			
Goeridae			
Lepidostomatidae			
Brachycentridae			
Sericostomatidae			
No. of taxa			

Group 2 taxa (BMWP:8)	ASPT	EPT	Cole.
Astacidae			
Lestidae			
Calopterygidae (Agriidae)			
Gomphidae			
Cordulegasteridae			
Aeshnidae			
Corduliidae			
Libellulidae			
Philopotamidae			
Psychomyiidae			
No. of taxa			

Group 3 taxa (BMWP:7)	ASPT	EPT	Cole.
Caenidae			
Nemouridae			
Rhyacophilidae (Glossomatidae)			
Polycentropodidae			
Limnephilidae			
No. of taxa			

Group 4 taxa (BMWP:6)	ASPT	EPT	Cole.
Neritidae			
Viviparidae			
Ancylidae (Acroloxidae)			
Hydroptilidae			
Unionidae			
Corophiidae			
Gammaridae (Crangonyctidae)			
Platycnemididae			
Coenagriidae			
No. of taxa			

Group 5 taxa (BMWP:5)	ASPT	EPT	Cole.
Planariidae (Dugesiidae)			
Dendrocoelidae			
Mesovelidae			
Hydrometridae			
Gerridae			
Nepidae			
Naucoridae			
Notonectidae			
Pleidae			
Corixidae			
Haliplidae			
Hygrobiidae			
Dytiscidae (Noteridae)			
Hydrophilidae			
Gyrinidae			
Dryopidae			
Elmidae			
Hydropsychidae			
Tipulidae			
Simuliidae			
No. of taxa			

Group 6 taxa (BMWP:4)	ASPT	EPT	Cole.
Baetidae			
Sialidae			
Piscicolidae			
No. of taxa			

Group 7 taxa (BMWP:3)	ASPT	EPT	Cole.
Valvatidae			
Hydrobiidae (Bithyniidae)			
Lymnaeidae			
Physidae			
Planorbidae			
Sphaeriidae			
Glossiphoniidae			
Hirudinidae			
Erpobdellidae			
Asellidae			
No. of taxa			

Group 8 taxa (BMWP:2)	ASPT	EPT	Cole.
Chironomidae			
No. of taxa			

Group 9 taxa (BMWP:1)	ASPT	EPT	Cole.
Oligochaeta			
No. of taxa			

	ASPT	EPT	Cole.
TOTAL NO. OF TAXA			
TOTAL BMWP SCORE			
ASPT			
NO. OF EPT TAXA			
NO. OF COLEOPT.			