METHOD FOR THE ASSESSMENT
OF RIVER WATER QUALITY
USING BENTHIC MACROINVERTEBRATES

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CONTENTS

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1. INTRODUCTION

A differential response of river fauna and flora to varying water quality has been recognised for many years (Kolkwitz and Marsson, 1909[4]). Since the early sixties this response has been utilised by authorities responsible for river management as a convenient way of assessment of water quality. The methods have been developed to produce a means of classifying rivers in terms of water quality. Since water quality is not an absolute concept, the use of biota for its assessment has been found to be considerably more effective if used in a comparative mode. Biological assessment is complementary to chemical monitoring and is a useful indicator of the effects of pollution control.

A select group of the river biota, the macroinvertebrates, has been found to be particularly suitable for this work. This group has become the most widely used section of the biota used for monitoring purposes. The advantage of these organisms is that they provide an integrated assessment of water quality and an audit of ecological quality.

2. DEFINITION

Macroinvertebrates are essentially a size-class of aquatic invertebrates comprising several phyla and orders within the animal kingdom. All are relatively sedentary in habit and live in close proximity to the river bed either amongst the river substrate or in association with attached benthic flora. The mesh aperture size of the sampling apparatus (the net) in some respects determines the size of organisms collected. (See 4.1 below)

3. PRINCIPLE

One of the factors affecting the presence of a species of macroinvertebrate in a river is the water quality. Changes in water quality affect the diversity of species and the number of individuals at any site on that river. Mild pollution exerts a differential effect on the members of a macroinvertebrate community. As pollution levels increase, species numbers decline and the resulting lack of competition can lead to proliferation of those pollution-tolerant species. Gross pollution, particularly toxic, usually results in a decline of all species.By analysing the numbers and types of animals at any particular place, a Biologist, through experience, can interpret the prevailing water quality conditions.

Many other factors influence the distribution of river fauna e.g. the geography and geology of the region, the physical nature of the site in terms of substrate, altitude, water velocity and shading. All these affect the presence of river fauna, either directly or indirectly, by affecting plant growth, water chemistry etc.

It is the task of the NRA Biologist to differentiate between water quality factors and other factors e.g. environmental and seasonal, influencing the fauna found at each location.

The method thus depends on obtaining a representative sample of the benthic macroinvertebrate community under study for comparison with

other stations or with an expected 'normal' community which could be predicted by the FBA river invertebrate prediction and classification system (RIVPACS).

In order to ensure comparability of results obtained from routine monitoring, the standard Anglian Water method described below must be used wherever possible. It should be recognised that the evaluation of environmental impact of discharges and abstractions, and the routine determination of change in quality in deep lowland rivers by this method may not be feasible or appropriate. In these cases an alternative method such as artificial substrate or naturalist dredge should be used.

4. EQUIPMENT

4.1 Sampling

A handnet consists of a handle and a frame holding a net in which the organisms are collected. Handles are usually made of metal or wood, the choice depending upon personal preference, and may have provision for extension in length. Frames, usually constructed in metal, have been made in various shapes, eg round, triangular, or essentially rectangular. Of these alternatives the essentially rectangular shape (see Fig 1) is preferred since the flat edge can be placed in close contact with the bed during use and the vertical sides permits a better cross-sectional area of water to enter the net than does a triangular shape. The frame should be large enough to allow a reasonable sample to be taken but not so large that the complete handnet offers too much resistance to the flow of water which could make sampling difficult in fast flows. Suitable rectangular handnets currently in use have evolved in the light of experience and have frame dimensions in the following ranges (eg Fig 1):

Width	(W)	200 - 250 mm
Height	(H)	190 - 220 mm
Shoulder	(S)	100 - 120 mm

The shape of the net is not particularly important from a sampling point of view.

The net material is normally sewn to strong canvas which is attached to an inner frame thereby reducing abrasion. Methods of joining the inner and main frames which facilitate replacement of the net in the field are clearly advantageous. Net material may be of either a monofilament weave or knitted but the latter, being stronger, is preferred. Synthetic fibre is preferable since it is stronger and less liable to decompose, but must be selected to ensure flexibility. The mesh size should be appropriate for the objective of the study; the maximum recommended aperture sizes are given in table 1.

Table 1 : Recommended handnet mesh sizes

Survey Objective	Mesh Threads per cm	Maximum Aperture Size	Recommended Minimum Depth	Comments
General/Routine Biological Surveillance: Data for surveys using BMWP/LQI	8	950um	400 mm	May not capture first instar stages of some insects
For Routine Surveillance with more complete records	12	610um	450 mm	More likely to capture first instar stages
For special surveys requiring data in complete detail	24	265um	550 mm	Ensures capture of first instar stages and very small organisms which may prove of value in water quality determination.

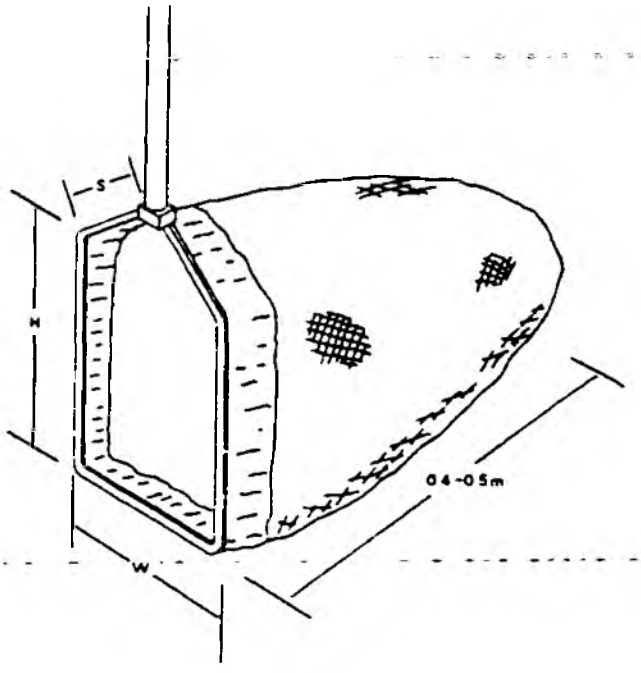

Figure 1 Basic handnet

In choosing an appropriate net two interrelated factors have to be considered;
(a) The dimensions and shape of the net;
(b) the mesh size of the net material.

Finer mesh sizes increase the risk of clogging with organisms and debris which reduces net efficiency by increasing the tendency of water and organisms to flow around rather than into the net. This effect can be minimised by increasing the depth of the net. On the other hand, an unnecessarily deep net can be inconvenient in use. An appropriate guide to the depth of a net best suited to mesh size is in Table 1.

Other equipment: Trays (approx. size 40x70cm), Forceps, Buckets, Hand lens, Specimen containers, Plastic bags, Waterproof marker pens, Labels.

4.2 Identification - Laboratory

Identification of the macroinvertebrates to a consistent level of accuracy is important and is a function of the quality of the magnifying instrument. Consequently a good stereomicroscope with up to 50x magnification and with supplementary directional cold light source is necessary.

A good quality compound microscope is also required.

4.3 Specimen Handling

The use of featherlight forceps minimises damage to specimens. Screw capped plastic containers of 15-50ml capacity should be used for specimen retention.

5. REAGENTS

70% Industrial Methylated Spirits (IMS) for the preservation of biological samples on site: (1:20 glycerol added minimises brittling of certain specimens). Preservation can lead to gross anatomical changes in soft bodied species, making identification difficult if not impossible. Preservation, therefore, should be avoided where identification is crucial.

6. SAMPLING AREA

The overall size of the area sampled will vary in accordance with the morphology of the watercourse. It is neither practical or necessary to define a set area for all sites due to the large range of site width but it is necessary to limit the length of watercourse sampled at a site in order to ensure compatibility in terms of total sampling effort. The sampling length should not exceed 25m either side of the selected sampling point, defined by a single grid reference. If sufficient habitats can be found which characterise the watercourse from shorter lengths than 50m and sufficient material can be collected, then a reduced sampling length would be acceptable. In exceptional circumstances where very few habitats are available which are widely spaced along the bank of a fenland drain, splitting the site into two or more sub sections may be required, but the total length of the site should still remain within the maximum of 50m.

In order to ensure continuity between samples taken at a site and between successive operators the sampling area should be clearly defined, preferably by a sketch map.

7. SAMPLING METHOD

7.1 Sample Collection

NOTE: This is the stage at which the largest error in the determination is likely to occur. The consistency of the technique used is therefore of paramount importance.

The kick, sweep and search elements should be used to collect sufficient material from the site, within a timed maximum sampling effort, to obtain a representative sample of macroinvertebrates. The basic principle of obtaining maximum faunal diversity from the site is the underlying feature of the method.

Full taxonomic characterisation of a site can be achieved in a relatively short time. Increased sampling time results in collection of additional taxa, the rate of accumulation of taxa decreasing with increasing sampling effort.

Factors which may influence the procedure adopted in given circumstances include:

a) The sampling objective - a comprehensive species list for the site, and the relative abundance of taxa within the selected biotope.

b) The characteristics of the site - including depth of water, current velocity, type and stability of the bed, and the amount of vegetation present.

When it is intended to collect as many species as possible a sample should be taken by a combination of the methods described below. (Sections 7.2, 7.3 and 7.4). It is customary to explore thoroughly all the types of substratum by this combination of methods, including sweeps through patches of weed and between the roots of overhanging trees.

Except in deep or static water or when sweeping the net through weeds or in the surface of mud or silt deposits, a handnet should be placed on the bed and the sampling carried out in such a way that the animals drift into it. In order to avoid excessive wear and tear on the net it should not be used like a shovel, unless absolutely necessary.

7.2 Hand-sampling in flowing shallow water

Hold the straight lower edge of the handnet against the stream bed and, by hand, turn over the stones immediately upstream of the net in the flowing water. Examine the stones and remove any attached or clinging species and add these to the sample. The finer, lower deposits should also be disturbed to dislodge further attached organisms. Repeat this procedure at several places across the river in order to include different microhabitats within the riffles.

7.3 Foot-sampling in polluted or deeper water

Where there may be a risk of pollutants affecting the hands, or where the fauna is suspected of being sparse or where the water is too deep for hand sampling, foot sampling may be used. Hold the net vertically on the river bed downstream of the foot, and with the toe or heel of the boot disturb the substratum to release material which will be caught in the net. Different habitats should be sampled by working across the river.

This method is somewhat selective in that fewer of the attached animals will be taken. Where practicable therefore some stones should be lifted and examined for such animals. These should then be added to the contents of the net and transferred to a container using the procedure described.

7.4 Sampling in slow-flowing and static water

In slow-flowing or static water the handnet may not be the most appropriate method for sampling. Consideration should be given to the use of grabs, dredges, corers, air-lift samplers or artificial substrates (HMSO 1980[1], 1983[2], 1983[3]).

Some habitats, at static sites, may be sampled by the hand-picking method (8.2) although the efficiency of collection may be lower. The best procedure is to remove stones carefully, agitate them vigorously in the net, and finally pick off by hand any animals which remain attached.

When sampling other slow-flowing or static water habitats the reduction or absence of water movement necessitates a different procedure from that used in flowing water where the current is employed to assist in sweeping dislodged animals into the net. In static water the relative motion between the fauna and the net must be supplied by the operator. The substratum may be disturbed with the feet and the dislodged fauna caught by repeated sweeps of the net through the water immediately above the disturbed area. In deeper static water where the substratum consists of weed or silt, the handnet may be carefully drawn or pushed through the surface layer of the substratum.

7.5 Sampling effort

Although constraints on sampling are imposed by limiting the length of watercourse sampled at a site, standardisation of sampling effort at a site is also necessary. This can be achieved by limiting the total sampling effort to a maximum of 10 minutes this is to include total time spent in the river, collecting material and characterising the site. In some cases sampling all habitats may be achieved in less time (National guidelines state "that the total amount of time spent actually taking the sample should be 3 minutes with 1 minute searching", this excludes moving about the river).

Allowance has to be made for different site conditions in determining the amount of material collected but it should generally be confined to 3 trays. Long periods of foot-sampling in a river with a rich benthic fauna can result in excessive catches to process, and if carried out frequently at the same sampling station the community may be adversely affected.

8. SAMPLE ANALYSIS

8.1 Sorting

a) Field sorting

The sample is emptied from the net into a white (or light coloured) bottomed plastic tray, animals clinging to the net need to be removed by hand. The taxa present and their relative abundance are recorded. A period of up to 45 minutes is taken for this stage. Results from previous samples may be taken into the field, but it is recommended that the sample should be analysed prior to any reference being made to past results. Unless there is a significant change in results samplers should avoid returning to the river to look for additional taxa. If necessary a duplicate sample should be taken.

Benthic macroinvertebrate specimens which cannot be identified with certainty, should be removed (using featherlight forceps) to separate leakproof containers without preservative but protected from heat, for identification back at the laboratory. Preservative (70% IMS) can be added if a considerable delay before examination is expected. Since biological samples are easily damaged, care must be exercised in their transportation and general treatment after collection and before sorting.

b) Laboratory sorting

Sorting in the laboratory should be carried out in the manner as described above for field sorting. Samples being transferred to the laboratory in buckets and examined as soon as possible, preferably whilst material is still alive.

8.2 Identification

The degree of identification of routine samples for calculation of Biological Monitoring Working Party (B.M.W.P.) scores and Lincoln Quality Indices (L.Q.I.) is to family level only. However, interpretation of the significance of change in B.M.W.P. scores and L.Q.I.'s is greatly enhanced by identification to species or generic level where this is possible without extensive examination of individuals present.

The majority of families, genera and species used for routine surveillance can be identified to a sufficient level of taxonomic depth in the field. However where any doubt arises or where necessary in order to make a proper interpretation of biological quality, individual specimens should be returned to the laboratory and examined microscopically.

It is prohibitive in time (and in some cases still impossible) to identify each individual organism to species level. A consistent (and thus comparable) level of identification is therefore carried out on each sample using the standard keys and textbooks for each taxonomic group. A list of these is given in Appendix 1.

Table 2 - Identification Level for Macroinvertebrate Fauna Groups
(required for routine monitoring)

Porifera	family
Platyhelminthes, Tricladida	species
Nemertini	genus
Nematomorpha	phylum
Rotifera	genus
Nematoda	phylum
Gastrotricha	phylum
Polyzoa	phylum
Mollusca, Gastropoda	species
Bivalvia	genus (pisidium)/species
Annelida, Polychaeta	species
Oligochaeta	family
Hirudinea	species
Arthropoda, Hydracarina	class
Aranea	species
Crustacea, Cladocera	order
Copepoda	subclass
Branchiura	genus
Malacostraca	species
Others	genus
Insecta, Collembola	class
Ephemeroptera	species
Plecoptera	species
Odonata	species
Hemiptera	genus/species
Hymenoptera	order
Coleoptera	family/genus except Hygrobiidae - species, Elminthidae - species, Dytiscidae - genus/species
Megaloptera	species
Neuroptera	species except Sisyridae - genus
Trichoptera	species
Lepidoptera	family
Diptera	Chironomidae - family/subfamily
Others	family/genus

Interpretation of the results will also be aided by estimating the relative abundance of taxonomic groups found.

The abundance values have been set on the following 1-5 scale:-

Table 3

Scale	Abundance
1	1
2	2 - 10
3	11 - 100
4	101 - 1000
5	>1000

9. EXPRESSION OF RESULTS

The outcome of the analytical procedure is a list of macroinvertebrates and their respective abundances for each sample taken.

The list of generic names has clear water quality significance to the hydrobiologist but to convey this information to others, conversion of this raw data to a more manageable form is necessary. To reduce lengthy descriptions of the water quality indicated by such an assemblage of animals the practice has been to summarise the data in the form of various biotic indices.

9.1 BMWP Score

The nationally recognised system for the assessment of biological quality or rivers is the BMWP score (Biological Monitoring Working Party report to DOE/NWC 1978[6]). Although values were revised in 1979 after further testing, the same principles are involved:-

a) all taxonomic families present at a site are listed
b) each family is given a score value (as indicated in Table 5)
c) by adding the scores for all families present, a total cumulative score is given.

For ease of interpretation, the BMWP cumulative total scores may be banded to distinguish broad categories of water quality as shown in Table 4.

Table 4 - Water Quality Banding of BMWP Scores

Description	Score Band
Poor	< 25
Moderate	26 - 50
Good	51 - 100
Very Good	101 - 150
Exceptional	> 150

Table 5 The BMWP Score System

Families	Score
Siphlonuridae Heptageniidae Leptophlebidae Ephemerellidae Potamanthidae Ephemeridae Taeniopterygidae Leuctridae Capniidae Perlodidae Perlidae Chloroperlidae Aphelocheiridae	10
Phryganeidae Molannidae Beraeidae Odontoceridae Leptoceridae Goeridae Lepidostomatidae Brachycentridae Sericostomatidae	
Astacidae Lestidae Calopterygidae Gomphidae Cordulegasteridae Aeshnidae Corduliidae Libellulidae	8
Psychomyiidae (+Ecnomidae) Philopotamidae	
Caenidae Nemouridae	7
Rhyacophilidae (+Glossosomatidae) Polycentropodidae Limnephilidae	
Neritidae Viviparidae Ancylidae (+Acroloxidae) Hydroptilidae Unionidae	6
Corophiidae Gammaridae Platycnemididae Coenagriidae	
Mesoveliidae Hydrometridae Gerridae Nepidae Naucoridae Notonectidae Pleidae Corixidae Haliplidae Hygrobiidae Dytiscidae Gyrinidae Hydrophilidae Scirtidae Dryopidae	5
Elmididae Chrysomelidae Curculionidae Hydropsychidae Tipulidae Simuliidae Planariidae (+Dugesiidae) Dendrocoelidae	
Baetidae Sialidae	4
Piscicolidae	
Valvatidae Hydrobiidae (+Bithyniidae) Lymnaeidae Physidae Planorbidae	
Sphaeriidae Glossiphoniidae Hirudidae Erpobdellidae	3
Asellidae	
Chironomidae	2
Oligochaeta (whole class)	1

Notes from table 5

1. Clamibidae has now been removed from the list.

2.a Helodidae has been renamed Scirtidae.
  b Elminthidae are now Elmididae.
  c Agriidae are now Calopterygidae.

3.a Bithyniidae are now separated in the National code list as a distinct family but they are still scored with Hydrobiidae.
  b Similarly Glossosomatidae should be scored with Rhyacophilidae.
  c Ecnomidae should be scored with Psychomyiidae.
  d Acroloxidae should be scored with Ancylidae.
  e Dugesiidae should be scored with Planariidae.

9.2 Average Score Per Taxon

The ASPT is obtained by dividing the BMWP score by the number of taxa used to calculate the score.

9.3 Lincoln Quality Index

9.3.1 Calculation of the LQI

The Lincoln Quality Index was developed in Lincoln Division and, following Regional consultation which resulted in some minor modification, has been adopted Regionally for assessing compliance with River Quality Objectives. The system was designed as an extension of the Biological Monitoring Working Party (BMWP) score system in order to target biological quality at different river uses.
The BMWP score alone is insufficient due to variability of the of the scores in relation to habitat diversity. By using a combination of BMWP score and the Average Score Per Taxon the influence of habitat diversity is reduced. It was found by experience that for small stream riffles with low habitat diversity an adjustment to the score levels was still found to be necessary to obtain comparable results. For this reason a judgement on whether or not the riffle at a small stream site is "habitat rich" or "habitat poor" is required. Normally this judgement is only made once and should not be changed unless a significant change in the habitat availability occurs due to river maintenance or flow alteration.

After the samples have been analysed and the BMWP Score and ASPT calculated, the LQI is assessed using the following tables.
The BMWP score is used to obtain rating X from tables 6 or 8 and the ASPT is used to obtain rating Y from tables 7 or 9.

Table 6 Standard BMWP Ratings for Habitat Rich Riffles

BMWP Score	Rating X
151+	7
121 - 150	6
91 - 120	5
61 - 90	4
31 - 60	3
15 - 30	2
0 - 14	1

Table 7 Standard ASPT Ratings for Habitat Rich Riffles

ASPT	Rating Y
6.0+	7
5.5 - 5.9	6
5.1 - 5.4	5
4.6 - 5.0	4
3.6 - 4.5	3
2.6 - 3.5	2
0.0 - 2.5	1

Table 8 Enhanced BMWP Ratings for Habitat Poor Riffles and Pools

BMWP Score	Rating X
121+	7
101 - 120	6
81 - 100	5
51 - 80	4
25 - 50	3
10 - 24	2
0 - 9	1

Table 9 Enhanced ASPT Ratings for Habitat Poor Riffles and Pools

ASPT	Rating Y
5.0+	7
4.5 - 4.9	6
4.1 - 4.4	5
3.6 - 4.0	4
3.1 - 3.5	3
2.1 - 3.0	2
0.0 - 2.0	1

The overall quality rating is obtained from the formula

$$\text{Overall Quality Rating} = \frac{X + Y}{2}$$

The ratings given in tables 6-9 have been designed to attenuate high ASPT and BMWP scores when they occur. Where a low BMWP score is associated with a high ASPT, or vice versa, the weighting given to the superior value will automatically increase the LQI.
Lincoln Quality Indices are obtained from table 10 and final values range from A (Excellent) to I (Very Poor).

Table 10 Overall Quality Ratings, Equivalent Lincoln Quality Index Values and Interpretation of results.

Quality Rating	Index	Interpretation
6 or better	A++	Excellent Quality
5.5	A+	" "
5.0	A	" "
4.5	B	Good Quality
4.0	C	" "
3.5	D	Moderate Quality
3.0	E	" "
2.5	F	Poor Quality
2.0	G	" "
1.5	H	Very Poor Quality
1.0	I	" " "

Using this system sites which support a very good fauna are classified as A (Excellent). Within this category it is also possible, however to distinguish sites of exceptional biological quality, and these would rate as A+ or A++. The common designation of A is used in these three cases for two reasons.
1. The status of ordinary A rated sites should not be diminished and:
2. From a management point of view, there is little practical benefit in distinguishing degrees of excellence.

9.3.2 Guidelines on the Classification of Habitat Types

Calculation of the Lincoln Quality Index requires classification of sites into those necessitating the use of "enhanced" or "standard" scales of BMWP scores and ASPT.
It is essential that habitats are defined consistently throughout the region and it is proposed that this can be accomplished by following the guidelines given in the original LQI paper published in 1987 (Extence et al 1987[10]). The principal difference between running water sites in the Anglian region is that they are either slow flowing over a mud/silt bed (pools) or faster flowing over a stony/gravel bed (riffles). Each of these habitat types will, in the absence of pollution, support a characteristic and quite different fauna although some cosmopolitan families will occur at both types of site.

Pools will tend to be dominated by lower scoring BMWP types such as water bugs, water beetles and snails, while riffles will tend to be dominated by higher scoring BMWP taxa such as mayflies, caddisflies and stoneflies. High scoring families can of course occur at slow flowing sites (eg Phryganeidae and Molannidae) but riffles undoubtedly have the potential to support a far greater diversity of pollution sensitive types. This dichotomy can be attributed to a number of factors including higher dissolved oxygen levels and more varied water depths and substrate types in a riffle. In pools habitat naturally tends to be less diverse, in that both flows and substrate are much more uniform.

In view of these factors enhanced LQI scales should always be used on deep slow flowing sites with a mud/silt bed irrespective of considerations such as development and diversity of macrophyte growth at the time of sampling.

Simply designating sites as habitat rich or poor is wholly unsatisfactory, since the paramount and fundamental difference between fast and slow flowing communities is ignored and other difficulties are created, for example there is a danger of a slow flowing site being defined as habitat rich in the summer and habitat poor in the winter. Experience has shown that the LQI method is robust enough to produce similar scores at virtually all sites throughout the year, provided the habitat is consistently defined.

Although in 99% of cases the distinction between riffles and pools is easy to make, it should be noted that riffles themselves can be highly variable. A stream may, for example be very narrow with no appreciable difference in current velocity, depth or substrate. Alternatively a wide riffly river will have a range of physical characteristics. It was therefore originally recommended that for riffles were factors

other than water quality are thought to be limiting the development of the invertebrate community then enhanced, ie pool scales, should be used.

Some general guidelines on defining habitat rich and habitat poor riffles can be offered:

1) Riffles in wider stretches of river will normally be habitat rich, particularly if alternating fast and slow sections are present and/or if slack areas of flow exist in marginal areas. Standard LQI scales should be used in these cases.

2) Narrow uniform riffles up to 2m wide will normally be habitat poor and enhanced scales should be used.

3) Important factors which may operate to restrict invertebrate development at a riffle site regardless of stream size include heavy shading and intermittent flows. These factors acting alone or in combination may result in a reasonably varied riffle site being reclassified as habitat poor, in which case enhanced scales should be used.

Many riffles in main rivers are of course habitat rich but with biologists being required to sample more comprehensively in future, a number of minor fast flowing streams which support much more restricted communities will be surveyed. It is important that the quality in these waters is not underestimated by using standard scales when enhanced scales are required.

Summary

1 Sites should initially be split into riffles and pools, enhanced scales must be used for the latter category.

2 Riffles may be habitat rich or habitat poor. In general riffles up to 2m wide will be habitat poor and enhanced LQI scales should be used. Wider more varied riffles will usually be habitat rich and standard LQI scales apply.

3 Factors such as shading may be important in restricting invertebrate populations at certain fast flowing sites (irrespective of their width) and it may be more appropriate to use enhanced LQI scales in these cases.

4 Once sites have been classified into habitat types, they should not be reassigned unless major environmental changes occur.

5 It is hoped to formally define habitat rich and habitat poor riffles in the future. However even without a formal definition of habitat poor and rich riffles, the the method still works well since few sites cause real problems and the LQI technique is remarkably robust.

9.3.3. LQI and RQO Classification

Of great importance is the association between LQI values and NWC class or river use (River Quality Objectives or RQOs). In recognising that discharge quality conditions (consent conditions), should be related to the needs of the river, RQOs have been specified for principal waters in the Anglian region, (Anglian Water Authority 1982[12]) RQOs form the basis of Anglian Water's programme of river quality management, and categories include; salmonid and cyprinid fisheries; potable water supply direct to treatment and via impoundment; and high, moderate and low amenity. Table 11 shows the minimum LQI required from routine biological samples to meet the target associated with various uses. High targets are set for uses such as FI fishery, and when a stretch of river has more than one RQO, the most stringent LQI is used as the objective.

Table 11 LQI targets for River Quality Objectives.

River Quality Objective	Minimum LQI Required
	A
F1	B
PWS (D), HA	C
PWS (I), F2	D
MA	E
	F
LA	G
	H
	I

key to ROOs

F1	-	Salmonid Fishery
F2	-	Cyprinid Fishery
PWS (D)	-	Potable Water Supply direct to Treatment
PWS (I)	-	" " " via Impoundment
HA	-	High Amenity
MA	-	Moderate Amenity
LA	-	Low Amenity

The suggested relationship between NWC class and LQI is shown in table 12.

Table 12 LQI targets for NWC classes

NWC Class	Minimum LQI Required
1A	A+
1B	B
2	D
3	F
4	G

Chemical criteria, particularly dissolved oxygen, biochemical oxygen demand (BOD), and ammoniacal nitrogen concentrations are used to define NWC class (National Water Council 1981[11]). High levels of oxygen and low levels of BOD and ammoniacal nitrogen are required for class 1A waters. Increasingly less stringent criteria are used to

define classes 1B, 2, 3 and 4. Class X waters comprise insignificant watercourses and ditches where the objective is simply to prevent nuisance developing.

Compliance with NWC targets can easily be checked in the field, or in the laboratory, using the LQI method.

The relationship between RQOs, the NWC classification and associated LQI values, has been derived from historical data on river stretches which have been monitored both chemically and biologically.

10. SAFETY

10.1 Introduction

All work in freshwater should be regarded as potentially hazardous, because of currents, submerged objects and slippery or muddy beds. No routine macroinvertebrate sampling should be carried out at night,during floods or in adverse weather conditions. If you have doubts about your personal safety at the site for any reason,leave.

10.2 Clothing

All clothing should be suitable for the job and for the worst potential weather; extra clothes should be carried when cold or wet. A pair of diving or domestic rubber gloves will reduce the risk of infection from cuts and abrasions, and can prevent excessive heat-loss from the hands in cold conditions.

Under normal conditions thigh waders or rubber boots should be worn; chest waders should be used only in exceptional circumstances, and never when working alone. All footwear must have adequate tread.

10.3 Equipment

When following an unfamiliar river course for more than a few hundred metres, a map should be carried.

When away from base, each person must have access to a first aid kit (normally kept in the vehicle).

If the excursion is likely to continue towards darkness, a torch and spare batteries must be carried.

Each person should carry adequate food and drink for the duration of the excursion.

All staff must wear life jackets when sampling or working on or near watercourses. The crewsaver 'crewfit' lifejacket is recommended as the most suitable.

10.4 Procedure

It is recommended that a procedure be adopted for recording the time that the Biologist(s) leave for and are expected to return from fieldwork, a list of the sites to be visited should also be left. If the staff have not returned within two hours of the stated time then action should be taken to ascertain there whereabouts.

For staff working regularly in freshwater, Leptospirosis card should be issued and a valid anti-tetanus vaccination is recommended. In addition, fresh waters may be a source of pollution, both biological and chemical, and contain pathogenic bacteria, so any cut or wound must be adequately treated with antiseptic as quickly as possible. Carcasses of drowned animals should not be handled.

If an area of freshwater in a site is fenced off, do not enter it without first obtaining permission or ascertaining the reason.

When working on rivers, always take note of the current and act accordingly, also bear in mind that the stillest waters are often the deepest and have the softest substrate. When climbing in or out choose a shelving area if possible, but if a steep bank has to be used take extreme care. Wading in rivers is potentially hazardous, because of currents and the uncertain nature of the substrate. Extreme care should be taken when placing the feet: always expect pot-holes and underwater obstacles, and tread with these hazards in mind, a handnet is often useful for testing the depth of water or the stability of a muddy river bed.

When working in lakes, though the currents may not be so hazardous, there may by pot-holes and underwater obstacles, so the feet should be placed carefully as in rivers. In addition, particular care should be taken in reed-beds and swamps.

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APPENDIX 1

LIST OF MAJOR REFERENCES USED FOR IDENTIFICATION OF AQUATIC MACROINVERTEBRATES

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