Using Diatoms and Macrophytes to Assess the Trophic Status of Rivers

A report of a workshop held at Lancaster, 7-8 March 1996

NERC Institute of Freshwater Ecology
IACR Centre for Aquatic Plant Management

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Statement of Use
This report is the second output from Project 694, IFE Document Reference number RL/T4073Q7/3. It summarises the findings of a workshop to discuss the applicability of the Mean Trophic Rank System and the Trophic Diatom Index to assessment of the trophic status of rivers. It is to be used for information as to the findings and recommendations of the workshop. A resumé is produced as R&D Progress report Ei/694/01.

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CONTENTS

EXECUTIVE SUMMARY

1 This report summarises the main conclusions of a workshop held at Lancaster on 7-8 March 1996 to discuss the application of the biological methods, namely the Trophic Diatom Index and the Mean Trophic Rank system, to monitor eutrophication under the direction of the EU Urban Waste Water Treatment Directive.

2 The objectives of the workshop were to exchange experiences and ideas on the two methods; to discern the usefulness of the methods for both the UWWTD and other applications; to digest the most recent findings from the two projects and; to feed recommendations into R&D Projects 618 and 694 and into the management of trophic status monitoring programmes within the Environment Agency.

3 Particular attention was focussed on the experiences of practitioners of the two methods over the last two years. The workshop used these experiences to set recommendations for method development and further R&D requirements.

4 The working definition of eutrophication used within the Environment Agency should be clarified and standardised. It should be expressed in terms which are measurable and achievable. Improvements could be measured against the criteria set out in the definition. A clear statement of what is included in the definition (water column, sediment, holistic picture of river system) should be made.

5 Both the TDI and MTR are capable of detecting differences in the trophic status downstream of qualifying STW discharges, although the sensitivity of the methods may be dependent upon the level of nutrient enrichment upstream of the discharge. The importance of complicating factors such as direct organic pollution is separable with the TDI but not at present with the MTR and should be investigated in the latter. In addition, it is recommended that the introduction of a system of weighted averages into the MTR system be investigated. Weighted averages would take account of regionally rare species and species with a known defined tolerance of organic pollution This should allow a more comprehensive environmental appraisal to be made.

6 It was recognised that the TDI and the MTR have much wider applications than monitoring eutrophication for the purposes of the UWWTD. Macrophyte based surveys, incorporating the MTR method, are used successfully by English Nature and the Industrial Research and Technology Unit (Northern Ireland) for typing riverine SSSIs, tracking non-point source pollution and measuring improvements in the aquatic habitat.

7 The importance of Quality Assurance as an integral part of both methods was emphasised. It is important that data derived from these methods should be right and robust. Suggestions for inclusion in the training element of a Quality Assurance programme were made.

8 It was emphasised that results should be presented in a clear, easily understandable format. Both the TDI and the MTR should operate on the same scale and in the same

direction. Actual scores and change in scores will be used for the purposes of the UWWTD. For other purposes, such as large scale national maps of eutrophication, a banding system will be developed.

9 Areas where the MTR method requires further testing were identified. Those not already included in the programme of R&D Project 694 were to be fed into the Project. Improvements to the method were identified and recommendations made for their implementation.

10 Minor revisions to, and clarifications of, the way MTR data are collected and recorded are necessary. This will be achieved by amendment of the standard methodology produced by the NRA for UWWTD macrophyte surveys.

11 Further trialing of both the TDI and MTR is necessary in all Environment Agency Regions, to establish the relationship between the two methods.

12 A set of detailed recommendations are presented in section 6 of this report, these feeding into R&D Project 694, the Agency's UWWTD monitoring programme and other research. Detailed recommendations concerning Project 618 are included in the output from that project (R&D Technical Reports E2 & E3).

13 Priorities for R&D are detailed in sections 6.9 to 6.11. These relate mainly to the use of artificial substrates for the TDI method, the establishment of levels of confidence in the MTR method and further underpinning research required.

1. INTRODUCTION AND BACKGROUND

1.1 National Rivers Authority

This report relates to a workshop held by the National Rivers Authority (NRA), a predecessor organisation to the Environment Agency, the latter being formed on 1 April 1996. The NRA R&D and operational programmes referred to in the text transferred to the Agency on vesting day.

1.2 The Workshop

This workshop was held in Lancaster, 7-8 March 1996, as part of two NRA R&D projects evaluating biological methods of assessing trophic status in rivers. The purpose of the first project (Number 618) was to test the diatom-based Trophic Diatom Index (TDI), developed by Kelly and Whitton, in several NRA Regions. This project was being led by A Lewis of Northumbria and Yorkshire Region, undertaken by Kelly (Bowburn Consultancy), and was completed in June 1996. The purpose of the second project (Number 694) is to evaluate the macrophyte-based Mean Trophic Rank (MTR), developed by Holmes (Alconbury Environmental Consultants) and to compare this with other biological methods, principally the TDI. This project is being led by KJ Rouen of North West Region, undertaken by the Institute of Freshwater Ecology and the Centre for Aquatic Plant Management, and is due to complete in 1997. This report is produced as part of the latter project. The programme of the Workshop is given in Appendix 4. This was organised to allow both formal presentations, group feedback and more general discussion.

The objectives of the workshop were several-fold:

1. To exchange experiences and ideas relating to the TDI and MTR systems, as far as their practicality and interpretation are concerned.

2. To discern the usefulness of the methods as far as the Urban Waste Water Treatment Directive (UWWTD) is concerned, and also other applications for other purposes.

3. To digest the most recent findings from the two projects.

4. To feed recommendations both into the R&D programme (including the two above projects) and into the management of trophic status monitoring programmes within the Environment Agency.

Participants at the workshop represented all NRA Regions, and included both practitioners of the two methods under discussion and staff with responsibility for management decisions regarding the results of the methods. The major exponents of the two methods were present, Martyn Kelly and Nigel Holmes, together with representatives from interested outside organisations and the Research Contractors for the two projects. A list of participants is given as Appendix 3.

2. THE NEED

Both the Environment Agency (NRA) and English Nature have business needs to assess the trophic status of rivers. These needs include areas of overlapping interest between the two organisations.

2.1 NRA / Environment Agency: Urban Waste Water Treatment Directive

Simon Leaf (EU Directives Officer, NRA Head Office) summarised the Authority's prime business need for developing methods to assess trophic status of rivers: the requirements of the Urban Waste Water Treatment Directive (UWWTD). Under this Directive, the Government has the following principal obligations: to provide collection systems for urban waste water; to provide sewage treatment facilities; to monitor effluents and receiving waters, to control trade effluents to foul sewer; to lay down requirements for certain (organic) trade discharges to surface waters; and to cease disposal of sewage sludge to sea. The obligation to provide sewage treatment facilities includes minimum levels of treatment and minimum effluent standards, and is dependent on the size of the discharge, the type of the receiving water (inland, estuary *etc*) and the sensitivity of the receiving water.

To comply with these requirements, 'Sensitive Areas (Eutrophic)' — abbreviated to SA(E)s) — are identified, these being those water bodies which are eutrophic, or which in the near future may become eutrophic if protective action is not taken. The definition of 'Eutrophication' according to the UWWTD is as follows:

> "Enrichment of water by nutrients, especially compounds of N and/or P, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned."

The Directive required these SA(E)s to be identified by 31/12/93, using the criteria listed in Annex II of the Directive.

Once identified, a decision must be reached as to whether, and which, nutrients should be removed from discharges into the SA(E). The size of discharges and type of receiving water are taken into account. In the case of most rivers, nutrient removal would usually be of P. However, only discharges for more than 10,000 p.e. qualify under the Directive. These 'qualifying discharges' (QDs) may discharge either directly into SAs or into the relevant catchment areas of SA(E)s, contributing to the pollution/eutrophication of these areas.

Once designated, the discharge requirements can be set for QDs in terms of P levels or a % reduction in P. However, no action is taken if it can be demonstrated that P-removal will have no effect upon the level of eutrophication.

A Government consultative paper was published in March 1992 (DoE *et al*, 1992), proposing criteria for identifying SA(E)s and subsequent procedures. This guidance was finalised in Annex

B of the paper published in March 1993 (DoE *et al*, 1993) on methodology for identifying SA(E)s. For riverine environments, the criteria relate to orthophosphate, chlorophyll *a*, algal biomass, water retention time (phytoplankton doubling time), dissolved oxygen, fauna (fish/invertebrates), macroflora and microflora.

Under the Government methodology as laid down in the March 1993 consultative paper, waters were only identified if affected by QDs. For rivers, the upstream limit of a SA(E) is either a QD or the point at which the symptoms of eutrophication become manifest. The downstream limit is where the effects are reduced to 'typical'.

In England and Wales, for the first round of designations in 1993, 62 candidates were submitted by the NRA to DoE. Of these, 20 were subsequently withdrawn by the NRA, and a further 9 were subsequently rejected by the DoE due to insufficient evidence. 33 SA(E)s were formally identified by the Government in May 1994. 41 qualifying STWs must have P removal by 31/12/98.

Future reviews will take place at least every 4 years, with a coordinated Environment Agency national monitoring strategy. 220 waters are being assessed in the period 1994 - 1996, this including the 33 already identified and including 370 qualifying STWs (the majority of which discharge to rivers). This monitoring will determine future candidates for P-stripping and monitor the effects of P removal at sites where P-reduction has been installed early.

Other ongoing and future work of relevance for rivers, includes:

1. DoE/IFE project - assessing the potential for P-reduction in river waters.

2. Environment Agency/WRc project - guidance for assessing and controlling non-point sources of P in rivers.

3. SNIFFER project - river eutrophication risk modelling; a GIS approach.

4. Regional Environment Agency investigational studies.

5. National Eutrophication Control Strategy (Toxic and Persistent Substances (TAPS) Centre, based in Environment Agency Anglian Region).

The UWWTD relates to only part of the eutrophication problem, moderate/small sized sewage discharges, P-discharges such as from fish farms, and diffuse sources being outside the scope of the Directive. The Eutrophication Control Strategy being developed by the Environment Agency TAPS Centre should help address some of these problems.

2.2 English Nature: Riverine SSSIs, SACs and Eutrophication from non-UWWTD qualifying sources.

Mary Gibson outlined English Nature's (EN) need for monitoring macrophytes and trophic status in rivers. EN are in the process of designating 27 river SSSIs on account of their macrophyte interest, and also advises the Government on the designation of Special Areas of Conservation (SACs) under the Species and Habitats Directive. Designation helps protection thereafter. However, it is important to understand the influences on the macrophyte communities at these sites, in order that appropriate standards can be set, and a framework for a monitoring programme can be put in place to determine whether the conservation (macrophyte) interest is being maintained over time.

EN have concerns relating to those situations of eutrophication not covered by the UWWTD, indeed they are concerned that the UWWTD is focusing attention away from the problems of eutrophication in general, to the inputs of the large sewage works only. Although P levels in rivers have been shown to be increasing over time. Much of this loading due to sewage discharges, many sewage discharges do not qualify under the UWWTD. If a series of moderate, say 3000 to 4000 p.e., discharges input into a river, then these are not catered for within the terms of the UWWTD, but can have a marked impact on the P loading of the receiving watercourse. This is of obvious concern, particularly if the receiving watercourse is designated as a SSSI or SAC. N.B. Results from the 1995 NRA survey suggest that average P concentrations have been declining in rivers in most Regions since 1990, but levels now are still higher than has been the case historically.

Some chemical standards have been devised by EN which may be used within the Special Ecosystem Class of the Statutory Water Quality Objectives. However, the approach to date has been pragmatic from necessity. It would be useful to be able to determine more precisely how the increase in P loading is affecting whole communities or individual species, also whether indicator species or critical changes can be identified. EN have tried using the MTR on smaller rivers, impacted by discharges from small-moderate sized sewage works, this being described below (4.4.1)

3 TROPHIC DIATOM INDEX

The final outputs of Project 618 were due in June 1996, these to incorporate the outcome of the discussions at this workshop. The record presented here is a brief overview of progress, at the time fo the workshop, in the application of the TDI for UWWTD monitoring purposes.

3.1 Development of TDI

An introduction to the TDI and its development was given by the principal author of the method, Dr Martyn Kelly. The work had started off as an NRA R&D fellowship to investigate the use of plants to monitor rivers. At this time, the requirements of the UWWTD became apparent, which focused the work on the assessment of trophic status. The prime focus was on the use of diatoms, there being a strong record of their use in monitoring acidification (paleolimnological studies) and in water quality monitoring in continental Europe.

The TDI is derived from the weighted-average equation of Zelinka & Marvan, using taxon sensitivities to nutrient status, indicator value (spread around the mean) and abundance. The resulting TDI will indicate the level of nutrients. However, when monitoring the impact of discharges from sewage works, the interpretation of results can be complicated by taxa which are responding to other components of the discharge (eg elevated suspended solids, ammonia, decreased O_2). Hence, a further value is also computed to indicate the contributing influence of organic pollution: the % of recorded taxa tolerant to organic pollution. This is used in conjunction with the TDI when interpreting results.

The TDI was developed using a data set of 70 sites free from significant organic pollution. Scores were assigned to taxa according to their sensitivity to nutrient status: for example, a score of 1 for those taxa restricted to nutrient poor situations, and a score of 5 for those tolerant of nutrient rich situations. A checklist of scoring taxa was compiled, with a finite number of taxa. Where possible, identification to genus level only is required. Species have been split from the genus only where this would give useful extra ecological information and the species is relatively easily identified. Final adjustments to taxon weightings (indicator values) have been empirical, but the results have been supported by multivariate statistical analysis.

The TDI has the following practical advantages: ease of sampling; suitable for combination with invertebrate (kick-sampling) programmes; reliance on a finite number of easily identifiable, widely-distributed taxa (minimises learning time); straightforward computation; permanent record of conditions (slides) for future reference/comparison; amenable to various sorts of analytical quality control.

3.2 Current Evaluation (Project 618)

As part of the current evaluation exercise, the TDI has been trialled in four NRA Areas of three Regions. Some minor adjustments to the system have been made, and taxa which are primarily planktonic have been removed. Subsequent to the workshop, the scale has been expanded from 1-5 to 0-100. Problems with sampling techniques have been identified and a flow-chart produced giving guidance on methodology. This includes an option for the use of artificial substrata if no suitable natural substrata are present (*e.g.* if no cobbles free of filamentous algae - see below for use of artificial substrata, plus section 6.9). In order to avoid the gross effects of organic pollution, it is advisable not to sample directly below discharges, but preferably to sample in the 'recovery zone'. A grid to facilitate interpretation of results has been produced. This shows 'TDI' on the vertical axis and the '% of taxa tolerant to organic pollution' on the horizontal axis. The relevant position of the d/s result compared to the u/s result allows the relative influence of eutrophication and organic pollution to be assessed.

	% of taxa tolerant to organic pollution →			
TDI ↓				
		u/s		
			d/s	

NRA staff in the four Areas of the participating Regions (Anglian (2), Thames (1), Severn Trent (1)) presented an account of their findings and experiences to date. Sites for TDI trials were mostly co-located with MTR sites, but tended to be those sites where it was difficult to carry out macrophyte surveys. Experiences differed, with some examples of nutrient effects being masked by organic and other types of pollution. However, at other sites the TDI results were encouraging and supported the conclusions of chemical and/or MTR results.

The full findings of the trials will be presented in the report produced at the end of Project 618 (R&D Technical Report E3).

3.3 Use of artificial substrata

Ben Goldsmith (University College London) is currently investigating the use of artificial substrata for diatom sampling, towards his PhD. He presented a summary of his findings to date, including the use of roof tiles, floor tiles and plastic rope. Although natural substrata are normally preferred where they are available in abundance, artificial substrata do offer certain advantages. For example:

a) Allows diatom sampling at otherwise unsuitable sites (*e.g.* where natural substratum is soft).

b) The substrata are in place for 28 days. This gives a defined period for colonisation, reduces the numbers of dead cells, and aids interpretation of results by giving a defined period for which the results relate.

c) Artificial substrata give improved resolution compared to natural substrata, as the same substratum is used at sites being compared, *e.g.* both upstream and downstream discharges.

d) Use of both natural and artificial substrata at sites where MTR data are not available would help strengthen evidence for UWWTD designation purposes.

3.4. Quality Assurance

A Quality Assurance procedure for the TDI methodology will be produced as part of Project 618. A brief account of the procedure was given at the workshop. Quality control of diatom counts is based on the assumption that diatoms on a slide follow a Poisson distribution and so confidence limits can be set according to the number of units counted. Confidence limits on low counts are wide, with narrower limits on high counts. The 'success' of the overall count of a slide therefore has to be judged according to the probability of each recorded taxon being found by the auditee. QA is an integral part of the TDI methodology. Details of the procedure, including criteria to be satisfied, will be given in the Project 618 report.

4. MEAN TROPHIC RANK SYSTEM

4.1 Development of MTR

An introduction to the MTR and its development was given by the author of the method, Dr Nigel Holmes. The method was devised for Anglian Region, to enable the requirements of the UWWTD monitoring programme to be met, and was aimed at using macrophytes to assess the trophic status of rivers. The method devised, the Mean Trophic Rank, is described in Holmes (1995). This was circulated to NRA Regions. A number of training courses were held by Holmes for NRA staff.

4.2 Further modification

Macrophyte data from 1995 from all Regions has been used by Holmes to make further modifications, and a copy of the report detailing the amended method was distributed to regional staff at the workshop (Holmes, 1996). Holmes presented an outline of the report at the workshop. Generally, the results were promising. Where the MTR fails, there are reasons for this, for example:

- in tidal reaches
- river too wide and deep
- past and present boat usage
- bad survey conditions
- shading not comparable at u/s and d/s sites
- excess *Lemna* or algal growth obscuring macrophytes
- not maximising techniques (not using glass-bottomed buckets)
- taxonomic problems (although examples are few)
- confusion as to whether to 'score' 'other filamentous green algae'
- errors in estimating cover
- transpositional errors (*e.g.* species noted on sketch map but not recorded on checklist)
- miscalculations of the MTR.

Some seasonal changes were noted.

The quality and content of sketch maps differed. However, as the prime purpose of the maps is to identify the 100 m reach on repeat visits, there is no requirement to make a detailed map of macrophyte cover.

A revised checklist has been produced, which conforms to 1996 nomenclature. Examples of changes compared to the March 1995 list include:

- a new category of *'Ranunculus* spp. indet.'
- a suffix of confidence given to the MTR depending on the comparability of sites (I - III), the conditions of survey (A - C) and the number of scoring taxa recorded (a - c).

Research is still needed, however, relating macrophyte scores to nutrients and communities. The question of which nutrients macrophyte communities are responding to needs addressing.

4.3 Surveys for UWWTD purposes: NRA / Environment Agency

Practitioners from all NRA Regions shared their experiences of using the MTR. Some of their concerns had already been addressed by Holmes in the amended method (Holmes, 1996). Other responses are summarised below (4.3.1). Subsequent to the workshop, these responses and the amended method of Holmes (1996) were incorporated into the internal EA document "Methodology for the Assessment of Freshwater Riverine Macrophytes for the Purposes of the Urban Waste Water Treatment Directive", May 1996 Version 2.

4.3.1 Practical Application of Survey Methodology

Identification difficulties were experienced with fine-leaved *Ranunculus* species, *Lemna minor/minuta*, *Callitriche* species, *Catabrosa*, fine-leaved *Potamogeton* species, *Veronica anagallis-aquatica/catenata*, hybrids, bryophytes and grasses. Difficulties in identifying algae are normally resolved if a specimen is taken back to the laboratory for identification. A category for *'Ranunculus* species indet.' has now been included in the amended Checklist, and the Checklist updated regarding taxonomic nomenclature (Holmes, 1996).

Some difficulties were experienced in deciding whether specimens were 'in' or 'out' of the water, especially bryophytes. This problem should be reduced when using the new (February 1996) Checklist as many of the marginal taxa have been removed from the list. Difficulties in knowing whether to record floating mats of algae were also expressed.

Biomass was felt to be a useful indicator of an impact, particularly in situations where the P-loading upstream of the discharge was high. Although this is not taken into account in the computation of the MTR, biomass information is worthwhile recording for interpretational purposes. Similarly, the presence/absence of sewage fungus provides useful information.

There was some confusion as to when to do an initial site investigation of 500 m up and downstream of the discharge to assess the applicability of the site for the method (eg substrate and shade compatibility).

The training courses run by Holmes in 1995 were very useful and helped to clarify a number of points. However, the benefit was limited to those staff attending.

Problems were experienced by all Regions in finding suitable sites. Difficulties related to: finding suitable sites within the recommended distance downstream of the discharge (substratum, shading, erosive nature *etc*); finding physically comparable sites upstream and downstream of discharges; and site access. Some Regions approached this problem by splitting reaches. The use of 'black holes' within the survey reach, whereby deep inaccessible areas are excluded from the survey, was also tried on a few surveys. Clarification was sought on the site selection criteria, what to do if a change of site is necessary to comply with these criteria, and the approach to deep/inaccessible pools within a reach.

Boats and/or under-water cameras had been used to varying degrees in the different Regions. Anglian Region had found the boats and underwater cameras to be very useful. In reaches with isolated pools, where use of a boat is not practicable, the use of dry-suits has been found to be successful in improving survey coverage. Very few surveyors had used glass-bottomed buckets to improve visual clarity in shallow waters, although this is a cheap and effective solution.

Sketch maps have been found to be useful at locating and identifying the survey site. In this respect, permanent features (*e.g.* on bank) need to be recorded. Other uses include: recording the location of rare/'difficult' taxa and depth-width profiles. Clarification on the primary purpose of the map (see above, MTR development) will reduce the amount of unnecessary effort spent mapping macrophyte cover. Photographs are useful in recording the physical nature of the site and the extent of macrophyte cover. However, their appearance is markedly improved by the use of a polarising filter.

4.3.2 The Checklist

Suggested additions to the checklist were *Alopecurus geniculatus* and *Lagarosiphon major*. The use of regional weightings, relating to the sensitivity of taxa at the edge of their geographical range, needs more research.

There was some confusion as to whether *Hildenbrandia* (for example) is counted in the 'total % cover figure'. Guidance is now given in Holmes (1996) allowing for examples where large/floating macrophytes overlay algae. For example, a total % cover value can exceed 100% where overlying taxa are both scoring and abundant.

Completion of the field-sheet may be easier if the order in which the taxa are listed is changed to an alphabetic order within type groupings. The following two supplementary lists would also useful: one of non-scoring taxa and one of regional rarities.

There was some concern amongst NRA biology staff concerning the low number of scoring taxa recorded on some surveys. However, a suitable approach is detailed in Holmes (1996), attaching confidence suffixes to the MTR score.

4.3.3 Performance of the MTR for UWWTD monitoring purposes

Consistent downstream reductions in MTR appeared to occur more frequently in reaches with relatively low P loadings upstream of the discharge than in those with high loadings. The use of biomass information in the interpretation of results may help in the latter situations (see above). At least one Region found the MTR to give more consistent results where the downstream site was close to the discharge.

The MTR appeared to give inconsistent results where physically comparable sites upstream and downstream of the discharge could not be found. Problems were experienced in some reaches of low summer/perennial flow, where the volume of effluent discharged, compared to the size of the receiving watercourse, resulted in a marked downstream change in the flow (discharge

category) of the watercourse. The MTR also did not appear to perform well on Chalk streams.

It must be remembered, however, that surveyors should not go out anticipating a positive result!

A modification to the methodology allowing surveys of a 5 m-wide strip at the edge of wide rivers had been tried in a few Regions. Both Thames and South-Western Regions found this to be a useful modification of the methodology, being time-efficient, not significantly affecting the MTR, and allowing surveys of otherwise un-surveyable reaches (*e.g.* River Avon at Bristol). However, reductions of around 30% of recorded taxa were reported by Anglian Region, with the importance of marginal plants being inflated. Anglian Region no longer use this methodology. Although the margins can be viewed simply as 'quadrats/transects' of a larger survey area, the evidence suggests that the MTR may have more impact on those making management/designation decisions if it relates to the whole channel rather than simply the margins.

4.3.4 Preliminary report from IFE on NRA data

Data from NRA regions has been passed to IFE as part of R&D Project 694. Although only a small proportion of data had been input to date, attention was drawn by Dr Hugh Dawson (IFE) to the following.

- Disparities in the completion of forms.
- Physical records: a suggestion that a '0' value should be inserted in boxes where appropriate, rather than no value.
- The most frequently recorded taxa to date are: *Cladophora*, 'other filamentous green algae', *Agrostis stolonifera*, *Phalaris arundinacea*, with few true aquatic species being recorded and moss species rarely recorded.
- Do identification skills need to be improved?
- Is there a need for additional species on the checklist?
- Are surveyors finding all the specimens at a site?

Consistency of approach in the completion of field sheets is needed.

4.4 Surveys for non-UWWTD purposes: English Nature and IRTU (Northern Ireland)

4.4.1 English Nature

Investigations into the use of the MTR to assess the impact of non-UWWTD-qualifying P-inputs, have been undertaken by Jane Southey for English Nature. Her brief was to investigate the possibility that a number of riverine SSSIs are subject to high P loading, with a resultant impact on the macrophyte flora. Sewage discharges surveyed were all from small or moderate sized sewage treatment works (< 10, 000 p.e.). Results were variable but encouraging. Overall, a downstream reduction in MTR was noted, although the % change downstream of discharges was often not great. This could possibly mean that the systems surveyed already have a high P-loading. NCC macrophyte classification was computed on the MTR sites. There was no clear relationship between the two sets of results, however it is felt that it is useful to use both systems when analysing changes of macrophyte floras over time. English Nature's studies show much potential for the MTR.

4.4.2 Northern Ireland

In Northern Ireland, experience of UWWTD monitoring requirements and applications of the MTR has been quite different from that of the NRA. Peter Hale, of the Industrial Research and Technology Unit, recounted the history of eutrophication problems in N.Ireland, dating back to the blue-green algae (*Anabaena flos-aquae*) blooms in Lough Neagh in 1986-87. The lake was deemed to be eutrophic, a freshwater investigation unit was set up by the DoE(NI), and much political pressure applied to resolve the problem. Eutrophication of the lake was found to be due to high P loadings. STWs accounted for 50% of P inputs into the catchment, with the remainder from diffuse sources. P-reduction was installed at eight major works, which resolved the problem of *Anabaena flos-aquae* blooms in Lough Neagh.

Attention was then turned to the catchment of Lough Erne, with the installation of P-reduction at major sewage works. It is planned that this will extend to small sewage treatment works in the L.Erne catchment in the future.

Given that a programme of P-reduction was already in place, there have been no UWWTD monitoring requirements in N.Ireland. However, macrophyte monitoring has continued in order to monitor trends in the eutrophic status of rivers. In the first surveys, use of a system devised by Haslam gave an indication of the location of the eutrophication problems. In 1995, methodology incorporated advice from Nigel Holmes. Currently, macrophytes are surveyed at all routine invertebrate monitoring sites, in two seasons of the year. The survey programme includes the monitoring of those sewage treatment works thought to be causing problems. In such cases, macrophyte, invertebrate and ecotoxicological work is undertaken upstream and downstream of the discharge, and this combined approach is found to be useful. In 1996 the TDI will be evaluated on a limited scale, as part of the monitoring of Environmental Change Sites in N.Ireland. Again a combined approach will be used, looking at the TDI in conjunction with the MTR and invertebrates. Only 16 sewage works will be included within this programme.

4.5 Improvements to the MTR system

In addition to comments made in feedback from practitioners (given above), the following suggestions/comments to improve the performance of the MTR were made.

1. The validity of the 100m reach as the basic survey unit needs to be confirmed, by surveying consecutive 100m reaches within a 500m reach. This has not yet been addressed in depth.

2. Taxa respond at different rates to nutrient inputs and to changes in nutrient inputs/levels. When evaluating the performance of the MTR and investigating possible means of improvement, it may be worth separating out those taxa which respond quickly to a reduction in P and those that do not. Both responses in time and in distance will be measurable with the MTR system. This necessarily will involve investigation of the influence of sediment chemistry on the macrophyte flora. This has not yet been addressed.

3. The variability of the method needs to be defined.

4. One possible means of improvement is to attach a weighted average for truly aquatic species.

5. Site selection is important, as seeding of species from tributaries into small watercourses has been perceived as a problem in 1994 and 1995.

6. Changes in macrophyte flora and MTR score downstream of a STW discharge may be due to influences other than nutrient enrichment. Any impact due to enrichment, for example, may be masked by the effects of organic pollution, suspended solids or toxicity associated with such discharges. Research needs to address this problem, in order to ensure that the changes in MTR do indicate changes in nutrient status. An additional suffix of confidence could be included to give an estimate of the contribution of organic pollution tolerant species, or their abundance, at an MTR survey site. Ecotoxicological work is being undertaken under the remit of other Environment Agency R&D projects.

4.6 Quality Assurance

There had been some experience of Quality Assurance of MTR surveys within the NRA. In Severn-Trent Region, external auditors re-surveyed MTR sites. The main problem this highlighted was the different decisions surveyors make as to whether specimens are 'in' or 'out' of the water. However, no clear pattern of differences emerged between the auditors and the NRA surveyors. In Anglian Region, a successful programme of internal AQC has been carried out, with a random selection of MTR sites being re-surveyed by another survey team. One way to organise this is to operate inter-Area AQC, using a survey team from another Area within the same Region.

There are several components to a successful Quality Assurance system.

1. Training to the same specification for all surveyors and auditors.
2. A procedural manual.
3. A re-survey, to be carried out with as little delay as possible (preferably the same or following day).
4. Levels of confidence.
5. (additional element dependent on application) QA of site selection.

Recommendations for a QA system are described within the Standard Methodology produced by Anglian Region (NRA, 1994).

5. GENERAL DISCUSSION

A number of issues were raised, during the course of the workshop, which were of general relevance to both the TDI, MTR and their applications.

5.1 Definition of eutrophication

There are three definitions of eutrophication currently used by the Environment Agency, and before that, the NRA, for different purposes:

1. **As laid down in the UWWTD:**

   "*Enrichment of water by nutrients, especially compounds of N and/or P, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.*"

2. **As laid down in the Nitrate Directive:**

   "*Enrichment of water by nitrogen compounds causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.*"

3. **As used by the TAPS Centre in the National Eutrophication Strategy:**

   "*The enrichment of waters by inorganic plant nutrients, which results in the stimulation of an array of symptomatic changes. These include the increased production of algae and macrophytes and deterioration of water quality. Such changes may be undesirable and interfere with water uses. (Modified from OECD 1982).*"

Interpretation of the definition of eutrophication given in the UWWTD can be problematic. For example:

(1) What are we trying to measure? Does eutrophication relate just to the water-column or to a more holistic picture of the river system, including the influence of sediment chemistry?

(2) What interpretation should be given to situations following installation of P-stripping, when there is lag between 'recovery' of the water column chemistry and the biological symptoms of eutrophication (*e.g.* the macrophyte flora). At what point will the designation/P-stripping be deemed to have been a success in such cases?

There is no clear answer to this problem. In answer to question (1), the focus is primarily on the water column. However, interpretation of the definition can allow for sediment chemistry to be

taken into account, and for the impact of a discharge on the whole river system (water column chemistry, sediment chemistry and biology) to be deemed significant.

In relation to question (2), although designation is based on the 'balance of evidence', including both chemical and biological, the Government's response to such situations is not yet known. It is not known whether de-designation or reversal of requirement for P-reduction are options after a specified time period in such scenarios.

5.2 Sensitivity

It is possible that both methods (TDI and MTR) will not be sensitive to changes in nutrient loading at highly eutrophic sites. Analysis of the UWWTD data during the R&D projects should allow this to be confirmed or refuted.

5.3 Delimiting Sensitive Areas

For reaches of river to be designated as SA(E)s under the UWWTD, the Environment Agency must show evidence not only of the impact from a qualifying discharge, but of the area demonstrating the symptoms of eutrophication: the SA must be delimited. The area must be downstream of the discharge, but may be several hundred metres downstream in cases where the symptoms do not manifest themselves immediately downstream. Under the current monitoring programme, most TDI/MTR surveys would not enable the SA to be delimited, as only one site is surveyed upstream and downstream of the discharge. In future monitoring, it may be necessary to assess more sites where appropriate.

5.4 Temporal variation/changes

With respect to seasonal variation, the TDI appears to be relatively stable during the year. Changes in community structure do occur, but the TDI itself does not markedly change. Values from the DQI (Diatom Quality Index - see 5.5.2) will follow the same trends. There is scope therefore for use outside the UWWTD survey season. 'Within season' variation of the MTR will be investigated as part of Project 694.

The suggestion was made as to whether it would be possible to composite data from 2-3 samples within a season, as for RIVPACS analysis of invertebrate populations. This idea has not been investigated as yet.

With respect to longer term temporal changes, it is not known, at the moment, whether the methods will demonstrate changes following installation of P-stripping. It is anticipated that both will, but that the MTR changes may occur over a longer timescale than the TDI. Post-designation monitoring is required to answer this question.

5.5 Results

5.5.1 Interpretation

There is a need for guidance to enable biology staff to interpret the TDI and MTR results in terms of trophic status. Such guidance will be included in the procedural manual produced as an output from Project 694, and should relate scores, changes in scores, and bands/classes to trophic status (see below for presentation of results).

At present, the significance of changes in TDI or MTR values, in terms of changes in trophic status, has not been determined. There are two aspects of 'significance' which need to be considered: the magnitude of the change and the consistency of the change.

With respect to the former, although there is some correlation between TDI levels and P concentrations, the relationship is not always clear. Such statistical analysis has not yet been carried out in relation to the MTR, but is within the remit of Project 694. Analysis of data from all Environment Agency Regions, together with additional trialling of both methods, will enable such changes in value to be given some context. This may also help in answering the question of whether the scales are linear in terms of nutrient status: is a x% change at the oligotrophic end of the scale of the same significance as the same value change at the eutrophic end of the scale?

With respect to the second aspect to be considered, consistent recording of the same value change downstream of a discharge, on repeated surveys and over a period of years, will indicate that a real impact is occurring, and hence give significance to those results.

5.5.2 Presentation and Communication

Results will be reported to non-biologists. They need to be presented in a consistent and easily understandable format to allow appropriate management decisions to be made. Both methods need to operate using the same scale and direction, and the results need to be communicated in a form appropriate to the specific application.

The TDI and MTR operate in different directions (a high value for TDI indicates eutrophic conditions, whereas a high value for MTR indicates oligotrophic conditions). The rationale behind these directions is as follows. For TDI, a high value represents a high nutrient loading. This recognises that higher nutrients do not always mean lower water quality, as a high nutrient status could be either natural or due to anthropogenic influences. For MTR, a high value represents "good" quality, with lower values representing increasing eutrophication. In addition, at the time of the workshop, the scales of the two methods were different: the TDI operating on a scale to a maximum of 5.0 and the MTR to a maximum of that imposed by floristic diversity and water chemistry at a particular site (approximately 100 in pristine sites). Subsequent to the workshop, the scale of the TDI was changed to give a maximum of 100.

> *Comment: The difficulty of operation of the MTR and TDI in a different direction and on a different scale has been addressed at an Environment Agency Regional Biologist's Meeting, held since the workshop. The outcome of discussions was that the TDI score*

(maximum 100) will be converted into a Diatom Quality Index which will operate on a scale of 1 to 100 and in the same direction as the MTR, i.e low scores indicate eutrophication. The calculation of the DQI is as follows:

$$DQI = 100 - TDI$$

However, due to the fundamentally different design of the two indices, a linear relationship should not be assumed, especially at high nutrient concentrations.

The most appropriate form in which to communicate results will depend on the specific application. For example, presenting results as actual scores, or as downstream changes in scores, may be the most appropriate form for monitoring of point discharges (*e.g.* UWWTD monitoring). A banding system may, however, be more appropriate for presenting an overview of the trophic status of a catchment, Area, Region, or nationally. This would allow easy mapping of results and assist management decisions (*e.g.* where to prioritise resources).

5.6 Widening the scope of methods

In addition to UWWTD monitoring, further potential applications of both the TDI and MTR are as follows.

1. Long-term monitoring of catchments where creeping eutrophication is suspected.

2. Monitoring of the impact of point nutrient discharges not qualifying under the UWWTD. The latter could include small or moderate sized sewage treatment works and fish farms. Evidence could be of significance in relation to SSSI/SAC designations (English Nature).

3. National Control of Eutrophication Strategy, currently being developed by the TAPS (Toxic and Persistent Substances) Centre in Anglian Region.

4. Catchment Management Plans.

5. Trophic window of General Quality Assessment.

6. Monitoring in Northern Ireland, Isle of Man, Scotland and Europe.

7. Inclusion in Biological Methods Manual.

8. Increase in scientific understanding of basic processes underlying eutrophication

5.7 Links with other/future Environment Agency funded research

5.7.1 Ecotoxicological research: This is currently being carried out and could yield insights into toxic effects of sewage on macrophytes/diatoms.

5.7.2 National Control of Eutrophication Strategy: This is being developed by the TAPS Centre.

5.7.3 Phosphatase assay development: This assay has potential uses for monitoring and predicting floral changes resulting from P-stripping. The method is based upon the relationship between the level of phosphatase activity in indicator species and the level of P in which the plant has been growing. The main advantage of the method, compared to other bioassay methods, is its speed (approximately 20 minutes), although it could be used in conjunction with other standard procedures. However, greater understanding of the issues is needed (*e.g.* responses of indicator species, how well the method would work at high P loadings). An R&D proposal has been submitted.

5.7.4 UK Freshwater Algal Flora Project: The British Phycological Society is in the process of compiling a flora for the UK. This will cover all the major freshwater algal groups (including blue-green algae) and is due to be published in two volumes in the year 2000. At the moment, the only keys/guides/floras available are either written in English but are too basic, or are not written in English, relate to overseas flora and are very expensive. There is thus a need for a UK flora. The project has involved a huge amount of effort to date, by experts both within the UK and overseas. However, the project needs additional funding, primarily for the post of 'Flora Coordinator' to maximise the usefulness of this effort. Phil Harding (Midlands Region) is currently undertaking a scoping study to determine the level of need for this work within the Environment Agency, with a view to the Environment Agency contributing funds to the project.

5.7.5 Biological Methods Manual: A project led by Sarah Chadd (Anglian Region) will be responsible for organising a manual of biological methods for the Environment Agency. The TDI, MTR (and phosphatase assay if developed) are strong contenders for inclusion in the manual. Future revisions may have to be made in the light of requirements from those European groups formulating Standard Methodologies. At the moment, however, such groups are working on sampling methodologies rather than systems of assessing water quality/trophic status *etc*, on which there is less likely to be disagreement.

5.7.6 Phosphate cycling in sediments: An R&D project is currently underway.

6 RECOMMENDATIONS

Some of the recommendations made during the course of the workshop are already addressed in the Project specifications, and as such are not listed here.

The following recommendations made at the workshop feed into three main areas:

A. UWWTD monitoring programme of the Environment Agency.
B. R&D Project 694.
C. Other Research

Recommendations specific to Project 618 (TDI) are addressed within the R&D outputs from that project.

6.1 Definition of eutrophication

The working definition of eutrophication used within the Environment Agency should be clarified and standardised. It should be expressed in terms which are measurable and achievable. Improvements could be measured against the criteria set out in the definition. A clear statement of what is included in the definition (water column, sediment, holistic picture of river system?) should be made. It is envisaged that the Environment Agency will adopt the definition in the National Eutrophication Control Strategy being produced by the TAPS Centre in Anglian Region.

6.2 Criteria for methods

a) Methods need to be **user-friendly**. With sophisticated biological methods this is aided by comprehensive training and continuing professional development.

b) The basic criteria need to be **right** and **robust**. The methods must give a clear indication of the trophic status of the sample site in question. This must be in the format of a statement which can be verified by other methods.

c) Results need to be **presented properly**. Presentation to lay-persons and scientific audiences is required, needing careful interpretation of the facts in order to minimise ambiguity.

d) Visible, publishable **quality control** on site selection, sample collection and taxon identification. Quality assurance must be an integral part of the initial methodology.

e) Both the TDI (DQI) and the MTR methods need to be **complementary and additive** to maximise information, and enable resources to be targeted efficiently and effectively.

6.3 Data collection

6.3.1 **Further trialling** of TDI and MTR at MTR sites is necessary in all Environment Agency regions. This action will establish the relationship between the two methods and enable consistency to be achieved. It is envisaged that regional staff will collect the samples but that the analysis may be external in this instance. It is recommended that in all Regions, diatom samples be collected coincidentally with MTR surveys during summer 1996.

6.3.2 **Additional data** are required from both the TDI and MTR to establish the spectrum of applicability of the methods with respect to eutrophication. Both systems will be tested within the remit of R&D Project 694, but additional testing should be carried out in order to verify the usefulness of both systems in areas not subject to monitoring requirements under the UWWTD. This testing must include rivers impacted by STW discharges **not qualifying under the UWWTD**, and more especially oligotrophic rivers.

6.3.3 **Minor revisions** to, and clarifications of the way data is collected and recorded are required to ensure harmonisation and consistency of approach across regions.

These revisions should include as a matter of urgency:

a) **Standard field recording sheets for MTR.**

i) These should be completed in a consistent manner.

ii) Taxa on the Checklist should be listed alphabetically within the following groups: Algae, Bryophytes, Higher plants. The sheet should include a 'Comments' box for useful information not itemised on the sheet, *e.g.* doubts on whether certain specimens/taxa were truly 'in' the water.

iii) The sheet should include a box(es) for sewage fungus (useful information for interpretation of results).

iv) A secondary taxa list should be available as an optional standard field sheet, to allow easier recording of non-scoring taxa. A list of regionally rare taxa to be available.

v) Substratum categories on the standard field sheet should be the same as used for invertebrate monitoring, with the addition of a 'sheet rock' category, and to be filled in with actual percentage values.

vi) Zero values for physical records should be input as '0' rather than left blank.

vii) A list of taxonomic synonyms to be included within the Standard Methodology.

viii) Biomass information to be retained on the Standard field sheet and used for interpretational purposes. Retain Method B of the Methods for the Examination

of Waters and Associated Materials: Methods for the use of Aquatic Macrophytes for Assessing Water Quality 1985-1986.

b) **Additional clear guidance required.**

i) This is needed on how to record unattached/floating algal matter within the Standard Methodology. The guidance must be applied consistently: Record those which do naturally move (*e.g. Lemna*), and do **not** record those which do **not** naturally move (*e.g.* moving, unattached *Cladophora*).

ii) Guidance on splitting reaches to allow for marked differences in physical characteristics.

iii) Clear guidance on the inclusion of "black holes" for very inaccessible areas within a survey reach should be given. For example what is the maximum area of a missing area within a survey reach which will not adversely affect the validity of the method?

iv) Guidance is required on the interpretation of results. This will include the significance of changes in TDI/MTR in relation to trophic status.

c) **Improvements to macrophyte survey methodology**

i) Ensure use of glass-bottomed buckets in turbulent water to improve visual clarity with respect to accurate identification of submerged macrophytes, as instructed in Holmes (1996).

ii) Use polarising filters on cameras.

Comment: Subsequent to the workshop, the above recommednations have been incorporated into the revised methodology for UWWTD macrophyte montoring and calculation of the MTR (Environment agency, 1996), with one exception (6.3.3.a.viii - biomass information)

6.3.4 Post-P-stripping monitoring, using both TDI and MTR, to determine ability to demonstrate changes after installation of P-stripping. This is dependent on the availability of a reliable and consistent historical data set. Lack of such a data set may limit the application of this method to demonstrate an improvement in a historical context. However post-P-stripping monitoring may be able to show measured improvements from 1996 data. Data from the 1996 surveys should be used as the baseline for improvement.

An examination of the time series of change to establish baseline variation in MTR scores should be carried out. Any changes due to P-reductions will be superimposed on this natural change.

6.4 Training

Training of all Environment Agency survey staff should be concluded prior to 1996 surveys. Training should be organised on a regional basis.

6.4.1 Standardised training

The most advantageous method of training in these methods is mainly "on-the-job". For the MTR, this informal approach should be structured around statutory training courses run by Holmes and additional annual refresher days.

Training should include training of all survey and audit staff in methods and interpretation of results; training in how to apply quality control to all aspects of the methodology; and, training in how to audit results obtained by another region or area.
Some suggestions for inclusion in the statutory training courses and for improving the take up of training in the MTR system are:

a) Training courses concentrating on 'difficult' taxa. (Bryophytes, *Ranunculus, Potamogeton* and *Callitriche*).

b) Use of the carousel of slides of aquatic macrophytes produced by Max Wade at the International Centre of Landscape Ecology at Loughborough University.

c) Examine the usefulness of producing a training video. This may allow future updating of methodology without the need for repeated training sessions and allow staff who join during the year to be trained independently.

d) Examine the usefulness of training material on CD-ROM.

6.4.2 IdQ

A broad guaranteed knowledge of aquatic plant taxa such as that offered by the British Museum IdQ is desirable because it inspires confidence by external organisations which are subject to the implications of the UWWTD monitoring programme. It also inspires confidence in the surveyors when they come across a difficult taxon in the field. There is a need for an internal Agency IdQ type standard which can be shown to be as acceptable as the IdQ to external organisations.

However, the point was made at the Workshop that the IdQ exam does not offer training specific to the needs of MTR surveyors and as such, a tailor-made IdQ, including only aquatic plants (primarily those on the MTR Checklist) would be most appropriate in this instance. This internal IdQ would be optional for staff. The true indication of "broad guaranteed knowledge" is a successful record in AQC-type audits.

6.5 Quality Assurance

Quality Assurance should be an integral part of the methodology. Quality Assurance is essentially the formal enforcement of a consistent approach to every part of the methodology, to ensure that the required standard is achieved.

A procedural manual, an essential element to the Quality Assurance procedure, will be produced as an output from R&D Project 694. Quality Assurance also includes the formalisation and external acceptance of training methods (section 6.4).

Quality Control within the methodology should include re-surveys carried out on a random number of sites, possibly by another Area from the same Environment Agency Region, within a short space of time. The number of sites re-surveyed could be based upon either a set maximum number of sites per person or on the basis of a set proportion (10%) of sites on a national basis. Site selection should be randomised.

Confidence limits for MTR scores and/or changes in MTR scores will be determined within R&D Project 694. These are needed in order to set the required standard for Quality Assurance.

Quality assurance should also include an additional element of 'site selection' where appropriate (*e.g.* for UWWTD monitoring). Upstream and downstream sites should conform to the requirements of similarity. Guidance on the permitted extent of dissimilarity of sites is required (*i.e.* what are the main factors that adversely effect the MTR score between sites).

6.6 Communication of results

It is important for the purposes of simplicity and perceived consistency of approach that both the TDI and MTR indices should operate in the same direction and to the same scale. A scale of 100 is recommended. The change in direction could be most simply achieved by subtracting the index in question from 100. No recommendation on the preferred direction of the indices was reached at the workshop. However the matter was referred to internal user groups (Regional Biologists' Meeting and EU Directives section at Head Office). Subsequent to the Regional Biologists Meeting the TDI can now be converted to the Diatom Quality Index (DQI) for the purposes of comparison with the MTR.

The DQI operates on a scale of 1-100 and indicates eutrophication at the low end of the scale (previously high end). This has ensured harmonisation and consistency within biological monitoring programmes aimed primarily at the UWWTD.

For the purposes of indicating trophic status, or change in trophic status, for the UWWTD, results will be presented as actual scores and changes in scores for each monitoring site. For the purposes of catchment management and the National Eutrophication Strategy a system of banding will be developed, either for scores and/or categories of severity of change. This banding system could be used for purposes where mapping and large scale comparisons are important (*e.g.* mapping trophic status regionally or nationally).

It is essential that the results are presented in a manner that makes them irrefutable and easy to understand for trained scientists and lay-persons alike. The advantages of a complex and sophisticated system of environmental appraisal must be presented in an easily understandable format.

6.7 Publication and promotion of results

The recommended methods as set out in Holmes (1996), with further amendments made in the light of 1996 fieldwork if necessary, should be published in an established scientific journal as soon as possible following the production of the final R&D outputs from Project 694. It may be possible to publish the methods prior to the publication of the final R&D outputs if no further modifications are necessary.

6.7.1 European standardisation of methodology: It was recommended that Martyn Kelly and Nigel Holmes are asked to represent the Environment Agency on the European Committee charged with standardising sampling methods. This committee falls under the auspices of CEN, a water quality group within Europe. Some progress towards a standardised method of sampling diatoms has been made. The Water Quality Committee (CEN/TC230) has established a sub task group (CEN/TC230/WG2/TG3) specifically charged with examining the use of plants in biological monitoring programmes. It is this task group on which the Environment Agency should be represented.

The methods need to be promoted widely within the Environment Agency and in the broader water industry. Careful consideration should be given to the way in which these methods are promoted as a valuable biological monitoring tool. Inclusion in the Environment Agency Biological Methods Manual may not be sufficient to establish the methods as a standard in a wider context.

6.8 Applications

6.8.1 UWWTD

There is room for interpretation within the UWWTD **definition of eutrophication**. It is recommended that the river be viewed both in terms of the water column quality and more holistically (sediment, catchment quality), although this may present problems in the communication of results.

Site selection criteria: For UWWTD monitoring purposes it is recommended that:

(i) TDI sites monitored downstream of STW discharges are within the recovery zone, in order to avoid the masking effects of organic pollution in the mixing zone. Further details are given in the output from Project 618.

(ii) MTR sites monitored downstream of STW discharges must be less than 500 m downstream of the discharge, subject to physical comparability with the upstream site. The

upstream site should be no more than 500 m upstream of the discharge.

Additional sites should be surveyed where appropriate, to enable accurate delimitation of the SA(E). Where eutrophication symptoms are not manifested in the macrophyte flora until a significant distance downstream of the discharge, then additional sites are required in this reach, in addition to the site immediately downstream of the discharge.

Additional sites should be surveyed if previous sites have been found to be inappropriate (for example, if sites do not meet the recommended site selection criteria). Previous sites should be retained and surveyed for continuity and comparison.

6.8.2 Other applications

It is recommended that the TDI and MTR are applied to more uses than UWWTD monitoring. These could include long-term baseline monitoring and monitoring of nutrient discharges not qualifying under the Directive (*i.e.* less than 10,000 pe). This would involve storage of permanent slides prepared for diatom analysis in order to compare taxonomic composition at a later date, perhaps after the installation of P-stripping.

It is recommended that active collaboration with English Nature on monitoring riverine SSSIs and SACs should be encouraged.

6.9 Artificial substrata for TDI

The use of artificial substrata allows diatom sampling at otherwise unsuitable sites (*e.g.* where natural substratum is soft). The substrata are in place for 28 days. This gives a defined period for colonisation, reduces the numbers of dead cells, and aids interpretation of results by giving a defined period for which the results relate.

Use of both natural and artificial substrata at sites where MTR data are not available would help strengthen evidence for UWWTD designation purposes.

It is recommended that further investigation is warranted into the use of artificial substrata for diatom sampling for the purposes of obtaining TDI (DQI) data for the monitoring requirements of the UWWTD. A detailed examination of published literature is required before any further practical work is warranted.

6.10 R&D Project 694

It is recommended that in addition to the issues included within the project specification the following questions require further research.

The project should examine the use of regional weightings for local taxa (nationally rare) and for taxa at the edge of their geographical range.

The application of a weighted average value should be considered (indicator value, c.f. TDI).

The validity of 100 m reaches for survey purposes should be established. Consecutive 100 m reaches should be surveyed within 500 m of the discharge (or in the recovery zone where appropriate).

Consideration should be given to identifying those taxa which respond quickly to nutrient inputs and/or changes in nutrient levels. The changes would be measured on a temporal and spatial scale of response.

Consideration should be given to the reproducibility of biomass estimates. Guidance on how and when to record this, plus interpretation, is required.

The inherent variability of the method should be defined.

Consideration should be given to ensuring that changes in MTR scores are due to nutrient enrichment rather than other factors. Investigation of the use of a grid to facilitate interpretation of results, taking into account the influence of organic pollution, should be devised for MTR, as has been developed for TDI.

Investigate the use of composite data from different seasons or from different surveys within the same season to establish trends or patterns of eutrophication and susceptibility of species.

6.11 Other research

6.11.1 Development of the phosphatase assay

This system is based on a cheap and easy assay of alkaline phosphatase activity of aquatic plants. It reflects the nutrient status of submerged plants. The surface enzyme activity of mosses, some angiosperms and algae can be assessed. The phosphatase activity in the plant is a measure of the phosphate concentration, or the availability of phosphate, at the time of the assay.

6.11.2 Funding of Freshwater Algal Flora project

This project is under the direction of a committee of the British Phycological Society. It requires substantial extra funding if it is to achieve its goal of publication by the year 2000. It will encompass CD-Rom technology and allow easy identification of every algal species in the UK.

6.11.3 Macrophyte sediment interactions and ecology

Underpinning research on the relationship between river macrophyte communities and nutrients, including the influence of sediment chemistry is urgently required to support some of the contentions within this project. The influence of accumulation of nutrients in sediments has not been adequately addressed in this context.

APPENDIX 1: LIST OF ABBREVIATIONS AND ACRONYMS

DoE(NI)	Department of the Environment Northern Ireland
DQI	Diatom Quality Index
EA	The Environment Agency
EN	English Nature
GQA	General Quality Assessment
IFE	The Institute of Freshwater Ecology
IRTU	Industrial Research and Technology Unit
MTR	Mean Trophic Rank system
NRA	National Rivers Authority
P	Phosphorus (usually SRP)
pe	population equivalent
QD	Qualifying Discharge under the UWWTD
SAC	Special Area of Conservation
SA(E)	Sensitive Area (Eutrophic)
SRP	Soluble Reactive Phosphorus
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
TDI	Trophic Diatom Index
UWWTD	Urban Waste Water Treatment Directive

APPENDIX 2: REFERENCES

Department of the Environment, Ministry of Agriculture & Welsh Office (1992) *Criteria and procedures for identifying sensitive areas and less sensitive areas (Urban Waste Water Treatment Directive) and Criteria and procedures for identifying 'polluted waters' (Nitrates Directive) in England and Wales*. Consultation Paper.

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Holmes N.T.H. (1995) *Macrophytes for water and other river quality assessments*. Report to Environment Agency Anglian Region.

Holmes N.T.H. (1996) *The use of riverine macrophytes for the assessment of trophic status: review of 1994/95 data and refinements for future use*. Report to NRA Anglian Region.

National Rivers Authority (1994) *Assessment of Freshwater Riverine Environments using Macrophytes*. Anglian Region, internal report, April 1994.

APPENDIX 3: LIST OF PARTICIPANTS

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Jane Southey	English Nature
Sarah Pritchard	Clyde River Purification Board
Peter Hale	Industrial Research and Technology Unit (Northern Ireland)
Benjamin Goldsmith	University College London

APPENDIX 4: WORKSHOP PROGRAMME

DAY ONE

	Arrival	Time	
1.	Assemble. Coffee/tea.	1230	
2.	Lunch	1300	
A.	**General Introduction**	Time	Chair: Roger Sweeting
1.	Purpose of Meeting	1400	Roger Sweeting
2.	Requirements to monitor trophic status [1]		
	a NRA: UWWTD	1410	Simon Leaf
	b English Nature	1425	Mary Gibson
B.	**TDI**	Time	Chair: Anne Lewis
1.	Introduction	1435	Martyn Kelly
2.	Results of Assessments by NRA Staff [1]		
	i Anglian Region, Northern Area	1450	Dave Balbi
	ii Anglian Region, Eastern Area	1500	Chris Adams
	iii Severn-Trent Region	1510	Ruth Maddocks
	iv Thames Region	1520	Anna McQueen/ Alison Hutchings
3.	Tea	1530	
4.	Use of artificial substrates [1]	1600	Ben Goldsmith (UCL)
5.	Analytical Quality Control procedures [1]	1610	Martyn Kelly
6.	Feedback & Discussion [2]	1620	Chair:Anne Lewis
	Summary and Recommendations		
	Finish	1800	
8.	Evening meal	1900	

DAY TWO

C.	**MTR**	Time	Chair: Phil Harding
1.	Introduction & Latest Developments [1]	0915	Nigel Holmes
2.	Feedback from practitioners: NRA Regions[3] (Chair: Karen Rouen)	0935	One representative from each NRA region
3.	Coffee	1030	
4.	Feedback from external organisations [1]	1100	
	a. English Nature		Jane Southey

	b. IRTU (Northern Ireland)		Peter Hale
5.	Discussion (including Quality Assurance) [2.] Summary and Recommendations	1115	Chair: Phil Harding
6.	Lunch	1230	
D.	**General Discussion**	Time	Chair: Roger Sweeting
1.	Discussion [2.]	1345	
2.	Summary and Recommendations	1510	Roger Sweeting/ Karen Rouen
3.	Tea	1530	
	Finish	1600	

Notes:

1. formal presentation(s)
2. general discussion session
3. group feedback session (see below)

FEEDBACK SESSION ON MTR

This session took the form of a group feedback from a panel of NRA representatives involved in MTR surveys; one representative per NRA region. The following questions had been circulated prior to the workshop and were addressed by the panel in turn. Questions (c) and (d) were open to discussion by all participants at the workshop, not just the feedback panel alone.

a Practical Application of the Survey Methodology

i Identification difficulties?

Taxonomic nomenclature. Clarification? Harmonisation?

ii Difficulties in interpreting how to do the surveys: are we all doing the same thing?

iii Finding suitable sites?

iv Use of boats / underwater cameras - do they work?

v Sketch maps - Are they useful? Clarification on purpose?

vi Other

b The Checklist and Application of the Scoring System

i Are amendments to the basic checklist recommended?
Are regional additives required?

ii Is simplification of the checklist feasible without losing valuable information?

iii Are confidence limits being achieved in terms of number of taxa recorded?
Does it matter?
How do we approach 'low confidence' records?

iv Clarification on how to apply the scoring system required?

v Other

c Does the MTR appear to work? *

i In what types of situations does the MTR appear to perform well?

ii In what types of situations does the MTR appear to perform badly?

iii How important is the physical nature of the site?

iv Is the use of 5m marginal strips a useful and valid method of surveying wide rivers?

v Where should sites be located in relation to a qualifying STW discharge?

vi Other

d Interpretation of MTR results

i How do the different MTR scores relate to trophic status?
What magnitude of d/s change in MTR score would be considered significant?
Would broad classes/bands of scores be useful when relaying information to non-biologists *e.g.* in submitting evidence for UWWTD designations?
Recommendations?

ii Other

* In terms of both the UWWTD requirements and also at assessing trophic status *per se*.

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