CIS - WFD

Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters

Produced by Working Group 2.3[1] – Reference conditions for inland surface waters (REFCOND)

[1] Working Group 2.3 was established under the EU Common Implementation Strategy (CIS) for the Water Framework Directive.

Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In the context of this strategy, the project “Development of a protocol for identification of reference conditions, and boundaries between high, good and moderate status in lakes and watercourses” was launched in December 2000 and named REFCOND. During 2001 the REFCOND project was widened to an informal working group included in the Common Implementation Strategy (working group 3.2). The final document to be produced was also changed from a more formal and binding protocol to a non-legally binding guidance document. Sweden is the lead country with responsibility of the co-ordination of the working group that is composed of ecologists and technical experts from governmental and non-governmental organisations. The Swedish Environmental Protection Agency (SEPA) has the responsibility for the administration and management and the Swedish University of Agricultural Sciences, as sub-contractor to SEPA, has the responsibility for the scientific project management.

The present guidance document is the outcome of this working group. It contains the synthesis of the output of the REFCOND group activities and discussions that have taken place since December 2000. It builds on the input and feedback from a wide range of experts and stakeholders from EU Member States and candidate countries that have been involved throughout the process of guidance development through meetings, workshops, conferences or electronic communication media, without binding them in any way to its content.

“*We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this guidance through written procedure during April 2003. We would like to thank the participants and, in particular, the Swedish leaders of the Working Group, for preparing this high quality document.*

We strongly believe that this and other guidance documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive. This guidance document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work. Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.”

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Introduction - A Guidance Document: What For?

To whom is this Guidance Document addressed?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the implementation of the Annexes II and V with special emphasis on inland surface waters and methods and principles for the establishment of reference conditions and class boundaries between high, good and moderate ecological status. If this is your task, we believe the guidance will help you in doing the job, whether you are:

- *Establishing reference conditions and ecological status class boundaries for inland surface waters yourself or participating in the process as a stakeholder;*
- *Leading and managing experts undertaking the ecological status analysis;*
- *Using the results of the ecological status analysis for taking part to the policy making process; or*
- *Reporting on the ecological status analysis to the European Union as required by the Directive.*

What can you find in this Guidance Document?

Purposes and timing (Section 1)

- *What is the role of the key elements in the REFCOND guidance document within the implementation process of the Directive?*
- *The timetable of the Directive - When are Member States expected to deliver something that requires that reference conditions and class boundaries have been established?*

Common understanding of concepts and terms (Section 2)

- *What are the key elements of the Water Framework Directive relating to reference conditions and ecological status classes?*
- *Where in the Directive are these elements made explicit or referred to?*
- *Which is the common understanding of the concepts "reference conditions" and "high ecological status", "good" and "moderate ecological status", "surface water bodies, "wetlands", "water body types" and "classification of ecological status" incorporating the Directive's terminology and requirements?*

Principles and methods for establishing reference conditions and ecological status class boundaries (Section 3)

- *Which are the key steps in the suggested approach for establishing reference conditions and ecological quality class boundaries?*
- *Which infrastructure is needed for a successful implementation of the suggested approach?*
- *How can differentiation of water body types be done in order to support the establishment of reference conditions and the intercalibration exercise?*

- *How can ecological criteria and pressure criteria be used in site selection and for setting class boundaries?*
- *What benchmark should we use to determine very minor and slight disturbance in terms of pressure criteria?*
- *What methods can be used to establish reference condition values and what are the strengths and weaknesses of different methods?*
- *How can reference conditions and quality class boundaries be validated?*
- *How can " sufficient level of confidence about the values for the reference conditions" be dealt with?*
- *How can "adequate confidence and precision in the classification of the quality elements" be dealt with?*
- *Which are the circumstances for excluding quality element indicators when establishing reference conditions?*
- *How can the ecological quality class boundaries be set, and are there any alternative approaches?*

The Toolbox (Section 4)

- *Which specific tools are available for establishing reference conditions and ecological quality class boundaries?*
- *How can these tools be further developed and tested in order to be tailored for different water body types, different pressures-impacts and different quality elements?*

Good practice Examples (Section 5)

- *What examples are available of current good practice in respect of at least one aspect of the suggested approach for establishing reference conditions and ecological quality class boundaries?*

Adaptation to regional and national circumstances

The Guidance Document proposes an overall methodological approach. Because of the diversity of circumstances within the European Union, the way to deal with the logical approach and answer to questions will vary from one river basin to the next. The proposed methodology would therefore need to be tailored to specific circumstances.

What you will not find in this guidance document

The guidance document focuses on definitions, methods, principles and criteria to be used when establishing reference conditions and when setting the boundaries between high, good and moderate ecological status for inland surface waters. The document does not include guidance for specific quality elements and specific water body types but is restricted to general guidance that applies to most quality elements and most inland surface water body types. The guidance does not focus on:

- *Groundwater, transitional water and coastal water (handled by CIS Working Group 2.8 (groundwater) and 2.4 (coastal and transitional water);*
- *Classification of poor and bad ecological status;*
- *Emission limit values and environmental quality standards for classification of chemical status (handled by Expert Advisory Forum on Priority Substances);*

- *Method standardisation and intercalibration (intercalibration is handled by CIS working group 2.7).*

Section 1. Introduction - Implementing the Directive

This Section introduces the overall context for the implementation of the Water Framework Directive and informs on the initiatives that led to the production of this Guidance Document.

1.1 December 2000: A Milestone for Water Policy

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force.

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the Water Framework Directive.

1.2 Purposes and timing

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- *Prevents further deterioration and protects and enhances the status of water resources;*
- *Promotes sustainable water use based on long-term protection of water resources;*
- *Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;*
- *Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and*
- *Contributes to mitigating the effects of floods and droughts.*

Overall, the Directive aims at preventing deterioration of the status of all bodies of surface water and achieving *good water status* for all waters by 2015. For surface waters, “good status” is determined by a “good ecological status” and a “good chemical status”. Ecological status is determined by biological quality elements, supported by hydromorphological and physico-chemical quality elements. The point of reference is given by “undisturbed” conditions showing no or only “very minor” human impacts.

The various articles of the directive describe what shall be done and the sometimes rather elaborate annexes are to be seen as a way to help Member States in doing the job and achieving the overall purpose of the directive. Hence, although the text at a first reading may seem difficult to comprehend, the purpose that it is intended to result in is simple and easy to understand.

The present guidance document (REFCOND guidance) will, together with the other Guidance documents published by the Commission, help Member States achieve that purpose. It does so by advising on how member states may proceed to establish reference conditions and ecological status class boundaries for lakes and watercourses.

It should be pointed out here, that the REFCOND guidance does not provide solutions in detail that may be copied and applied as such. Rather, it offers principles, ways of reasoning and suggestions on alternative pathways of action. It is up to Member States themselves to implement these principles and suggestions under their own circumstances and to be able to verify that the solutions meet the requirements of the directive. Harmonization between Member States will be achieved through intercalibration (which is described in a separate guidance document) and participation in the work in Pilot River Basins and International River Basin Districts.

Guidance on the establishment of reference conditions and class boundaries are needed at several stages in the implementation of the directive (Figure 1). They will first be needed for the selection of sites for the draft register of intercalibration sites which should be completed in December 2003. More specifically, criteria for selecting minimally disturbed sites (on the high/good boundary) and slightly disturbed sites (on the good/moderate boundary) representative of different water body types will be needed. The present guidance document will also be needed for selection of complementary sites for the final register of intercalibration sites which should be completed in December 2004. The actual intercalibration exercise should be completed 18 months after the final register on sites have been established (described in guidance document on intercalibration). As the intercalibration excercise will be completed before the monitoring programmes are fully operational (see Figure 1) pressure criteria for selection of sites will have to be used together with existing survey data on ecological status.

The analysis of characteristics of River Basin Districts and the assessment of the risk for individual water bodies of failing the environmental objectives in accordance with Article 5 and Annex II in the Directive will also require guidance on reference conditions and classification. This analysis should be completed at the latest in December 2004. As the monitoring programmes will not be fully operational this risk assessment will have to rely very much on pressure information.

According to Article 8 of the Directive monitoring programmes shall be operational at the latest in December 2006. The REFCOND guidance will here be needed for the specification of the monitoring requirements of reference sites (high status sites) and assessing ecological status of all monitoring sites.

Finally, the REFCOND guidance will be needed when producing the first River Basin Management Plans which should be published at the latest in December 2009. In these plans type-specific reference conditions shall be listed together with map presentations on ecological status classifications for surface waters.

The dates given in Figure 1 outlines the time schedule for Member States to deliver documentation indicating that reference conditions and class boundaries have been established. In practice this means that work has to be done well in advance and should be started immediately. The time needed to do the job will vary with circumstances, such as the variability and complexity of the water bodies in Member States as well as the available expertise.

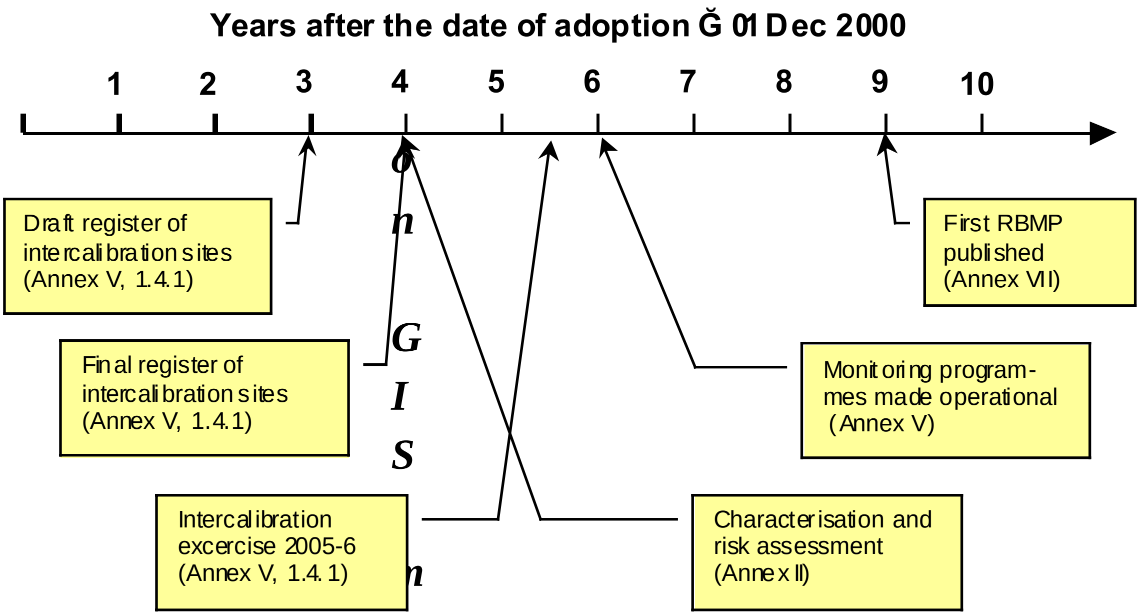


Figure 1. Timetable for implementation of parts of the Water Framework Directive which are depending on guidance from WG 2.3 (REFCOND).

1.3 What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (Article 3, Article 24);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, establishing a register of protected areas lying within the river basin district and finally assessment of the risk for individual water bodies of failing the environmental objectives by 2004 (Article 5, Article 6, Annex II, Annex III);
- To make operational the monitoring networks by 2006 (Article 8);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (Article 11, Annex III);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- To make the measures of the programme operational by 2012 (Article 11);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (Article 4)

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six-year cycles of planning and implementation of measures.

1.4 Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

1.5 Integration: a key concept underlying the WFD

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States, for river basins** shared by several countries, existing and/or future Member States of the European Union.1.6 What is being done to support implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support for the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community (see Annex I for the overall structure of the Common Implementation Strategy).

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding guidance documents (see Table 1). A strategic co-ordination group (SCG) oversees these working groups and reports directly to the water directors of the European Union and the Commission that play the role of overall decision body for the Common Implementation Strategy.

Table 1. Working Groups in the "Common Implementation Strategy" with description of lead countries/organisations (see also Annex A).

Working group	Lead
2.1 Analysis of pressures and impacts (IMPRESS)	UK & Germany
2.2 Heavily modified water bodies (HMWB)	UK & Germany
2.3 Reference conditions and ecological status class boundaries for inland surface waters (REFCOND)	Sweden
2.4 Typology, classification of transitional & coastal waters	UK, Germany, France, Sweden & EEA
2.5 Intercalibration	Joint Research Centre
2.6 Economic analysis (WATECO)	France & Comm.
2.7 Monitoring	Italy & EEA (ETCw)
2.8 Tools on assessment & classification of groundwater	Austria
2.9 Best practices in river basin planning	Spain
3.1 Geographical Information Systems, GIS	Joint Research Centre
4.1 Integrated testing in Pilot River Basins	Comm., SCG

1.7 Working group 2.3 – REFCOND

A working group has been created to deal specifically with issues relating to the establishment of reference conditions and ecological status class boundaries for inland surface waters. The short-term objective of this working group, with the acronym REFCOND, was the development of a non-legally binding and practical guidance to support the implementation of the relevant parts of the Water Framework Directive, specifically the Annexes II and V.

The members of the REFCOND group are ecologists and technical experts from governmental and non-governmental organisations from each European Union Member States and from Norway. A number of candidate countries and stakeholders have also been involved in the working group. A list of REFCOND partners and other contacts is given in Annex B.

To ensure an adequate input and feedback during the guidance development phase from a wider audience, the REFCOND group has organised three workshops. The first workshop, with focus on the review of techniques and principles used in Member States for identification of reference conditions and boundaries between quality classes, was held in Uppsala, Sweden, 14-15 May 2001. The second workshop, with focus on evaluation of techniques used for establishing reference conditions and quality class boundaries, was held in Ispra, Italy 5-6 December 2001. The third workshop, with focus on review and validation of the first draft guidance document, was held in Stockholm, Sweden, 5-6 September 2002. Full documentation of presentations, group discussions etc are currently available at the Circa System and at the REFCOND web site (http://www-nrciws.slu.se/REFCOND/).

A questionnaire has been used to collect information for the review of techniques and principles used in Member States for identification of reference conditions and boundaries between quality classes using the quality elements included in the WFD. The questionnaire and a summary of the questionnaire returns is available at the Circa System and the REFCOND web site (see above).

Based on the questionnaire returns and other available information four discussion papers have been produced by the REFCOND group to be used for the evaluation of techniques used in Member States (De Wilde & Knoben 2001, Johnson 2001, Owen et al. 2001 and Van de Bund 2001). These documents are concerned specifically with the processes involved in the definition and setting of reference conditions, the setting of class boundaries and typology. All papers are available at the Circa System and the REFCOND web site (see above).

The present guidance document is based on information from REFCOND workshops, questionnaire returns, discussion papers for evaluation of techniques and other available information, eg. from on-going EU and national research projects, CEN (European Committee for Standardization), national strategy papers and from literature reviews.

Developing the guidance document: an interactive process

Within a very short time period, a large number of experts have been involved at varying degrees in the development of this Guidance Document. The process has included the following activities:

- Regular meetings with the REFCOND lead group;
- Regular meetings with the Strategic Co-ordination Group and meetings with the other work group leaders in Brussels;
- Organisation of three workshops to follow up the work programme and preliminary output of REFCOND;
- Regular interactions with experts from other working groups of the Common Implementation Strategy, mainly those dealing with typology and classification of transitional and coastal waters (WG 2.4) and intercalibration (WG 2.5);
- Regular interactions with experts from past and on-going EU-funded research projects, mainly AQEM, STAR, FAME and EUROLAKES;
- Participation in several meetings and workshops organised by Member States, European organisations or EU on the subject of reference conditions and ecological status classifications.

In Annex E of this document past and on-going EU-funded research projects relevant for REFCOND are listed with full names, acronyms and web sites if available.

Section 2. Common understanding of concepts and terms

2.1 Reference conditions and high ecological status

Excerpts from the Directive pertaining to reference conditions and high ecological status:

Annex II: 1.3 (i-vi) Establishment of type-specific reference conditions for surface water body types:

For each surface water body type….type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydro-morphological and physico-chemical quality elements specified….for that surface water body type at high ecological status….Type-specific biological reference conditions shall be established, representing the values of the biological quality elements…for that surface water body type at high ecological status….

…. Type-specific biological reference conditions may be either spatially based or based on modelling, or may be derived using a combination of these methods. Where it is not possible to use these methods, Member States may use expert judgement to establish such conditions.

Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods. The methods shall use historical, palaeological and other available data ….

Annex V: 1.2 Normative definitions of ecological status classifications. Table 1.2. General definition of high ecological status:

There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.

The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion.

Annex V: 1.2.1-1.2.2 Definitions for high, good and moderate ecological status. Values of quality elements at high status:

Tables 1.2.1 (rivers) and 1.2.2 (lakes) provide normative definitions of high ecological status in rivers and lakes for each biological, physico-chemical and hydromorphological quality element. In every case, the definition includes the following clause in the status description of the biological quality elements:

The [specific quality element value] "corresponds totally, or nearly totally, to undisturbed conditions".

In addition, more specific criteria are provided for specific pollutants:

Specific synthetic pollutants: *"concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use".*

Specific non-synthetic pollutants: *"concentrations remain within the range normally associated with undisturbed conditions (background levels)".*

Conclusions and recommendations

- Reference conditions (RC) do not equate necessarily to totally undisturbed, pristine conditions. They include very minor disturbance which means that human pressure is allowed as long as there are no or only very minor ecological effects;
- RC equal high ecological status, i.e. no or only very minor evidence of disturbance for each of the general physico-chemical, hydromorphological and biological quality elements;
- RC shall be represented by values of the relevant biological quality elements in classification of ecological status;
- RC can be a state in the present or in the past;
- RC shall be established for each water body type;
- RC require that specific synthetic pollutants have concentrations close to zero or at least below the limits of detection of the most advanced analytical techniques in general use[2];
- RC require that specific non-synthetic pollutants have concentrations remaining within the range normally associated with undisturbed conditions (background values) [3];

The last two bullet points above have been subject to a long debate (cf. OSPAR) and it is clear that no scientific specification can be given for terms like “close to zero”. These issues are being examined by a sub group of the Expert Advisory Forum on Priority Substances dealing with Analysis and Monitoring (AMPS). It is recommended that the approach adopted by the EAF PS, AMPS group, be adopted for substances for which national detection limits and background concentrations are to be set.

[2] Examples on how to select the specific pollutants that are relevant to a particular water body are described in the guidance document from Working Group 2.1 (IMPRESS).
[3] See footnote 1.

2.2 Good and moderate ecological status

Excerpts from the Directive pertaining to good and moderate ecological status :

Annex V: 1.2 Normative definitions of ecological status classifications.. Table 1.2 General Definitions

> **Good ecological status:** *The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.*
>
> **Moderate ecological status:** *The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.*

Annex V: 1.2.1-1.2.2 Definitions for high, good and moderate ecological status. Values of quality elements at good and moderate status:

Table 1.2.1 (rivers) and 1.2.2 (lakes) provides normative definitions of good and moderate ecological status in rivers and lakes for each biological quality element. In every case, the definition includes the following clause in the status description:

> **Good ecological status:** *There are slight changes in the [specific biological quality element] compared to the type-specific communities.*
>
> **Moderate ecological status:** *The [specific biological quality element] differs moderately from the type specific communities. The values are significantly more disturbed than under conditions of good status.*

For general physico-chemical quality elements it is stated that the conditions for good ecological status should *"not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements"* (Annex V: 1.2).

In addition, more specific criteria are provided for good ecological status for synthetic pollutants:

> **Specific synthetic and non-synthetic pollutants***: "concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 (environmental quality standards - EQS)*[4]*".*

[4] Detailed procedures for the establishment of EQS is under elaboration in the Expert Advisory Forum on Priority Sub-stances.

Conclusions and recommendations

For any surface water body type in **good ecological status** the following criteria should be met:

- The values of the biological quality elements show slight deviation from reference conditions (low levels of distortion resulting from human activity);
- The levels of the general physico-chemical quality elements do not exceed the range ensuring ecosystem functioning and the achievement of the values associated to biological quality elements at good status;
- Concentrations of specific synthetic and non-synthetic pollutants are not in excess of environmental quality standards (EQS) established in accordance with Annex V 1.2.6. or under relevant Community legislation.

For any surface water body type in **moderate ecological status** the following criteria should be met:

- The values of the biological quality elements show moderate deviation from reference conditions (moderate signs of distortion resulting from human activity);
- Conditions consistent with the achievement of values for the biological quality elements and significantly more disturbed than under conditions of good status.

2.3. Surface water bodies

Excerpt from the Directive pertaining to surface water bodies:
Article 2, point 10:

> *"Body of surface water" means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water".*

The recommendations given below are mainly based on the horizontal guidance document on the application of the term "water body" in the context of the WFD. The REFCOND guidance may need to be revised in the light of the final version of the horizontal guidance on water bodies.

Most of the elements of the Directive's definition of surface water body are relatively clear and do not require further elaboration. The horizontal guidance document provides guidance to two other points that do need to be elaborated, however, namely size and whether parts of lakes or watercourses may be regarded as water bodies.

Concerning the second point, the horizontal guidance document explicitly says that significant changes in status (i.e. level of impact) should be used to delineate water bodies so that water bodies provide for an accurate description of water status. This means that rivers and lakes may be sub-divided into those parts that are impacted by human activities and those parts that are not or not much affected, e.g. a lake may be split into more than one "water body". Sub-divisions of surface waters into smaller and smaller water bodies that does not support a clear, consistent and effective application of its objectives should, however, be avoided.

The purpose of the Directive is to establish a framework for the protection of all waters including inland surface waters, transitional waters, coastal waters and groundwater[5]. Member

[5] Article 1

States must ensure that the implementation of the Directive's provisions achieves this purpose. However, surface waters include a large number of very small waters for which the administrative burden for the management of these waters may be enormous.

The Directive does not include a threshold for very small "water bodies". However, the Directive sets out two systems for differentiating water bodies into types[6]. System A and System B. Only the System A typology specifies values for size descriptors for rivers and lakes. The smallest size range for a System A river type is 10 – 100 km^2 catchment area[7]. The smallest size range for a System A lake type is 0.5 – 1 km^2 surface area[8]. No sizes for small transitional and coastal waters are given. The application of system B must achieve, at least, the same level of differentiation as system A. It is therefore recommended to use the size of small rivers and lakes according to system A. However, it is recognised that in some regions where there are many small water bodies, this general approach will need to be adapted. Having said that, it may be appropriate to aggregate water bodies into groups for certain purposes as outlined in the horizontal guidance document o water bodies in order to avoid unnecessary administrative burden.

However, there are still large numbers of discrete rivers and lakes that are smaller than these thresholds. A possible approach for the protection of these waters is outlined in the horizontal guidance document.

Conclusions and recommendations

- "Surface water bodies" must not overlap with each other;
- A surface water body must not cross the boundaries between surface water body types;
- Physical features (geographical or hydromorphological) that are likely to be significant in relation to the objectives of the Directive should be used to identify discrete elements of surface water;
- A lake or reservoir will normally be identified as one water body. However, where different reference conditions apply within a lake due to morphological complexity (eg. sub-basins), the lake must be sub-divided into separate water bodies (see example in Figure 2). Furthermore, where there are significant differences in status in different parts of a lake, the lake must be sub-divided into separate water bodies to achieve the desired environmental outcome in the most cost effective way;
- A whole river, stream or canal can be a "water body". However, where different reference conditions apply within a river stream or canal, it must be sub-divided into separate water bodies. Furthermore, where there are significant differences in status in different parts of a river, stream or canal, it must be sub-divided into separate water bodies to achieve the desired environmental outcome in the most cost effective way;
- The lower size limit of surface water bodies may be set lower than the ones prescribed in typology system A (described in Annex II of the Directive) in certain cases, i.e. if Member States decide that certain smaller water bodies are significant and require separate identification. This is of specific ecological relevance for lakes.

[6] Annex II 1.2
[7] Annex II 1.2.1
[8] Annex II 1.2.2

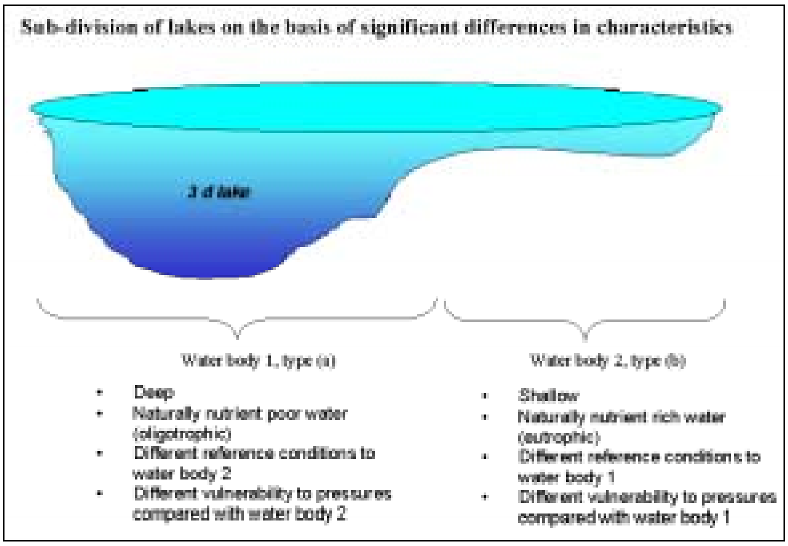


Figure 2. Sub-division of lakes on the basis of significant differences in characteristics (from the horizontal guidance on water bodies).

2.4 Wetlands

Excerpts from the Directive pertaining to wetlands:

Article 1

> *The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, which: prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems.*

Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in CIS horizontal guidance documents water bodies and further considered in guidance on wetlands.

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal guidance paper on wetlands.

2.5. Water body types

Excerpts from the Directive pertaining to water body types :
Annex II: 1.1 (ii)

> *For each surface water category, the relevant surface water bodies within the river basin district shall be differentiated according to type. These types are those defined using either "system A" or "system B" identified in section 1.2.*

Annex II: 1.1 (iv)

> *If System B is used, Member States must achieve at least the same degree of differentiation as would be achieved using System A. Accordingly, the surface water bodies within the river basin district shall be differentiated into types using the values for the obligatory descriptors and such optional descriptors, or combinations of descriptors, as are required to ensure that type specific biological reference conditions can be reliably derived.*

The Directive requires that Member States differentiate the relevant surface water bodies with respect to type and that Member States establish reference conditions for these types. The main purpose of typology is consequently to enable type specific reference conditions to be defined which in turn is used as the anchor of the classification system. The following guidance may be given relative to specific issues concerning types.

”System A” versus ”System B”
The two systems are about the same in that the same obligatory factors are to be used in both: geographic position, altitude, size, geology and, for lakes, depth. The difference is that System A prescribes how water bodies shall be characterised spatially (ecoregions) and with respect to specific altitude, size and depth intervals, and that System B, besides lacking this prescription, permits the use of additional factors. It is up to Member States to decide on what system to use, and most Member States have indicated that they prefer to use System B.

Degree of differentiation
The Directive requires that System B, if used, must achieve at least the same degree of differentiation as would System A. This is interpreted to mean that if System B is used, it should result in no greater degree of variability in type specific reference conditions than if System A had been used. Hence, if it can be demonstrated that the same or a lower degree of variability in reference condition values may be achieved with a lower number of types than would be derived using System A, this would be acceptable, since the purpose of typing is to establish reference conditions as precisely as possible. This comparison of “degree of differentiation” does not imply an obligation to compare one system with the other in great detail, but rather at a more general level based on existing data and expert judgement. What is important is that the established typology system assist in achieving an adequate confidence in reference conditions and the subsequent classifications.

Reducing variability
Member States must establish type-specific biological reference conditions for each quality element used for classification. Where the natural variability of a quality element in a type as a whole is much larger than the natural variability expected for it in any particular water body, Member States should be able to utilise a suitable reference value for the water body when interpreting monitoring results and calculating environmental quality ratios. The relevant reference value will be from within the range of values established for the type as a whole. The reference value arrived at in this way will be water body specific. The possibility to

revise the typology system or to exclude a quality element indicator showing large natural variability in reference conditions should also be considered (Annex II: 1.3 (vi)).[9]

Use of optional factors
Concerning optional factors, the interpretation of the Directive is that these are factors that may be included according to the choice of the user, who may very well also decide to use others than those suggested in the Directive.

Catchment geology
An interpretation is also needed with respect to the Directive's alternative descriptors of geology. The Directive is interpreted here to mean a relevant catchment area of the water body and to mean, in System A, the geology with the predominating influence of the water body. This is up to Member States to decide, depending on the circumstances.

Conclusions and recommendations

- Water body types may be differentiated using ”System A” or ”System B”;
- The two systems are similar in that they contain the same obligatory factors: Geographic position, altitude, geology, size and (for lakes) depth;
- Optional factors of System B can be used as desired by Member States and can be complemented with factors other than those mentioned in the Directive;
- The Directive´s descriptors of geology (in System A) refer to the dominating character (calcareous, silicious, etc.), expected to have the strongest influence on ecological quality of the water body;
- The Directive´s requirement that Member State must achieve the same degree of differentiation with System B as with System A is interpreted to mean that if System B is used, it should result in no greater degree of variability in type specific reference conditions than if System A had been used. Hence, if a lower number of types, using System B, results in equally low or lower variability of reference conditions values as would be given by System A, this would be acceptable;
- Water body specific reference conditions, within a range of values for the type as a whole, may be used in order to cope with natural variability within types.[10]

[9] It should be stressed that the Directive only requires type specific reference conditions to be established and that water body specific reference conditions only should be regarded as a complementary approach.
[10] See footnote 4.

2.6 Classification of ecological status

Excerpts from the Directive pertaining to ecological status:

Article 2(17):

> *"Surface water status" is the general expression of the status of a body of surface water, determined by the poorer of the ecological status and the chemical status.*

Article 2(21):

> *"Ecological status" is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V.*

The Directive requires surface water classification through the assessment of ecological status. Annex V, Table 1.1, explicitly defines the quality elements that must be used for the assessment of ecological status (see Table 2 below). Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used by Member States in the assessment of ecological status.

Annex V, Table 1.2, in the Directive provides a general definition of ecological quality in each of the five status classes. For each relevant quality element and a set of indicators, more specific definitions for ecological status at high, good and moderate status in rivers (Table 1.2.1) and lakes (Table 1.2.2) are given. These general and specific definitions are referred to as "normative definitions" (Table 1.2, 1.2.1 and 1.2.3 in the Directive and are listed in Annex C).

The specific hydromorphological quality elements are required for determination of high status. For other status classes the hydromorphological elements are required to have "conditions consistent with the achievement of the values specified [in Tables 1.2.1 and 1.2.2] for the biological quality elements."

The specific physico-chemical quality elements are required for determination of high and good status. For other status classes the physico-chemical elements are required to have "conditions consistent with the achievement of the values specified [in Tables 1.2.1 and 1.2.2] for the biological quality elements."

These relative roles of biological, hydromorphological and physico-chemical quality elements in status classification are presented in Figure 3.

Annex V, section 1.4.2. (i) Presentation of monitoring results and classification of ecological status and ecological potential

> *For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below.*

To classify ecological status, the Directive stipulates that the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements should be used (Annex V, 1.4.2. (i)). This implies, de facto, that Member States will need to establish methods/tools for assessing ecological status for both the biological and physico-chemical quality elements. Figure 3 illustrates that there are separate criteria in WFD Annex V, 1.2, for establishing appropriate ranges for physico-chemcial elements at high and good status. It can also be concluded that classification of ecological status should be on the quality element level, i.e. not on parameter level (the quality elements are listed in Table 2).

There is a clear distinction between the role of general physico-chemical quality elements and specific pollutants in classification of ecological status. In good ecological status, general physico-chemical quality elements should not reach levels outside the range established to ensure ecosystem functioning and the achievement of the values specified for the biological quality elements ((a) in the middle box in Figure 3) and specific pollutants should meet the Environmental Quality Standards (EQS) set in accordance with section 1.2.6 in the Directive ((b) in the middle box in Figure 3).

Once European EQS have been established, priority substances are not included in the ecological status, but are relevant for assessment of chemical status (Article 2, Annex X and Article 16(7) dealing with priority substances). For the purpose of assessing ecological status the quality elements for specific pollutants listed in Annex V, 1.1 and 1.2 ("specific synthetic pollutants" and "specific non-synthetic pollutants") must be considered and their national quality standards must be met[11]. Shifting of priority substances for which EU-wide quality standards have been set from ecological to chemical state assessment does not compromise the good status of a water body because for good status, both ecological and chemical status must be good.

The Expert Advisory Forum on Priority Substances will continue the discussion on these points in order to ensure a smooth transition from the current requirements to the upcoming proposals under Article 16 of the Water Framework Directive.

Annex V: 1.4.1 (ii). Comparability of biological monitoring results

> *In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.*

Classification of ecological status is to be based on ecological quality ratios, which are derived from biological quality values as illustrated in Figure 4. No EQR scheme or intercalibration exercise is envisaged in the Directive for classification of ecological status for the supporting physico-chemical quality elements. Member States need to develop their own methods/tools for assessing ecological status for these supporting elements (see above, and Figure 3).

The issue of how to use physico-chemical quality elements for classification of ecological status will be further developed within the work programme of the Common Implementation Strategy during 2003.

[11] Examples on how to select the specific pollutants that are relevant to a particular water body are described in the guidance document from Working Group 2.1 (IMPRESS).

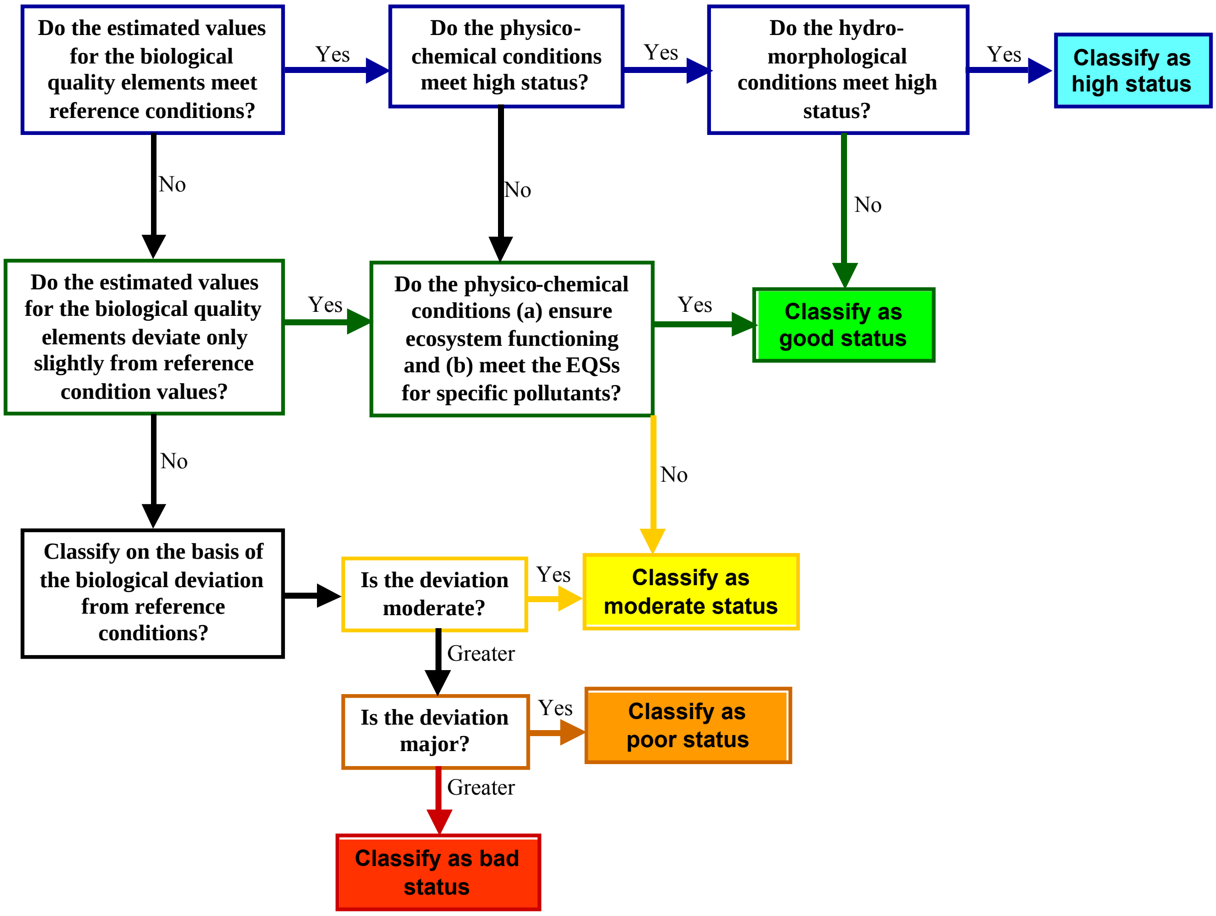


Figure 3. Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according the normative definitions in Annex V:1.2. A more detailed understanding of the role of physico-chemical parameters in the classification of ecological status will be developed in specific guidance on this issue during 2003.

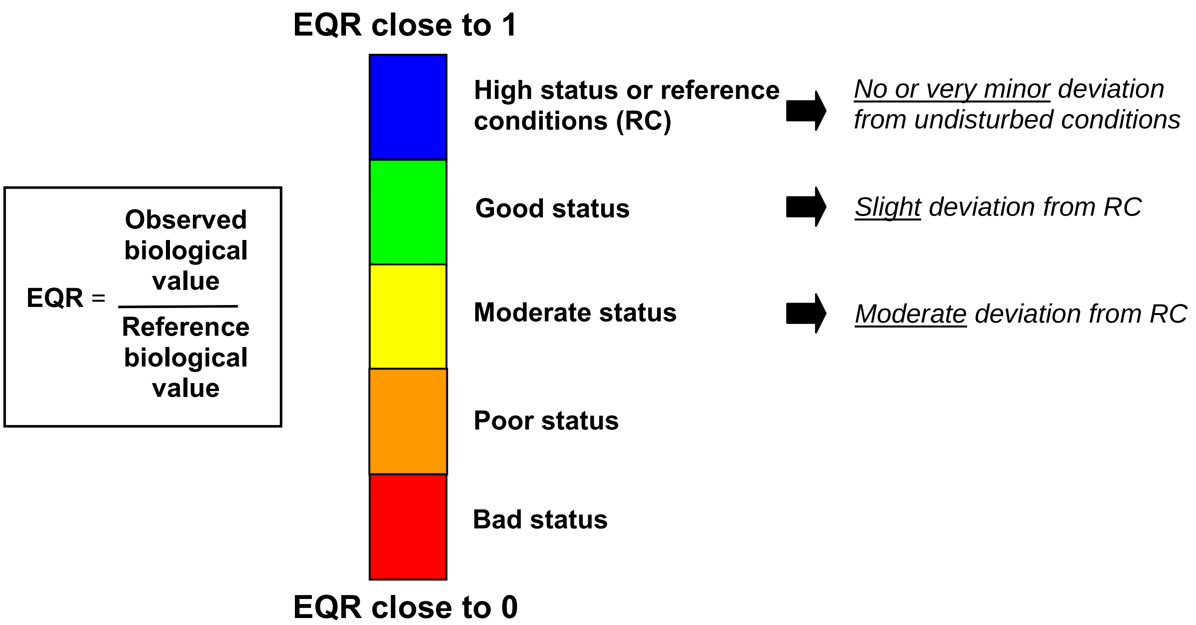


Figure 4. Basic principles for classification of ecological status based on Ecological Quality Ratios.

Table 2. Quality elements to be used for the assessment of ecological status based on the list in Annex V, 1.1, of the Directive.

Annex V 1.1.1. RIVERS	**Annex V 1.1.2. LAKES**
Biological elements	
• *Composition and abundance of aquatic flora*[12] • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*

Hydromorphological elements supporting the biological elements	
• *Quantity and dynamics of water flow* • *Connection to ground water bodies* • *River continuity* • *River depth and width variation* • *Structure and substrate of the river bed* • *Structure of the riparian zone*	• • *Residence time* • *Connection to the ground water body* • *Lake depth variation* • *Structure and substrate of the lake bed* • *Structure of the lake shore*

Chemical and physicochemical elements supporting the biological elements	

• *Thermal conditions*
• *Oxygenation conditions*
• *Salinity*
• *Acidification status*
• *Nutrient conditions*
• *Specific pollutants*
  • *pollution by priority substances identified as being discharged into the body of water.*
  • *pollution by other substances identified as being discharged in significant quantities into the body of water.*
	• *Transparency*
	• *Thermal conditions*
	• *Oxygenation conditions*
	• *Salinity*
	• *Acidification status*
	• *Nutrient conditions*
	• *Specific pollutants*
	  • *pollution by priority substances identified as being discharged into the body of water.*
	  • *pollution by other substances identified as being discharged in significant quantities into the body of water.*

Conclusions and recommendations

- The normative definitions of the Directive (Annex V, Table 1.2) provide the basis for classifying surface waters according to their ecological status and each Member State must develop classification systems that conform to these status definitions;

[12] Phytoplankton is not listed as a quality element in rivers in Annex V, 1.1.1., but is included as a quality element in Annex V, 1.2.1. It should therefore be possible to use phytoplankton as a separate quality element, if needed and appropriate especially in low land large rivers where phytoplankton may be important.

- Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used by Member States in the assessment of ecological status (relative roles illustrated in Figure 3);
- Ecological status classifications should be made on the basis of the relevant biological and physico-chemical results, and classification should be made using quality elements and not parameters;
- The ecological status is represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements. The practical implementation is to be developed within the work programme of the Common Implementation Strategy during 2003;
- Classification of ecological status is to be based on ecological quality ratios, which are derived from biological quality values as illustrated in Figure 4, and on the Member States assessments of ecological quality for physico-chemical quality elements;
- No EQR scheme is envisaged in the Directive for classification of ecological status based on physico-chemical monitoring results. Member States will apply their own methods/tools for assessing ecological quality for these quality elements (see above);
- No definitions are given in the Directive for physico-chemical or hydromorphological quality elements in poor and bad status;
- All Issues relating to how to use physico-chemical quality elements for classification of ecological status will be further developed within the work programme of the Common Implementation Strategy during 2003.

Section 3. General guidance on principles and methods for establishing reference conditions and ecological status class boundaries

3.1 Overview – a stepwise approach

The establishment of reference conditions and the establishment of ecological quality class boundaries are closely interconnected. To establish the boundary between high and good ecological status it is necessary to identify conditions representing very minor anthropogenic disturbances. To establish the boundary between good and moderate ecological status it is necessary to identify conditions corresponding to slight anthropogenic disturbances. Both the establishment of reference conditions and the setting of class boundaries are dealt with in this chapter.

Figure 5 schematically shows a number of steps that may be taken to establish reference conditions and ecological class boundaries. Reference conditions and ecological class boundaries must be established by Member States for all surface water body types and all relevant quality elements. Member State's classification systems will also be compared in the intercalibration exercise (Annex V: 1.4.1), and the outcome of this intercalibration will be used to set the class-boundaries.. This means that the process of intercalibration is closely interrelated with the process of establishing reference conditions and quality class boundaries. The process of intercalibration is described in a separate guidance document.

The different steps in the approach outlined in Figure 5 are described in the following sub-sections of Section 3.

The suggested approach for establishment of reference conditions and ecological quality class boundaries involves several technical considerations that might not be transparent to the public, water users and stakeholders. These considerations are, however, crucial for the judgement of the risk that individual water bodies will fail to reach the overall objective good water status by 2015. It is therefore important to involve the public, water users and stakeholders at an early stage in order to reach acceptance for the quality class boundaries finally set. It is also in line with Article 14 in the Directive to involve all interested parties in the implementation of the Directive.

The guidance document on "Public Participation", produced by a sub-group within Working Group 2.9 (Best practices in river basin management) will tell more about these forms of participation. In short the Directive mentions the following:

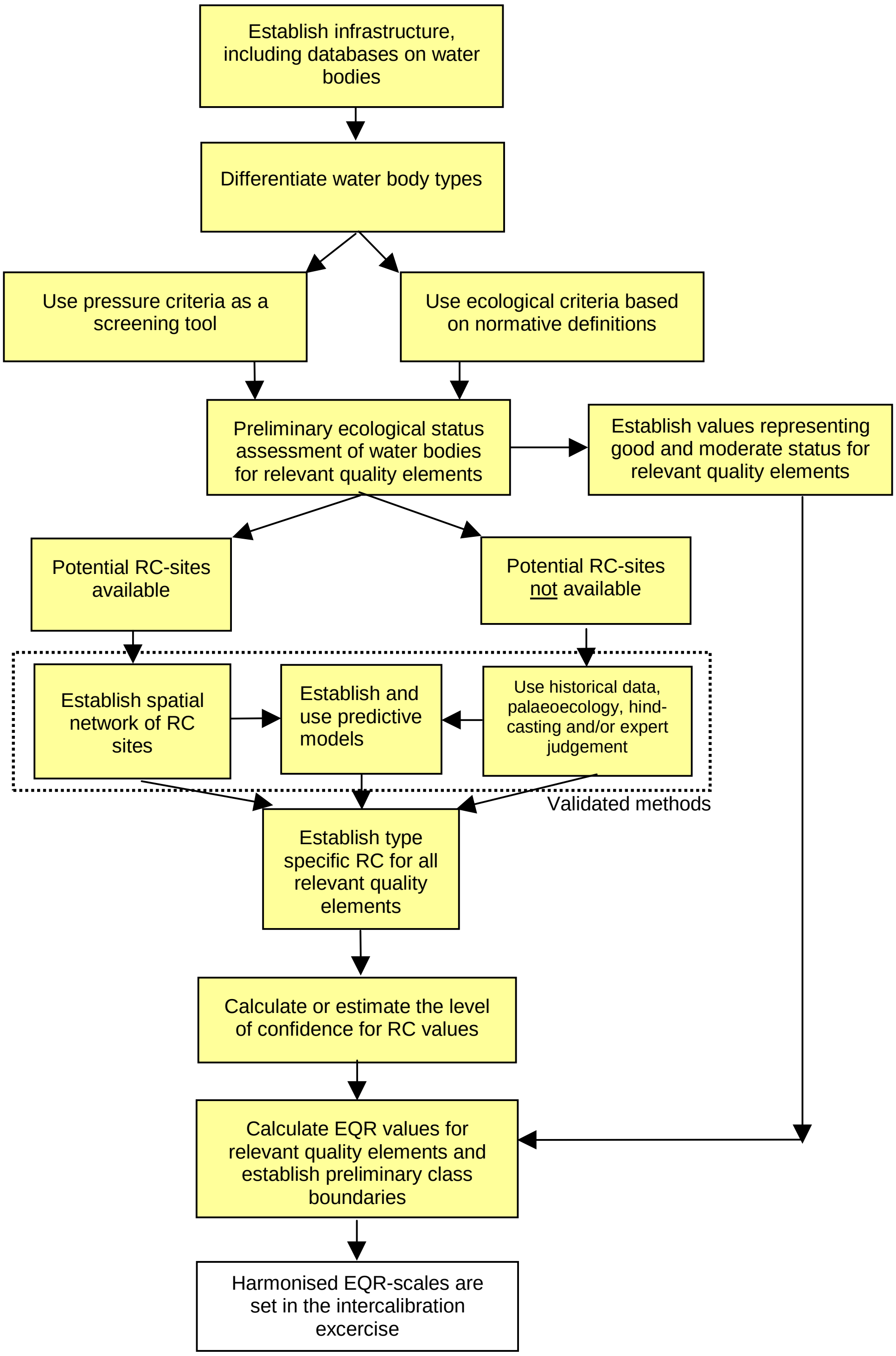


Figure 5. Flow-chart of the suggested step-by-step approach for establishing reference conditions and boundaries between high, good and moderate ecological status classes (RC=reference conditions, EQR=Ecological Quality Ratio).

Article 14 promotes the active participation of all interested parties in the development of River Basin Management Plans, and requires Member States to inform and consult the public. Stakeholder participation is important as it can fulfil many functions:

- Developing a process agreed by all will increase the legitimacy of its outcome;
- Stakeholders can be a useful source of information and have expertise of direct use for the reference condition analysis (see Table 1 in Annex G);
- Surveys of the public can be useful to understand how people value improvements in the environment and quality of our waters, and how far they are ready to pay for environmental improvements;
- Public involvement and the network of partners developed through participation can be useful to develop a sense of ownership over the River Basin Management Plans and may increase the effectiveness of measures taken to meet the Directive's objectives.

The Directive only specifies key dates for consultation, but rightly does not specify dates for the participation process, as this will depend on local institutions and socio-reference condition set-up. However, it will be important to start the participation process early (e.g. as part of the characterisation of the river basin before 2004) to improve its effectiveness.

See also Annex G at the back of this document showing who needs to get involved in carrying out and using the REFCOND guidance.

3.2 Need for infrastructure

Paramount to the implementation of the directive is an infrastructure at the national as well as the water district level consisting of:

- Expertise;
- Databases;
- Assessment methods, models and other tools;
- Organisational structure.

If a robust infrastructure is not available, it would initially be important to set up a group of experts including, for matters relating to reference conditions and classification, ecological, chemical, hydrological, and statistical expertise as well as expertise on modelling, GIS and databases.

Databases are needed for the identification of relevant water bodies and characterisation of relevant pressures and ecological status, and subsequently for unconstrained implementation of the Directive. State variables would be those required in the Directive for characterisation and classification of water bodies (Annex II and V) plus optional variables suggested in the directive or other variables preferred by Member States (see section 3.3). Pressure variables would include measures of land-use, point source discharges, hydromorphological alterations, etc (see section 3.4).

Assessment methods, models and other tools should include (i) models for determining point-source and diffuse loadings of nutrients, metals and other substances, (ii) methods for determining biological state variables, and (iii) GIS applications.

The *organisational structure*, finally, will vary depending on the circumstances in Member States, and in many cases it will require a great effort of co-ordination among responsible authorities and stakeholders.

3.3 Differentiation of water body types

The Directive requires that Member States differentiate the relevant surface water bodies with respect to type (using either ”System A” or ”System B”.) and then establish reference conditions for these types. In the following section guidance is given on the use of System A and B. Interpretations and clarifications regarding concepts and terms are given in section 2.5.

Of the two systems prescribed in the Directive, System A is the most straightforward and simplest to implement. One clear disadvantage of System A is that the classes established may not adequately partition the variability of the quality elements used, resulting in poor detection of ecological change. Given the inflexibility of System A, most Member States are likely to use System B as a basis for characterising water body types.

System B provides, as indicated above, greater flexibility in defining water body typologies. Implementation of System B should contain both the obligatory factors given in Annex II:1.2 of the Directive and other relevant factors deemed useful by the Member State for minimising quality element variability.

Based on the data-availability, types may be delimited using various grouping procedures; these may be based on commonly used clustering techniques or more intuitive (expert opinion) methods. Statistical methods are also available for determining if “groups” differ from one another (e.g. using randomisation techniques) and if among-group variance can be adequately explained (e.g. using discriminant analysis). The objective of establishing typologies is to partition among-group variance to better detect ecological change.

Unlike the guidance document on transitional and coastal waters no common European typology system is proposed for inland surface waters. One reason for this difference is the apparent need for a common typology of coastal waters shared between countries. In contrast to coastal and transitional waters, a number of Member States presently use typology systems for inland surface waters.

Member States sharing the same (eco)region may, however, initiate activities to harmonise typology for inland surface waters on the most appropriate (eco)regional scale as soon as possible or latest in early 2003. This harmonisation should at least cover the types selected to be included in intercalibration and will help in the selection of sites to be included in the draft register for intercalibration network during 2003.

The suggested procedure and timetable for the development of (eco)region specific surface water body typologies to be used for selection of types and sites to be included in the intercalibration exercise is further outlined in Annex F.

Conclusions and recommendations

(Partly repeated, for the sake of clarity, from section 2.5)

- Water body types may be differentiated using "System A" or "System B";
- The two systems are similar in that they contain the same obligatory factors: geographic position, altitude, size, depth (for lakes) and geology;
- Optional factors of System B can be used as desired by Member States and can be complemented with other factors;
- A data base including, at the least, values of the obligatory factors for relevant water bodies is a prerequisite for differentiation of water body types;
- System A is simple and easy to adopt but has the potential disadvantage of giving a lower level of precision of reference values;
- Using System B, types may be differentiated using various mathematical-statistical clustering methods, regional classifications or more intuitive methods, including expert opinion.

3.4 Use of pressure criteria and ecological criteria

It follows from the Directive that ecological criteria are the definitive test of high ecological status (Annex V:1.2). However, the use of both ecological and pressure criteria may be the most efficient way for screening of potential reference sites or values or needed to aid in at least a preliminary assessment of status of waters. Indeed, to establish reference conditions it could be most cost-effective to start with pressure criteria, because the reference community is defined as the biological community expected to occur where there is no or only very minor anthropogenic disturbance. In other words, to avoid circularity (see section 3.6.1), pressure criteria may be used conveniently to screen for sites or values representing potential reference conditions. Once identified, biological elements should be used to corroborate this ecological high status.

Figure 6 shows how ecological and pressure criteria may be used (i) for determining potential reference sites or values and setting class boundaries between high and good ecological status, (ii) for determining potential sites for the intercalibration network, and (iii) for identifying bodies at risk of failing to achieve the Directive's objectives. Focus here is on how ecological and pressure criteria may be used for delineating potential reference sites or values and setting class boundaries. However, the approach outlined in Figure 6 may also be used to establish the class boundaries between good and moderate ecological status. Good status is defined in ecological terms as slight deviation from the expected biological reference condition. The setting of class boundaries should however explicitly incorporate the normative definitions for the ecological criteria as stipulated in the Directive (Annex V 2.1). In other words, while pressure criteria might be a proxy measure for assessing risk or screening for sites or values, their role in defining good status is secondary. Ultimately, as mentioned above, it is the biological data assessed against the normative definitions in Annex V 2.1, which will definitively assign water bodies to status classes.

For pressures and quality elements where critical loading models are established (i.e. phosphorus and phytoplankton, or acid rain and fish), pressure criteria can be used to estimate values for the related biological quality element. If the response of the biological quality element is in accordance with the normative definitions for good and moderate status, the values for the biological quality element corresponding to the critical load value can be used to set the border between good and moderate status for that element.

3.4.1 Setting a benchmark for very minoralterations

With regard to the definitions of high and good ecological status given in the Directive, it is necessary to come to a view on the spatial or temporal benchmark to set in respect of anthropogenic pressures so that appropriate comparison against the current condition of water bodies can be made across all Member States.

This allows a determination of whether current conditions in any water body equates to reference state or if a prediction of reference state will be required. The following benchmark for high ecological status or reference conditions is suggested:

- High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemistry, hydromorpology and biology.

This implies that there should be no fixed temporal and spatial benchmark but raises the problem of not knowing what we are accepting as the degree of change in an anthropogenic pressure that is incorporated into the concept of reference condition.

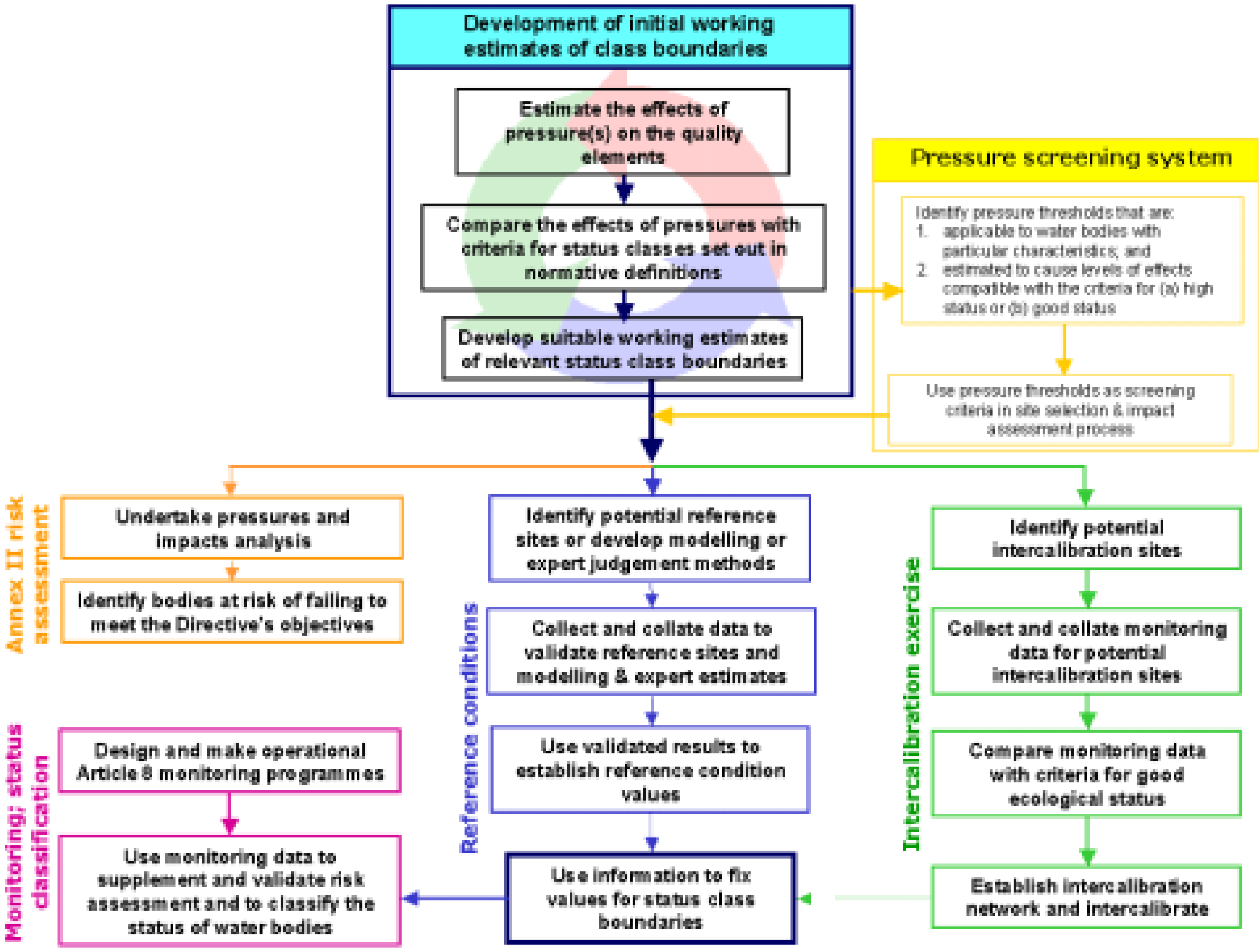


Figure 6. The respective roles of pressure criteria and ecological criteria in identifying status classes.

Bearing in mind the Directive's requirement that reference condition should represent totally, or nearly totally, undisturbed condition but also assuming that an absolutely pristine, post-glacial state is not realistic, then it is proposed that a flexible temporal benchmark as suggested above best fits the legislative intention. However, the temporal benchmark need not be coincidental for each pressure - merely chosen such that reference conditions can be adequately described.

If a water body was physically modified in the past the following recommendations are given:

- If the water body has changed category (e.g. a river impounded by a dam to form a lake) and can therefore be considered for designation as a heavily modified water body, it cannot be used as part of a network of sites for deriving spatially based type-specific reference conditions (e.g. as a reference site for lakes) under Annex II (1.3) of the Directive (see Guidance on heavily modified and artificial water bodies);

- If a water body has changed neither category nor type and the biology shows no or only minor changes, the water body can be considered as a reference site (e.g. kettle hole lakes in Northern Europe which have been artificially increased in size);

For current uses, for example water abstraction, guidance is provided on the degree of acceptable change (ie. with negligible effect on ecological structure and functioning) within the reference condition. This should be qualified in each case by the over-riding requirement to demonstrate no or only very minor ecological change (see tool 1 in the Toolbox section).

3.4.2 Pressure criteria as a screening tool

To facilitate the assessments of status classes, the basic process outlined in Figure 6 can be used to identify generic pressure thresholds (or criteria), which, for any water bodies with a specified set of characteristics, would be expected to result in effects that are compatible with a particular status class. These thresholds can then be used to help screen water bodies in order to identify potential reference sites or values, intercalibration sites or bodies that can be confidently identified as not at risk or at risk of failing to achieve their objectives. Critical loads for acid deposition are an example of such thresholds, although the ecological effects they reflect need to be validated with the criteria relevant to the boundary between good and moderate ecological status.

Tool no 1 in the Toolbox section suggests a set of criteria which elaborate on the degree of acceptable change in an anthropogenic pressure, that would provide the limits of reference condition sites or values and, hence, be used as a screening tool. However, if no or only very few reference sites are available, it would be advisable to consider use of reference state sites in unaltered parts of water bodies elsewhere slightly altered, or use of sites that are altered only regarding certain biological elements. The existence of only minor alteration for all biological elements (relevant for the type) is, however, a prerequisite for the definition of reference sites. Such sites can, accordingly, not be treated as "true" reference sites even if data for a specific quality element is used for establishing reference conditions.

Different water body types will respond differently to one and the same pressure. The proposed pressure screening criteria should therefore be regarded as illustrating concepts and principles to be used for developing water body type specific pressure screening criteria. A prerequisite for the use of pressure screening criteria is that the relationship between pressure-state-impact is established and that the state correspond to the normative definitions in the Directive (Annex V: 1.2).

3.4.3. Use of ecological criteria

Although the ecological status definitions must be used as the firm basis for establishment of classification systems by Member States (Annex V: 1.2), it might be considered useful to provide some further practical guidance on how such definitions can be developed into more quality element specific descriptions of expected ecological conditions at high, good and moderate status.

The development of robust ecological criteria requires further work beyond this guidance document and it is recommended that this should be given high priority. An indicative approach has been provided for the biological quality elements as interim guidance (Tool 2 in the Toolbox section) but it should be noted that this approach may not be suitable for all types and all pressures. Certain pressures may induce specific needs for ecological status assessment and the choice of parameters may need adjustment according to type and also to prevailing monitoring systems.

With the exception of fish[13] no specific guidance is given in the directive as to the level of taxonomic resolution that is required for the purpose of the characterisation of the biological communities at reference condition and for the derivation of the interpretations of the status of these communities at the various quality classes. Depending on type of water body and pressure, different levels of taxonomic resolution might be necessary to achieve a sufficient level of confidence in classification. Even if it is not required by the Directive, a consensus on the level of taxonomic resolution will be beneficial between Member States sharing similar water body types in the intercalibration exercise, at least concerning data provided for intercalibration.

3.5 Methods for establishing reference conditions

According to the Directive reference conditions need to be established for water body types and quality elements which in turn are represented by parameters indicative of the status of the quality elements. Quality elements may however be excluded from the assessment procedure, and hence establishment of reference conditions is not necessary, if they display high degrees of natural variability (see section 3.7). In addition, it may be difficult to establish type-specific reference communities for all quality elements with acceptable precision. However, certain biological quality element indicators, such as taxa richness or the presence of sensitive taxa, may be less variable than others (e.g. community composition) and hence more reliably inferred (e.g. if few reference sites are available). Furthermore, it should be emphasised that the reference conditions should be established for the same quality element indicators that will be used for the classification of ecological status.

The basis for the identification of reference conditions is given in Annex II, 1.3 in the Directive. Without any specific ranking of the methods the main options for establishing reference conditions are:

- Spatially based reference conditions using data from monitoring sites;
- Reference conditions based on predictive modelling;

[13] For fish quality elements the Directive (Annex V 1.2.1 – 1.2.2) specifically referes to species.

- Temporally based reference conditions using either historical data or paleoreconstruction or a combination of both;
- A combination of the above approaches.

And where it is not possible to use these methods, reference conditions can be established with expert judgement.

A short description of a number of methods commonly used to ascertain reference conditions is given below. It should be noted that establishing reference conditions for many quality elements may involve using more than one of the methods described below.

3.5.1 Spatially based reference conditions

If undisturbed or minimally disturbed sites are available and numbers are adequate for determining a reliable measure of mean, median or mode and distribution of values (percentiles, confidence limits), then the use of survey data is one of the most straightforward methods available for establishing reference conditions. This is done a priori by collection of data from reference sites only, by using inclusion/exclusion criteria for delineating a reference population. One of the reasons that spatially based or survey approaches are commonly used is that they can be designed to include natural (both spatial and temporal) variability. For example, in establishing reference communities using field surveys, water body and site stratification (e.g. by size, altitude, substratum, etc) should insure adequate representation and precision of distinctive ecosystem types. In addition, the importance of temporal variability can be dealt with directly if among-year variability is measured. A disadvantage of this approach is that spatially extensive data sets are needed to cover the inherent variability within all water body types.

3.5.2 Reference conditions based on predictive modelling

When adequate numbers of representative reference sites are not available in a region/type, predictive modelling, using the data available within a region/type or “borrowing” data from other similar regions/types, can be used in model construction and calibration.

One of the advantages of using predictive approaches is that the number of sites needed for reliable estimates of mean or median and error are usually lower than those needed if spatial approaches are used. This usually results in fewer sites that need to be sampled, and lower implementation costs. A second advantage of using predictive approaches is that the models can often be “inverted” to examine the likely effects of mitigation measures. It must be stressed that predictive models only are valid for the ecoregion and water body type they are created for.

3.5.3 Temporally based reference conditions

Temporally based reference conditions may be based on either historical data or paleoreconstruction, or a combination of both approaches. Both of these approaches are commonly used in areas where human-induced stress is widespread and unperturbed references are few or lacking entirely. For example, paleoreconstruction of past conditions may be determined either (i) directly, based on species presence/absence from fossil remains or (ii) indirectly, using relationships between fossil remains and inference to determine other values such as the reference pH situation. One of the strengths of a paleo-approach is that it can often be used to validate the efficacy of other approaches if the conditions are stable. Another advantage is that recent step-changes in ecological status are more easily determined.

A third strength of palaeoreconstruction is that if strong relationships exist between land use and ecosystem composition and function, a predictive approach (hindcasting or extrapolating dose-response relationships) may be used to predict quality elements prior to major alterations in land use (e.g. pre-intensive agriculture).

Both of these approaches share, however, some of the same weakness. They are usually site- and organism-specific, and hence may be of limited value for establishing type-specific values. Regarding palaeoreconstruction, caution should also be exercised in unequivocal reliance on this method as providing the definitive value, as choice of the calibration dataset used to infer ecological status may result in different values. Regarding the widespread use of historical data, it may be limited by its availability and unknown quality.

3.5.4 Establishing reference conditions using expert judgement

Expert judgement usually consists of a narrative statement of expected reference condition. Although an expert´s opinion may be expressed semi-quantitatively, qualitative articulation is probably most common. Use of expert judgement may by warranted in areas where reference sites are lacking or few. However, one of the strengths of this approach is that it may also be used in combination with other methods. For example, expert judgement may be used to extrapolate findings from one quality element to another (i.e. paleoreconstruction using fossil diatom remains may be used to infer invertebrate community composition) or to extrapolate dose-response relationships to those expected in unperturbed sites. Another strength of this approach is that both empirical data and opinion can be amalgamated with present-day concepts of ecosystem structure and function.

However, as a number of weaknesses are inherently associated with this approach, caution should be exercised when using this approach as the sole means of establishing reference condition. For example, subjectivity (e.g. the common perception that it was always better in the past) and bias (e.g. even sites with low diversity can be representative) may limit its usefulness. Other drawbacks include the lack of clarity or low degree of transparency in assumptions used to establish reference and the lack of quantitative measures (e.g. mean or median values) for validation. A further weakness of this (and many other approaches) is that the measure obtained is often static, and hence does not include the dynamic, inherent variability often associated with natural ecosystems.

3.5.5 Concluding remarks

Many of the above approaches may be used either singly or in concert for establishing and/or cross-validating reference condition. Knowledge of the inherent strengths and weaknesses of the various approaches or the potential problems associated with using different methods is, unfortunately, weak and fragmentary. A summary of the strengths and weaknesses with different methods is presented in Table 3. Regardless of the approach(es) used to establish reference condition, the variability (or errors) associated with the method(s) should be estimated.

In areas where human-generated disturbances are low or not widespread (e.g. in the Nordic countries), spatial approaches may be used either singly or in concert with predictive modelling to establish potential reference conditions for the quality elements. In contrast, in areas that are/have been strongly affected by single or multiple pressures, identification of potential reference conditions may require a suit of methods and substantial validation.

Table 3. Strengths and weaknesses of a few approaches commonly used to determine reference condition.

Approach	**Strengths**	**Weaknesses**
Spatially based using survey data	Region specific	Expensive to initiate
Predictive modelling	Site-specific	Requires data, calibration and validation
Historical data	Often inexpensive to obtain	Variable data, few parameters and data quality may be poor or unknown, static measure
Palaeoreconstruction	Incorporates both physico-chemical and biological data	Basically limited to lakes, high initial costs
-Direct	Site-specific	Few parameters
-Indirect	Calibration models currently available for modelling a number of stressor variables; pH, total phosphorus and temperature reconstructions	
Expert opinion or best judgement	May incorporate both historical data/opinion and present day concepts	Bias may be present

3.6 Validation of reference conditions and ecological class boundaries

Knowledge of the variability or uncertainty associated with establishing reference conditions and setting ecological class boundaries is a crucial step in the process of determining the ecological status of water bodies. Clearly, estimating the errors associated with ecological banding schemes and validation of reference conditions are important steps. An intercalibration exercise will be facilitated by the Commission in accordance with Annex V, section 1.4.1, in the Directive. This exercise will calibrate the class boundaries established by the Member States. As there is a guidance document available on intercalibration this section will focus more on validation of reference conditions.

3.6.1 Minimise risk of circularity

To minimise risk of circularity in establishing reference conditions, ideally mainly physico-chemical, hydromorphological and pressure criteria (i.e. community driving forces) should be used in a first step. Inclusion of biological quality elements in this first step of screening for potential reference sites or values may introduce bias (e.g. different persons/experts may have different perceptions of what reference conditions represents) and circularity (i.e. use of the same variable to delineate and validate reference condition). There will also be a risk that naturally occurring rare water body types (e.g. naturally nutrient poor, low diversity water bodies) will not be detected. In practice, however, it is likely that Member States may have to resort to using all data currently available (including biological data), to initially identify potential reference sites or values. If biological quality elements are used in this initial stage, it is important that additional biological data (e.g. for other quality elements) is collected to verify the final identification of a site as a reference.

If a water body fulfils the requirements for reference conditions in this first step, biological reference conditions can then be established in the next step. The suggested procedure can be described as follows:

- Find sites at which on the basis of all the identified pressures, the physico-chemical, hydromorphological and biological quality elements are believed to be subject to no more than minor disturbance. Use Tool 1-2 in the Toolbox section for this initial risk assessment;

- Sample the biological quality elements to see if they appear to be only affected, if at all, by minor alterations to the physico-chemical and hydromorphological quality elements. If sampling shows that a biological value is more disturbed than predicted by the risk assessment, further investigation of possible pressures and their effects should be undertaken (i.e. refinement of the risk assessment);

- If sites deviate from what is expected to occur under reference conditions, but no known human-generated pressures are evident, removal of these sites should be considered. Care should, however, be exercised as these sites may indicate the true, natural, variability expected to occur.

3.6.2 Secure documentation

As part of the decision-making process, it is important to document how the values representing reference conditions and ecological quality class boundaries have been established. Likewise, the steps taken to validate reference and class boundaries need to be documented in detail.

3.6.3 Validation of methods

Since different methods used to establish reference conditions most likely have different inherent errors, some form of validation procedure needs to be performed. Clearly the main issue is to determine whether the reference values obtained can be used to achieve robust classifications of ecological status (see section 3.7). When several methods have been used for establishing reference conditions, they should be compared, if possible, using the same quality element(s). If the outcome of this comparison is that there is a significant difference between the different methods there has to be an expert judgement on how to set the value.

3.7 Assessing variability in reference conditions

The Directive requires a "sufficient level of confidence about the values for the reference conditions" regardless of which method is used for establishing reference conditions (Annex II, 1.3). Adequate confidence and precision in the classification of the quality elements is an other statistical requirement mentioned in the Directive (Annex V, 1.3).

Neither "sufficient level of confidence about the values for the reference conditions" nor "adequate confidence and precision in the classification" is specified in statistical terms in the Directive. It is, consequently, up to the Member States to decide about this definition, taking into account the natural spatial and temporal variability for different quality elements together with errors associated with sampling and analysis.

The Directive´s requirements about confidence levels require relevant databases including data of several years for a good temporal variations appraisal. Such databases will, however, not be necessarily available for the first River Basin Management Plan publication in 2009. So, the databases have to be improved during the first RBMP implementation and at the latest 3 years after the first RBMP publication to be able to consider in 2015 if the WFD targets have been failed or fulfilled on sufficient statistical basis.

Methods for establishing reference condition and setting class boundaries must include an estimate of error. This information is needed to determine the confidence and precision in status classification. For example, estimates of a biological reference condition will incorporate the natural (i.e. real) variability of the quality element in time and space and the errors in the method of estimation.

3.7.1 Sources of errors

A multitude of factors can affect measurement uncertainty and confound interpretations using biological parameters. The most common errors are related to measurement and include errors associated with sampling effort and sample processing. The importance of natural variability can also vary among organism groups. For example, small organisms such as those making up the phytobenthos community may change markedly over a period of weeks, whereas macrophyte and fish communities may have much longer response scales (e.g. years). An understanding of how uncertainty is related to different methods is needed to better interpret humans-induced deviations from those naturally expected to occur.

Regardless of the method used to establish reference condition, it is important to estimate the errors that are inherently associated with the method used and how levels of uncertainty relate to specific quality elements. Errors can be intrinsically related to different quality elements, and different methods used to establish reference condition can vary in accuracy and precision. For example, paleoreconstruction is probably more precise than spatially based approaches in reconstructing reference conditions of specific sites. This approach may, however, be less accurate than methods that provide estimates of mean or median values. For example, if the site measured is not representative of the type-specific population, and if an adequate number of sites are not measured to obtain reliable measures of mean or median (e.g. for regional patterns), this method can be less accurate than other methods.

The sources of uncertainty in the observed biological quality fall roughly into the following categories:

- **Sampling errors (natural spatial variation).** Within each site/water body there will be spatial heterogeneity in the microhabitats. This means e.g. that taxonomic richness and composition will vary between samples taken during the same period;
- **Sample process errors.** When e.g. sorting the material in a new macroivertebrate sample and identifying the taxa, some taxa may be missed or misidentified. This may lead to underestimation of the EQR-value for number of taxa at the site;
- **Analytical errors.** For chemical quality elements the errors associated with different analytical techniques may vary for the same substance;
- **Natural temporal variation**. The taxa present at a site will vary naturally over time.

3.7.2 Choice of quality element indicators

The indicators used in establishing reference conditions and the subsequent classification must enable significant impacts to be reliably detected and recorded through the assignment of an ecological status class. Indicators that do not do this will be unsuitable.

The selection of indicators will be an iterative process, requiring consideration of the factors described below.

- **Relevance**. An indicator should indicate the condition of the quality element. It should be capable of indicating the effects of pressures, and thus represent the response of the quality element to pressures;
- **Responsiveness**. Different indicators may be sensitive to different pressures. The use of different indicators for the same quality element may be appropriate depending on which pressures are affecting a water body;
- **Range of sensitivity**. Indicators may detect effects over a range of pressures but reach their maximum response at a low level of pressure (e.g. a sensitive species may disappear). It may be necessary to use one set of indicators for the lower classes and another for higher classes;
- **Ability of Member States to estimate reference values**. Values for some indicators may be more easily estimated than others. For example, where there are no sites at reference condition, other options may be to borrow sites from neighbour regions or states, use historical data, modelling or expert judgement to estimate reference conditions for some indicators.;
- **Variability**. Indicators whose natural variability is high and poorly understood are likely to be unsuitable. Indicators measured by methods that produce large sampling

and analysis errors, or for which the size of the sampling and analysis errors has not been quantified, are also likely to be inappropriate;

- **Confidence**. Indicators should be selected so that there is good and demonstrable confidence and precision in classification of ecological status. If confidence is low, the range of uncertainty in the value of the quality element may span the boundaries of several or all the classes. This will result in random allocations of status class and false indications that class has changed.

If the risk of misclassification is too large, more than one indicator may be used to estimate the value of the quality element. In such cases, the number of indicators, and the means by which the data for these are combined, should be such as to achieve the required degree of confidence in the estimate for the quality element.

3.7.3 Exclusion of indicators and quality elements

The reference value for each indicator should be identified, including an estimate of the variance associated with it. The variance should be estimated so that a decision can be taken as to whether the indicator can be used to achieve reliable classification. If the variance is too high, reliable classification will not be possible and the indicator should not be used. One reason for excluding a specific quality element from assessment of ecological status is that the natural variability is too large. This would mean that the natural variability is too high for all relevant quality element indicators. This exclusion principle is described in the Directive in the following way:

Annex II 1.3 (vi) Establishment of type-specific reference conditions for surface water body types:

> *Where it is not possible to establish reliable type-specific reference conditions for a quality element in a surface water body type due to high degrees of natural variability in that element, not just as a result of seasonal variations, then that element may be excluded from the assessment of ecological status for that surface water type. In such circumstances Member States shall state the reasons for this exclusion in the River Basin Management Plan.*

3.8 Setting EQR-based class boundaries

Excerpts from the Directive pertaining to setting quality class boundaries is given in the following sections of the Directive:

Annex V: 1.4.1 (ii). Comparability of biological monitoring results

> *In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.*

Annex V: 1.4.1 (iii)

> *Each Member State shall divide the ecological quality ratio scale for their monitoring system for each surface water category into five classes ranging from high to bad ecological status, as defined in Section 1.2, by assigning a numerical value to each of the boundaries between the classes. The value for the boundary between the classes of high and good status, and the value for the boundary*

between good and moderate status shall be established through the intercalibration exercise described below.

Annex V: 1.4.1 (iv)

The Commission shall facilitate this intercalibration exercise in order to ensure that these class boundaries are established consistent with the normative definitions in Section 1.2 and are comparable between Member States.

Annex V: 1.4.1 (vi)

Each Member State monitoring system shall be applied to those sites in the intercalibration network which are both in the ecoregion and of a surface water body type to which the system will be applied pursuant to the requirements of this Directive. The results of this application shall be used to set the numerical values for the relevant class boundaries in each Member State monitoring system.

3.8.1. Options for setting class boundaries

Based on theoretical considerations and the experience from EQR-based classification systems currently used in Member States, the following guidance may be given on alternative options for setting class boundaries. These alternatives are further elaborated in tool 3 in the Toolbox section. It should be noted, that whereas Member States may set their own class boundaries, harmonisation within a European scale will be achieved through the intercalibration procedure.

The suggested options for setting class boundaries need to be further developed and tested in Pilot River Basins and future work of the Common Implementation Strategy during 2003-4.

Within each of the alternative options A, B and C below, several alternative methods may apply (e.g. different statistical measures). It is recommended to use the method considered most relevant for the available data set.

A. With access to sufficient data from sites or historical records, derived as described in sections 3.4-3.7, class boundaries may be set as follows for an individual quality element indicator[14]:

1. Establish a suitable summary statistic (e.g. median value or arithmetic mean) of the values pertaining to reference conditions or high status – the reference value[15].

2. Divide the values pertaining to reference conditions (or high status) by the reference value, thus creating a set of normalised values pertaining to reference conditions (or high status). These values are ratios between observed values and the reference value, and as such potential EQR values for the borderline between high and good status.

[14] Note: Class boundaries will have to be developed for each quality element indicator

[15] The mean or median value from the distrubution of reference site values are considered the most rubust values to be used as the reference value in classification of ecological status (relatively few data/sites needed for sufficient confidence in RC). One disadvantage with using the mean or median value as the reference value is that many reference sites will fall outside the range 0-1 (>1). However, if sufficient amount of data from the reference population exist a high percentile (eg. the 75th, 90th or 95th percentile) may be used as the reference value. This would reduce the problem of many reference sites lying outside the range 0-1. On the other hand, reference values established this way will be very much influenced by extreme values. The conclusion is that the mean or median values from the reference site/data population is considered the best staring point when establishing the classification schemes for ecological status.

3. Invert the normalised values if the nominal values increase toward the "bad end" of the scale. This is necessary in order to achieve a final scale that descends from 1 to 0, as required by the Directive.

4. Select a suitable statistic among the normalised values to represent the class boundary between high and good status, e.g. the 10th percentile.

5. Repeat step 2 (and if necessary 3) for values pertaining to good status, i.e. divide by the reference value and (if necessary) invert.

6. Select a suitable statistic among the normalised values arrived at in the preceding step to represent the class boundary between good and moderate. If the 10th percentile were selected in step 4, the same statistic (of the values representing good status) would be selected here.

The same procedure as described above may be used to set the remaining class boundaries if nominal values representing these quality classes are available.

B. With scarce access to data from sites or historical records corresponding to ecological quality criteria, class boundaries may be set as follows for an individual quality element indicator[16]:

1. Establish a tentative scale of ecological quality ratios based on expert judgement of what may be considered to represent appropriate intervals from high to bad quality.

2. Apply the scale on a number of real or virtual data sets and compare, by expert judgement, the resulting classification with the ecological quality criteria given by the normative definitions and, if available, further developments of these such as those described in Tool 2 in the Toolbox section.

3. If necessary adjust the scale and repeat the procedure described in Step 3 above until a scale of class boundaries has been established that results in a classification corresponding to the ecological quality criteria.

C. A statistical distribution approach may be used as an alternative to the above one based on expert judgement if the ecological quality criteria represented by the normative definitions and the developments thereof are deemed too weak to support any judgement of where the borderlines between quality classes should be:

1. Establish a suitable summary statistic (e.g. mean value or percentile) of the reference values.

2. Calculate EQR ratios by normalising all values of the reference dataset (i.e. divide all values by the selected reference value).

3. Determine the "upper anchor" and in doing so the width of the high or reference band by selecting an appropriate statistic (e.g. the 10th percentile) using the distribution of the

[16] Note: Class boundaries will have to be developed for each quality element indicator

reference values. The width of this class is determined by the natural variation associated with undisturbed or least impaired reference sites. The upper anchor is also the class boundary between high and good ecological status.

4. Determine the width of the four remaining classes by dividing the interval between the upper and lower anchors equally. The lower anchor used in setting classification band widths can be a zero value. However, some thought should be given to using the minimum value measured or expected to occur in nature. Setting the lower anchor to a value > 0 might be more ecologically relevant and should result in lower probabilities of committing type 2 errors.

3.8.2 Errors associated with classification schemes

Once a classification scheme has been established, the error associated with the individual classes (i.e. misbanding errors) needs to be determined. Determination of the error or uncertainty associated with a classification scheme can be done using a number of randomisation tests. In brief, uncertainties in classification need to explicitly address the question of "what is the probability that a site is assigned to the wrong class?" If a site is incorrectly placed in a class denoting poorer ecological status than the actual condition this is considered as a type 1 or false positive error. If a site is incorrectly placed in a class denoting higher ecological status than the actual condition this would be classified as a type 2 or false negative error. False negative errors (ie. wrongly assigned to a higher class) mean that ecological degradation may proceed undetected, while false positive errors may cause hugely wasted effort and investment in monitoring and measures. Consequently, both kinds of errors have serious associated problems.

Furthermore, attempts at lowering false negative error frequencies are in line with the European Councils precautionary principle. Article 7 of this resolution states that the Council "considers that use should be made of the precautionary principle where the possibility of harmful effects on health or the environment has been identified and preliminary scientific evaluation, based on the available data, proves inconclusive for assessing the level of risk" (European Council Resolution on the Use of the Precautionary Principle, 14328/00, 5 December 2000).

The errors associated with classification schemes can be alarmingly high. Therefore, an understanding of the errors associated with misclassification is needed so as to design and implement cost-effective monitoring and assessment programmes.

Section 4. The Toolbox

The toolbox includes the following elements and instruments which can be seen as examples illustrating possible ways of implementing the different steps in the REFCOND guidance. All tools need to be further developed and tested by Member States for specific water body types and pressures The Pilot River Basin testing during 2003-4 will also contribute in the development of the REFCOND tools and tools from other guidance documents.

List on tools included in the toolbox:

1. Pressure screening criteria for high status sites or values;
2. Ecological criteria or interpretations of normative definitions for the biological quality elements;
3. Examples on setting class boundaries according to alternative A, B and C in section 3.8.

Tool 1. Proposed pressure screening criteria for selecting potential reference condition sites or values.

In the table below a set of criteria is suggested which elaborate the degree of acceptable change in an anthropogenic pressure that would provide the limits of high status sites or values. The table may be used as a screening tool alongside with ecological criteria for selection of potential reference sites or values. A prerequisite for the use of pressure screening criteria is that the relationship between pressure and ecological impact is well established and that the impact correspond to the normative definitions in the Directive (Annex V: 1.2).The screening criteria is suggested to be further developed into water body type specific criteria and tested in Pilot River Basins and future work of the Common Implementation Strategy during 2003-42004..

	High ecological status
General statement	• High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemistry, hydromorpology and biology.
Diffuse source pollution	
Land-use intensification: Agriculture, forestry	• Pre-intensive agriculture or impacts compatible with pressures pre-dating any recent land-use intensification.
	• Pressures pre-dating any recent intensification in airborne inputs that could lead to water acidification.
Point source pollution	
Specific synthetic pollutants	• Pressures resulting in concentrations close to zero or at least below the limits of detection of the most advanced analytical techniques in general use (A Selection process for relevant pollutants in a river basin is presented as an example of best practice in section 6 of the guidance document from Working Group 2.1, IMPRESS).
Spec. non-synthetic pollutants	• Natural background level/load (see reference above)
Other effluents/discharges	• No or very local discharges with only very minor ecological effects.
Morphological alterations	
River morphology	• Level of direct morphological alteration, e.g. artificial instream and bank structures, river profiles, and lateral connectivity compatible with ecosystem adaptation and recovery to a level of biodiversity and ecological functioning equivalent to unmodified, natural water bodies
Lake morphology	• Level of direct morphological alteration, eg. structural modifications that hinder fluctuations of the water surface, compatible with ecosystem adaptation and recovery to a level of biodiversity and ecological functioning equivalent to unmodified, natural water bodies
Water abstraction	
River and lake water abstraction	• Levels of abstraction resulting in only very minor reductions in flow levels or lake level changes having no more than very minor effects on the quality elements. •

Flow regulation	
River flow regulation	• Levels of regulation resulting in only very minor reductions in flow levels or lake level changes having no more than very minor effects on the quality elements.
Riparian zone vegetation	
	• Having adjacent natural vegetation appropriate to the type and geographical location of the river.
Biological pressures	
Introductions of alien species	• Introcuctions compatible with very minor impairment of the indigenous biota by introduction of fish, crustacea, mussels or any other kind of plants and animals. • No impairment by invasive plant or animal species.
Fisheries and aquaculture	• Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends • Stocking of non indigenous fish should not significantly affect the structure and functioning of the ecosystem.. • No impact from fish farming.
Biomanipulation	• No biomanipulation.
Other pressures	
Recreation uses	• No intensive use of reference sites for recreation purposes (no intensive camping, swimming, boating, etc.)

Tool 2. Interpretations of normative definitions for the biological quality elements

The table may not be suitable for all types and all pressures. Choice of indicators may need adjustment according to prevailing monitoring. The table suggested to be further developed and tested in Pilot River Basins and future work of the ECOSTAT cluster. Interpretations of the normative definitions will also be needed for physico-chemical and hydromorphological quality elements.

Rivers	High Status	Good Status	Moderate Status
Phytoplankton	**Taxonomic composition** – the phytoplankton community will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will reflect the type specific phytoplankton community. Any taxa present that are not from the type specific reference phytoplankton community list are likely either to be at very low abundance or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. Size structure of the phytoplankton community is indistinguishable from the type specific reference conditions. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Biomass** – The biomass of the phytoplankton community will be within the range of values expected at reference conditions. **Transparency**- The average transparency will not be significantly changed from that expected at type specific reference conditions as a result of phytoplankton. **Planktonic blooms** – The frequency and intensity of planktonic blooms will be within the range found at reference conditions. **Note:-** *taxonomic composition and abundance are relevant to all pressures; biomass, transparency and planktonic blooms are relevant primarily to eutrophication*.	**Taxonomic composition** – the phytoplankton community may be slightly changed from the type specific reference conditions. The community may contain a minority of taxa which indicate changes from the type specific reference community. Taxa which reflect the type specific reference phytoplankton community are likely still to be dominant. Size structure of the phytoplankton community is near or just outside the type specific reference conditions. **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Biomass** – The biomass of the phytoplankton community will be higher than the range of values at reference conditions. The overall increase in abundance of algae will not be sufficient to significantly alter the light climate or alter the physico-chemical quality of the water or the sediment and thus change the composition of other biota from their expected condition. **Planktonic blooms** – blooms may occur more frequently than expected, but will not be sufficiently frequent or intense so as to cause any significant damage to other quality elements.	**Taxonomic composition** – the phytoplankton community may be significantly changed from the type specific reference conditions. The community may contain taxa which indicate a significant change from the type specific reference community. Size structure of the phytoplankton community is significantly outside the type specific reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Biomass** – The biomass of the phytoplankton community will be significantly higher than the range of values at reference conditions. Other quality elements, such as macrophytes and benthic invertebrates, may be altered by the increased algal abundance. (e.g. depth of colonisation of macrophytes may be demonstrably affected and significant areas of channel vegetation may have been lost.The benthic invertebrate fauna may be significantly altered as a result of the increased biomass) **Planktonic blooms** – persistent blooms will occur regularly. Even in types where plankton blooms are common at reference condition, these will be considerably more intense than expected at reference conditions and will frequently consist of taxa that do not usually dominate at reference conditions.
Macrophytes and phytobenthos	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list.	**Taxonomic composition** – this will differ slightly from the type specific reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference	**Taxonomic composition**–– this will differ significantly from the type specific reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific

[17] Applies only to organic matter pollution.
[18] Applies only to organic matter pollution.

	The number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list, will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. The total vegetated area will be within the range expected at reference conditions. **Bacterial tufts and coats[17]** - No bacterial films due to human activity present. (Bacterial tufts and coats should also be considered to include other decomposers such as fungi and microscopic animals)	condition may constitute a significant part of the flora. The number of taxa present will be near or just outside the distribution of values at reference conditions. Dominant taxa at reference condition are likely still to be dominant **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Bacterial tufts and coats[18] -** Bacterial films due to human activity may be present underneath stones etc., but not above.	list (particularly pollution tolerant taxa) may dominate the flora. The number of taxa present will be significantly outside the range expected at reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions and taxa from outside the type specific list may dominate the flora. **Bacterial tufts and coats[19]** - Bacterial tufts and coats visible to the naked eye may be present on the upper surfaces of stones and other substrate, but are likely to cover less than a moderate proportion (for example, 25%) of the available substrate.
Benthic Invertebrate Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list and the number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Taxa known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Diversity** – The balance of the number of taxa present and their individual abundances is within the range expected at reference conditions. Major Taxonomic Groups **–**Taxonomic groups which are usually found at reference conditions are present in their expected proportion.	**Taxonomic composition -** the number of taxa present will be near or just outside the distribution of values at reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition are likely to be present. Dominant taxa at reference condition are likely still to be dominant **Abundance** – Some of the taxa present will be outside their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Some taxa known to be sensitive to the pressures to which the waterbody is subject may be absent. **Diversity** – The balance of the number of taxa present and their individual abundances may be outside the range expected at reference conditions. Major Taxonomic Groups **– Most** taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and occasionally major groups are absent.	**Taxonomic composition** – the number of taxa present will be significantly outside the range expected at reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of taxa will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the taxa known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Diversity** – The balance of the number of taxa present and their individual abundances will usually be outside range expected at reference conditions. This may be due, for example, to large increases in the relative abundance of a few insensitive taxa, combined with the loss of sensitive taxa. Major Taxonomic Groups **–** Some of the taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and some of the major groups are absent.

[19] Applies only to organic matter pollution.

Fish Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. Any species present that are not from the type specific list will be naturally uncommon or rare species or their presence will be attributable to the chance occurrence of species outside their normal distribution range. In either case, their presence will not be indicative of disturbance. The number of species present will usually be within the range of values expected at reference conditions. **Abundance** - Nearly all the species present will be within their expected abundance values at reference conditions. The overall fish abundance will be within the range expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Age classes** - All expected age classes of the type specific species must be present.	**Taxonomic composition** - the number of species present will usually be just within or just outside the distribution of values expected at reference conditions. The majority of species present will be in the type specific species list, but species that are not commonly found at reference condition may be present. Dominant species at reference condition will still be dominant **Abundance** - Some of the species present may be outside their expected abundance values at reference conditions. The overall fish abundance will usually be near or just outside the range of values expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels near or just outside the lower end of the range of values expected at reference conditions. **Age classes** - All expected age classes of the type specific dominant species must be present. Age classes of minor species may be absent.	**Taxonomic composition** – the number of species present will be significantly outside the range expected at reference conditions. As few as half of the species present may be regularly found in the type specific species list. Species from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of species will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the species known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Age classes** - The type specific dominant species is still present, although expected age classes may be missing. Minor species may be completely absent or represented only at abundances significantly outside the expected range of values for reference condition sites.

Lakes	High Status	Good Status	Moderate Status
Phytoplankton	**Taxonomic composition** – the phytoplankton community will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will reflect the type specific phytoplankton community. Any taxa present that are not from the type specific reference phytoplankton community list are likely either to be at very low abundance or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. Size structure of the phytoplankton community is indistinguishable from the type specific reference conditions. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Biomass** – The biomass of the phytoplankton community will be within the range of values expected at reference conditions. **Transparency**- The average transparency will not be significantly changed from that expected at type specific reference conditions as a result of phytoplankton. **Planktonic blooms** – The frequency and intensity of planktonic blooms will be within the range found at reference conditions. **Note:-** *taxonomic composition and abundance are relevant to all pressures; biomass, transparency and planktonic blooms are relevant primarily to eutrophication.*	**Taxonomic composition** – the phytoplankton community may be slightly changed from the type specific reference conditions. The community may contain a minority of taxa which indicate changes from the type specific reference community. Taxa which reflect the type specific reference phytoplankton community are likely still to be dominant. Size structure of the phytoplankton community is near or just outside the type specific reference conditions. **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Biomass** – The biomass of the phytoplankton community will be higher than the range of values at reference conditions. The overall increase in abundance of algae will not be sufficient to significantly alter the light climate or alter the physico-chemical quality of the water or the sediment and thus change the composition of other biota from their expected condition. **Planktonic blooms** – blooms may occur more frequently than expected, but will not be sufficiently frequent or intense so as to cause any significant damage to other quality elements.	**Taxonomic composition** – the phytoplankton community may be significantly changed from the type specific reference conditions. The community may contain taxa which indicate a significant change from the type specific reference community. Size structure of the phytoplankton community is significantly outside the type specific reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Biomass** – The biomass of the phytoplankton community will be significantly higher than the range of values at reference conditions. Other quality elements, such as macrophytes and benthic invertebrates, may be altered by the increased algal abundance. (e.g. depth of colonisation of macrophytes may be demonstrably affected and significant areas of vegetation may have been lost. The benthic invertebrate fauna may be significantly altered as a result of the increased biomass) **Planktonic blooms** – persistent blooms will occur regularly. Even in types where plankton blooms are common at reference condition, these will be considerably more intense than expected and will frequently consist of taxa that do not usually dominate at reference condition.

Macrophytes and phytobenthos	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list. The number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. The total vegetated area will be within the range expected at reference conditions. **Bacterial tufts and coats** - No bacterial films due to human activity present. (Bacterial tufts and coats should also be considered to include other decomposers such as fungi and microscopic animals)	**Taxonomic composition** – this will differ slightly from the type specific reference condition. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition may constitute a significant part of the flora. The number of taxa present will be near or just outside the distribution of values at reference conditions. Dominant taxa at reference conditions are likely still to be dominant **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Bacterial tufts and coats** - Bacterial films due to human activity may be present underneath stones etc., but not above.	**Taxonomic composition**–– this will differ significantly from the type specific reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list (particularly pollution tolerant taxa) may dominate the flora. The number of taxa present will be significantly outside the range expected at reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Bacterial tufts and coats** - Bacterial tufts and coats visible to the naked eye may be present on the upper surfaces of stones and other substrate, but are likely to cover less than a moderate proportion (for example, 25%) of the available substrate..
Benthic Invertebrate Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list and the number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Taxa known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Diversity** – The balance of the number of taxa present and their individual abundances is within the range expected at reference conditions.	**Taxonomic composition** - the number of taxa present will be near or just outside the distribution of values at reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition are likely to be present. Dominant taxa at reference condition are likely still to be dominant **Abundance** – Some of the taxa present will be outside their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Some taxa known to be sensitive to the pressures to which the waterbody is subject may be absent. **Diversity** – The balance of the number of taxa present and their individual abundances may be outside the range expected at reference conditions. **Major Taxonomic Groups** – Most taxonomic groups that are	**Taxonomic composition** – the number of taxa present will be significantly outside the range expected at reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of taxa will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the taxa known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Diversity** – The balance of the number of taxa present and their individual abundances will usually be outside range expected at reference conditions. This may be due, for example, to large increases in the relative abundance of a few insensitive taxa, combined with the loss of sensitive taxa. **Major Taxonomic Groups –** Some of the taxonomic groups that are usually found at reference conditions

	Major Taxonomic Groups –Taxonomic groups which are usually found at reference conditions are present in their expected proportion.	usually found at reference conditions are present but numbers of individuals of some of these may be low and occasionally major groups are absent.	are present but numbers of individuals of some of these may be low and some of the major groups are absent.
Fish Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. Any species present that are not from the type specific list will be naturally uncommon or rare species or their presence will be attributable to the chance occurrence of species outside their normal distribution range. In either case, their presence will not be indicative of disturbance. The number of species present will usually be within the range of values expected at reference conditions. **Abundance** - Nearly all the species present will be within their expected abundance values at reference conditions. The overall fish abundance will be within the range expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Age classes** - All expected age classes of the type specific species must be present.	**Taxonomic composition** - the number of species present will usually be just within or just outside the distribution of values expected at reference conditions. The majority of species present will be in the type specific species list, but species, that are not commonly found at reference condition, may be present. Dominant species at reference condition will still be dominant **Abundance** - Some of the species present may be outside their expected abundance values at reference conditions. The overall fish abundance will usually be near or just outside the range of values expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels near or just outside the lower end of the range of values expected at reference conditions. **Age classes** - All expected age classes of the type specific dominant species must be present. Age classes of minor species may be absent.	**Taxonomic composition** – the number of species present will be significantly outside the range expected at reference conditions. As few as half of the species present may be regularly found in the type specific species list. Species from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of species will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the species known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Age classes** - The type specific dominant species is still present, although expected age classes may be missing. Minor species may be completely absent or represented only at abundances significantly outside the expected range of values for reference condition sites.

Tool 3. Numerical examples on setting class boundaries according to alternative A, B and C in section 3.8.

The setting of class boundaries is illustrated below, using imaginary data on a particular quality element indicator – species richness of benthic macroinvertebrates. The description follows the steps outlined in section 3.8.1.

A. Sufficient data from sites (or historical records) are available

1. Observations at reference condition sites representative of rivers of type XX gave the following set of data (numbers of species per unit area or per effort): 35, 28, 29, 43, 45, 31, 37, 29, 33, 34, 39, 35, 32.

The median value – 34 – was selected to represent the reference value.

2. The data set was divided by the reference value, thus creating a set of normalised values: 1.03, 0.82, 0.85, 1.26, 1.32, 0.91, 1.09, 0.85, 0.97, 1.00, 1,15, 1.03, 0.94.

3. Species richness does not increase toward the ”bad” end of the scale. Hence, there was no need to invert the values arrived at in the previous step in order to achieve a scale that descends from 1 to 0.

4. A lower percentile of the normalised data set arrived at in step 2 above, in this case the 10th percentile, was selected to represent the class boundary between high and good status: 0.83.

5. Observations at sites of river type XX considered to be representative of good ecological status gave the following data set: 30, 27, 28, 31, 27, 29, 28, 23, 27, 24.

6. Division by the reference value (34) gave the following set of normalised values: 0.88, 0.79, 0.82, 0.91, 0.79, 0.85, 0.82, 0.68, 0.79, 0.71.

7. The 10th percentile was, again, selected to represent the class boundary: 0.68.

In summary, the following class boundaries were thus established in terms of EQR values:

High status: ≥ 1.00 – 0.83
Good status: 0.83 – 0.68.

The remaining class boundaries might have been established in the same way, had nominal values representing these quality classes been available.

Finally, one would have to decide weather the scale developed for a particular type of river would be applicable to all types. If not, separate scales would have to be developed.

B. Few data from sites (or historical records) available

1. The following tentative scale of EQR values was established by a group of experts, based on their judgement of what would be appropriate intervals from high to bad in terms of species richness of benthic macroinvertebrates:

High status: ≥1.00 – 0.80
Good status: 0.80 – 0.60
Moderate status: 0.60 – 0.40
Poor status: 0.40 – 0.20
Bad status: <0.20

2. Application of the tentative scale on a number of real and virtual data sets and consideration of whether the scale is compatible with the normative definitions of ecological status in Appendix V, 1.2, of the Directive, and the interpretations of the normative definitions given in Tool 2 of the toolbox of this Guidance document, caused the group of experts to adjust the class boundaries upwards into the following scale:

High status: ≥1.00 – 0.85
Good status: 0.85 –0.70
Moderate status: 0.70 – 0.55
Poor status: 0.55 – 0.40
Bad status: <0.40.

3. No further iterations were considered necessary. It was recommended that the scale be subject to re-evaluation as more data become available from monitoring and intercalibration procedures.

It was decided to apply the scale on all types of rivers, pending re-evaluation with more data.

C. A statistical approach (alternatives A and B deemed not applicable)

1. Same as A1 above.

2. Same as A2 above.

3. The 10th percentile was selected as the ”upper anchor” and the class boundary between high and good (same as A4 above): 0.83.

4. The width of the four remaining classes was evenly spaced over the remaining interval (the ”lower anchor” was set to 0 as there was considered to be no need to set a higher value). This resulted in the following class boundaries:

High status: ≥1.00 – 0.83
Good status: 0.83 – 0.62
Moderate status: 0.62 – 0.41
Poor status: 0.41 – 0.20
Bad status: <0.20.

The scale would presumably have been levelled off to more even figures, since there was no quantitative basis for a two decimal accuracy.

General comment to tool3:
When establishing the class boundaries it will be obvious that some sites/data that was pre-selected for a specific quality class will fall in an other class in the classification scheme

(sites/data close to the boundaries). This means that the first preliminary classification have to be reassessed for these sites/data in the final status classification.

Section 5. Examples on Good Practice

Example 1. Development of a risk based prioritisation protocol for standing waters in Great Britain, based on a georeferenced inventory, as an aid to defining reference conditions.

Principle

Standing waters respond to catchment pressures (including development, land use, changes in land management, and atmospheric deposition) by displaying changes in their physicochemical environment. This in turn leads to changes in the condition of the biological elements supported, and in WFD terms, may lead to movement away from reference condition. The rationale is developed therefore that a measure of catchment pressures will give an indirect estimate of proximity to reference condition. This approach can ,can, therefore, be regarded as a preliminary screening tool or risk assessment method to identify potential reference sites which can then be tested against the ecological criteria of the WFD for reference condition. The crux of this approach is the definition of the WFD high status class boundary based on pressure criteria for "no or only very minor" disturbance, this has not yet been achieved.

Method

Implementation of the WFD requires a procedure to identify lakes at risk of a deterioration in water quality as a result of the presence of a hazard(s) in their catchment. A protocol using a three-tiered hierachical prioritisation system was developed to assess environmental harm using nutrients and acid deposition as example hazards. In order to carry out these prioritisations, basic information was required on the location, number and size of lakes, in association with ecological and water quality data and target (reference) conditions. Since no single comprehensive inventory of lakes and reservoirs in Great Britain existed, prior to this study, the development of a georeferenced inventory of standing waters in Great Britain and their physical, chemical and ecological properties was an integral part of the project.

In Great Britain there are some 46000 standing waters identified on the 1:50,000 OS maps, and some 14000 waters of >1ha surface area. The regulatory agencies have little data on most of these waters, including many of the larger waters which have been assumed to be in good condition. The only realistic approach to collating information on the bulk of these waters to assist in implementing the WFD was seen as using macro scale datasets covering most of the land surface of GB, together with some simple models to derive estimates of various pressures. The focus of the project to date has been the identification of waters at risk of failing to meet the requirements of the WFD, and this work is described below.

The inventory itself contains basic physical characteristics for all standing waters in Great Britain derived from the 1:50 000 ordnance survey panorama digital dataset. For those water bodies >1 hectare, catchment boundaries were generated and associated attribute data were derived, to allow implementation of the risk based prioritisation protocol. The inventory was linked to external databases using a meta-data system and summary water chemistry data were collated from some of these databases for over 400 water bodies. It is hoped that further meta-data and summary data can be added in the future as and when data become available.

Project outline

The project was comprised of two phases, Phase 1, completed in 2001, was a scoping study to identify the content and structure of the inventory and to design the risk based prioritisation protocol. During Phase 2, the inventory has been populated and the risk based prioritisation protocol further developed, tested and refined. The approach used to develop the risk based prioritisation protocol largely follows the framework for environmental risk assessment and management detailed by the DETR (2000). The scheme is based on the three properties, importance, hazard and sensitivity, and appropriate measures of each were determined. A three-tiered approach was adopted whereby an initial rapid assessment is made at Risk Tier 1 for all standing waters in Great Britain (approximately 14,000 greater than 1ha), based on the minimum of information gained from already available data sources. This assessment is then used to guide the acquisition of further data for more detailed evaluation of a subset of standing waters at Risk Tier 2 (a few hundred to a few thousand) and, in even finer detail at Risk Tier 3 on a very small subset of waters (a few tens) for which remedial action is likely to be taken.

Phosphorus as an indication of nutrient enrichment

The anthropogenic phosphorus load (human sewage, run-off from land and domestic farm animal waste – the latter data were not available for Scotland) was used as a measure of the eutrophication hazard. The loads were converted into in-lake concentrations using relevant OECD equations, and lakes were given a rank on the basis of the standard Vollenweider classifications of lake trophic status. Retention time was used to identify lakes where the algae would remain in the lake long enough to utilise the phosphorus in the water. Depth data were unavailable for most lakes so that modelled depths were used in calculations.

Acidification from atmospheric deposition

The Risk Tier 1 estimation of hazard and sensitivity to acidification was much simpler since the appropriate data sets had already been compiled for other purposes. Total acid deposition load was used to identify the level of hazard. Five classes were defined and only those in class 1 (<0.5 keq/ha/y) were not passed through to the sensitivity assessment. Data were already available on the sensitivity of lakes to acidification. The data are available at 1 km square grid scale and relate to the buffering capacity of the dominant soil type and baseline geology within each square. Five sensitivity classes were defined. Only classes 1 and 2 (High and medium-high, respectively) were passed on to the final tier 1 risk assessment. The acid deposition class and freshwater sensitivity class for each lake was assessed jointly and lakes with specified combinations of deposition class and sensitivity class were passed through to the Risk Tier 2 assessment.

Identification of potential reference sites

Eutrophication and acidification have been identified as the two major causes of downgrading of water quality in standing waters across Europe (Ref: Dobris Assessment). The method described here permits National screening of all standing waters greater than 1 ha in size for exposure to the risk of damage from these two hazards. The sub-set of standing waters identified as having minimal exposure to catchment pressures in the Tier 1 assessment form the basis for a Tier 2 more detailed assessment at the site level, both to validate the assessment of the principle pressures of enrichment and acidification and to assess other pressures and impacts of relevance to reference condition such as impoundment, shoreline development etc.

Testing of the protocol outputs

Application of the protocol to 30 test lakes across Great Britain indicates that the schemes for both eutrophication and acidification produce reliable risk assessments. These 30 lakes were sites which are well studied by direct survey and sampling of both their physicochemical and ecological quality. Additionally some sites had undergone palaeolimnological investigation.

It is recommended that this method of identifying potential reference lakes is employed as a first screening step offering a method of dealing with a large number of standing waters for which no direct evidence of condition exists. It could be used in conjunction with the method outlined in Example 2 in this section of this guidance, The use of palaeolimnology and species turnover measures to select potential reference lakes, to provide a two way assessment of sites for further evaluation

Example 2. The use of palaeolimnology and species turnover measures to select potential reference lakes

Principle

The Water Framework Directive requires lakes to be classified according to the assemblage of biological elements they currently support. The system specified for this classification is a state-changed system, comparing any lake's current condition with its condition at a reference state (where: There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions). The identification of a suite of lakes at an undisturbed condition is difficult in Western Europe, and presupposes that all possible causes of disturbance are known and quantified. An alternative method exists for lakes – the use of palaeolimnology. This permits a direct comparison of sub-fossil elements of the biological assemblage representing conditions at some previous undisturbed state with the same biological element in its current state.

Method

In Great Britain most palaeolimnological investigations have worked with diatoms, and for this reason diatoms are the most practical choice for the identification of potential reference lakes across all lake types. Additionally, diatoms have been shown to be amongst the most sensitive of biological elements and responsive to the two most significant pressures in Western European lakes, eutrophication and acidification (Ref: Dobris Assessment). Sediment cores from the deepest part of lakes may be dated and the diatom assemblages characterised and their development traced over long periods of time. For the purposes of the WFD, undisturbed conditions may be interpreted as being those pertaining before the intensification of agriculture and before any gross disturbance by industrialisation. For Great Britain this broadly indicates a period circa 1850. Classification of diatom assemblages existing around this date allows a provisional "diatom based typology" of lakes to be made and comparison of sediment strata at this date with current diatom assemblages permits an assessment of the proximity of each lake to reference condition.

Project outline

Analysed sediment cores exist for 166 lakes across the United Kingdom (England, Scotland, Wales and Northern Ireland) and the strata for circa 1850 or earlier were examined and their diatom assemblages described. Analysis by Ward's minimum variance clustering produced an optimal number of 6 end groups of diatom assemblage. The 166 lakes in the diatom dataset appear to represent a broad range of UK lake types and cover a wide geographical distribution, their diatom assemblages from circa 1850 may be taken then, in the first instance, as representing the major reference assemblages for UK lakes.

Comparison of these bottom core strata with diatom assemblages in the most recent strata allows a direct comparison of previous and current diatom assemblages. The degree of floristic change (diatom species turnover) between the core bottom and surface sample for each of the 166 lakes was assessed using a simple chord distance dissimilarity measure. The scores range from 0 to 2 whereby 0 indicates that two samples are exactly the same and 2 indicates that they are completely different. Any score <0.39 can be judged to have insignificant species turnover at the 2.5th percentile, a score <0.48 at the 5th percentile, and a score <0.58 can be judged to have insignificant species turnover at the 10th percentile.

Within each of the six diatom end groups, the lakes are ranked according to the degree of floristic change between the base and surface core sample.

In Group 1 there are very few lakes with low species turnover, with only two having a chord distance of <0.48. This indicates that there are currently few examples of potential reference lakes for this group in the diatom dataset. Similarly for Group 2, where only 4 lakes have a chord distance <0.48. Both Groups 1 and 2 are largely lowland sites in relatively productive catchments and hence many are impacted by eutrophication. It may be difficult, therefore, to find good examples of potential reference lakes for these lake types.

In Group 3 there are many examples of lakes with low species turnover (c. 50% of lakes in this group have a chord distance of <0.48). Therefore, good examples of reference lakes are available for this lake type. Note, however, that there are very few lakes in this group in England and Wales.

In Group 4, only 7 lakes have a species turnover of < 0.48. Given that this group includes most of the large (deep) lakes, more examples of potential reference lakes in this group may need to be found.

In Group 5, 11 lakes have a species turnover of < 0.48. Many lakes in this group have acidified.

In Group 6, 15 lakes have a species turnover of < 0.48. Whilst there are a number of potential reference lakes, many lakes in this group have been impacted and the pressures appear to include both eutrophication and acidification.

Testing of the project outputs

Sites selected as potential reference sites will be cross checked using pressure criteria from Example 1 in this section of the guidance “Development of a risk based prioritisation protocol for standing waters in Great Britain, based on a georeferenced inventory, as an aid to defining reference conditions”.

Representative sites having a chord distance of <0.4 from each of the 6 diatom based types have been selected for survey and sampling to determine their current biological assemblages. These data should prove useful for classification tool development and for intercalibration purposes.

At each stage, assessment will be made of compliance with reference state criteria as described in the WFD.

Example output from analysis: Type 4 lochs (highlighted potential reference lochs).

SITE code	Site name	grid ref	country	WBID	Wardcluster	chord distance
MARE	Loch Maree	NG 985675	S	14057	4	0.12908
LOMO	Loch Lomond North Basin	NS 365945	S	24447	4	0.2199
RANN	Loch Rannoch	NN 610580	S	22782	4	0.25262
CRAI	Loch of Craiglush	NO 042444	S	23557	4	0.32084
ECK	Loch Eck	NS 141939	S	24996	4	0.41377
WAST	Wast Water	NY 165060	E	29183	4	0.43559
EINI	Loch Einich	NN 913990	S	21191	4	0.47976
LOWS	Loweswater	NY 126217	E	28986	4	0.52396
AWE	Loch Awe North Basin	NM 930 065	S	24025	4	0.65754

BUTT	Loch of Butterstone	NO 058449	S	23531	4	0.67202
CLUN	Loch of Clunie	NO 115442	S	23561	4	0.71851
AWE	Loch Awe South Basin	NM 930 065	S	24025	4	0.73948
LDE	Loch Dee	NX 470790	S	27948	4	0.74503
BALA	Lake Bala or Llyn Tegid	SH 905347	W	34987	4	0.76477
CWEL	Llyn Cwellyn	SH 560549	W	34002	4	0.80267
MARL	Marlee Loch	NO 145443	S	23553	4	0.87704
MENT	Lake of Menteith	NN 580005	S	24919	4	0.94378
BASS	Bassenthwaite Lake	NY 214296	E	28847	4	0.97801
LOWE	Loch of Lowes	NO 049439	S	23559	4	1.17712
DOON	Loch Doon	NX 495985	S	27604	4	1.21363
ESTH	Esthwaite Water	SD 358969	E	29328	4	1.33895
EARN	Loch Earn	NN 640235	S	24132	4	1.62814

Example 3. The establishment and validation of reference conditions for lakes and large rivers in German parts of the Central European Lowland, ecoregion 14, using paleolimnology

Introduction

The member states of the European Community shall finish the establishment of type-specific reference conditions for surface water body types up to 2004. Not for all types of lakes and rivers in the ecoregion 14 such reference conditions can be derived spatially based, especially for shallow and flushed lakes methods based on modelling are required. Type-specific biological and physico-chemical reference conditions based on modelling may be derived using hindcasting methods. One valid opportunity to obtain quantitative data about the natural biota and physico-chemical conditions is to analyse fossil diatom communities in sediment cores and to reconstruct nutrient concentrations based on diatom-environment-transfer functions. These quantitative paleolimnological approaches make use of multivariate statistics and regional calibrated data sets.

Situation in the ecoregion 14

In northern Germany there are approximately 500 lakes each greater than 50 ha. Trophic status ranges from oligotrophic to hypereutrophic. The water bodies are 1 to 68 m deep and fully imbedded in the loamy sand of the Weichselian ice age moraines. Groundwater is rich in hydrogen carbonate and phosphorus, coming from Interglacial lake deposits. The lake internal phosphorus concentration strongly depends on residence time (<0.1 to >30 years) and the latter on lake volume and catchment size (1 to 20,000 km²). All the lake catchments were clear cut during the 12^{th} to 13^{th} centuries and no one lake can be classified undisturbed. After 1750 approximately 30% of the landscapes have been afforested. An assemblage of approximately 30 lakes with small catchment areas was kept from agriculture during the last 200 years and have been quasi renaturalized. These lakes form the web of ecological reference sites of the oligotrophic and slightly mesotrophic stratified lake types. The higher mesotrophic and eutrophic reference conditions for lakes with larger catchments and inflow of surface water by rivers are not available from present-day conditions. Therefore three cooperating REFCOND-relevant paleolimnological projects are in work or start in October 2002:

- Paleolimnological reconstruction of reference conditions for flushed lakes in the catchment area of the lowland river Havel (Brandenburg Office for the Environment, funded by Federal Ministry of Education and Research, 2002-2004)
- Biotic reference conditions for shallow lakes: Paleolimnological studies on diatoms, algal pigments, chironomids and macrophytes in the catchment area of the lowland river Spree (Brandenburg University of Technology Cottbus, funded by Ministry of Agriculture, Environment and Structural Development Brandenburg, 2001-2002)
- Reconstruction of natural biotic reference conditions in combination with hydromorphological, hydraulic and hydrochemical conditions on rivers in the northeastern German lowland (Leibniz-Institute of Freshwater Ecology and Inland Fisheries Berlin, funded by the Senate Department of Urban Development Berlin, 2002-2004).

Type specific reference conditions for lakes using diatoms – principle and first results

The paleolimnological approach is used to reveal undisturbed diatom communities (benthic and planktonic) and to quantify the relationship between catchment size and undisturbed water chemistry with respect to the assumed strong influence of lake morphology. Weighted-averaging regression and calibration of 304 indicator taxa with tolerance down-weighting and classical deshrinking was used to develop transfer functions between littoral diatoms and TP, TN, DIC, pH, chloride and the DOC:TP ratio in 84 German lakes and river sites (Schönfelder et al. 2002). Transfer functions based on littoral diatoms have been used successful for the reconstruction of past water chemistry in flushed and shallow lakes, for example in the lake Großer Treppelsee, see Fig. 1). For deep lakes a diatom data set based on profundal samples from >100 sites is in progress. Twelve lakes have been selected to drill long sediment cores. They can be grouped into four lake types in respect to their water residence times. Diatom based inferences of TP and TN will be used to establish a model to predict in-lake TP and TN as a bivariate function of lake catchment size and lake volume for undisturbed conditions. The model will be validated using data from the most renaturalized lakes in the region. Recent studies on flushed lakes with a great catchment area such as Großer Treppelsee have shown that the anthropogenic influence on water quality was evident since AD 1250. In other lakes with smaller catchment areas anthropogenic pressures from setteling and intensifying agriculture were indicated by fossil diatoms not before the end of the 18th century.

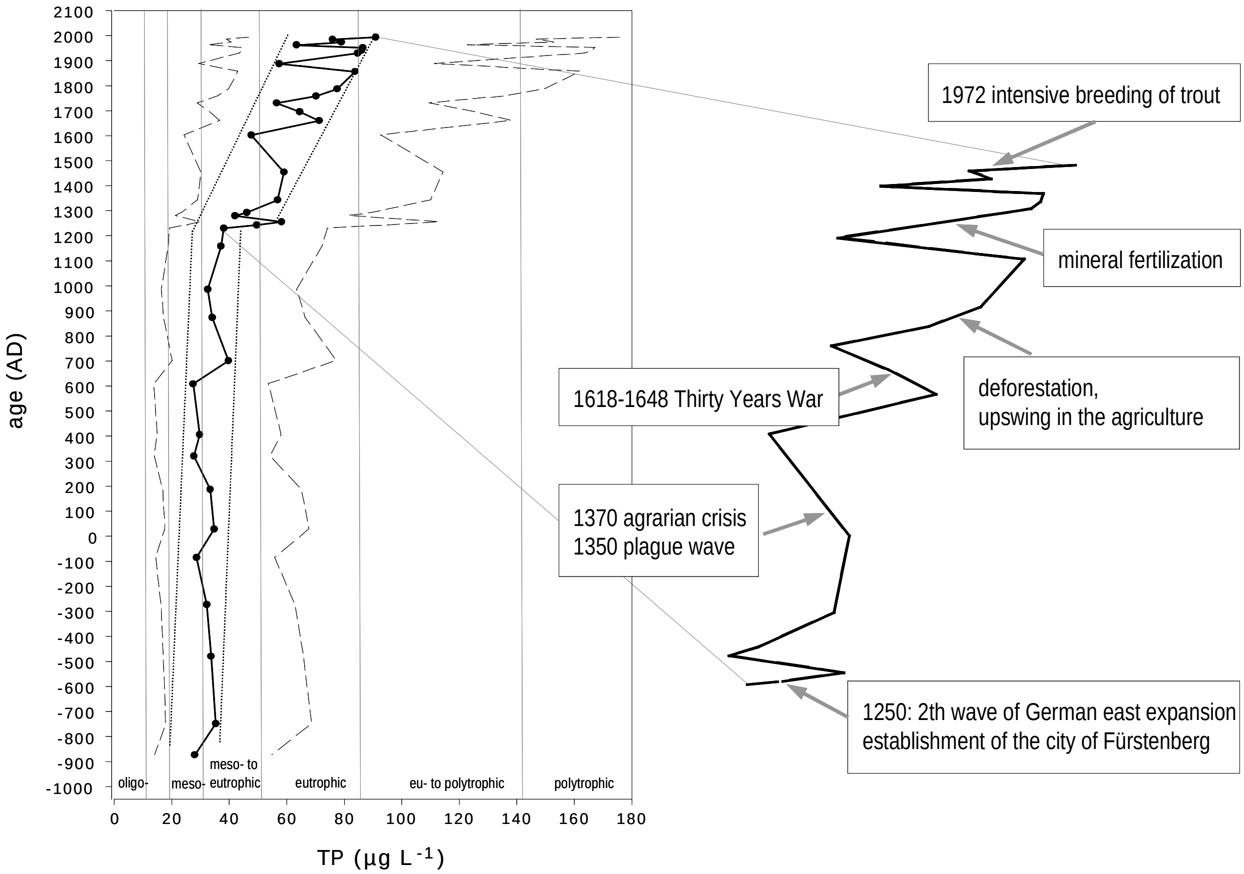


Figure 1. Long term changes of TP concentration of the lake Großer Treppelsees based on diatoms and the main historical events in the catchment which led to higher or lower TP concentrations. The strong anthropogenic impact in this flushed lake began already 1250. To reconstruct undisturbed

conditions in such lake types with great catchment area the water authorities require a quantitative look on past centuries.

References:

Schönfelder, I., J. Gelbrecht, J. Schönfelder & C. E. W. Steinberg, 2002. Relationships between littoral diatoms and their chemical environment in northeastern German lakes and rivers. J. Phycol. 38: 66-82.

References

AQEM consortium 2002. Manual for the application of the AQEM system. A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive. Version 1.0, February 2002.

Cardoso, A.C., Duchemin, J., Margarou, P. & Premazzi, G., 2001. Criteria for the identification of freshwaters subject to eutrophication. Their use for implementation of the "Nitrates" and Urban Waste Water Directives. – Environment Institute, Water research and Monitoring Unit, JRC Ispra & Directorate General for Environment, European Commission. EUR 1910 EN.

CEN 2002. A guidance standard for assessing the hydromorphological features of rivers. CEN TC 230/WG 2/TG 5: N30. Fifth revision: March 2002

Clarke, R. 2000. Uncertainty in estimates of biological quality based on RIVPACS. pp 39-54, In: J. F. Wright, D. W. Sutcliffe, and M. T. Furse (eds). Assessing the biological quality of freshwaters. RIVPACS and other techniques. Freshwater Biological Association, Ambleside, UK.

De Wilde, A.J. &. Knoben, R. A.E. 2001. Setting classboundaries for the classification of rivers and lakes in Europe. – REFCOND discussion paper for evaluation of techniques. Royal Haskoning, The Netherlands.

Fozzard, I., Doughty, R., Ferrier, R.C., Leatherland, T., and Owen, R. (1999) A quality classification for management of Scottish standing waters. Hydrobiologia 395/396 pp 433-453

Johnson, R.K. 2001. Defining reference conditions and setting class boundaries in ecological monitoring and assessment. – REFCOND discussion paper for evaluation of techniques. University of Agricultural Sciences, Department of Environmental Assessment, Sweden.

Nixon, S., Grath, J. & Bøgestrand, J. 1986. EUROWATERNET. The European Environment Agency´s Monitoring and Information Network for Inland Water Resources. Technical Guidelines for Implementation. Technical Report no 7. EEA, Copenhagen 1998.

Oberdorff, T., Pont D., Hugueny, B., Chessel D. 2002. A probabilistic model characterizing fish assemblages of French rivers: a framework for environmental assessment. Freshwater Biology, 46: 399-415

Oberdorff, T., Pont D., Hugueny B., Porcher J.P. 2002. Development and validation of a fish-based index (FBI) for the assessment of 'river health' in France. Freshwater Biology, 47: 1720-1734

Owen, R., Duncan, W. & Pollard, P. 2001. Definition and Establishment of Reference Conditions. - REFCOND discussion paper for evaluation of techniques. Scottish Environment Protection Agency, Aberdeen, Scotland.

OSPAR, 2000. 00/9/2 OSPAR Add.6 and OSPAR 00/20/1, § 9.5b. Euroharp Draft Guideline 6: Quantification and Reporting of Nitrogen and Phosphorus Losses from Diffuse Anthropogenic Sources, and Natural Background Losses. Reference Number: 2000-12.

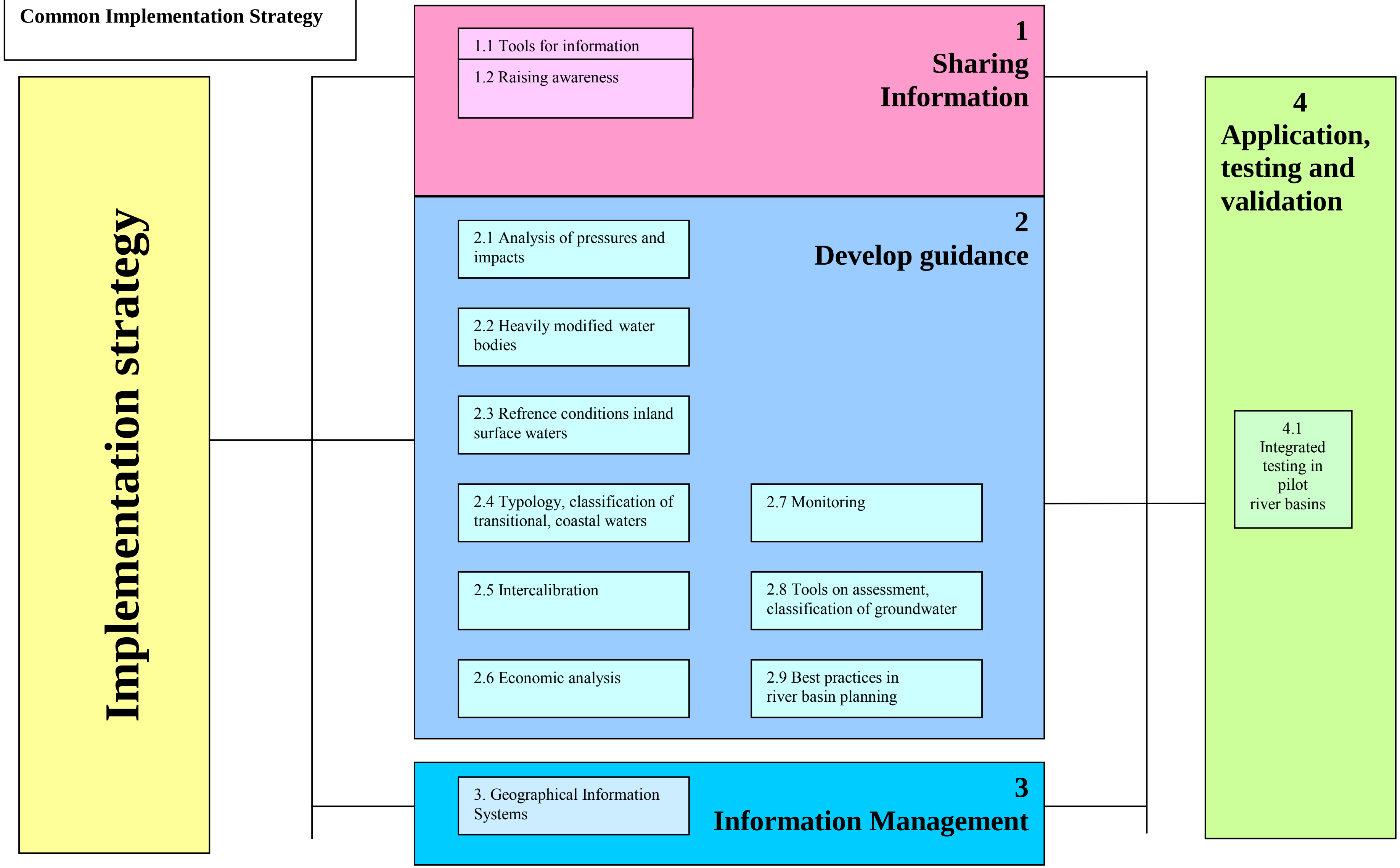
SEPA, 2000. Environmental Quality Criteria – Lakes and Watercources. – Swedish Environmental Protection Agency (SEPA). Report 5050.

SNIFFER (Scottish and Northern Ireland Forum for Environmental Research. (2000) Palaeolimnological investigation of Scottish freshwater lochs. ENSIS Ltd. Ref: SR(00)02S. Available from Foundation for Water Research.

UBA, 1996. Manual on methodologies and criteria for mapping critical levels/loads and geographical areas where they are exceeded. UN/ECE Convention on Long-range Transboundary Air Pollution. – Federal Environment Agency (Umweltbundesamt), Texte 71/96, Berlin.

US EPA 1998. Lake and Reservoir Bioassessment and Biocriteria: Technical Guidance Document (1998) – US Environmental Protection Agency. EPA 822-B00-98-001.
US EPA 2000. Nutrien criteria technical guidance Manual. Lakes and reservoirs. 1st edition. – US Environmental Protection Agency. EPA 841-B-98-007. Office of Water and Technology, Washington DC 20460.
Usseglio-Polatera, P., Beisel, J.-N., Archaimbault, V. & de Crespin de Billy,V. 2002. Biological and ecological traits in macrobenthic community: a bioassessment -system using faunal lists achieved with a French Standardized Protocol (IBGN). AQEM Conference, 9-10th December 2002, Ede (The Netherlands)
Van de Bund, W. 2001. Assigning water body types: an analysis of the REFCOND questionnaire results. - REFCOND discussion paper for evaluation of techniques. European Commission, Joint Research Centre, Institute for Environment and Sustainability, Inland and Marine Waters Unit, Ispra, Italy.
Wright, J. F, Sutcliffe, D. W. & Furse, M. T. 2000. Assessing the biological quality of freshwaters. RIVPACS and other techniques. Freshwater Biological Association, Ambleside, England.

Annex A. Overall structure of the Common Implementation Strategy



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Annex C. Normative definitions in WFD of ecological status classifications for rivers and lakes.

1.2 Normative definitions of ecological status classifications

Table 1.2 General definition for rivers, lakes, transitional waters and coastal waters

The following text provides a general definition of ecological quality. For the purposes of classification the values for the quality elements of ecological status for each surface water category are those given in tables 1.2.1 - 1.2.4 below.

	High status	Good status	Moderate status
General	There are no, or only very minor, anthropogenic alterations to the values of the physicochemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions. The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion. These are the type specific conditions and communities.	The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

Waters achieving a status below moderate shall be classified as poor or bad.

Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad.

1.2.1 Definitions for high, good and moderate ecological status in RIVERS

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition of phytoplankton corresponds totally or nearly totally to undisturbed conditions. The average phytoplankton abundance is wholly consistent with the type-specific physicochemical conditions and is not such as to significantly alter the type specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.	The composition of planktonic taxa differs moderately from the type specific communities. Abundance is moderately disturbed and may be such as to produce a significant undesirable disturbance in the values of other biological and physico-chemical quality elements. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differs moderately from the type-specific community and is significantly more distorted than at good status. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa from the type-specific communities The ratio of disturbance sensitive taxa to insensitive taxa shows slight alteration from type specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific communities. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance sensitive taxa to insensitive taxa, and the level of diversity, are substantially lower than the type specific level and significantly lower than for good status.

Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type specific disturbance sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of any particular species.	There are slight changes in species composition and abundance from the type specific communities attributable to anthropogenic impacts on physicochemical and hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of anthropogenic disturbance, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	**High status**	**Good status**	**Moderate status**
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements [20]

Element	High status	Good status	Moderate status
General conditions	The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 [21] without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

20 The following abbreviations are used: bgl = background level, eqs = environmental quality standard

21 Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels: (eqs>bgl)

1.2.2 Definitions for high, good and moderate ecological status in LAKES

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition and abundance of phytoplankton correspond totally or nearly totally to undisturbed conditions. The average phytoplankton biomass is consistent with the type-specific physicochemical conditions and is not such as to significantly alter the type specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.	The composition and abundance of planktonic taxa differ moderately from the type specific communities. Biomass is moderately disturbed and may be such as to produce a significant undesirable disturbance in the condition of other biological quality elements and the physico-chemical quality of the water or sediment. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbance to the balance of organisms present in the water body or to the physicochemical quality of the water. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with, and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to the undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels	There are slight changes in the composition and abundance of invertebrate taxa compared to the type-specific communities. The ratio of disturbance sensitive taxa to insensitive taxa shows slight signs of alteration from type specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific conditions Major taxonomic groups of the type-specific community are absent. The ratio of disturbance sensitive to insensitive taxa, and the level of diversity, are substantially lower than the type specific level and significantly lower than for good status

Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type specific sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.	There are slight changes in species composition and abundance from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, level, residence time, and the resultant connection to groundwaters, reflect totally or nearly totally undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Lake depth variation, quantity and structure of the substrate, and both the structure and condition of the lake shore zone correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements [22]

Element	High status	Good status	Moderate status
General conditions	The values of physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity, transparency and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity, transparency and salinity do not reach levels outside the range established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 [23] without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

□ The following abbreviations are used: bgl = background level, eqs = environmental quality standard

□ Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels

Annex D. Glossary

Complementary to Article 2 in the Directive

[Will be completed following the agreement on the overall glossary for the WFD Common Implementation Strategy.]

Annex E. List of Relevant EU-funded research projects

EU-funded projects can provide a strong support as far as the classification of inland surface water status is concerned, but very little has been and is being done as far as the definition and identification of reference conditions is concerned. Most of the past or on-going EU-funded projects have also been directed towards streams and rivers. This means that limited support for classification of ecological status of lakes can be gained from these projects.

For the first aspect, at least five main projects, among the others in the list in Annex E, have to be cited, because they represent today the main effort carried out at European level with the objective of development and standardisation of assessment methodologies. One of these projects, the AQEM project, was recently concluded with the production of all the expected deliverables. The AQEM web site (www.aqem.de/) contains in a downloadable format all the main results of AQEM:

- assessment software
- manual how to apply the AQEM system
- taxa list (>7700 European macroinvertebrate taxa)
- several reports, tools and interesting software products

AQEM (http://www.aqem.de/)
Development and testing of an integrated assessment system for the ecological quality of streams and rivers throughout Europe using benthic macroinvertebrates.
The aim of the project is to develop and test an assessment procedure for streams and rivers which meets the demands of the EU Water Framework Directive using benthic macroinvertebrats. The assessment system will be based on a European stream typology and on near-natural reference conditions. The method will be adapted to regional conditions in order to allow comparable use in all EU member states. It will be combined with methods for stream assessment and indication currently used in the EU member states. If these methods supply additional information for certain regions they will be included in the assessment system as additional modules. Data bases on European macroinvertebrate taxa used for the assessment system will be generated. Finally, the method will be transferred into water management application via a manual and a PC program.

PAEQANN (http://www-cesac.ecolog.cnrs.fr/~paeqann/)
Predicting Aquatic Ecosystem Quality using Artificial Neural Networks: Impact of Environmental characteristics on the Structure of Aquatic Communities (Algae, Benthic and Fish Fauna).
The goal of the project is to develop general methodologies, based on advanced modelling techniques, for predicting structure and diversity of key aquatic communities (diatoms, micro-invertebrates and fish), under natural (i.e. undisturbed by human activities) and under man-made disturbance (i.e.submitted to various pollutions, discharge regulation, ...). Such an approach to the analysis of aquatic communities will make it possible to: i) set up robust and sensitive ecosystem evaluation procedures that will work across a large range of running water ecosystems throughout European countries; ii) predict biocenosis structure in disturbed ecosystems, taking into account all relevant ecological variables; iii) test for

ecosystem sensitivity to disturbance; iv) explore specific actions to be taken for restoration of ecosystem integrity. Among the available modelling techniques, artificial neural networks are particularly appropriate for establishing relationship among variables in the natural processes that shape ecosystems, as these relationship are frequently non-linear.

STAR (http://www.eu-star.at/)
Standardisation of river classifications : Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive.
The ecological status of rivers will be determined in the STAR project from a range of taxonomic groups and a variety of methods. Most Member States will have their own assessment procedures, but a common European standard is still missing. Through field sampling and desk studies the project aims to: 1) cross-calibrate and integrate assessments using different methods and taxonomic groups 2) recommend which procedures to use in which situations 3) define the precision and reliability of each method and 4) assist the EU in defining the boundaries of classes of ecological status. A decision support system will be developed for applying the project findings. The research will be used to assist in the establishment of a European standard for assigning the ecological status of rivers on the basis of multiple sources of ecological data. The STAR project builds upon the results of the previously funded AQEM project and will be clustered with the complementary FAME project.

FAME (http://fame.boku.ac.at/)
Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers: A Contribution to the Water Framework Directive.
The objective of the project is to develop, evaluate and implement a standardised Fish-based Assessment Method for the ecological status of European rivers (FAME), a method identified as priority requirement for the implementation of the Water Framework Directive. FAME will follow a pan-European approach in developing models to characterise reference and degraded conditions based on existing fish data of 17000 sites (5200 rivers) in 16 of the 25 eco-regions of Europe. An integrated system to assess the ecological status will be developed in close co-operation with end-users integrated into the project as "Applied partners". The new method will be evaluated by field tests within ongoing national monitoring programmes. A manual and PC-software will be produced and made available to the public via a project web site. FAME will be clustered with the complementary STAR project.

ECOFRAME
Ecological quality and functioning of shallow lake ecosystems with respect to the needs of the European Water Framework Directive.
Contact address: Prof. Brian Moss, School of Biological Sciences, Derby Building, University of Liverpool, Liverpool L69 3GS, UK (brmoss@liverpool.ac.uk). The ECOFRAME project was recently concluded and a draft summary final report is available. Using expert workshops and subsequent field testing a practical pan-European typology and classification system have been developed for shallow lakes, which can be expanded to all lakes. It is minimal, based on current limnological understanding and as cost-effective as possible given the provisions of the Directive. The typology is a core typology that can be expanded easily in particular States to met

local conditions. The core includes 48 ecotypes across the entire European climate gradient and incorporates climate, lake area, geology of the catchment and conductivity. The classification system is founded on a liberal interpretation of Annexes of the Directive and uses variables that are inexpensive to measure and ecologically relevant. Taxonomic expertise is minimised. The scheme has been through eight iterations, two of which were tested in the field on tranches of 66 lakes. The final version, Version 8, is offered for operational testing and further refinement by statutory authorities.

Full list on relevant EU-funded research projects

- **AASER** - ARCTIC AND ALPINE STREAM ECOSYSTEM RESEARCH - ENV4-CT95-0164

- **AQEM** - DEVELOPMENT AND TESTING OF AN INTEGRATED ASSESSMENT SYSTEM FOR THE ECOLOGICAL QUALITY OF STREAMS AND RIVERS THROUGHOUT EUROPE USING BENTHIC MACROINVERTEBRATES - EVK1-CT-1999-00027 - http://www.aqem.de/

- **BIOMASS** - BIODIVERSITY OF MICROORGANISMS IN AQUATIC SYSTEMS - ENV4-CT95-0026

- **ECOFRAME** - ECOLOGICAL QUALITY AND FUNCTIONING OF SHALLOW LAKE ECOSYSTEMS WITH RESPECT TO THE NEEDS OF THE EUROPEAN WATER FRAMEWORK DIRECTIVE - EVK1-CT-1999-00039 –

- **EMERGE** - EUROPEAN MOUNTAIN LAKE ECOSYSTEMS: REGIONALISATION, DIAGNOSTICS & SOCIO-ECONOMIC EVALUATION - EVK1-CT-1999-00032 – http://www.mountain-lakes.org/index.html

- **ERMAS** - EUROPEAN RIVER MARGINS: ROLE OF BIODIVERSITY IN THE FUNCTIONING OF RIPARIAN SYSTEMS - ENV4-CT95-0061

- **FLOBAR-1 –** FLOODPLAIN BIODIVERSITY AND RESTORATION PART 1: HYDROLOGICALAND GEOMORPHOLOGICAL MECHANISMSINFLUENCING FLOODPLAIN BIODIVERSITY AND THEIR APPLICATION TO THE RESTORATION OF FLOODPLAINS – ENV4-CT96-0317

- **MOLAR** – MEASURING AND MODELLING THE DYNAMIC RESONSE OF REMOTE MOUNTAIN LAKE ECOSYSTEMS TO ENVIRONMENTAL CHANGE: A PROGRAMME OF MOUNTAIN LAKE RESEARCH- ENV4-CT95-0007 – http://www.mountain-lakes.org/molar/index.html

- **PAEQANN** - PREDICTING AQUATIC ECOSYSTEM QUALITY USING ARTIFICIAL NEURAL NETWORKS: IMPACT OF ENVIRONMENTAL CHARACTERISTICS ON THE STRUCTURE OF AQUATIC COMMUNITIES (ALGAE, BENTHIC AND FISH FAUNA). - EVK1-CT-1999-00026 - http://www-cesac.ecolog.cnrs.fr/~paeqann/

- **STAR** - STANDARDISATION OF RIVER CLASSIFICATIONS : FRAMEWORK METHOD FOR CALIBRATING DIFFERENT BIOLOGICAL SURVEY RESULTS AGAINST ECOLOGICAL QUALITY CLASSIFICATIONS TO BE DEVELOPED FOR THE WATER FRAMEWORK DIRECTIVE - EVK1-CT-2001-00089 - http://www.eu-star.at/

- **SWALE** - SHALLOW WETLAND LAKE FUNCTIONING AND RESTORATION IN A CHANGING EUROPEAN ENVIRONMENT - ENV4-CT97-0420 - http://swale.sbs.liv.ac.uk/index.html

- **TARGET** - INTEGRATED ASSESSMENT TOOLS TO GAUGE LOCAL FUNCTIONAL STATUS WITHIN FRESHWATER ECOSYSTEMS - EVK1-CT-1999-00005 - http://bscw.bio.ua.pt:3000/

- EUROLAKES - INTEGRATED WATER RESOURCE MANAGEMENT FOR IMPORTANT DEEP EUROPEAN LAKES AND THEIR CATCHMENT AREAS - EVK1-

- FAME - DEVELOPMENT, EVALUATION AND IMPLEMENTATION OF A STANDARDISED FISH-BASED ASSESSMENT METHOD FOR THE ECOLOGICAL STATUS OF EUROPEAN RIVERS: A CONTRIBUTION TO THE WATER FRAMEWORK DIRECTIVE – EVK1-CT-2001-00094 – http://fame.boku.ac.at/

Annex F. (Eco)region specific typology

One important use of typology systems is for the selection of types and sites to be included in the intercalibration exercise (see separate guidance document on intercalibration). Ideally, the chosen typology system should be validated using biological data from reference condition sites. Monitoring programmes will, however, not be fully operational until 2007 and the availability of biological data for validation purposes will be scarce before that. Below a stepwise approach is suggested for establishing inland surface water body types for the purpose of selecting sites for the intercalibration network.

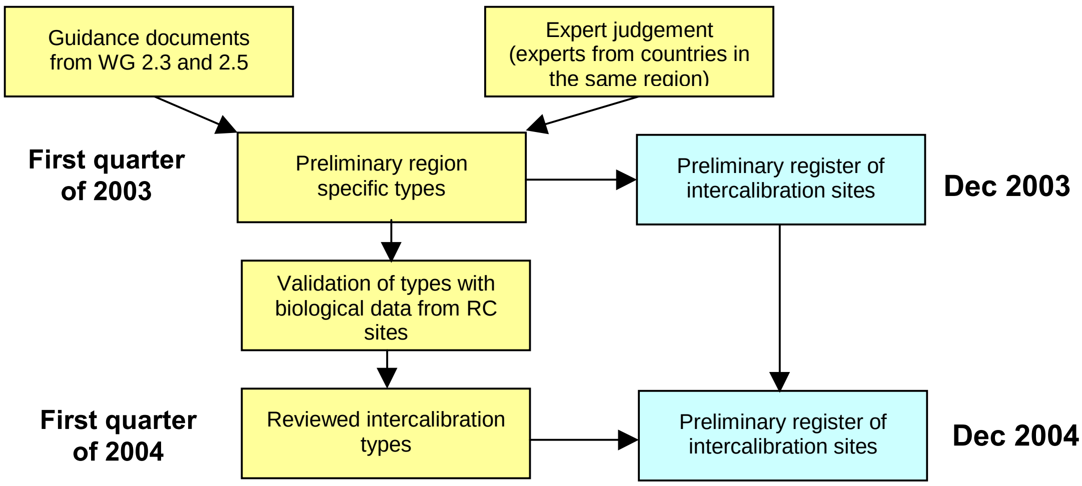
Based on the information in the guidance documents from workgroup 2.3 (REFCOND) and 2.5 (Intercalibration) together with expert judgement preliminary (eco)region specific typology system is suggested to be developed in co-operation between Member States sharing the same (eco)region. Based on the preliminary (eco)region specific typology, types are selected for the preliminary selection of intercalibration sites.

Hydromorpological, physico-chemical and biological data is collected from the selected sites together with data on different human pressures. Data from potential high status sites are used for validating the preliminary types (only reference sites can be used for testing and validation to avoid impact from human pressure on the typology). The minimum requirement on the validation result is that the variability in reference conditions within types is smaller than the variability between types.

Depending of the outcome of the validation procedure the types may be revised and complementary types and sites are selected for the final register of intercalibration sites. The typology system may be revised once again when monitoring data from all water bodies at risk and other selected water bodies will be available.

The suggested procedure and timetable for the development of (eco)region specific surface water body types to be used for selection of intercalibration sites is described in the figure below.

Annex G.



Assessing "who needs to get involved" in the reference condition and class boundary analysis requires addressing some of the following questions:

- Who will be responsible for the analysis?
- Who will undertake the analysis?
- Who will provide input into the analysis?
- Who will control the quality of the analysis?
- Who will use the results of analysis?
- Who will pay for the analysis?

Answers to these “Who” questions are likely to include a wide range of organisations, stakeholders and individuals according to questions. For example, experts from the Ministry of Environment or other ministries (land planning, nature protection units, GIS units, agriculture, etc), experts from river basin agencies or regional authorities, managers in charge of developing river basin management plans, ministry heads of water departments, researchers and consultants, historians, the public and a wide range of stakeholders that have developed expertise in specific fields (see table 1) and are involved in water management.

Developing a stakeholder analysis with possible involvement of key stakeholders can be an appropriate step for finding answers to these questions. It also helps in identifying key steps in the analytical process when involvement or input from specific stakeholders is required (different “Who” for different steps).

Table 1. Key Stakeholders can be a Very Important Source of Information and expertise

Key Stakeholders	Where they can help with information and expertise
Water Service Suppliers	➢ Characterising water services and their relations to the river system condition, e.g. impact on groundwater levels ➢ Knowledge about previous water quality situation ➢ Developing trends in water services and their impact on river system conditions
Experts from Ministries (agriculture, transport, planning, finance…) -	➢ Characterising water uses and their impact of the anticipated reference condition ➢ Assessing changes in key national and regional policies and drivers for the trend analysis, e.g. drainage of wetlands ➢ Defining coherent methodologies for assessing key variables at Member State level
Environmental NGOs	➢ Identifying key environmental issues ➢ Providing information about previous stage of the river system ➢ Developing methodologies for estimating impacts on anticipated reference condition ➢ Assessing political complications related to choosing between various reference condition alternatives ➢ Providing social acceptance of agreed reference condition
Economic sectors (farmers, industrialists, etc)	➢ Assessing trends in economic sectors and their previous impact on the river system ➢ Identifying possible measures needed for achieving a certain water quality status based on an anticipated reference condition, and their costs
Researchers/Experts	➢ Assessing key policies/drivers for the trend analysis ➢ Assessing impact of such policies on pressures ➢ Assessing impact of climate change on water quality ➢ Assessing the impact of previous impacts and pressures on water status (e.g. via modelling)
Stakeholders/civil society/public	➢ Assessing changes in key policies/drivers for the trend analysis ➢ Assessing (local, regional, national) priorities *vis-à-vis* water quality improvements, ➢ Providing input into the assessment of disproportionate costs and analysis aimed at explaining derogation, when taking into account various reference condition alternatives ➢ Providing input into the assessments of socio-economic impacts and costs ➢ Providing historic knowledge about the river system in previous decades / centuries