NRA-Water Quality Series 5

PROPOSALS FOR STATUTORY WATER QUALITY OBJECTIVES

Report of the
National Rivers Authority

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PREFACE

Since the National Rivers Authority (NRA) was set up in the autumn of 1989, much has happened within the organization. Major overhauls of past methods of working have been undertaken in order to obtain consistency across England and Wales based on the best practices and experience available. Reviews and public consultation exercises have been held in order to set discharge consents in the future on a sound and equitable basis. Registers of consents have been overhauled, and a scheme introduced for recovering the costs falling on the NRA with respect to consenting and monitoring discharges. Reviews have also been held internally with respect to many aspects of the NRA's pollution control work, including the major sources of diffuse pollution. Methods and models required for catchment planning and management have been developed. Information technology and services have been thoroughly examined and strategies for national networks and communications sorted out. A national R&D programme has been set up.

In the environment, a major survey has been carried out in order to obtain the best possible picture of the current state of the nation's rivers, including the use of novel assessment techniques. In the laboratories a vast range of equipment has been installed and new instruments are being developed. New boats are being built.

All of this activity has been, in part, a process of obtaining the necessary tools to do a specific job: the maintenance, and improvement where necessary, of our aquatic environment. The framework for doing this job, and the essential corner-stone of the NRA's water quality responsibilities under the 1989 Water Act, is that of the setting and achievement of water quality objectives which, for the first time, will have a statutory basis and will be the means by which a national plan of improvement will be implemented.

Under the legislation (the recently-consolidated Water Resources Act 1991), it is for the Secretary of State to prescribe (by Regulations) a system of classifying the quality of controlled waters, and then to set water quality objectives by reference to that classification for the purpose of maintaining and improving the quality of the waters to which the particular objective relates. The Secretary of State has said that he wishes to establish the classification schemes next year with a rolling programme thereafter for setting objectives, starting with rivers. As a first step, the Department invited the NRA to give its advice and assistance, in the shape of this consultation paper, which discusses the issues involved, makes certain recommendations, and invites views. Once comments have been received and considered, the NRA will advise the Secretary of State on the options. It will then be for the Secretary of State to consult on draft Regulations for the classification of waters and to submit them to Parliament.

The implications of the new system are considerable. It is important to develop a scheme which is sound and receives full support from all those involved, particularly those who stand to benefit and those who will have to bear the cost.

DR R J PENTREATH
Chief Scientist

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The development of the NRA's views on water quality objectives, and how they may best be introduced on a statutory basis, has been a task of the Water Quality Survey Group, chaired by Dr John Stoner. Members of the Group, past and present were:

Dr John Stoner	Welsh Region
Mr David Brewin	Severn Trent Region
Mr Peter Chave	National Head Office
Mr Eddie Douglas	Northumbria Region
Dr Alun Gee	Welsh Region
Dr Andrew Haig	Clyde River Purification Board
Dr Roger Sweeting	Thames Region
Dr Tony Warn	Anglian Region
Dr James Wharfe	Southern Region
Mr John Seager	National Head Office

A number of other people have additionally contributed towards the final document. The assistance of Mr Morlais Owens, the Institute of Freshwater Ecology, and the Water Research Centre is gratefully acknowledged. Special thanks are however due to Tony Warn for the analysis of the results of the 1990 Water Quality Survey from which the proposals for a new river quality classification scheme have been derived, and to his substantial contribution to the preparation of this report.

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The Starting Point

1.1 The existing classification scheme for rivers and canals provides the basis for assessing water quality according to the following classes:

Class 1a	)	Good
Class 1b	)	
Class 2		Fair
Class 3		Poor
Class 4		Bad

Informal water quality objectives using these schemes have been applied to rivers since the 1970s; thus for example, a stretch of river currently of Class 2 quality might have as its objective the achievement of Class 1b by 1995. The existing system covers some 40,000 km of rivers. There is a similar classification scheme for estuaries with four quality classes:

Class A	Good
Class B	Fair
Class C	Poor
Class D	Bad

1.2 Powers provided in the 1989 Water Act allow the Secretaries of State for the Environment and for Wales to introduce new classification systems and to use them as the basis for setting new Statutory Water Quality Objectives (SWQOs).

The Purpose of the Paper

1.3 The Secretaries of State have agreed with the NRA, as a first step, that the NRA should consult on options for the nature and introduction of a new system, and then to put proposals to them, together with the responses to their consultation process. This paper sets out the NRA's proposals.

The Purpose of the New System

1.4 The new statutory system will provide a firmer framework for deciding the policy that governs the determination of consents for discharges into each stretch of controlled waters and the means by which pollution from diffuse sources can be dealt with. It will extend the system to coastal waters, lakes and groundwaters. It will provide a basis for requiring a steady improvement in quality in those waters that are polluted. The objectives will be introduced by statute and will provide certain, clear and fixed targets for regulators and dischargers alike. In short, the new scheme provides a key mechanism for maintaining existing good quality water and for improving it where this is needed.

Implications of the New System

1.5 The implications will be widespread. In some areas the costs of improving water quality could be substantial; they are likely to have an impact on investment, employment and, inevitably, on prices paid by consumers. With such interests at stake, the procedures for establishing a new statutory system assume considerable importance.

Criteria Influencing System Design and Implementation

1.6 The system itself will need to strike a balance between conflicting requirements. Simplicity and flexibility will be needed if the system is to be introduced and extended quickly, readily understood, and easily applied and administered. However, comprehensiveness is necessary for effective environmental control; thus a degree of complexity is almost unavoidable if the system is to be able to cope with a wide range of circumstances; and certainty is necessary for regulators and investors alike as a basis for long-term planning. Effectiveness as an instrument of environmental control may require the introduction of new, relatively untried, techniques whose accuracy and reliability may be open to challenge; yet reliability, accuracy, and robustness to challenge are essential in a statutory system which ultimately could have to be enforced through the courts.

1.7 Speed of implementation is equally important if improvements in water quality are to be achieved without delay. There will be a statutory period of consultation over the setting of SWQOs and extensive informal consultation will undoubtedly be required beforehand. Where major improvements are needed, these consultations could be extensive. The introduction of distinct water quality objectives, for each individual stretch of the 40,000 km of rivers that will need to be covered, is bound to take some time. Substantial challenges, if they arose, could significantly delay formal implementation.

Recommended Approach

1.8 Reconciling these conflicting requirements will not be easy. The most effective approach may be to introduce rapidly a fairly simple system and then to develop it over time. Even then, a great deal of work needs to be done. A phased approach, starting with rivers, and priority catchments, is recommended. The system can then be progressively extended.

THE PROPOSALS

Aims

1.9 Existing classification schemes for rivers, canals and estuaries were introduced by the then National Water Council (NWC) in the late 1970s. The aim now is to expand the coverage of classification schemes, on a consistent basis, to <u>all</u> types of waters (ie including coastal waters, lakes, groundwater); and also to produce systems which are more objective, produce a better test of the "health" of a water body, and relate better to the range of uses for which waters are expected to be suitable. At the same

time, the new system needs to incorporate the requirements of relevant EC Directives, and to control the total quantities of persistent and bioaccumulative substances which are discharged into specific areas.

The Main Elements

1.10 The detailed proposals and the reasons for them are set out in the report. In outline the main elements are:

i) a set of "Use" categories, with appropriate standards covering the following:

- Basic amenity
- General ecosystem
- Special ecosystem
- Salmonid fishery
- Cyprinid fishery
- Migratory fishery
- Commercial harvesting of marine fish
- Commercial harvesting of shellfish
- Water contact activity
- Abstraction for potable water supply
- Abstraction for industrial and agricultural use

ii) relevant EC Directives, eg. those covering the following:

- Dangerous substances
- Abstraction for potable water supply
- Quality of fresh water for fish life
- Bathing water quality
- Quality required for shellfish waters

iii) a new General Classification Scheme - say, Classes A, B, C, D and E - incorporating standards for key chemical parameters (including dissolved oxygen, ammonia and biochemical oxygen demand), and a biological measurement (based on the extent to which a macroinvertebrate community of the watercourse falls short of what would be expected in a 'clean', or unpolluted system).

Statutory Application

1.11 The Use Classes will form the main part of the formal regulatory framework. Each Use category will have an accompanying set of standards (chemical, and potentially, biological) according to the needs of that Use.

1.12 The General Classification Scheme could continue to be used as the basis for 5-yearly surveys of overall water quality, and may be used for determining overall targets and priorities.

1.13 Statutory Water Quality Objectives will be set by the Secretaries of State serving notice(s) on the NRA in relation to individual stretches of water. It is intended that each notice will:

- define the stretch of water to which it applies;
- identify one or more appropriate Use Classes, and the corresponding quality standards;
- incorporate the standards required by such EC Directives as are relevant to the stretch of water;
- apply the quality standards relevant to one of the General Classes (if it is decided that the General Classification Scheme should be formally incorporated into SWQOs); and
- set dates by which each of the relevant sets of standards is required to be met.

An illustration of a set of Statutory Water Quality Objectives is given in Chapter 7.

NEXT STEPS

Establishing the Scheme

1.14 This paper seeks comments on the proposed Classification Schemes and associated provisional standards which have so far been identified. The NRA will summarise and assess the responses and put them, together with final proposals, to the Secretaries of State by Spring 1992. The Secretaries of State will consider the revised proposals and the representations that have been made. They will then formulate Regulations for introducing the Classification Schemes and standards. These will be published in draft in the Summer of 1992. Following a consultation period, the Secretaries of State will consider any objections or representations that have been made and lay Regulations before Parliament in the late Autumn of 1992. It is intended by the DoE that they will take effect before the end of 1992.

Setting Statutory Water Quality Objectives

1.15 The process described in the previous paragraph will establish the scheme. As with the existing classification scheme, the new scheme would not, of itself, set standards for individual watercourses. It simply represents the range of possible water quality standards from which particular standards will, in due course, be set; its application to particular stretches of water requires a separate process leading to the serving of a formal notice setting SWQOs.

1.16 The paper suggests a phased introduction beginning with rivers. Early next year the Secretaries of State, in consultation with the NRA, will prepare guidance on which catchments, rivers, or stretches of rivers, should be selected for the first wave of implementation of SWQOs, and general criteria for determining which Use Classes, and standards, should be applied to each stretch.

1.17 The NRA will then formulate draft proposals for the selected stretches. Following an informal local process of consultation on their proposals, the NRA will put them to the relevant Secretary of State.

1.18 The Secretary of State, having considered the NRA's proposals and local reaction to them, will formally publish a draft notice or notices setting SWQOs for each of the stretches of water to be covered. There is then a statutory period of at least three months for the making of objections and recommendations. The Secretary of State will consider any objections and representations, and then formally serve notice(s) on the NRA specifying for each stretch of water the SWQOs to be met after a given date.

Implementing Water Quality Standards

1.19 The NRA, and the Secretary of State, are required to have regard to the SWQOs when determining new applications for discharge consents and when reviewing existing ones. Thus it is through the process of determining and reviewing discharge consents and through actions to deal with pollution from diffuse sources that SWQOs are implemented and enforced.

Issues for Discussion

1.20 The NRA invites comments on the proposed scheme, in particular:

- as to whether or not the system strikes the right balance between the conflicting criteria set out in paras 1.6 and 1.7 above;
- on the proposal that the new system should be implemented in a phased manner starting with rivers, on a priority catchment basis;
- on the timescale for seeking improvements (see 7.9);
- on the role of the General Classification Scheme - should it form part of the formal statutory framework, or should it be used solely to make regular assessments of overall water quality across the country, determine priorities, enforce policy etc (see 6.23 to 6.26);
- on the proposed use of techniques of biological quality assessment as the basis for setting ecological standards - the need is clear, but are the techniques sufficiently reliable and robust to be incorporated forthwith into a statutory system (see 4.13 to 4.18; 6.7 to 6.10 and Appendices 2 and 3);
- on the standards which have been proposed for the Use-related Classes - are they clear, unambiguous and enforceable, and are they set at the level appropriate for the Use to which they relate (see Appendix 2); and
- on the way in which a precautionary approach to setting standards for dangerous substances is or can be implemented via the system of SWQOs (see 4.4 to 4.7).

2. GENERAL BACKGROUND

INTRODUCTION

2.1 The Water Act of 1989, for the first time under UK legislation, allows for a system of water quality objectives to be introduced under statute; these will serve as the framework for a national policy with regard to water quality, and both the Secretaries of State (that is the Secretary of State for the Environment and the Secretary of State for Wales), and the NRA have a general duty placed upon them to achieve the objectives once set. The White Paper on the Environment, "This Common Inheritance" [1], published in 1990, confirmed that Government would set water quality objectives by law on a consistent basis.

2.2 In practice, the objectives may therefore be seen as a series of plans which are stepping-stones towards improving water quality where necessary, or of maintaining it at a given level. Each objective will have a defined purpose, including consideration of the use of the water, and a date by which it has to be achieved. The achievement of such objectives will be the driving force behind the setting of consents to discharge, and any other means of controlling water quality. The justification for such an approach is essentially that which was set out in a report by the House of Commons Select Committee on the Environment in 1987 [2], which considered that such a system was necessary to:

- clarify priorities between areas and different types of improvement;
- require pollution control authorities, and all those water users they regulate, to follow standards and practices compatible with the achievement of the objectives; and
- allow necessary investment levels to be identified and planned for by the utility companies and industrial dischargers.

2.3 The means by which water quality objectives can be introduced and implemented via the Water Act remains, at present, fairly flexible. An essential feature, however, is that classification systems for controlled waters need to be established by the Secretary of State, by Regulations, before water quality objectives can be introduced under statute. In essence, therefore, classification schemes of controlled waters in themselves have no legal effect; in order for them to do so, they have to be incorporated into statutory water quality objectives established under Section 105 of the 1989 Water Act. Conversely, water quality objectives can only be set by reference to a classification scheme.

HISTORICAL BACKGROUND

2.4 The reporting of river classification in England and Wales began in 1970 with the publication by the Department of the Environment (DoE) of the River Pollution Survey [3]. An unofficial survey had in fact been carried out in 1958, but the results were only published with the results of 1970. These surveys recorded the general state of rivers, canals and estuaries. They have been repeated every five years since 1970, and have allowed an assessment to be made of the effectiveness of the pollution control authorities in the United Kingdom in maintaining and improving

water quality. There have been no similar surveys for coastal waters or ground waters.

2.5 The 1970 classification exercise placed rivers and canals in four classes based on measurements of the Biochemical Oxygen Demand (BOD) and other less precise criteria involving the type of effluents discharged and the number of complaints received. The assessment of river class was consequently rather a subjective exercise. The biological quality was also measured.

2.6 A comparison of the chemical and biological classifications was reported in 1970, but this failed to show the agreement between the classifications which was considered necessary before biological data could be used to report on river water quality on a national scale.

2.7 Following the creation of the Water Authorities in 1974, the National Water Council (NWC) reviewed both the classification of river water quality and the policy on setting consents for discharges [4]. One of the aims was to produce greater consistency; as a result, from 1978 to 1979, all the Water Authorities classified their rivers using a new classification system. A new scheme developed by the Marine Pollution Monitoring Management Group (MPMMG) was also introduced in 1980 for the classification of estuarial quality which incorporated chemical, biological, and aesthetic criteria. In later years it became the custom to define water quality by specifying the NWC Class. The NWC also broke new ground by suggesting that the classification be used to define water quality objectives; an important element of the scheme was that there should be 'No Deterioration' from existing river quality.

2.8 The main chemical determinands used in the NWC Class were those of BOD, dissolved oxygen, and ammonia, which are particularly relevant to the assessment of water quality in rivers receiving effluents from sewage treatment works. The Classes were defined in terms of the levels of these determinands needed to protect the more important uses of the watercourse, such as fisheries and abstraction for potable water supply. In addition, the better quality Classes were expected to meet the standards set up to protect freshwater fisheries by the European Inland Fisheries Advisory Commission (EIFAC). These were therefore called 'EIFAC Standards'.

2.9 The NWC Classification for rivers also referred to the Surface Water Abstraction Directive issued by the European Commission (75/440/EEC). Certain of the Classes were required to meet the standards set out in this Directive; if the river met these standards, it could be said to be suitable for abstraction for potable water supply.

2.10 It has become the custom to say that in providing attributes like a fishery or a water supply, the river is being *Used*. The fishery requirements and the supply of water are examples of *Uses*. Water quality standards needed to protect a Use were therefore called Use-related Standards. Other Use-related Standards were applied in river quality management, though generally on a case-by-case basis. One exception was the former Anglian Water Authority where Use-related Standards were an integral part of the system for managing water quality.

2.11 Each NWC Class therefore attempted to provide both an absolute measure of river quality and a means by which rivers could be compared; in principle, it also allowed the use of the NWC Class to report trends. But the scheme also tried to give an indication of the Uses which the river could support, particularly through the EIFAC Standards and the Surface Water Abstraction Directive.

2.12 One problem with the dual nature of the NWC Class was that new Uses, new Use-related Standards, and new EC Directives were being introduced steadily over the years. If these were to be incorporated within the NWC Class, the Class would cease to be an absolute measure of water quality, because not all Uses apply to all rivers. Also, if the definition of Class changed over time, the facility to use the Class to indicate national trends in water quality would be lost. Recognising this, the former Water Authorities Association Working Group on Statutory River Quality Objectives recommended that the industry define a new Class specifically to show 'absolute' quality. Rivers would then be checked separately for compliance with Use-related Standards. The new Class was similar to the NWC Class but based only on the BOD, the dissolved oxygen, and the ammonia determinands.

2.13 Even with the introduction of the NWC Class, the details by which Class changes in rivers were assessed varied across the ten Water Authorities. The main reason for this was statistical. The process by which a river was placed in a Class was sensitive to random chance associated with taking samples. This produced a risk of 10% to 30% that a river might be placed in the wrong Class. The Water Authorities adopted various strategies for controlling this error. This is discussed further in Appendix 3.

2.14 Thus, in summary, the existing NWC classification system has no statutory basis and faces increasing difficulties in assessing absolute water quality at the same time as showing whether the water is suitable for its agreed uses. The UK has a statutory obligation with regard to a number of EC Directives which relate to the aquatic environment. The majority of these relate to one or more uses of water, they contain standards which are required to be met, and dates by which compliance with them should be achieved. They also apply in different ways to different stretches of water. In short, each of this type of EC Directive is in effect a 'water quality objective'. The 1989 Water Act therefore provided a means of formally implementing a nationally-consistent system, which incorporates EC Directives and other use-related objectives specific to local needs, as discussed in the following chapters.

3. STATUTORY WATER QUALITY OBJECTIVES UNDER THE 1989 WATER ACT

INTRODUCTION

3.1 The means and purposes of setting Statutory Water Quality Objectives are covered by Sections 104, 105, 106 and 120 of the 1989 Water Act.* These Sections are reproduced in Appendix 1. Collectively, they provide the means by which a scheme of setting different types of water quality objectives, for different reasons, by different dates, and incorporating different EC legislation, can be developed and used. Thus although admirable in its flexibility, there is also the risk of considerable confusion as a plethora of such statutory objectives is brought in. It therefore seems sensible to consider the utility, for the purposes of the 1989 Water Act (WA), of an umbrella scheme for what might be called Statutory Water Quality Objectives (SWQOs) which would embrace all of these elements. In order to understand how the scheme might work, therefore, it is first of all necessary to discuss briefly the implications of these Water Act Sections.

WATER ACT (1989) CLASSIFICATION SCHEMES

3.2 Section 104 allows the Secretary of State to prescribe, by Regulations, a system of classifying "Controlled Waters" - a term used by the Water Act to cover essentially all groundwaters, lakes, reservoirs, rivers and canals, estuaries and the first three miles out to sea - with regard to their quality. The criteria to be used could consist of, either separately, or in combination:

- general requirements with regard to the purpose to which the waters would be put;
- substances which are present in, or absent from, the water, and their concentrations; or
- specific requirements as to any other characteristics of the water.

During a debate at Committee stage in the House of Lords, comments were made with regard to the desirability of including specific reference to nature conservation interests within the classifications. A commitment was then given by the Government to incorporate nature conservation interests within the water quality objective scheme.

3.3 Classification schemes are to be introduced via regulations; that is to say, by the publishing of Statutory Instruments (SIs). Indeed three such SIs have already been issued under Section 104(1) of the 1989 Water Act. The first (SI 1989/1148) concerned the classification of surface fresh waters with regard to their suitability for abstraction by water undertakers for supply, after treatment, as drinking water. Three Classes (DW1, DW2 and DW3) are described, with some 21 parameters, in order to give effect to the requirements of the relevant EC Directive on the same subject (75/440/EEC). The three Classes are hierarchical, in that the standards are tighter for

* Although references are made in this document to Sections in the 1989 Water Act, from 1st December 1991, those references should be taken as applying to the corresponding provisions in the 1991 Water Resources Act.

DW1 and most relaxed for DW3; this reflects the extent to which the water would require treatment before being put into public supply.

3.4 The second Statutory Instrument (SI 1989/2286) has only two Classes, DS1 and DS2, which are not hierarchical but refer to fresh waters and marine waters respectively. Each lists a number of 'dangerous' substances, and gives concentrations of each which should not be exceeded on an annual basis, primarily in order to give effect to a number of other EC Directives.

3.5 The third Statutory Instrument (SI 1991/1597) concerns water quality requirements for bathing waters as defined by the EC Directive (76/160/EEC) on Bathing Water Quality. Criteria are given for one Class only, BW1. Compliance is to be assessed against criteria for microbiological and physico-chemical determinands with specified minimum sampling frequencies.

WATER QUALITY OBJECTIVES

3.6 Classifications drawn up under Section 104 only have effect if incorporated into water quality objectives. The purpose of these is set out in Section 105 of the Water Act as being to maintain and improve the quality of controlled waters. Technically, a water quality objective can be set for any particular body of water under Section 105 by the Secretary of State serving a notice on the NRA which specifies:

- one or more of the classifications prescribed under Section 104;
- the waters to which they apply; and
- the date by which compliance should be achieved.

The public Water Act registers maintained by the NRA are required to contain details of all such notices served on the NRA under Section 105.

3.7 There are occasions, in particular associated with the incorporation of EC Directives into the water quality objective system, where the Secretary of State may also find it necessary to issue a formal Direction to the NRA under Section 146 of the Water Act setting out further requirements, such as specific monitoring arrangements required by the European Commission, or the action to be taken by the NRA in handling related discharge consent applications. A Direction has so far been issued in this way in relation to the Directives concerning dangerous substances (for which the classification requirements under Section 104 were met via SI 1989/2286).

3.8 Additionally, in order to establish or vary a water quality objective under Section 105, the Secretary of State has to:

- give notice of the proposal, allowing at least three months for representations or objections to be made; and
- consider the response before acting.

Such a notice of proposal has to be published such that it is brought to the attention of persons likely to be affected by it, which would include the various industries who may discharge any chemicals identified, owners of waters affected, and so on. A

copy of the notice has also to be served on the NRA and entered on the Water Act register.

3.9 In addition to the requirements under Section 105, the Secretary of State may, under Section 120, cause a local inquiry to be held with respect to the establishment or review of a water quality objective.

COMPLIANCE WITH WATER QUALITY OBJECTIVES

3.10 Section 105 requires that, for the waters to which it relates, the conditions of a water quality objective need to be met 'on and at all times' after the date set. Section 106 gives three important requirements:

- that the duty to ensure that the water quality objectives are met falls on both the Secretary of State and the NRA;
- that their achievement at all times is ensured 'so far as is practicable' by the exercise of the powers available to the Secretary of State and the NRA; and
- that the powers referred to are only those relating to pollution control, contained in Part III, Chapter 1, of the 1989 Water Act.

These requirements need to be read together and considered against the background of sampling and statistical techniques which are the only practical means of assessing compliance. It follows that standards have to be specified in such a way that assessments of compliance are technically feasible and sufficiently reliable to provide a robust basis for setting enforceable standards for dischargers. Equally, there will have to be procedures for dealing with occasional failures, through chance or otherwise, to meet water quality objectives, which can never be wholly avoided in practice. The statistical basis for assessing compliance is discussed in Appendix 4.

3.11 In view of its general responsibilities with regard to implementing water quality objectives, a specific duty is also placed on the NRA under Section 106 of the Water Act with respect to monitoring the extent of pollution in Controlled Waters.

REVISING WATER QUALITY OBJECTIVES

3.12 The Water Act also allows for the revision of water quality objectives, such allowance having two important consequences on their use. Effectively, the Secretary of State, under Section 105, cannot vary an existing water quality objective unless it has been reviewed, and such a review can only take place:

- at intervals of at least five years; or
- if the NRA requests such a review after consultation with water undertakers and any other bodies that the NRA considers appropriate.

Thus, once set, dischargers are entitled to at least some period of stability before being requested to review their practice, providing that the water quality objective is being met. This does not, however, negate the NRA's ability to enforce discharge consents, nor to review consent conditions after a two-year period.

THE NRA'S ROLE IN SETTING WATER QUALITY OBJECTIVES

3.13 The responsibility for the setting of water quality objectives quite properly lies with the Secretary of State; the interests of everyone must be taken into account. Nevertheless, apart from the introduction of EC Directive requirements via Sections 104 and 105, the Secretary of State clearly requires advice as to:

- what water quality objectives may be generally or specifically required;
- what water quality standards would need to be met and how these compare with the existing quality of the water;
- the waters to which they may apply;
- for what reason;
- how they may be achieved;
- by when may they reasonably be achieved; and
- what the financial, economic and other implications are likely to be.

Naturally the NRA has a large role to play in this respect, and indeed the Water Act places a duty on the NRA under Section 118 to provide the Secretary of State with such advice and assistance when requested to do so.

3.14 Quite evidently, any national scheme needs to be well thought out in advance, such that it is internally consistent and yet sufficiently flexible to accommodate future requirements without having to be completely overhauled. One option would be to apply a purely descriptive classification scheme, with the Regulations doing no more than to set down requirements such as "suitable to permit the passage of representative migratory fish". However, such a subjective scheme may raise legal and practical difficulties. There is a need for clear-cut standards to be introduced through Regulations such that compliance can be assessed in an unambiguous way. From the precedents already set, it would appear that Regulations can be used to introduce classification schemes which are either 'hierarchical' or of a 'pass/fail' nature, but for which (numerical) values are required, upon which compliance or otherwise with the scheme can be assessed. It would also appear that any national scheme to set SWQOs needs to take account of the following:

- Use-related Classes;
- EC Directive requirements where relevant;
- classification schemes used in the past for UK rivers and estuaries; and
- the general requirements of the 1989 Water Act and the NRA's duties and powers in relation to it.

3.15 The question remains, therefore: to what extent can these requirements be brought together for the purposes of SWQOs? These issues are discussed in the following chapters. Before doing so, however, it is finally worth noting that although water quality objectives are considered primarily in relation to pollution control, the concentrations of substances in water are affected by the amount of water abstracted, which is also controlled by the NRA. Indeed, the attainment of future water quality within any one catchment will be a reflection of a plethora of management techniques which are applied to it, from discharge consenting to flood protection.

4. USE-RELATED CLASSES FOR CONTROLLED WATERS

INTRODUCTION

4.1 In Chapter 2, the approach adopted in recent years for the management of water quality in the United Kingdom was discussed. It was noted that it already centred upon the informal application of schemes aimed at the protection of different water uses, and involved the application of Environmental Quality Standards (EQSs) which define the needs for the protection of different uses identified for a given stretch of water. Discharge control strategies were then based on the achievement of the EQSs in the receiving waters. The levels of water quality to be achieved were then defined according to either a single Use-related Class or a system of hierarchical Use-related Classes. Standards for individual determinands were then set for each of the Classes. A major advantage of this approach is that it allows resources to be concentrated on solving the real problems caused by conflicts between the various demands placed on waters, particularly in relation to their ability to assimilate pollution.

4.2 The alternative approach to water pollution control, widely applied in other countries, is to set uniform emission standards on the levels of contaminants in the discharges. The standards are generally set in relation to what is technically feasible for different types of industry.

4.3 The EQS approach is sensitive not just to the effects of an individual discharge, but to the combined effects of the whole range of different discharges into a water body. It enables an overall limit on levels of contaminants to be set according to the required uses of the water body. This approach does however have limitations where the substances involved are persistent, and have a tendency to build up in the environment and accumulate in aquatic biota. Because the control is applied in terms of the resulting concentration in the environment, there will be cases, for receiving waters with high dilution capacity, where the total amount, or load of pollutant permitted to be discharged may be quite large, and may be greater than the discharger is capable of achieving by treatment. This effect is particularly marked in coastal waters, where the dilution available is very large indeed.

4.4 In relation to substances which tend to be particularly toxic, persistent or bioaccumulative, it is therefore necessary to adopt a more precautionary approach, and constrain the amounts - and/or total loads - permitted to be discharged by means of emission standards. This approach has already been formally introduced into national legislation by the 1990 Environmental Protection Act, where effluents for certain prescribed processes are required to be based on Best Available Techniques Not Entailing Excessive Costs (BATNEEC), via the system of Integrated Pollution Control (IPC) being implemented by Her Majesty's Inspectorate of Pollution (HMIP). European legislation has also introduced requirements for minimum uniform emission standards to be applied in the UK. The Urban Waste Water Treatment Directive, for example, defines the type and level of treatment which is required according to the size of population served, and sets minimum standards for the resulting effluents. Controls also need to be exercised to reduce the total amount of potentially polluting chemicals entering catchments from all sources, both point source and diffuse, on the

basis of catchment accountability for the means by which such waters and their adjacent coastal waters may become contaminated.

4.5 Both approaches - although incomplete - are already well established in UK pollution control management, and it is clear that effective water quality management in the future will require the integration of both use-related and emission-based approaches.

4.6 Nevertheless, it is suggested that, in general, in introducing SWQOs, a use-based approach should be adopted. Past experience shows that this approach provides a robust and scientifically defensible regime of management. This therefore leads to the first recommendation.

... RECOMMENDATION 1: In order to develop SWQOs, it would be sensible to build on, and harmonise, past practice by selecting a number of Uses for Controlled Waters. It would then be necessary to define and set Use-related Classes relevant to each of these Uses, and the Standards necessary for the protection of these Uses by which compliance could be assessed. As necessary, these Use-related Classes should be included in the SWQOs set for individual stretches of Controlled Waters.

4.7 It is also recognised that the use-based approach may, of itself, for the reasons set out above, not always meet the requirements of a precautionary approach. The NRA is, however, committed to the adoption of this approach in relation to those discharges where it is necessary to prevent the build-up of persistent toxic substances in the environment. Where this is necessary, this is the approach which the NRA has advocated in its review of discharge consenting policy, and which it intends to follow in setting consent limits. For the purposes of providing an integrated framework for water quality management, it would therefore be preferable, in relation to dangerous substances, that the adoption of a BATNEEC-based approach to consenting should explicitly form part of the scheme of SWQOs.

USES OF CONTROLLED WATERS

4.8 Although not all of the Uses will apply to each category of Controlled Water, many will apply to most categories. It is therefore suggested that a national scheme of Use-related Classes will provide a uniform approach to the management of Controlled Waters. It will recognise the differences between the categories of Controlled Water, and deal properly with the individual needs of different stretches of waters within each category. It is suggested that a system of Use-related Classes will provide the best means to respond quickly and efficiently to the changing needs of waters. Through a process of regular review it will be possible to introduce new Uses and new EQSs as necessary.

4.9 So far, a number of discrete categories of water Use have been identified; these fall into several distinct types. There are those Uses which relate to the exploitation of a water body for a specific kind of activity. These are:

- abstraction for potable water supply;
- water contact activity;
- salmonid fishery;

- cyprinid fishery;
- migratory fishery;
- commercial harvesting of shellfish;
- commercial harvesting of marine fish; and
- abstraction for industrial and agricultural use.

There are also those Uses which relate to the protection of the water body to safeguard the integrity of aquatic ecosystems. These are:

- general ecosystem; and
- special ecosystem.

A Use has also been included which relates to the aesthetic aspects of a water body, that of:

- basic amenity.

4.10 Table 1 shows which Uses apply to the different categories of Controlled Water; it also lists the Use-related Classes and gives notes and examples to illustrate how the Uses might apply to particular sites and circumstances. Only those Uses which can be affected by the quality of the environment are included; thus navigation, for example, has been excluded on the assumption that it requires only the achievement of the Class criteria for Basic Amenity. The needs for the protection of Uses which rely on adequate water quantity as well as water quality will be dealt with through the development of Catchment Management Plans, which are aimed at balancing the demands of all water users. Such plans will result from a multi-functional and multi-use appraisal of a catchment which identifies present and potential future uses of water and associated land, considers interaction and possible conflicts, and proposes an action plan which allocates responsibilities for achieving improvements. Pilot plans in priority catchments are currently being drawn up, and depending on the outcome of these studies, procedures will be derived which can be applied on a national basis.

4.11 It is also imperative to stress that recognition is given to the legitimate use of Controlled Waters for activities such as the disposal of waste waters, the support of river flow, flood defence, and the abstraction of gravel; but these have been excluded from the scheme of Use-related Classes because they are essentially constrained by the need to protect the other Uses already identified. The quality of the waters used for the support of river flow, for example, will be constrained by the conditions of the SWQO placed on the receiving water. Thus there is already in the Water Act the power to apply the necessary control measures to the donor water to ensure that the SWQO placed on the receiving water would be met. It is also recognised that in flood defence the need to safeguard lives and property has paramount importance. In special circumstances this may over-ride other Uses and constrain ambitions to achieve the requirements of some Use-related Classes. This factor can be addressed in the specification of SWQOs for individual stretches of Controlled Waters.

4.12 The Uses listed in Table 1 warrant further explanation. The first, that of Basic Amenity, refers to the activities which take place in close proximity to a water body

Table 1: Proposed Uses of Controlled Waters to be included in the Scheme of Statutory Water Quality Objectives

	USE	USE-RELATED CLASS REQUIREMENTS	APPLIES TO					EXPLANATORY NOTES	EXAMPLE
			R	L	E	C	G		
1.	Basic amenity	Maintain or improve water quality so as to prevent public nuisance arising from visual and smell problems.	x	x	x	x		Refers to the minimum general aesthetic acceptability of the Controlled Waters to people close to, but not intimately in contact with, the water.	Walking
2.	General Ecosystem								
A)	For Controlled Waters of, or near to pristine conditions, receiving no substantial direct or indirect charges	Promote all aquatic life and dependent non-aquatic organisms, so that the ecosystem is typical of a Controlled Water with those physical and chemical characteristics, flow regime and location.	x	x	x	x		Includes all aquatic flora & fauna and dependent organisms, excluding those fish covered by objectives 4,5,& 6. It is implicit that A) includes all the sub-objectives outlined in B) where appropriate.	
	OR								
B)	For Controlled Waters receiving substantial discharges, and where achievement of pristine conditions is impracticable	Ensure that: a) for rivers and lakes it can provide a flora & fauna capable of supporting relevant fish populations (see objectives 4 and 5)	x	x				a) & b) These more limited objectives would apply where it was economically or practically infeasible to return the Controlled Water to its natural state. The ecological quality class to be achieved would be specified in this case.	
		b) for estuarine and coastal waters: i) it supports a variety of aquatic life & dependent non-aquatic organisms			x	x			
		ii) where appropriate fish and shellfish are protected			x	x			
		iii) where appropriate it supports a flora & fauna essential to sustain sea fisheries.			x	x			
3.	Special Ecosystem	Safeguard the special conservation interest for which the Controlled Water is identified.	x	x	x	x			National Nature Reserves, SSSIs
4.	Salmonid Fishery	Sustain a breeding population of salmonids appropriate to the physical characteristics of rivers, lakes and reservoirs and to the flow regime of the river where this is not precluded by natural physical barriers.	x	x					

Table 1 (continued)

USE	USE-RELATED CLASS REQUIREMENTS	APPLIES TO					EXPLANATORY NOTES	EXAMPLE
		R	L	E	C	G		
5. Cyprinid Fishery	Sustain a breeding population of cyprinids appropriate to the physical characteristics of rivers, lakes, and reservoirs, and to the flow regime of the river where this is not precluded by natural physical barriers.	x	x					
6. Migratory Fishery	Maintain or improve water quality so as to protect passage of all relevant species of migratory fish where this is not prevented by natural physical barriers	x	x	x	x		Applies to migratory fish such as salmon, sea trout and eels.	
7. Commercial harvesting of marine fish for public consumption	Ensure that commercial marine fish quality shall be acceptable for human consumption as determined by the appropriate Competent Authorities (eg MAFF)			x	x		Applies only to suitability for human consumption; the general health of the fish themselves is protected under Use 2.	
8. Commercial harvesting of shellfish for public consumption	Ensure that commercial shellfish quality shall be acceptable for human consumption as determined by the appropriate Competent Authorities (eg MAFF)			x	x		Applies only to suitability for human consumption; the general health of the shellfish themselves is protected under Use 2.	
9. Water Contact Activity	Maintain or improve water quality so as to protect those engaged in water contact-related activities	x	x	x	x		Includes only those activities where there is a risk of intimate contact with water.	Bathing, Wind Surfing, Water Skiing, Skin Diving
10 Abstraction for Potable Water Supply	Safeguard potable supply at defined abstraction points	x	x			x	Takes into account quality consideration only.	
11 Industrial and/or Agricultural Use	Safeguard industrial abstractors, and where water is used for agricultural purposes, maintain water quality so as to protect the health and well being of affected animals, avoid damage to crops, and safeguard public health.	x	x	x	x	x	Different types of abstraction would be safeguarded by the specific quality standards applied. Will apply to all waters used for abstraction for industrial/agricultural use.	

Key: R = Rivers; L = Lakes & Reservoirs; E = Estuaries; C = Coastal Waters; G = Groundwater

but not intimately in contact with it. Many people live adjacent to water courses and many more come to visit them for recreational activities such as walking and fishing. The visual appearance and odour of waters is therefore of particular importance to the general public, irrespective of the water's chemical or biological quality. Indeed, the general public is more likely to assess achievements in pollution control against the aesthetic properties of a water body than by any invisible chemical or biological parameters. Adverse visual appearance caused by litter, foaming, oils and unnatural coloration is amenable to corrective action through the powers relating to pollution control in the Water Act. The introduction of SWQOs therefore presents an opportunity to introduce formal Use-related Classes for Basic Amenity Use. This would allow the setting of targets against which the removal of visual and odour problems could be properly planned and monitored. It could be argued that such factors as foaming, colour, or the presence of litter are difficult to quantify and thus out of place within any form of classification scheme. In this context, therefore, it is of interest to note that the 1990 Environmental Protection Act has requirements that relate to litter zones, and these are to be divided into four categories according to quantitative criteria. The littering of rivers and other waters could thus similarly be categorised; it should also not be forgotten that the NRA has successfully brought a prosecution for 'littering' a river. A proposed scheme which would provide the basis for the classification of waters for Basic Amenity Use in terms of visual and odour criteria is set out in Appendix 2; this leads to the next recommendation.

... RECOMMENDATION 2: A Basic Amenity Use-related Class be set relating to the aesthetic qualities of waters which are amenable to pollution control measures.

4.13 The second Use, termed General Ecosystem, refers to the protection of the integrity of aquatic ecosystems. This is a fundamental requirement, because by safeguarding ecosystem 'health', other uses, such as fisheries for example, are also likely to be protected. Furthermore, it now seems likely that European Community legislation will require that formal systems are introduced for the assessment and classification of the ecological quality of waters. General Ecosystem Use may be applied to all Controlled Waters, although there will be some cases - such as canalised rivers - where the establishment of any natural biological community will not be possible.

4.14 The establishment of Use-related Classes will require the setting of ecologically-based targets through the development of a classification scheme. The question then arises as to what form this classification scheme should take and how the standards should be expressed. One option would be to derive chemical standards on the basis of our knowledge of the ecotoxicological effects of chemical substances on aquatic flora and fauna. This has been the conventional way of setting standards in the past. However, such an approach has a number of weaknesses. Firstly, it relies on using the results of laboratory tests to set no-effect levels for 'real-life' biological communities. These tests are usually unrepresentative of field conditions and the application of the results to the setting of standards is therefore an uncertain process. Secondly, in reality it will not be possible to set and monitor performance against standards for more than a few chemical parameters; yet biological communities respond to the sum total of their chemical environment, which may be a complex mixture of different substances. Thirdly, again for practical reasons, it will not be possible to monitor all Controlled Waters at a frequency which will guarantee the

detection of all polluting events. However, many waters are affected by episodic pollution and biological communities will respond to these events. Taking all these factors into account, a preferable option would be to derive and apply standards which relate directly to the nature and composition of biological communities themselves rather than to any surrogate chemical criteria.

4.15 The majority of European countries with classification schemes for their waters do use some form of biological component, varying from aquatic plants to fish. Most use biological information to supplement chemical classification schemes, but the practice of setting standards within the context of ecological classification schemes is not widely applied. In the past, biologically-based scoring systems - such as the Biological Monitoring Working Party (BMWP) score and Average Score Per Taxon (ASPT) - have been applied in the UK in assessing river quality. These systems are relevant only to certain groups of animals which live on or in the bottom sediments, called the benthic macro-invertebrates. The scoring systems reflect the status of communities of those animals with respect to the degree to which they are affected by pollution. One option therefore would be to use these existing systems to develop an ecologically-based classification scheme for rivers. A major drawback with these systems, however, is that they do not take account of the natural physical and chemical properties of rivers which have a fundamental influence on aquatic communities. This makes it difficult to make meaningful regional comparisons between scores because of the influence of the geology and topography of catchments, and physiographic properties of rivers which will differ around the country. Because of this, the existing scoring systems are not ideally suited to provide nationally-consistent criteria for a General Ecosystem Classification Scheme.

4.16 Computerised models have recently become available which enable predictions to be made about the nature and composition of biological communities based on certain natural physical and chemical properties at a given river site. These approaches show potential for the development of nationally-applicable criteria, because they take into account the natural properties of catchments which determine the nature of biological communities. Using these systems it is therefore possible to separate the influence of the natural factors from those which are pollution-related. This allows direct comparisons to be made of the status of aquatic communities between catchments and river sites. One such model, called "RIVPACS" (River Invertebrate Prediction and Classification System) developed by the Institute of Freshwater Ecology, has recently been applied extensively by the NRA in biological surveys of rivers. It allows a prediction to be made of the composition of the invertebrate community that would be expected for an unpolluted site according to its geographic location, and certain natural physical and chemical properties of the river, including the river bed and the water. It is then possible to compare the status of the invertebrate community which is actually present in the river with that which would be expected were that site to be unpolluted. The ratio of the observed to predicted status can be expressed as an Ecological Quality Index (EQI).

4.17 This predictive approach therefore presents an attractive possibility to serve as the basis for a General Ecosystem Classification Scheme. The EQI could be used to define Classes in a hierarchical manner. Objectives could then be set and compliance assessed in terms of EQI bands. This option has the advantage that the EQI directly

reflects the influence of water quality on biological communities, and presents an opportunity for setting standards which would be relevant across the whole of England and Wales. The data collected during the 1990 national biological survey of rivers is currently being evaluated to assess the extent to which this system is capable of providing reliable and robust ecological standards for setting objectives within a General Ecosystem Classification Scheme. One possible approach to defining the Classes is given as an example in Appendix 2. The third recommendation is therefore as follows:

... RECOMMENDATION 3: A General Ecosystem Use be defined which, for rivers, would have requirements and standards that were defined biologically by way of an Ecological Quality Index (EQI).

4.18 Although the General Ecosystem Classification Scheme would be based primarily on ecological criteria in order to set water quality objectives, it should be capable of reflecting water quality status. Thus the highest Class would apply to those waters where essentially natural ecological conditions prevail and which have not been fundamentally affected by human activities. The lower Classes would reflect the effects of differing degrees of pollution on biological communities. It is recognised that in some cases the establishment of natural biological communities will be affected by factors other than water quality - such as in concrete-lined, canalised rivers. These factors will have to be taken into account when setting realistic objectives.

4.19 At present, workable systems for applying ecological classification schemes and standards are only available for invertebrate communities in rivers. Research is currently in progress to examine the feasibility of developing and introducing comparable systems for other categories of Controlled Waters and other groups of aquatic flora and fauna.

4.20 The General Ecosystem Classification Scheme should be capable of allowing Use-related Classes to be applied to most waters. However, there are cases where certain sites, including National Nature Reserves and Sites of Special Scientific Interest, have been given special protection status for nature conservation reasons. These sites may have special water quality requirements according to the types of species or habitats which are to be protected. The standards which are applied at such sites will therefore need to reflect these specific requirements. Because it will not be feasible to allow for all these different requirements in a General Ecosystem Classification Scheme, the preferred option would be to include a separate Use which could take account of the requirements of identified protection sites; hence the next recommendation.

... RECOMMENDATION 4: A Special Ecosystem Use should be considered which would allow Use-related Classes to be set for those designated sites which have special requirements for nature conservation reasons.

4.21 Both the Basic Amenity and General Ecosystem Uses would require 'hierarchical' classification schemes; but for other Uses certain standards will apply on what is essentially a 'pass/fail' basis, in that the quality of the water is either sufficient for

the Use or it is not. Taking the case of fishery Uses, for example, the water either is or is not of a sufficient quality to sustain salmonid or cyprinid fisheries. Because the water quality requirements of the two categories of fishery are to some extent different, the question arises as to whether they should be combined into a "hierarchical" classification system, in which the salmonid fishery is of a higher Class than the cyprinid fishery. Furthermore, different types of cyprinid fishery may have differing water quality requirements. This may arise as a result of the different sensitivities of cyprinid species to pollution, and the acclimatisation of fish to local water quality conditions; for example, it is well known that some rivers in England and Wales support good cyprinid fisheries yet exceed the ammonia standard in the EC Freshwater Fisheries Directive of 0.78 mg N/l. Where this has been demonstrated, a more relaxed standard of 2.33 mg N/l has been considered to be acceptable. It could therefore be argued that a hierarchical classification system is required with respect to the differing water quality requirements of cyprinid fisheries.

4.22 A national fisheries classification system is currently being developed for the purposes of fisheries management. When completed, this system could provide the mechanism for defining fishery Classes within a hierarchical classification scheme, but a major difficulty is that in reality it is difficult to separate different classes of fishery in terms of their water quality requirements because not enough is yet known about the relative sensitivities of different fish species to pollution. Furthermore, there would be a dilemma in how different Classes of fishery would be perceived. For example, a stretch of river only suitable for supporting a cyprinid fishery could be regarded as a highly acceptable coarse-fishery river, or as a river of a lower Class with regard to the type of fishery that it supported. In view of the advantages of Use-related site specificity, it is therefore suggested that specific 'pass/fail' criteria be used in such cases.

4.23 The arguments relating to salmonid and cyprinid fisheries apply equally to migratory fisheries: the waters to which they apply either will or will not be of sufficient quality to allow the passage of migratory fish to the extent that a fishery could be sustained. And the same may again apply for marine fisheries in specified areas. Similarly, 'pass/fail' criteria are likely to apply with regard to the suitability of the receiving water for industrial or agricultural use, although this may eventually depend on the exact parameters and standards chosen. A 'pass/fail' classification scheme would also appear to be necessary with regard to the definition of Special Ecosystems - which would be freshwater, estuarine or marine. This therefore leads to the next recommendation.

... RECOMMENDATION 5: In order to specify the needs of individual stretches of water, to assess properly the remedial measures which may be required, and in order to assess compliance with objectives arising from different interest groups, separate 'pass/fail' Use-related Classes be applied for the following Uses: Salmonid, Cyprinid, Migratory and Marine Fisheries, Industrial/Agricultural Use and Special Ecosystems.

4.24 There are also a number of other Uses for which a 'hierarchical' classification scheme would appear to be the more appropriate. This is particularly the case where the extent to which the water could actually be used is dependent upon the effort willing to be spent on dealing with it - as with the suitability of water abstracted for

drinking. The relevant EC Directive recognises three categories, in direct relationship to the degree of treatment required subsequent to abstraction. Similarly, the quality of water suitable for rearing shellfish will be different, depending on the level of treatment - by holding shellfish in 'purification' tanks - required prior to their consumption by the public. The recently introduced EC Directive on "Shellfish Hygiene" (91/492/EEC) requires that waters are classified according to three separate categories depending upon the microbial content of the shellfish taken from them and the consequent level of treatment required. Where separate criteria are required for molluscan and crustacean fisheries, two parallel schemes will be necessary; this will depend on advice received from MAFF.

4.25 Another Use which could be 'hierarchical' is that relating to Water Contact Activities. The health risks associated with water quality may be different for different kinds of activity, such as bathing or wind surfing, although this may, in practice, be difficult to quantify. This is the subject of ongoing research and, dependent upon its outcome, decisions will have to be made as to whether a risk-related classification scheme with different standards according to the kind of activity is warranted.

STANDARDS FOR USE-RELATED CLASSES

4.26 For each Use it will be necessary to identify and apply appropriate standards which, when complied with, will ensure the protection of that Use at the required degree of reliability, and will provide the means by which the achievement of Use-related Class requirements can be assessed. Thus for each Use-related Class a set of parameters will need to be selected and numerical values, with associated compliance criteria, will have to be set. Appendix 2 gives a range of proposed standards which could be applied for each of the Uses which have been recommended to be included within the framework of the scheme of SWQOs. These standards should only be considered as indicative at this stage.

4.27 In some cases these standards will relate to hierarchical classification schemes and in others to pass/fail criteria which have been discussed previously in this chapter. For practical reasons it will be neither technically nor economically feasible to set and monitor compliance against standards for all kinds of potentially polluting substances at all times and at all places. It is also essential not to have to develop a programme of monitoring which would be so complex and time consuming that it detracted from the efforts required to attain real improvements in water quality. It has therefore been necessary to prioritise according to those parameters which are fundamental to the protection of a given Use and for which robust, tried-and-tested standards are available. Although many of the standards proposed are well established and have been widely applied, they should be open to review in the light of new knowledge. Additional standards will also need to be included as necessary, according to the different requirements of each Use. In many cases, tried-and-tested standards are not available and require further development.

COMPARISON WITH EC DIRECTIVES

4.28 A number of the Uses described in Table 1 are similar to all, or parts of, certain EC Directives. Indeed, as has been noted, some of them are in effect water quality objectives as envisaged under Sections 104 and 105 of the 1989 Water Act. They already have standards set, and dates for compliance. It is therefore reasonable to ask: why have the Uses in Table 1 been separately defined? There are four principal reasons for this:

- the Standards required to be met, and the selection of them as a basis of demonstrating compliance, are not necessarily those best suited for UK practice;

- with the exception of the Directives on Urban Waste Water Treatment, the compliance criteria in the Directives take no account of the influence of chance on sampling, thus producing a potential risk that sites may be declared wrongly to have failed;

- the EC Directives only cover a limited number from the wide range of different Uses of Controlled Waters; and

- an EC Directive applies only to designated or identified stretches of water as required by the terms of the Directive, even though other areas may be used for the same purpose.

4.29 A good example of such differences is that between the Use for Water Contact Activity and the EC Bathing Water Directive. The latter only includes the practice of bathing, and only applies to certain beaches identified under the terms of the Directive. Some nineteen parameters are listed, eleven of which have numerical standards, but only some of which are mandatory. The NRA has, along with others, in any case questioned the relevance of some of the parameters - such as phenols - to the primary use requirements, and questioned the validity of some of the numeric values, such as the zero requirements for salmonella and viruses. The Water Act therefore allows the UK to implement its own parameters, as well as to set values which have an epidemiological base. Similar comments apply to other long-established Directives, such as that relating to the quality of Shellfish Waters (79/923/EEC), for which other standards - such as those for tributyl tin - may be needed. Similarly, some of the parameters relating to the Freshwater Fish Directive (78/659/EEC) are now considered to be inappropriate, and aspects of the Surface Water Abstraction Directive - such as the pesticide parameter - are now outdated and need revision. Nonetheless, compliance with existing EC Directives will still need to be demonstrated in those waters to which they apply, as discussed in the next chapter.

5 EC DIRECTIVES

INTRODUCTION

5.1 Several EC Directives which affect UK Controlled Waters have been introduced through European legislation. The Directives place a responsibility on Member States to introduce measures to comply with environmental standards and controls. Member States are expected to incorporate these measures within their national legislation and, as discussed in Chapter 3, the UK Government is addressing these requirements by the introduction of Regulations in the form of Statutory Instruments (SIs) and notices via the 1989 Water Act.

5.2 The number of Directives, and the extent of their influence, has grown steadily since the mid-1970s. In parallel, the DoE has required more reports on compliance. For water-related Directives in England and Wales, the NRA is the 'competent authority' with regard to their practical aspects; compliance with the Directives, however, is a matter between the EC and Member States.

5.3 The Directives vary in scope and type. Some have been developed for named Dangerous Substances, or for specific uses such as Fisheries or Bathing; others have been targeted at individual industries, and some apply only to particular categories of waters. Because the UK has a commitment to comply with EC Directives by the dates set, it is clearly essential to incorporate them into any generalized scheme. It would clearly be unacceptable to record that a stretch of water satisfied a SWQO under the 1989 Water Act if it failed the standards upon which the UK Government assessed compliance for a relevant Directive to the satisfaction of the European Commission.

RANGE OF DIRECTIVES

5.4 A wide range of Directives is relevant to the aquatic environment but not all include specific numeric standards or require a regular monitoring programme. A list of the Directives which specify water quality standards which should be included as part of the SWQO scheme is given in Table 2. These Directives fall into several categories. There are those which set conditions for specific uses of waters, such as the Directives for Surface Water Abstracted for Drinking, Bathing Water, Freshwater Fisheries and Shellfish Waters. The requirements of these Directives apply to identified or designated sampling points or stretches of water. Other Directives, such as those concerning Dangerous Substances and Nitrates, are substance-specific. These Directives do not specify conditions for any water uses but are aimed at reducing the levels of certain substances in the aquatic environment. Finally, there are those Directives which are industry-specific such as those for Titanium Dioxide, Chlor-Alkali and Asbestos. As new Directives with specific standards are introduced, they can be incorporated as required. Standards for EC Directive List II Substances are set by individual Member States; these, too, can be introduced as required.

Table 2: Directives with Water Quality Standards for Controlled Waters appropriate for Statutory Water Quality Objectives

EC DIRECTIVE	DIRECTIVE NO
Quality of Surface Water for Drinking	75/440/EEC
[Surface Waters (Classification) Regulations, 1989 Statutory Instrument No 1148]	[SI 1148]
Pollution caused by Discharge of Dangerous Substances into the Aquatic Environment	76/464/EEC
[Surface Waters (Dangerous Substances) (Classification) Regulations, 1989 Statutory Instrument No 2286]	[SI 2286]
Limit Values and Quality Objectives for Mercury Discharges by the Chlor-Alkali Electrolysis Industry	82/176/EEC
Limit Values and Quality Objectives for Mercury Discharges by Sector other than the Chlor-Alkali Electrolysis Industry	84/156/EEC
Limit Values and Quality Objectives for Discharges of Cadmium	83/513/EEC
Limit Values and Quality Objectives for Discharges of Hexachlorocyclohexane	84/491/EEC
Limit Values and Quality Objectives for Discharges of Certain Dangerous Substances included in List I of the Annex to Directive 76/464/EEC (Carbon tetrachloride, DDT and PCP)	86/280/EEC
Amending Annex 2 to Directive 86/280/EEC (The Drins: Dieldrin, Aldrin; Isodrin; Endrin; Hexachlorobenzene, Hexachlorobutadiene, Chloroform) Amending Annex 2 to Directive 86/280/EEC (1, 2 Dichloroethane, Trichloroethane, Perchloroethane, Trichlorobenzene)	88/347/EEC 90/415/EEC
List II Substances - The Implementation of EC Directives on Pollution caused by Certain Dangerous Substances Discharged to the Aquatic Environment	DOE Circular 7/89
Quality of Fresh Waters needed to support Fish Life	78/659/EEC
Bathing Water Quality	76/160/EEC
Quality required for Shellfish Waters	79/923/EEC
Titanium Dioxide Waste and Monitoring	78/176/EEC 82/833/EEC
Protection of Waters against Pollution caused by Nitrates from Agricultural Sources	

5.5 The classification schemes of these Directives are also of interest and relevance. For that relating to Surface Water Abstraction, as discussed in Chapter 3, a hierarchy of Classes exists; for others, such as those relating to individual 'dangerous' substances, standards are given as concentrations such that data obtained from water samples from a given area could be used to decide whether or not the quality of water in that area may be judged to have either passed or failed.

5.6 Several other Directives which relate to the aquatic environment are listed in Table 3. These impose a general obligation to protect the aquatic environment but have no specific water quality standards. Thus although they may have a bearing on the management of water quality they are not directly relevant to the setting of SWQOs;

but due regard will continue to be given to their requirements within the NRA's general duty of protecting and improving the water environment.

APPLICATION OF DIRECTIVES

5.7 The application of the Directives appropriate to SWQOs (Table 2) and to the five categories of Controlled Waters, is shown in Table 4. The NRA's current monitoring programmes are outlined below for each appropriate Directive, together with a note on the current reporting practice.

SURFACE WATER ABSTRACTED FOR DRINKING

5.8 The NRA has schedules of abstractions from rivers and reservoirs but, although the relevant standards have been translated into Regulations, no formal Water Quality Objectives have yet been set.

DANGEROUS SUBSTANCES, LIST I

5.9 The NRA monitors Controlled Waters at sites in the vicinity of discharges which contain List I Substances. It also undertakes general environmental monitoring at locations further removed from these discharges. A series of Directives has been issued which set out standards and requirements for certain dangerous substances. The NRA reports the results of monitoring and compliance assessment annually to the DoE.

DANGEROUS SUBSTANCES, LIST II

5.10 The water quality standards for individual List II Substances have been introduced steadily by the DoE. With each new standard, monitoring programmes are introduced. The NRA reports the results of monitoring and compliance assessment annually to the DoE.

Table 3: Relevant Directives but with no specific Water Quality Standards appropriate for Statutory Water Quality Objectives

EC DIRECTIVE	DIRECTIVE NO
On Waste	75/442/EEC
Disposal of PCBs and PCTs	76/403/EEC
Toxic and Dangerous Waste	78/319/EEC
Protection of the Environment when Sewage Sludge is used in Agriculture	86/278/EEC
Disposal of Waste Oils	75/439/EEC
Supervision and Control within the EC of the Transfrontier Shipment of Hazardous Waste	84/631/EEC
Adapting Directive 84/631/EEC on Transfrontier Shipment of Hazardous Waste	85/278/EEC
On Detergents	73/404/EEC
Control of Biodegradability of Anionic surfactants	73/405/EEC
On the Testing of the Biodegradability on Non-Ionic Surfactants	82/242/EEC
Prevention and Reduction of Environmental Pollution by Asbestos	87/217/EEC
Prohibiting the Placing on the Market and use of Plant Protection Products containing Certain Active Substances	79/117/EEC
Major Accident Hazards of Certain Industrial Activities	82/501/EEC
Export Accident Hazards of Certain Dangerous Chemicals	REG EEC 1734/88
Assessment of the Effects of Certain Public and Private Projects on the Environment	82/501/EEC
Sampling and Analysis of Surface Water for Drinking	79/869/EEC
Quality of Water intended for Human Consumption	80/778/EEC
Protection of Groundwater against pollution caused by certain Dangerous Substances	80/68/EEC
Urban Waste Water Treatment	91/271/EEC
Shellfish Hygiene	91/492/EEC
Fishery Product Hygiene	91/493/EEC

Table 4: Application of Directives to Controlled Waters in Statutory Water Quality Objectives

DIRECTIVE	APPLIED TO:			
	RIVERS	LAKES/ RESERVOIRS	ESTUARIES	COASTAL WATERS
Quality of Surface Waters for Drinking 75/440/EEC (SI No 1148)	*	*		
Pollution caused by Discharge of Certain Dangerous Substances into Aquatic Environment 76/464/EEC (SI No 2286) (including all Daughter Directives listed in Table 2)	*	*	*	*
Department of the Environment Circular 7/89	*	*	*	*
Quality of Freshwaters needed to support Fish Life 78/659/EEC	*	*		
Bathing Water Quality 76/160/EEC	(*)	(*)	*	*
Quality required for Shellfish Waters 79/923/EEC			*	*
Titanium Dioxide Waste & Monitoring 78/176 & 82/833/EEC	*		*	*

(*) = No Inland Waters are currently Designated

FRESHWATER FISHERIES

5.11 Reports to the DoE on this Directive for rivers, lakes and reservoirs have been made at five-yearly intervals. The last was for 1989. A shorter frequency is planned in future. Compliance assessments of stretches which are Designated under this Directive are made from the results of monitoring programmes, which are largely common to those used for the classification of rivers.

BATHING WATERS AND SHELLFISH WATERS DIRECTIVES

5.12 Sampling and monitoring programmes for identified waters are well established and compliance reported annually. It is anticipated that the number of identified waters will increase over the coming years. The recently introduced Directive on Shellfish Hygiene requires that shellfish rearing waters are identified and classified according to the microbial content in the flesh. This may lead to an increased number of sites designated under the Shellfish Water Quality Directive, which requires that certain conditions in the water are met.

GROUNDWATER DIRECTIVE

5.13 At present, there is no requirement for routine reporting to the DoE of compliance with this Directive.

PROPOSED DIRECTIVE ON ECOLOGICAL QUALITY OF SURFACE WATERS

5.14 The European Commission is proposing to issue a Directive which aims to improve the ecological quality of waters in EC Member States. Definitions of a reference point of 'high ecological quality' may be given and Member States required to draw up and implement programmes to ensure the improvement of the ecological state of waters towards this reference point. This Directive will have an important bearing on the SWQO scheme, because ecological quality objectives will have to be set for all controlled surface waters. The biological methods already developed for the General Ecosystem Class could provide the vehicle for the implementation of this Directive, thus emphasising the importance of ecosystem objectives in the proposed Use-related scheme.

TRENDS IN COMPLIANCE

5.15 It is a fact that, for nearly all of the Directives, the definition of failure masks the chance effects from sampling; thus assessments of performance can be volatile, and this leads to the production of lists of failed sites which mix together the serious and trivial failures. The NRA is developing techniques to assess as to whether or not the Directives's failures at identified areas are either trivial or significant.

6. GENERAL CLASSIFICATION SCHEMES

INTRODUCTION

6.1 Although the driving force behind the achievement of higher water quality for particular stretches of water will be the need to meet standards associated with different uses of such waters, there is nevertheless some merit in being able to make a general statement about the 'quality' of similar types of water at any one time. Thus it would seem unwise, and indeed undesirable, not to have a system similar to that of the River Quality Surveys of the past, because with different stretches having different Use-related standards, different designations with regard to different EC Directives, and different dates by which compliance with them might have to be met, it might well be asked: what does all this add up to at any one time?

6.2 It is therefore worth examining in further detail what sort of 'general' classification system could be used, and how it could relate to a SWQO scheme for the purposes of the 1989 Water Act.

RIVER CLASSIFICATION SCHEMES

6.3 The existing NWC Classification scheme classifies rivers on the basis of their concentrations of BOD, oxygen, and ammonia, into those of Good Quality (sub-divided into Classes 1A and 1B), Fair Quality (Class 2), Poor Quality (Class 3), and Bad Quality (Class 4). Classes are assigned according to Class-limiting criteria which are expressed as 95-percentiles. In its report on the River Quality Survey of 1985 [3], the DoE/Welsh Office stated that: "The Survey has revealed methodological differences between the Authorities in the monitoring and classification of rivers, canals and estuaries. These differences and the classification schemes will be reviewed with the Authorities to see whether changes are necessary." During 1990 the NRA carried out a similar survey of the quality of rivers, canals and estuaries (5). Waters were classified according to the NWC scheme to enable a comparison to be made with the results of 1985. The 1990 Survey again highlighted the difficulties of making comparisons across England and Wales because of the different ways that the NWC scheme had been interpreted and applied in each of the NRA Regions.

6.4 These methodological differences are explained in detail in Appendix 3. Essentially, they have arisen because the existing classification scheme allows a certain degree of subjectivity in its application and different Water Authorities exercised their own judgements in different ways in assigning quality Classes to stretches of water.

THE NEED FOR A NEW (NRA) RIVER CLASSIFICATION SCHEME

6.5 If a General Classification system is to be included in the scheme of SWQOs it will be necessary to eliminate, as far as is possible, subjectivity in how it is interpreted and applied in order to secure a consistent approach throughout England and Wales. Such a system should be capable of controlling the risk of mis-classification by providing an unambiguous methodology for placing a river stretch in a Class. This will enable a more objective assessment of water quality. The specific reasons as to why a new classification is required are expanded upon in Appendix 3 and options

are put forward for a proposed new system which could overcome some of the problems that have been experienced in the past.

6.6 The suggested new scheme contains chemical criteria which are similar to those of the NWC system; these are based on the recommendations of the former Water Authorities Association. Only dissolved oxygen, BOD and ammonia are used to assign Classes. Other criteria such as the EIFAC standards have not been included. This will make the scheme more straightforward to apply whilst retaining those parameters which have the most widespread influence on river water quality. Strict rules will be applied to the processing of data, to the calculation of percentiles, and to the decisions for placing a river stretch in a Class. A standard approach is also recommended for dealing with rivers for which the BOD is elevated by the effect of algal growth.

6.7 It has become common knowledge that, although some rivers have been consistently placed in a particular NWC Class, anecdotal evidence indicates that there have been changes in their ecology. Indeed, it is not the 'chemistry' of a river based on the measurement, however precise, of three determinands at regular intervals which is of interest, but the state of the 'living' river. The difficulty has been, however, that although such determinands can be measured precisely, they do not necessarily give an accurate picture even of the 'chemical' state of the river with respect to its ability to support various forms of aquatic life; even though the concentrations of all three have a direct effect on aquatic life. In the past, biological information has been used in some cases to assist in making assessments about placing a river stretch in a Class although there has never been any formal basis to guide these judgements. With the recent development of more quantitative methods for assessing the biological quality of rivers (as described in Chapter 4) there is now an opportunity to use biological information more objectively in making decisions on Class assignment.

6.8 Assessing the biological quality of a river gives a very different measure from its chemical quality. The former is an indicator of the 'living' state of the river whilst the latter provides a link to the discharges and pollution control requirements. Both kinds of information are important for the purposes of water quality management, and there are therefore good reasons why the two should be combined in a river classification scheme. Furthermore, it is recognised that there is an inherent risk of mis-classifying a river stretch from the result of routine chemical sampling programmes because of the effect of sampling error. This is explained in detail in Appendix 4. However, biological communities will reflect not only the influence of the prevailing quality of the water, but also the effect of pollution episodes which may not be detected by routine chemical sampling. The inclusion of biological information in a river quality classification scheme should therefore reduce the risk of placing a river stretch in the wrong Class.

6.9 If it is accepted that both chemical and biological information are important in placing a river stretch in a Class, then the question arises as to what is the most appropriate way of combining these two quite different measures of water quality into a single classification scheme. It could be argued that because the two provide very different kinds of information it would be impractical to attempt to combine them at all. One option would therefore be to have separate chemical and biological

classification schemes which would be applied independently at a river site. The stretch would then be assigned both a chemical and a biological Class. However, such a scheme would probably be complicated to apply and might lead to confusion, particularly in cases where wide discrepancies between chemical and biological Classes assigned for a given stretch were to occur. A preliminary analysis of the 1990 Survey data suggests that it would, indeed, be possible to combine both chemical and biological criteria in a single classification scheme. The results from this Survey suggest that the most effective way of doing this would be to apply a 'biological over-ride' to the chemical classification. This would operate by making an assessment of the biological quality of sites which fall into each of the chemical Classes. Criteria would then be applied to make decisions as to whether a change of Class is warranted, depending on whether the biological quality was better or worse than expected for that particular chemical Class. The options for the criteria which could govern the application of a 'biological over-ride' are discussed fully in Appendix 3, and examples using the data collected during the 1990 River Quality Survey are presented.

... RECOMMENDATION 6: A new General Classification System should be introduced for rivers which has strict rules governing the application of chemical criteria, and includes a 'biological over-ride' which should be used in combination with the chemical data in assigning quality Classes.

6.10 The proposal above, and covered in more detail in Appendix 3, for a new General Classification Scheme which incorporates biological criteria, represents a fundamental change from existing classification schemes. It should also be noted that further evaluation of the results of the 1990 Survey is required before any final decisions can be taken on the exact form of any new classification scheme.

CLASSIFICATION SCHEMES FOR LAKES, PONDS AND RESERVOIRS

6.11 The NRA and its predecessors have had no formal scheme for the classification of still fresh waters. Several European States classify lakes according to the concentrations of chemical nutrients, the levels of chlorophyll, the general clarity of the water, or the amount of sewage-derived bacteria. They have also produced systems which define the trophic status of the lake. The NRA plans to develop, as for rivers, a basic chemical classification with a Biological Over-ride related to lake biology. Research is already in progress. The development of such Classes for lakes, ponds and reservoir waters will also need to include a consideration of levels of chemical nutrients like phosphate and nitrate and a measure of algal biomass.

CLASSIFICATION SCHEMES FOR ESTUARIES

6.12 In Section 103 of the Water Act, estuaries are considered in the same category as coastal waters. Estuaries are however distinct in terms of their salinity, the patterns of their flow, and their biological communities; estuaries therefore require their own Classes. In 1958, 1970 and 1975, estuaries were classified into four Classes according to levels of BOD and dissolved oxygen. In 1980 the National Water Council introduced a revised methodology; this was a point-scoring system based on

measurements of the biological quality, the aesthetic quality, and the chemical quality. It was used for the Surveys of 1980, 1985 and 1990.

6.13 This method of assigning Class is subjective and experience has shown that the system is insensitive to changes in the quality of estuaries. As a consequence it is suggested that a new scheme is devised which would provide a more objective means of placing estuary reaches in a Class. The components of such a scheme are outlined in Appendix 3. Not all of these components are yet supported by tried-and-tested methodologies and these are the subject of ongoing research. Thus, if all of the proposed components are to be included in the final scheme, there are two options: either to wait until methods are available for all components - this will not be before the end of 1995 - or to introduce the scheme in a phased manner. The second option is preferred because it will allow the introduction of a workable scheme based on most of the components at an earlier date. Such a scheme could be ready for introduction by the end of 1993.

6.14 The components of the scheme which could be introduced at an earlier date relate to the chemical and aesthetic aspects of the water. It is proposed that dissolved oxygen and ammonia are the most appropriate determinands, because they will generally reflect the degree of organic loading causing pollution in estuaries. The methods of measurement of these determinands and the strategies for sampling in different types of estuaries are currently being reviewed. The use of mathematical models to optimise sampling efficiency and the increased use of automated monitoring devices, for example, are options under consideration.

6.15 As in the existing NWC classification, it is suggested that a component which relates to the aesthetic aspects of water quality is included in the scheme. Measurement of aesthetic quality is subjective and dependent, to a large extent, on what is perceived as being a nuisance. In the absence of absolute criteria, the distinction is made between discharge-derived material likely to cause an aesthetic problem and all other quality-influencing parameters. The primary objective of these criteria is to ensure that gross contamination by faecal solids, oils, sewage debris and so on, is avoided. Estuaries, or zones of estuaries receiving untreated or unscreened discharges, are excluded from Class 1. The Class criteria proposed provide a measure of the likely success in removing aesthetic problems as a result of regulatory control.

6.16 Eutrophication in estuaries is of concern throughout the European Community, particularly for Member States bordering the North Sea. This topic is also addressed in the EC Directive on Urban Waste Water Treatment and leads to a need to keep a general watch on the levels of chemical nutrients like phosphate and nitrate and the trophic status of the water. It is therefore suggested that these determinands could be included in the General Classification Scheme for estuaries. Appropriate Class-limiting criteria for these determinands are currently being developed through the NRA's research and development programme. It is envisaged that preliminary Class-limiting criteria for nutrients could be introduced into the first phase of the scheme. The inclusion of a measure of trophic status, such as chlorophyll levels, will need to be considered in the light of the results of ongoing research into the factors which promote and control the growth of algae in estuaries.

6.17 Estuaries are sites of accumulation of materials transported via rivers to the sea. They also receive materials carried from the sea by the more saline, dense, inflow of water over the top of which the fresh water flows. They are also much used as ports and harbours, and are the sites of many industrial complexes. As a consequence of all of these factors, it is clearly essential to have regard to the accumulation of persistent dangerous substances in them. This could be achieved by setting hierarchical standards for the concentrations of such chemicals in bottom sediments, characterised by particle size and normalised for chemical composition, which would reflect their degree of industrial contamination. Sediments act as sinks for persistent substances. The concentrations of these substances will thus be affected by factors such as geology and natural history, but will also reflect the effect of pollution control measures. It is therefore suggested that sediment-based criteria should be included as an important component of a General Classification Scheme.

6.18 The question of what are the appropriate sediment-based criteria is being addressed through a current research programme. It is envisaged that a set of basic criteria for priority substances could be introduced in the short-term which would provide a means of assessing the concentrations of these substances relative to those typical of an unpolluted site. However, it is recognised that there are many factors which influence the concentrations of pollutants in sediments. The identification of these factors and the assessment of their relative importance is the subject of current research. It will be necessary to take these into account in producing a set of normalised criteria which could be nationally-applicable and allow us to make comparisons of sediment concentrations not only over periods of time but also from place to place. Thus, although it should be possible to introduce workable sediment criteria for assigning Classes and assessing changes in Class within a given estuary in the first phase of the General Classification Scheme, they should be regarded as an interim measure and will need to be refined dependent upon the outcome of the ongoing research.

6.19 For the same reasons as given for the General Classification Scheme for rivers outlined in Section 6.7, it would be desirable to include a biological component in the estuary classification scheme. The existing NWC scheme does make provision for biological quality, but the criteria are only descriptive and therefore open to subjective interpretation. What is needed is a more quantitative approach to assessing ecological quality in estuaries along the lines of the methods already developed for rivers. It is suggested that, like rivers, the benthic invertebrate fauna should be used as a measure of ecological quality. Although detailed ecological investigations have been carried out in certain estuaries in the past, there has not yet been a comprehensive national survey in which consistent methods have been applied at all sites, as has been the case for rivers. This will need to be carried out before decisions can be made over what are the appropriate biological quality criteria which could be applied in the classification scheme. This component of the scheme would therefore need to be introduced at a later date depending on the outcome of the necessary research programme. However, for the purposes of the introduction of the first phase of the programme, the biological criteria in the existing estuarine classification scheme could continue to be applied as an interim measure.

... RECOMMENDATION 7: A new General Classification Scheme should be introduced for estuaries. This should include dissolved oxygen and ammonia in water, the concentrations of which affect the ability of migratory fish to pass through them, plus a measure of the aesthetic quality, the levels of persistent substances in sediments, nutrients, and a system for the assessment of ecological quality.

CLASSIFICATION SCHEMES FOR COASTAL WATERS

6.20 In England and Wales there is no formal classification scheme for coastal waters. Scotland, however, has its own classification scheme, but this does not provide an absolute measure of water quality. Other coastal European States are also developing schemes for the assessment of the quality of coastal waters. The NRA's responsibility for the quality of coastal waters extends to a distance of three nautical miles out to sea. This represents an area of some 20,000 square kilometres; a vast expanse of water, widely used for many purposes, and controlled with respect to factors affecting its water quality by several authorities. The nature and use of it, however, does argue for some form of sub-division, parallel to the coast. The inshore area is used for particular purposes, such as bathing and molluscan shellfisheries; it can also be sampled from the shore. The offshore area is used differently for water sports, is where the crustacean and fin fisheries also take place, and can only be monitored and surveyed by boat or from the air. Although there is much overlap in the various inshore and offshore activities it is suggested that, for the purposes of classification, a practical way of separating near and offshore coastal waters would be:

- nearshore waters (which extend from the landward limit to a line 200 metres offshore from the spring tide low water mark); and

- offshore waters (which extend from the 200 metre line to the Three Nautical Mile Limit).

6.21 The components of such a scheme will need to reflect the principal water quality concerns in coastal waters. It is suggested that, like estuaries, for nearshore waters a measure of the aesthetic quality should be included based on the presence/absence and level of treatment of discharge from coastal sewerage systems. Criteria for the microbiological quality of such waters should also be derived and applied. A proposed hierarchical classification for the aesthetic and microbiological components is given in Appendix 3. These could be introduced as the first phase in the proposed scheme. Like estuaries, there is concern over the risk of coastal eutrophication caused by elevated nutrient concentrations. Criteria for nutrients, particularly nitrate, should therefore be considered for inclusion in the scheme depending on the outcome of the research programme which is in progress to recommend appropriate standards. Other components which could be considered for inclusion in the scheme are criteria for the accumulation of persistent substances in sediments and an ecological classification system. Again, these could be introduced in a phased manner as recommended for estuaries. Offshore water areas will require different criteria, and particular emphasis would have to be given to the relevance of spot sampling combined with aerial surveillance - for example, to determine the frequency and

extent of algal blooms - which might reflect the general quality of such a vast expanse of water.

... RECOMMENDATION 8: The classification of coastal waters be based on a near-shore and offshore zone division; the former should at least contain aesthetic and microbiological criteria which reflect its use for bathing, and further consideration should urgently be given to other criteria for nutrients and ecological quality. Such an evaluation would have to be done in collaboration with MAFF.

CLASSIFICATION SCHEMES FOR GROUNDWATERS

6.22 The United Kingdom has no formal scheme for the classification of groundwaters. There is only one general use for such waters, that of water supply; the standards which underpin this use will thus not change very much in the future. This simplification means that the Use-related Class can also act as the General Class. The range of uses runs from potable supply to a low grade supply suitable for certain types of industry.

... RECOMMENDATION 9: General Classes for groundwater should be the same as the Use-related Classes - those which relate to abstractions for water supply. The Classes should incorporate parts of the Directive on the Quality of Water Intended for Human Consumption.

THE UTILITY OF GENERAL CLASSIFICATION SCHEMES

6.23 Classification schemes have been applied in the past as tools in water quality management for assessing the quality status of waters at regular intervals. This has allowed comparisons to be made between the results of surveys such that broad changes in water quality can be assessed. Such schemes have been used to identify those waters which need to be improved and have provided the basis for implementing the pollution control measures to secure the necessary improvements. The question then arises as to what purpose such General Classification Schemes would serve within the framework of SWQOs. It has been argued so far that the proposed scheme of SWQOs should include a system of Use-related Classes and the requirements of EC Directives. These requirements would be specific either to the Uses to which any particular stretch of water was put, or to the discharge of various substances for which legislation exists. Although it is possible to assess whether or not these requirements have been met against the various compliance criteria, there is still a need to demonstrate that the overall quality of the water has been maintained or improved irrespective of the Uses, which may themselves change with time. It therefore seems desirable to include General Classification Schemes within the proposals for SWQOs as a means by which overall progress can be assessed, both in terms of the chemical and biological quality status of Controlled Waters.

6.24 One option for the use of General Classification Schemes within the context of setting SWQOs would be to set target Classes for stretches of water and monitor for compliance against them. In this way the target Classes would in themselves constitute Water Quality Objectives which would need to be achieved within a given timescale. If applied in this way, the General Classification Schemes should be

capable of allowing reliable assessments to be made as to whether a given stretch of water had changed in Class over a period of time. Careful consideration would therefore need to be given to the most appropriate statistical expressions for the Class-limiting criteria to enable changes with time to be assessed. This is discussed further in Appendix 3. It also needs to be born in mind, however, that the NRA's ability to attain such a 'target' Class is restricted to its ability to control inputs of chemicals, not of 'biology'. The biological character of a given body of water can change as a result of a plethora of factors which are not related to chemical discharges.

6.25 An alternative option would therefore be to use the General Classification Schemes to allow a general statement to be made about the quality of waters at regular, say five-yearly, intervals as in the past. As such, the classification scheme would not be used to set targets but would serve to provide an overall 'snapshot' of water quality at any given time. Used in this way, the General Classification Schemes would provide a more general statement of progress in maintaining or improving water quality.

6.26 To date, General Classification Schemes have not been applied on a statutory basis in the UK. Furthermore, it is recognised that certain aspects of the proposed schemes are novel and require further developmental work.

7 WATER ACT STATUTORY WATER QUALITY OBJECTIVES (SWQOs) IN PRACTICE

INTRODUCTION

7.1 The following chapter addresses the question of what should be used in practice to set SWQOs for particular, identified, bodies of water; what information is required; who should be consulted; and how it would work. There are clearly different elements which need to be brought together, and it is essential that the scheme should not be introduced in too fragmented a manner. It is also essential not to wait too long. A logical, phased introduction is therefore in order.

THE ELEMENTS OF A WATER ACT SWQO

7.2 From the preceding chapters it is evident that a SWQO, for a particular stretch of water, as envisaged by the concept in the 1989 Water Act, should consist at least of the following elements. That, by and after a certain date, the water satisfied the requirements of:

- one or more Use-related Classes; plus
- any EC Directives which applied to any or all of that stretch of water.

There is also an argument in favour of the inclusion of a General Classification Scheme which would be applied either to set and monitor compliance with target Classes or to make more general assessments of water quality status at regular intervals.

... RECOMMENDATION 10: The proposed scheme of SWQOs should contain three main elements; the requirements of relevant EC Directives, compliance with the water quality standards associated with Use-related Classes, and the application of General Classification Schemes.

7.3 If all of these elements were to be put together, for separate stretches of a river, this would produce a scheme along the lines of that given in Table 5. Overall compliance with the Water Act SWQO would require compliance with all of its individual components.

THE PROCESS OF IMPLEMENTATION

7.4 This paper marks the first formal stage in working to implement the SWQO scheme. The NRA's purpose is to seek the views of interested parties, and to assist it in putting together proposals for relevant Classification Systems to be submitted to the Secretaries of State for the Environment and for Wales. Dependent upon the outcome of this consultation process, the NRA aims to make such proposals in the spring of 1992.

7.5 It will then be for the Secretaries of State to prepare the formal classification Regulations (Statutory Instruments - SIs) which, as explained in Section 3 above, will be needed in order to set objectives. It follows from the above proposals that such

Regulations would need to set up the system for classifying each type of Controlled Water with respect to:

- Use-related Classes;
- EC Directives (in addition to, or subsuming, those Directives for which Classification Regulations have already been made under the Water Act 1989); and
- the General Classification Scheme.

It is expected that the Secretaries of State will wish to prepare draft Regulations in 1992, after considering the NRA's advice, and that they will wish to consult widely on the draft Regulations before formally seeking Parliament's approval.

7.6 Once the necessary Regulations are in force, it will be for the Secretaries of State actually to set Water Quality Objectives. Under the terms of the Water Act, where the Secretary of State proposes to set a Water Quality Objective, he is required first to publish notice of his intention to do so, giving a period of at least three months for the making of objections or representations; and to consider any objections or representations which are duly made. Having done so, and having (if necessary) modified the proposed objectives, the Secretary of State sets the Water Quality Objectives by serving notice(s) on the NRA, specifying, for each identified stretch of water, which of the relevant classifications (from the Regulations) should be met, by and after a given specified date.

NRA'S ADVICE

7.7 This naturally raises the question as to how the Secretaries of State should know what objectives they propose to set, for which waters, for what Classes, and by what dates. The NRA will clearly be the principal, but not the only, source of advice with regard to the setting of SWQOs; the NRA would expect that it would put proposals, for individual stretches of water, to the Secretaries of State after initial consultation with interested parties.

7.8 Bearing in mind their overall purpose - as stepping-stone plans to improve water quality where necessary, and to maintain it where not - SWQOs will need to be set in context. In this regard, therefore, the role of catchment planning is essential such that sets of SWQOs are not seen as ends in themselves but as part of an overall strategy for the management of the water environment. Catchment planning provides the context in which the demands of all water users can be balanced against water quality requirements. This will necessarily involve an analysis of the financial and other implications associated with the desired environmental quality goals in determining the final strategy. Catchment planning also provides the mechanism for assessing and controlling the overall loading of pollutants within whole river catchments and, consequently, into the sea, irrespective of the uses to which those waters are put. The need for 'catchment accountability' is becoming increasingly important in order to ensure that both national and international requirements to reduce pollutant loadings are properly planned for and achieved.

Table 5: Application of Statutory Water Quality Objectives to a River Catchment

			Components of the Statutory Water Quality Objective				Compliance with Component			Overall Compliance with Statutory Water Quality Objective
Name of River	Name of Stretch	Length (km)	NRA Class		Use-related Class (URC)	EC Class (EEC)	TC	URC	ECC	
			Current	Target (TC)						
First River	Upper	3.0	B	B	ba,ge, ...	None	✓	✓		✓
	Middle	4.5	D	C	ba,ge, ...	None	x	✓		✓
Tributary	Upper	1.9	uc	uc	ba,ge, ...	None		✓		✓
	Upper Middle	8.0	A	A	ba,ge,sf, ...	ff	✓	✓	✓	✓
	Lower Middle	7.0	B	B	ba,ge,cf, ...	ff	✓	✓	✓	✓
	Lower	4.0	C	B	ba,ge,cf, ...	None	x	✓		✓
First River	Middle Lower	11.0	E	C	ba,ge,CF	ii	X	X	✓	X
	Lower	9.0	D	C	ba,ge,pw,CF,	FF,sw	x	X	X	X
Next River	Upper	4.0	uc	uc	ba,ge, ...	None		✓		✓
	Upper Middle	5.5	A	A	ba,ge,pw,....	None	✓	✓		✓
	Lower Middle	8.0	B	B	ba,ge,sf,as..	None	✓	✓		✓
	Lower	11.0	B	B	ba,ge,cf.....	FF	✓	✓	X	X

Key:	A - NRA Class A	ba -	Basic Amenity	ff -	Fisheries Directive	✓ -	compliance
	B - NRA Class B	ge -	General Ecosystem	sw -	Surface Water Directive	X -	non-compliance
	C - NRA Class C	sf -	Salmonid Fishery	ii -	Dangerous Substances	x -	non-compliance
	D - NRA Class D	cf -	Cyprinid Fishery		(List II) etc		(Statistically
	E - NRA Class E	pw -	Potable Water Supply				insignificant)
		as -	Agricultural Supply				
	uc - Unclassified		etc				
UPPER CASE DENOTES A CURRENT FAILURE							

7.9 Where several 'steps' are likely to be needed to meet the longer-term objective, this should be clearly stated. Each 'step' should be demonstrably achievable within a reasonable time frame. This will involve the setting of interim targets in terms of the Uses of the water which are required and the quality Classes which are to be achieved over the agreed period of time. The time frame for achieving the set targets should be sufficient for the necessary measures for water quality improvements to be put in place. It should also be set in such a way that the identified actions are achieved promptly. The agreed timescale will clearly depend on the measures required for each stretch of water. It is suggested that for most cases, a three to five year time frame would be reasonable.

7.10 Progress against the set targets will, of course, need to be monitored on an ongoing basis. Water quality monitoring programmes should be capable of allowing compliance to be clearly assessed against the relevant standards for each element of the SWQO set for a given stretch. It will be essential to minimise, as far as practicable, any element of subjectivity in assessing compliance; this aspect is discussed further in Appendix 4. The monitoring system will allow summary

information on water quality and the achievement of SWQOs to be prepared for publication by the NRA and for submission to the Secretaries of State.

7.11 Because decisions on proposed objectives for individual stretches of water will have to be made on information provided locally, the NRA would intend, before putting its proposals to the Secretaries of State, to consult relevant parties, at a local level, through the system of NRA Regional Committees - in particular, the Regional Rivers Advisory Committees on which the various water users, major dischargers, local authorities, and the general public, are represented. Where necessary, the NRA would also seek advice from local offices of other Government organisations, including MAFF and the nature conservation bodies. For the reasons set out above, it is clear that initial implementation would be directed particularly towards rivers.

7.12 For the documentation, the NRA needs an unambiguous and precise way of defining a stretch of water. This should take account of the existing stretches used for the purpose of water quality classification and management. Consideration will also need to be given as to the desired Uses of a waterbody and the requirements of EC Directives in defining stretches appropriate for the implementation of SWQO's. The scheme must also be suitable for efficient manipulation by computer systems. The prime information for defining a Stretch should be:

(a) the upstream National Grid Reference and,

(b) the downstream National Grid Reference, which would be supplemented by,

(c) a river name;

(d) a unique stretch name;

(e) a river length; and

(f) a numeric code.

Items (a) and (b) would also prepare the way for Geographical Information Systems, and items (c) and (d) will be written according to a standard protocol in order to facilitate the search of the database by name, and in order to provide the option to produce sensible lists in alphabetical order.

7.13 It will be necessary to allow for the fact that, after the original submission, a stretch may have to be sub-divided into smaller units. This could happen if a new quality objective were to be introduced which applied only to part of an existing stretch. Stretches might also be amalgamated (at least for reporting purposes). The databases created for the 1990 River Quality Survey have been specially designed to facilitate this.

BASIS FOR SETTING SWQOs

7.14 Having developed a standard format for acquiring and submitting information for a given stretch of water, the NRA will have to consider the following:

- what is the current quality state;
- what is the state of EC Directive compliance;
- what are the current Uses;
- what are the desired Uses;
- what are the benefits, and can they in any way be quantified;
- what is necessary to achieve them;
- how many choices of achieving them are possible;
- what are the consequences, including the costs, falling on dischargers and others in order to achieve them; and
- can they be achieved within a three to five year time frame?

7.15 The first step in determining SWQOs is to assess the current status of the stretch of water. This should include the following elements:

a) the water quality Class given by the recommended General Classification Scheme using both chemical and biological information;

b) the EC Directives which apply to that stretch or any designated sampling point within that stretch, and the current state of compliance with the conditions of the relevant Directives; and

c) the existing Uses of the water.

Much of this information is stored on centralised or Regional computerised databases within the NRA and is therefore readily available. The water quality Classes for all monitored river stretches have been determined following the 1990 Survey. Information on EC Directives is compiled on a routine basis for reporting purposes. NRA Regions have already assessed the existing Uses of river stretches for their own water quality planning needs. This will need to be done on a more formal, nationally-consistent basis on a standard NRA proforma, currently being developed, according to the proposed Uses set out in Chapter 4 of this document.

7.16 The next step will involve an assessment to be made of the desired Uses and Use-related Classes for the stretch of water. This would normally include the identified existing Uses although there may be cases where a particular Use may no longer be considered to be appropriate. The introduction of new Uses will be assessed following local consultation with representatives of the water users and, where necessary, following advice from Government organisations. Some of the Uses defined in Chapter 4, such as Basic Amenity and General Ecosystem, would apply to most Controlled Waters. The classification schemes associated with these Uses will therefore need to be introduced for the first time for most stretches of waters. The introduction of other Uses will need to be considered on a case-by-case basis.

7.17 Having identified the desired Uses of the water it will then be necessary to make an assessment of what measures would be needed to ensure that they are achieved and protected. This will involve an assessment of the water quality requirements for each of the Use-related Classes. If any improvements in water quality are needed to achieve a particular Use, or combination of Uses, over a given timescale, the options for the required improvements will need to be considered in detail. Discharge control

and catchment management strategies will therefore need to be reviewed and preferred options identified.

7.18 Inevitably there may be constraints on achieving all the desired Uses for a given stretch of water. Thus, having identified the preferred options for water quality improvements it will be necessary to carry out feasibility analyses which take into account all the practical and financial limitations. This will need to be done in consultation with the dischargers and other affected water users. Depending on the outcome of this stage, it may be necessary to review the options. There may be cases where the achievement of a desired Use is considered possible, but over a longer timescale. Where this is the case, the achievement of that Use will need to be planned as a series of interim steps for water quality improvement.

7.19 When all the benefits have been weighed against the technical and financial constraints, the recommended SWQO can be put forward to the Secretary of State. This will need to include all the agreed Use-related Classes and the EC Directives which are applicable to the stretch of water with the relevant dates for implementation and the target dates for achievement. Meeting the SWQO over the given timescale may mean that water quality management plans will need to be re-assessed. This may require the use of water quality modelling procedures for planning purposes. The performance statistics of discharges will have to be analysed and, where appropriate, discharge consents may need to be reviewed. Problems that can be dealt with through catchment management planning, and particularly those arising from diffuse sources of pollution, will also need to be addressed. In the final analysis the Secretary of State will need to know what are the associated costs of achieving the recommended SWQO, both to the dischargers and others where water quality improvements are required, and to the NRA for implementation and compliance monitoring. With more than 42,000 km of rivers and canals, 2,600 km of estuary and over 20,000 km^2 of coastal waters to take into consideration, it is clear that all of this adds up to a significant task.

8. CONCLUSION

8.1 The 1989 Water Act allows for considerable flexibility in setting future objectives for the quality of water, based on schemes of classification, and incorporating both UK and EC legislation. Although such flexibility is, in part, to be welcomed, there is also a danger that a miscellany of schemes, objectives, and EC Directives could develop such that it would be difficult for anyone to judge what exactly was the state of compliance with the relevant legislation at any one time. Such confusion is also not conducive to the best means of managing and monitoring improvement schemes: it should therefore be avoided.

8.2 The task of cleaning up our waters needs to be tackled urgently, so it is important to introduce the new statutory system quickly. This will inevitably involve finding a workable balance between the desired water quality improvements and the measures required to achieve them.

8.3 It would therefore seem sensible to devise an overall scheme which would be simple to use, meaningful to those whose task it will be to achieve it, to those who will have to pay for it, to those who will benefit, and to those who will have to defend it. It is suggested that a scheme of Statutory Water Quality Objectives, as discussed in the preceding chapter, best serves this purpose under the 1989 Water Act. If such a premise is accepted, the final question remains - by when can it be implemented?

8.4 The answer to this, in part, is dependent on the effort which can be expended upon it. A number of the elements of the proposed schemes for Use-related and General Classes still require further research and development. This, in itself, places limits on the overall time frame. There is, however, no necessity to introduce the entire scheme at the same time; indeed this would be disadvantageous.

8.5 Much of the information required for the implementation of SWQOs for rivers was collected during the 1990 Survey. It would therefore be logical to introduce the scheme for rivers first. The necessary information for other categories of Controlled Waters is currently being collected and relevant classification schemes and standards are being developed. When completed, SWQOs for these waters could then be introduced progressively. Such a 'block' by 'block' approach with a tentative time frame is indicated in Table 6.

8.6 The views of interested parties are invited on the proposed scheme of SWQOs set out in this document and on how it should be implemented. Comments would be particularly welcome on the following issues: the use of computer-based predictive modelling approaches as the basis for setting ecological standards; the role of General Classification Schemes and the criteria which should be applied to define Classes; the water quality standards for the Use-related Classes; the timescale for improvements; and the way in which a precautionary approach to setting standards for dangerous substances is or can be implemented via the system of SWQOs.

Table 6: Proposed Timetable for the Introduction of Statutory Water Quality Objectives

		Proposed dates for the Introduction of the General Classification Scheme				
		Rivers and Canals	Lakes, Ponds & Reservoirs	Estuaries	Coastal Waters	Groundwater
	D	Spring 1992	Winter 1994	Winter 1993	Winter 1993	Winter 1993
	I	Spring 1993	Winter 1995	Winter 1994	Winter 1994	Winter 1994
		Proposed dates for the Introduction of the Use-related Classes				
Use		River and Canals	Lakes, Ponds & Reservoirs	Estuaries	Coastal Waters	Groundwater
Basic Amenity	D	Spring 1992	Winter 1994	Winter 1993	Winter 1993	not needed
	I	Spring 1993	Winter 1995	Winter 1994	Winter 1994	
General Ecosystem	D	Spring 1992	Winter 1994	Winter 1994	Winter 1994	not needed
	I	Spring 1993	Winter 1995	Winter 1995	Winter 1995	
Special Ecosystem	D	Spring 1992	Winter 1994	Winter 1994	Winter 1994	not needed
	I	Spring 1993	Winter 1995	Winter 1995	Winter 1995	
Salmonid Fishery	D	Spring 1992	Winter 1994	not needed	not needed	not needed
	I	Spring 1993	Winter 1995			
Cyprinid Fishery	D	Spring 1992	Winter 1994	not needed	not needed	not needed
	I	Spring 1993	Winter 1995			
Migratory Fishery	D	Spring 1992	Winter 1994	Winter 1993	Winter 1993	not needed
	I	Spring 1993	Winter 1995	Winter 1994	Winter 1994	
Commercial Harvesting of Marine Fish	D	not needed	not needed	Winter 1993	Winter 1993	not needed
	I			Winter 1994	Winter 1994	
Commercial Harvesting of Shellfish	D	not needed	not needed	Winter 1993	Winter 1993	not needed
	I			Winter 1994	Winter 1994	
Water Contact	D	Spring 1992	Winter 1994	Winter 1993	Winter 1993	not needed
	I	Spring 1993	Winter 1995	Winter 1994	Winter 1994	
Abstraction for Potable Water Supply	D	Spring 1992	Winter 1994	none planned	none planned	Winter 1993
	I	Spring 1993	Winter 1995			Winter 1994
Abstraction for Industrial & Agricultural Use	D	Spring 1992	Winter 1994	Winter 1993	Winter 1993	Winter 1993
	I	Spring 1993	Winter 1995	Winter 1994	Winter 1994	Winter 1994

Key: D = Date by which schemes for General Classification and Use-related Classes could be developed
I = Date by which schemes could be implemented. This will be dependent upon the timetable for the introduction of Statutory Instruments for SWQOs

REFERENCES

[1] Government White Paper: This Common Inheritance - Britain's Environmental Strategy. HMSO, London, September 1990.

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[3] River Quality in England and Wales - 1985. HMSO London, 1986.

[4] National Water Council (1977). River Water Quality: the Next Stage. Review of Discharge Consent Conditions. London.

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APPENDIX 1

RELEVANT SECTIONS OF

THE 1989

WATER ACT

RELEVANT SECTIONS OF THE 1989 WATER ACT

Classification of quality of waters

104.-(1) The Secretary of State may, in relation to any description of controlled waters (being a description applying to some or all of the waters of a particular class or of two or more different classes), by regulations prescribe a system of classifying the quality of those waters according to criteria specified in the regulations.

(2) The criteria specified in regulations under this section in relation to any classification shall consist of one or more of the following, that is to say -

a) general requirements as to the purposes for which the waters to which the classification is applied are to be suitable;

b) specific requirements as to the substances that are to be present in or absent from the water and as to the concentrations of substances which are or are required to be present in the water;

c) specific requirements as to other characteristics of those waters;

and for the purposes of any such classification regulations under this section may provide that the question whether prescribed requirements are satisfied may be determined by reference to such samples as may be prescribed.

Water Quality Objectives

105.-(1) For the purpose of maintaining and improving the quality of controlled waters the Secretary of State may, by serving a notice on the Authority specifying -

a) one or more of the classifications for the time being prescribed under section 104 above; and

b) in relation to each specified classification, a date,

establish the water quality objectives for any waters which are, or are included in, waters of a description prescribed for the purposes of that section.

(2) The water quality objectives for any waters to which a notice under this section relates shall be the satisfaction by those waters, on and at all times after each date specified in the notice, of the requirements which at the time of the notice were the requirements for the classification in relation to which that date is so specified.

(3) Where the Secretary of State has established water quality objectives under this section for any waters he may review objectives for those waters if -

a) five years or more have elapsed since the service of the last notice under subsection (1) or (6) of this section to be served in respect of those waters; or

b) the Authority, after consultation with such water undertakers and other persons as it considers appropriate, requests a review;

and the Secretary of State shall not exercise his power to establish objectives for any waters by varying the existing objectives for those waters except in consequence of such a review.

(4) Where the Secretary of State proposes to exercise his power under this section to establish or vary the objectives for any waters he shall -

a) give notice setting out his proposal and specifying the period (not being less than three months from the date of publication of the notice) within which representations or objections with respect to the proposal may be made; and

b) consider any representations or objections which are duly made and not withdrawn;

and, if he decides, after considering any such representations or objections, to exercise his power to establish or vary those objectives, he may do so either in accordance with the proposal contained in the notice or in accordance with that proposal as modified in such manner as he considers appropriate.

(5) A notice under subsection (4) above shall be given -

a) by publishing the notice in such manner as the Secretary of State considers appropriate for bringing it to the attention of persons likely to be affected by it; and

b) by serving a copy of the notice on the Authority.

6) If, on a review under this section or in consequence of any representations or objections made following such a review for the purposes of subsection (4) above, the Secretary of State decides that the water quality objectives for any waters should remain unchanged, he shall serve notice of that decision on the Authority.

General Duties to achieve and maintain objectives etc.

106.-(1) It shall be the duty of the Secretary of State and of the Authority to exercise the powers conferred on him or it by or under the following provisions of this Chapter in such manner as ensures, so far as it is practicable by the exercise of those powers to do so, that the water quality objectives specified for any waters in a notice under section 105 above, or in a notice under section 30C of the Control of Pollution Act 1974, are achieved at all times.

(2) It shall be the duty of the Authority, for the purposes of the carrying out if its functions under this chapter, to monitor the extent of pollution in controlled waters and to consult, in such cases as it may consider appropriate, with river purification authorities in Scotland.

Provision and acquisition of information etc.

Information and Assistance

118.-(1) It shall be the duty of the Authority, if and so far as it is requested to do so by the Secretary of State or the Minister, to give him all such advice and assistance as appears to it to be appropriate for facilitating the carrying out by the Secretary of State or the Minister of his functions under this chapter.

(2) Subject to subsection (3) below, the Secretary of State, the Minister or the Authority may serve on any person a notice requiring him to furnish the Secretary of State, the Minister or, as the case may be, the Authority, within a period or at times specified in the notice and in a form and manner so specified, with such information as is reasonably required by the Secretary of State or the Minister or by the Authority for the purpose of carrying out any of his or, as the case may be, its functions under this chapter.

(3) The Secretary of State or the Minister may by regulations make provision for restricting the information which may be required under subsection (2) above and for determining the form in which the information is to be so required.

(4) A person who fails without reasonable excuse to comply with the requirements of a notice served on him under this section shall be guilty of an offence and liable on summary conviction to a fine not exceeding level 5 on the standard scale.

Local inquiries for the purposes of Chapter 1

120. The Secretary of State may cause a local inquiry to be held in any case in which he considers it appropriate for such an inquiry to be held -

a) for the purposes of the establishment or review under section 105 above of any water quality objectives or otherwise in connection with any provision of this chapter;

b) with a view to preventing or dealing with pollution of any controlled waters; or

c) in relation to any other matter relevant to the quality of any such waters.

APPENDIX 2

PROPOSED WATER QUALITY STANDARDS

FOR

USE-RELATED CLASSES

PROPOSED WATER QUALITY STANDARDS FOR USE-RELATED CLASSES

The water quality standards in Table A2.1 are those suggested for inclusion in the scheme of SWQOs associated with the proposed Use-related Classes. The standards relate either to pass/fail Classes or to Classes in a hierarchical scheme, and have been selected on the basis of a review of existing tried-and-tested standards which have been shown to provide both adequate protection of relevant Uses and to be workable in practice. They should apply to programmed, routine, spot samples taken within the normal day-time sampling window. Samples taken during operational investigations, pollution incidents, or continuous or automated monitoring systems, should not be included for compliance assessment purposes.

All standards are expressed as 95-percentiles unless otherwise stated, except for faecal streptococci (90-percentile) and dissolved oxygen (5-percentile). These statistical expressions are those that have been widely applied in the past, although it is recognised that there are arguments for and against alternative expressions. Any change in the statistical expression would mean that the numerical values of the standards would have to be revised; the standards suggested in Table A2.1 should therefore be considered only as indicative at this stage, and are not intended to be binding or final.

Some of the standards proposed for the Use-related Classes originate from relevant EC Directives. Most of these are applied as 95-percentiles. However, in the past, using existing methods for applying 95-percentiles, insignificant and serious failures have assumed equal significance due to the effects of chance on sampling. It is therefore proposed that a more rigorous application of 95-percentiles should be introduced for those standards applied under the SWQO scheme. This will more clearly identify failures of significance, and provide a sound statistical basis on which to argue the case for water quality improvements and to secure and target the necessary resources. The statistical basis for compliance is discussed in Appendix 4.

Water quality standards exist for a range of dangerous substances. Standards for EC Directive List I substances are set in the Directives and would therefore be included in EC Classes within the scheme of SWQOs. Standards for EC Directive List II substances are set by Government in relation to various water Uses. These standards, set out in the DoE Circular 7.89, have been incorporated, where appropriate, into the proposed Use-related Classes. The standards would normally only apply to waters receiving discharges of these substances.

The proposed standards relate only to the quality of Controlled Waters to which Use-related Classes would apply. They would provide the basis for the control of discharges such that the agreed Uses of those waters could be protected. However, it is recognised that other authorities are responsible for applying standards which are directly dependent upon water quality, such as those which apply to the quality of fish and shellfish flesh intended for human consumption, and to the quality of drinking water. Where this is the case, the NRA would respect its specific environmental duty to investigate any water quality problems as they arise and take the necessary measures to resolve them where possible.

APPENDIX 2

Table A2.1: Proposed Water Quality Standards For Use-Related Classes

USE	APPLIES TO				PARAMETERS FOR USE-RELATED CLASS	VALUE	COMMENT
	R	L	E	C			
1. Basic Amenity	*	*	*	*	Colour Transparency Odour Oil Litter Foam Biological growth Dissolved Oxygen	 >10% saturation	Classification scheme under evaluation and development by NRA (Note 1). Scheme only relevant to rivers at present.
2. General Ecosystem	*	*	*	*	Ecological Quality Index (EQI) for BMWP ASPT No. of Taxa		Classification scheme under development by NRA (Note 2). Scheme only relevant to rivers at present.
3. Special Ecosystem	*	*	*	*			Standards to be identified & applied according to the special requirements of identified sites.
4. Salmonid Fishery	*	*			Dissolved Oxygen BOD Un-ionised Ammonia Total Ammonia pH Temperature Max Temperature Diff List II Substances	5 mg/l 5 mg/l 0.021 mgN/l 0.78 mgN/l 6-9 21.5°C 1.5°C	 (Note 3) (Note 4) (Note 5) (Note 6)
5. Cyprinid Fishery	*	*			Dissolved Oxygen BOD Un-ionised Ammonia Total Ammonia pH Temperature Max Temperature Diff List II Substances	3 mg/l 8 mg/l 0.021 mgN/l 1.5 mgN/l 6 - 9 28°C 3.0°C	 (Note 3) (Note 7) (Note 7) (Note 4) (Note 5) (Note 6)
6. Migratory Fishery	*	*	*	*	Dissolved Oxygen BOD Un-ionised Ammonia Total Ammonia Temperature Max Temperature Diff pH List II Substances	3 mg/l 6 mg/l 0.021 mgN/l 1.5 mgN/l 21.5°C 1.5°C 6-9	 (Note 3) (Note 5) (Note 4) (Note 6)
7. Commercial Harvesting of Marine Fish for Human Consumption			*	*	List II Substances and Prescribed Substances under the 1990 Environmental Protection Act		(Note 8)

TABLE A2.1 (continued)

USE	APPLIES TO				PARAMETERS FOR USE-RELATED CLASS	VALUE	COMMENT
	R	L	E	C			
8. Commercial Harvesting of Shellfish for Human Consumption			*	*	List II Substances and Prescribed Substances under the 1990 Environmental Protection Act		(Note 8)
9. Water Contact Activities	*	*	*	*	Faecal coliforms Faecal streptococci Staphylococci Bacteriphages		(Note 9)
10. Abstraction for Potable supply	*	*			EC Surface Water Directive List II Substances		
11. Industrial and Agricultural Abstraction	*	*					(Note 10)
11a. Irrigation	*	*			pH Conductivity Chloride Sulphate Fluoride Arsenic Boron Cadmium Chromium Copper Iron Lead Molybdenum Nickel Selenium Vanadium Zinc	5.5-8.5 1500 uS/cm 100-900 mgCl/l 150-1350 mgSO_4/l 1.0 mgF/l 0.04 mgAs/l 2.4 mgB/l 0.02 mgCd/l 2.0 mgCr/l 0.5 mgCu/l 1 - 2 mgFe/l 2.0 mgPb/l 0.03 mgMo/l 0.15 mgNi/l 0.02 mgSe/l 0.08 mgV/l 1.0 mgZn/l	Dependent on crop type. Dependent on crop type. Metals as annual averages.
11b. Livestock Watering	*	*			pH Conductivity Chloride Sulphate Fluoride Dissolved Oxygen Arsenic Chromium Copper Lead Nickel Zinc	6-9 3000 uS/cm 1000 mgCl/l 250 mgSO_4/l 2.0 mgF/l 3.0 mg0_2/l 0.2 mgAs/l 1.0 mgCr/l 0.2 mgCu/l 0.1 mgPb/l 1.0 mgNi/l 25.0 mgZn/l	Metals as annual averages.

KEY: Rivers = Rivers, L = Lakes & Reservoirs, E = Estuaries, C = Coastal Waters

APPENDIX 2

PARAMETERS FOR USE-RELATED CLASSES - NOTES

NOTE 1 Basic Amenity Classification

Basic Amenity is concerned with the general aesthetic acceptability of the water body expressed in terms of transparency, odour, aerobic condition, colour, and the presence of mineral oil, litter, foam and biological growth. It is recommended that each of these eight parameters should be assessed in relation to one or more scale factors which reflect the extent of pollution, from any of them. Because of the inherently subjective nature of some of the aesthetic criteria, corroborative evidence such as chemical samples or photographic records will be required in certain instances.

Pollution indices may be calculated by giving a score to each parameter where it occurs and multiplying it by the scale factor. The sum of these scores can be averaged for a given period and ranked into four Classes to give an overall assessment of the Basic Amenity condition of a river stretch. Using such a system, each river stretch could be set a target Basic Amenity Class.

For example:

$$\text{Average score for river stretch} = \frac{\text{(Total number of parameters present) x (scale factor)}}{\text{Total number of samples}}$$

Basic Amenity Class	Average Score
Class 1	eg 0 - 1
Class 2	2 - 4
Class 3	5 - 6
Class 4	>8

NOTE 2 General Ecosystem Classification

The national survey of the biological quality of rivers carried out during 1990 has resulted in the development of a substantial database from which options for ecological classification systems are being assessed. The current preferred option is based on Ecological Quality Index (EQI) values resulting from the application of "RIVPACS". This system allows predictions to be made about the nature and composition of benthic macro-invertebrate communities based on a certain number of natural physical and chemical properties at a site. The comparison of the type of community observed with that predicted from "RIVPACS", allows a quotient to be calculated as the EQI. Thus, where the observed biological quality is the same as that predicted, the EQI would be equal to 1.

"RIVPACS" can be applied to make predictions on two biotic scores: the Biological Monitoring Working Party (BMWP) Score and the Average Score Per Taxon (ASPT). These give a numerical expression of the biological quality at a site in relation to the degree of organic pollution of the water. Predictions can also be made about the total number of different groups of animals at different taxonomic levels. To provide as comprehensive an indication as possible of the biological quality, it is recommended that the BMWP, ASPT and Number of Taxa (NOT) are used. The EQI values for each of these might be banded in the classification system as follows;

General Ecosystem Class	Description	EQI (ASPT)	EQI (NOT)	EQI (BMWP)
1	Good	≥ 0.89	≥ 0.79	≥ 0.75
2	Fair	0.77 - 0.88	0.58 - 0.78	0.50 - 0.74
3	Poor	< 0.77	< 0.58	< 0.50

The final designation of General Ecosystem Class is determined on the basis of all EQI values for a given site by taking the median of the three Class assessments.

NOTE 3 The test refers to 'inhibited' BOD; the influence of algae on the BOD test is also excluded from the assessment and the application of this provision will be applied nationally.

NOTE 4 pH values recorded outside the proposed ranges may be derogated if they are due to natural circumstances outside the control of NRA.

NOTE 5 Temperature maxima apply in waters affected by the impact of thermal discharges. Natural temperatures may exceed these values.

NOTE 6 List II substances from DOE Circular 7.89. These are copper, nickel, zinc, chromium, lead, arsenic, boron, iron, vanadium, organo-tin compounds and mothproofing agents. The standards only apply to waters receiving consented discharges of these substances.

NOTE 7 It is well known that, for certain rivers, sustainable cyprinid fish populations exist where these standards for ammonia would not normally be met. Where this can be demonstrated to be the case, derogations may apply whereby a less stringent standard for total ammonia of 2.3 mg N/l, and for un-ionised ammonia of 0.032 mg N/l, may be applied. For such rivers, experience suggests that these less stringent standards would provide sufficient protection for the resident cyprinid fish populations.

NOTE 8 It is recognised that other authorities are responsible for applying standards which relate to the levels of contaminants in both fish and shellfish flesh with regard to their wholesomeness for human consumption. The NRA will respect its specific environmental duty to investigate problems when they are notified, take the necessary measures to resolve them where possible and exert the necessary control measures to ensure that the relevant water quality standards are met. Standards for the existing List I Substances would be applied within the proposed scheme of SWQOs according to the relevant EC Directives and the Statutory Instrument No 2286 of 1989. Where any List II Substances (see Note 6) are identified as causing a problem, the relevant water quality standards listed in the DoE Circular of July 1989 would be applied. Additionally, the 1990 Environmental Protection Act lists prescribed substances to be controlled by the application of water quality standards. Some of these would already be covered by the legislation on List I Substances. However, some of the remaining substances are also potentially bioaccumulative and may cause problems. The remaining prescribed substances not classified under the 1989 Surface Waters (Dangerous Substances) (Classification) Regulations (SI No 2286) are: polychlorinated biphenyls, dichlorvos, 1,2-dichloroethane, all isomers of trichlorobenzene, atrazine, simazine, tributyltin compounds, triphenyltin compounds, trifluralin, fenitrothion, azinphos-methyl, malathion and endosulfan. The NRA will apply the relevant water quality standards, which are currently being derived, to the receiving waters at all sites where prescribed processes are in operation.

NOTE 9 There is a strong argument that a hierarchical system should be used, along the lines of the G/I division of the EC Bathing Water Directive. Whatever system is used, however, the determined values should be derived on a 'risk per exposure' basis. The NRA is not responsible for health related matters and thus extensive advice is required from other government departments.

NOTE 10 The water quality for existing Uses will be protected under a policy of no deterioration. The water quality requirements associated with any new Uses will need to be assessed by the NRA with a view to identifying the appropriate standards.

APPENDIX 3

PROPOSALS

FOR

GENERAL CLASSIFICATION SCHEMES

PROPOSALS FOR GENERAL CLASSIFICATION SCHEMES

1. INTRODUCTION

This Appendix deals with the technical aspects of the proposals for new General Classification Schemes for rivers, estuaries and coastal waters. The difficulties with previous classification schemes are discussed and the need for new, more objective systems explained. Recommendations are provided as to the criteria to be included in the proposed new schemes both in terms of chemical and biological quality.

The criteria to be applied will be dependent upon final decisions taken as to the exact role of General Classification Schemes within the framework of SWQOs. The options have already been set out in Chapter 6 of the main part of this document. The choice of option will determine whether the General Classification Schemes should be primarily used for making assessments of change over time, or whether they would be used in a more general way to make periodic 'snapshot' assessments of water quality. The schemes set out in this Appendix should therefore be considered as flexible and potentially adaptable to either purpose.

Many of the suggested elements of the proposed schemes, and particularly the incorporation of biological information, have never before been included in formal classification schemes in the UK. In some cases there is still further development work to be carried out to define appropriate criteria. Where this is the case, examples have been given to provide an illustration of how the schemes might look and how they could be applied.

2. GENERAL CLASSIFICATION SCHEME FOR RIVERS

2.1 THE NEED FOR A NEW SYSTEM

Experience with the use of existing classification schemes suggests that a new scheme would be needed in order to:

- minimise subjectivity and thus provide a scheme which is suitable for the introduction of Statutory Water Quality Objectives under the 1989 Water Act;
- secure consistency throughout England and Wales; and
- control the risk of mis-classification and provide an objective and unambiguous assessment of compliance.

These over-lapping topics are discussed below.

2.1.1 Subjectivity

The existing NWC Classification Scheme has been used in the past as the basis for reporting the results of quinquennial river quality surveys and for the purposes of routine water quality management. It has never been applied on a statutory basis. Past experience has shown that the scheme has been interpreted in different ways and that the assignment of water quality Classes could include an element of subjective judgement. The assessment of Class largely ignored the statistical uncertainty caused

by sampling error because the decision-making process included other checks and balances. Any new scheme, applied as part of a SWQO, should eliminate, as far as is possible, any subjectivity so that Class assignment can be carried out in a nationally-consistent way.

2.1.2 Consistency

The report of the 1985 River Quality Survey [1] revealed differences between the former Water Authorities in the monitoring and classification of rivers. The 1990 Survey attempted to reproduce the 1985 Survey as closely as possible, in order to obtain consistency with the past. The differences within England and Wales are illustrated in Table A3.1 for areas now covered by the Regions of the NRA. Table A3.1 shows the percentage of river length in each area which changed NWC Class between 1980 and 1990. This reveals a pattern of stability in some Regions and volatility in others. Such differences can largely be explained by differences in procedure.

Table A3.1: Percentages of River Length Changing Class: 1980 - 1990

Region	1980 to 1985			1985 to 1990		
	Up	Down	Net	Up	Down	Net
Anglian	21	13	+ 8	9	11	- 2
Northumbria	4	1	+ 3	2	5	- 3
North West	4	12	- 8	7	11	- 4
Severn Trent	10	7	+ 3	10	9	+ 1
Southern	19	20	- 1	23	16	+ 7
South West	4	45	-41	18	40	-22
Thames	15	18	- 3	19	33	-14
Welsh	22	21	+ 1	20	18	+ 2
Wessex	27	10	+17	4	3	+ 1
Yorkshire			+ 2	4	9	- 5
England and Wales	12	14	- 2	11	15	- 4

The work done by the NRA and its predecessors in preparation for the 1990 Survey showed differences between the former Water Authorities in:

- the statistical methods used to obtain the summaries of water quality (mainly 95-percentiles);
- the inclusion or exclusion of any analytical results suspected as being in error because they differed markedly from others from the same site (or because they were caused by extreme events like floods, drought, freezing or plant growth);
- the sampling frequencies;
- the number of years' data used for the assessment;
- the inclusion of non-routine samples (like those for pollution incidents);
- the pooling of data for different sites;
- the procedure used to interpolate between sampling points;

- the use of judgements based on the effects of algae, biological data and visual pollution to qualify or over-rule the classification suggested by other data;
- the weight given to the EIFAC standards, especially for un-ionised ammonia;
- the status given to non-compliance with standards in EC Directives (especially metals); and
- the allowance made for statistical sampling error when deciding whether a river had changed Class.

It is a fact, often over-looked, that the summary statistics which are used in classification (such as percentiles) are estimated with low precision in relation to the ranges of concentration which define the better quality Classes. If left unconstrained, this low precision may lead to large numbers of random changes in Class. Faced with this, some of the Water Authorities sought confirmation that small apparent changes were real by looking at extra data. Typical cases included:

- sites which 'failed' a chemical standard because of a single bad analytical result at a place where river quality was good according to all the other indicators, such as biological data, were recorded as passes;
- some sites which 'complied' with all the standards but had no fishery or poor biology were often downgraded; and
- sites which failed (or passed) marginally after several years of compliance (or failure), but for which there was no obvious cause for the change, were not re-classified.

By using this extra information, these Authorities damped out the damaging effects of low precision in the estimates of percentiles. Had they not done this, 20 to 30% of sites might have been placed in the wrong Class.

Other Authorities preferred to adhere strictly to the classification scheme but took account of poor precision and other factors in the process of deciding whether they really needed to take action to restore water quality. Either way, the former Authorities sensibly tried to avoid the expenditure of effort and money in trying to minimise downgradings caused by chance.

Another problem with the NWC Scheme is that new water quality standards and new Directives are being introduced steadily over the years. If these were to be incorporated within the Class criteria in the same way as the EIFAC Standards and the Surface Water Directive Standards, the system would cease to be usable as an absolute measure of water quality because not all the additional standards would apply to all rivers. Also, if the definition of Class changes over time in this way, it could not be used sensibly to indicate national trends in water quality. Instead, the system would produce apparent changes in Class which are due to changes in the method of classification.

Recognising this, the former Water Authorities Association recommended a new classification system specifically to show absolute quality. Rivers would be assessed separately for compliance with other standards and EC Directives. The new classification system was similar to the NWC scheme but based only on the biochemical oxygen demand (BOD), the dissolved oxygen and ammonia standards. These recommendations form the basis of the discussion below.

APPENDIX 3

2.1.3 Mis-classification

A benefit of the subjectivity of the NWC scheme is that judgement can be used to reduce the statistical risk of mis-classification. The classification procedure, if applied punctiliously, produces a high probability that a site may be declared wrongly to have changed Class when the actual quality of the site may not have changed at all. The NRA proposes to reduce the risk of mis-classification, using three developments as follows.

Firstly, the calculation of percentiles should be based on three years' data.

Secondly, it is suggested that the joint use of chemical and biological data has the potential to provide better precision than could be obtained from just one set of data; biological information was often used informally as part of the NWC scheme and associated decision-making.

With these two developments it is estimated that the risk of mis-classification could be reduced to about 10%.

Thirdly, the NRA would plan to use the data collected in the 1990 NRA Survey to establish a baseline as a sound statement of river quality in 1990. After 1990, using this new baseline, the problem of poor precision can be managed by looking for statistically significant changes.

This point may require explanation. Until now, each of the River Quality Surveys has involved carrying out the following steps for each stretch of river:

- calculating percentiles;
- comparing percentiles with the Class limits;
- assigning Class according to the worst determinand;
- comparing the Class with that obtained last time; and
- reporting the changes.

Even with 3 years' data, this process produces a risk of 20% to 30% of wrongly reporting that a river has changed Class when no such change has really occurred.

It is therefore recommended that the above procedure should be applied to the results of the 1990 Survey but that for subsequent Surveys, for each river, the procedure would be to:

- start with the Class assigned last time (the current Class);
- calculate percentiles;
- compare percentiles with the current Class limits;
- check for:
  (a) statistically significant non-compliance with the current Class limits,
  (b) statistically significant compliance with the Class limits of better or worse Classes;
- assign a new Class where a statistically significant change has occurred; and
- report the changes.

This process would reduce the risk of reporting wrongly that a river has changed in Class. The acceptable risk can be fixed at any required level. A level of 5% appears reasonable and is consistent with the risk accepted for assessing non-compliance of effluent discharges, and the risk allowed by the EC Directive on Urban Wastewater Treatment.

In effect this means, for example, that it is unlikely that a river would be downgraded from Class B to Class C if the estimated value of the 95-percentile BOD increases from 4.7 to 5.2 mg/l. This change crosses the upper Class B boundary of 5.0 mg/l. The reason that this case should not be considered significant is that such a small change could be attributable to the effect of chance on sampling. Similarly, it is unlikely that a river would be upgraded from Class B to Class A if the estimated value of the 95-percentile BOD decreases from 3.2 to 2.8 mg/l. This passes through the lower Class B boundary of 3.0. Clearly, it is important that the application of any new General Classification Scheme should have a sound statistical basis to ensure that the assessment of water quality is not obscured by insignificant changes in Class.

2.1.4 Continuity

Against all of this is the possible drawback that the results from a new scheme could not be compared sensibly with the results from past Surveys, such that apparent trends in river quality, which are caused by a change in methods, might be taken as real changes. In view of the inaccuracies of the past methods, this is not an argument for resisting change. In any case, the need for continuity has been addressed by the NRA by setting up procedures by which both the existing and new systems can be applied to the data collected in 1990. Thus the NRA has used the existing system to compare the results of 1985 and 1990. The results of the 1990 Survey to which the existing NWC Classification Scheme has been applied have been published in a separate report. It is intended that the new scheme will be applied to the 1990 Survey results following the consultation process. Future changes in water quality could then be assessed against this new baseline.

2.2 THE PROPOSED NEW GENERAL CLASSIFICATION SCHEME

This section describes the details of a new General Classification Scheme for rivers which would provide an improved means of assessing real changes in water quality, and a suitable, nationally-consistent methodology for inclusion in the proposed scheme of SWQOs.

2.2.1 Standards and percentiles

For the purposes of this report, the proposed new Classes are called the **NRA Classes**. Although the NRA Classes would be designed to reflect absolute quality, it is recommended that past practice is continued and that the limited set of standards used to define the better Classes are those which are consistent with the protection of fisheries and suitable for abstraction for drinking water. The chemical criteria were suggested by the former Water Authorities Association, and are given in Table A3.2. It is suggested that these are used to define the NRA Classes.

Table A3.2: Chemical Criteria for the NRA Classes

	Dissolved Oxygen	Biochemical Oxygen Demand (ATU)	Ammonia
Class	(% saturation) 5-percentile	(mg/l) 95-percentile	(mgN/l) 95-percentile
A	80	3	0.3
B	60	5	0.7
C	40	9	3.0
D	10	17	-
E	<10	-	-

It should be noted that the 5-percentile dissolved oxygen standards require that the percentage saturation exceeds the value in Table A3.2, whereas the 95-percentile standards require that the values are not exceeded.

The possibility of replacing the 95-percentiles with other statistics has been considered. This would have required different concentrations from those in Table A3.2, but there is a statistical case for the use of the median or a less extreme percentile, like the 80-percentile. The 80-percentile, and especially the median, could be estimated with more precision than the 95-percentile; this would make it easier to detect smaller changes in quality.

Against this, when it comes to managing water quality, the NRA and its predecessors have seen the need to take into account the variability of water quality. This is better done with the 95-percentile than with the 80-percentile. This is because the application of the 80-percentile can result in instances where a set of water quality data for a river indicates compliance with the standard despite the existence of pollution which may cause up to 20% of the samples to be of poor, and potentially damaging, quality. Taking into account the considerable experience in the UK of taking decisions based on the application of percentiles, it would not seem sensible to depart from past practice unless there are more obvious benefits to set against the risks. Thus, on balance it is suggested that 95-percentiles should be retained.

None of this rules out the separate use of other statistical methods, such as the mean and median, to assess absolute changes in water quality. Indeed, in showing whether a change in water quality has occurred, the application of these statistics would be more effective than assessing changes in Class.

2.2.2 Putting a river in a Class

In deciding just how to place a river in a Class, there are the following options:

a) allow the worst determinand to dictate the Class;

b) downgrade only if two determinands are in the poorer Class; or

c) use statistical techniques to assign the most probable Class.

On balance, it is suggested that option (a) is followed in order to retain consistency with the proven methodology of the past. Options (b) and (c) would, however, provide a system which was less volatile.

In order to evaluate the issues raised by the introduction of a new General Classification Scheme, the NRA has used the data collected for the 1990 River Quality Survey to assign NRA Classes to rivers using option (a) and the criteria in Table A3.2. In doing this, the NRA used a uniform methodology throughout England and Wales. Details of this are given in Section 2.4.

The discipline demanded for SWQOs necessitates the application of strict rules on the processing of data and on the calculation of percentiles. The protocol should avoid methods of calculating percentiles which make assumptions about the data, even if the rejected methods would have been preferred, technically, had the scheme remained non-statutory. The avoidance of assumptions is essential if the classification scheme is to provide an unambiguous assessment of water quality.

These restrictions on the method of calculation of percentiles and some of the other procedures outlined in Section 2.4 result in higher and more volatile estimates of percentiles. This means that option (a), above, will tend to put rivers in worse Classes than would have been the case in the old system. This is evident in the illustrative results presented later in this section.

2.2.3 Effect of algae on the test for BOD

Some clean rivers with low velocity could be placed in Classes D or E because of the effect of algae on the measurement of BOD in the laboratory. This is an artificial effect on the test which may give rise to results which are not representative of the oxygen demand in the river. There are four options for dealing with this:

a) accept the fact that relatively clean rivers are placed in poor quality Classes;

b) remove BOD from the classification altogether;

c) use measurements of chlorophyll to estimate the influence of algae on the BOD measurement, then take this into account in the calculation; or

d) identify rivers affected by algae and refuse to downgrade if the only factor is a high BOD which is caused by the effect of algae on the test.

On balance, option (d) is recommended. Option (c) is attractive in theory but has proved expensive and unworkable in practice.

2.2.4 Biological information

The case for the inclusion of a biological component in the General Classification Scheme has been put forward in the main body of this document. It has been argued that biological information should be used in combination with the chemical data to provide a more integral assessment of water quality and to improve precision in placing a stretch of river in a Class. The question then arises as to how these two, quite different, measures of water quality can be combined to produce a single, workable system.

The collection of a large database on the biological quality of several thousand sites on rivers in England and Wales during the 1990 Survey has provided the opportunity to carry out the necessary analyses to answer this question. A preliminary analysis of the relationships between the chemical and biological quality of the river stretches sampled during the Survey suggests that it would be, indeed, feasible to derive and apply a biological over-ride to the chemical classification. The analysis has also suggested that the Ecological Quality Index (EQI) based on the ratios of observed to predicted Average Score Per Taxon (ASPT) from RIVPACS (see Appendix 2 for details), could be used as one way of doing this. As an example, one possible scheme for the application of a biological over-ride to the NRA chemical Class is given in Table A3.3. It should be emphasised that this scheme is based only on a preliminary analysis of the 1990 Survey database and has only been given as an example of how the biological over-ride might be applied. Further detailed work will be needed to produce a finalised methodology.

Table A3.3: A Biological Over-ride based on the Ecological Quality Index for ASPT

NRA Class	Ecological Quality Index
A	0.90 -
B	0.65 - 0.99
C	0.60 - 0.85
D	0.40 - 0.65
E	- 0.55

Table A3.3 provides EQI bands which can be applied to assess whether or not a change in Class is justified. For example, Table A3.3 shows rivers in Class C with an EQI in a range from 0.60 to 0.85. A river whose chemistry is placed in Class C would be downgraded to Class D if the EQI were less than 0.60 and upgraded to Class B if the EQI were more than 0.85. If the EQI were less than 0.40 the river would be downgraded to Class E. A score of more than 0.99 would cause a move to Class A.

Although the preliminary analysis of the 1990 Survey results suggests that there may be statistical advantages in using the EQI for ASPT as the basis for a biological over-ride, it should be pointed out that the ASPT does have certain limitations. It is a

biotic scoring system which is particularly relevant to the assessment of biological quality in relation to the degree of sewage pollution in rivers. Thus, while the ASPT should reflect the levels of those determinands in the classification scheme, which are themselves indicators of sewage pollution, it has **not** been designed to reflect the effects of other kinds of pollution in rivers, such as acidification and elevated metal concentrations. This is currently being addressed through the analysis of the 1990 Survey biological database with a view to developing a system which makes full use of the available biological information.

2.3 PRELIMINARY ANALYSIS OF THE 1990 SURVEY RESULTS

This section provides a preliminary analysis of the chemical and biological information collected during 1990 according to the proposed new General Classification Scheme. The rules applied in assigning Classes are derived from the preferred options discussed in previous sections. These results should only be considered as illustrative. They are provided as an example to show how a new classification scheme with biological over-ride could be applied, and what the outcome might be. Finalisation of the methodology will be completed following the consultation process on the proposals for SWQOs.

Table A3.4 shows the percentage of river lengths falling into each Class for each of the 10 NRA Regions according to the chemical information only.

Table A3.4: Results of the 1990 Survey using the proposed NRA General Classification Scheme (Chemical data only)

Region	% Length in each NRA Class				
	A	B	C	D	E
Anglian	0.3	29.7	50.9	19.0	0.1
North West	21.1	22.7	24.8	23.9	7.5
Northumbria	11.3	49.4	26.0	10.6	2.7
Severn Trent	7.4	25.6	40.9	21.8	4.2
South West	18.4	45.2	28.9	5.8	1.6
Southern	8.0	34.2	36.1	18.2	3.6
Thames	4.4	33.0	38.5	22.3	1.9
Welsh	27.8	43.6	22.0	5.1	1.6
Wessex	7.6	33.9	35.4	20.6	2.6
Yorkshire	10.0	27.6	26.5	29.6	6.3
England & Wales	12.1	33.6	33.7	17.4	3.1

Table A3.5 compares the results of the 1990 Survey using both the proposed NRA General Classification Scheme and the existing NWC Scheme. Although the river quality criteria are similar in the two systems, the Classes in the NRA Scheme generally represent cleaner river quality than those in the NWC Scheme. As

discussed above, this is because the NRA Scheme has strict rules governing its application. In particular the procedure:

- forbids the exclusion of any analytical results suspected as being in error because they differed markedly from others from the same site;
- requires the use of methods of estimating percentiles which exclude statistical assumptions;
- demands that no subjective allowance is made for the effect of random chance in sampling; and
- excludes the informal use of biological and other data to amend Class.

Table A3.5: Comparison of the results of the 1990 Survey using the NRA (Chemical data only) and NWC Classification Schemes

NWC Class	% Length in Class	NRA Class	% Length in Class
1a	31	A	12
1b	34	B	34
2	23	C	34
3	10	D	17
4	2	E	3

Table A3.6 shows how the application of a biological over-ride to the chemical results might affect the classification of river lengths. Using the scheme based on the EQI for ASPT as outlined in Table A3.3, the percentage of river lengths upgraded as a result of applying the biological over-ride outweighed that for downgraded lengths, giving a net upgrading in all the 10 NRA Regions.

Table A3.6: The Effect of a Biological Over-ride based on the EQI for ASPT

Region	% Length Changed by the Over-ride		
	Upgraded	Downgraded	Net
Anglian	34	0.4	+ 34
North West	17	5	+ 12
Northumbria	29	1	+ 28
Severn Trent	34	2	+ 32
South West	23	0.5	+ 22
Southern	50	0.8	+ 49
Thames	23	1	+ 22
Welsh	25	1	+ 24
Wessex	32	0.1	+ 32
Yorkshire	14	2	+ 12
England & Wales	28	1	+ 27

Table A3.7 shows the percentage of river lengths in each of the new NRA Classes to which the biological over-ride has been applied. The overall effect of the inclusion of biological information in the NRA Scheme is to compensate for the apparent downgrading of the highest Class, such that the overall result for England and Wales is similar to that obtained by applying the existing NWC Scheme. However, although the overall result is similar, major differences exist at the Regional level.

Table A3.7: NRA Classes with the Biological Over-ride

Region	% Length in each NRA Class				
	A	B	C	D	E
Anglian	14.8	47.5	28.0	9.0	0.8
North West	22.8	19.3	26.1	25.4	6.4
Northumbria	39.1	38.2	14.0	8.2	0.5
Severn Trent	21.2	30.9	37.3	9.6	1.0
South West	46.9	34.1	14.8	3.3	1.0
Southern	29.8	44.8	20.2	4.7	0.6
Thames	22.6	34.0	27.4	14.5	1.5
Welsh	57.9	30.5	9.9	1.3	0.4
Wessex	43.8	43.1	11.5	1.4	0.2
Yorkshire	17.9	24.6	26.9	25.9	4.6
England & Wales	31.1	34.5	23.1	9.8	1.6

2.4 TECHNICAL BACKGROUND - PUTTING A RIVER IN A CLASS

2.4.1 Assigning Class

In assigning the NRA Class to a stretch of river all NRA officers followed the instructions listed below.

i) For each sampling site assign the length(s) of river(s) which the site will be assumed to characterise.

ii) The Class assigned for that site will then be considered to be representative of the entire length.

iii) Use only the results from the routine, pre-determined sampling programme.

iv) Include all the results collected over the three years 1988-90.

v) For sites having less than 20 or more results, use the Wiebull Method (a non-parametric procedure) to estimate percentiles.

vi) For sites having less than 20 results the Wiebull Method is inappropriate. Use a standard parametric method (Method of Moments) to estimate percentiles. Assume the log-normal distribution for BOD and ammonia and the normal distribution for dissolved oxygen.

vii) Exclude no outliers.

viii) Results qualified as "less-than" should be taken as half the value specified.

ix) Compare the percentiles with the Class Limits in Table A3.2; assign the Class according to the worst determinand.

2.4.2 The Database

Each Region assembled a database which included:

a) the name of the reach;
b) category of river flow (as defined for past Surveys);
c) the length of the reach (km);
d) the upstream map reference;
e) the downstream map reference;
f) the name of the chemical sampling point;
g) the Grid Reference for the chemical sampling point;
h) the NWC Class for the reach in 1985;
i) the NWC Class for the reach in 1990;
j) the 1990 NRA Class for the reach;
k) whether the BOD is exempted;
l) the 95-percentile BOD;
m) the 95-percentile ammonia;
n) the 5-percentile dissolved oxygen;
o) the number of chemical samples used in the assessment of each of the above;
p) the name of the biological sampling point (if any);
q) the BMWP Score and RIVPACS prediction;
r) the ASPT Score and RIVPACS prediction;
s) the number of biological samples used to compute Scores.

2.4.3 Estimation of Percentiles

For sites with more than 19 samples the Wiebull Method was used. Otherwise the Parametric Methods were followed. These are described below.

(a) Wiebull Method

If the data are arranged in order from smallest to largest then the P-percentile is estimated by the 'r-th' ranked result, where r is given by:

$$r = (P/100) * (n+1)$$

and where n is the number of sample results.

For 39 samples, the 38th value estimates the 95-percentile.

Where r is not a whole number use linear interpolation. Thus for 50 samples and the 95-percentile, r is 40.8. This should be interpreted as 0.8 of the way from the 40th

to the 41st value. So if these values were 31.3 and 35.8, the required estimate would be calculated by the weighted average as follows:

$$0.2\ (31.3) + 0.8\ (35.8) = 34.9$$

(b) **Parametric Method**

For dissolved oxygen assume a **Normal Distribution**. First compute the mean, m, and the standard deviation, s. An estimate of the 5-percentile is q in:

$$q = m - 1.6449\ s$$

If this gives a negative value of q, call it zero.

For the BOD and ammonia assume a **Log-normal Distribution.** Compute m and s but convert them to the values for the logarithms of the data using the **Method of Moments**:

$$S = \sqrt{\ln\ (1 + s^2/m^2)}$$

$$M = \ln\ [m / \sqrt{\ (1 + s^2/m^2)}]$$

M and S are estimates of the mean and standard deviation of the logarithms of the data. The characters, ln, denote the natural logarithm. The 95-percentile is estimated as the exponential of (M + 1.6449 S):

$$q = e^{(M + 1.6449\ S)}$$

Example: $m = 2.0;\ s = 1.0$

$$S = \sqrt{\ln\ (1 + 0.25)} = 0.4724$$

$$M = \ln\ [m / \sqrt{(1 + 0.25)}] = 0.5816$$

$$q = e^{(0.5816 + 1.6449 * 0.4724)}$$

$$= 3.89$$

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3. GENERAL CLASSIFICATION SCHEME FOR ESTUARIES

The need for a new, less subjective, General Classification Scheme for estuaries has been discussed in the main body of this document. What is required is a nationally-consistent methodology which can be applied as part of the scheme of SWQOs. It has been recommended that a new scheme should contain the following components:

- dissolved oxygen, ammonia and nutrients in the water;
- aesthetic criteria based on sewage-derived material;
- the concentration of persistent substances in sediments; and
- a measure of ecological quality based on benthic invertebrates.

Because appropriate criteria are not yet available for some of these components, it has been recommended that the scheme be introduced in a phased manner. In the short-term, the scheme could therefore include criteria for dissolved oxygen, ammonia, nutrients, aesthetic quality, and interim criteria for persistent substances in sediments and for ecological quality. Further work is required to develop reliable, nationally-applicable criteria for these last two components. Thus, whilst it would be possible to introduce interim criteria in the short-term, the finalised criteria for these two components will have to be included at a later stage dependent upon the outcome of the research and development programmes which are currently in progress. A proposed General Classification Scheme for estuaries is given in Table A3.8.

Table A3.8: A Proposed General Classification Scheme for Estuaries

CLASS	WATER QUALITY (Note 1)			AESTHETIC QUALITY	SEDIMENT QUALITY	ECOLOGICAL QUALITY
	Dissolved Oxygen (%saturation)	Ammonia mgN/L	Nutrients (Note 2)	(Note 3)	(Illustrative) (Note 4)	(Illustrative) (EQI) (Note 5)
1	> 60	< 0.7		All discharges screened and/or treated.	< Level 1	> 0.7
2	> 40	< 0.7		All discharges > 2,000 p.e. screened and/or treated. Discharges < 2,000 p.e. unscreened and untreated but which cause no serious problems.	< Level 2	> 0.4
3	> 10			Discharges > 2,000 p.e. unscreened and untreated but which cause no serious problem. Discharges < 2,000 p.e. which cause intermittent problems.	< Level 3	> 0.1
4	≤ 10			Discharges unscreened and untreated which cause serious problems.	≥ Level 3	< 0.1

Notes to Table A3.8

Note 1: All water quality criteria to be applied as 95-percentiles.

Note 2: Appropriate criteria for nutrients have yet to be defined. However, there is some evidence to suggest that phosphorus may be limiting in upper, low salinity reaches

and that nitrogen may be limiting in the lower, higher salinity areas. Thus, it is suggested that criteria should be set for both total phosphorus and total nitrogen in estuaries.

Note 3: These criteria refer to all discharges affecting the aesthetic quality of the water, including those on rivers which may give rise to sewage-derived debris in estuaries. Further details of the proposed criteria are as follows.

Class 1 Estuary, or zone of an estuary, which receives no discharges of effluent, or where all controllable sources of whatever size are below mean low water of spring tides and subject to either appropriate fine screening[1] or another treatment process[2] to prevent aesthetic[3] problems.

Class 2 Estuary, or zone of an estuary, where all major discharges[4] (>2,000 population equivalent) are below mean low water of spring tides and subject to either appropriate fine screening or another treatment process to prevent aesthetic problems, but where some minor discharges (<2,000 population equivalent)[5] might not meet all these requirements but do not cause serious aesthetic problems.

Class 3 Estuary, or zone of an estuary, where some major discharges (>2,000 population equivalent) are above mean low water of spring tides and/or are not subject to either appropriate fine screening or another treatment process to prevent aesthetic problems.

Class 4 Estuary, or zone of an estuary, where there is contamination with intact faecal material or where there are inputs of any size giving rise to serious smell problems.

Note 4: Refers to accumulation of persistent substances in the < 63 µm sediment fraction. The substances to be included in the scheme are the existing EC List I compounds (cadmium, mercury, DDT, hexachlorocyclohexane, hexachlorobenzene, dieldrin and PCBs), and the List II Metals (arsenic, chromium, copper, lead, nickel and zinc). The accumulation levels will be expressed relative to a reference concentration typical of an unpolluted estuary.

Note 5: Ecological quality to be expressed as an Ecological Quality Index (EQI) based on the nature and composition of benthic invertebrate communities. Decisions on the final form of the EQI system will have to be made following the necessary supportive research work.

1 "Fine Screening" should be equivalent to 6mm and removal of screenings for disposal elsewhere.

2 "Another treatment Process" equates to provision of primary or secondary treatment, septic tank, oil interceptors. etc; it does not encompass maceration only.

3 Aesthetic contamination should include all discharge derived discolouration, oil and debris etc.

4 "Major discharges" have been defined using the population equivalent criteria provided by the EC Urban Waste Water Treatment Directive.

5 "Minor discharges" should include all storm discharges.

4. GENERAL CLASSIFICATION SCHEME FOR COASTAL WATERS

The development of a coastal water classification scheme has been discussed in the main part of this document. The application of such a scheme to the vast expanse of coastal water around England and Wales, for the first time, would present new challenges. However, these are not considered to be insurmountable. The application of the scheme would have to be carefully planned such that limited resources are utilised in the most effective way to assess whether or not the quality of coastal waters has been maintained, or where necessary, improved.

The components of the proposed scheme are given in Table A3.9. They are similar to those proposed for the estuary classification scheme (see Section 3), except that dissolved oxygen and ammonia are not included because they rarely give rise to problems in coastal waters, and a microbiological component has been added to reflect the requirements of bathing waters. It should be noted that there may be more meaningful and reliable microbiological parameters for assessing the health risks associated with bathing (see Appendix 2). However, until workable water quality standards for these parameters become available, the standards suggested in Table A3.9 could be applied as an interim measure. It is recognised that different criteria may be required to reflect the different characteristics and uses of near-shore and off-shore waters. This needs further investigation. However, for the time being it is suggested that the proposed single scheme could be applied to all coastal waters.

Table A3.9: A Proposed General Classification Scheme for Coastal Waters

CLASS	WATER QUALITY		AESTHETIC QUALITY	SEDIMENT QUALITY	ECOLOGICAL QUALITY
	Microbiological Quality (Coliforms per 100ml)	Nutrients (Note 1)	(Note 2)	(Illustrative) (Note 3)	(Illustrative) (EQI) (Note 4)
1	< 10,000 total < 2,000 faecal as 95-percentile < 500 total < 100 faecal as 80-percentile		All discharges screened and/or treated.	< Level 1	> 0.7
2	< 10,000 total < 2,000 faecal as 95-percentile		All discharges > 2,000 p.e. screened and/or treated. Discharges < 2,000 p.e. unscreened and untreated but which cause no serious problems.	< Level 2	> 0.4
3	< 10,000 total < 2,000 faecal as 67-percentile		Discharges > 2,000 p.e. unscreened and untreated but causing no serious problem. Discharges < 2,000 which cause intermittent problems.	< Level 3	> 0.1
4	< 10,000 total < 2,000 faecal as < 67-percentile		Discharges unscreened and untreated which cause serious problems.	≥ Level 3	≤ 0.1

Notes to Table A3.9

Note 1: Appropriate criteria for nutrients in coastal waters have yet to be developed. There is some evidence to suggest that nitrogen may limit algal growth in nearshore coastal waters; thus it seems likely that the criteria would be set in terms of the levels of total nitrogen.

Note 2: Criteria refer to all discharges affecting the aesthetic quality of coastal waters, including those to rivers and estuaries which may give rise to sewage-derived debris in coastal waters. Further details of the proposed criteria are as follows.

Class A Length of coastline not contaminated by discharges elsewhere along the coastline or where all controllable sources of whatever size are below mean low water of spring tides and subject to either appropriate fine screening or another treatment process to prevent aesthetic problems.

Class B Length of coastline not contaminated by discharges elsewhere along the coastline and where all major discharges (>2,000 population equivalent) are below mean low water of spring tides and subject to either appropriate fine screening or another treatment process to prevent aesthetic problems but where some minor discharges (<2,000 population equivalent) might not meet all these requirements but do not cause serious aesthetic problems.

Class C Length of coastline suffering significant aesthetic contamination from discharges elsewhere along the coastline or which receives direct major discharges (>2,000 population equivalent) which are above mean low water of spring tides and/or not subject to either appropriate fine screening or another treatment process to prevent aesthetic problems, or which receives some minor discharges (<2,000 population equivalent) which cause intermittent aesthetic problems.

Class D Length of coastline where there is evidence of contamination with intact faecal material, or where there are inputs of any size giving rise to a serious smell problem.

Note 3: Same approach as recommended for estuaries (see Table A3.8).

Note 4: Same approach as recommended for estuaries (see Table A3.8).

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1. River Quality in England and Wales - 1985. HMSO London, 1986.

2. Ellis, J. C. The Design and Interpretation of Routine Sampling Programmes. Report NS29, Water Research Centre, February 1989.

APPENDIX 4

STATISTICAL BACKGROUND

STATISTICAL BACKGROUND

1. INTRODUCTION

This Appendix discusses the errors which arise from the use of sampling to assess water quality and from the use of classification systems. It explains what is meant by a Water Quality Standard and how compliance with it is evaluated. This Appendix also describes the way in which change in water quality is evaluated. For some of this discussion, rivers and fisheries have been used as an example, but the principles apply to other waters and other uses.

River quality is monitored by trained staff who make regular visits to carefully selected sites. These officers check for any signs of damage to the river and look for evidence of a risk of damage. They also carry out one or two simple measurements at the river bank and take a sample of the river water which is subsequently analysed for a range of 10 to 100 determinands depending on the circumstances. The selected sites or sampling points are, on average, spaced 6 to 10 kilometres apart and they are sampled, as a rule, at least monthly for most rivers.

The NRA would take immediate action if any of this activity revealed anything of concern, but in most cases the results are unlikely to lead to an immediate response, and they are archived so that they can be assessed later for evidence of longer-term problems. This subsequent analysis may also lead to action to improve water quality and, in particular, to tighter standards on discharges, to increased surveillance, and to negotiations with potential polluters.

2. COMPLIANCE AND STANDARDS

The risk of damage is assessed by comparing measurements of water quality with Water Quality Standards. If the measured water quality meets the standard, it is said to have complied.

The standards used for the assessment of longer-term effects have a margin of safety built into them so that, for the most part, one or two failed samples forewarn of a risk, but need not require immediate action. The system is thus deliberately arranged so that moderate non-compliance indicates an unwelcome risk of damage as opposed to the certainty of real damage.

The standards should be set in such a way that there is a sufficient level of protection for a given Use; for example, for the protection of fisheries, the standard should be set so that the risk of damage to fish populations is minimised. This usually involves assessing available information on the toxic effects of a substance and applying an appropriate safety factor. The standard can be converted to a 95-percentile by comparing information on fishery status and water quality. Thus, if the river meets the standard for 95 percent of the time, the risk of damaging the fish population should be acceptably small. If the standard is exceeded for more than 5 percent of the time, action would be taken. In most cases, this advance warning ensures that action can be taken before real damage occurs. It is possible that some sites may fail the 95-percentile standard yet escape real damage. However , the aim of effective

pollution control is to reduce the general risks of damage until they are acceptably small everywhere.

3. SAMPLING AND SAMPLING ERROR

Water quality is highly variable and it is generally only practicable to take a limited number of samples at each site. This produces a risk that sometimes there will be a failure to record the periods when river quality is poor; it is also likely that sometimes, again by chance, a set of samples is obtained in which the water quality was poor only when sampled.

The effect of chance on sampling can be substantial in its own right, but the risk of error is aggravated if there is any tendency, for example, for poor quality to occur at night or weekends, and if sampling is restricted to normal working hours.

In practice, the effect of these loopholes is minimised because sampling staff inspect the river for evidence of recent pollution and the NRA also monitors the quality of discharges. Also, biological sampling provides an indicator of recent pollution because the river life, once damaged, requires time in which to recover. Finally, critical sites will be subjected to continuous monitoring for a few key indicators of water quality, and a proportion of samples will be taken outside normal working hours.

Even in the absence of other errors and bias, the results of sampling are influenced by the Laws of Chance because it is not practicable to sample all the time. This produces risks that particular rivers are wrongly declared to be compliant or non-compliant with respect to the water quality standards. For those wrongly considered compliant, this may result in complacency about river water quality. For those wrongly declared to have failed, there is the risk that expenditure, by the NRA and by others, is wasted on achieving unnecessary improvements to water quality.

Fortunately, the risk of drawing a wrong conclusion from sampling can be calculated using statistical techniques. The uncertainty stemming from a selected number of samples is called **Sampling Error**. It is quantified by calculating **Confidence Limits**.

4. CONFIDENCE LIMITS

Suppose 36 samples are collected at site on a river and these give a 95-percentile concentration of 2.0376 mg/l. This is a precise arithmetic result from the 36 samples. It is not, however, a precise estimate of the true 95-percentile at the site - it is only an approximate estimate. To calculate the true 95-percentile requires continuous, accurate monitoring. Had the samples been taken on different dates, different samples of water would have been obtained, and it is highly improbable that this 95-percentile would also have been 2.0376 mg/l. The use of sampling therefore produces an uncertain estimate of the true 95-percentile.

The range of these possible estimates of the 95-percentile therefore needs to be known. This would define the error in the particular value which was obtained from the set of 36 samples. This is done by calculating confidence limits. This means

that in addition to the estimate, say 2.0376, a pair of confidence limits are calculated, (1.0345 and 3.1325) which span the range within which the true 95-percentile is expected to lie. It is common to calculate the 95% confidence limits. (The calculation of confidence limits is a standard procedure the details of which need not be detailed here).

To continue with the above example, this means that 1.0345 and 3.1325 define the 90% **Confidence Interval** on the estimate of the 95-percentile, 2.0376. This means that there was a chance of only 5% that the true 95-percentile was less than 1.0345 but that, through chance, our samples gave a value as high as 2.0376. Similarly there is a chance of only 5% that the true 95-percentile was greater than 3.1325 but that, through chance, the samples gave a value as low as 2.0376.

If high concentrations indicate poor water quality, the lower confidence limit is called the **Optimistic Confidence Limit**. The upper limit is then the **Pessimistic Confidence Limit**.

It is sobering to calculate the uncertainty associated with 12 to 36 samples. Taking the case of ammonia as an example, an estimate of a 95-percentile equal to 1.0 mg/l will have a 90% confidence interval of 0.5 to 2.3, if based on 36 samples. This estimate presumes that the actual sampling and analysis contains no errors or bias, which may, in themselves, create additional uncertainty.

Using the estimates given in this example, it would not be sensible to accept that the river had complied with a 95-percentile standard of, say 2.0 mg/l, even though the estimate of the 95-percentile was only 1.0 mg/l. Equally, it might not be justifiable to spend large sums of money to improve the quality to a standard of 0.7 mg/l when it is conceivable that the river is already at this level.

The example above illustrates how confidence limits can be applied to take account of sampling error. The results from samples are used to calculate the value of the compliance statistic - the 95-percentile or whatever is chosen. The 95% confidence limits on the estimate of the 95-percentile can then be calculated. Then:

- if the standard is greater than the Pessimistic Confidence Limit there is more than 95% certainty of compliance;
- if the standard is less than the Optimistic Confidence Limit there is more than 95% certainty of failure; and
- where the standard lies between the Confidence Limits it is impossible to declare compliance or failure with at least 95% confidence - where this is the case, there would be a 5-50% probability that any decision taken on this basis might be wrong.

The gap between the Confidence Limits widens as the sampling frequency is decreased. When the number of samples is small the gap may be so wide that compliance or failure could seldom be discerned. Conversely, extra sampling increases the likelihood that small degrees of compliance or failure with the required level of confidence could be assessed.

5. COUNTING FAILED SAMPLES

Compliance can be assessed by counting the number of samples which exceed the standard. If the standard is a 95-percentile then it can be checked if more than 5% of samples have failed. However, the proportion of failed samples is only an estimate of the proportion of time the river actually failed to comply. There is a risk that the period when water quality was poor just happened to occur at the time when the water was sampled. Similarly, by chance, a set of samples taken when river quality was good when sampled will sometimes be obtained. As before, the confidence limits need to be estimated.

Consider 20 samples and 1 failure. This set of results would, on average, be produced at a site which failed for 5% of the time. If the confidence limits on this estimate of 5% are calculated, the values of 0.3% and 22% are obtained. This means that there is a chance of 5% that 19 out of 20 compliant samples could be taken from a river which failed for as much as 22% of time. Also there is a chance of 5% that this set of samples came from a site which failed for only 0.3% of time. Because of sampling error, the estimate of the time spent in failure is likely to be imprecise and may lead to wrong decisions unless the confidence limits are also calculated. It would clearly not be acceptable to take actions which might be unnecessary and unfair to dischargers because the effect of sampling error was not taken fully into account. To deal with this, a permitted number of failed samples is defined according to the number of samples taken. This is done through the use of a Look up Table.

6. LOOK UP TABLE

A Look up Table is a simple device which is the mathematical equivalent of using Confidence Limits to determine compliance. In the following Look-up Table, the permitted number of failed samples has been set so there is at least 95% certainty that a site has failed. This gives at most a risk of 5% that a site is declared wrongly as a failure.

THE LOOK-UP-TABLE

Number of Samples	Permitted Number of Failed Samples
4 - 7	1
8 - 16	2
17 - 28	3
29 - 40	4
41 - 53	5
54 - 67	6

This example is a simplified version of that which forms part of the legal document defining the allowable limits for discharges from sewage treatment plants. It is also used to define failure for the purposes of the EC Urban Wastewater Treatment Directive.

Just as extra failures to confirm proof of failure are allowed, so fewer failures to confirm proof of success should be demanded. To be 95% sure of complying with a standard for 95% of the time, a minimum of 60 samples with no failures would be required!

The NRA plans to use estimates of compliance and failure which take proper account of Sampling Error [1]. This will ensure that sound decisions are taken.

7. EFFECT OF SAMPLING ERROR ON CLASSIFICATION

The average uncertainty arising from the use of 36 samples to estimate percentiles has been calculated as follows:

Determinand	90% Confidence Interval
BOD	- 19% to + 34%
Ammonia	- 31% to + 68%
Dissolved Oxygen	- 6% to + 9%

A site with a true 95-percentile BOD of 4.2 mg/l would appear to be in Class B because 4.2 lies between the Class limits of 3 and 5 mg/l. However, this site will generally have, with 36 samples, a confidence interval which is even wider than the Class boundaries of Class B. Thus it is not possible to be certain that the river is really in Class B. Typically, it may have the following probabilities of being classified:

A: 1%	B: 82%	C: 17%

Thus, there is a chance of 18% of wrongly reporting the Class.

This error is worse if there is a need to detect change. In the first period, the percentile might actually be in Class B but the probability calculations might typically show (using the above example but merging A and B for simplicity):

Probability of B	83%
Probability of C	17%

which is taken as Class B. In the next period, the data could give a result that suggests:

Probability of B	40%
Probability of C	60%

which suggests Class C. Over the two periods this looks like a downgrading from B to C, but the range of possibilities is:

From B to C	50%
From B to B	33%
From C to C	10%
From C to B	7%

So there is a strong possibility, 50%, that the reported deterioration from B to C did not really happen. There is a small chance, 7%, that quality actually improved (but was recorded as a downgrading).

The practical consequence of these effects is that the reported Class can change randomly back and forth, every year or so. The effect on a large number of sites can be calculated by a **CL**ass **A**llocation Model, CLAM [2]. The results are given in Tables A4.1 and A4.2.

Table A4.1: Errors in Classification

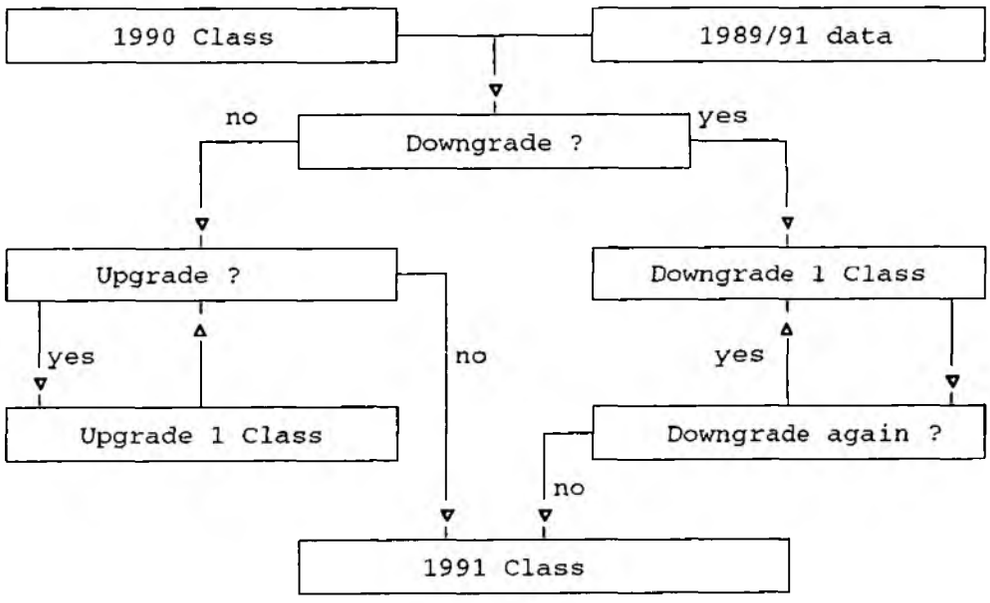
Total number of assessments = 10,000 Number placed in wrong Class = 20%					
BREAKDOWN OF ERRORS					
True Class	Assigned Class				
	A	B	C	D	E
A	1136	82	0	0	0
B	496	3649	623	1	0
C	0	234	2022	330	0
D	0	0	107	1102	168
E	0	0	0	6	45

Table A4.2: Error in Detecting Change of Class

Total number of assessments = 10,000					
Number of wrong declarations that the Class has changed = 29%					
BREAKDOWN OF ERRORS					
Class in Period One	- Class in Period Two -				
	A	B	C	D	E
A	1232	374	6	0	0
B	411	2955	622	4	0
C	9	608	1823	316	0
D	0	2	295	1000	111
E	0	0	1	149	82

To control these errors it is necessary to use standard statistical techniques for assessing whether Class has changed [1]. The procedure is outlined in Figure 1.

Figure 1: Assessing Change of Class



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2. Warn, A. E. Class Allocation Model. National Rivers Authority Report. Anglian Region, 1990.

GLOSSARY OF TERMS

Algae

Simple plants which may be microscopic, or very large plants but which lack true stems, all of which are capable of photosynthesis. Algae occur in water and are often discussed in the context of Eutrophication (ibid).

Ammonia

A chemical found in water, often as the result of discharge of sewage effluents. High levels of ammonia affect fisheries and abstractions for potable water supply.

Aquifer

Layers of underground porous rock which contain water and allow water to flow through them.

Benthic

Pertaining to the bed of a river, lake, or the sea, etc.

BOD and BOD (ATU) - Biochemical Oxygen Demand

A measure of the amount of oxygen consumed in water, usually as a result of organic pollution. The simple BOD value can be misleading because much more oxygen is taken up by ammonia in the test than in the natural water. This effect is suppressed by adding a chemical (allylthiourea) to the sample of water taken for testing, hence, BOD (ATU). Without ATU, the BOD is "uninhibited".

Biological Classification

A way of placing waters in categories according to the status of biological communities. Data on macro-invertebrates are particularly useful for this purpose.

Biota

The total flora (plants) and fauna (animals).

Catchment Management Plans

Integrated plans for a catchment which cover all the functions of the NRA. These Plans will provide the strategy by which the catchments will be managed. They will also provide a vehicle for consulting on SWQOs.

Carbon tetrachloride

An organic solvent commonly used as a dry-cleaning agent; a Dangerous Substance (ibid).

Chemical Classification

A way of placing waters in categories according to assessments of water quality, based on measurements of the levels of particular chemicals in the water (especially BOD, dissolved oxygen and ammonia).

Chloroform

An organic solvent commonly used throughout industry, a Dangerous Substance (ibid).

Competent Authority

An organisation designated by the Government as being responsible for the implementation or operation of a Directive.

Compliance Assessment

A procedure applied to the results of a monitoring programme to determine whether or not a water has met its agreed Quality Standards.

Consent

A statutory document issued by the NRA to indicate any limits and conditions on the discharge of an effluent to a controlled water.

Controlled Waters

All rivers, lakes, groundwaters, estuaries and coastal waters to three nautical miles from the shore.

Cyprinid Fish

Coarse fish like roach, dace and bream.

Dangerous Substances

Substances defined by the European Commission as in need of special control because of their toxicity, bioaccumulation and persistence. The substances are classified as List I or List II (ibid) according to the EC Dangerous Substances Directive.

Diatom

Microscopic unicellular algae (ibid).

Directive

A type of legislation issued by the European Community which is binding on Member States in terms of the results to be achieved.

Dissolved Oxygen

The amount of oxygen dissolved in water. Oxygen is vital for life so this measurement is an important, but highly variable, indicator of the 'health' of a water; it is used to classify waters.

DDT

An abbreviation for Dichloro-diphenyl-tetrachloroethane. This is a persistent pesticide no longer approved for use in the United Kingdom, and classified as a Dangerous Substance (ibid).

Determinand

A general name for a characteristic or aspect of water quality; usually a feature which can be described numerically as a result of scientific measurement.

Drins

The abbreviated name for a group of persistent insecticides, including Aldrin, Dieldrin and Isodrin; Dangerous Substances (ibid).

EC Class

A composite of all the standards from EC Directives which apply to a stretch of water. If all relevant Directive standards are met the water passes its EC Class.

EIFAC

An acronym for the European Inland Fisheries Advisory Commission.

Eutrophic

A description of water which is rich in nutrients. At worst, such waters are sometimes beset with unsightly growths of algae (ibid).

Faecal Bacteria

Bacteria found in the human gut; used as an indicator of pollution by sewage.

Groundwater

Underground water especially in or from aquifers (ibid).

Hexachlorobenzene

A fungicide which was commonly used for treating cereal crops; a Dangerous Substance (ibid).

Hexachlorobutadiene

An intermediary compound commonly used in the plastics industry; a Dangerous Substance (ibid).

Invertebrates

Animals which lack a vertebral column; a group of animals used for Biological Classification (ibid).

List I Substances

Dangerous Substances (ibid) which are particularly hazardous on account of their toxicity, bioaccumulation potential, and persistence, and in need of special controls. Standards are set by the European Commission.

List II Substances

Dangerous Substances (ibid) which are less hazardous than List I (ibid) and which are controlled by water quality standards defined by individual Member States (ibid).

Macro-invertebrates

Invertebrate (ibid) animals of sufficient size to be retained in a net with a specified mesh size; a group of animals used for Biological Classification (ibid).

Member States

Countries which are part of the European Community.

Mesotrophic
Pertaining to moderate enrichment by nutrients.

NNR
National Nature Reserve.

NWC Class
A summary of the quality of river water based largely on the measured chemical quality for the purposes of classification and reporting; originally devised by the National Water Council.

95-percentile
A level of water quality, usually a concentration, which is exceeded for 5-percent of the time.

95-percentile Standard
A level of water quality, usually a concentration, which must be achieved for at least 95-percent of the time.

Nutrient
A chemical essential for life. If present in excess concentration, nutrients can produce the effects of eutrophication (ibid)by promoting algal growth.

Oligotrophic
Pertaining to low nutrition; waters which are relatively low in nutrients.

PCBs
Polychlorinated Biphenyls. These substances were widely used in the manufacture of electrical insulators; Dangerous Substances (ibid).

PCTs
Polychlorinated Triphenyls. These substances were widely used in the manufacture of electrical insulators; Dangerous substances (ibid).

Pentachlorophenol
An organochlorine fungicide, used primarily for timber preservation; a Dangerous Substance (ibid).

Percentile
In this report, a level of water quality, usually a concentration, which is exceeded for a set percentage of the time; hence, 95-percentile (ibid).

Phytoplankton
The microscopic forms of drifting or floating plant life found in seas, rivers and lakes etc.

Quality Objective
The level of water quality that a body of water should achieve, in order to be suitable for its agreed uses.

Quality Standard

A level of a substance or any calculated value of a measure of water quality, which must be met in order to protect a given use of a water body. The standard is expressed as a pairing of a specific concentration or level of a substance with a summary statistic such as a percentile (ibid) or a maximum.

RIVPACS

River Invertebrate Predication and Classification System. A computer-based model used to predict the status of invertebrate communities in a river relative to certain natural physical and chemical properties; used to calculate the Ecological Quality Index.

Salmonid Fish

Game fish, eg trout and salmon.

SSSI

An abbreviation for a Site of Special Scientific Interest. A site given a statutory designation by English Nature or the Countryside Council for Wales because it is particularly important, on account of its nature conservation value.

Statistically Significant

A description of a conclusion which has been reached after making proper allowance for the effects of random chance.

Statutory Water Quality Objective

A Quality Objective to be given a statutory basis by a notice service on the NRA in accordance with the procedures in Section 105 of the 1989 Water Act.

General Classification

A classification of water quality designed to be used as a measure of absolute quality and to monitor change.

Trophic

Pertaining to nutrition and feeding. The trophic state of a water is its status with respect to the level of nutrients. Hence eutrophic, mesotrophic and oligotrophic (ibid).

Use-related Class

A composite of all the standards needed to protect all the Uses which apply to a stretch of water. If all the standards are met the water passes its Use-related Class.

NRA

National Rivers Authority