UK Technical Advisory Group

on the Water Framework Directive

UK ENVIRONMENTAL STANDARDS AND CONDITIONS (PHASE 2)

Final

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SECTION 1 – INTRODUCTION

The UK Technical Advisory Group on the Water Framework Directive (UKTAG) is developing environmental standards[1] and conditions to underpin the implementation of the Directive. The UKTAG is a working group of experts drawn from environment agencies and conservation agencies[2].

The UKTAG provides technical advice to the UK's government administrations and the member agencies of the UKTAG. The UKTAG also includes representatives from the Republic of Ireland.

A technical report on proposals for a first set of standards and conditions was published for review in 2006 [1]. The revised report was issued in August 2006 in the form of a recommendation to the UK governments[3]. The UKTAG updated the report in November 2007[4]. Sections in that report on nutrients in lakes and coastal waters were removed. The updated sections are in this present report.

This document is the UKTAG's proposals for a second set of standards and conditions. This too defines environmental conditions that the UKTAG views as supporting healthy communities of aquatic plants and animals. The standards and conditions will help focus efforts to protect the water environment.

(The UKTAG is preparing advice on the classification of water bodies and how such classification makes use of all the standards and conditions that are established for water bodies).

This report covers standards and management approaches for temperature, nutrients and suspended solids. It also proposes a system for assessing the impact of changes to freshwater flows to estuaries[5] and the effect of managed flows, such as the releases to rivers from impoundments. The report also proposes a system for assessing the structure or condition of the beds and banks[6] of lakes, estuaries and coastal waters.

The UKTAG expects that the standards and conditions will be used to help develop policy, and to guide the Directive's first cycle of river basin management plans. Similarly, as understanding improves, the standards and conditions will be revised.

As part of the technical review of the proposals, the UKTAG welcomes your comments via its website: www.wfduk.org/stakeholders_reviews.

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[1] These encompass the words in Annex V of the Directive - values, concentrations and Environmental Quality Standards.

[2] Countryside Council for Wales (CCW), Natural England (NE), Environment Agency (England and Wales), Environment and Heritage Service (Northern Ireland) (EHS), Joint Nature Conservation Committee (JNCC), Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH), Republic of Ireland's Department of Environment Heritage and Local Government (DEHLG).

[3] The first report can be accessed from the UKTAG website http://www.wfduk.org/UK_Environmental_Standards/

[4] The UKTAG updated this first set of standards by adding criteria that would help sub-divide waters that are reported as less than good status under the Water Framework Directive. This will be published as a revision of the 2006 report.

[5] The Water Framework Directive refers to these as transitional waters.

[6] Morphology.

The UKTAG has taken your comments into account in producing this final report. The report will be sent as advice to Defra, to the administrations of the devolved governments, and to the environment and conservation agencies.

The approach to the adoption and implementation of proposals might vary for each country within the UK, depending on present and proposed legislation, and on policy in each country. This is for Ministers to decide; it is subject to the normal policy-making considerations of the administrations and their agencies. Some of these agencies have been designated as competent authorities under the legislation that transposed the Directive into UK law.

Scope of the report

New standards and conditions are being developed in stages. This is because, in some cases, progress depends on the completion of classification schemes, or on European negotiations.

This report sets out the second set of proposals by the UKTAG to support good ecological status[1]. Table 1 summarises the proposals in this report along with those made in August 2006.

(Two additional reports have been released for stakeholder review alongside this report; the UKTAG report on what the Directive calls Specific Pollutants and a report on classification schemes for groundwater).

There are also standards that will be important for the Water Framework Directive but which are beyond the scope of the work of the UKTAG. These cover pollutants that have been identified by the European Union as Priority Substances. Standards for these are being developed at the European level.

Also outside the scope of this report are the procedures associated with protected areas[2] identified under other European water legislation. As discussed later in this report these may require different standards and conditions from those proposed in this report.

The report does not address the details of the regimes for monitoring, for assessing compliance and for using the standards to take decisions. These are matters for the individual countries within the processes for achieving the overall requirements of the Directive. But, as discussed later, the UKTAG has defined standards whose form matches the technical requirements of these activities and their consistent application.

Environmental objectives and standards in the Water Framework Directive

The Water Framework Directive[3] sets out objectives for the water environment. These include the default objectives[4]:

- prevent deterioration of the status of all surface water and groundwater bodies;
- protect, enhance and restore all bodies of surface water and groundwater with the aim of achieving good status for surface water and groundwater by 2015.

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[1] This report concentrates on the boundary between good and moderate status. Where possible, the UKTAG also makes proposals for the boundary between high and good status, and those between moderate and poor, and poor and bad.

[2] The protected areas include, for example, Bathing Waters (under the Bathing Water Directive) and Special Areas of Conservation (under the Habitats and Birds Directives). Standards and procedures for protected areas are already set for the legislation establishing the protected areas, or they are being derived through separate processes.

[3] 2000/60/EC

[4] Article 4(1) of the Directive sets out its objectives for the water environment including those not set out above. When the UKTAG refers to objectives in this report, it refers to these default objectives listed above.

Table 1: Environmental standards and conditions – this and the UKTAG's previous report			
Environmental condition	**Category**	**2006: final proposals**	**2007: final proposals**
Surface water – supporting conditions			
General water quality (General physico-chemical quality elements)	Rivers	• Biochemical Oxygen Demand and Dissolved Oxygen, Ammonia • pH • Nutrient: phosphorus	• Temperature • Suspended solids
	Lakes	• Dissolved oxygen • Salinity • Acidification • Nutrient: phosphorus	• Temperature • Suspended solids • Update phosphorus
	Estuaries and Coastal	• Dissolved Oxygen • Nutrient: nitrogen	• Temperature • Suspended solids • Update for nitrogen
Water Resources Water flow and water levels	Rivers	• Change from natural flow conditions	• Managed flows
	Lakes	• Change in the outflow from the lake	
	Estuaries and coastal		• Freshwater flow to estuaries
Physical structure and condition of the bed, banks and shores (morphological quality elements)	Rivers	• Type and degree of physical alteration	
	Lakes		• Type and degree of physical alteration
	Estuaries and coastal		
Chemical pollutants			
Toxic pollutants (Specific Pollutants)	Rivers, lakes, estuaries and coastal		• Standards for pollutants discharged in significant quantities
Groundwater			
Water balance and water levels	Groundwater		• Groundwater classification system
Water quality			

Alternative objectives

The UK does not always have to achieve the Directive's default objective of good status by 2015. Alternative objectives can be set if, for example, the measures required to achieve good status by 2015 would be technically infeasible or disproportionately expensive[1]. In such a case, the Directive allows an extension to the timetable for achieving good status by up to 12 years, or an objective that is less stringent than good status.

[1] The circumstances under which these alternative objectives may be used is outlined in UKTAG guidance 13c 'Draft principles for an objective setting framework for river basin management planning in accordance with the Water Framework Directive' (refer: http://www.wfduk.org/tag_guidance/Article%20_11/POMObjectivesetting/WFD13cObjectivesetting) and also in the European guidance on objective setting (refer: http://ec.europa.eu/environment/water/water-framework/objectives.html).

Note that:

1. alternative objectives cannot be set without first assessing the measures that might be needed to achieve good status by 2015;

2. the standards and conditions that are proposed in this report will not, alone, determine the costs of implementation, because the cost depends on the process of setting objectives and the measures available and adopted for achieving them.

This differs from other water directives. Most of these specify environmental standards or emission standards but provide little flexibility to set other objectives. The Water Framework Directive allows an approach that is more firmly based on risk, and where action can be taken in proportion to what it can achieve and what it will cost.

Biology and setting standards

The UK environment agencies have been developing biological methods and associated standards alongside environmental standards that describe the ecology. This has focused on identifying the relationship between the biology and the pressures on the environment.

The environmental standards in this report have been checked against the emerging biological methods. For example, phosphorus standards for lakes were checked against biological and chemical data on sites across the UK. Similarly, the UKTAG is checking its proposals against the European exercise known as intercalibration[1]. This focuses on biological data.

The research reports that outline the biological methods will be placed on the UKTAG web-site, as they become available.

If biological monitoring over the first river basin planning cycle shows that the environmental standards do not protect the aquatic flora and fauna, or that they are too strict, the reasons will be investigated and, as necessary, new standards will be proposed in line with options permitted by the Directive.

Role of standards in taking action

The environment agencies need environmental standards and conditions in order to work out, for example, how much water can be abstracted, or how much of a pollutant can enter the environment, without causing harm to the communities of aquatic plants and animals[2] - harm that would compromise the achievement of the Directive's default objectives.

[1] Intercalibration is discussed at page 15 in this report

[2] This is in addition to any established standards needed to protect other uses of water. These may be seen as part of the Water Framework Directive and this footnote then serves only as a reminder that such standards are applied. The standards cover, for example, the established requirements for drinking water and spray irrigation.

For example: suppose that for good status a particular chemical in river water should be less than an annual average concentration of 20 milligrams per litre. The UK agencies might monitor the concentration of the chemical in the water and find that run-off from land had raised it to an annual average of 31 milligrams per litre. Their assessment would be that there is a significant risk to plants and animals. To restore the water body to conditions that are consistent with good status, they would aim to reduce the annual average in the water to 20 milligrams per litre.

Similarly there might be a standard for water resources that applies to a river when flows are low. This might suggest that no more than 10 per cent of such flows are abstracted.

Use of standards and conditions in decision making

There are at least two distinct ways by which environmental standards are used to make decisions. An important consideration in using standards is to specify way the standards should be used.

Direct Model

This approach applies where there is confidence that compliance with the standard defines all that is needed from the activities that cause failure. There is no need, for example, to seek corroboration by looking at local biological data. An example of the Direct Model is setting numeric limits in discharge permits for ammonia, in order to meet a water quality standard for ammonia in a river [1]. In this report the Direct Model is suggested for some of the proposed standards for temperature.

Indirect Model

This applies where there is less confidence that simple failure of the standard is enough to judge the cause of damage or risk. We need supporting evidence.

In the Indirect Model we might propose the use of a checklist to confirm whether a water body is damaged or at risk. This checklist could include, for example, the absence of key species, or the occurrence of nuisance species.

As an example of the Indirect Method, a chemical standard is used to help decide when to designate sensitive areas under certain Directives[1]. Failure of the chemical standard is taken with other indicators, some biological, as confirming that action is needed. In this report the standards for lakes, transitional and coastal waters, and the condition limits[2] for water flow, water levels and morphology are proposed for use in Indirect Models[3]. In these Indirect models many of the details remain to be established through the processes of the Water Framework Directive.

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[1] For example under the Directive on Urban Waste Water Treatment

[2] In its reports, the UKTAG uses the term 'condition limits' to help make it clear that the criteria are not used in the same way as some of the 'environmental standards' developed, for example, for water quality. Condition limits are not used to define good status. They indicate a risk that good status is threatened.

[3] What is done in this regard in the classification of waters, and in taking decisions to improve a water body, will depend on the interpretation established for the "one out, all out" principle in Paragraph 1.4.2(i) of Annex V of the Directive

An advantage of the checklist approach is that it perpetuates the gathering of evidence on the link between ecology and standards for specific water bodies, and so helps in the development of better standards.

Whether or not the need to act is established through a Direct or Indirect Model the type of action may take at least two forms, depending on the confidence about cause and effect at particular locations, and the link between action and outcome. For example:

- calculating local and bespoke controls, in order to meet exactly the water quality standard in the river downstream;

- imposing general and uniform controls across all operators in a region of a certain type or size. This constitutes “a step in the right direction” that can be reviewed at the next opportunity. This type of control is used in the Directives on Nitrate and Urban Waste Water Treatment.

In this report the latter option is proposed for controls on nutrients.

Assessing compliance with standards

In some cases this involves using data from monitoring to make some form of comparison with the standard. In other cases it might involve calculations using models developed for and operated by the environment agencies. Nearly always these data or models will be associated with errors and uncertainty. The UKTAG requires that the errors be quantified, and proposes that and they be used to set up statements of confidence that a standard has been met or has been failed.

The Directive expects us to know and report these levels of confidence. Along with the other factors mentioned in Annex V of the Directive, they will be used to decide the amount of monitoring required to detect particular levels of failure or deterioration. The confidence that the standard has been failed will be considered when deciding what action to take under the Directive's programmes of measures[1].

Controls recommended within the Programmes of Measures and detailed within draft River Basin Management Plans will also be subject to regulatory impact assessment and strategic environmental assessment. This is likely, for example, to include the future costs of energy, the “costs of carbon” and other economic costs associated with sustainable development.

Existing and new standards

There is already a wide of range of standards in use, especially for water quality. These have either been drawn from other European directives, or developed independently at a country level. They inform the planning of protection and improvement of the environment by the environment agencies.

[1] Given that the standard applied will be that associated with the objectives that are eventually set. Uncertainty allows a lower objective to be applied, and hence different measures than might otherwise have been required

The level of protection for the environment provided by standards and procedures used in other directives will, after review, transfer to the Water Framework Directive either directly, or as the equivalent. The proposals for standards and conditions set out in this report would augment these to define some of the extra requirements of the Water Framework Directive.

The environment agencies already use standards to assess and control the impact of industry and land use, both urban and rural. They use environmental standards to assess where action might be needed, for example, by working out the controls they must impose on discharges in order to protect water quality.

The Water Framework Directive defines new targets for rivers, lakes, estuaries and coastal waters. The environmental standards must reflect these. As outlined above, the Directive requires that Member States protect the ecological status of surface water bodies from deterioration and, where necessary and proportionate, aim to restore them to good status. The standards and conditions proposed by the UKTAG will help work out what might need to be done.

In 2004, the UKTAG started a review designed to lead to standards and conditions to support good ecological status. The review covers rivers, lakes, estuaries and coastal waters and:

- water quality standards;
- conditions for water flow and water level;
- a framework to support decisions about the structure and condition of beds, banks and shores of water bodies (i.e. their morphology).

The review involved many of the UK's leading independent experts in ecology, hydrology, geomorphology and chemistry. The results of monitoring from thousands of sites across the UK, and scientific literature from around the world, have informed the process.

Classification

Classification is a way of reporting the state of the environment. If done properly it shows where the environment is good quality or otherwise. Classification provides a way of comparing waters and a way of looking at changes over time[1].

Classification schemes are being developed for the Water Framework Directive by the environment agencies across the UK. Surface water bodies will be assigned to one of the five ecological status classes: high; good; moderate; poor; or bad.

To classify water bodies, the UK agencies will monitor and assess the condition of plants and animal communities using the new methods of biological assessment. This monitoring started at the end of 2006. It will be some years before there is enough of this information to classify every water body with sufficient accuracy.

[1] The UKTAG expects that classification will indicate the national or regional trend to say Good Status but that trends in the summary statistics used to define class boundaries will be powerful additional information.

Certain water uses, such as navigation, flood defence and the generation of hydropower, might depend on substantial physical alterations to a water body. These might be incompatible with the achievement of good status. Where appropriate, such waters can be defined under the Directive as heavily modified. Objectives can be set for them that can be achieved without significantly affecting the identified use. Each such heavily modified water body[1] will be assigned to one of the five classes of ecological potential: maximum; good; moderate; poor; or bad – as required by the Directive.

For surface water bodies, the achievement of relevant environmental standards will be taken into account, along with the results of biological monitoring, in deciding the status class. For example, if a water quality standard identified for good status is not met, the water body will be moderate or worse. For a water body to be high status, it must meet all the environmental standards and conditions associated with high status – water quality; water flow; water levels; and the requirements for morphology.

Checking procedure

It may not always be possible, with current knowledge, to identify standards or conditions that would not be over or under protective in some situations. To reduce this risk over time, European guidance proposes that Member States assess mismatches between the monitoring for biological quality and the physico-chemical quality elements. This is called a "checking procedure". If such assessments indicate that a standard or condition is too lax or too stringent, Member States must revise them.

It might be that as a result of this "checking procedure", some standards used as discussed above in the context of an Indirect Model, can be replaced eventually by standards that can be used in a Direct Model. By this we mean that failure of the new standard can be taken as sufficient evidence of the requirement to take strong action to protect a water body, in the absence of corroborative evidence from biology for that water body. It may then be possible that uniform controls across a catchment can be replaced with specific actions at particular sites that have been calculated precisely to achieve the standard in the water body[2].

The first results of classification will be published in the first river basin management plans. These must be finished in 2009. These classifications will be based on only two years of monitoring, and will therefore provide only an initial view.

The environment agencies will use the results of classification to review the pressures and impacts on water bodies. This must be completed by 2013. It will provide the basis for the second cycle of river basin management plans. The second plans must be finished in 2015.

Further information on classification is on the UKTAG's website: www.wfduk.org[3].

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[1] And any waters designated as an artificial water body under the Directive.

[2] But the UKTAG doubts that this would lead us to suggest changes in the approaches recommended, for example, for nutrients. There are statistical difficulties in applying the "checking procedure" to individual waters and for groups of water bodies the results will probably match the data that led to the standard in the first place.

[3] TAG PAPER WP 11a (i) provides an overview of the classification schemes for surface waters and groundwaters that are needed for river basin planning.

Ecological status

The Water Framework Directive provides, in the 'normative' definitions of Annex V, a description of high, good, moderate, poor and bad ecological status. Each describes a different degree of impact on the plants and animals.

For example, for high status: *there are no, or only very minor, anthropogenic alterations to the values of the physicochemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions*. *The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion.*

And for good status: *the values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions*.

We are required to use these descriptions to set out what each class means in biological terms. For example, we might specify the number of different groups of species expected in a river of good status. To do this, the UKTAG is developing new methods for assessing biology. Some of these, such as one for the assessment of invertebrates in rivers, are built on methods that have been used for many years[1].

Such methods have meant that in some cases the UKTAG, and particularly for its first report, could take data previously collected from hundreds or thousands of sites across the UK and use them to develop new methods. Where this has been possible, the UKTAG has also looked for corresponding information on the environmental conditions to which the plants and animals are most sensitive. This has helped identify standards that correspond to sites that match the current view of good status.

For example, the UKTAG based the standards proposed in this report for phosphorus in lakes on sites that have good status for plant communities[2].

In other cases, in estuaries and coastal waters for example, and generally for pollutants not subject to national programmes of monitoring, there are insufficient data to derive standards in this way. Instead, the UKTAG has used the most up-to-date scientific understanding of the causes of ecological change.

The UKTAG has then compared this understanding with the Directive's descriptions of the condition of plants and animals in the different status classes. In doing this, the UKTAG has relied on advice from leading independent experts from a range of scientific disciplines.

The UKTAG has used the latter approach to identify condition limits for water flow and water levels, and to set up its proposed frameworks and condition limits for morphology.

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[1] The established approach for reporting river quality for invertebrates – RIVPACS (River InVertebrate Prediction and Classification System).

[2] In terms of diatoms.

In doing all this the UKTAG is required to seek out information that leads to standards that can apply generally to water bodies of the same type; standards that can lead to monitoring programmes and unbiased estimates of compliance; to the classification of water bodies; and so help take decisions improve and protect the environment.

Standards and protected areas

The procedures associated with protected areas identified under other European water legislation are outside the scope of this report. The UKTAG is developing guidance for protected areas.

Ecological status for water bodies under the Water Framework Directive needs to be interpreted separately from those standards and objectives set under the relevant source legislation for the protected areas. Article 4(1c) of the Water Framework Directive, states that member states are required to achieve compliance with those standards and objectives specified in the community legislation under which the individual protected areas have been established. Where a water body has more than one objective, the most stringent applies.

Comparisons with other Member States

All Member States[1] are also attempting to quantify what the Directive means by good status. The UK has been working with these countries, and with the European Commission, to compare methods of biological assessment and classification. This is a formal process known as intercalibration.

The aim of intercalibration is to ensure that the boundaries for good status given by each country's biological methods are consistent with the Directive's descriptions of good status. Because of constraints on data, the first exercise considers only a limited number of the groups of plants and animals included in the Directive's descriptions of good status. It will also consider the effects of only a limited range of environmental pressures.

For example, intercalibration is not expected to produce harmonised class boundaries for methods of biological classification that are sensitive to the impact of man-made alterations to water flows, water levels or morphology. Work has started on research but this will not inform the development of the UKTAG's proposals for the first river basin planning cycle.

The UK has taken an active role in intercalibration. For example, the UK has helped develop EU guidance on:

- the process of intercalibration;
- the protocol for deriving biological class boundaries;
- the interpretation of class boundaries.

[1] And Norway

River basin management plans

The UK environment agencies are required to produce the first draft river basin management plans for public consultation by the end of 2008. These plans must set out the objectives considered appropriate for each water body and, where this objective is less than to achieve good status by 2015, the reasons for this adopting this objective[1].

To prepare these plans, the environment agencies will estimate the shortfall in meeting the standards and conditions that are associated with good status. The UK must do this for all the water bodies identified at risk of failing good status. The environment agencies will often need to do more monitoring and assessment, targeted at the water bodies at risk, and focused on the reasons for these risks.

They will then have to calculate by how much the pressures on each water body at risk would have to be reduced to achieve the standards.

It is an important aspect of the Directive, in making decisions on which measures are required, is that all the causes of failure are considered. This will mean looking in an integrated way at water quality, water quantity, and the impact of man-made structures. It will involve checking the contributions from groundwater to the failure of surface water standards. The agencies will look at the impact of physical changes to water bodies, and at the impact of present and future abstractions.

The environment agencies, in partnership with others, will appraise options to meet the objectives, and identify the most cost-effective combinations of measures.

For many activities that could harm the water environment, there is an option to control them through licences or permits. All significant point source discharges and abstractions, are, and will be, subject to such controls. For pressures for which this option is unavailable, such as some aspects of land use that give rise to diffuse pollution, the environment agencies will use standards and conditions to work out the level of change to these activities needed to contribute to achieving good status.

The Directive's provisions for setting objectives allow environmental improvements to be phased over the cycles of river basin management plans, whilst enabling sustainable uses of the water environment to continue. This report has mentioned above the Directive's process for setting alternative objectives.

Protecting the environment from deterioration

The existence of a standard does not necessarily mean, for example, that a new discharge will be allowed to cause a pollutant in a water body to increase up to the limit defined by the environmental standard. This would place the water body at risk of deterioration from its present status.

[1] As discussed above for alternative objectives (8)

The environment agencies will continue to control developments and growth in a way that manages the risk of deterioration of status[1] and ensures that sustainable uses of the environment can continue. They will assess the effectiveness of their efforts through the classification of water bodies, and by calculating the impacts of changes in terms of movement within classes.

Revising the standards

The UKTAG believes that the proposals in this report are based on the best assessment possible, given the current scientific understanding, the particular requirements of the Directive for standards, and the demands of the Directive's timetables. This report aims to advise the UK administrations on the standards and conditions that the environment agencies should use for the first river basin management plans.

A small number of the proposals may be reviewed in the short term as a result of the current round of intercalibration. Most standards will be subject to review over the longer term. The agencies will revise the standards if understanding improves as a result of:

- the application over the next few years, to a large number of water bodies, of the new methods of biological classification. This is part of the monitoring for the Directive;
- research;
- information from other countries in future rounds of intercalibration;
- the collation of new data across the international river basin districts on the island of Ireland. The application of some of the standards in Ireland and Northern Ireland[2] may be subject to further harmonisation as standards are developed in the Republic of Ireland.

The UKTAG anticipates that this review will be done in 2012. This will mean that the environment agencies can use the results of the review for the second river basin management plans[3]. These will be published in 2015.

[1] This is explained more fully in TAG guidance: *UKTAG (2006) WP 13e) Prevent Deterioration of Status.*
[2] Ecoregion 17 under the Water Framework Directive
[3] For more information on how standards will be used, refer to: Water Framework Directive (WFD): Note from the UK administrations on the development of environmental standards and conditions.

SECTION 2 – PROPOSED STANDARDS AND CONDITIONS

Technical details providing more detailed information on the standards and conditions outlined in this report are in background documents. A list of some of these is at the back of this report.

These and other documents are available on the UKTAG's website. They describe where leading experts have contributed, and where the UKTAG has compared methods with best practice in the UK and Europe. The reports show how work across Europe and in the UK might bring changes. They also contain details of research within the UKTAG and the agencies that has not been included at this time. The UKTAG will update these reports as knowledge improves.

General approach for standards to support biology

The UKTAG set out to develop standards that mean that plant and animal communities are protected if compliance is achieved. We require standards by which the regulatory action needed to achieve the standards can be determined properly. For this the UKTAG aimed to express standards as ideal standards[1].

There are different groups of surface water standards and conditions. These are:

- **physico-chemical :** numeric values have been developed which are matched to biology;
- **hydrological:** a decision framework using best available knowledge supported by condition limits;
- **morphological:** a decision framework using best available knowledge supported by condition limits.

The UKTAG proposals for water flow, water level and morphology reflect that the science linking pressures to an impact on biology is limited. "Condition limits" are therefore proposed. They indicate a risk that good status is threatened whereas environmental standards indicate a risk that good status is failed.

Table 2 gives a summary of the proposals for this report indicating whether the proposal is a standard or a condition limit.

[1] We mean “ideal” in the context of being able to make a sound and correct assessment of compliance as intended by the 1997 Royal Commission on Environmental Standards [2]. It does not necessarily mean that the standard is “ideal” in terms of getting a perfect match between the value of the standard and the risk of damage. That depends on the derivation of the standard. Once a standard has been derived it is then necessary to express it as a “ideal” standard in order to assess compliance properly and in order to calculate the action needed to secure compliance.

Table 2: Phase 2 proposals – standards and conditions		
Environmental Condition	**Proposal**	**Standards or condition limits**
General water quality	Temperature	Standards
	Lake Phosphorus	Indirect standards
	Marine Nitrogen	Indirect standards
	Suspended Solids	Management approach (indirect standards)
Hydromorphology	Freshwater flow to estuaries	Condition limits (indirect standards)
	Management flow	Condition limits (indirect standards)
	Morphology of estuaries and coastal waters	Condition limits (indirect standards)
	Lake morphology	Condition limits (indirect standards)

Typology

Rivers, lakes, estuaries and other transitional and coastal waters were grouped[1] mainly on the basis of natural characteristics that might influence biological communities – altitude, latitude, longitude, geology and size. The method by which waters of similar ecological sensitivity are grouped into types for the Directive, is referred to as a typology[2].

Environmental standards for the Water Framework Directive will be type specific - different types of waters will have different standards. The UKTAG has found, in some cases and for present data, that it can propose a single standard for several or all types[3]. In other cases, the UKTAG has used a number of types. As we gain a better understanding of the environment through monitoring, and by applying these standards, the UKTAG expects to be able to refine and develop the typologies and so amend some of the standards.

[1] In accordance with Annex II of the Directive.

[2] The term, type, has particular meaning and use in the Directive. The Directive sees the ecology as determined by type and so seeks to characterise water bodies according to type.

[3] Where the UKTAG has combined types in this way it may appear that it has used less differentiation than required by Annex II - but the original analyses were at least as differentiated as required by Annex II.

TEMPERATURE

In this chapter the UKTAG proposes standards for use in for classification of rivers and in calculating the action needed achieve a target class for rivers. It is proposed that the values are not used for the classification of lakes, estuaries and coastal waters, but are used for these waters to calculate the action needed to achieve a target class, and for day-to-day operational control of discharges and abstractions [3].

Water temperature has an influence on aquatic species. The effects can be seen in their growth and development, how they tolerate and metabolise toxic substances, success in reproduction, in resistance to disease and, ultimately, whether they survive or die.

Temperature can also have an indirect effect on aquatic species by causing changes to water chemistry, and by its effect on the solubility and metabolic consumption of oxygen.

Aquatic species prefer particular ranges of temperature and have some capacity to adapt to change. Water temperatures are influenced by sunshine and shade, the temperature of the air, the shape of the channel, and the velocity and depth of the water. Temperature is also affected by discharges of effluents, by abstractions, and by changes in land-use.

In rivers, summer temperatures generally increase from headwater to estuary. Vertical differences are found in lakes and estuaries. Variations are also associated with tides and seasons. By 2050, mean annual temperatures may increase by 1-2ºC because of climate change. Over the next century surface temperatures of the sea are forecast to rise by 0.5 to 4ºC.

Present monitoring

The monitoring of temperature is usually based on spot measurements taken, for convenience, at the same time as routine chemical samples. Typically these are monthly samples. This regime gives estimates of summary statistics such as the annual mean and annual percentiles, and, especially through pooled data, the shape of the statistical distributions underlying these summary statistics.

Standards set in the form of such summary statistics work on the expectation that the achievement of them through regulatory action reduces to acceptable levels the risk from rarer peaks of temperature.

In some cases where there are regular threats, say from low dissolved oxygen, temperature is measured continuously as part of the control regime. These cases include locations such as abstractions for drinking water, and waters requiring real-time control of the effects of storm sewage[1]. These data also help define the more detailed variability within the statistical distributions of temperature, including the bias that can arise with spot measurements taken only in office hours.

[1] For example, downstream of large conurbations.

Typologies

A single typology has been developed for all surface waters and is presented in Table 6. This was derived from the review for rivers, lakes, estuaries and coastal waters. The background is set out below.

River Typology

The typology selected for was developed from that for the general effects of water quality on fish communities. It is summarised in Table 3 along with the labels used later in this report[4].

Table 3: River typology based on fish community

Type and label	Key species	Complementary species	Abundance / comments
R1	Brown trout	Salmon Bullhead	Very high abundance of trout
R2	Salmon Brown trout	Bullhead Stone loach	Very high abundance of salmon
R3	Brown trout	Eel Bullhead Stone loach	Very high abundances of minor species and high abundance of trout
R4	Brown trout Eel	Lamprey Flounder	Relatively high abundance of diadromous species plus some coastal species
R5	Barbel Chub	Grayling Stone loach	Relatively high abundance of barbel, indicative of main river stem of large rivers
R6	Roach Bream	Gudgeon; chub; dace; perch	Relatively high abundances of common cyprinid species
R7	Pike Bleak	Roach	Presence of bleak and relatively high abundances of pike and bream indicative of larger lowland rivers
R8	Salmon Grayling	Brown trout Pike	Relatively high abundances of grayling, salmon and pike. Constitutes sites from Hampshire chalk rivers Test and Itchen

Lake typology

The UKTAG has proposed lake types that are based on key fish species present (Table 4).

Table 4: Lake types for temperature		
Type and label	Key species	Complementary Species
L1	Charr; vendace; powan	Brown trout
L2	Brown trout; salmon	Eel
L3	Bream; roach	Perch, pike

Typology for temperature

The types for rivers and lakes were grouped and condensed according to the temperature preferences of fish species. Two categories were distinguished: cool-water (formerly 'salmonid') and warm-water (formerly 'cyprinid'). This suggests that the groupings for the Freshwater Fish Directive remain adequate.

This condensed typology for rivers and lakes was then compared with fish species for transitional waters and coastal waters. It was identified that all the types fall into the "cool water" group.

Table 5 indicates the grouping and gives the final typology, using the labels defined in Tables 3 and 4.

Table 5: Final temperature water body typology	
Cool water	R1, R2, R3, R4, R8, L1, L2, TW1-6[1], CW1-12[2].
Warm water	R5, R6, R7, L3

Existing standards – Freshwater Fish Directive

The Freshwater Fish Directive requires that designated stretches of fresh water (rivers, lakes and reservoirs) meet standards that enable fish to live and breed. The standards have sometimes been applied to transitional waters in the absence of more suitable standards.

The Directive identifies two categories of water: those suitable for salmonid fish and those for cyprinid fish. It also distinguishes 'Imperative Standards', which must be met in order to comply with the Directive, from 'Guideline Standards' which should be met 'where possible'. Table 6 shows the Imperative Standards for temperature. There are no Guideline Standards for temperature.

[1] See Tables 25 and 38 for a description of the types.
[2] The typology for coastal waters is based on Section 1.2.4, Annex 5 (System B), of the Water Framework Directive.

There is an additional temperature standard of 10ºC for salmonid waters during the spawning season. This seeks to protect species that need cold water for reproduction. A provision is also made that sudden variations in temperature should be avoided. A key aspect of the standards for temperature is that they apply where there are thermal discharges, and they are not used generally in assessing all waters.

Table 6: Imperative Standards from the Freshwater Fish Directive	
The temperature measured downstream of a point of thermal discharge (at the edge of the mixing zone) must not exceed the unaffected temperature by more than the following: Salmonid: 1.5 ºC Cyprinid: 3 ºC	Caveat: sudden variations in temperature should be avoided
The following temperatures should not be exceeded at the edge of the mixing zone, for more than 2 per cent of the time: Salmonid: 21.5 ºC Cyprinid: 28 ºC	Caveat: species that require cold water for reproduction are protected by an upper limit of 10ºC during the breeding season

Member States may decide derogations, limited in geographical scope, if the competent authority can prove that there are no harmful consequences for the balanced development of the fish population[1].

Existing standards – Shellfish Waters Directive

Member States are required to designate areas of coastal waters needing protection or improvement in order to support shellfish. The Directive's 2ºC limit for a rise in temperature has sometimes been adopted as a standard for marine waters generally, although it is a Guideline value only, for shellfish waters designated under the Directive. The Directive sets no Imperative value for temperature.

Environment agencies are under an obligation to endeavour to observe the guideline value, as well as a principle of no increased pollution.

In the particular procedure used for Review of Consents[2] for the Habitats Directive an interim 2^{o}C uplift standard was adopted for marine Special Protection Areas and marine Special Areas of Conservation designated under the Habitats Directive.

[1] There have been applications for derogations for Scotland.

[2] This took place in England and Wales. Although the title of the review includes the term "consents", it included other permits and abstraction licences.

In this way, a Guideline Standard might be used as part of the preliminary assessments, for example, of the impact of a new discharge to a pristine stretch of water. The UKTAG proposes that this use of Guideline Standards continues for transitional and coastal waters, but that such standards are not used for classification of water bodies under the Water Framework Directive. (This is discussed below).

The power industry has pointed to the natural establishment and continued development of clam and oyster beds in transitional waters around the outfalls from power stations although temperature increases greater than 2ºC are routinely observed.

Normative definitions for communities of fish

In developing standards for the Water Framework Directive, the UKTAG used the Directive's definition of classes. This is described in Table 7.

Table 7: Summary of normative definitions for communities of fish	
High	The expected fish species are present and their abundance is consistent with undisturbed conditions.
Good	There are slight deviations in the expected abundance of species, or the expected community structure for example, age class; some ages classes may be under-represented.
Moderate	There is moderate disturbance, some of the expected species are absent or present in reduced abundance.
Poor	The communities deviate substantially from those normally associated with the water body. Key species may be absent.

Derivation of standards for temperature for the Water Framework Directive

In its first report, the approach of the UKTAG to standards in rivers for ammonia and phosphorus was based on the analysis of thousands of pairs of data on chemistry and biology. This option is not available in this case because the adverse effects of temperature on biology are rare, and tend to be mixed with the effects of other pressures. This means that it we cannot isolate pairs of data on temperature on biology for this kind of analysis.

The UKTAG's review of standards, and of the temperature requirements for fish species, was carried out by searching the literature and the Internet, and by correspondence with international specialists. The review has focused on fish. Macroinvertebrates are being investigated more fully by the PRINCE project [5]. The UKTAG has reviewed this project and the environment agencies propose that the information is not yet suitable for setting standards for temperature and for making changes to the approach set out in this section. The UKTAG recommends that the issue be kept under review during the first cycle of River Basin Plans.

The UKTAG concludes that three criteria are relevant: lethal temperatures, a preferred range of temperature, and the requirements for spawning. The preferred range covers feeding, growth, swimming and resistance to disease.

Proposed standards for the Water Framework Directive

The proposed standards for the Water Framework Directive are intended to supersede the standards in the Directives on Freshwater Fish and Shellfish Waters when these directives are repealed in 2013.

As noted above, two types have been distinguished: cool-water and warm-water (Table 7). While the salmonid and cyprinid groupings for the Freshwater Fish Directive match these types, the new standards encompass, in principle, all types of freshwater, estuarine and marine fish.

Temperature preferences were represented by the concept of a "niche" – fish spend two-thirds of their time within 2°C of a preferred temperature. The proposed boundary between high and good status for rivers is the upper limit of the niche in which most fish will spend two-thirds of their time (±2ºC of the preferred temperature). Similarly the boundary between good and moderate status is the upper limit of the niche in which most fish will spend all of their time (±5ºC of the preferred temperature).

The standards for the Water Framework Directive are expressed as boundaries between high, good, moderate, poor and bad (Table 8).

The boundary between moderate and poor status is the lower limit of the range in estimates of lethal temperatures for species. The proposed standards are values at the edge of the mixing zone[1] that must be achieved for 98 per cent of the time.

The UKTAG proposes that these standards are used in the classification of rivers receiving thermal discharges and in calculating the action needed to achieve a target class for rivers. It is proposed that the values are not used for the classification of lakes, estuaries and coastal waters; but are to be used for these waters to calculate the action needed to achieve a target class, or for day-to-day operational control of discharges and abstractions. In the regulation of thermal discharges more specific locally derived background reference conditions may be required if the thresholds below are not appropriate.

Table 8: Proposed boundaries for temperature

	Temperature (ºC) (Annual 98-percentiles)			
	High	**Good**	**Moderate**	**Poor**
Cold water	20	23	28	30
Warm water	25	28	30	32

[1] A concept used in the regulation of discharges – a zone allowing the initial mixing with the receiving water.

In these proposals the boundaries for good status for warm water bodies matches the Imperative Standard for cyprinid fish under the Freshwater Fish Directive. The boundaries for high and good for cool water bodies span the Imperative Standard for salmonid fish under the Freshwater Fish Directive.

For lakes there is inadequate information to link ecological status to the complex thermal structure created by temperature gradients. In setting regulatory controls for lakes the environment agencies would seek to ensure that any thermal structure of a lake was maintained where this was necessary to protect sensitive species of fish. The uplift values will be used outside of the mixing zones in lakes and applied to the average temperature of the mixed water layers in a lake.

For estuaries and coastal waters there is also inadequate information to link the ecology generally to the complex thermal structure created by temperature gradients. Controls here would continue to be focussed on the individual thermal discharges and making sure that the extent of the mixing zone allows the ecology to meet the objectives of the Water Framework Directive.

Uplift values - not proposed for use in classification

The work of the UKTAG confirmed generally that standards from the Freshwater Fish Directive should be protective of salmonid and cyprinid fisheries in rivers, lakes and reservoirs.

The validity of the 'uplift' values of 1.5ºC and 3ºC (Table 8) in the Freshwater Fish Directive was less clear. These aim to ensure that a step rise or a sharp gradient is not a thermal barrier to fish movement.

The UKTAG was unable to find good evidence of the reality of such thermal barriers in rivers and estuaries, except with temperature rises of more than 3°C or near the lethal limit of temperature (which is already protected by standards for maximum temperature).

The UKTAG therefore proposes that the 1.5°C uplift and drop values are not used for classification of rivers under the Water Framework Directive[1]. They can be used to calculate the action needed to achieve a target class, and for day-to-day operational control of discharges and abstractions.

It is proposed that a 3°C uplift is used in this way except for waters of high ecological status where a 2°C uplift limit is proposed.

Release of water to rivers from the cold depths of reservoirs may result in reduced downstream river temperatures and adverse effects on ecology. It is proposed that a maximum allowable temperature drop be applied that mirrors the maximum uplift values. A step of 3°C should be used for all cases except for waters of high ecological status. In this case a maximum allowable drop of 2°C is proposed.

[1] It is also proposed, in line with the Freshwater Fish Directive, that where they are used, the proposed uplift standards are the 98-percentile at the edge of the mixing zone.

Limits on the drop in temperature may also be needed for gasification plants at liquid gas terminals, where cold water may be discharged.

Lower limit for spawning – not proposed for use in classification

A review of the spawning temperatures of UK species indicates that generally, the existing standard in the Freshwater Fish Directive, a maximum 10°C during the spawning season, should protect spawning of cool water species. No such limit should be applied to warm water bodies.

Again the UKTAG proposes that this is not used in classification of rivers, lakes, estuaries and coastal waters for the Water Framework Directive but used, where appropriate, to regulate the operation of thermal discharges.

Compliance with proposed standards

Compliance of rivers with the Freshwater Fish Directive suggests few failures (Table 9).

Table 9: Length of rivers failing temperature standards

	Northern Ireland		Wales		England	
	Cool water	**Warm water**	**Cool water**	**Warm water**	**Cool water**	**Warm water**
2000	None	None	None	None	None	None
2001	None	None	None	None	1 site[1]	None
2002	None	None	None	None	None	None
2003	None	None	None	None	1 site	None
2004	None	None	None	None	None	None
2005	None	None	None	None	None	None

In Scotland, monitoring from 2003 to 2006 for the purposes of the Freshwater Fish Directive gives 1.4 per cent of failed sites for the standard of 21.3 ºC in the Freshwater Fish Directive (Table 6) and 0.9 per cent of failed sites for the standard of 23 ºC (Table 8).

PHOSPHORUS IN LAKES

This topic was discussed in the previous report of the UKTAG [1]. The UKTAG recommended then that detailed consultation be postponed until more was known of the results of Intercalibration. The UKTAG then revised the standards in the light of wider range of quality elements. This led to the discussion in this report on phosphorus in lakes.

The UKTAG proposes a standard that is expressed as the mean annual concentration of total phosphorus. Total phosphorus includes the available phosphorus - that which is bound to particulate material and that contained in phytoplankton. Total phosphorus is an established indicator for lakes and it is simple to measure [6].

Additions of phosphorus to lakes can result in changes in the composition and biomass of biological communities. The most apparent impact is an increase for phytoplankton, but changes in the distribution and species composition of macrophytes and phytobenthos also occur. The combined effect can alter the habitat (through reduced dissolved oxygen and lower water transparency) and this can lead to changes in the communities of fish and invertebrates.

If we had data for thousands of lakes, the UKTAG would have applied to lakes the same methods that worked well for river [1]. As we do not have such data, the UKTAG has used another method of looking across a number of lakes – mathematical models.

Even lakes in a natural condition receive different amounts of phosphorus. The natural state of their fertility will also vary, and the impact of additional phosphorus depends on the sensitivity of the lake. As a result of all this, each lake could require its own standard.

To an extent this variation can be accommodated by a change to the typology used for reporting on lakes in Great Britain. This change divides lakes into three types based on depth, rather than just two, but with no distinctions based on size or altitude. It results in a typology that is the same as that for Intercalibration (Tables 10 and 11). The original typology also included organic (humic lakes), however the UKTAG feels there is currently insufficient information to justify different phosphorus standards for these lakes and thus for the first River Basin Plans we propose to allocate all lakes to the above typology.

Despite this change, the UKTAG still proposes standards that are specific to individual lakes. This is because, for example, some lakes fall close to the boundary between types. Such lakes would either be over protected, or under protected, by a standard based on type.

Because the proposed standards are specific to individual lakes, it is difficult to provide a simple summary of them. To provide an indication, and to allow a comparison with standards for other Member States, the UKTAG has summarised its proposals by lake type (Table 13). This shows the median value for the type, and the expected range of standards within the type[1].

[1] These are values under the headings, "Type".

Table 10: Geological types for lakes

1st tier types (Geology)	Type	Catchment	Alkalinity mg/l of calcium carbonate	Conductivity[1] µS/cm	Colour mgPt/l
Siliceous	Low Alkalinity	More than 90 per cent siliceous solid geology	< 10	< 70	<= 30
	Moderate Alkalinity	More than 50 per cent siliceous solid geology	10 to 50	70 to 250	
Calcareous	High Alkalinity	More than 50 per cent calcareous geology	> 50	> 250 to 1000	
	Marl	More than 65 per cent limestone			

Table 11: Depth types for lakes

2nd tier types		Mean depth (metres)
Depth	Very Shallow	Less than 3
	Shallow	3 to 15
	Deep	More than 15

Type-specific standards where models are insufficiently reliable

In some cases it may be impossible to determine a lake-specific standard. This will happen, for example, when there are too few data for the mathematical models. For other lakes, the models are unreliable. Marl lakes, for example, have lower natural phosphorus than the models predict. Unless other models become available, the UKTAG proposes for this type of lake, to apply a type-specific standard.

Where there is a need to use such type-specific standards, the UKTAG proposes that these be defined as the median of the range of lake specific standards. These ranges, and the median values, are listed in Table 12. For comparison, Table 12 shows the thresholds used by the Environment Agency in the context of its Review of Consents[2] for England and Wales under the Habitats Directive.

[1] Conductivity is used only as a guide to type – the units are micro Siemens per centimetre.
[2] This took place in England and Wales. Although the title of the review includes the term "consents", it included other permits and abstraction licences.

Site-specific standards for lakes

To determine a lake-specific standard the UKTAG proposes at first the use of a model to predict a reference[1] level of phosphorus for the lake. A factor would then be applied to this reference level. The factor represents the degree of change in the reference level which, based on the understanding of the way a variety of biological quality elements[2] respond to increases of phosphorus, is consistent with the UKTAG's understanding of the Directive's definitions of good and moderate status. In addition we will use an override to the model to ensure that the total phosphorus for the high and good boundaries are not less than 5µg/l and 8µg/l respectively.

The values in Table 12 were determined in this way using reference values derived from a particular model [7]. This model uses geographic location[3] and alkalinity to reflect the availability of background phosphorus to affect ecology. The model uses the mean depth of the lake to indicate the extent to which a lake is able to retain its phosphorus naturally, without causing damage to ecology.

The model was calibrated from a large number of European lakes that are in reference condition[2]. It can be applied to all lakes in Great Britain, except those on limestone. The UKTAG proposes to base its standards on this model. In a few cases in Scotland where this model does not work well, previously used models, based on historic land-use and on the fossil remains of diatoms preserved in the sediments of lakes[4], will continue to be used [8].

For the first cycle of river basin planning, the UKTAG proposes that the standards for lakes on limestone are type-specific and based on the relationship between phosphorus and the taxonomic composition of macrophytes.

The ecological consequences of elevated phosphorus can include increased amounts of phytoplankton, undesirable blooms of blue-green algae, changes to the aquatic vegetation, and, ultimately, the loss of sensitive species of fish. It is difficult to predict how any particular lake will respond. Other nutrients may limit the growth of phytoplankton in some lakes. In others grazing by zooplankton may reduce the sensitivity of the lake to enrichment.

All this contributes to the uncertainty in the links between ecological change and phosphorus. Because of this uncertainty, the standards in Table 12 should be interpreted and applied in a way that is similar to the way standards are used for Sensitive Areas under the Directive on Urban Waste Water Treatment (that is, as an indirect model). Actions to deliver improvements in lakes should be taken where ecological data from biologically sensitive elements confirm that there is, or that there is likely to be, a problem. The environment agencies will use the standards as part of their processes of defining the controls to be placed on new applications for discharges.

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[1] "Reference" is the term used by the Directive to define conditions that are close to pristine.

[2] This considered the biomass of phytoplankton as chlorophyll a, the taxonomic composition of macrophytes, and changes to diatoms preserved in sediments of lakes.

[3] The UK is divided into two broad regions based on climate and geology: a Northern/Atlantic region (covering Wales, South West England, and the uplands of England and Scotland); and a Central region (covering the lowlands of England other than the South West).

[4] A research report provided the basis of this model – see [7] for details.

Table 12: Standards for phosphorus for lakes								Existing criteria
Type of lake		Reference level of Phosphorus[1]		Class Boundaries				Habitats Directive[2]
				High		Good		
		Range	Type[3]	Range	Type	Range	Type	
		Annual (geometric) mean (µg/l)						
High Alkalinity – deep		There are too few lakes of this type						
High Alkalinity shallow	Northern/ Atlantic	8-17	13	10-22	16	14-30	23	35
	Central	12-27	20	16-34	25	22-46	35	
High Alkalinity very shallow	Northern/ Atlantic	12-29	18	15-36	23	21-48	31	35
	Central	18-44	28	23-55	35	33-75	49	
Moderate Alkalinity, Deep		3-8	6	5-11	8	8-16	12	15
Moderate Alkalinity – shallow		5-11	8	7-15	11	10-21	16	
Moderate Alkalinity – very shallow		8-19	12	10-25	15	15-36	22	20
Low Alkalinity – deep		2-7	4	5-9	5	8-15	8	10
Low Alkalinity – shallow		2-10	5	5-13	7	8-19	10	
Low Alkalinity – very shallow		3-17	7	5-23	9	8-34	14	10
Marl – shallow		N/a	N/a	N/a	9	N/a	20	20
Marl – very shallow		N/a	N/a	N/a	10	N/a	24	20

Implications for phosphorus

There are limited data with which to assess compliance. Tables 13 to 16 show the percentage of lakes that might be reported as worse than good as a result of the UKTAG's proposals for phosphorus. Fifteen per cent of lakes in Scotland, 75 per cent in Northern Ireland, 80 per cent in Wales and 67 per cent in England are likely to be worse than good status when this is judged at 95 per cent confidence.

[1] Derived from the Morpho Edaphic Index (MEI) model calibrated against European data for lakes at reference condition.

[2] The criteria for the Habitats Directive represent the views of experts at the time for the nutrient conditions considered by the conservation agencies as relevant to the ranges of conservation interests associated with what the Habitats Directive calls Favourable Conservation Status. This is in the context of the particular processes by which the Habitats Directive leads in its Review of Consents to recommend changes in the conditions in consents, permits and licenses.

[3] Because the proposed standards are specific to individual lakes, it is difficult to provide a simple summary of them. To provide an indication, Table 14 gives these summaries by lake type - the median value for the type.

The UKTAG would have expected the proportion of lakes worse than good status to be higher in England and Northern Ireland than in Scotland because of the differences in pressures. But the figures for Wales, for example, should be closer to those for Scotland. The current evaluation of the ecological status does not indicate a large difference between, say, lakes in Wales and Scotland.

The UKTAG suspects that contamination of the samples is occurring during sampling or analysis. The Environment Agency is investigating and will ensure that reliable data are available for lakes in England and Wales.

Standards for moderate, poor and bad status

The UKTAG has looked at standards that could define lakes of moderate, poor and bad status. When these are used they have the average result that 15 per cent of the lakes that are worse than good status have bad status, and 30 per cent are poor.

For these standards the UKTAG doubled the boundary values. So the boundary between moderate and poor status is twice the boundary for good and moderate, and the boundary between bad and poor is double that for moderate and poor boundary. This represents our best understanding of relationships with the biological quality elements.

Table 13: Implications for lakes in Wales

Type	Number of lakes	Per cent less than high status		Per cent less than good status	
		With at least 50 per cent confidence	With at least 95 per cent confidence	With at least 50 per cent confidence	With at least 95 per cent confidence
Low and moderate alkalinity, shallow and very shallow	21	100	95	95	81
High alkalinity shallow and very shallow	7	100	100	100	71
All deep lakes	2	100	100	100	100
All lakes	30	100	97	97	80

Table 14: Implications for lakes in England

Low and moderate alkalinity, shallow and very shallow	30	93	90	77	67
High alkalinity shallow and very shallow	40	83	83	73	63
All deep lakes	9	100	100	100	89
All lakes	79	89	87	77	67

Table 15: Implications for lochs in Scotland

Low and moderate alkalinity, shallow and very shallow	116	47	32	22	15
High alkalinity shallow and very shallow	26	62	54	46	38
All deep lakes	45	40	22	7	2
All lakes	187	47	33	22	15

Table 16: Implications for lakes in Northern Ireland

Low and moderate alkalinity, shallow and very shallow	8	88	88	88	75
High alkalinity shallow and very shallow	19	94	84	84	79
All deep lakes	0	-	-	-	-
All lakes	27	93	85	85	78

NITROGEN (TRANSITIONAL AND COASTAL WATERS)

In this report the UKTAG has changed its proposed standards for dissolved inorganic nitrogen to include thresholds related to the turbidity for estuaries[1]. The first part of this chapter (up to page 39) is the same as the first report [1]. The UKTAG also includes in this report its proposals for standards for moderate, poor and bad classes

The UKTAG proposes that coastal waters be assessed using the winter mean of dissolved inorganic nitrogen[2]. (Ecological impacts in coastal waters are less likely to be caused by phosphorus. Further consideration will be required for specific estuaries) [9].

The proposed thresholds for high and good status are based on the thresholds developed for UK assessments made for the OSPAR Convention (OSPAR)[3]. OSPAR has set out the relationship between its Common Procedure [10] and the Water Framework Directive. In Table 17, the boundary between high and good status is given as OSPAR's "background" value.

The boundary between good and moderate is OSPAR's "Assessment Level". This reflects the natural variability in water quality, plus a "slight" disturbance, as defined by OSPAR. (It is actually OSPAR's "background", increased by 50 per cent). The UKTAG has used this to define offshore thresholds and reference conditions for the Water Framework Directive.

The UKTAG then derived standards for coastal and transitional waters that are related to salinity. This provides single values for UK offshore, coastal and transitional waters (normalised for salinity) for:

- reference values (or the boundary between high and good status);
- threshold values (or the boundary between good and moderate status).

<table>
<tr><th colspan="7">Table 17: OSPAR's Common Procedure and the Water Framework Directive</th></tr>
<tr><td rowspan="2">OSPAR's Common Procedure</td><td>Initial Application</td><td colspan="2">Non-problem area</td><td colspan="2">Potential problem area</td><td>Problem area</td></tr>
<tr><td>Further Application</td><td colspan="3">Non-problem area</td><td colspan="2">Problem area</td></tr>
<tr><td colspan="2">Water Framework Directive</td><td>High</td><td colspan="2">Good</td><td colspan="2">Less than Good</td></tr>
<tr><td colspan="2"></td><td>OSPAR background</td><td colspan="2">OSPAR background plus 50 per cent</td><td colspan="2"></td></tr>
</table>

[1] Called transitional waters for the Water Framework Directive.

[2] The winter mean is based on data collected at minimum monthly from November to February. It is recommended that five years data is used e.g. 2001-2205 to calculate the mean

[3] Convention for the Protection of the Marine Environment of the North-East Atlantic. OSPAR replaced both the Oslo and Paris Conventions.

In the original methods for OSPAR, nutrients are assessed using the mean for the winter period. The estimate of the winter mean is compared with a background mean that is specific to the region. For waters close enough to freshwater inflows to be influenced by them, measured levels of nutrients are adjusted to the value for a particular salinity.

Thresholds for off-shore waters

The original background values used as thresholds for OSPAR have been applied to waters with salinity greater than 34[1]. (These were set for UK waters under OSPAR's comprehensive procedure (2002) [10]).

To allow for natural variability, and in the absence of specific information, an "assessment level" was defined as 50 per cent more than the salinity-related concentration set up in the first application of the OSPAR's Comprehensive Procedure, or 50 per cent more than the area-specific background concentration [11].

Gowen [12] recommend a threshold winter mean of dissolved inorganic nitrogen between 6.3 and 8.8μM[2] at the continental shelf, with a mean of 7.2μM. Baseline values for waters off the west coast of Scotland and the northern North Sea were measured at 11μM and 12μM respectively [13, 14, 15]. Thus if the UKTAG were to take a range of regional offshore values, the baseline would vary from 7.2 to 12μM. There is also variability in such measurements from year to year, and the variation within the winter period leads to uncertainties in the estimates of the winter mean.

Therefore the UKTAG proposes to take one value to represent all UK offshore waters: a winter mean of 10μM. This would apply only to waters with salinity greater than 34. Thus for all UK offshore waters the boundary between high and good status would be set at 10μM. The boundary between good and moderate status would be set at a 50 per cent deviation from this baseline: 15μM (Table 18).

Table 18: Nitrogen boundaries for offshore UK waters

Sea Area	UK Areas	Reference or baseline value (High)	OSPAR threshold (50 percent deviation from reference values) (Good)
		(Winter mean of Dissolved Inorganic Nitrogen - μM)	
North Sea Irish Sea Channel Celtic Sea	All offshore coastal areas with salinity greater than 34	10	15

[1] Salinity is a measure of the concentration of dissolved salts in seawater - it has no units but is nearly equal to the weight in grams of dissolved salts per kilogram of seawater.

[2] Micromoles per litre: one micromole per litre is 62 micrograms per litre of nitrate, 14 micrograms per litre as nitrogen.

Thresholds for coastal and transitional waters

The UKTAG has developed thresholds for coastal waters and transitional waters by deriving a salinity gradient from the freshwater to the salt-water end of a water body.

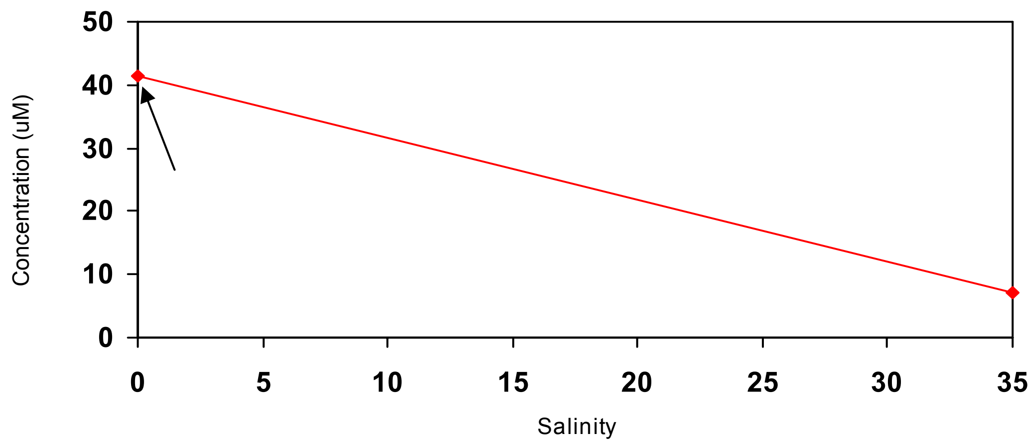
Coastal waters are defined as located within 1 or 3 nautical miles[1] off the coast, or having a salinity of 30 to 34.5. Transitional waters (estuaries) are generally described by a salinity of less than 30.

Levels of dissolved inorganic nitrogen may be elevated in waters that are influenced by freshwater flows. These raised levels can be used with mixing curves and so adjusted to give figures that would correspond to a specific and single value of the salinity. This latter or "normalised" estimate of the level of dissolved inorganic nitrogen can then be compared with the regionally specific background.

In order to construct the mixing curve we need data on freshwaters. As there is limited information on reference points for the freshwater ends of UK estuaries, the UKTAG used the River Leven, which runs into Liverpool Bay. The Leven drains an area of 566 km^2 (including Lake Windermere) in south Cumbria, and is unaffected by major inputs of nutrients from point or diffuse sources. It is considered representative of an unpolluted river draining 21st century land use.

The mean dissolved inorganic nitrogen for the Leven is 42µM. This[2] provides a reference value for zero salinity [16] for the freshwater end of the mixing curve (Figure 1). This, coupled with the reference value for the salt-water end, gives the relationship for dissolved inorganic nitrogen against salinity.

Figure 1: Dilution line for dissolved inorganic nitrogen



[1] Coastal waters extend out to 1 nautical mile in England, Northern Ireland and Wales. Under Scottish legislation, coastal waters extend out to 3 nautical miles.

[2] Data from the Environment Agency – 42µM is 2.6 mg/l as nitrate. The 50 mg/l limit used - in freshwaters is over 800µM

The UKTAG suggests that this mixing line applies to estuarine and coastal waters in the UK with salinity of 25 and above. It should not be used for rivers or for the upper end of estuaries because it does not reflect any relationship that might apply between biology and nitrogen in fresh waters. Further work may be required for the low salinity parts of estuaries.

The UKTAG used Figure 1 to derive the values in Table 19 and so provide thresholds that are "normalised" to a selected standard salinity - 25 for transitional waters, and 32 for coastal waters. This allows the thresholds shown to be presented in a simple table, so long as it is understood that measurements of the winter mean of dissolved inorganic nitrogen are transformed to the standard salinity using Figure 1. For a particular water body the average salinity would be estimated and used with the graph to read off the appropriate standard.

The “threshold values" in Table 19 correspond to the boundary between good and moderate status for the Water Framework Directive. It also represents the difference between a “non-problem area” and a “potential problem area” for OSPAR’s Comprehensive Procedure (2002).

The “reference values" in Table 19 give the boundary between high and good for the Water Framework Directive and is the “reference condition” under OSPAR’s Comprehensive Procedure (2002) [10].

Table 19: Thresholds for nitrogen for OSPAR and the Water Framework Directive

Area	Assessment	Salinity	Dissolved Inorganic Nitrogen (Winter mean as micromoles per litre)	
			Reference value (High - Good boundary)	Threshold value (Good - Moderate boundary)
Offshore	OSPAR	> 34.5	10	15
Coastal (at salinity 32)	OSPAR	30 - 34.5	13	20
	WFD	Variable		
Transitional (at salinity 25)	OSPAR	< 30	20	30
	WFD	Variable		

Comparison with OSPAR, and recommendations for the UK

Whilst accepting the scientific principles behind the values in Table 19, expert advice has identified that the values move some coastal areas of the UK into conflict with the values used in delivering the assessments for OSPAR.

Therefore the UKTAG proposes thresholds for coastal waters of 12μM for the boundary between high and good and 18μM for the boundary between good and moderate. This aligns with the values used for OSPAR. They should apply to all UK coastal waters (given that data are "normalised to a salinity of 32) (Table 20).

Table 20: Proposals for nitrogen for coastal and transitional waters				
Area	Assessment	Salinity	Dissolved Inorganic Nitrogen (Winter mean as micromoles per litre)	
			Reference value (High - Good boundary)	Threshold value (Good - Moderate boundary)
Offshore	OSPAR	More than 34.5	10	15
Coastal (at salinity 32)	OSPAR WFD	30 - 34.5	12	18
Transitional (at salinity 25)	OSPAR WFD	Less than 30	20	30

The above thresholds expressed as micrograms of nitrogen per litre are 168 and 252 in coastal waters (salinity 32) and 280 and 420 in transitional waters (salinity 25).

Preliminary assessment of implications for UK

The UKTAG has used the Water Framework Directive's database to place water bodies in high, good or moderate status using the boundaries in Table 20. In doing this:

- the assessment is based solely on the winter mean of dissolved inorganic nitrogen[1];
- the UKTAG used the data for the last 6 years, for salinity from 32 to 34.5;
- the data are from many different programmes and agencies. Accuracy will increase as sampling falls into line with the requirements of the Water Framework Directive;
- water bodies with fewer than five samples were excluded. This gave 121 waters.

When assessed against the recommended thresholds of 12 and 18 μM, 45 per cent of the 121 water bodies are high status; 19 per cent are good and 36 per cent are moderate. This is for a rule where we require at least 50 per cent confidence to place the water body in the lower class. For 95 per cent confidence, 56 per cent are high status, 15 per cent are good and 29 per cent are moderate. The breakdown is in Table 21. This analysis is only for water bodies with sufficient data. This may not be a true picture for all UK water bodies.

If the threshold for dissolved inorganic nitrogen for good status is failed, the UKTAG proposes that, before action is taken to secure compliance, a second assessment is done to evaluate whether the failure has caused, or is likely to cause biological impacts. This would take into account factors such as potential productivity, and the evidence of elevated chlorophyll and depressed dissolved oxygen.

[1] This is November to February, inclusive.

This is an example of the use of the indirect model described earlier in the report. The indirect model is already used in this context to identify where action is necessary under the Nitrates Directive or the Urban Waste Water Treatment Directive and hence which waters should be designated as polluted waters or sensitive areas under these Directives.

Table 21: Classification of water bodies with sufficient data

	Face value[1]			95 per cent confidence[2]		
	High	Good	Moderate	High	Good	Moderate
England	3	6	34	7	7	29
Northern Ireland	3	2	5	6	2	2
Scotland	42	9	0	47	4	0
Wales	6	6	5	9	4	4

The new material starts here.

Extension to Poor and Bad Classes

The deviation of the boundary for good and moderate is a general increase of 50 per cent in the reference baseline. UKTAG proposes to extend this idea to derive boundaries between moderate and poor status, and between poor and bad.

This gives the thresholds for all coastal and transitional waters in Table 22. The UKTAG suggests that these are used for guideline purposes to prioritise action and that they should not be used to classify ecological status. This is for the reasons given above: the secondary biological effects should be considered before the final status is declared.

They can also be used to help show in general terms whether waters that are worse than good are improving.

[1] In the face value approach the simple estimate of the arithmetic mean is compared with the standard. If this estimate exceeds the standard the water is said to fail (and to fall into the next worse class). In this method no account is taken of the statistical uncertainties in sampling and analysis; there is at least 50 per cent confidence that the water has failed a standard. This means that there is a high risk (up to 50 per cent) that a particular water is said wrongly to have failed.

[2] In this case account is taken of the statistical uncertainties from monitoring and analysis and the water is said to fail the standards only when there is at least 95 per cent confidence that the failure is not caused by uncertainties in monitoring.

Table 22: Proposals for nitrogen for coastal and transitional waters					
Area	Salinity	Class boundaries			
		Dissolved Inorganic Nitrogen (Winter mean as micromoles per litre)			
		High	Good	Moderate	Poor
Coastal (at salinity 32)	30 - 34.5	12	18	27	40.5
Transitional (type clear at salinity 25)	<30	20[1]	30	45	67.5

The above thresholds expressed as micrograms of nitrogen per litre are 168, 252, 378 and 567 in coastal waters (salinity 32) and 280, 420, 630 and 945 in transitional waters (salinity 25).

When the 121 coastal water bodies are assessed against the proposed thresholds in Table 22, 45 per cent are high status, 19 per cent are good, 12 per cent are moderate, 12 per cent are poor and 13 per cent are bad. This is for a rule where we require at least 50 per cent confidence before we place the water body in the lower class.

For 95 per cent confidence, 56 per cent are high status, 15 per cent are good, 13 per cent are moderate, 6 per cent are poor and 10 per cent are bad. The numbers of water bodies are set out in Table 23. This analysis is only for water bodies with sufficient data. This may not be a representative picture across all UK water bodies.

[1] this standard for high also applies to transitional waters for the following types: very turbid , medium turbidity and intermediate turbidity

Table 23: Classification of water bodies with sufficient data										
	Face value					95 per cent confidence				
	H	G	M	P	B	H	G	M	P	B
England	3	6	7	13	14	7	7	12	6	11
Northern Ireland	3	2	4	0	1	6	2	1	0	1
Scotland	42	9	0	0	0	47	4	0	0	0
Wales	6	6	3	1	1	9	4	3	1	0

Key: H: High; G: Good; M: Moderate; P: Poor; B: Bad

Nutrient thresholds related to turbidity

The assessment of thresholds of nutrients in transitional waters requires an understanding of how different types of estuaries respond to nutrients. Plant growth depends on a supply of nutrients and light.

The susceptibility of waters to nutrient enrichment is controlled by the attenuation of light within the water body, which in turn is controlled partly by the amount of suspended matter in the water column.

To account for this, the UKTAG has established nutrient thresholds for three types of water bodies, based on the level of turbidity. These stem from measurements of the attenuation of light under the surface, and measurements of the suspended particulate material. They cover 382 locations in transitional, coastal and offshore waters around the UK. These data were supplemented with 12000 values for suspended particulate material from the Environment Agency's database.

The proposed thresholds have been calculated using a model. This estimates the biological response to concentrations of nutrients. The results are strongly influenced by the availability of light and this is affected by the suspended matter in the water column. Table 24 gives the proposals for nitrogen thresholds for waters of different turbidity, associated with eutrophication[1]. The model produces estimates of "maxima". In line with its general requirements for standards, the UKTAG proposes these are treated as annual 99-percentiles.

Table 24: Thresholds for nitrogen under different conditions of turbidity

Category	Range in suspended matter (mg/l)	Nitrogen threshold (micromoles per litre)	Types
Very turbid	More than 300	270	TW1, TW3
Medium turbidity	100-300	180	TW2, TW4
Intermediate to clear	Less than 100	70	TW5, TW6

The UKTAG proposes that the general standards in transitional waters in Table 20 are used in the context of Table 24. Table 25 shows the values from Table 20 for offshore, coastal and transitional waters, together with the supplementary values for transitional waters based on turbidity and the typologies for the Water Framework Directive.

The thresholds based on winter mean nutrients would be assessed first. These are in the top half of Table 25. If these are met the status of the water body is at least good. If the threshold for good status is exceeded for a transitional water, then the turbidity related value is brought in and the water body downgraded to moderate only if this too is failed.

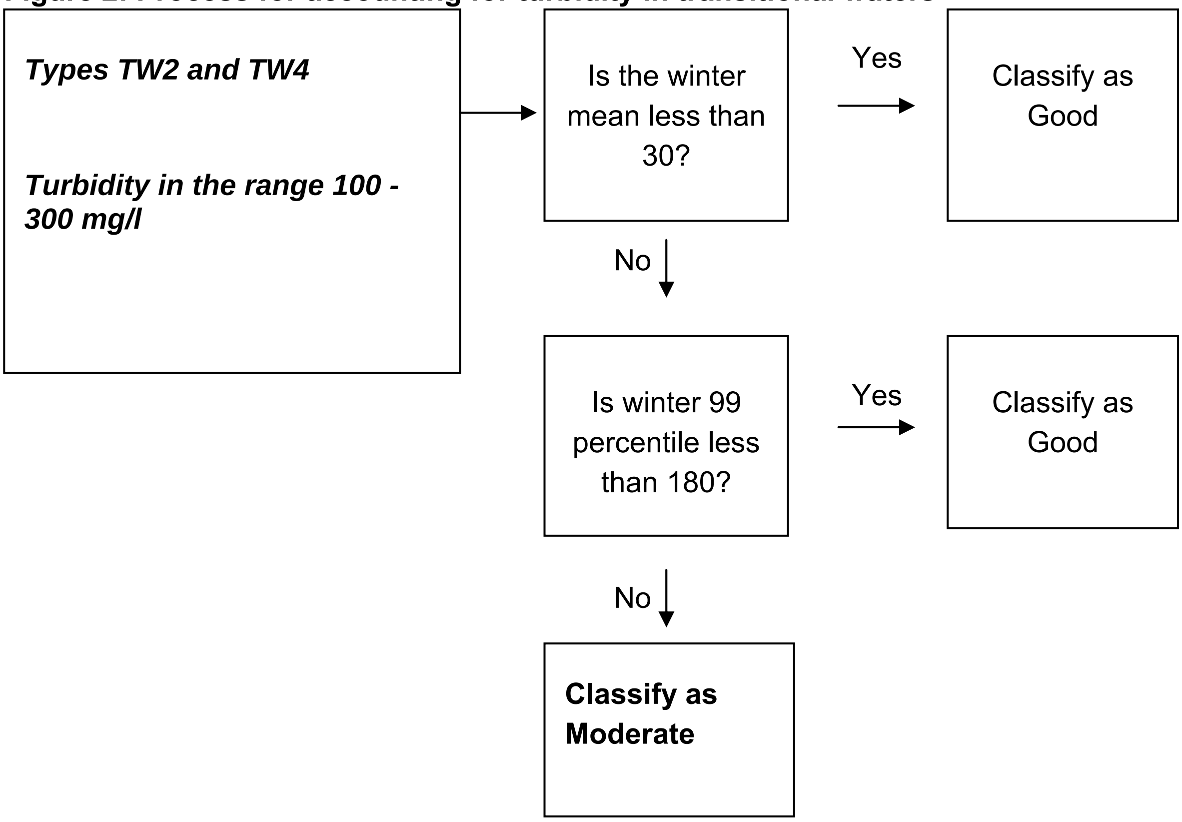
[1] Primary production of 300 grams of carbon per square metre per year. This threshold was proposed for assessing the status of a water body as "eutrophic".

Table 25: Thresholds for all waters			
Area	Salinity	Dissolved Inorganic Nitrogen (micromoles per litre)	
		Winter mean	Winter mean
		High - Good	Good - Moderate
Offshore	> 34.5	10	15
Coastal (at salinity 32)	30 - 34.5	12	18
Transitional (type clear at salinity 25)	< 30	20	30
If a transitional water fails the Good boundary, look at the turbidity and type …			
Turbidity and type of transitional water (at salinity 25) [1]		Winter mean	99-percentile
		Good - Moderate	
Very turbid, TW1,TW3	< 30	30	270
Medium turbidity, TW2, TW4		30	180
Intermediate/Clear, TW5, TW6		30	70
Typologies for the Water Framework Directive: TW1: Partly mixed or stratified, meso or polyhaline, macro-tidal, intertidal or shallow subtidal, predominantly sand and mud. TW2: Partly mixed or stratified, meso or polyhaline, meso-tidal, intertidal or shallow subtidal, predominantly sand and mud. TW3: Fully mixed, polyhaline, macro-tidal, sand or mud substratum, extensive intertidal areas. TW4: Fully mixed, polyhaline, meso-tidal, sand or mud substratum, extensive intertidal areas. TW5: Transitional Sea Lochs. TW6: Transitional Lagoons			

An example of a flowchart for waters of medium turbidity, and types TW2 and TW4, is in Figure 2.

[1] The 99 percentile standard for moderate for very turbid, medium turbid and intermediate/clear types are 405 270, 105 respectively. The 99 percentile for poor for very turbid, medium turbid and intermediate/clear types are 607.5, 405 and 157.5 respectively.

Figure 2: Process for accounting for turbidity in transitional waters



Preliminary assessment of implications

The UKTAG has undertaken a preliminary assessment of the impact of the proposed regime. Of the 191 transitional waters for the UK, 43 had sufficient data[1]. Of these 24 (56 per cent) would be classed as moderate (with 95 per cent confidence) using the winter mean threshold.

The process for checking turbidity levels was then applied. Seventeen (40 per cent) would still be classed as moderate as they also exceed the values associated with the turbidity threshold. Further work is required to apply the standards to the remaining water bodies so that an improved assessment of overall compliance can be derived.

[1] A minimum 20 samples from 2001-5.

SUSPENDED SOLIDS (ALL SURFACE WATER BODIES)

Suspended material may reduce light penetration, and cause scouring of riverbeds. Where flows are low in rivers, solids may fall out of suspension, smothering substrates, and filling the spaces between gravel. This can be damaging if it is excessive, or if it reduces the dissolved oxygen in critical patches of habitat.

Measurements of suspended material in environmental waters have usually been expressed as concentrations for parameters called suspended solids or turbidity.

Suspended solids occur naturally in waters. Some will be the result of natural erosion; in other places this may be exacerbated (for example) by deforestation. In areas of extensive urban development, inputs of suspended solids may be dominated by human impact. The range of types of solids, their origins, and their extreme variability in time, makes it difficult to derive standards that can used helpfully and generally in the classification of water bodies.

The chapter describes the proposed management approach to deal with the smothering effects of sediments. The approach follows from the view of the UKTAG of the complexity and natural variation of suspended solids, the way many of its impacts depend on the intensity and frequency of rare events, and depend on the effect of the particle size, water velocity and degree of turbulence. This makes it difficult to set up a general standard for use in classification, even though there are plenty examples where measurements of suspended solids have helped evaluate and correct particular cases of pollution by suspended solids.

For many of the standards developed by the UKTAG and others the value of a summary statistic like the annual mean is strongly linked, for example, to the risk of damage from rare events to waters generally. For suspended solids such an assessment might need to be based upon individual catchment characteristics and the monitoring of the specific events that cause particular types of damage. There may need to be a number of thresholds taking into consideration length of time of exposure, the return period of incidents of exposure, and the time taken for a population to recover. The range of these combinations cannot for suspended solids be embraced within a summary statistic like an annual mean or an annual 95-percentile that can apply to waters generally.

This chapter excludes the effects of damaging substances within or adsorbed onto particles of sediments. These would be discussed for the particular pollutants involved, looking at the proportion of pollution delivered to sensitive species from sediments compared with to the proportions from other routes, for example, directly from the concentration dissolved in the water. If the amounts of pollution within suspended particles have an effect, it could still be that improvements should focus on controlling the concentrations dissolved in water.

In its first report, the UKTAG was able to use for some standards the analysis of thousands of pairs of data on chemistry and biology. This option is not available for suspended solids because the biology, if it shows damage, is likely to have been affected by other pressures. Neither is there scope to use the laboratory-based toxicological approaches applied by the UKTAG for some of the Specific Pollutants.

Given the fundamental complexity, the lack of data and a clear approach, and the timetable for the Directive, the UKTAG has focussed on checking the suitability of existing standards for use in the first cycle of river basin plans.

Fresh waters

The Freshwater Fish Directive gives a Guideline Standard for suspended solids. (There is no Imperative Standard). The Guideline Standard is an annual mean of 25 mg/l. Member states are required “endeavour to respect” the Guideline Standards, whilst an Imperative Standard must be met.

It is the Imperative Standards that have directed action under the Freshwater Fish Directive. It has been the view that such action, and measures under other Directives and action under domestic policy, leads to progressive improvements against Guideline Standards for suspended solids and other determinands.

These improvements include those under present policies on the permitting of discharges; investment in sewerage services; improvements under the Urban Waste Water Treatment Directive; and, in England and Wales, improvements made to meet River Quality Objectives. This action, although targeted on requirements such as those for the biochemical oxygen demand, dissolved oxygen, ammonia and phosphorus, also reduces the levels of suspended solids.

The UKTAG proposes that the Guideline Standard for suspended solids in the Freshwater Fish Directive should not move directly into the definition of good ecological status under the Water Framework Directive. An annual mean that exceeds 25 mg/l should not lead to a declaration that ecological status is not good.

One of the reasons for this view is that this form of standard, the annual mean, is suited for picking out and dealing with continuous discharges of relatively steady[1] concentrations of suspended solids like those in the treated discharges from sewage treatment works. In this instance a water quality standard for suspended solids is not needed because action is vested in other measurements such as the biochemical oxygen demand.

For discharges from wastewater treatment plants, the required control of suspended solids is likely to be met automatically by the action for biochemical oxygen demand and ammonia. In other cases an annual mean of 25 mg/l of suspended solids is used as a check or guideline for use in calculating controls on more or less continuous discharges of suspended solids to waters.

The environment agencies use the Guideline Standard of 25 mg/l to help set controls on discharges of inorganic material[2] from quarries, open caste coal sites, and mines. This will continue.

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[1] Compared with those washed off land by storms.
[2] As opposed to the organic solids associated with the biochemical oxygen demand.

Concentrations in chalk streams are typically less than 5 mg/l, so an annual mean 25 mg/l for such a water would represent a large increase and a considerable concern. So non-compliance in this context would provide support for action in the context of the procedure proposed below.

Managing incidents of sediment release

When and wherever good ecological status (or other objectives under the Water Framework Directive) is at risk (for example, as indicated by ecological data) the environment agencies will determine the causes, and act on them in the manner required by the Water Framework Directive. This means that high levels of suspended solids might be considered a reason, for example, that water quality is judged as insufficient for good ecological status. But the UKTAG proposes that there is no useful water quality standard by which to assess this in a reliable way.

The type of standard set as a Guideline Standard in the Freshwater Fish Directive, an annual mean, is not appropriate for tackling occasional events such as run-off from land[1]. We would need an approach that is closer to how we currently manage incidents of similar impact and low frequency. If this included a water quality standard, a 95-percentile, or a more extreme percentile[2], would be better than the annual mean because such a percentile goes some way towards the very rare percentiles associated with actual damage[3].

If failure of the 95-percentile did turn out to be correlated with the risk of damaging events, management and monitoring might then be targeted at risk, according to the type of land, time of year, rainfall, and how the land is managed. In the past such correlations have not been obvious.

Accordingly, for damage caused by sediments washed into environmental waters from land by heavy rain the UKTAG sees the case for action at particular sites or regions being made up from a checklist of items of, such as:

(a) An estimate or assessment of the propensity for damage to the type of water body beyond natural variation and a natural response to the weather. This would be predicted by, for example, land use and land management, the characteristics of rainfall, run-off and soil type, and information on the water body. This might lead to targeted monitoring, tailored to the type of risk.

(b) A record of incidents or near misses and evidence from these in terms of photographs taken at the incident and measurements of impact in terms of, for example, appropriate measurements of suspended solids, the scale and extent of, for example, resulting deaths to fish and invertebrates, and the time taken for recovery.

[1] A series of 11 measurements of zero, and one result of 400 mg/l, gives an annual mean of 33. This exceeds 25 mg/l but the estimate of 33 has confidence limits between zero and 95 . Also the annual standard was not designed to control the causes of these types of monitoring results.

[2] For example, a 98 or 99 percentile - though the more extreme the percentile the larger the errors of estimation. An estimate of the 95-percentile from 12 routine samples, 11 zero and one at 400 mg/l gives a face-value 130 with a conservative estimate of the range in confidence from 50 to 750. The 99-percetile is 380 (120-4000).

[3] Though the episodic nature of the variability may make it unhelpful to use even these summary statistics in classification.

(c) Calculations that indicate the probability of future events based on the density of potential causes, the nature of the catchment, the type of water body, and statistics on the scale and frequency of past events.

(d) Compliance with any standards suggested for this purpose. These might be based on the sort of laboratory results[1] produced from samples taken during incidents that caused particular types of damage. It may also involve calculations using mathematical models.

There are ways in which turbidity can be monitored continuously through light scattering data loggers. The sampling of deposited solids may also be required. There is a variety of methods that can be used for this.

In time, the role of (d) could become more important than (b) and (c). Monitoring results alone could then suggest priorities for investigative work on causes. Considering the evidence provided by (a) to (d), the UKTAG proposes that the response should be in the form of increasing measures of pollution prevention[2] designed to minimise the risk of actual damage. The UKTAG suggests that actions for rivers and lakes should include General Binding Rules and similar measures[3].

We will improve our understanding through research and by keeping up with the scientific literature, through action at sites designated for nature conservation, and through initiatives such as the project on Catchment Sensitive Farming. This may lead to numeric standards or guidelines for sediment loads or concentrations, based on catchment characteristics.

Coastal and transitional waters

Whilst transparency is noted as a parameter for the Water Framework Directive, the measured values vary greatly in space and time. This means that transparency is not useful as a numerical standard because estimates of compliance, and the basis of the need to act on failures, will have such large errors.

As for freshwater above, where the plant and animal communities as reflected by good ecological status (or other objectives under the Water Framework Directive) are at risk from increased sediment or suspended solids, the environment agencies will undertake monitoring with a view to assessing the likelihood and scale of impact and determining the causes. As a consequence of this, the agencies will seek action on causes in the manner required by the Water Framework Directive.

All this will involve keeping up with scientific publications that assess the effects of elevated suspended sediment concentrations on a range of ecological receptors.

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[1] With the associated procedures for quality control in sampling and measurement.

[2] Pollution prevention is the term given to the type of control that involves, for example, a structured programme of visits to selected sites, followed by recommendations of action, and follow-up visits,

[3] These are standard sets of conditions that apply to all sites engaged in particular activities. They are national measures that are not generally adjusted to local conditions. Examples include General Binding Rules; authorisations or registrations based on these; standards of good agricultural practice; planning advice notes; and regulations such as the Control of Pollution (silage, slurry and agricultural fuel oil) (Scotland) Regulations 2003.

Approaches to control suspended solids

The environment agencies work, for example, with organisations like the Construction Industry Research and Information Association on guidance and training[1]. Examples include:

- Environmental Good Practice Site Guide (C650). 2005
- Control of water pollution from linear construction projects. 2005
- Control of Water Pollution from Construction Sites (C532). 2000
- Pollution Prevention Guidance Note 5. Works in, near or liable to affect watercourses
- Pollution Prevention Guidance Note 6. Working at construction and demolition sites

The Environment Agency's work on *Best Farming Practices. Think Soils* (currently being piloted) is an example of how advice is promulgated for reducing erosion from farmland. Similarly, Defra has issued a *Code of Good Agricultural Practice for the Protection of Soil*[2] and advice on *Controlling Soil Erosion* (2005) and a *Cross Compliance Handbook - Soil Management Guidance* (2006) and the *Soil Protection Review* (2006)

The UKTAG sees this type of approach as a basis for moving forward in the future. A system of farm plans should be designed to help regulate in a consistent manner the risks of soil erosion.

[1] Pollution Prevention Guidance Notes: www.environment-agency.gov.uk/ppg.

[2] October 1998 (currently being revised into a code of good practice for farmers). See the Defra website.

WATER RESOURCES

This chapter looks at alterations to the freshwater flows to estuaries, and changes to river flow caused by managed releases of flow from reservoirs and impoundments[1] [17,18].

Under the Water Framework Directive, the UK is required to manage hydrological change to ensure that all surface water bodies aim to achieve good ecological status and that there is no deterioration in status. In terms of classification, the Directive specifies that hydromorphological quality elements must be explicitly considered when classifying for high status. For other status boundaries, the Directive does not require explicit consideration of hydromorphological features.

Changes in river flows caused by abstractions and discharges were considered in the UKTAG's first report on environmental standards and conditions [1,19]. This report also covered changes in the flow and level in lakes caused by abstractions and discharges.

There are no standards currently available to assess where alterations to the freshwater flows to estuaries may have ecological impacts. Neither are there standards to assess the changes in flow downstream of a reservoir or impoundment. The current regulation of these issues by the environment agencies is based largely on expert judgement.

Natural river flows vary, depending on a number of factors such as:

- the preceding weather
- the size of the catchment
- the geology of the catchment and the contribution of groundwater to river flows.

The variability of flow can be expressed in Flow Duration Curves as the percentage time a flow is exceeded over a long period of time (usually 10 years or more).

Impacts on flows from abstractions and discharges are controlled by restrictions on the quantities usually set in permits and licences. Dams and impoundments may be required to release controlled volumes of water to rivers; these too can have significant effects on river flows and ecology.

There are limited quantitative data on the relationships between changes in hydrology and the ecology of estuaries, and between ecology and the changes in flows downstream of reservoirs, but it is clear that such changes in hydrology do have an impact on ecology.

In response to the lack of data to support the development of ‘evidence-based’ standards, condition limits[2] have been developed that make use of assessments of the hydrological pressures to determine the risks to ecology.

[1] Some of these types of releases are called compensation flows - they compensate the river for natural flows lost because of the impoundment.
[2] In its reports, the UKTAG uses the term 'condition limits' to help make it clear that the criteria are not used in the same way as some of the 'environmental standards' developed, for example, for water quality. Condition limits are not used to define status. They indicate a risk that status is threatened.

The UKTAG's proposals will be used for screening purposes in order to assess if there is risk that a particular status may not be achieved. They will not be used as indicators of ecological status. Water bodies subject to significant impacts, as defined by the UKTAG's proposals, should be subject to further investigations that examine the need for action.

The methods used for in this chapter are underpinned by professional judgement. The methods will be updated, as new evidence becomes available. Over time, the aim is to confirm or replace professional judgement with more empirically tested data.

IMPACT ON ESTUARIES OF THE ABSTRACTION OF FRESHWATER FLOW

Typology for transitional water bodies

Many of the principles governing condition limits for flows in rivers apply also to flows to estuaries (transitional waters)[1] [1,19].

The typology used to characterise transitional water bodies for the Water Framework Directive was based on mixing characteristics, the salinity, and the tidal range. The mixing characteristics used an estimate of the average freshwater flow, and compared this with the volume of water in the water body.

The ecology in the zone of mixing between fresh and saline water is not well researched. Neither is the movement of this zone over the tidal cycle and with the range of freshwater inflows. It is considered that the benthic ecology of this zone is adapted to such variations, and that fish and migratory species are the most likely to be affected by changes in the regime.

A number of physical parameters were considered that might indicate a difference in the sensitivity to changes in the freshwater inflow. These included the volume of water of the tidal prism, the flushing volume between high and low tide, the time for such flushing to occur, and the volume of the inflow of freshwater.

To determine the freshwater flow condition limits applicable to a transitional water UKTAG will classify the transitional water as being of the Type specified in Table 26 below. This corresponds with the applicable description specified in Column 2 of this table.

[1] For estuaries, the Directive uses the term transitional waters.

Table 26: Criteria for identifying types of transitional water to which the freshwater flow conditional limits for transitional waters apply	
Type	Ratio of the total Qn_{95} freshwater inflow (in cubic metres per second) into the transitional water, or part thereof, from rivers with a catchment area ≥ 10 km^2; to the volume (in cubic metres) of water in the transitional water, or part thereof, at mean high water (V_H) $= \frac{\sum Qn95}{V_H} \times 1000$
High sensitivity (HS)	> 60
Medium sensitivity (MS)	35 - 60
Low sensitivity (LS)	< 35

Higher values of P_{95} or P_H indicate a greater proportion of fresh to saline water and are assumed to indicate a greater degree of sensitivity to the impacts of the abstraction of freshwater flow. For the majority of the 89 transitional water bodies assessed, both methods gave the same sensitivity.

The freshwater flow from the main river and the tributaries to the main estuary channel is considered to be the primary influence. Flows from areas adjacent to the transitional water body, that are not part of designated river water bodies, were considered to be significant in supporting the intertidal ecology but not to the ecology of the transitional water body as a whole. Such flows are small compared with flows from river water bodies and are unlikely to affect water quality or salinity gradients across the whole water body.

The method of ranking was not applied to sea lochs and saline lagoons. These were assigned high sensitivity because of their high dependence overall on inflows of freshwater in order to maintain stratification or flushing.

How the standards were developed

There are insufficient data to derive statistically valid relationships between ecological change and the impacts of abstraction on estuaries.

The UKTAG used workshops to draw on the advice of UK experts to develop its proposals. The workshops covered macrophytes, macro-invertebrates and fish, and considered combinations of physical parameters that could indicate the sensitivity of estuaries to the impacts of abstraction on freshwater flow [19].

Proposed conditions for freshwater flows

The UKTAG's proposed condition limits are in Tables 27, 28 and 29. The limits refer to natural flows. For example, the natural flow exceeded for 60 per cent of the time is labelled Qn60 in these tables. The condition limits are expressed as a reduction in terms of these summary statistics, of the natural inflow of freshwater to the estuary.

As noted above, the UKTAG proposes that these condition limits are used for screening.

Table 27: Condition limits for transitional waters likely to support good status

Type	Daily flows greater than or equal to Qn_{60}	Daily flows less than Qn_{60} but greater than or equal to Qn_{70}	Daily flows less than Qn_{70} but greater than or equal to Qn_{95}	Daily flows less than Qn_{95}
High sensitivity	40% of Daily Qn	35% of Daily Qn	30% of Daily Qn	25% of Qn95
Medium sensitivity	45% of Daily Qn	40% of Daily Qn	35% of Daily Qn	30% of Qn95
Low sensitivity	50% of Daily Qn	45% of Daily Qn	40% of Daily Qn	35% of Qn95
Inflows from areas adjacent to transitional waters that are not part of a defined water body are screened for net abstraction that are less than 30 per cent of Qn95				

Table 28: Condition limits for transitional waters likely to support moderate status

Type	Daily flows greater than or equal to Qn_{60}	Daily flows less than Qn_{60} but greater than or equal to Qn_{70}	Daily flows less than Qn_{70} but greater than or equal to Qn_{95}	Daily flows less than Qn_{95}
High sensitivity	55% of Daily Qn	50% of Daily Qn	45% of Daily Qn	40% of Qn95
Medium sensitivity	60% of Daily Qn	55% of Daily Qn	50% of Daily Qn	45% of Qn95
Low sensitivity	65% of Daily Qn	60% of Daily Qn	55% of Daily Qn	50% of Qn95

Table 29: Condition limits for transitional waters likely to support poor status

Type	Daily flows greater than or equal to Qn_{60}	Daily flows less than Qn_{60} but greater than or equal toQn_{70}	Daily flows less than Qn_{70} but greater than or equal to Qn_{95}	Daily flows less than Qn_{95}
High sensitivity	70% of Daily Qn	65% of Daily Qn	60% of Daily Qn	55% of Qn95
Medium sensitivity	75% of Daily Qn	70% of Daily Qn	65% of Daily Qn	60% of Qn95
Low sensitivity	80% of Daily Qn	75% of Daily Qn	70% of Daily Qn	65% of Qn95

Conditions for High Status

The UKTAG proposes that condition limits suggesting a threat to high status be defined according to the following impacts on the major inflows of freshwater. These are the same as high status for river water bodies:

- a net abstraction of less than 5 per cent of flows below Qn95; and,
- a net abstraction of 10 per cent of other flows.

Additional considerations in the method of assessment

- Freshwater inflows should be assessed separately for the 'arms' of a transitional water body as well as 'net' for the whole water body.

- Water bodies should be assessed as rivers to the point where the tidal influence occurs, and as transitional water bodies below this point.

- Abstractions and discharges within the transitional water body should be included in the assessment.

- Methods may need to be developed to assess the freshwater inflows from the marginal catchments.

- Freshwater flows to some estuaries may be higher than natural where there is significant input from discharges such as sewage treatment works. But this is rare in the UK and would need to be handled as site-specific issue.

Comparison with existing standards

Freshwater flow to transitional waters in the UK

There are no general methods for deciding the freshwater flows needed by estuaries. The topic was not considered in the Catchment Management Abstraction Strategies of the Environment Agency nor has it been considered by the agencies in Scotland and Northern Ireland.

IMPACTS OF MANAGED FLOWS

Impoundments, such as dams and their reservoirs, are constructed for a range of purposes including water supply, the generation of hydropower and the control of floods. The objective is to store water that may be used later for a variety of purposes. The use or release of the water may have significant impacts on the river flow downstream.

Given that some types of reservoirs can, for short periods, store all the flow from the upstream catchment (though large floods may pass the spillway), the flow regime downstream might be totally controlled by the operation of the impoundment. Active management is therefore required to generate a flow regime downstream.

This contrasts with abstraction, where many of the elements of the flow regime are largely untouched (for example, the variability of the regimes, and the high flows). For abstractions, the aim is to manage flow by restricting the quantities that can be taken.

The degree of manmade change to a flow regime will vary according to the size of the impoundment in relation to its catchment, and the purpose for which it was constructed. The operation of releases for hydropower will have different impacts than releases downstream of reservoirs used for public water supply. Similarly, the distance over which the changes to the flow can be detected will vary with the scale and time of change, and the inputs to the downstream river from tributaries and discharges.

Flows can be managed in a number of other ways. They might be augmented to increase low river flows to enable abstraction to take place downstream and to protect the flow in the river below the abstraction point. The augmentation may come from intermittent releases from the reservoir, or by pumping from groundwater.

In urban catchments, particularly those located in the headwaters of rivers, discharges of treated sewage effluent may lead to flows that exceed the natural because the returned flows exceed those abstracted upstream for water supply.

Development of criteria for managed flows

Managed flows can differ from the natural flows in a manner that is more complex than can be described as the simple percentages of flow used in setting criteria for rivers generally. The timing of the releases of flow, their variability, the magnitude of the high and low flows, and the duration of flows, may all be very different from the natural condition.

Causal links between ecology and managed flow regimes are also poorly understood, though there is increasing understanding of elements of a flow regime that may benefit different stages of the life cycle of a number of biota.

A number of workshops with experts considered how flow standards could be set for ‘managed flows’. These looked at which flow statistics could be used to consider a deviation from natural flow that would affect ecological status

Indicators of Hydrological Alteration

A suite of ‘Indicators of Hydrologic Alteration’ (IHA) was set up as means to assess the degree of artificial influence on river flow. These were identified through a review of the literature.

This suite uses 32 parameters to characterise the statistics of the flow regime that are relevant to the biology of a river. The parameters include the monthly flows, the magnitude and timing of annual extremes, the frequency and duration of high and low pulses of flow, plus the rate and frequency of changes.

The 32 indicators were used in an appraisal of the change in flows caused by impoundments. This can be done by comparing flow regime after the impoundment (the post-impounded regime) with that before the impoundment was built (the pre-impounded regime).

In many cases there are no flow data for the situation before the impoundment. In this case, the data will need to be synthesised from records of rainfall (and knowledge of the characteristics of the catchment), or from records of flow and other information from neighbouring catchments that have no impoundment. Another method is to calculate the effect of the impoundment on the measured river flows downstream, and use this to estimate the natural flows before the impoundment was built.

Any method of synthesising a long record of river flow data will have a level of uncertainty. Any summary statistic used to indicate significant differences between the pre- and post-impoundment flow regimes will have large confidence bands that reflect this uncertainty.

Studies of 480 upland catchments in England, Wales and Scotland show high degrees of correlation between the 32 parameters. These studies suggest that UK flow regimes may be characterised adequately by the 10 parameters listed in Table 30. Nearly all of these can be estimated simply from records of river flows, using gauged flows or flows estimated by the standard procedures used to support water resource planning (such as Low Flows 2000).

Table 30: Relationship between IHA parameters and Low Flows 2000

IHA parameter	Low Flows 2000 statistics, etc
mean January flow	mean January flow
mean April flow	mean April flow
mean July flow	mean July flow
mean October flow	mean October flow
mean of annual minimum 7 day flow	Q_{95} [1]
mean of annual maximum 7 day flow	Q_5
mean number of times per year the flow exceeds Q_{25}	Estimates based on the ratio of Q_{50}:Q_{95}
mean number of times per year the flow is less than Q_{75}	
mean fall rate - mean difference between falling flows	
mean number of rises in flow	Not available

Mean monthly flow

There is a high correlation within winter, spring, summer, autumn flows. This allows flow statistics for a single month to be used as an indicator of season.

The ratio between managed and natural flow can vary between the months, but especially between seasons. For example, compensation flows may be higher than natural in summer, but lower than natural in winter. Comparison of all the ratios of managed to natural monthly flows should ideally be made and the worst month used for assessment. Comparison for the

[1] The flow exceeded for 95 per cent of the time. Hence Q_5 is the flow exceeded for 5 per cent of the time, etc.

four single months chosen to represent the seasons is likely to be adequate to assess the degree of change.

Flow statistics for the cases with and without an impoundment can be calculated in a number of ways depending on the availability of data. Confidence in the data will vary according to the method of derivation.

Confidence in the results will depend on the source of data. Greatest confidence will derive from the use of recorded data. The use of calculations for natural flows based on Low Flows 2000, with recorded flows downstream of the impoundment, will have lower confidence than where the natural flows are measured directly. The use of Low Flows 2000 for the natural flows, and an impoundment model to estimate flows downstream of the impoundment, will have less confidence still.

Suggested thresholds for the degree of change in the chosen flow statistics are shown in Table 31. The flow statistics provide links to the criteria for rivers described in the first report by the UKTAG [1,19].

The method can be used to screen the hydrological impacts of ‘managed flows’, to assess the degree of departure from natural flows, and so form a basis for further investigations.

Table 31: Condition limits for alterations to river flow regimes

Flow statistic describing river flow regime	**Failure of any of the limits in this column indicates a risk to good status**
	Percentage deviation from natural flow regime
Monthly mean flow	$\pm$ 40 (in any month)
Qn_5	$\pm$ 40
Qn_{95}	+40[1]
Qn_{mean}/Q_{95}	$\pm$ 40
Mean number of rises in flow per year[2]	$\pm$ 40

The UKTAG suggests that values in the table are used for screening purposes to assess the hydrological alteration to flows downstream of impoundments. They should also be used to assess the distance downstream of the impoundment that the flow regime may be impacted.

In some cases there may be a negative relationship of one parameter and a positive relationship for another. This indicates that the flow regime has been skewed from its natural state. For example, high flows have been reduced and low flows have been increased. The degree of skew may also be indicated by the ratio of Q50 to Q95.

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[1] Condition limit refers only to increases in flow compared with Qn_{95}.

[2] This looks at turning points. It refers to the average number of days per year when the average flow is bigger than the average for the previous day and where, In turn, this flow for the previous day is smaller than the average for the day before that [16].

Implications

The proposed condition limits represent the first step in developing a more objective framework for decision-making. Further development will be possible after an extension project has been completed, examining the results of screening many managed flow regimes in the UK.

This is the first time condition limits for alterations to river flow regimes have been proposed for UK rivers. Consequently, the UKTAG would particularly welcome your views on these limits. If you operate an impoundment, the UKTAG would also welcome data you may hold on flow statistics downstream of the dam, so that we can compare these with the relevant condition limits as part of the testing phase.

MORPHOLOGICAL ALTERATIONS TO LAKES AND TRANSITIONAL AND COASTAL WATERS

This chapter describes risk assessment tools that have been developed to help determine whether changes to the morphology could pose a risk to ecology for:

- lakes;
- estuaries and costal waters – generally called Transitional and Coastal (TraC) waters for the Water Framework Directive .

Both tools are based on the method for rivers[1]. The tools are called Lake-MImAS[2] and TraC-MImAS. The principles underpinning them are similar.

Introduction

There are no environmental standards available to assess the ecological impacts of alterations to the morphology of lakes, estuaries and coastal waters. Where regulation occurs, decisions are based largely on expert judgement.

Under the Water Framework Directive, the UK is required to manage morphological change to ensure that all surface water bodies aim to achieve good ecological status and that there is no deterioration in status. In terms of classification, the Directive specifies that morphological quality elements must be considered explicitly when classifying for high status. For other status boundaries, the Directive requires that morphological conditions are consistent with the achievement of the values required for the biological quality elements.

There is limited quantitative data describing the relationships between morphological conditions and ecological status. It is clear however that human induced morphological pressures impact on ecology. It is recognised that different biological parameters may be more sensitive to certain hydrological or morphological processes than others, and that the relative sensitivities will differ according to variables such as the type of water body.

In the absence of data that are suitable to derive standards in an empirical way, two risk assessment tools have been developed. These employ the best available information on common morphological alterations and how these alterations affect morphological features and the flora and fauna these features support. Due to the lack of suitable data, the tools are underpinned by professional judgement. Over time, the aim is to confirm or replace such judgment with those based on empirically tested data.

The tools are intended to help regulators determine whether proposals to alter morphological features could threaten the objectives of the Water Framework Directive. The tools will not replace case specific use of expert judgment or case specific impact assessments. The tools will complement these and provide guidance to inform regulatory decisions.

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[1] Details of the Rivers-MImAS approach can be found on the UKTAG website. Technical details of the Lake-MImAS and TraC-MImAS tools can also be found on the UKTAG website [20-24]

[2] MImAS stands for <u>M</u>orphological <u>Im</u>pact <u>A</u>ssessment <u>S</u>ystem

General approach to regulating new proposals to alter morphology

The tools have been developed to help regulators determine whether morphological alterations could:

- threaten the achievement of good ecological status; or
- result in a deterioration of ecological status

Information on risks to ecological status will help regulators determine:

- when more detailed assessments will be necessary; and
- when deteriorations of status may need to be managed, for instance, by considering an exemption1.

Each UK agency will develop its own approach to undertaking more detailed assessments. These assessments are likely to include site specific case work and may include validation of the risk assessment, a more detailed assessment of the current morphological conditions, and a consideration of proposed mitigation measures.

The scope of any such assessment will be determined by the nature and complexity of the proposed activity and the perceived degree of risk to ecological status. Many such proposed activities already require a full or limited environmental assessment. The developer is usually responsible for undertaking the assessment to the satisfaction of the regulatory body.

Other elements of regulatory decision-making include ensuring:

- good practice guidelines are followed;
- proposals meet flood management requirements;
- conservation and biodiversity objectives are met; and
- the needs of interested parties are considered appropriately.

Concepts and Definitions

This section summarises the common principles and definitions underpinning the tools (Lake-MImAS and TraC-MImAS). Details for each tool are provided in later sections that are written so that readers can focus either on lakes or estuaries and coastal waters. This makes for some duplication for those reading both sections.

The tools comprise a series of interdependent modules. Collectively, the modules provide an assessment of the risk of impacts to *morphological conditions* from combinations of *morphological alterations*.

[1] On the basis of benefits to human health, human safety or sustainable development. Article 4.7 of the Water Framework Directive

Morphological conditions – *this refers to the list of attributes in Annex V of the Directive. For lakes, these attributes include the variation in depth, the quantity, structure and substrate of the bed of the lake, and structure of the shore. For estuaries and coastal waters the attributes include the variation of depth, the quantity, structure and substrate of the seabed, and structure of the intertidal and sub-tidal zones.*

Morphological alterations – *these are any pressures acting on the water environment that could affect morphological conditions. Examples include shoreline reinforcement and dredging.*

The tools use a concept of 'system capacity' to measure impacts on morphological conditions. It is assumed that different morphological alterations will use up different amounts of system capacity, with the amount of capacity being used depending on the:

- type of alterations;
- the sensitivity of the water environment to the alterations; and
- the spatial scale of the alterations.

System Capacity – *a measure of the ability of the water environment to absorb morphological alterations. The likelihood (or risk) that morphological and ecological conditions are degraded will increase as system capacity is consumed. This concept does not infer that degradation of the environment is acceptable; rather it assumes that there is a degree to which minor changes can be tolerated by the system.*

Where a new morphological alteration is proposed, the tool can be used to predict the impact of the proposal on 'system capacity'. By considering such impacts, the tool can be used to assess the level of risk presented by a proposal. This information can be used to inform regulatory decisions and to identify where more detailed assessments are required.

To help quantify the risk that a new morphological alteration could impair achievement of the objectives of the Water Framework Directive, a series of 'morphological condition limits' have been defined. Details of the proposed limits are provided in the following sections. Exceeding a morphological condition limit would indicate a risk to the ecological status of a water body.

Morphological Condition Limits (MCLs) – *thresholds of alteration to morphological conditions beyond which there is a risk that the Ecological status objectives of the WFD could be threatened. The limits are expressed in percentage capacity.*

The tools employ a series of assumptions:

- the section of water under assessment has some capacity to accommodate morphological change without changes to its ecological status;
- there is a relationship between the extent of morphological alteration and the impact on ecological status;
- the response of waters morphology to an engineering or other pressure is predictable for that type of water body; and

- the response of the ecology to morphological change is predictable and depends on the sensitivity of the ecology of the water body.

The tools are used to undertake risk assessments. The tools are not intended to:

- replace the need for detailed assessments or professional judgment;
- act as an engineering design tool;
- define remediation options;
- provide a quantitative assessment of the presence or quality of habitats; or
- consider conservation requirements (protected habitats and species or special features)[1].

Validation and Review

In recognition of the limited empirical information describing how morphological alterations influence flora and fauna, particularly for relatively modest alterations, a programme of validation and refinement is being developed. In the medium to long term, the aspiration is to incorporate information generated from monitoring undertaken for the Water Framework Directive and from dedicated scientific research programmes. Efforts will focus on:

- reviewing and test the assumptions underpinning the tools;
- refining the tools to reflect new evidence on the interaction between morphology and ecology, including replacing expert judgment with empirical data where possible; and
- generating further scientific evidence on the links between morphological alterations and ecological status.

In the short term, both tools have been subject to peer review and field trials. The trialling work compared decisions based on professional judgement of the ecological status of water bodies with the outputs from the tools. The decisions based on professional judgement on each water body were collated from workshop discussions and independent assessments.

The lake tool was tested on 95 water bodies in England, Wales, Scotland and Northern Ireland. The tool was shown to agree with professional judgment in 70 per cent of cases and was within one class boundary in 98 per cent of cases.

The tool for estuaries and coastal waters was tested on 30 water bodies in Northern Ireland, the Republic of Ireland and Scotland. The tool was shown to agree with professional judgement in over 80 per cent of cases. Where there were disagreements the tool was within one class boundary.

Documents summarising the results of the trialling and peer review work are on the UKTAG website.

[1] Conservation objectives will be dealt with through separate regulatory procedures. The MImAS tools would not replace or supersede any existing conservation assessments, targets or duties.

Application in regulation

It is envisaged that the tools will be applied in a two-stage screening process. In both stages, the tools would first be applied to assess current conditions. They would then be applied to assess whether there is a risk that a proposed alteration would cause a deterioration of ecological status. This assessment would be based on assessing whether a proposed morphological alteration would cause a condition limit to be exceeded.

Stage 1 would be a preliminary risk assessment. Within this it is expected that the tools would be applied at a local-scale (looking at lakes in sections of 0.5 kilometres and estuaries and coastal waters in areas of 0.5 square kilometres). This assessment would be used to identify low risk proposals that do not threaten ecological status.

Proposals that exceed the morphological condition limits at a local scale would be subject to Stage 2. Within this, the tools would be applied at a larger scale to determine if the morphological condition or the ecology of a water body could be threatened by a morphological alteration. This assessment may require extra data including information on the condition of the surrounding landscape.

The outputs from Stage 1 and Stage 2 would help determine:

- when more detailed assessments will be necessary; and
- when deteriorations of status may need to be managed, for instance, by considering an exemption[1] on the basis of benefits to human health, human safety or sustainable development.

A description of the spatial scaling rules that would be applied to assess risks to water bodies is provided in the following sections.

The most detailed assessments, including any further assessments to determine whether an test for regulatory exemption would be required, would typically be reserved for proposals exceeding the morphological condition limits at a water body scale. When determining whether an exemption would be required, each UK agency would be responsible for defining standard protocols for determining where additional expert judgment or other information (including information from detailed assessments) should be used to complement or validate the assessment made using the MImAS tools.

The risk assessment tools and condition limits

Lake-MImAS

The lake tool is based on five interrelated modules. Collectively the modules provide an assessment of impacts. All impacts are measured in terms of the effect on 'system capacity'. Each module is designed to be semi-independent of the others, allowing individual modules to be updated as more information becomes available. The modules are described below.

[1] Under Article 4.7 of the Water Framework Directive

1. The Attribute Module

This defines a list of attributes that can be used to assess morphological and ecological function and condition. The attributes are closely related to the morphological quality elements in Annex V of the Water Framework Directive. They cover such things as bathymetry, bed forms, substrate condition and the structure of the shore. Each attribute was chosen for its role in the direct or indirect support of ecological communities and the processes needed to create and maintain the physical environment on which ecological communities depend. Attributes have been defined for two lake zones: open water (pelagic/sub-littoral); and, shore.

2. The Typology Module

The typology contains six classes of lake type (Table 32) and incorporates the reporting typologies of the Irish and British eco-regions. Some types in the reporting typologies have been grouped. The groups are based on an assessment of similarities in physical characteristics and similarities in the likely responses to morphological alterations. These groupings will be subject to further review through validation and testing.

The typology allows an assessment of the relevance of the attributes (contained in the attribute module) to the different lake types. Where attributes are not relevant to a particular lake type, they would be excluded from assessments carried out on that lake type. For attributes that are relevant, the assumption is that they will display responses to morphological alterations that can be predicted.

Although typologies are simplified representations of complex and dynamic physical characteristics, they have been shown to be useful when assessing the likely physical and ecological responses to morphological alterations.

Table 32: Typology for the morphology of lakes[1]

Code	Depth (i)	Alkalinity/Geology (ii) (iii)
P/LA-vS	Very Shallow (vS)	Low Alkalinity (LA) to Peat catchments
P/LA-ShD	Shallow to Deep (ShD)	Low Alkalinity (LA) to Peat catchments
MA-vS	Very Shallow (vS)	Medium Alkalinity (MA)
MA-ShD	Shallow to Deep (ShD)	Medium Alkalinity (MA)
HA/M-vS	Very Shallow (vS)	High Alkalinity (HA) to Marl
HA/M-ShD	Shallow to Deep (ShD)	High Alkalinity (HA) to Marl

(i) Very Shallow – less than 3 metres deep; Shallow - 3 to 15 metres; Deep – more than 15 metres deep
(ii) Low Alkalinity – less than 10 mg/l as calcium carbonate; Medium Alkalinity – 10 to 50 mg/l ; High Alkalinity – more than 50 mg/l
(iii) Peat lakes –catchment areas with more 75 per cent of peat deposits; Marl lakes – catchment areas more than 65 per cent limestone.

[1] For lakes bigger than 50 hectares

3. Sensitivity Module

The Sensitivity Module is in two parts – ecological sensitivity and morphological sensitivity. For lakes, sensitivity incorporates a consideration of the resistance to change (the ability to absorb change) and the resilience to change (the ability to recover from change).

For the morphology component, the assessment considers the intrinsic sensitivities of each attribute to physical disturbances. This is carried out for each lake type. For the ecology component, the assessment considers whether a degradation of community or species integrity is likely to occur in response to a disturbance to individual attributes. Again, this is carried out for each lake type. The ecological assessment considers all biological quality elements covered by the Water Framework Directive – fish, benthic invertebrates, phytoplankton, and other aquatic flora.

All assessments within the sensitivity module are based on professional judgement. This was necessary given the current lack of empirical data on the links between biology and morphology. Testing and validating the sensitivity module will be a priority, and the module will be updated to reflect new evidence.

4. The Pressure Module

This module comprises two components – (i) an assessment of the likelihood that a morphological alteration will have an impact on an attribute (contained within the attribute module), and (ii) an assessment of whether the impacts are likely to be contained within the local vicinity of the pressure, or whether they will extend beyond this. The latter assessment defines the 'zone of Impact'.

Nineteen pressures have been incorporated in this module (Table 33[1]). They include shoreline pressures such as 'hard' engineering for bank protection, and whole-lake pressures such as impoundments. Not all the pressures are regulated. Where appropriate, non-regulated pressures may be considered as part of a risk assessment. The Pressure Module is not type specific. The difference in response to the pressures between lake types is captured by combining the Sensitivity Module with the Pressure Module.

[1] this list of morphological alterations may be reflected elsewhere by the other UKTAG environmental standards

Table 33: Morphological alterations considered for lakes	
Morphological Alteration	*Description*
Water level control and regulation	
Water level adjustment (active)	Active impounding structures (e.g. dam, sluice, weir) used to control lake level.
Raising or lowering (passive)	Changes in water level associated with outflow deepening or abstraction. Includes passive or abandoned lake level control structures.
Shore zone alterations	
Bank protection (hard engineering)	The use of consolidated materials such as concrete and steel sheet piling to stabilise shorelines (do not include water control structures, but do include docks and marinas made of hard engineering materials). Include use of rip-rap for bank-toe protection.
Bank protection (soft engineering)	Stabilisation of the shoreline using ‘soft’ materials including basket-work, planted saplings and live willow, dumped natural debris (to re-nourish sediment supply) and soft synthetic materials. Also includes earth-moving where re-sectioning and re-profiling takes place.
Flow/sediment altering structures	A range of engineering activities, which may be composed from a range of consolidated materials designed to afford shelter for ports, harbours, marinas and anchorage sites. Includes groynes that are introduced to counter the effects of longshore drift and promote the retention of beach sediments.
Piled structures	Range of constructions raised on one or more foundation structures extending out into the lake, e.g. bridges, piers, jetties and fishing platforms.
Outfalls & off-takes	Outfalls are artificial discharge structures, e.g. hydropower or cooling releases, while off-takes may be shore –based water abstraction schemes.
Flood embankments	An artificial bank of earth or stone created to prevent inundation of riparian areas and valuable infrastructure.
Within lake structures/activities	
Land claim	Engineering activities involving enclosing shore, littoral to sub-littoral areas with impermeable banks followed by infilling.
Dumping	Deliberate dumping of materials can range from mineragenic (rock and soil debris) to tipped debris (construction materials) and landfill waste.
Sediment extraction	Extraction of littoral zone substrates, most commonly associated with dredging to facilitate navigation, or aggregate extraction or habitat management.
Causeway	A physical barrier projecting from the shore lakewards whose foundations extend to the lake bed and where gaps in the foundings represent < 20% of the total length. Typically used to support transport routes.
Floating/tethered structures	A variety of floating structures, including cages used for commercial fish farming.
Macrophyte manipulation	Macrophyte management. This can be commercial harvesting of reeds, or the removal of vegetation growth to clear water for recreational activities.
High density moorings	Anchorage sites, typically concrete or metallic mooring blocks positioned in the littoral and sub-littoral zones to which boats are attached.
Lakeside/catchment pressures	
Riparian vegetation loss	Describes loss of natural vegetation cover and structure with implications for shading, cover, carbon fluxes etc.
Intensive recreational pressures	Intensive recreation activities occurring within and around a lake, includes motor boating activities.
Catchment area impounded	Percentage of upstream catchment regulated by reservoirs.
Intensive catchment land use	Percentage of catchment with intensive land us, includes urban, intensive agriculture or plantation forestry.

5. The Scoring System

The scoring system combines the information contained in each module to calculate a numerical 'impact rating'. Each morphological alteration in the pressure module has its own impact rating, which is specific to each lake type. The impact rating is calculated for each attribute in turn, and then averaged for attributes within the open water zone (pelagic/sub-littoral) and shore zone. This value is then multiplied by the zone of impact to give an overall impact rating for each morphological alteration.

The formula used to calculate the impact rating can be summarised as:

Equation 1

Impact rating										
=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
	Output from typology module		Output from sensitivity module		Output from sensitivity module		Output from pressure module		Output from pressure module

Table 34 and 35 summarise the impact ratings for the open water zone and the shore zone calculated using Lake-MImAS.

To determine the percentage capacity used within a particular lake or section of lake, the impact ratings are combined with 'alteration footprints' for all morphological alterations present within the section of estuarine or coastal water being assessed.

An 'alteration footprint' describes the type and extent of a morphological alteration. Different alterations will have different footprints, for instance, the footprint for shoreline reinforcement is the length over which the reinforcement occurs, whereas the footprint for dredging is the area over which dredging occurs.

The formula used to calculate the capacity consumed by a single pressure, or combination of pressures within a predetermined assessment area/length, can be summarised as:

Equation 2

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length of assessment unit}} \right) \times 100$$

Where n is the number of morphological alterations within the assessed length; and ∑ ( ) is the sum of results given by the equation specified in the parenthesis for each of the 'n' alterations.

Table 34: Impact ratings for morphological alterations – open water zone						
	Lake Type (Table 31)					
Morphological Alteration	P/LA-vS	P/LA-ShD	MA-vS	MA-ShD	HA/M-vS	HA/M-ShD
Water level control and regulation						
Water level adjustment (active)	1.40	0.50	1.20	0.60	0.80	0.40
Raising or lowering (passive)	1.00	0.35	0.85	0.45	0.65	0.30
Shore zone alterations						
Bank protection (hard engineering)	0.10	0.00	0.10	0.00	0.03	0.00
Bank protection (soft engineering)	0.10	0.00	0.10	0.00	0.03	0.00
Flow/sediment altering structures	0.25	0.13	0.20	0.15	0.10	0.10
Piled structures	0.23	0.04	0.19	0.04	0.08	0.04
Outfalls & off-takes	0.70	0.25	0.00	0.30	0.40	0.20
Flood embankments	0.20	0.03	0.00	0.05	0.13	0.03
Within lake structures/activities						
Land claim	0.90	0.34	0.38	0.38	0.45	0.26
Dumping	0.83	0.30	0.38	0.34	0.41	0.23
Sediment extraction	0.79	0.30	0.75	0.30	0.34	0.19
Causeway	1.20	0.50	0.00	0.60	0.60	0.40
Floating/tethered structures	0.25	0.10	0.25	0.10	0.10	0.08
Macrophyte manipulation	0.30	0.11	0.75	0.11	0.11	0.08
High density moorings	0.20	0.08	0.50	0.08	0.08	0.05
Lakeside/catchment pressures						
Riparian vegetation loss	0.15	0.03	0.35	0.03	0.05	0.03
Intensive recreational pressures	0.30	0.15	0.00	0.15	0.13	0.10
Catchment area impounded	0.30	0.20	0.50	0.23	0.25	0.15
Intensive catchment land use	0.45	0.20	0.25	0.23	0.25	0.15

Table 35: Impact ratings for morphological alterations – shore zone

Morphological Alteration	P/LA-vS	P/LA-ShD	MA-vS	MA-ShD	HA/M-vS	HA/M-ShD
	Lake Type (Table 31)					
Water level control and regulation						
Water level adjustment (active)	2.10	2.10	2.10	2.10	1.20	1.20
Raising or lowering (passive)	1.35	1.35	1.35	1.35	0.98	0.98
Shore zone alterations						
Bank protection (hard engineering)	0.60	0.60	0.60	0.60	0.41	0.41
Bank protection (soft engineering)	0.40	0.40	0.40	0.40	0.28	0.28
Flow/sediment altering structures	0.75	0.75	0.75	0.75	0.45	0.45
Piled structures	0.45	0.45	0.45	0.45	0.30	0.30
Outfalls & off-takes	0.90	0.90	0.90	0.90	0.50	0.50
Flood embankments	0.28	0.28	0.28	0.28	0.15	0.15
Within lake structures/activities						
Land claim	1.10	1.10	1.10	1.10	0.60	0.60
Dumping	1.10	1.10	1.10	1.10	0.60	0.60
Sediment extraction	1.20	1.20	1.10	1.10	0.65	0.65
Causeway	1.00	1.00	1.00	1.00	0.60	0.60
Floating/tethered structures	0.40	0.40	0.40	0.40	0.25	0.25
Macrophyte manipulation	0.60	0.60	0.56	0.56	0.23	0.23
High density moorings	0.35	0.35	0.35	0.35	0.18	0.18
Lakeside/catchment pressures						
Riparian vegetation loss	0.35	0.35	0.35	0.35	0.18	0.18
Intensive recreational pressures	0.45	0.45	0.45	0.45	0.20	0.20
Catchment area impounded	0.50	0.40	0.40	0.40	0.23	0.23
Intensive catchment land use	0.40	0.40	0.40	0.40	0.23	0.23

Morphological condition limits for lakes

Morphological condition limits are defined for two lake zones – open water (pelagic / sub-littoral) and shore. Distinguishing between these zones provides a simple method of identifying which aspect of a lake is likely to be impacted. This information is useful when defining the scope of a more detailed assessment.

The proposed morphological condition limits are in Table 36. Exceeding these limits would indicate a risk to the status objectives of the Water Framework Directive. All morphological condition limits will be subject to review as new evidence becomes available.

Table 36: Proposed morphology condition limits for lakes

Zone	*System capacity used (%)*			
	High	**Good**	**Moderate**	**Poor**
Pelagic / sub-littoral	5	15	30	45
Shore	5	15	30	45

The limits in Table 36 are not type specific. The differences in response between lake types are taken into account within the scoring system of the tool.

As the impact rating for a particular morphological alteration influences how much system capacity an alteration consumes, the limits do not simply mean, for instance, that 5 per cent of the shoreline can be reinforced before a risk to high status is identified.

Operational guidelines will be developed to protect those high status sites with special features that are not explicitly considered within Lake-MImAS.

Spatial scaling rules for assessing risks to lake water bodies

Each lake water body would be treated as a discrete entity. Equation 2 would be applied directly to each water body to calculate the capacity consumed from all current and proposed morphological alterations. The capacity used by these alterations would be compared with the condition limits to assess risks to ecological status. Where a lake comprises more than one water body, the tool would be applied to each water body.

Estuaries and coastal waters: TraC-MImAS

This tool is also based on five interrelated modules that provide an assessment of impacts to morphological conditions. All impacts from morphological alterations are quantified as impacts to ‘system capacity’. Each module is semi-independent of the others, allowing them to be updated as more information becomes available. The modules are described below.

1. The Attribute Module

This defines a list of attributes used to assess geomorphic and ecological function and condition. The attributes are related closely to the morphological quality elements in Annex V of the Water Framework Directive. They cover such things as variation in depth, the flow, quantity and structure of substrate and bed, and exposure to waves. Each attribute was chosen for its role in the direct or indirect support of ecological communities and the supporting processes needed to create and maintain the physical environment on which ecological communities depend. Attributes have been defined for three zones – hydrodynamic, inter-tidal and sub-tidal zone. The hydrodynamic zone describes the movement of water, including tides, currents and freshwater mixing.

2. The Typology Module

The typology established for the eco-regions of Great Britain and the Republic of Ireland have been simplified into six types (Table 37). Groupings were based on an assessment of similarities in physical characteristics and similarities in likely responses to morphological alterations. To improve the assessment of morphological responses to alterations, dominant geology has been incorporated into the typing of coastal water bodies. This creates three coastal water body subtypes: sheltered coastal sedimentary, exposed coastal sedimentary and coastal bedrock (sheltered to exposed). These groupings will be subject to further review through validation and testing of the tool.

The typology allows a simple assessment of the relevance of the attributes (contained in the attribute module) to the different types. Where attributes are not relevant to a particular type, they would be excluded from any assessments carried out on that type. For attributes that are relevant, the assumption is that they will display predictable responses to morphological alterations.

Although typologies are simplified representations of complex and dynamic physical characteristics, they have been shown to be useful when assessing the likely physical and ecological responses to morphological alterations.

Table 37: Typology for estuaries and coastal waters		
TRaC Type	**Morphological characteristics**	**MImAS Code**
TW6, CW10	TraC Lagoons	TraC lagoons
TW5, CW11,CW12	TraC Sea Lochs.	TraC sea lochs
TW1 to TW4	Partially to fully mixed, meso-tidal to macro-tidal, intertidal or shallow subtidal, sand and mud	Transitional meso- to macro-tidal
CW7 to CW9	Sheltered, micro-tidal to macro-tidal. Sedimentary	Sheltered coastal - sedimentary
CW1 to CW6	Moderately to exposed, macro-tidal. Sedimentary	Moderately to exposed coastal- sedimentary
CW1 to CW9	Sheltered to exposed, micro to macro-tidal	Coastal bedrock

3. Sensitivity Module

The Sensitivity Module is divided into two parts – ecological sensitivity and morphological sensitivity. Sensitivity incorporates consideration of the resistance to change (the ability to absorb change) and the resilience to change (the ability to recover from change).

For the morphology component, the assessment considers the intrinsic sensitivities of each attribute to physical disturbances. This is carried out for each type. For the ecology component, the assessment considers whether a degradation of community or species integrity is likely to occur in response to a disturbance to individual attributes. Again, this is carried out for each type. The ecological assessment considers all biological quality elements – fish, benthic invertebrates, phytoplankton, and other aquatic flora.

All assessments within the sensitivity module are based on professional judgement. This was necessary given the current lack of empirical data on the links between biology and morphology. Testing and validating the sensitivity module will be a priority, and the module will be updated to reflect new evidence.

4. The Pressure Module

This module comprises two components: (i) assessment of the likelihood that a morphological alteration will have an impact on an attribute (contained within the attribute module); and (ii) an assessment of whether impacts are likely to be contained within the local vicinity of the pressure, or whether they will extend beyond this. The latter assessment defines the 'zone of Impact'.

Fifteen pressures are included (Table 38[1]). They cover shoreline pressures such as 'hard' engineering for bank protection, and pressures such as barrages and dredging. The Pressure Module is not type specific. The difference in response to the pressures between types is captured by combining the Sensitivity Module with the Pressure Module.

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[1] this list of morphological alterations may be reflected elsewhere by the other UKTAG environmental standards

5. The Scoring System

The scoring system combines the information contained in each module to calculate a numerical 'impact rating'. Each morphological alteration contained with the pressure module has its own impact rating, which is specific to each type of water body. The impact rating is calculated for each attribute in turn, and then averaged for attributes within hydrodynamic, intertidal and subtidal zones. This value is then multiplied by the zone of impact to give an overall impact rating for each morphological alteration.

The formula used to calculate the impact rating can be summarised as:

Impact rating										
	=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
		Output from typology module		Output from sensitivity module		Output from sensitivity module		Output from pressure module		Output from pressure module

Tables 39 to 41 summarise the Impact ratings calculated for each zone – hydrodynamic, intertidal and subtidal.

To determine the percentage capacity used within a water body or section of water body, the impact ratings are combined with 'alteration footprints' for all morphological alterations present within the section of estuarine or coastal water being assessed.

An 'alteration footprint' describes the type and extent of a morphological alteration. Different alterations will have different footprints, for instance, the footprint for shoreline reinforcement is the length over which the reinforcement occurs, whereas the footprint for dredging is the area over which dredging occurs.

The formula used to calculate the capacity consumed by a single pressure, or combination of pressures within a predetermined assessment area/length, can be summarised as:

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length/area of assessment unit}} \right) \times 100$$

Where n is the number of morphological alterations within the assessed length/area; and ∑ ( ) is the sum of results given by the equation specified in the parenthesis for each of the 'n' alterations.

Table 38: Morphological alterations considered for estuaries and coastal waters	
Morphological Alteration	*Description*
Land and channel alteration	
Land claim- High impact	Recent or proposed enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Also used for land claim that has taken place in the past and is still deemed to be having a significant impact.
Land claim- Low impact	Historic (e.g. >50yrs ago) enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. Can also be used for more recent land claim where the impacts are minimal or where the surrounding environment has partly recovered natural habitats and features.
Tidal channel realignment- High impact	Recent or proposed realignment of a tidal channel. Also used for realignments that have taken place in the past and is still deemed to be having a significant impact.
Tidal channel realignment- Low impact	Low impact alterations to the course or the planform of upper estuaries where the channel remains river-like. Includes straightening and removal of meanders to increase channel gradient and flow velocity. Typically used to cover historic work (e.g. >50yrs ago) and where the channel has partly recovered natural habitats and features.
Sediment manipulation	
Dredging- High Impact	The excavation of sediments where there is likely to be considerable damage caused to seabed environment, both within and out with the area dredged. Typically reserved for situations where dredging has not taken place in the past or where dredging has taken place within the last 10 years and impacts are still likely to be present. Typically reserved for situations where sediments are removed to a depth of greater than 1m.
Dredging- Low impact	The excavation of sediments where the damage is likely to be restricted to the area being dredged. May be used for capital dredging where the impacts are likely to short lived or are being minimised through the use of best practice. Could also be used to capture areas that have been dredged in the past and where there is evidence that some impacts still exists. Some forms of trawling could be captured under this category.
Other alterations to bed substrate	Any other temporary disturbances to bed morphology or substrate character where the impacts are likely to be remain restricted to the area of bed directly disturbed and where the bed is likely to recover significantly over time. Could include some forms of trawling.
Disposal of dredged materials	The deposit of dredged material onto intertidal and subtidal areas for the purposes of disposal.
Flow/sediment altering Structures	
Piled Structures	A range of structures raised on one or more foundation structures extending out into the adjacent water body e.g. bridge and pier supports. This category also includes wind turbine monopiles.
Flow/sediment manipulation structures	Hard engineering structures built to stabilise waterways for navigation and counter the effects of longshore drift. These include breakwaters, piers, groynes, flow deflectors, training walls etc.
Impounding structures	A temporary (e.g. barrage) or permanent structure that extends across a channel that is used to impound, measure or alter flow (e.g. weirs, sluices).
Causeway	A physical barrier projecting from the shore whose foundations extend to the bed and where gaps in the foundings represent < 20% of the total length. Typically used to support transport routes.
Shoreline alterations	
Shoreline reinforcement – High Impact	The use of consolidated materials, e.g. rock armour, revetments, retaining walls, gabion baskets, seawalls, wharves, sheet piling etc. to protect vulnerable coastlines or harbours from erosion. Refers to situations were the reinforcement is having a persistent influence over the intertidal or subtidal zone.
Shoreline reinforcement – Low impact	Stabilisation of the shoreline using beach material to maintain beach levels and dimensions. May include use of synthetic materials. Also includes other forms of low impact shoreline protection, for instance protection that is set back and does not have a persistent influence over the intertidal or subtidal zones.
Flood defence embankment	An artificial bank of earth or stone created to prevent inundation of estuarine and coastal floodplains.

Morphological Alteration	Transitional	Transitional or coastal		Coastal		
	Meso-Macro tidal	Lagoon	Sea Loch	Sheltered Sedimentary	Exposed Sedimentary	Sheltered to Exposed Bedrock
Land and channel alteration						
land claim- High impact	0.50	0.50	0.50	0.25	0.25	0.25
land claim- Low impact	0.13	0.13	0.13	0.06	0.06	0.06
Tidal channel realignment- High impact	0.38	0.19	0.19	0.19	0.19	0.19
Tidal channel realignment- Low impact	0.13	0.06	0.06	0.06	0.06	0.06
Sediment manipulation						
Dredging- High Impact	0.06	0.00	0.00	0.06	0.00	0.00
Dredging- Low impact	0.06	0.00	0.00	0.06	0.00	0.00
Other alterations to bed substrate	0.06	0.00	0.00	0.06	0.00	0.00
Disposal of dredged materials	0.06	0.00	0.00	0.06	0.00	0.00
Flow/sediment altering Structures						
Piled Structures	0.06	0.06	0.06	0.06	0.06	0.06
Flow/sediment manipulation structures	0.06	0.00	0.00	0.06	0.06	0.09
Impounding structures	0.50	0.50	0.50	0.25	0.25	0.25
Causeway	0.28	0.28	0.28	0.19	0.19	0.19
Shoreline alterations						
Shoreline reinforcement – High Impact	0.06	0.06	0.06	0.06	0.06	0.06
Shoreline reinforcement – Low impact	0.00	0.00	0.00	0.00	0.00	0.00
Flood defence embankment	0.00	0.00	0.00	0.00	0.00	0.00

Table 39: Impact ratings for morphological alterations - hydrodynamic zone

Morphological Alteration	Transitional	Transitional or coastal		Coastal		
	Meso-Macro tidal	Lagoon	Sea Loch	Sheltered Sedimentary	Exposed Sedimentary	Sheltered to Exposed Bedrock
Land and channel alteration						
land claim- High impact	1.33	0.83	0.83	1.00	1.67	0.33
land claim- Low impact	0.50	0.29	0.29	0.33	0.58	0.08
Tidal channel realignment- High impact	0.88	0.56	0.56	0.63	1.13	0.25
Tidal channel realignment- Low impact	0.42	0.25	0.25	0.25	0.50	0.08
Sediment manipulation						
Dredging- High Impact	0.67	0.67	0.67	0.67	0.67	0.33
Dredging- Low impact	0.25	0.25	0.25	0.25	0.25	0.13
Other alterations to bed substrate	0.13	0.13	0.13	0.13	0.13	0.08
Disposal of dredged materials	0.25	0.25	0.25	0.25	0.25	0.13
Flow/sediment altering Structures						
Piled Structures	0.33	0.21	0.21	0.25	0.42	0.08
Flow/sediment manipulation structures	0.31	0.25	0.25	0.31	0.50	0.13
Impounding structures	1.33	0.83	0.83	1.00	1.67	0.33
Causeway	0.28	0.28	0.28	0.19	0.19	0.19
Shoreline alterations						
Shoreline reinforcement – High Impact	0.17	0.13	0.13	0.17	0.25	0.08
Shoreline reinforcement – Low impact	0.13	0.08	0.08	0.13	0.13	0.00
Flood defence embankment	0.17	0.13	0.13	0.17	0.25	0.08

Table 40: Impact ratings for morphological alterations – intertidal zone

Morphological Alteration	Table 41: Impact ratings for morphological alterations – subtidal zone					
	Transitional	Transitional or coastal		Coastal		
	Meso-Macro tidal	Lagoon	Sea Loch	Sheltered Sedimentary	Exposed Sedimentary	Sheltered to Exposed Bedrock
Land and channel alteration						
land claim- High impact	1.33	0.67	0.83	1.00	1.33	0.33
land claim- Low impact	0.50	0.25	0.29	0.33	0.42	0.08
Tidal channel realignment- High impact	0.88	0.50	0.56	0.63	0.88	0.25
Tidal channel realignment- Low impact	0.42	0.25	0.25	0.25	0.33	0.08
Sediment manipulation						
Dredging- High Impact	0.50	0.67	0.50	0.83	0.17	0.33
Dredging- Low impact	0.19	0.25	0.19	0.31	0.06	0.13
Other alterations to bed substrate	0.08	0.08	0.13	0.17	0.00	0.08
Disposal of dredged materials	0.19	0.19	0.19	0.31	0.06	0.13
Flow/sediment altering Structures						
Piled Structures	0.33	0.17	0.21	0.25	0.33	0.08
Flow/sediment manipulation structures	0.31	0.19	0.19	0.31	0.44	0.13
Impounding structures	1.00	0.50	0.63	0.75	1.00	0.25
Causeway	0.28	0.28	0.28	0.19	0.19	0.19
Shoreline alterations						
Shoreline reinforcement – High Impact	0.31	0.19	0.19	0.31	0.44	0.13
Shoreline reinforcement – Low impact	0.17	0.08	0.08	0.17	0.17	0.00
Flood defence embankment	0.13	0.08	0.13	0.13	0.21	0.08

Morphological condition limits for estuaries and coastal waters

Morphological condition limits are defined for the three zones- hydrodynamic, inter-tidal and sub-tidal zone. Distinguishing between these zones provides a simple method of identifying which aspect of a water is likely to be impacted. This information will be useful when defining the scope of a more detailed assessment.

The morphological condition limits proposed for these zones are set out in Table 42. Exceeding these limits would indicate a risk to status objectives of the Water Framework Directive. All morphological condition limits would be subject to review as new evidence becomes available.

Table 42: Proposed morphology condition limits for estuaries and coastal waters

Zone	*System capacity used (%)*			
	High	**Good**	**Moderate**	**Poor**
Hydrodynamic	5	15	30	45
Intertidal	5	15	30	45
Subtidal	5	15	30	45

The capacity limits presented in Table 42 are not type specific. The differences in response between types are taken into account within the risk assessment tools scoring system.

As the impact rating for a particular morphological alteration influences how much system capacity an alteration consumes, the limits do not simply mean, for instance, that 15 per cent of the shoreline can be reinforced before a risk to good status is identified.

Operational guidelines will be developed to protect those high status sites with special features that are not explicitly considered within TraC-MImAS.

Spatial scaling rules for assessing risks to TraC water bodies

A set of Regulatory guidelines for applying TraC-MImAS to assess risks to water bodies are outlined below. These guidelines will be reviewed in light of new evidence.

Water body spatial scaling: rule one

Equation 2 is recommended for use in calculating:

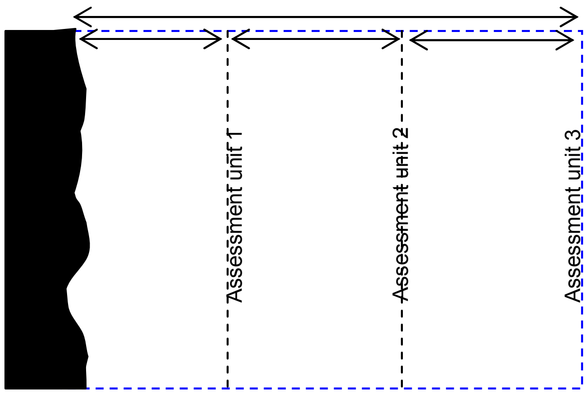
(a) the capacity being used in each zone (hydrodynamic, intertidal and subtidal) within a water body by all the existing morphological alterations to the water body; and

(b) the capacity which would be used in each zone by the combination of the existing alterations and any proposed additional alterations.

The results of applying Equation 2 would be compared with the condition limits in Table 42 to assess risks to ecological status. This rule is water body scale dependent – i.e. more alteration could occur in larger water bodies before a risk to status is detected.

For TraC waters that are lagoons, lochs and estuaries, rule one would be applied directly to the whole water body. For coastal water bodies that extend beyond 1 nautical mile to sea, if considered appropriate the water body may be split into distinct units. For example, each unit could be 1 nautical mile seaward width. Each would be assessed separately. The overall status of the water body would then be based on the lowest status recorded in any unit (Figure 3).

Figure 3: Water bodies that extend beyond 1 nautical mile to sea



Equation 2:

$$\text{Capacity of hydrodynamic zone used} = \sum n \left(\frac{IR_H \times F}{A_H} \right) \times 100$$

$$\text{Capacity of intertidal zone used} = \sum n \left(\frac{IR_I \times F}{A_I} \right) \times 100$$

$$\text{Capacity of subtidal zone used} = \sum n \left(\frac{IR_S \times F}{A_S} \right) \times 100$$

Where:

"F" is the footprint of a morphological alteration as measured by the total area in km^2 or length in km of that alteration in the water body or in the appropriate part thereof indicated in Figure 3;

"A_H" is the area in km^2 of the hydrodynamic zone of the water body or the appropriate part thereof indicated in Figure 3 above; "A_I" is the corresponding area in km^2 of the intertidal zone and "A_S" is the corresponding area in km^2 of the subtidal zone; and

"IR_H" is the impact rating of a morphological alteration with respect to the hydrodynamic zone; "IR_I" is the impact rating with respect to he intertidal zone and "IR_S" is the impact rating with respect to the subtidal zone.

Water body spatial scaling rule two

Equation 3 is recommended for determining spatial condition limits for discrete morphological alterations. Failure of these limits would indicate that the adverse impacts resulting from a discrete morphological alteration are likely to be significant enough to affect the status of a water body. Equation 3 should not be applied to generate spatial condition limits for transitional water lagoons or coastal water lagoons.

Equation 3:

$$SCL = \frac{MCL \times A_{SCL}}{IR_L}$$

Where:

"SCL" is the spatial condition limit for an alteration and is given as the maximum discrete area (km^2) or length (km) of the alteration, depending on whether the scale of the alteration is measured in terms of area or length;

"MCL" is the morphological condition limit specified in Table 42 with which the water body complies in accordance with rule one above.

"A_{SCL}" is the area (km^2) or length (km) of the part of the water body to which the spatial condition limit applies. This should not exceed 20 km if the scale of the alteration is measured in terms of the length of the alteration; or 32 km^2 if the scale of the alteration is measured in terms of the area of the alteration; and

"IR_L" is the largest of the impact ratings specified in Tables 39, 40 or 41and applicable to the morphological alteration.

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