# MAT Scoring and Weighting System

# for Water Quality Improvements

Final Version 1999

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# 1. OVERVIEW

## 1.1 Introduction

This note presents the multi-attribute based methodology which has been used by the Environment Agency in assessing the benefits of surface water quality improvements as part of the third Periodic Review. The impetus behind the development of this methodology was the need for water quality planners within the Agency to assess the relative costs and benefits of all schemes being proposed for discretionary expenditure as part of AMP3. This requirement stems from the Environment Act 1995, which placed a duty upon the Agency to consider the wider costs and benefits of its actions. This duty, however, is not prescriptive in nature, allowing the Agency to determine the most appropriate approach for taking such costs and benefits into account.

Although this methodology was developed specifically to assist with the Periodic Review, it is only one of a number of different assessment approaches which is being used by the Agency to assist in assessing costs and benefits. In the context of water quality planning, other methods being used include proformas and economic cost-benefit analysis [including application of the Foundation for Water Research Manual on 'Assessing the Benefits of Surface Water Quality Improvements' (FWR, 1996)]. Together, these different approaches are seen as providing the Agency with a hierarchy of assessment tools which can be called upon as appropriate to assist with different types of decisions.

In developing the methodology presented here, the aim was to prepare a system which would provide a robust assessment of potential benefits, yet could be readily applied given time and resource constraints. Furthermore, as this methodology is one of a set to be used by planners, it was also been developed to be as complementary as possible to other existing assessment approaches. Of significance in this regard is the FWR Manual, which was referred to when developing the scoring and weighting systems presented below, although other data were also been taken into account. Work was also undertaken to ensure that the results of the two approaches are broadly comparable.

This methodology was used to assist in screening, ranking, prioritisation (in terms of cost-effectiveness[1]) and justification (through comparison of costs and benefits) of proposed schemes for submission as part of non-core (discretionary) expenditure. It was designed for assessment of the benefits associated with river water quality improvements. A companion methodology exists for the assessment of schemes affecting coastal and estuarine waters. In some cases, the two systems may need to be used together, for example, where a scheme would impact on both river based activities (such as migratory fisheries) and on coastal activities. Work on the development of similar systems for other environmental and resource management issues is currently under consideration.

1 Strictly speaking, because effectiveness is measured in terms of a number of different attributes, the resulting measure is one of cost-utility. This is discussed in more detail in Section 11.

## 1.2 Overview of the MAT Methodology

Multi-attribute or multi-criteria techniques are often noted as alternatives to the use of cost-benefit analysis for project or programme assessment and prioritisation. In common with cost-benefit analysis, the aim of such techniques is to provide a means for aggregating disparate information on impacts into either a single, common measure of impact or a reduced number of impact indicators. A wide range of techniques is included under the general heading of multi-attribute techniques, where these include highly sophisticated methodologies through to the application of simple rating systems.

In general, multi-attribute techniques (MAT) are characterised by four steps:

- problem structuring;
- application of a scoring or rating system to predicted impacts;
- application of a weighting system to indicate the importance of one impact category as compared to another; and
- the aggregation of weighted scores into an overall measure of impact.

One of the advantages that this type of methodology has over the use of full monetary cost-benefit analysis (such as the approach provided within the FWR Manual) is that, through the use of subjective weights, the viewpoints of different groups within society can be examined in a more transparent manner.[2] This includes identifying whether different value systems would change the conclusions of an assessment. This compares to cost-benefit analysis which effectively relies on a single set of weights for aggregation.

*Problem Structuring*

The methodology presented here was developed for assessing continuous discharges as it relies in many cases on the use of information concerning changes in River Ecosystem (RE) Classification and General Quality Assessment (GQA) classification.[3] The different types of benefits which may arise from water quality improvements in any particular stretch of river are then as follows (based on the categories defined in the FWR Manual):

- informal recreation;
- angling;
- in-stream recreation;
- agriculture;
- industrial and drinking water abstractions;

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2 Cost-benefit analysis as carried out using the FWR Manual relies on the use of mean willingness to pay values to provide an indication of the 'value' of an environmental improvement. As a result, a single unit of measure (money) and associated weight (the mean value) is assumed, although sensitivity analysis can be undertaken to test the implications of assuming different valuations. In general, however, reliance on the use of mean values reduces information on the spread of views within a given population.

3 At this point in time, the methodology set out in the existing UPM Manual concerning the assessment of intermittent discharges is not compatible with the type of approach set out here. Further work to enable such assessment would be required.

- amenity value (to urban and rural property);
- nature conservation; and
- scheme costs.

Most of these impact categories are centred around direct and indirect use of the river environment by man, reflecting the importance of changes in water quality to such uses. The impacts of water quality changes on the functioning of ecosystems and the natural environment generally are also important, and the latter category has been developed to reflect this aspect (although some may argue that this is inadequate). In assessing the impact of water quality changes to each of the impact categories, the methodology considers a number of different attributes which will affect the resulting value of a change in quality.

To the degree possible, these attributes included within this system are the same as those which would be considered when applying economic cost-benefit analysis, for example, using the approach presented in the FWR Manual. There are some exceptions, however, with the most important being the treatment of nature conservation. These differences are noted in the relevant Sections.

In terms of other potential impacts, efforts were made to include an attribute representing the nuisance associated with sewage treatment works. However, it soon became clear that Agency staff would face considerable difficulties in collecting the data required for such an assessment. As a result, inclusion of such effects will have to be considered as part of further development work, taking into account the availability of data on complaints, levels of heavy goods traffic associated with sewage sludge disposal, etc. The other main issue which requires further work should this system be developed for future applications is whether or not it could provide a better indication of the degree to which a scheme contributes to achieving sustainable development principles. Within the time frame available for development and application of this system, there was concern over the potential for double-counting if higher level 'sustainability' attributes such as economic development were introduced into the system. As a result, a decision was made not to attempt to add specific sustainability attributes at this point in time, leaving the question of how to explicitly address sustainability to future development activities.

*Scoring or Rating of Impacts*

A number of different approaches could be adopted for defining the scores to be placed on different levels of impact. Numerical ranges can be developed based on physical units of measure for different impacts, or qualitative descriptors can be used in cases where measurement problems exist. Standards, technological performance limits, etc. can also form the basis for defining numerical ranges. Similarly, expert judgement and public perception surveys can be relied upon for establishing the scaling system.

In mathematical terms, the aim is to transform impacts into a common linear scale of damage or desirability which is amenable to weighting and aggregation. The preferred approach is to score each individual attribute on a proportional basis, with 100 representing the highest possible score and zero the lowest. So for example, the longest length of river would score 100, with all other rivers then being scored in proportion to that length. This approach was considered initially, but was not adopted. Given the number of parameters which would need to be scored in total and the number of schemes under consideration (over 900 different river improvement schemes), the scoring requirements would become overly complex and time consuming.

Instead, a Likert scale running from 1 to 5 was adopted, where 1 represents a low level of impact and 5 a high level of impact. Within this scale, scores of 1, 3 and 5 are the three main scores, with these relating to poor/low, fair/moderate/average and good/high. Scores of 2 and 4 are allowed for 'fuzziness', with descriptions of factors which should be taken into account in this regard given for some impact categories. These scores are used where the characteristics or aspects of a particular attribute mean that, say, neither a score of 1 nor of 3 really reflects the situation, and familiarity with a river and the relevant characteristics indicates that slightly higher scores are warranted. This degree of flexibility is believed to be important within a system such as this. In all cases, a score of 'O' is assigned where the impact is not applicable.

Note that negative scores may also be assigned within the system. In particular, it is recognised that water quality improvements may, in some cases, decrease the conservation value of a site. Scheme costs, on the other hand, are by their nature a 'negative' impact when included within the same system as environmental benefits.

Within the system, scores are also assigned to all of the attributes which are independent of a change in water quality but are significant to determining the potential magnitude of the benefits arising from a given change. For example, attributes such as the number of people living within a given distance of the river, the length of the river, whether a fishery is privately owned or there is public access, etc., are all independent of the impacts of any change in water quality. Different levels of these will, however, affect the magnitude of any benefits.

With regard to water quality changes, the scores assigned to different quality changes were developed, in many cases, with reference to the economic valuation data provided in the FWR Manual by linking the nature of the change in water quality to the order of magnitude for the corresponding economic valuations. These water quality scores are used as multiplicands in relation to the various independent attributes.

In adopting the type of scoring approach used here, it is important that the scaling system used are as linear as possible to allow for weighting and aggregation in later stages. Attempts have been made to ensure that this is the case within the systems developed here. Concern has been expressed, however, over the assumptions implicit to the system concerning the cut-off points which had to be set in developing a five point scale. By way of example, one of the attributes which features in many of the impact categories is that of length of river affected by the water quality change. Scoring of length of river against a scale of 1 to 5 required specification of different lengths for each score (e.g. < 3km gets a score of 1, while > 3km and < 7km gets a score of 2). The drawbacks of such scaling are that the approach does not enable small changes in the physical measures to be fully taken into account.

This problem was accounted for within the existing framework through changes in the formulae used in calculating benefit scores. Statistical analysis of the results of trial applications of the MAT indicated those attributes which are the most important predictors of 'value'. These attributes are also those where the issue of cut-off points is of most concern (e.g. river bank length and site accessibility). Based on the results of the analysis, these attributes were used as multipliers (instead of being additive) with the result that the proportionality between the relationship of score to physical measure is improved.

*Weighting and Aggregation*

In order to aggregate scores across the various impact categories, weights must be developed which reflect the relative (proportional) importance of changes in one impact category as compared with another. Such weights can be developed through a range of different approaches, for example, through:

- use of informed expert judgement;
- surveys of the general population; or
- use of focus groups.

The Agency adopted two different approaches to the development of these relative impact weights. The first involved elicitation of the views of the Agency's Regional Environmental Protection Advisory Committee (REPAC) members, who are considered to act as a group of experts in this regard. The weights developed by these groups provided an important backdrop to those developed through the second approach: the use of more intensively run focus group sessions, whose members were selected to represent the range of general regional interests.

Three different focus group sessions were held, with each group comprised of a cross-section of stakeholders representing different interests within the regions of concern. Within each focus group session, a structured approach was taken to eliciting each individual participant's relative impact weights. The key activities involved were:

1) an introduction to the MAT system, including a review of how the results could be used to assist the Agency in scheme prioritisation and justification;

2) a summary of what it means to score the maximum number of points within each of the various impact (benefit and cost) categories;

3) a ranking exercise, during which each participant ranked the different impact categories in terms of the order of importance of gaining the maximum score;

4) a weighting exercise, during which each participant moved from their rankings to the development of relative importance weights (using a swing-weighting procedure) for each of the impact categories; and

5) a general discussion session during which the differences in rankings and weightings were explored, and participants were asked their views on the overall exercise and use of the MAT system itself.

Discussions held during the sessions examined each participant's views on the value of the exercise, the ease of assigning the weights, the participants confidence in (or happiness with) the weights, other information which would have assisted the exercise and the MAT system itself. For a more detailed description of the focus group sessions see the report on 'Development of Weights for the MAT Water Quality System: Focus Group Results'.

The relative impact weights developed by the REPACs and the focus groups were then applied to the impact scores to allow for aggregation across the different impact categories. Two levels of aggregation were undertaken:

a) The first approach was to aggregate across all impact categories, including costs, to develop an overall measure of net effect. This indicated whether or not the benefits of a scheme appear to outweigh the costs given a particular set of relative impact weights. The results provide an indication of whether or not a scheme is worthwhile in resource terms.

b) The second approach involved aggregation of environmental impact scores, but excluded scheme costs; this allowed the calculation of a measure of net environmental effect, which could then be divided by scheme costs to provide an indication of the ratio of net benefits to costs (a cost-effectiveness/utility indicator). These ratios were then used in prioritisation of schemes on the basis of benefits per unit of expenditure.

## 1.3 Assessment Requirements

Undertaking the assessment set out here involved a multi-functional team, including staff from water quality, water resources, FRCN and potentially planning. Individual scheme assessments took anywhere from a few hours to several hours depending on data availability, etc. They also required a range of data, such as OS maps (1:25,000 as a maximum scale), population data at both a ward and wider regional/water supply company level, and general data on angling and other recreational clubs (and associated user numbers).

## 1.4 Defining With and Without Project: The Assessment Baseline

Water quality schemes may be aimed at either improving water quality (i.e. moving from a poorer quality state to a higher quality state) or preventing a degradation in quality to maintain current (or near to current) quality standards. In applying this system, the baseline adopted varied over these two objectives:

- for improvements in water quality, the baseline is current water quality (the 'without' case) and benefits relate to the gains associated with better quality under the 'with' project scenario; and

- for maintenance of water quality, the baseline should be what would occur in the future 'without' the project (a degradation in water quality) and the benefits then relate to the gains associated with moving from the 'without' project to the 'with' project state.

A second issue which may arose in applying the methodology is how to deal with benefits experienced over multiple river stretches, and in particular where the resulting change in water quality differs (e.g. stretch 1 involves improvements by more that one river ecosystem (RE) while stretch 2 will experience only 'within class' improvements).

Where stretches would be differentially affected in terms of changes in water quality, benefits were assessed on a stretch by stretch basis and were summed and normalised to provide totals for each impact. This approach is consistent with the way in which the scoring is undertaken within each impact category and ensures that the full information on benefits is retained. Where the change in quality would be similar across stretches, then these were assumed to act as a single stretch of river within this system.

## 1.5 Organisation of Document

Sections 2 to 10 of this document set out the scoring and weighting systems developed for each of the impact categories listed above. Section 11 then discusses the development of the relative impact weights in more detail and how these are used in aggregation of the normalised impact scores to develop the two measures of scheme performance defined above.

# 2. INFORMAL RECREATION

## 2.1 Overview

Informal recreation applies to all of the recreation activities undertaken on the bankside of a river, where this includes walking, hiking, picnicking, bird watching, etc. For the purposes of this assessment, it is assumed that the following factors are relevant to determining both the current significance of informal recreation activities along a river stretch and the potential benefits of water quality improvements (or of preventing degradation in water quality):

- length of the river;
- access to the river; and
- visitor day potential.

Note, if there is no access to the affected river stretches for informal recreation purposes, a score of zero was assigned to this impact category unless actual plans exist for access to be created in the future (e.g. as part of restoration works).

## 2.2 Length of River

The magnitude of informal recreation activities which take place along a river and which could benefit from either quality improvement or quality maintenance will depend, in part, on the length of river which will be affected under the 'with' project scenario. The longer the length of river affected, the greater the potential magnitude of activity which could be affected. In order to develop scores for length of river, consideration was given to the minimum, average and maximum length of river stretches as defined for GQA assessments. Although these vary by region, it was decided that there was enough similarity to define a system generic to all regions, particularly as the aim is to reflect the potential for recreation related gains. The scoring system used is set out in Table 2(a) and is discussed further in Annex 1. It is important to note that scores were assigned so as to reflect the length of river which gains from the 'with' project scenario, where this may be more than one GQA stretch.

**Table 2(a): Scores for length of river affected**

| Length Affected | Score |
|---|---|
| < 3 km affected | 1 |
| > 3 km and less than 7 km affected | 2 |
| > 7 km and less than 15 km affected | 3 |
| > 15 km and less than 30 km affected | 4 |
| > 30 km affected | 5 |

## 2.3 Accessibility

Access to the river relates to whether or not there are footpaths or other forms of access (such as a local park) along the river, with the main factor in scoring being the length of river to which there is access. Scoring for the length of river with access, where this relates to one or the other bank, was undertaken as set out in Table 2(b). Where both banks are accessible over the same distance then the score may have been increased by one (e.g. from 3 to 4) if both banks are used.

Scoring on the basis of length alone ignores other factors which may increase accessibility such as the existence of a country park along the river, or the presence of car parks. Where such factors are important, they were taken into account in the scoring.[4] Where there is a car park, access from a main road, or the site acts as a local park, the scores should have been raised by one point. Where a honeypot site (one which is likely to attract a few hundred thousand visitors as a result of its attractions - whether built or natural) adjoins the river, then the score should have been raised by two points if the river is one of the features of the site. The maximum score, however, was 5.

**Table 2(b): Factors in categorising quality of access**

| Quality | % River Length Accessible | Score |
|---|---|---|
| Poor | ≤10% | 1 |
| Fair | >10% to ≤30% | 3 |
| Good | >30% | 5 |

## 2.4 Visitor Day Potential

A number of difficulties arise when trying to predict the actual number of people currently visiting a site and the increase in visitor rates which would occur following a change in water quality. With regard to the latter issue, although improvements in water quality might increase the number of individuals visiting a particular river site, very little data currently exist to determine the magnitude of such increases in different situations. Care is also required to make sure that any assumed 'increases' are not simply shifts in visits from one site to another.

Some data do exist on the number of visits a person is likely to make to rivers within different distances from their home. The Office of Population and Census Statistics[5] and

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4 Note that the preceding version of this methodology including a separate attribute related to the attractiveness of the river setting. Concern over the potential for this attribute to be strongly correlated with access has led to its removal to reduce the potential of double-counting. The results of statistical analysis do not indicate that this should significantly affect the robustness of the scoring for this impact category. Instead, it should improve.

5 OPCS (1991): Leisure Day Visits in Great Britain 1988/89, London: HMO.

the Countryside Recreation Network[6] have produced figures which provide an indication of general levels of activity and visiting patterns which provide a useful background to the development of this scoring system. However, more specific to the issues being addressed within this methodology are standard relationships which have been developed by Middlesex University as part of research on river recreation (including both pre-project surveys and post-project appraisal work). These formulae establish visit rates per adult head of population living within 1 and 3 km of a site, although the relationships also take into account visitors from outside these distances. It is these formulae which provided the basis for the scoring of demand potential. The exception to these formulae are 'honeypot' sites, which are likely to draw several hundred thousand visitors per annum.

The existence of alternative sites will also impact on the degree to which the local population will use any particular river. Where there are several sites which provide similar recreational activities, then it is unlikely that all visits can be assigned to the river in question.

There are also many regions of the country which experience high levels of environment-based tourism. In such areas, rivers may form an important resource and may be visited by large numbers of tourists. Constraining the population to only those within 3km disregards this potential group of river users. As a result, adjustments to scores may have been undertaken to account for such tourism. For example, where a site is heavily used (e.g. gets more than 150,000 visitors) for bankside recreation, analysts may have scored the site as a honeypot (with scores decreasing for lower numbers of visitors). Table 2(c) presents the scoring system, with flow charts provided at the end of this section indicating how it was applied in practice.

**Table 2(c): Factors in categorising local visitor day potential**

| Visitor Potential | Population within 3km of River | Number of Alternative Sites | Tourism/Visit Potential | Score |
|---|---|---|---|---|
| Poor | <10,000<br>>10,000 | None or many Alternative sites available and within a few km | Little tourism based on outdoor activities; not a local park or honeypot site | 1 |
| Fair | >10,000<br><35,000<br><br>>35,000 and upwards | No alternative sites<br>Few alternative sites<br>Several alternative sites | Some outdoor tourism which relates to rivers, e.g. long distance paths running alongside river; the existence of a local park which draws visitors | 3 |
| Good | >35,000<br><br>>50,000 | No alternative sites<br>Few alternative sites | Some to significant levels of outdoor tourism relating to river; honeypot site | 5 |

6 Countryside Recreation Network (1994): 1993 UK Day Visits Survey, Vol 2, No 1, Cardiff: Department of City & Regional Planning, University of Wales College of Cardiff.

## 2.5 Water Quality Scores

In order to assess the impact of an improvement in water quality, the above factors were brought together and weighted by the environmental improvements associated with both changes in chemical water quality and in aesthetic parameters.

The scores applied to changes in chemical quality are set out in Table 2(d). The link being made here between chemical quality and informal recreation relates to the enjoyment gained by visitors to a river which is able to support a greater diversity of species and those demanding higher chemical quality. For further details of relevant willingness to pay and related research see the section on informal recreation in the FWR Manual (1996).

With regard to aesthetics, the weights used are based on the Agency's GQA classification system. For information purposes, the classification system is set out in Annex 2 to this document, while the manner in which changes between classes was scored is set out in Table 2(e).

Where achievement of a higher GQA classification would also be dependent on litter removal, the costs of removal activities were added to the capital and operating costs associated with other works required by the proposed scheme. For example, work in Welsh Region has found a cost of roughly £700 per 250m stretch for litter removal in moving from a Category C to A river (using the old GQA classification system).

**Table 2(d): Water quality scores**

| Water Quality Change | Score |
|---|---|
| Improvement within a class | 1 |
| Improvement from bottom of class to top of class, remaining within class | 2 |
| Improvement by 1 class | 3 |
| Improvement from bottom of lower class to top of next class (e.g. from bottom of class 3 to top of class 2) | 4 |
| Improvement by more than 1 class | 5 |

**Table 2(e): Aesthetics scores**

| Change in Classification | Score |
|---|---|
| Grade 4 to Grade 3 or better | 5 |
| Grade 3 to Grade 2 or better | 3 |
| Grade 2 to Grade 1 | 1 |

## 2.6 Example Calculation

The formula used for deriving the overall informal recreation score for a change in water quality on a given river stretch is:

(Length x Access x Visitor Potential) x (Water Quality + Aesthetics) = Benefit Score

In order to illustrate how the formula is applied, let us assume that the river scored as follows across the various determining factors and on water quality:

- Length: 3 (13 km affected)
- Access: 4 (fair proportion of stretch accessible; some car parking)
- Visitor Potential: 3 (>35,000 with few alternative sites)
- Water Quality: 3 (RE 4 to RE 3)
- Aesthetics: 5

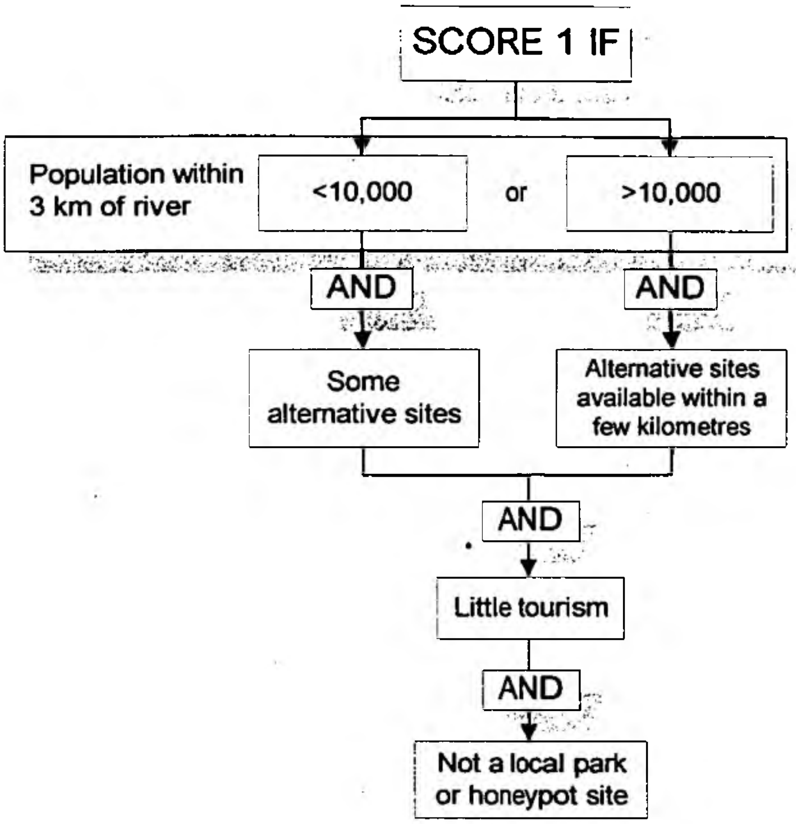
Given the above scores, the total benefits related to informal recreation would be calculated as follows:

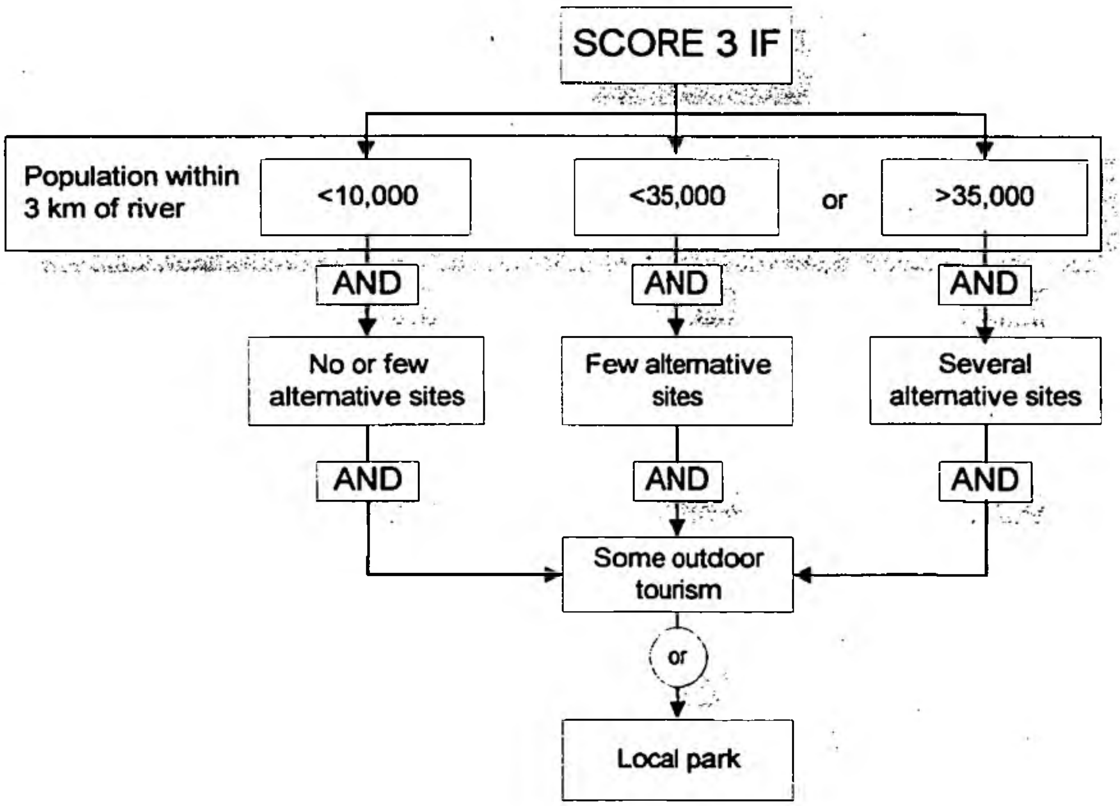
$$(3 \times 4 \times 3) \times (3 + 5) = 288$$

The maximum potential score is 1250. Thus, in order to normalise the above score to a base of 100, it should be divided by the maximum and multiplied by 100. The calculation is as follows for our hypothetical example:

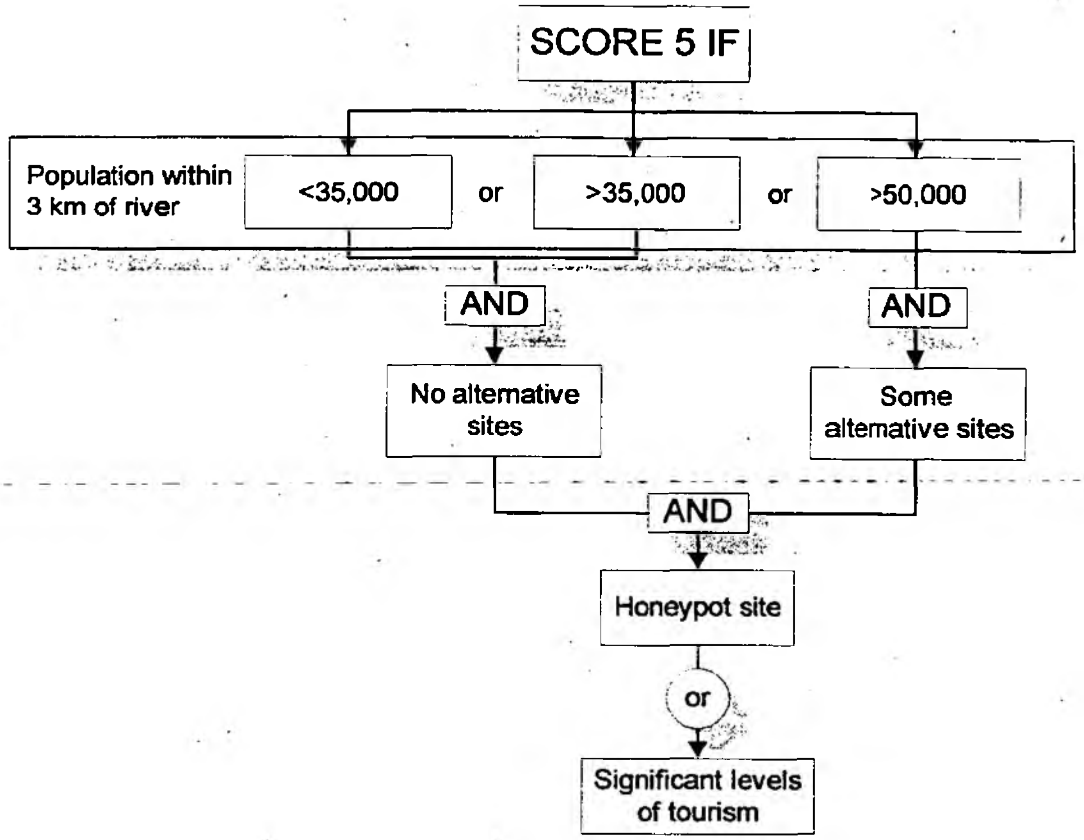
Normalised informal recreation benefit = (288/1250) x 100 = 23

## Flow Chart (A) to Assist Scoring According to Table 2(c)



**Flow Chart (B) to Assist Scoring According to Table 2(c)**



# 3. ANGLING

## 3.1 Overview

Fisheries and hence angling activities may be impacted by water quality changes as a result of improvements in the stock of available fish and of changes in fish species (with higher quality water supporting more desirable species). Past work has found that it is important to consider coarse angling separately from game (i.e. trout and salmon) angling, as the benefits of water quality improvements vary between the different types of fisheries in terms of anglers' willingness to pay.

However, it must be recognised that in nature such distinctions do not exist, with improvements in quality impacting both coarse and salmonid species. As a result, there may be cases where improvements in, or maintenance of, river water quality would result in benefits to both types of fishery. This may be within a single stretch or across different stretches. For example, improvements in quality of a downstream stretch of river could enable the creation (or protection) of a migratory fishery in an upstream stretch. In such cases, the benefits stemming from improvements in (or protection of) both types of fisheries should be considered.

Furthermore, improvements in river quality may give rise to improvements in estuarine fisheries, and vice versa. Where such further angling benefits may be significant, they also need to be accounted for within a scheme's scoring.

In addition to the impact of quality changes, a number of other attributes are important to determining the magnitude of potential benefits:

- the length of river affected;
- the suitability of the river habitat for the different types of fisheries;
- the level of access to the fishery (e.g. whether privately owned, club owned or day ticket) to the fishery; and
- the potential demand for angling activities.

However, where no recreational fishery currently exists or it is unlikely that one would develop (e.g. owing to no access to the river) as a result of water quality improvements, a score of zero was assigned to this impact category.

## 3.2 Coarse Fisheries

### *Length of River Affected*

As with informal recreation, the magnitude of potential angling benefits will be determined, in part, by the length of river and hence fisheries which would be affected by water quality improvements (or protection). Note that length relates to improvements in fisheries both up and downstream of a scheme as appropriate. Length was scored in the same manner as for informal recreation, using the scoring system set out in Table 3(a).

| Table 3(a): Scores for length of river affected | |
|---|---|
| **Length Affected** | **Score** |
| < 3 km affected | 1 |
| > 3 km and less than 7 km affected | 2 |
| > 7 km and less than 15 km affected | 3 |
| > 15 km and less than 30 km affected | 4 |
| > 30 km affected | 5 |

### *Habitat*

The FWR Manual highlights the importance of considering factors such as habitat in determining the angling benefits associated with water quality improvements. The approach used in the Manual is to assume that river gradient acts as an indicator of habitat quality and availability and thus indicates the suitability of the river for different fish types. Tables (on page 103, FWR Manual) set out the probability that a river of a particular velocity (also assumed to reflect gradient) will support 'no' to 'good' quality fisheries. Converting this information into a set of scores for coarse fisheries required some simplification of the information, but is considered to be broadly representative of river potential. See Table 3(b) for the scoring system.

It was also essential to consider whether or not a stretch of river may never be a fishery for reasons other than gradient and river velocity. For example, there may be physical barriers to the establishment of a fishery; or the river bed characteristics and/or the aesthetic quality of the river setting may prohibit it from becoming a recreational fishery. Fisheries officers were consulted if there was any doubt in this regard.

| Table 3(b): Scores for habitat potential for coarse fish | | |
|---|---|---|
| **Habitat Potential** | **River Velocity (and Gradient)** | **Score** |
| Poor | Rapid to very rapid ( > 4 m/km) | 1 |
| Fair | Moderate velocity (between 2 to 4 m/km) | 3 |
| Good | Slow velocity <2 m/km | 5 |

### *Access*

The third factor which needs to be taken into account is the nature of access to the fishery. Three categories of access were identified for these purposes, where these are private fishery (fished by riparian owner only), club fishery (where rights are owned or leased by a club or a number of clubs), and day ticket or public fishery open to all. The scores which were assigned to these different categories are as given in Table 3(c). Where more than one type of access exists, the higher scoring type was assumed.

Note that analysts had to use their judgement when scoring access. For example, in cases where access to a public fishery is poor, through poorly maintained footpaths or an inadequate number of fishing beats, the score may have been reduced from 5 to a lower number (e.g. to a 4 or to a 3 depending on site characteristics).

There may also be exceptions to the scores given below, for example, where a club with a large membership owns a fishery, improvements in quality may confer significant benefits to its members and/or may allow an increase in club membership.

**Table 3(c): Scores for access to a coarse fishery**

| Access | Ownership/Availability | Score |
|---|---|---|
| Poor | Private fishery | 1 |
| Fair | Club owned fishery | 3 |
| Good | Day ticket or public fishery | 5 |

*Angling Demand Potential*

The fourth factor which was taken into account is the potential demand for angling in the area. This relates to two different attributes, with the first being the population within 30 km of the site, as this demarks the average maximum distance which anglers will travel for a day of coarse fishing (based on OPCS Leisure Day and NRA National Angling Survey data[7]). In this case, population is assumed to be indicative of the number of rod licence holders within travelling distance.

The second attribute relates to the number of alternative sites within the 30 km distance from the site which will compete for anglers (particularly if the fisheries are of equal or better quality). As defined here, few relates to three or less alternative sites, while several relates to more than three.

The scoring system used is set out in Table 3(d) overleaf. Again, the flow charts given at the end of Section 2 assisted in scoring demand potential.

*Water Quality*

Instead of linking benefits directly to changes in water quality, scoring of angling benefits reflects the change in the quality of the fishery after improvements in water quality. The scores to be applied to different levels of fishery improvement/protection were based upon the figures given in the FWR Manual. The scoring system set out in Table 3(e) was, therefore, developed to reflect anglers' willingness to pay per day's activity as expressed through surveys (note they are not a combination of values and visit rate but represent values alone). As defined here, the scores are indicative of the incremental value of

[7] NRA (1994): **National Angling Survey**, NRA: Bristol.

| **Table 3(d): Scores for coarse angling demand potential** | | | |
|---|---|---|---|
| **Demand Potential** | **Population within 30 km of River** | **Number of Alternative Sites** | **Score** |
| Poor | <10,000<br>>10,000 | None or many<br>Several alternative sites available of equal or higher quality | 1 |
| Fair | >10,000<br><35,000<br>>35,000 and upwards | No alternative sites<br>Few alternative sites<br>Several alternative sites | 3 |
| Good | <10,000 and upwards<br>>35,000<br><br>>50,000 | Honeypot site<br>No alternative sites of equal/ better quality<br>Few alternative sites | 5 |

| **Table 3(e): Scores for improvements in coarse fishery quality** | | | |
|---|---|---|---|
| **Quality Before Improvements** | **Quality After Change** | | |
| | **C1** | **C2** | **C3** |
| No fishery | 5 | 5 | 3 |
| C3 | 3 | 1 | 0 |
| C2 | 3 | 0 | 0 |

changes in fishery class, moving from a poor coarse fishery (C3) to a sustainable, good quality coarse fishery (C2) to a high quality coarse fishery (C1). For a further discussion of these different classifications see the FWR Manual.

## 3.3 Salmonid Fisheries

For the purposes of this methodology, non-migratory (trout) and migratory (trout and salmon) salmonid fisheries were assessed together. The factors which were considered are similar to those for coarse fisheries (length of river, habitat potential, access, angler demand potential and change in fishery quality), as are the caveats or further considerations highlighted above. Table 3(f) provides the scores which were assigned to the independent attributes dictating the potential magnitude of benefits to these recreational fisheries. Note that the key difference between this scoring system and that for coarse fisheries concerns the scoring of habitat potential and river velocity. As can be seen from Table 3(f), the scoring system for salmonid fisheries was the reverse of that for coarse fisheries.

Table 3(g) provides the scores associated with improvements in fishery quality as indicated by willingness to pay surveys.

**Table 3(f): Scores for assessment of salmonid fisheries**

| **Length Affected** | | | **Score** |
|---|---|---|---|
| < 3 km affected | | | 1 |
| > 3 km and less than 7 km affected | | | 2 |
| > 7 km and less than 15 km affected | | | 3 |
| > 15 km and less than 30 km affected | | | 4 |
| > 30 km affected | | | 5 |
| **Habitat Potential** | **River Velocity** | | **Score** |
| Poor | Very slow to slow (<2 m/km) | | 1 |
| Fair | Moderate velocity (2 to 4 m/km) | | 3 |
| Good | Rapid velocity (>4 m/km) | | 5 |
| **Access** | **Ownership/Availability** | | **Score** |
| Poor | Private fishery | | 1 |
| Fair | Club owned fishery | | 3 |
| Good | Day ticket or public fishery | | 5 |
| **Demand Potential** | **Population within 30 km of River** | | **Score** |
| Poor | <10,000<br>>10,000 | None or many<br>Many substitute sites of equal or higher quality | 1 |
| Fair | >10,000 and <35,000<br><35,000<br>>35,000 and upwards | No alternative sites<br>Few alternative sites<br>Several alternative sites | 3 |
| Good | <10,000 and upwards<br>>35,000<br>>50,000 | Honeypot site<br>No alternative sites of equal/better quality<br>Few alternative sites | 5 |

**Table 3(g): Scores for improvements in migratory and non-migratory fishery quality**

| **Quality Before Change** | **Quality After Change** | | | |
|---|---|---|---|---|
| | **S1** | **T1** | **T2/S2** | **T3** |
| **No fishery** | 5 | 4 | 3 | 3 |
| **C1** | 5 | 4 | 2 | 1 |
| **T3** | 5 | 3 | 1 | 0 |
| **T2/S2** | 5 | 2 | 0 | 0 |
| **T1** | 3 | 0 | 0 | 0 |

### 3.4 Example Calculations

Separate calculations were undertaken for coarse fisheries and salmonid fisheries. The formula used to derive the total score for the benefits to coarse and salmonid anglers associated with a change in water quality is, however, the same:

(Habitat + Access + Demand) x Length x Fishery Quality = Benefit Score

In order to illustrate how the formula was applied, let us assume that the river has scored as follows across the determining factors for a coarse fishery:

- Length of river: 2 (7 km of river with a coarse fishery affected)
- Habitat potential: 5
- Access: 4 (day ticket site but a number of alternative sites exist)
- Demand potential: 5 (>35,000 with no alternative sites of equal quality)
- Fishery quality: 3 (C2 to C1)

Given the above scores, the total benefits related to the coarse fishery would be calculated as follows:

(5 + 4 + 5) x 2 x 3 = 84

Note that this score relates to a maximum score of 375 for coarse (or salmonid) angling. Normalisation to a base of 100 generates a normalised score of 22.4 [= (84/375) x 100)].

Let us assume that the same scheme would also result in improvements to a salmonid fishery in the upper reaches of the affected river, with the various attributes being scored as follows:

- Length of river: 3 (11 km of river with a salmonid fishery affected)
- Habitat potential: 3
- Access: 1 (day ticket site but with several alternative sites exist)
- Demand potential: 3 (<35,000 with few alternative sites)
- Fishery quality: 3 (T3 to T2)

Given the above scores, the total benefits related to the salmonid fishery would be calculated as follows:

(3 + 3 + 1) x 3 x 3 = 63

Note that this score also relates to a maximum score of 375, resulting in a normalised score of about 16.8.

The two scores calculated above were then carried forward separately to the aggregation stage (see Section 11). If only one type of fishery would be affected, then only that score was carried forward and a score of zero was entered for the other fishery type.

# 4. IN-STREAM RECREATION

## 4.1 Overview

In-stream recreation covers a range of different activities, such as canoeing, rowing, sailing, boating, swimming, water skiing and other water sports. Before proceeding with this aspect of the assessment, analysts had to first establish whether any of these activities currently take place on the water body under consideration, or whether they may develop as a result of water quality improvements. For most rivers, it is unlikely that such activities will take place, although there is an increasing demand for such activities on larger rivers.

Where no in-stream recreation takes place this category was assigned a score of zero.

If in-stream recreation does currently take place along the river, or there is a definite potential for it to do so, then the following factors were considered in the assessment of benefits:

- the length of river associated with in-stream recreation;
- the degree to which commercial operations are involved;
- the intensity of in-stream recreation activity; and
- the changes in the chemical and aesthetic quality of the river.

## 4.2 Length of River

As with informal recreation and angling, the length of river affected is important to determining the magnitude of potential impacts of water quality improvements (or maintenance of water quality). In addition, whether the river is an isolated waterway (e.g. a closed system which provides no access to other waterways) or is part of a network is also likely to affect levels of use.

The system used for scoring river length is set out in Table 4(a), with this being modified from that used for the other impact categories to take into account the fundamental difference in the nature of many of these activities.

**Table 4(a): Scores for length of river affected**

| Length Affected | Score |
|---|---|
| < 3 km and an isolated system | 1 |
| > 3 km and less than 7 km affected and a isolated system | 2 |
| > 3 km and less than 7 km and a linked system or<br>> 7 km and less than 15 km and an isolated system | 3 |
| > 7 km and less than 15 km and a linked system or<br>> 15 km and less than 30 km and an isolated system | 4 |
| > 15 km and less than 30 km and a linked system or<br>> 30 km and an isolated system | 5 |

## 4.3 Level of Commercial Activity

Where sailing, boating and other water sports take place, these may be accompanied by commercial hire, mooring and other operations (which could be seasonal or year round). The presence of these commercial activities may also be important to the local economy by bringing in visitors from outside the area. The scoring system which was developed to reflect the benefits associated with these types of activities is given in Table 4(b) below. Analysts will also have had to use their judgement in assigning scores to ensure that they reflected the importance of commercial recreation to the area; for example, there may only be a few large operators but the turnover of these companies is very high (e.g. >£1 million).

**Table 4(b): Scores for level of commercial activity**

| Level of Activity | Number of Commercial Hire Operations | Score |
|---|---|---|
| Very low | One or two small operators only | 1 |
| Low | Several small operators or a large operator | 2 |
| Average | Several small operators and a large operator; or a few larger operators | 3 |
| Above average | A mix of large and small operators | 4 |
| High | A large number of operators with high levels of rental activity | 5 |

## 4.4 Intensity of Activity

The intensity of non-commercial activities along the relevant stretch of the river is related to the level of commercial activity, but was scored separately in order to reflect benefits to these users of the river under examination. Again, all in-stream activities (boating, rowing, canoeing, sailing, swimming, etc.) were considered together and thus were treated as additive in determining levels of activity.

The intensity of non-commercial activity was linked to either the number of visitor days occurring along the river stretches affected by changes in water quality or, the population within 30 km of the river. The former was used where in-stream activities are well established and/or levels of activity are unlikely to be significantly affected by changes in water quality. The latter was used where the change in water quality is likely to have a significant effect on the demand for these activities.

With regard to the intensity of activity, this was scored in terms of the 'level of service' which has been assigned to a waterway (a concept recently introduced into the Agency based on a British Waterways Model), where Category 1 waterways relate to high usage, Category 2 to moderate usage, Category 3 to low usage and 'other' representing those waterways with no formal levels of service. Although this is appropriate for boating activities, it may undervalue activities such as sailing, rowing, canoeing or water skiing, which may occur in Category 3 or other waterways. Where these are important activities, thought was given to levels of activity, whether or not competitions are held on the river, etc. Where appropriate relevant clubs, associations and national representatives (e.g. the British Canoe Union in the case of canoeing) were consulted.

The scoring systems applied for both intensity and demand potential are presented in Tables 4(c) and (d), taking into account the above discussion (see also the flow chart at the end of Section 2 with regard to Table 4(d)). The phrase 'other visits' as used in Table 4(c) refers to those water sport activities which do not require that a river be a designated waterway/navigation.

**Table 4(c): Scores for intensity of boating, canoeing, rowing, sailing and other in-stream recreation activities**

| Level of Activity | Average Number of Non-Commercial Trips Per Year to Site | Score |
|---|---|---|
| Very low | 'Other' waterway and/or <500 other visits/annum | 1 |
| Low | Category 3 waterway and/or <1,000 other visits/annum | 2 |
| Average | Category 2 waterway and/or >1000 to <5000 other visits/annum | 3 |
| Above average | Category 2 waterway and/or >5000 other visits/annum | 4 |
| High | Category 1 waterway | 5 |

**Table 4(d): Scores for in-stream recreation demand potential**

| Demand Potential | Population within 30 km of River | Number of Alternative Sites | Score |
|---|---|---|---|
| Poor | <10,000<br>>10,000 | None or many<br>Many alternative sites available of equal or higher quality | 1 |
| Fair | >10,000<br><35,000<br>>35,000 and upwards | No alternative sites<br>Few alternative sites<br>Several alternative sites | 3 |
| Good | <10,000 and upwards<br>>35,000<br>>50,000 | Honeypot site<br>No alternative sites of equal/ better quality<br>Few alternative sites | 5 |

### *Changes in Water Quality*

There are two key water quality parameters of concern in the assessment of benefits to in-stream recreation users. The first relates to changes in the chemical quality of the water, while the second is the aesthetic classification. The benefits associated with changes in these were assumed to be similar to those which would accrue to informal recreation users, and thus the scoring systems indicated in Tables 4(e) and (f) are the same as those given in Section 2.

**Table 4(e): Water quality scores**

| **Water Quality Change** | **Score** |
|---|---|
| Improvement within a class | 1 |
| Improvement from bottom of class to top of class, remaining within class | 2 |
| Improvement by 1 class | 3 |
| Improvement from bottom of lower class to top of next class (e.g. from bottom class of 3 to top of class 2) | 4 |
| Improvement by more than 1 class | 5 |

**Table 4(f): Aesthetics scores**

| **Change in Classification** | **Score** |
|---|---|
| Grade 4 to Grade 3 or better | 5 |
| Grade 3 to Grade 2 or better | 3 |
| Grade 2 to Grade 1 | 1 |

## 4.5 Example Calculation

The formula that was used to derive the raw score for in-stream recreation benefits (covering both commercial and non-commercial activities) is as follows:

(Commercial + Non-Commercial Demand) x Length x (Water quality + Aesthetics) = Benefit score

Note that the maximum score for in-stream recreation using this formula is 500, requiring normalisation to a base of 100 as for the previous impact categories.

# 5. AGRICULTURE

## 5.1 Introduction

Changes in water quality may affect use of river water for irrigation purposes. Improvements may allow farmers to switch to direct river abstraction from potable water supplies, lead to changes in crop yields, or in the types of crops grown (e.g. to higher value vegetable or fruit crops).

Before assuming that irrigation benefits would arise, however, the following questions were considered:

- Is the availability of water a constraining factor? (Note that it may only be so for a few crops, such as such as potatoes, sugar beet and some vegetable and fruit crops.)
- Do farmers hold unused abstraction licences?
- Would further river abstraction be licensed? **Would there be objections to increased abstractions owing to concerns over the impacts on river flows and/or any adjacent wetland areas?**

If the answer to the above questions was no, then no benefits under this category were assumed and a score of zero was assigned.

Note that other uses of river water, for example for golf courses or ornamental ponds, are classed here as industrial uses.

## 5.2 Scoring System

For the purposes of this assessment, benefits relate to:

- the availability of 'additional/increased/new' abstraction supplies for use in irrigation to increase crop yields and/or quality; or
- the prevention of the loss of irrigation owing to a degradation of quality under the 'without' project scenario.

Application of the scoring system involved first scoring the change in crop value associated with increases in crop yield and quality, and the number of hectares which would be affected for the key crops. This may have required some generalisation, for example, by assuming that one crop is dominant or is representative of the potential benefits across all farms. For example, potatoes may be assumed to be the key crop for a given area, while other crops are assumed to play a much more minor role with regard to irrigation demand.

Scoring benefits then required consideration of the sensitivity of the key crop to different quality levels and the change in water quality. The scores assigned to the different independent attributes of yield and area are given in Tables 5(a) and (b). Table 5(c) identifies the sensitivity of different crop types and indicates the scores assigned to the impacts of a water quality change given these different crop sensitivities.

| **Table 5(a): Scores for potential increase in yield (as would be measured by £/ha)** | | |
|---|---|---|
| **Potential Change in Yield** | **Crop Types** | **Score** |
| Low | Winter wheat, barley, grass, peas | 1 |
| Moderate | Early potatoes, sugar beet, vining peas, carrots, french beans, lettuce, onions | 3 |
| High | Main crop potatoes, cabbage, french beans, runner beans, brussel sprouts, fruit | 5 |

| **Table 5(b): Scores for potential area to be irrigated** | | |
|---|---|---|
| **Potential Area** | **Hectares Affected** | **Score** |
| Small | <1,000 | 1 |
| Medium | >1,000 ha to < 5,000 ha | 3 |
| Large | > 5,000 ha | 5 |

| **Table 5(c): Weights for water quality change** | | | |
|---|---|---|---|
| **Water Quality Change** | **Weight** | | |
| | **Low Sensitivity*** | **Moderate Sensitivity**** | **High Sensitivity***** |
| Improvement within a class | 1 | 1 | 1 |
| Improvement from bottom of class to top of class, remaining within class | 1 | 1 | 3 |
| Improvement by one class | 1 | 1 | 3 |
| Improvement from bottom of lower class to top of next class (e.g. from bottom of class 3 to top of class 2) | 1 | 3 | 5 |
| Improvement by more than one class | 1 | 3 | 5 |

* Low sensitivity crops include: sugar beet, cabbage, lettuce, carrots onions, beans.
** Moderate sensitivity crops include: potatoes, barley, wheat, maize, oats, peas.
*** High sensitivity crops include: fruit (e.g. apples, blackcurrants, strawberries, raspberries).

## 5.3 Example Calculation

In this example, there is the potential for increased abstraction from the river in question for most years (with the licence carrying restrictions for periods when conditions fall below environmentally acceptable flows), and the water quality change is an improvement from the bottom of one to the top of the next class. The crop to be irrigated is potatoes, with irrigation to be applied to an extra 7,000 ha.

The weighted benefit score was calculated using the following formula:

Output x Area x Water Quality = Weighted Benefit Score

Given the above assumptions, the score for this example would be:

5 x 5 x 3 = 30

The maximum potential score given the above scoring system is 125. Normalisation to a base of 100 would then result in the above score being 24 [= (30/125) x 100].

# 6. INDUSTRIAL ABSTRACTIONS

## 6.1 Overview

Industrial abstractions of river water may be used for cooling water, steam generation or as part of a production process. Under this heading are also included abstractions for ornamental ponds, golf course watering, etc. It is very unlikely that any improvements in river water quality would have an impact on the costs incurred by industry in using a river source. However, there may be benefits associated with maintaining current quality, where these relate to the avoidance of increased treatment or other costs associated with deteriorations in quality.

This impact category was given a score of zero unless there was actual information indicating that an industry's costs would be affected (lowered in the case of improvements or increased under a failure to maintain current quality).

When undertaking this component of the assessment, analysts had to confirm that abstraction either already takes place or is feasible (e.g. an unused licence is held or would be given by the Agency). It also required information on the industries of concern to properly reflect whether or not they would benefit from an improvement in water quality. In addition, reference was made to the FWR Manual to ensure that the correct links are made between changes in different water quality parameters and benefits.

## 6.2 Scoring System

The scoring system for industrial abstraction relies on consideration of two factors. The first is the volume of water used per day and the second is the implication of a change in water quality on the source of supply and the degree of treatment required. Note that it is assumed that a switch from a potable supply to an abstraction source would provide significant savings in costs even if treatment of the river source would be required. The scoring systems applied to these two factors are set out in Tables 6(a) and (b) respectively.

**Table 6(a): Scores for volume abstracted**

| Size of Supply Requirement | Volume of Water Used (Ml/day) | Score |
|---|---|---|
| Small | < 1.5 Ml/day | 1 |
| Medium | >1.5 Ml/day and <3 Ml/day | 3 |
| Large | >3 Ml/day | 5 |

| Table 6(b): Scores for savings in water supply costs | | |
|---|---|---|
| **Initial Supply Source** | **Change with Water Quality Improvements/Maintenance** | **Score** |
| Abstraction with either disinfection of screening | No further requirements for disinfection or screening | 1 |
| Abstraction with corrosion control and disinfection or with filtration | No further requirements for corrosion control and disinfection or for filtration | 3 |
| Potable supply source | Switch to river abstraction | 5 |

## 6.3 Example Calculation

Using the above system, the total benefit score for industrial abstractions were calculated as follows:

Volume x Change in Supply Costs = Benefit Score

For example, assume that there are two industrial facilities located along the river. One of these abstracts around 1 Ml/day from the river and treats this water for corrosion control and filtration. The other facility uses around 3 Ml/day of a potable supply source. The improvement in water quality would eliminate the treatment requirements of the first facility and allow the second facility to make use of an existing but unused abstraction licence (although some treatment of the river supply would still be required).

In this case, some adjustments to the scores would have been necessary to account for the differing nature of the industries, with the resulting scores being as follows:

2 x 4 = 8

The maximum potential score for this benefit category using the above formula is 25. Given that this maximum values is below the normalisation base of 100, scores were multiplied by 4 to calculate the end normalised score. In the above example, the normalised score would be 32.

# 7. DRINKING WATER SUPPLY ABSTRACTIONS

## 7.1 Overview

Water undertakers will rarely forego treatment because of an improvement to upstream river water quality. The importance of public perceptions will tend to make this type of action too risky and the nature of existing plant may limit the operational ability to modify treatment processes. As a result, the only cases where there may be a significant benefit to water supply companies is when water quality improvements result in the 'creation' or reclamation of a water resource, or when a failure to maintain current quality would result in the need for additional treatment.

As for industrial abstractions, it is very unlikely that there would be any benefits falling under this heading from water quality improvements. Where no benefits were predicted, a score of zero was entered against this impact category.

## 7.2 Scoring System

The key independent attribute which needed to be scored under this category is the volume of water treated, defined in terms of megalitres per day (Ml/day). The scores applied to different levels of throughput are given in Table 7(a).

**Table 7(a): Scores for treatment plant throughput (Ml/day)**

| Size Category | Throughput | Score |
|---|---|---|
| Small | <50 | 1 |
| Medium | >50 to <100 | 3 |
| Large | >100 | 5 |

For new plant, treatment type was broken into three categories as follows (where these are consistent with those given in the FWR Manual - see pages 205 to 216):

- A1 Works: disinfection; physical treatment (rapid gravity filtration); contact tank; buildings; inlet, site works and pipeworks.
- A2 Works: disinfection; physical treatment (rapid gravity filtration); contact tank; buildings; inlet, site works and pipeworks; prechlorination; coagulation; and sedimentation.
- A3 Works: disinfection; physical treatment (rapid gravity filtration); contact tank; buildings; inlet, site works and pipeworks; prechlorination; coagulation; sedimentation; granular activated carbon (GAC); and ozone.

In general, the benefits of moving from an A3 to an A2 works, or from an A2 to an A1 works, in terms of levels of treatment required correspond to a saving in capital costs of roughly 40%. As a result, the scoring system relied on the use of a single score (of 3) to represent the magnitude of benefits associated with improvements in water quality which would be significant enough to allow one class lower of treatment plant (or preventing water quality from falling to a level which would require one class higher of treatment plant). However, if the change in quality would result in the 'creation' of a new supply source (or prevent the loss of a supply source as a result of poor quality), then a greater score was assigned to the benefits, as indicated in Table 7(b).

**Table 7(b): Scores for savings in treatment costs for new plant**

| Level of Savings / Plant Type | Implications of Water Quality Change | Benefit Score |
|---|---|---|
| New Plant : roughly 40% | A3 to A2<br>or A2 to A1 | 3 |
| | New Source | 5 |

With regard to existing plants, benefits relate to a reduction in the operating costs associated with treatment of turbidity, colour and nitrates (or preventing an increase in such costs). For colour, treatment costs were assumed to be roughly constant per unit of treatment and, thus, a single score was assigned to the benefits associated with reduced treatment requirements. For turbidity and nitrates, the per unit costs of achieving lower levels increase as greater levels of reduction are required and this was reflected in the scoring system. The savings in costs across these different parameters vary in magnitude, however, so these variations were also reflected in the benefit scores. The resulting scoring systems are presented in Table 7(c).

**Table 7(c): Scores for savings in treatment costs for existing plant**

| Existing Quality Level | Change in Treatment Requirements | Benefit Score |
|---|---|---|
| Colour: (mg/litre Pt) | per unit reduction | 3 |
| Turbidity (NTU): >51 | >11 to <51 | 1 |
| >11 | >4 to ≤11 | 3 |
| >4 | ≤4 | 5 |
| Nitrates (mg/l): >76 | >51 to ≤76 | 1 |
| >51 | ≤50 | 3 |

## 7.3 Example Calculation

Using the above system, the benefit score for savings in water supply treatment costs would be calculated as follows:

Throughput x (Savings + Colour + NTU + Nitrate) = Benefit Score

Note the maximum possible benefit score using the above formula is 80, requiring the score to be multiplied by 1.25 to convert it to a base of 100.

# 8. AMENITY VALUE

## 8.1 Overview

As described here, amenity refers to the additional value, or premium, placed on properties which benefit from being located along rivers of higher quality. US valuation studies have assumed that property values reflect three different attributes with regard to water quality: aesthetics; wildlife support capacity; and recreational opportunity. A series of criteria was developed to allow for the rating of a property against these attributes, and they form the basis for the approach which is used in the full application of the FWR Manual. The approach itself recognises the potential for there to be double-counting if no consideration is given to the possible link between changes in property values and recreation and nature conservation related benefits. The approach, therefore, allows for the three different attributes to be considered separately in the assessment in order to limit the degree to which any double-counting might occur. The scoring system applied here built upon drew upon this approach.

## 8.2 Scoring System

The significance of a change in water quality to property prices depends not only on the level of change, but also on the number of properties in proximity to the river and their value. In addition, the magnitude of any impacts may be affected by the degree to which there is the potential for regenerating a site, whether urban or rural.

For this scoring system, the number of properties was determined by the number within 600 metres (2,000 feet) of the river, and value was related to Council Tax Bands (or average price data if available). The scores applied to each of these factors are summarised in Tables 8(a) and (b). Note that Council Tax Bands vary between England and Wales and the scoring system was developed to reflect this. It also assumed that the middle band of properties is more likely to respond to environmental quality changes than either the lower or upper bands. Where it was believed that this would not be the case for a particular area, users were recommended to discuss whether or not changes in the aesthetic and visual character of the river would have any effect on prices (rather than saleability of the property) brief discussions with an estate agent.

The scores for applied to regeneration potential are presented in Table 8(c). Note that scores for regeneration potential may be low as development has already occurred or because it is unlikely to occur, with an area remaining depressed.

| Table 8(a): Scores for properties in proximity to the river stretch | | |
|---|---|---|
| **Potential for Premium Related Benefits** | **Number in Proximity** | **Score** |
| Very low | <50 | 1 |
| Low | >50 and < 150 | 2 |
| Average | >150 and <300 | 3 |
| Above average | >300 and <500 | 4 |
| High | >500 | 5 |

| Table 8(b): Scores for property values | | | |
|---|---|---|---|
| **Property Value Category** | **Valuation Band for England** | **Valuation Band for Wales** | **Score** |
| Low | Bands A to D (£0 to £88,000) | Bands A to D (£0 to £66,000) | 1 |
| Average | Bands E and F (£88,001 to £160,000) | Bands E and F (£66,001 to £120,000) | 5 |
| High | Bands G and H (>£160,000) | Bands G and H (>£120,000) | 3 |

| Table 8(c): Scores for regeneration potential | | |
|---|---|---|
| **Category** | **Regeneration Potential** | **Score** |
| Low | Potential for development is low; little relationship between development and river | 1 |
| Average | Some redevelopment underway and river adjoins this area, or could form part of attraction | 3 |
| High | Redevelopment underway and river is the focus or could form the focus for new developments | 5 |

The relationship between an increase in property prices and changes in chemical water quality has been found to be fairly weak by economic valuation studies. As a result, it was assumed in this methodology that an improvement by one RE class is equivalent to a 1% change in price, while a two RE class improvement yields a 1.5% change and a three class improvement a 2% change (or the prevention of a drop in quality by similar amounts). As a result, water quality was scored differently here than for the other impact categories. Experience indicates that litter and general aesthetics can also be important to people's perceptions of environmental quality and hence property values and, indeed, may be the over-riding factor. For this reason, both chemical water quality and GQA aesthetics classification were included in scoring benefits.

Table 8(d) presents the system used for scoring the impact of water quality on property prices. Note that these scores applied regardless of the starting point in terms of the RE class prior to the water quality improvement (or under the 'without' case for schemes aimed at maintaining quality). Furthermore, the highest score which could be awarded is 3, reflecting the fact that chemical water quality is likely to be much less important than changes in aesthetic quality for this impact category. Table 8(e) presents the scores used for the impact of changes in GQA classification on property values.

**Table 8(d): Scores for water quality change**

| Water Quality Change | Score |
|---|---|
| Improvement by one RE class | 1 |
| Improvement by two RE classes (including bottom of one to top of next) | 2 |
| Improvement by three RE classes (including bottom of one and top of class two above) | 3 |

**Table 8(e): Aesthetics scores**

| Change in Classification | Score |
|---|---|
| Grade 2 to Grade 1 | 1 |
| Grade 3 to Grade 2 or better | 3 |
| Grade 4 to Grade 3 or better | 5 |

## 8.3 Example Calculation

The generalised formula used for calculating the score for property benefits is:

(No. of properties + Tax Band + Regeneration) x (Water Quality + Aesthetics) = Benefit Score

The following example illustrates how this was applied in practice. Assume that there are 90 properties along the river, falling into tax band E. River water quality is going to improve from the bottom of RE4 to the top of RE3. The area is an urban one which is undergoing significant regeneration, with this including local campaigns to clean up large amounts of litter (currently GQA 4 - likely to go to 3 maybe 2), etc. from the river banks. The weighted benefit score is, therefore, as follows:

(2 + 5 + 5) x (2 + 5) = 84

Note that the maximum benefit score for property related effects using the above formula is 120, with normalisation requiring that the score is multiplied by 0.83 [= (100/120)].

# 9. NATURE CONSERVATION

## 9.1 Overview

People value the conservation of environmental resources for a range of different reasons, with these relating to their desire to use them in the future, to conserve them for use by future generations, or out of more preservationist motives not linked to use by man. In the field of environmental economics, these are referred to as non-use (or passive use) values. With regard to water quality, willingness to pay surveys have been undertaken to derive estimates of the non-use values held by people for improving water quality for ecological support and conservation purposes. Interestingly, these suggest that the general public may value more highly the improvement of poor quality rivers to the improvement of already fair to high quality rivers. The willingness to pay values are general across all rivers, however, and do not reflect differences in the scientific, nature conservation values which are attached to different rivers. As a result, they neglect a key factor which should be taken into account when assessing the impacts of changes in river water quality.

In addition, there are fundamental questions surrounding the question of who holds non-use values towards the protection of any given river resource. At the extreme, it can be argued that the entire UK population may hold such values, while at the other end it might be argued that only those living within a short distance from the river are likely to hold non-use values towards the river. At this point in time, there is a paucity of data on the relationship between willingness to pay, distance to the site, type of site, the nature of scientific interest, etc., which prevents specification of the most appropriate population for use in a system such as this.

In contrast, conservation organisations are able to indicate preferences for the types of sites/habitats which are more highly valued in scientific terms and thus the value which should be assigned to water quality changes which would protect or improve such sites. As a result, the scoring system developed here considers only the scientific, nature conservation value of the river and associated ecosystems.

## 9.2 Scoring System

The first component that was scored relates to the importance of a river system in terms of its biodiversity value. The UK Biodiversity Action Plan identifies species and habitats which require protection, where the former are broken into priority species and habitats (short and middle lists), other species of conservation concern (the long list) and other habitats or species.

The second key factor is whether or not a river supports any designated sites. In terms of designations, these may include those which are directly related to the river or which are attached to the land/habitat areas adjacent to the river (for example, wetland areas). Of particular importance is whether or not a site has an international designation, such as being a Special Area of Conservation (SAC) or a Special Protection Area (SPA), or is irreplaceable in nature. Note that the highest scoring designation across all designated sites was taken as the basis for scoring, and that scores were not treated as additive (i.e. one priority list species and one species of local concern generates a score of 5 and not a score 6).

Increased treatment and improvements in chemical water quality may not be of benefit to all of the species and habitats of concern, however. Certain species or habitats may require poorer quality water (e.g. high nutrient levels). For this reason, negative scoring of impacts on nature conservation value was also allowed.

**Table 9(a): Scores for Biodiversity Action Plan classification**

| Direction of Change | Class | Score |
|---|---|---|
| Benefit | Other species of local concern | 1 |
| Benefit | Species of conservation concern (BAP long list) and red data book species | 3 |
| Benefit | Priority species (short and medium lists) and priority habitats (river related habitat types include chalk river, fens, reed beds, mezotrophic lake or grazing marsh) | 5 |
| Damages | Priority species (short and medium lists) and priority habitats (river related habitat types include chalk river, fens, reed beds, mezotrophic lake or grazing marsh) | -5 |
| Damages | Species of conservation concern (BAP long list) and red data book species | -3 |
| Damages | Other species of local concern | -1 |

**Table 9(b): Scores for scientific conservation value**

| Direction of Change | Designation | Score |
|---|---|---|
| Benefit | No national designations, but of local or regional/county importance | 1 |
| Benefit | AONB, or other such national designations (including heritage and archaeological related to the site) | 3 |
| Benefit | Non-internationally designated SSSIs | 4 |
| Benefit | International designations including, RAMSAR site, SPA and SAC; also all irreplaceable SSSI habitat | 5 |
| Damages | International designations including, RAMSAR site, SPA and SAC; also all irreplaceable SSSI habitat | -5 |
| Damages | Non-internationally designated SSSIs, | -4 |
| Damages | AONB, or other such national designations (including heritage and archaeological related to the site) | -3 |
| Damages | No national designations, but of local or regional/county importance | -1 |

The last factor to be scored was the length of river affected, as this has implications for the extent of ecological or conservation gains. The scoring system used here was similar to that adopted for informal recreation and fisheries; see Table 9(c).

| **Table 9(c): Scores for length of river affected** | |
|---|---|
| **Length Affected** | **Score** |
| < 3 km affected | 1 |
| > 3 km and less than 7 km affected | 2 |
| > 7 km and less than 15 km affected | 3 |
| > 15 km and less than 30 km affected | 4 |
| > 30 km affected | 5 |

The scoring system developed to reflect the benefits of a change in river water quality is provided in Table 9(d). Benefit estimates derived through survey methods relate to only two step changes in water quality, with these being a change from poor quality (RE5 or 4) to medium quality (RE3) and then from medium quality to good quality (RE3 to RE1 or 2). The scoring system presented below modified this by recognising the full range of possible changes, given that these may have a bearing on the ecological quality or scientific conservation value of a river.

| **Table 9(e): Scores for water quality change** | |
|---|---|
| **Water Quality Change** | **Score** |
| Improvement within class | 1 |
| Improvement from bottom to top of class, remaining within the same class | 2 |
| Improvement by one class | 3 |
| Improvement from bottom of one class to top of next class (e.g. from bottom of 3 to top of 2) | 4 |
| Improvement by more than one class | 5 |

## 9.3 Example Calculation

The above scoring system was applied as follows:

(Class + Designation) x Length x Water Quality = Benefit Score

As for informal recreation and angling, statistical analysis highlighted the importance of length in assessing ecological and nature conservation gains (or losses). As a result, length was again used as a multiplicand, together with water quality.

By way of example, let us assume that the water quality improvement in a river stretch is a change of one class. The stretch is 17 km long, has a small otter population (priority list) and has two designated sites on the land adjoining the river, with one of these being a nationally designated SSSI and the other being a local designation.

The benefits in this example would be scored as follows:

$$(5 + 4) \times 4 \times 3 = 108$$

Note that the maximum score which could be achieved is 250. Normalisation to a base of 100 would revise the above score to 43.2 [= (108/250) x 100)].

# 10. SCHEME COSTS

## 10.1 Overview

In order to provide an indication of whether a balance is being achieved between the costs and benefits associated with a given scheme (or indeed, whether one is likely to be greater than the other), scheme costs were included within this overall scoring and weighting system.

Scoring and normalisation of costs was treated in a different manner from the other impact categories, however, as there would be significant within and between region variations in the cost of schemes. In this case, no separate scoring of individual cost elements took place, with normalisation of scheme costs alone used to determine the end impact score. The normalisation process adopted is described further below.

## 10.2 Normalisation of Scheme Costs

The first step in the normalisation process was to determine the highest cost scheme which provided the basis for normalisation. As the focus group weights were derived during sessions involving the grouping of regions, the highest cost scheme in present value terms (where this includes both capital and operating costs) being proposed out of all of the schemes being put forward by the regions in the group was taken as providing the maximum for normalisation.

Once the highest cost scheme had been identified across the group of regions, referred to hereafter as $PV_{max}$, it was given a normalised score of -100. Other schemes were then scored against this by dividing their costs by $PV_{max}$. The formula used for deriving scheme cost scores is therefore as follows:

$$\text{Cost Score} = (PV_{scheme} / PV_{max}) \times 100$$

Note that the end score was negative in sign to reflect the fact that these are costs.

## 10.3 Example Calculation

Let us assume that three regions were grouped together for the purpose of deriving relative impact weights. The highest costing scheme (in present value terms) being proposed across these groups is estimated at £25 million, with the lowest cost scheme estimated at £100,000. The schemes range from major improvements in STWs linked to large urban conurbations through to smaller CSO schemes. Most schemes are estimated to cost between £5 million and £10 million. These different PV cost estimates would translate into normalised scores as follows:

- Cost Score = - (£25m / £25m) x 100 = - 100
- Cost Score = - (£10m / £25m) x 100 = - 40
- Cost Score = - (£ 5m / £25m) x 100 = - 20
- Cost Score = - (£100k / £25m) x 100 = - 0.40

These normalised cost scores were then directly included in the aggregation of weighted benefit/disbenefit scores to develop an overall indicator of scheme performance, as discussed in Section 11.

# 11. AGGREGATION AND PRIORITISATION

## 11.1 Introduction

As indicated in the introduction to this document, the impact scores developed through the above scoring systems were used in two different manners as part of that are calculated using the above formulae can be used in scheme justification and prioritisation.

1) Aggregation across all impact categories, including costs, to develop an overall measure of net effect. This level of aggregation provided an indication of whether or not the benefits of a scheme appear to outweigh the costs given a particular set of value weights. This information then fed into decisions as to whether or not a scheme appeared to be justified in resource terms, given the balance of costs and benefits.

2) Aggregation of impact scores with the exception of costs. This level of aggregation allowed the calculation of a measure of net environmental benefit, which could then be divided by scheme costs to provide an indication of the ratio of net benefit to costs (a cost-effectiveness or cost-utility indicator). These indicators were valuable for prioritisation of schemes, where the aim was to maximise the benefits gained for a given amount of expenditure.

Both approaches involved the aggregation of the normalised impact scores across different impact categories. As noted in Section 1, this required the application of weights to reflect the relative importance which different stakeholders place on achieving the benefits associated with one impact category relative to other categories. These stakeholder weights were been developed through two different approaches. The first set of weights were defined through consultation with the regional REPACs. The second approach involved the use of regional focus group exercises comprised of a number of different stakeholders with a background in the following areas:

- fisheries;
- recreation and tourism;
- conservation;
- consumer protection;
- local authorities;
- agricultural interests; and
- industry interests.

Further details on the focus group sessions are available in the Agency report titled 'Development of Weights for the MAT Water Quality System: Focus Group Results'.

## 11.2 Derivation of the Relative Impact Weights

As discussed in Section 1, the weights were developed so as to ensure that they reflected the relative importance of impacts falling under one category as compared to another. In order to do this, a combined ranking and 'swing' weighting procedure was adopted.

The first step in this process involved explaining to participants what conditions would have to be met for a scheme to receive maximum scores. For each benefit category, therefore, descriptions were given of both the river and site attributes which would have to exist and the level of water quality change which would have to take place for a normalised score of 100 to be assigned. Similarly, the scheme costs associated with a maximum score of -100 was made clear.

Participants were then told to rank the different impact categories in the order of importance to them as an individual. In doing this, they were instructed to focus on the maximum score and the conditions that it related to for each of the impact categories. In other words, they should consider how important achieving the maximum informal recreation benefits were to achieving the maximum coarse angling benefits. This approach was important to ensuring that all participants were ranking and then weighting on a common basis.

Once participants had ranked the impact categories in terms of their importance, they were then asked to weight these in relative terms. To do this, the highest ranking impact category was assigned a weight of 100 and participants were asked to determine how much of the benefits associated with category they would be willing to give up to get the benefits associated with the second ranked category. So, for example, a participant might be willing to give up 80% of informal recreation benefits to gain 100% of the angling benefits. On this basis, angling benefits receive a weighting of 80 compared to the 100 assigned to informal recreation. The third ranked category was then compared to the second ranked category, again with the individual asking himself/herself how much of the higher ranked impacts he/she would be willing to give up to get the lower ranked benefits. This process then continued until relative importance weights had been derived for all of the impact categories.

As would be expected there were wide variations in the relative weights assigned by the different participants to the different impact categories. There was also some variation across regions as to the overall ranking given to different types of impacts. Again, for further discussion of the focus group results, reference should be made to the Agency report.

## 11.3 Determination of Scheme Worthiness Using Relative Weights

The focus group and REPAC weights have been used in a different manner in developing priorities for funding in AMP3. The focus group weights have been used to identify funding priorities at different levels in terms of the degree to which the benefits of implementing a given scheme would appear to outweigh the costs. The REPAC weights (or where the REPAC did not provide explicit weights, those of the focus group which were considered to best reflect the Agency's duties) were then used to prioritise schemes within each of the priority levels and, hence, overall.

Identification of funding priorities using the focus group weights, involved the generation of three lists comprising:

- List A: those schemes which received a positive net impact score (with costs included) across all participants relative value weights. In other words, no matter whose weights were adopted, the benefits of undertaking the scheme outweighed the costs;
- List B: those schemes which received a positive net impact score (with costs included) using some of the participants relative value weights, but not across all of the sets of weights; in other words, the benefits appeared to outweigh the costs given some participants' values but did not given other participants' values;
- List C: those schemes which consistently received a negative impact (with costs included) across all participants weights.

## 11.4 Scheme Prioritisation

Within each of these lists, the cost-effectiveness of the schemes was then determined and ranked using the following formula:

$$\frac{\text{Environmental Net Benefit Score}}{\text{“Geometric Cost Score” x 10}}$$

Because the environmental net benefit score assigned to a scheme would vary across each of the participant's sets of weights, a single set of weights had to be applied for prioritising schemes within each of the three lists. It was decided that the most appropriate set of weights to be used for determining cost-effectiveness were those developed through consultation with the REPACs. This ensures that not only are stakeholder's views taken into account when putting forward schemes, but also that the need for the Agency to fulfil its duties and responsibilities is recognised within the decision-making process.

In developing indicators of scheme cost-effectiveness, a second factor had to be taken into account. As indicated in Section 1, in order to develop a scoring system which could readily be applied to a large number of schemes, a scalar approach to scoring was adopted. By its very nature, the adoption of 1 to 5 scales, limits the maximum value of benefits which any scheme can achieve. Scheme costs, when acting as the denominator within the above formula, are not limited in the same manner. As a result, a non-linearity in the relationship between benefits and costs arises, with large schemes being penalised relative to smaller schemes. In order to overcome, this small versus large scheme bias, the present value of scheme costs were re-scored for inclusion in the above cost-effectiveness formula using a rough geometric series (with this respecting proportionality between each cost band).

The geometric group scores were assigned as indicated in Table 11.1. It should be noted that this series was developed to embrace the full spectrum of water company cost estimates prior to the 'challenged' scheme costs data became available from OFWAT. Given time constraints, the Agency had to make sure that its systems encompassed possible all possible end estimates.

| Table 11.1: Geometric Group Scores for Costs | |
|---|---|
| **Score** | **Scheme Cost** |
| 1 | < 20k |
| 2 | <50k |
| 3 | <125k |
| 4 | <300k |
| 5 | <750k |
| 6 | <1.8m |
| 7 | <4.5m |
| 8 | <11.0m |
| 9 | <27.0m |
| 10 | <70.0m |

Once (unweighted) scheme costs had been re-scored using the above system, the schemes within each of the three lists were then ranked in order using the ratio of net benefits per unit of expenditure. The three ranked lists were then combined to provide a long-list of schemes.

## 11.5 Final Scheme Ranking

Before submitting the long list of schemes to the Secretary of State or consideration, a final stage of review took place. The aim of this final stage was to ensure that the rankings reflected local and regional priorities, stemming from factors not captured within the MAT. Where such priorities were felt to over-ride the rankings assigned to a scheme, the scheme was to re-ranked with a commentary provided as to the justification for change scheme order. In all cases, the number of schemes to be re-prioritised in this manner was limited.

## ANNEX 1:

## SCORES FOR RIVER LENGTH

# SCORES FOR RIVER LENGTH

## A1.1 INTRODUCTION

A number of concerns relating to the scores for 'river length' have been raised, which appear to boil down to two issues:

- should the benefits associated with a 2X km river stretch be twice those associated with an X km stretch (all other things being equal)? and
- is the scoring system is too coarse?

Currently, the river length scores are based on those given in Table 2(a) of the main text, which is represented below as Table A1(a).

**Table A1(a): River Length Scores**

| Score | Min$^m$ River Length (km) | Max$^m$ River Length (km) |
|---|---|---|
| 1 | less than 3 | 3 |
| 2 | 3 | 7 |
| 3 | 7 | 15 |
| 4 | 15 | 30 |
| 5 | 30 | more than 30 |

## A1.2 EXISTING RIVER LENGTHS

Table A1(a) was based, in part, on information provided from all eight regions on existing river stretch lengths for GQA classes - as presented in Table A1(b).

**Table A1(b): Existing River Stretch Lengths (per GQA Class)**

| Region | Minimum (km) | Maximum (km) | Average (km) |
|---|---|---|---|
| Anglian | 0.1 | 42.5 | 5.1 |
| Midlands | 0.1 | 62.9 | 5.3 |
| North East | 0.1 | 51.0 | 3.7 |
| North West | 0.1 | 30.6 | 5.6 |
| South West | 0.0 | 33.5 | 3.0 |
| Southern | 0.1 | 38.2 | 4.1 |
| Thames | 0.1 | 34.0 | 6.5 |
| Welsh | 0.1 | 20.0 | 4.2 |

From the data, the following observations can be made:

- the data from each region are very similar;
- the minimum stretch is about 100 m;
- the maximum stretch is about 60 km; and
- the average stretch is 4.7 km (with regional averages ranging from 3.0 to 6.5 km).

## A1.3 CORRELATING SCORES WITH LENGTHS

The next stage of the analysis was to represent the 'half-scores' by river length (based on information provided in Table A1(a)) and to provide a simple correlation of the form: $score = length^{b}$. The results are shown in Table A1(c).

**Table A1(c): Stretch Length and 'Half-Scores'**

| Stretch Length (km) | Half-score (implied) | Half-score (estimated[1]) |
|---|---|---|
| 0.1 | 0.5 | 0.4 |
| 3.0 | 1.5 | 1.6 |
| 7.0 | 2.5 | 2.3 |
| 15.0 | 3.5 | 3.2 |
| 30.0 | 4.5 | 4.3 |
| 60.0 | 5.5 | 5.8 |

Note: 1. Half-score (estimated) derived from $score = length^{0.43}$

The implication of this is that there is not a linear relationship between benefits and stretch length - for example, doubling the length would lead to a 35% increase in benefits (based on $2^{0.43}$). This, in turn, implies that more 'small' schemes (in terms of length of river affected) would be preferable to a few 'large' schemes. The question remains as to whether this is a reasonable approach - or, more specifically, would the use of a direct linear scale of the form one point per km of river be better?

We believe that the approach adopted is reasonable on the following grounds:

- the use of a power function favours 'small' schemes (or, to put it another way, reflects the 'law' of diminishing returns);
- the use of a five point scale is much more amenable to rapid scoring;
- in practice, the majority of schemes would involve stretches of no more than 5km; and
- over a relatively small range of distances, there is a greater degree of 'linearity'.

## A1.4 NEED FOR SCALE REFINEMENTS?

The second area of concern is that the current scaling is perhaps too coarse. One possible remedy is to introduce 'half-scores' and a possible set of values is given in Table A1(d).

**Table A1(d): Proposed Revised Scoring System**

| Proposed Score | Stretch Length (km) | Current Score |
|---|---|---|
| 0.5 | < 0.5 | 1 |
| 1 | 0.5 - 2.0 | 1 |
| 1.5 | 2.0 - 4.0 | 1 or 2 |
| 2 | 4.0 - 7.0 | 2 |
| 2.5 | 7.0 - 10 | 3 |
| 3 | 10 - 15 | 3 |
| 3.5 | 15 - 20 | 4 |
| 4 | 20 - 30 | 4 |
| 4.5 | 30 - 40 | 5 |
| 5 | > 40 | 5 |

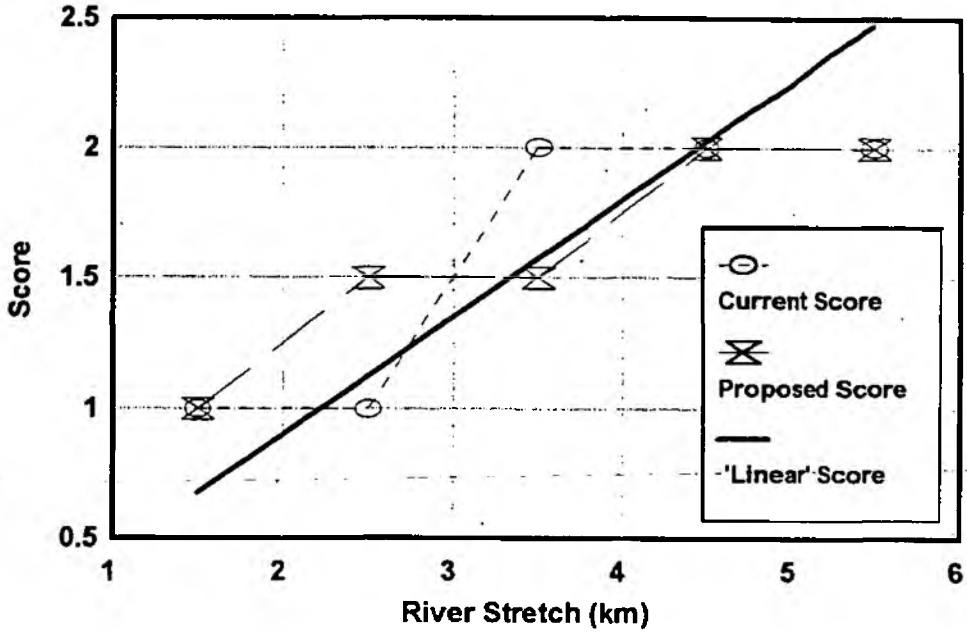
Now, consider a range of 'typical' schemes with stretch lengths of, say, 1.5, 2.5, 3.5, 4.5 and 5.5 km respectively. The associated scores based on the both the existing system and that proposed above are given in Table A1(e). In addition, scores are provided on the basis that *score = 0.45 x stretch length* (to represent a true linear relationship).

**Table A1(e): River Stretch Scores**

| Stretch Length (km) | Current Score | Proposed Score | Linear Score |
|---|---|---|---|
| 1.5 | 1 | 1 | 0.7 |
| 2.5 | 1 | 1.5 | 1.1 |
| 3.5 | 2 | 1.5 | 1.6 |
| 4.5 | 2 | 2 | 2.0 |
| 5.5 | 2 | 2 | 2.5 |

The values presented in table A1(e) are also presented graphically in Figure A1(a).

Figure A1(a): Scores vs Stretch




As can be seen from both Table A1(e) and Figure A1(e), there is a considerable degree of consistency amongst the results generated from a 'linear' scale and those based on the current and proposed scoring systems over the range of interest.

Nevertheless, it is accepted that since many schemes will currently score either 1 (less than 3 km) or 2 (3 to 7 km), it is considered that there would be considerable merit in refining the scoring system to include 'half scores' (as set out in Table A1(d) above) for future versions of the MAT system.

## A1.5 SUMMARY

The purpose of this Annex has been to briefly examine possible scoring systems for river length. The current system (as presented in the main text) was based on consideration of the current distribution of river lengths (per GQA class) across all eight regions of the Agency. As a result, the focus has been on shorter river stretch lengths (typically less than 5 km) and it is not considered necessary to introduce a linear scale ranging up to around 60 km.

Nevertheless, given the focus on shorter river stretch lengths (and its importance in scoring a range of aspects), it is recommended that the current scale is refined from a 5 point to 10 point scale through the use of 'half scores' in future versions of the MAT scoring system.

# ANNEX 2:

# GQA CLASSIFICATION SYSTEM

# ENVIRONMENT AGENCY

# GQA AESTHETICS CLASSIFICATION SYSTEM

## 1. General Principles

The final classification of a site for aesthetic quality is four grades, 1 - 4, described as Aesthetically Good Quality, Aesthetically Fair Quality, Aesthetically Poor Quality and Aesthetically Bad Quality. The grade is derived from individual classes for each parameter, again four classes 1-4. Each class for each parameter is then assigned a numerical score. The scores for all parameters are summed to derive the overall score for the site. This score gives the overall Aesthetic Grade for the site.

## 2. Class Tables for each Parameter

Tables 1 and 2 show how to assign a class for each parameter surveyed. Table 1 is for a "2 Bank Site" and Table 2 for a "1 Bank Site". Litter parameters are classified on the total number of items counted for each parameter. Oil, scum, foam, sewage fungus and ochre are classified on the percentage cover of the water. Colour is classified by a combination of the hue and intensity of the sample. Odour is classified by a combination of the type of odour and its intensity.

## 3. Final Classification Scheme

Table 3 details how the classification of a site is derived based on the "score" allotted to each parameter. The number of "points" for each parameter has been allocated based on the relative importance given to each parameter from a public perception study undertaken as part of the research phase of the schemes development, and after consultation with Regional representatives on the national rivers group. The final total score is simply the sum of the number of points for all parameters. The total score then places the site in one of the Grades as shown in the table. The scheme is designed such that a site can be classified as "bad" by one parameter with a high perception of poor quality scoring highly, or by a combination of several parameters being identified as present during sampling. Conversely a site will not be classified as poor or bad if only one parameter with a low perception of indicating bad quality is scored as class 4.

**March 1997**

**Table 1** **GQA AESTHETICS - CLASS TABLE (2 BANK SITE)**

| LITTER (Total Number of Items) | | | | |
|---|---|---|---|---|
| TYPE | CLASS 1 | CLASS 2 | CLASS 3 | CLASS 4 |
| Gross | 0 | 1-2 | 3-9 | 10+ |
| General | 0-5 | 6-49 | 50-99 | 100+ |
| Sewage | 0 | 1-5 | 6-24 | 25+ |
| Faeces | 0 | 1-5 | 6-24 | 25+ |

| Other Aesthetic Parameters (Percentage Cover) | | | |
|---|---|---|---|
| Oil, Scum, Foam, Sewage Fungus, Ochre | | | |
| CLASS 1 | CLASS 2 | CLASS 3 | CLASS 4 |
| 0 | > 0.5% | > 5.25% | > 25% |

| COLOUR | | | |
|---|---|---|---|
| | Blue/Green | Red/Orange | Brown/Yellow/Straw |
| Colourless | Class 1 | Class 1 | Class 1 |
| Very Pale | Class 1 | Class 2 | Class 1 |
| Pale | Class 3 | Class 3 | Class 2 |
| Dark | Class 4 | Class 4 | Class 3 |

| ODOUR | | | |
|---|---|---|---|
| | Group 1 | Group 2 | Group 3 |
| No Smell | Class 1 | Class 1 | Class 1 |
| Faint Smell | Class 1 | Class 2 | Class 3 |
| Obvious Smell | Class 2 | Class 3 | Class 4 |
| Strong Smell | Class 3 | Class 4 | Class 4 |

**Group 1:** Tolerated/Less indicative of water quality. Musty, Earthy, Woody.
**Group 2:** Rated as indicators of poor water quality. Farmy, Disinfectant, Gas, Chlorine.
**Group 3:** Rated as indicators of very poor water quality.
Sewage, Polish/Cleaning Fluid, Ammonia, Oily Smell, Bad Egg (Sulphide).

Table 2 **GQA AESTHETICS - CLASS TABLE (1 BANK SITE)**

| **LITTER (Total Number of Items)** | | | | |
|---|---|---|---|---|
| **TYPE** | **CLASS 1** | **CLASS 2** | **CLASS 3** | **CLASS 4** |
| Gross | 0 | 1-2 | 3-6 | 7+ |
| General | 0-5 | 6-39 | 40-74 | 75+ |
| Sewage | 0 | 1-5 | 6-19 | 20+ |
| Faeces | 0 | 1-3 | 4-12 | 13+ |

| **Other Aesthetic Parameters (Percentage Cover)** | | | |
|---|---|---|---|
| **Oil, Scum, Foam, Sewage Fungus, Ochre** | | | |
| **CLASS 1** | **CLASS 2** | **CLASS 3** | **CLASS 4** |
| 0 | > 0.5% | > 5.25% | > 25% |

| **COLOUR** | | | |
|---|---|---|---|
| | **Blue/Green** | **Red/Orange** | **Brown/Yellow/Straw** |
| Colourless | Class 1 | Class 1 | Class 1 |
| Very Pale | Class 1 | Class 2 | Class 1 |
| Pale | Class 3 | Class 3 | Class 2 |
| Dark | Class 4 | Class 4 | Class 3 |

| **ODOUR** | | | |
|---|---|---|---|
| | **Group 1** | **Group 2** | **Group 3** |
| No Smell | Class 1 | Class 1 | Class 1 |
| Faint Smell | Class 1 | Class 2 | Class 3 |
| Obvious Smell | Class 2 | Class 3 | Class 4 |
| Strong Smell | Class 3 | Class 4 | Class 4 |

**Group 1:** Tolerated/Less indicative of water quality. Musty, Earthy, Woody.
**Group 2:** Rated as indicators of poor water quality. Farmy, Disinfectant, Gas, Chlorine.
**Group 3:** Rated as indicators of very poor water quality.
Sewage, Polish/Cleaning Fluid, Ammonia, Oily Smell, Bad Egg (Sulphide).

**Table 3 GQA AESTHETICS - CLASSIFICATION SCHEME**

Each aesthetic parameter is assigned a class from 1 to 4 (see class tables). Each parameter then scores a number of "points" related to the class achieved. Points are allocated as in the table below. The points have been awarded to each parameter giving weight to the perceived importance of it's aesthetic acceptability.

| | CLASS 1 SCORE | CLASS 2 SCORE | CLASS 3 SCORE | CLASS 4 SCORE |
|---|---|---|---|---|
| Sewage Litter | 0 | 4 | 8 | 13 |
| Odour | 0 | 4 | 8 | 12 |
| Oil | 0 | 2 | 4 | 8 |
| Foam | 0 | 2 | 4 | 8 |
| Colour | 0 | 2 | 4 | 8 |
| Sewage Fungus | 0 | 2 | 4 | 8 |
| Faeces | 0 | 2 | 4 | 6 |
| Scum | 0 | 1 | 3 | 5 |
| Gross Litter | 0 | 0 | 1 | 3 |
| General Litter | 0 | 0 | 1 | 3 |
| Ochre | 0 | 0 | 0 | 1 |

The points allocated for each parameter are then summed to give the "Total Score". The overall grade of the site is then allocated according to the table below:

| | | Total Score |
|---|---|---|
| **Grade 1** | Aesthetically Good Quality | 1, 2, 3 |
| **Grade 2** | Aesthetically Fair Quality | 4,5,6,7 |
| **Grade 3** | Aesthetically Poor Quality | 8,9,10.11 |
| **Grade 4** | Aesthetically Bad Quality | >= 12 |