Draft Final R&D Note R&D Project 237

Assessment of Low Flow Conditions
Phase 2 Evaluation of Methodology

Scott Wilson Kirkpatrick

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INTRODUCTION

This R&D Note summarizes the results of R&D Project B2.2, "Assessment of Low Flow Conditions" which has as its objective the development of a standard method for the assessment of low flow conditions, generally arising from over-abstraction.

The method developed is based on the use of four Indicators and two Adjustment Factors as follows:

The Indicators are:

Hydrological
Ecological
Landscape/Amenity
Public Perception

Each Indicator is evaluated by combining scores assigned to a number of weighted Parameters which contribute to the Indicator. The Indicators can then be combined in a number of ways to determine for any site:

* the severity of the condition
* the reliability of the assessment
* whether the problem is "real" or "perceived"

In order to assess the priority which each site should receive for alleviation, two **Adjustment Factors** are introduced to take account of:

* the **Size** of the affected site, i.e. the length and size of watercourse affected, and
* the **Cost**, or more correctly the benefit/cost ratio, of alleviation

The "scores" and "weights" proposed are based upon experience and upon the results of field testing carried out in the late summer of 1991.

The full scope, history and background to the study are set out in the Final Project Report, dated December 1991, which is available from each Regional R&D Coordinator, but this is not necessary for the application of the method.

However, a number of points should be understood before applying the method:

i) Not all Indicators or Parameters need to be used and indeed there are restrictions placed in some cases on the number of Parameters that can be used within an Indicator. This is because there is a degree of overlap or redundancy in the parameters, so that the user can select from a "menu" of Parameters those for which data are available and/or are most relevant to the particular site

ii) The amount and quality of data used in the assessment is reflected in the **Reliability Index** of the assessment.

iii) The method will not distinguish between low flows caused by drought and those caused by long-term abstraction. The assessment must therefore be reviewed in the context of the degree of drought occurring in the years over which the data on which the assessment is made were collected.

iv) The method was developed during 1990 under the normal constraints of time and budget and was concluded before the results of some other very relevant and important research work became available, notably the evaluation by the Institute of Hydrology (IH) of the program "PHABSIM" which offers the prospect of a reasonably reproducible method of assessing minimum ecologically acceptable flows.

The method is explained in more detail in the following chapters, which are extracted from the full report and retain the numbering from that report.

The calculation of each Indicator is set out on sample calculation sheets and a spreadsheet-based macro, developed in Lotus 1-2-3, is also available to facilitate these calculations.

renumbering

6. INTRODUCTION TO ASSESSMENT METHOD

The Assessment Method is based on obtaining adequate evidence from four Indicators and two Adjustment Factors, namely:-

Hydrological Indicator
Ecological Indicator
Landscape/Amenity Indicator
Public Perception Indicator
Size Adjustment
Cost of Alleviation Adjustment

The steps involved in the assessment are shown on Table 6.1.

Scores are assigned to each Indicator and they can be combined in a number of ways (as set out in Section 12) to determine for any site:-

* the severity of artificially-induced low flows (*The Severity Index*)
* the reliability of the assessment (*The Reliability Index*)
* the degree to which the problem is *real or perceived* ~~only~~
* the *priority* which the site should receive, Regionally or Nationally for alleviation

The Indicators can be used at two levels:-

* **Preliminary Screening**, which requires minimum data and staff resource
* **Full Assessment**, which requires a large data base and input from staff working in a number of disciplines.

For the Preliminary Screening, scores may be assigned directly to the Indicators by the assessor (see Section 12). However, this level of assessment will result in a low Reliability Index, as it relies on very limited data.

For the Full Assessment the score for each Indicator is calculated by combining scores assigned to a number of weighted parameters related to each Indicator (see Sections 7 to 10). The Full Assessment is comprehensive and time consuming and it is expected that it will only be applied to those sites for which some form of Preliminary Screening has suggested that the stream is suffering the effects of low flows.

In either case, it is not necessary to use every one of the Parameters or Indicators, but only those for which data is available, or those for which data can be collected at minimum cost.

Prior to evaluation of the Indicators, the assessor must first decide whether the length of watercourse affected should be treated as one site or as a whole series of separate sites. This is of particular significance where a length of several kilometres of river is affected. The decision rests with the assessor, but if treated as several sites, it is recommended that the sites should be selected either

- to reflect natural breaks, e.g. hydraulic controls, locks, different land uses
  or
- by dividing the river into (arbitrary) lengths of 1km

If divided, each length of (say) 1km can be assessed separately for Severity Index (SI) and Reliability Index (RI), with the option of taking the mean of them to produce the SI and RI for the whole of the affected length.

If the whole length is assessed as one, the assessor will, in effect, have to "average" the data for each parameter, over the whole length. Either approach should be valid.

Table 6.1 : THE SEQUENCE OF THE ASSESSMENT

STEPS	Assessment required at each step
1	Define whether *Preliminary Screening or Full Assessment* required
2	Select Main Indicators of low flows (at least one for Preliminary, all for Full) Hydrological Indicator Ecological Indicator Landscape/Amenity Indicator Public Perception Indicator
3	Assign scores for the appropriate parameters of every Indicator used
4	Calculate *Severity Index* and *Reliability Index* for each of the indicators selected
5	Combine the Indicator Indices to obtain Overall Severity Index, and Overall Reliability Index
6	Adjust Overall Severity Index to take account of: Size, and Cost
7	Decide on the further action for the stream system.
8	Repeat steps 2 to 7 if more data is available

7. THE HYDROLOGICAL INDICATOR

The Consultants propose that the Hydrological Indicator should be assessed on the basis of six parameters. Each of these parameters and the system of their scoring is discussed in the following sections. Table 7.1 shows a summary of all the parameters proposed.

7.1 <u>Groundwater Balance Parameter (H1)</u>

This parameter, applicable to streams mainly supported by groundwater flow would be calculated for the groundwater catchment considered to be suffering low flows . It is the sum of all annual groundwater abstraction licences (ALA) divided by the calculated annual recharge (AR), for the catchment upstream of an assessment point.

$$H1 = \frac{ALA}{AR}$$

Licensed surface water abstractions (SWALA in table 7.2) and effluent returns (ER in table 7.2) would be included only if

a) parameter H2 is not used, and

b) abstraction is primarily supported by spring flow. Otherwise they would be ignored.

Scoring would be as follows:

$\frac{ALA}{AR}$ *10yrDrought**	Score
>1	4
0.7 - 1.0	3
0.4 - 0.7	2
0.2 - 0.4	1
<0.2	0

* see (iii) below.

The weighting assigned is 50%.

SUMMARY OF HYDROLOGICAL INDICATOR	
Groundwater Balance parameter H1 =	Annual Licensed Abstraction / Annual Recharge (1 in 10 yr. drought) (ALA/AR) Groundwater catchment. May need to add 'licence-exempt' abstractions, surface water abstractions and effluent returns. *Weighting = 50%.*
Riverflow Balance parameter H2 =	Daily Maximum Licensed Abstraction / Q95 "Natural" or Q95 "Natural" / Reservoir Compensation Flow Surface water catchment: Non-reservoired or Reservoired May need to add 'licence-exempt' abstractions, groundwater abstractions, effluent returns and downstream channel abstractions *Weighting = 50%.*
Groundwater Level parameter H3 =	Mean annual decline in minimum groundwater levels / Mean Seasonal Range *Weighting = 10%.*
Stream Morphology parameter H4 =	Channel Size (% of Channel) Percentage of 'normal low flow channel' occupied by low flows at end of August. Ratio of XSA(current) : XSA(normal). *Weighting = 10%.*
Flow and Ecology relationship parameter H5 =	Residual Flow / Minimum Ecologically Acceptable Flow Residual flow = (Q95 "Natural" - DMLA) for Non-reservoired catchments Residual flow = Compensation Flow (+ additions) for Reservoired catchments *Weighting = 90%.*
Movement of Springhead parameter H6 =	Change in Stream Type Length of stream reaches with changed classification (perennial - intermittent, intermittent - ephemeral). *Weighting = 10%.*

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Table 7.1 : Summary of parameters related to the Hydrological Indicator

Three points should be made concerning the application of this parameter

i) As many affected sites are in the headwaters, it is likely in some (or many) cases that abstraction in adjacent catchments may affect low flows. Some judgement will be required to decide what is the appropriate catchment to be considered, or whether groups of catchments should be considered together.

ii) Some Regions stressed the occasional importance of unlicensed abstractions such as trickle irrigation, private domestic and stock watering usage. It is therefore proposed that where the assessor adjudges currently licence-exempt activities (x) to represent a significant proportion of the total annual abstraction within the catchment, an estimate is made and cumulatively accounted for in the form

$$H_1 = \frac{ALA + (x)}{AR}$$

iii) It had initially been assumed that this parameter would be calculated on the basis of the *average annual recharge* on the grounds that the marking system can be adjusted to allow for drought years. However, there is a strong argument for using the calculated annual recharge in the *1-in-10 year drought* (return period as defined by the Met Office, based upon the cumulative departure of monthly rainfall from the long-term mean indices) in order to more directly take into account drought conditions used by the Regions when setting abstraction licences

7.2 Riverflow Balance Parameter (H2)

This parameter, applicable to streams supported mainly by surface runoff, would be calculated for the surface water catchment. It is calculated differently for reservoired and non-reservoired catchments. For non-reservoired catchments, it consists of the sum of the daily maximum licensed abstraction (DMLA) divided by the naturalised 95 percentile flow (Q_{95}) assessed by the Institute of Hydrology (IH) Low Flow Study methods. Significant unlicensed abstractions and effluent returns would be added algebraically to the DMLA. In the event that parameter H1 is not used, licensed groundwater abstractions deemed to have a direct impact on low flows (e.g. within 250m of the river) would be similarly added.

Non-reservoired catchments:

$$H_2 = \frac{DMLA}{Q_{95}natural}$$

For reservoired catchments, storage usually permits the yield (i.e. reservoir abstraction) to greatly exceed Q_{95}. DMLA is not relevant, therefore, and a different approach to the calculation of the riverflow balance parameter is required. In this case, it consists of the Q_{95} natural divided by the reservoir compensation flow (COMP). Licensed abstractions from the channel downstream of the reservoir (DMLCA), significant unlicensed abstractions and effluent returns would be added algebraically to COMP. Licensed groundwater abstractions with a direct impact on low flows would again be added.

Reservoired catchments:

$$H_2 = \frac{Q_{95}natural}{COMP}$$

Scoring would be as follows:

$H2 = \frac{DMLA}{Q_{95}}$ $H2 = \frac{Q_{95}}{COMP}$	Score
>1	4
0.7 - 1.0	3
0.4 - 0.7	2
0.2 - 0.4	1
<0.2	0

The weighting assigned is 50%.

In collecting the data to assign a score to this parameter the following points should be noted:

i) There has been some discussion on the relative merits of Q_{95}, the 95 percentile flow based on the flow duration curve and MAM the Mean Annual Minimum flow based on the flow frequency curves. Both of these measures are derived from the same basic data set and may not be truly representative of the 'natural' or 'historic' conditions since this data may include some flow data affected by long term abstraction.

It is understood that neither measure is 'better' than the other but consultation with the Regions indicated that Q_{95} is more commonly used in this context.

ii) The Consultants have also considered whether the 1-day, 7-day or 10-day Q_{95} should be used. Provided that the same measure is consistently used, we do not believe it is critical which is selected. However, since current and future IH low flows work is standardising on 7-days, we would propose that the 7-day Q_{95} is used where such data is readily available.

iii) We recommend that licensed abstractions should be used in preference to actual abstractions. Where this is the case, licensed effluent returns should also be added to the balance. If, however, actual abstraction figures are used, actual effluent returns must be added, and not licensed quantities.

iv) Although the parameter is calculated quite differently for reservoired and non-reservoired catchments it is not as simple as it may appear to distinguish between the two; particularly where a regulating reservoir is some way upstream of, and therefore regulates a relatively small part of the catchment to, the site to be assessed. In this case the non-reservoired catchment parameter should be used, the compensation releases should be added algebraically to DMLA and any licences upstream of the reservoir should be ignored.

The reservoired catchment parameter is only applicable where the majority of the catchment is reservoired and there is a high degree of regulation.

The interpretation of "high degree of regulation", "some way upstream" and "regulates a relatively small part of the catchment" is left to the judgement of the user, but in borderline cases both reservoired and non-reservoired parameters can be assessed and the most appropriate one used.

7.3 Groundwater Level Parameter (H3)

Originally conceived within Phase 1 as an Aquifer Gradient Parameter, this effectively proved unworkable during evaluation by the Regions due to the sparsity of historic gradient data and the subjectivity of old contour maps.

During consultation with Regions it was consistently stated that a measure based on groundwater levels should be included, as level decline, if demonstrated, would be a clearer indication of lowering of aquifer levels.

This parameter would be calculated from the longer-term records of annual maximum and minimum groundwater levels, typically collected and tabulated as part of Regional monitoring networks, many originally instigated by the 1963 Water Resources Act.

If available, a borehole within the critical catchment under evaluation should obviously be chosen for the computation of H3. However, it is recognised that many 'upper' catchment zones and associated interfluve areas suffer from a dearth of monitoring boreholes. In such cases it is suggested that Regional hydrogeological staff utilise discretion to decide whether an alternative borehole record can be substituted. Although such a borehole may be in an adjacent catchment or downstream of the area under evaluation, it may be that similar aquifer characteristics and a comparative (radial) distance from the suspect groundwater abstraction zone may allow its utilisation.

This parameter simply aims to identify a gradual fall in aquifer storage, manifested by a decline in the annual minimum groundwater level. The annual low point (minima) of the groundwater hydrograph is noted for a sequence of at least five years. The mean annual decline (MAD) in the minima is then calculated over the chosen period of years.

In order to account for the natural seasonal variability in groundwater levels and allow for the significant differences in storage characteristics between the UK's major aquifers, it is suggested that the MAD is expressed as a ratio of the mean seasonal range (MSR) exhibited by the groundwater hydrograph over the same time period.

Hence

$$H3 = \frac{MAD}{MSR}$$

It is recommended that at least 10 years of continuous records be used, to help 'average-out' individual, or an occasional sequence of climatic extremes, such as dry (low recharge) winters and summer droughts.

Scoring will be as follows:

$\frac{MAD}{MSR}$	Score
< 0.1	0
0.1 - 0.3	1
0.3 - 0.5	2
> 0.5	3
*	4

* Where local hydrogeological knowledge is of sufficient confidence to directly inter-relate absolute (datum) levels of the affected river stretch with groundwater - for example a fissure zone originally contributing base flow but now allowing bed leakage due to reversed groundwater gradients - a discretionary higher score of 4 may be awarded.

The weighting assigned to the parameter is 10%.

7.4 Stream Morphology Parameter (H4)

This parameter reflects the proportion of the "normal low flow channel" occupied by low flows at the end of August. It would be calculated as the mean of the ratios of current cross-sectional area of flow (XSA current) to 'normal' cross-sectional area of flow (XSA normal) at not less than 5 representative cross sections.

A suggested definition of 'normal low flow channel' is the channel occupied by the base flow at the end of the month in which a Soil Moisture Deficit first occurs.

This is based on the premise that the impact of abstraction on low flows is far greater at the end of the dry season (when storage is drawn down) than at the beginning of the dry season, when storage should be more or less full. The Consultants have considered using wetted perimeter or hydraulic radius but have concluded that cross-sectional area is most appropriate. Since this parameter is based on relative rather than absolute areas, we believe it is acceptable to calculate area as surface width x maximum depth. However, this parameter must be used with caution,

a) because following a dry winter in which full recharge does not occur, the 'normal low flow' may be abnormally low

b) it is also a measure of the 'flashiness' of the river which is dependent on other factors such as geology and land use and

c) It must not be used where the flow is significantly influenced by backwater effects from a control i.e. it should only be used where cross-section area is approximately proportional to flow.

$$H4=\frac{XSA(Current)}{XSA(Normal)}$$

Scoring would be:

% of Channel	Score
<10%	4
10 - 30%	3
30 - 50%	2
50 -70%	1
>70%	0

The weighting assigned is 10%.

7.5 Flow and Ecology Relationship Parameter (H5)

The development of techniques to establish minimum ecologically acceptable flows (MEAF) is the subject of another NRA research project, reference B2.1 discussed in Chapter 2 of this report.
In using the MEAF it should be noted that the ecologically acceptable flow will not be a single value for a given river but will vary with season. As the methodology has not yet been defined its application in low flow assessment is, to an extent, premature. However, when such techniques are available, the relationship between low flow occurring and MEAF will be the most important single parameter in describing the severity of the problem and in monitoring and managing low flows. The following parameter is therefore proposed.

As a measure of low flow problems in surface water areas, the proposed parameter would be calculated differently for reservoired and non-reservoired catchments.

For non-reservoired catchments:

$$H5 = \frac{Q_{95} - DMLA}{MEAF}$$

where Q_{95} = 95 percentile flow for 'natural' catchment calculated from IH Low Flows Study. In this case MAM_7 may be a better measure than Q_{95} since it is based on a consecutive run of low flows).

DMLA = as defined in H2 above

MEAF = minimum ecologically acceptable flow in the critical month (September)

For reservoired catchments, DMLA is often much greater than Q_{95} and therefore the parameter as given above is invalid as a low flow indicator. The residual flow in reservoired situations is equivalent to the compensation flow (COMP) and therefore the parameter should be:

$$H_5 = \frac{COMP}{MEAF}$$

Licensed abstractions from the channel downstream of the reservoir (DMLCA), significant unlicensed abstractions, effluent returns and tributary inflows (the sum of the Q_{95} for each tributary) would be added algebraically to COMP.

A possible problem is that the ecologically acceptable flow may be achieved in the month which is critical in terms of minimum flow but the (higher) ecologically acceptable flow required at some other time of year may not be achieved, ie the critical time in terms of low flows may not coincide with the critical time in terms of ecologically acceptable flows.

The compensation flow for reservoired catchments should be determined at the same time of year as the MEAF. Generally, COMP will be the minimum compensation flow and MEAF will be the "minimum ecologically acceptable flow" in the year. However, the timing of these may not always coincide.

This parameter is more difficult to quantify where the abstraction is primarily from groundwater and in such a case the measured residual flow may have to be used.

The scoring would be as follows:

Parameter Value $H5=\frac{Q_{95}-DMLA}{MEAF}$ $H5=\frac{COMP}{MEAF}$	Score
<60%	4
60 - 80%	3
80 - 100%	2
100 - 120%	1
>120%	0

The weighting assigned is 90%

7.6 Movement of Springhead (H6)

Stream reaches can be classified into 3 main types: perennial, intermittent and ephemeral. These are defined, for this project, as follows:

> Perennial reaches flow throughout the year.
>
> Intermittent reaches flow for most of the year but are dry for at least 2 weeks (in the summer).
>
> Ephemeral reaches only flow during and immediately after rainfall or snow melt.

The change in classification of a stream reach from either perennial to intermittent or intermittent to ephemeral is assumed to indicate a low flow problem. Such a change during a 1 in 10 year drought, however, is an exception to this and is not included. The "change" in stream parameter is defined as:

> The total length of reaches of a stream, upstream of the assessment point, that have changed their classification from either perennial to intermittent, or intermittent to ephemeral.

H6 = *Total Length of River with Changed Classification*

Scoring would be as follows:

Length of river (Km)	Score
>8	4
4 - 8	3
2 - 4	2
0 - 2	1
0	0

Equal importance is assumed for a change from perennial to intermittent, as a change from intermittent to ephemeral. Changes from perennial to ephemeral are unlikely but can be scored in exactly the same way.

The weighting assigned is 10%.

7.7 Accretion/Depletion Profiles (H7)

If available, such profiles are very descriptive of the problem but not easy to convert to a simple parameter. They measure the quality of the problem rather than its quantity. For the present it is not therefore proposed to include this in the list of assessment parameters.

7.8 Sample Calculation of Hydrological Indicator

Once all the parameters related to the Hydrological Indicator have been decided, based on data availability and suitability of the parameters for the catchment area, scores are calculated by the assessor. The score of four is the maximum that any parameter may be given. The degree of significance of each parameter is determined by a parameter weight, which is multiplied by the given score to arrive at a weighted score. The weighted scores are added together and divided by four times the sum of weights of parameters actually used, which will give the value of the *Hydrology Severity Index (HSI)*.

Hydrology Reliability Index (HRI) is the sum of Weight of Parameters used.

Example Calculation of the Hydrological Indicator

Parameter	Parameter weight *(a)*	Weight of parameters used	Score (out of 4) *(b)*	Weighted score *(a) * (b)*
H1	0.5	0.5	4	2.0
H2	0.5	-	-	-
H3	0.1	0.1	3	0.3
H4	0.1	-	-	-
H5	0.9	-	-	-
H6	0.1	-	-	-
Totals		0.6 *(Y)*		2.3 *(Z)*

From the above example the following calculations may be made:

Hydrology Severity Index (HSI)

$$HSI = \frac{TotWeightedScore}{TotWeightofParms*4} = \frac{Z}{Y*4} = \frac{2.3}{0.6*4} = 0.96$$

Hydrology Reliability Index (HRI)

$$HRI = TotWeightofParmsUsed = 0.6$$

A complete sample calculation for a sample stream is shown on Table 7.2. Blank sheets for use of assessors when the assessment is undertaken by the Regional NRAs are given in Annex I. The calculation has been set up on a LOTUS spreadsheet for ease of calculation.

As a result of the evaluation (Phase 2) the parameter weights have been amended and the amended weights are shown in Table 7.2.

Two other amendments have also been made in the form of restrictions on the use of parameters, namely:

i) The total weight of parameters used must not exceed 1.0, i.e. not all of the parameters may be used.

ii) H1, H2, H5 are PRIMARY parameters.

iii) H3, H4, H6 are SECONDARY parameters.

iv) If any PRIMARY parameter is used, not more than one SECONDARY parameter may be used with it.

v) If H1 and H2 are used together, the weight of each should be reduced from 0.5 to 0.4, to reflect the overlap of these two parameters.

The purpose of these amendments (which may appear rather complicated) is to prevent the same data being used in several parameters to produce a high score.

TABLE 7.2 : SAMPLE CALCULATION

HYDROLOGICAL INDICATOR

NRA REGION: A region   NAME OF STREAM: River Example   DATE: 12/8/92

(see Report Chapters 7.1 to 7.8 for full explanation of the methodology)

H1 GROUNDWATER BALANCE PARAMETER – ANNUAL LICENSED ABSTRACTION / ANNUAL RECHARGE

Total Groundwater ALA =	1200	m3/a	(GWALA)	
Calculated AR (1 in 10 yr drought) =	1500	m3/a	(AR)	
Total Annual 'Licence-exempt' Abst. =	1100	m3/a	(X)	*- ONLY enter if significant*
Total Surface Water ALA =		m3/a	(SWALA)	*} ONLY enter if H2 not used and*
Licensed Effluent Returns (annual) =		m3/a	(ER)	*} ALA is supported by spring flow*

ALA/AR = (GWALA+X+SWALA-ER)/AR = 1.53

ALA/AR	Score
>1.0	4
0.7-1.0	3
0.4-0.7	2
0.2-0.4	1
<0.2	0

Assign score: H1 = 4   *PRIMARY*

H2 RIVERFLOW BALANCE PARAMETER – DAILY MAXIMUM LICENSED ABSTRACTION / Q95 "NATURAL" or Q95 "NATURAL" / RES.COMP.FLOW

Total Surface Water DMLA =		m3/d	(SWDMLA)	*- ONLY enter for non-res. catchments*
Reservoir Compensation Flow (mean daily) =	500	m3/d	(COMP)	*- ONLY enter for reservoired catchments*
Total downstream channel abstraction (daily) =	150	m3/d	(DMLCA)	*- ONLY enter for reservoired catchments*
Total 'Licence-exempt' abstraction (daily) =	50	m3/d	(X2)	*- ONLY enter if significant*
Q95(7) =	300	m3/d	(QNF)	
Total Groundwater DMLA (with direct impact) =		m3/d	(GWDMLA)	*}*
Licensed Effluent Returns (daily) =		m3/d	(ERTWO)	*} ONLY enter if H1 not used*

Non-reservoired catchments: Total DMLA/Q95 = (SWDMLA+X2+GWDMLA-ERTWO)/QNF =

Reservoired catchments: Q95/COMP = QNF/(COMP-DMLCA-X2-GWDMLA+ERTWO) = 1.00

DMLA/Q95 or Q95/COMP	Score
>1.0	4
0.7-1.0	3
0.4-0.7	2
0.2-0.4	1
<0.2	0

Assign score: H2 = 4   *PRIMARY*

H3 GROUNDWATER LEVEL PARAMETER

Mean Annual Decline in minimum groundwater levels =		m	(MAD)
Mean Seasonal Range =		m	(MSR)

MAD/MSR =

MAD/MSR	Score
*	4
>0.5	3
0.3-0.5	2
0.1-0.3	1
<0.1	0

* If MAD/MSR > 0.5, see Report Chapter 7.3 to assign score

Assign score: H3 =   *SECONDARY*

TABLE 7.2 : SAMPLE CALCULATION (con't.)

HYDROLOGICAL INDICATOR

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NRA REGION: A region NAME OF STREAM: River Example DATE: 12/8/92

(see Report Chapters 7.1 to 7.8 for full explanation of the methodology)

H4 STREAM MORPHOLOGY PARAMETER

Cross Section	Current XSA of flow (m2)	Normal XSA of flow (m2)	Current / Normal
1	8	35	23%
2	9	44	20%
3	15	49	31%
4	22	63	35%
5	14	66	21%
		Mean =	26%

% of Channel	Score
<10%	4
10-30%	3
30-50%	2
50-70%	1
>70%	0

Assign score: H4 = 3 *SECONDARY*

H5 FLOW AND ECOLOGY RELATIONSHIP PARAMETER - RESIDUAL FLOW / MINIMUM ECOLOGICALLY ACCEPTABLE FLOW

Q95(7) =		m3/d	(QNF)	} *ONLY enter for non-res. catchments*
Total DMLA (see H2) =		m3/d	(DMLA)	}
Reservoir Compensation Flow (mean daily) =		m3/d	(COMP)	}
Total downstream channel abstraction (daily) =		m3/d	(DMLCA)	}
Total 'Licence-exempt' abstraction (daily) =		m3/d	(X2)	} *ONLY enter for reservoired catchments*
Licensed Effluent Returns (daily) =		m3/d	(ERTWO)	}
Tributary Inflows (sum of Q95s) =		m3/d	(TRIB)	}
MEAF (critical month) =		m3/d	(MEAF)	*(Note: MEAF is under development as part of NRA R&D Project B2.1 and is as yet undefined)*

(Q95-DMLA)/MEAF or COMP/MEAF	Score
<60%	4
60-80%	3
80-100%	2
100-120%	1
>120%	0

Non-res. catchments: (Q95-DMLA)/MEAF =

Res. catchments: (COMP-DMLCA-X2+ERTWO+TRIB)/MEAF =

Assign score: H5 = *PRIMARY*

H6 MOVEMENT OF SPRINGHEAD parameter

Total length of reaches changed from perennial to intermittent = km

Total length of reaches changed from intermittent to ephemeral = km

Sum = km

Sum of reaches (km)	Score
>8	4
4-8	3
2-4	2
0-2	1
0	0

Assign score: H6 = *SECONDARY*

CALCULATION OF HYDROLOGICAL INDICATOR

Parameter	Param. weight		Weight of params. used	Score	Weight x Score
H1	0.5	*) If H1 & H2 are BOTH used,*	0.4	4	1.6
H2	0.5	*} set both weights to 0.4*	0.4	4	1.6
H3	0.1				0
H4	0.1		0.1	3	0.3
H5	0.9				0
H6	0.1				0
		SUM1 =	0.9 (max.1)	SUM2 =	3.5

Hydrology Severity Index = SUM2/(SUM1x4) = 0.97

Hydrology Reliability Index = SUM1 = 0.90

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8. THE ECOLOGICAL INDICATOR

8.1 Introduction

8.1.1 Introduction - the 2.2 Low Flows Study TOR

The brief for the B2.2 Low Flows study was to develop a rapid low flows assessment methodology to be used nationally in ranking sites already flagged by the NRA as possible low flow problems. This would enable the finite funds available to the NRA for dealing with low flows to be distributed to Regions with the most serious problems.

To fulfil the TOR, it was necessary to consider the following points when developing the methodology

1) There was to be a minimum requirement for data collection, so the system should be based on established methods and incorporate historical data.

2) The methodology should be able to incorporate a wide range of data, collected by the various Regions in a non-uniform way, and usually for purposes other than low flows assessment

3) The methodology should be simple and non-time-consuming and should be understandable by non-specialists.

4) The methodology should extract as much information as possible from the data, which were likely to be scarce.

5) The methodology should be applicable to watercourses and river types in different geographical regions.

These constraints were particularly important when considering the ecological factors involved in low flows assessment, as biological data have been traditionally collected in an unstandardised way by the water industry for water quality monitoring rather than habitat assessment and conservation purposes.

8.1.2 Philosophy behind the ecological indicator

The assessment methodology provides a framework around which hydrological, ecological, landscape, cost and public perception information can be assembled and evaluated. The values or scores generated can then be used to rank sites which are competing for the NRA's limited low flows alleviation resources.

The ecological indicator generates scores which reflect the extent to which low flows are jeopardising the channel and riparian communities which depend on groundwater or a surface watercourse. To generate valid scores, the ecological indicator must first define the function of flowing water to the channel and riparian communities, and secondly, assess the extent to which this function is being fulfilled.

The function of running water for aquatic communities is to generate and maintain the habitat features the constituent populations require and to provide physico-chemical conditions within the range they can tolerate. There is therefore a complex inter-relationship between water chemistry, habitat structure and instream plant, fish and benthic macro-invertebrate community structure, which is central to the design of the ecological indicator.

Where food resources are adequate, habitat is sufficiently diverse and physico-chemical conditions lie within a particular range, a stable, diverse and well-balanced stream community will develop. This may include macro-invertebrates, submerged aquatic vascular plants and game or coarse fish. Changes in habitat or water chemistry caused by low flows, effluents, channel engineering or any other stresses will displace the delicate balance between the channel environment and colonising communities. This invariably causes a restricted species assemblage to adopt the habitat.

For example, cold, good quality, flowing water is important in generating the eroding habitats and physico-chemical conditions required by game fish and certain macro-invertebrate species. If these conditions change, the community will alter, as species adapted to exploit the newly established environment gain prominence. This change in community structure may occur as a direct response to changes in water chemistry and habitat structure, or may be the indirect effect of water quality on habitat structure.

Low flows affect both habitat generation and water quality, so the problem when developing the assessment methodology was to separate low-flow-induced effects from those caused by other factors affecting water chemistry and habitat, such as enrichment with sewage effluent and channel maintenance.

Flow decreases may derogate habitat by increasing sediment deposition and temperature, which in turn encourages the establishment of surface dwelling and emergent plants.

Decreases in water quality may debilitate sensitive species directly or may cause sediment or colonial algae/bacteria to accumulate at the channel surface thus altering the substrate available for colonisation.

Engineering activities may remove habitat features, alter flow regime/sedimentation and alter water chemistry.

By studying community structure, the condition of the stream ecosystem can be assessed. The aim of the community structure aspects of the macro-invertebrate, fisheries and plant parameters was to establish target communities, which, provided flows have been adequate, should have been achieved. If these targets are not met, then the shortfall is likely to be the result of low flows, which may be reducing water quality or affecting habitat or both. The method must be able to take account of the effects non-low-flow-related changes in water quality, channel engineering and river type have had on community structure up to the time of sampling. This is much the same as the 'tare' function on a laboratory balance which accounts for the weight of the beaker in order to display the weight of its contents.

SUMMARY OF ECOLOGICAL INDICATOR	
E1 Invertebrate Community Parameter (potential : measured ASPT)	Based on Average Score Per Taxon (ASPT). Ratio of measured ASPT : potential ASPT. *Weighting = 40%.*
E2 Fishery parameter (Non-tidal, Tidal, Access to migratory fish)	Decline in fish community from Game species through to Coarse species; also declines in tidal fisheries and access to migratory fish, all primarily due to low flows Also loss of fishing in short-term. *Weighting = 20%.*
E3 Fish Stocks parameter (present/potential fish stock x 100%)	Ratio of present fish stock : 'potential' fish stock. *Weighting = 30%.*
E4 Plant parameter	Seasonal change in terrestial plants in channel and long-term change in bankside flora. *Weighting = 10%.*
E5 Conservation parameter	Assessed on basis of formally designated sites and conservation value of non-designate sites. *Weighting = 30%.*

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Table 8.1 : Summary of parameters related to the Ecological Indicator

8.1.3 Overview of parameters comprising the ecological index

Five ecological parameters are proposed (Table 8.1), of which the first four will measure the impact of existing flow conditions and the fifth, conservation, will be used only if there is other evidence (hydrological or ecological) that low flows are occurring. The reasons for this are explained below. Data on invertebrates and fisheries will be used as measures of low flow conditions because they respond to sustained periods of low flows. These invertebrate and fish parameters may appear to be complicated, but this is essential so that the effects of low flows can be differentiated from effects of water quality and engineering. Bankside plants may contribute some limited information about the lowering of the water table.

Macro-invertebrate community parameter - It was decided to use average score per taxon (ASPT) as an index of macro-invertebrate community structure, and to down-weight the index to take account of non low-flow-induced factors such as water quality and engineering influences. The suitability of ASPT for this purpose is discussed further in section 8.~~1.~~2

Angling and Fishery parameter - There was no convenient summary fish-community index, so the method had first, to specify the changes in community structure which might be caused by water quality and habitat changes, and secondly to suggest the extent to which community change resulted from low flows. To attach factors to down-weight the effects of effluents, channel engineering and geographical location to the classification would have made it complex and cumbersome. For this reason, the implementation of the fishery parameter requires a fishery scientist to judge the extent to which low flows are responsible for changes in the fishery.

A further aim of this parameter was to incorporate information on 'fishing interests' as well as 'the fishery', which are not necessarily congruous. For example, trout spawn in gravel redds up tributaries and in headwaters, so if these habitats are lost due to low flows, the stream's 'fishing' could be made up by ensuring adequate water depth, and restocking with mature fish. This, however, would derogate 'the fishery'. So, satisfying the immediate needs of the angler does not necessarily ensure a successful fishery. However, it was felt that the parameter should take account of fishing interest, and respond to short- term effects such as the loss of fishing due to acute low flow incidents, as well as responding to long-term changes in community structure.

Fish stocks parameter - Low base flows affect community structure by reducing water quality and altering the eroding nature of the habitat. Low flows caused by river abstraction in contrast, are likely to reduce fish production and displace the age structure of the community in favour of young fish. In other words, although spawning may still occur, fewer fish will survive to develop the older year classes. Non-low-flow-related changes in water chemistry and habitat destruction may also affect fish stocks, so, as with other parameters, it is necessary to separate the influence of channel modifications and sewage effluents on fish stocks from that caused by flows. This will be done by introducing a scoring procedure similar to that suggested for the macro-invertebrates community. Alternatively, the fishery scientist may assess the extent to which low flows are contributing to the decline and allocate a score.

The aim was to develop a methodology which was adaptable enough to incorporate whatever data was considered by the fishery scientists in the Regions to reflect their low flows problem. For this reason, the framework of the methodology has been kept simple and flexible.

Plant parameter - There is a dearth of data concerning plant distribution in the Regions but a plant parameter was included in the method to ensure that data which was available, could contribute to the low flows assessment. Again an informed judgement must be made by biologists in the Regions as to the extent to which low flows were responsible for the changes.

Conservation parameter - The final section of the ecological indicator, scores a catchment according to the presence of nationally or locally important conservation features. However, because the presence of conservation and landscape features provides no direct indication of the severity of low flows in the catchment, the conservation parameter should be used only when there is direct evidence that low flows are a problem. This is to avoid the accumulation of high scores on the basis of strong public perception of a problem in an area of outstanding conservation value with high water quality, but for which there is no direct evidence that low flows are causing the problem. In other words, the fact that a stream is of high water quality or supports a valuable wetland habitat or contains rare plant, fish or animal species is relevant only when there is hydrological or ecological evidence that low flows are threatening the catchment.

8.1.4 Long-term NRA-funded research to develop methods of determining Minimum Ecologically Acceptable Low Flow - MEAF

Research in North America and New Zealand during the late 1970's and early 1980's aimed to quantify the flow needs of the various stream communities. To protect the welfare of these fisheries that the Co-operative Instream Services Group of the US Fish and Wildlife Service developed the 'Incremental Flow Method' (IFM) in 1976. This system enables the amount of physical habitat available for various lifestages of fish to be estimated at different flows. Suitable habitat features must include the presence of sufficient water depth for the fish populations and the presence of eroding riffles (redds) in which eggs can be laid.

Similar habitat management methodology (Physical HABitat SIMulation - PHABSIM, NRA R&D topic 2.1) is presently being funded by the NRA and will eventually enable MEAF's to be determined for UK rivers. When this research is complete the MEAF will provide a benchmark against which to low flow derogation can be measured. This will eliminate the need for the more a methodology to assess the extent of habitat and community derogation by low flows.

8.2 Invertebrate community parameter (E1)

8.2.1 Development of the macro-invertebrate community parameter

There are various tools available to the NRA for analysing macro-invertebrate community structure. Most however have been developed for water quality monitoring purposes and must be specifically adapted for use in low flows assessment. The aim of the ecological assessment is to generate a target community; the community which would have existed at the site before the present low flows had influenced the habitat. If the present community fails to meet this target, then derogation will be indicated, for which low flow is likely to be the cause.

It is cumbersome to adapt a system such as **RIVPACS*** for this purpose, as it predicts community structure from the physico- chemical conditions associated with the low-flow derogated habitat rather than that at the site under 'natural' conditions. The former is adequate when considering water quality because although the predicted fauna may be restricted, it can be concluded that water quality is not limiting when this fauna has been achieved. However, the latter is needed when considering low flows, as it is necessary to show that the community is below potential, is unbalanced and that the site probably supports smaller populations of fish than would otherwise be the case.

Unless historic physico-chemical data is available, adapting RIVPACS for low flows assessment would involve estimating the conditions (substrate size, alkalinity, depth, width, distance from source, gradient) which existed at the site before low flows became a problem. RIVPACS could then use these to predict the 'natural' assemblage for the site, which could then be compared with the present assemblage to give a measure of habitat derogation.

However, for the present assessment methodology, it was decided to adopt a simpler approach and to modify biological quality indices to generate macro-invertebrate community targets.

(*RIVPACS - River invertebrate prediction and classification system - was developed from research carried out by IFE - Institute of Freshwater Ecology - in the 1980's. Macro-invertebrate communities associated with a range of unpolluted streams throughout the UK were investigated in co-operation with the water industry. Species lists were manipulated with the multivariate statistics packages 'TWINSPAN' - TWo-way INdicator SPecies ANalysis - and 'DECORANA' - DEtrended COrrespondence ANAlysis - to cluster sites with similar community structure. These site clusters were then correlated with physico-chemical variables by Multiple Discriminant Analysis. When this information had been assembled it was possible to develop a package (RIVPACS) to operate in the reverse direction - in other words to predict the assemblages which might be expected at sites displaying a given set of physico-chemical characteristics.)

8.2.2 The ASPT-based macro-invertebrate community parameter

The indices of macro-invertebrate community structure which are most widely used for water quality purposes are the Biological Monitoring Working Party score (BMWP) and the related Average Score Per Taxon (ASPT). Unlike diversity indices, they do not rely on equating individuals per species with total number of species per site and are not greatly influenced by temporal changes. BMWP score and ASPT reflect biological quality by scoring the presence or absence of particular invertebrate types at a site. Both indices may vary in different geographical regions, scores at lowland sites being generally lower than those at upland sites.

ASPT differs consistently between sites in upland and lowland areas and this effect is removed in the methodology by applying a factor of 0.8. The factor was developed from the IFE's analyses of the performance of BMWP score and ASPT at 268 sites in 41 catchments in the early 1980's (Armitage et al., 1983). Unpolluted upland site had maximum ASPT's of around 6.8, whereas lowland sites could have ASPT's as low as 5.4.

The following points were considered when developing the low flows assessment methodology around ASPT rather than BMWP.

a) BMWP score increases with sampling effort and is not a particularly useful index when comparing data between Regions, as the data will have been collected in different ways. ASPT suffers less in this respect.

b) BMWP will be greater at a habitat-diverse site (where there are many types of invertebrate, each adapted to exploit a particular habitat niche) than at a site with a relatively homogeneous habitat. Differences in ASPT between sites with diverse and homogenous habitats is less extreme.

c) Both BMWP score and ASPT decline as habitat structure at a site changes from predominantly eroding to more depositing (beetles, bugs and species adapted to quiescent conditions score lower than lotic species). This decline in habitat may be caused by low flows or by increases in effluent discharge or by a combination of the two.

d) Both BMWP score and ASPT decline as the organic component (from sewage effluent, run-off etc) of the channel flow increases. This may be caused by low flows or by increases in effluent discharge or by a combination of the two.

It has been argued that at sites with relatively homogeneous habitat structure comprising habitat niches containing high scoring invertebrates (such as small mountain streams in Cumbria), the loss of some of these niches due to low flows will not alter ASPT but would alter species diversity. However, on a national scale, flows which reduce the number of habitat niches in a channel but do not destroy the eroding nature of the channel are far less severe than those which severely alter the nature of the habitat. The ASPT-based method would rightly score streams displaying habitat loss higher than those that do not.

If the high current velocities in mountain streams declined sufficiently to severely disadvantage the stoneflies, mayflies and caddisflies that compete effectively under such conditions, then other less-high-scoring species would increase in dominance. This would then reflect in ASPT.

The maximum achievable ASPT might therefore be a useful starting point from which to adapt water quality data for low flows application. The Consultants proposal is to successively down rate the index to take account of stresses due to water quality, channel engineering, and location (ie whether the source is in an upland or a lowland, and whether the site is in a headstream, mid-reach or lower reach). The product would be a coarse estimate of the ASPT potential of a stretch of river. If the ASPT measured for the stretch failed to reach this value, then it would indicate derogation, for which flow is likely to be the cause. The procedure would start with the question:

1) Is macro-invertebrate data available?

If the answer is 'NO' then the algorithm ends but if the answer is 'YES' then proceed to 2

2) Generate potential ASPT, as shown on flow chart in Figure 8.1.

This would score the invertebrate communities in fast flowing eroding headwaters with various proportions of sewage effluent differently from those in slower flowing more depositing reaches with similar sewage effluent components. In the same way, ponded depositing or 'heavily-managed' lower river reaches could be scored.

3) Relate the measured ASPT to the potential ASPT, and generate a score for the river stretch from the table below:

Measured ASPT	Potential ASPT					
	<4.5	4.5-5.0	5.1-5.5	5.6-6.0	6.1-6.5	>6.5
<4.5	0	1	2	3	4	4
4.5-5.0		0	1	2	3	4
5.1-5.5			0	1	2	3
5.6-6.0				0	1	2
6.1-6.5					0	1
>6.5						0

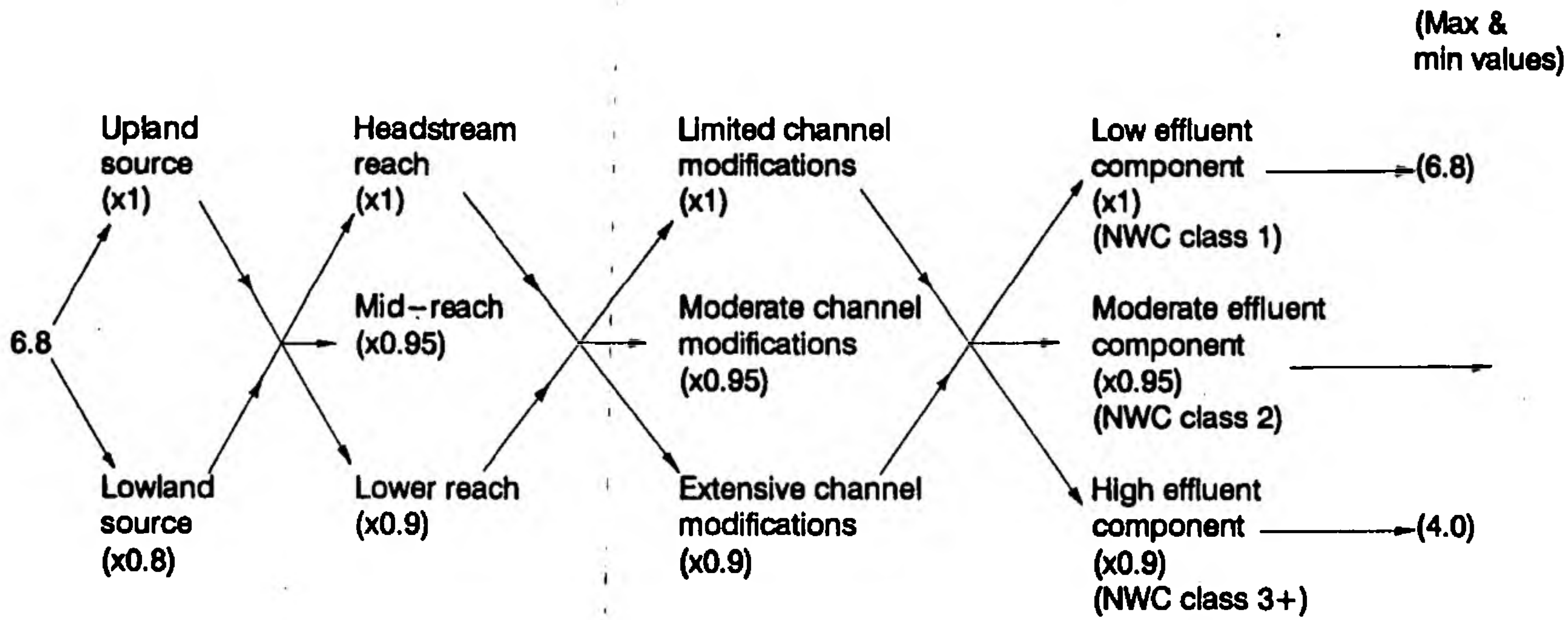

Figure 8.1. Flow Chart to Generate Potential ASPT

Thus, the maximum score of 4 would be allocated where potential ASPT was high, and the ratio of measured to potential ASPT was low.

The weighting for this invertebrate community parameter, (E1) is 40%

8.3 Fishery parameter (E2)

The fishery parameter is based on the fact that a river can be divided into the following zones on the basis of fish community structure:

1) Trout-salmon zone

2) Grayling zone

3) Barbel-chub-dace zone

4) Bream-roach-tench zone

A change from one zone to another reflects changes in habitat and water chemistry and our assumption is that low flows affect fisheries primarily by altering these variables.

Data on species composition, population density and biomass is variously collected in the NRA regions, so the aim of the fishery parameter is to use this available data to score any changes in community structure and/or fishing potential which result from low flows. As with the invertebrate parameter, the main task is to separate low-flow-induced changes in water quality and habitat from those produced by effluents and channel modifications.

As there is no convenient summary index of fish community structure, the method must first, specify the changes in community structure which might be caused by water quality and habitat changes, and secondly, suggest the extent to which community change results from low flows. To incorporate a system to down-weight the effects of effluents, channel engineering and geographical location would have made the classification system complex and cumbersome, so the implementation of the fishery parameter requires the fishery scientists in the Regions to judge the extent to which low flows are responsible for changes in their fisheries.

A further aim of this parameter is to incorporate information on 'fishing interests' as well as 'the fishery', which, as mentioned in the overview of the ecological indicator, are not necessarily congruous. By responding to fishing interests, the method is able to make use of data on the short-term loss of fishing due to acute low flow incidents, as well as data on longer-term changes in community structure.

If there is evidence that a decline in fish community is due to low flows, then scores will be assigned from the table below. Decline might occur in, headstream, non tidal or tidal reaches. In non-tidal reaches the decline may involve deterioration in the quality of a game fishery, a coarse fishery or a conversion from a game to a coarse fishery. There might also be a loss of access for migratory species.

Alternatively, the short-term impact of low flows on angling can be assessed by awarding scores of 0 to 4 where there is a decline in fishing in a river reach as a result of low flows:

Score	Description
0	No evidence of short-term impact of low flows on angling.
1	
2	
3	
4	No fishing was possible during a season due to low flows.

It is suggested that the maximum score from either the above source or the following table is carried forward for use in calculating the ecology indicator

Table of scores to be allocated where low flows produce changes in fish community structure:

Non Tidal Fisheries	Fish community under 'normal' flow conditions	Decline due to low flows							
		(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Game	HEADSTREAM:								
	(a)Trout, salmon	2	3	4	-	-	-	-	-
	(b) Small trout only (+ loss of older year classes)	-	2	3	-	-	-	-	-
	(c)Minor species only (loss of spawning habitat)	-	-	2	-	-	-	-	-
	(d)Complete loss lower reaches	-	-	-	-	-	-	-	-
	LOWER REACHES:								
	(e)Trout	2	3	4	-	1	2	3	4
Coarse	(f)Barbel, chub, dace, perch, pike	-	3	4	-	-	1	2	3
	(g)Small populations of species (f) (+ loss of older year classes)	-	2	3	-	-	-	1	2
	(h)Bream, perch, roach, tench	-	3	4	-	-	-	-	1
	(i)Small populations of species (h) (+ loss of older year classes)	-	2	3	-	-	-	-	-

Tidal Fisheries			
	Decline due to low flows		
	a	b	c
(a)No reduction in Game or Coarse	-	2	4
(b)Seasonal decline to euryhaline spp	-	-	2
(c)Permanent decline to euryhaline spp	-	-	-

Access to migratory Fish			
	Decline due to low flows		
	a	b	c
(a) No reduction	-	2	4
(b) 20% reduction	-	-	2
(c) 50% reduction	-	-	-

The weighting of the fishery parameter (E2) is 20%.

Clarification of table needed. Put detailed table 1st, followed by simple version on p62.

8.4 Fish Stocks Parameter (E3)

Low base flows affect community structure by reducing water quality and altering the eroding nature of the habitat. This may cause a succession from a game to a coarse fishery, or result in the survival of only ubiquitous bottom-feeding species. In contrast, low flows caused by river abstraction are likely to reduce fish production and displace the age structure of the community in favour of younger fish. In other words, although spawning may still occur, fewer fish will survive to develop the older year classes.

The loss of older year classes is incorporated in the community structure table in the above section but the methodology should also be able to detect low-flow-related declines in production. This is the function of the fish stocks parameter.

As with other parameters, non-low-flow-related declines in water chemistry and habitat destruction may affect fish stocks, so, it is necessary to separate the influence of channel modifications and sewage effluents from that caused by low flows. This will be done by introducing a scoring procedure similar to that suggested for the macro-invertebrate community. Alternatively, the fishery scientist may assess the extent to which low flows are contributing to the decline and allocate a score accordingly.

The fish stocks parameter is based on a comparison of present fish stocks and the 'potential' fish stock. Potential fish stock would be derived by down-weighting fish stock measured before the low flow were a problem, to take account of subsequent adverse impacts of sewage effluents and channel modifications. An algorithm similar to that used for macro-invertebrates for this purpose is shown below.

This parameter (E3) may be calculated where present and archive data on fish stocks are available, or where the fishery scientist can reasonably predict the potential fish stock of a stretch of river. This system is flexible in that data in various forms can be used. These might include population density, biomass or which ever variable is measured in the individual Regions.

The procedure on the flow chart below would start with the question:

1) Are ~~Is~~ data on fish stock available for the period before low flows were perceived as a problem (or can a reasonable estimate of such fish stocks be made)?

   If the answer is 'No', then the algorithm ends, but if the answer is 'Yes' then use the flow chart below to generate potential fish stocks.

	Channel modifications	Effluent component (NWC Class)	Potential fish stock value (NP)
Past stock (N)	Low (x1)	Decrease (x1)	
	Moderate (x0.9)	No change (x1)	
	High (x0.8)	Increase (x0.8)	

2) Compare the measured present fish stock (NM) with the potential fish stock (NP) as the ratio:

$$\frac{NM}{NP}$$

and then convert to a percentage (multiply by 100).

A value of less than 100% indicates that a decline in fish stocks has occurred and may result from low flows. The greater the stock depletion, the more serious the effects of low flows. A value greater than 100% indicates that there is probably no decline in fish stocks due to low flows.

3) A scoring system for this parameter is suggested below.

Score	Value to which fish stock has decline	Severity of low flow related decline in fish stock
4	<40%	Serious decline
3	40 - 59%	Large decline
2	60 - 79%	Moderate decline
1	80 - 99%	Slight decline
0	>100%	None

The weighting of this Fish Stock (E3) parameter is 30%

8.5 Plant Parameter (E4)

In upland reaches, high flows and current velocities erode and scour the channel, and encourage the colonisation of submerged, well attached algae and thin-leaved vascular plants.

Thin leaves reduce the risk of dislocation during spates but at the same time protect against burial during periods of sediment deposition. In contrast, low flows may increase sediment deposition and temperature and cause surface dwelling, strap-leaved and emergent plants to establish. The establishment of this community may then encourage further sediment deposition, leading eventually to the establishment of riparian species within the channel.

Algal and aquatic vascular plant data is not widely available in the Regions. However, abnormal short-term invasion of the channel by riparian species during summer months, and the longer- term changes in herbs, shrubs and trees on the river banks should be scored. As in the fishery parameter, an informed judgement must be made by biologists in the Regions as to the extent to which low flows are responsible for the changes.

Score	Description
0	No change, other than normal seasonal variation in channel or bankside flora.
2	Abnormal invasion of the river channel in summer by marginal terrestrial plants.
4	Bankside flora has changed or is changing due to a lower water table.

The plant parameter (E4) weighting is 10%.

8.6 Conservation parameter (E5)

This parameter (E5) assesses the value of river corridors in conserving natural habitats and wildlife. The assessment is based on two sources of information. First, it takes account of the formal designation of conservation areas which rely on groundwater or surface water to maintain their character. Secondly, this parameter incorporates the duty of the NRA to conserve the whole river system, including groundwater levels and springs.

The NRA's code of practice (Water Act 1989, section 9) states that priority should be given to the conservation of SSSI's and sites of national importance. SSSI's based on fisheries assets have not been widely designated but English Nature is undertaking that task at present. Assessments for this parameter should be made by Conservation Officers in the Regions who will have access to English Nature's list of designated sites and the data from river corridor surveys commissioned by the NRA.

After liaison with the NRA it has been decided to include the water quality standard of a river stretch in this parameter. However, the presence of good quality water and conservation/landscape features provides no direct measure of the severity of low flows in the catchment, so the conservation parameter should be used only when there is direct evidence that low flows are a problem. The conservation parameter will then assist in prioritising sites for support. This is to avoid the accumulation of high scores based on strong public perception of a problem in an area of high conservation value with high water quality, but for which there is no direct evidence that low flows are causing a problem.

The scores apply to ponds and open water as well as flood plain meadows, marshlands, swamps, fens, carrs, mires, flushes and river banks and islands. Formally designated sites should be awarded scores as outlined in the upper section of the table below. Sites within the river system should be awarded scores as indicated in the lower table and the two scores added together. Cumulative scores should be divided by 2 to calculate this ecological parameter. A maximum score of 4 can be generated.

The conservation parameter (E5) should be given a weighting of 30%.

Score	Channel, riparian or other habitats depending on surface or groundwater for their character
5	RAMSAR Sites, National Nature Reserves (NNR's) Marine Nature Reserves (MNRs') Special Protection Areas (SPA's). Sites of Special Scientific Interest (SSSI's) Habitat of species protected by EC Directive or Wildlife and Countryside Act
4	Conservation sites of regional or county importance (eg Naturalist Trust Reserve, RSPB reserve).
3	Local nature reserve*
0	No formal designation

'Local nature reserves'* is an umbrella term for features referred to variously as Heritage sites, c-sites, local nature reserves and sites of historic interest.

Score	Instream and riparian habitat
3	High conservation value, eg a diverse, natural and typical habitat of a viable size and containing species sensitive to disturbance. NWC class 1 stretch
2	Moderate conservation value, eg a smaller or less diverse site; or a site with natural or typical habitat but no particularly threatened species. NWC class 2 stretch
1	Site of minor conservation value NWC class 3 stretch
0	Site of no conservation value. NWC class 4 stretch

8.7 Sample Calculation of Ecological Indicator

A full sample calculation for the Ecological Indicator is shown in Table 8.2. Blank calculation sheets to use in NRA Regions are attached in Annex I.

As a result of the evaluation (Phase 2) the parameter weights have been amended and the amended weights are shown on Table 8.2.

In addition further restrictions have been placed on the use of parameters as follows:

i) The total weight of parameters used must not exceed 1.0, i.e. not all of the parameters may be used.

ii) Parameter E5 should not be used unless there is other firm evidence of low flows, from at least two of parameters H1, H2, H5, E1, E2, E3.

TABLE 8.2 : SAMPLE CALCULATION

ECOLOGICAL INDICATOR

NRA REGION: A region **NAME OF STREAM:** River Example **DATE:** 12/8/92

(see Report Chapters 8.1 to 8.7 for full explanation of methodology)

E1 INVERTEBRATE COMMUNITY PARAMETER

Generate potential ASPT:

Select multipliers:

SOURCE =	1.00	SOURCE: Upland = 1; Lowland = 0.8
REACH =	0.95	REACH: Headstream = 1; Mid = 0.95; Lower = 0.9
CHAN.MODS. =	0.95	CHANNEL MODIFICATIONS.: Limited = 1; Moderate = 0.95; Extensive = 0.9
EFF.COMP. =	1.00	EFFLUENT COMPONENT: Low (NWC class 1) = 1; Moderate (NWC class 2) = 0.95; High (NWC class 3) = 0.9

Potential ASPT = 6.14

Measured ASPT = 4.80

Score		Potential ASPT					
		<4.5	4.5-5.0	5.1-5.5	5.6-6.0	6.1-6.5	>6.5
	<4.5	0	1	2	3	4	4
	4.5-5.0		0	1	2	3	4
Measured	5.1-5.5			0	1	2	3
ASPT	5.6-6.0				0	1	2
	6.1-6.5					0	1
	>6.6						0

Assign score: E1 = 3

E2 FISHERY PARAMETER

Non-Tidal Fisheries:

Score	Fish community under 'normal' flow conditions	Decline due to low flows							
		b)	c)	d)	e)	f)	g)	h)	i)
Game	Headstream								
	a) Trout, salmon	2	3	4	-	-	-	-	-
	b) Small trout only (+ loss of older year classes)	-	2	3	-	-	-	-	-
	c) Minor species only (loss of spawning habitat)	-	-	2	-	-	-	-	-
	d) Complete loss	-	-	-	-	-	-	-	-
	Lower reaches								
	e) Trout	2	3	4	-	1	2	3	4
Coarse	f) Barbel, chub, dace, perch, pike	-	3	4	-	-	1	2	3
	g) Small populations of species f) (+ loss of older year classes)	-	2	3	-	-	-	1	2
	h) Bream, perch, roach, tench	-	3	4	-	-	-	-	1
	i) Small populations of species h) (+ loss of older year classes)	-	2	3	-	-	-	-	-

Tidal Fisheries:

	Decline due to low flows		
	a	b	c
a) No reduction in Game or Coarse	-	2	4
b) Seasonal decline to euryhaline spp	-	-	2
c) Permanent decline to euryhaline sp	-	-	-

Access to migratory Fish:

	Decline due to low flows		
	a	b	c
a) No reduction	-	2	4
b) 20% reduction	-	-	2
c) 50% reduction	-	-	-

OR:

Short-term impact parameter	Score
No fishing was possible during a season due to low flows	4
No evidence of short-term impact of low flows on angling	0

Assign score: E2 =

TABLE 8.2 : SAMPLE CALCULATION (cont'd)

ECOLOGICAL INDICATOR

page 2 of 2

NRA REGION: A region NAME OF STREAM: River Example DATE: 12/8/92

(see Report Chapters 8.1 to 8.7 for full explanation of methodology)

E3 FISH STOCKS PARAMETER

Generate potential fish stock: Past fish stock (N) = [ ]

Select multipliers: CHAN.MODS. = [ ] CHANNEL MODIFICATIONS: Low = 1; Moderate = 0.9; High = 0.8

EFF.COMP. = [ ] EFFLUENT COMPONENT: Decrease = 1; No Change = 1; Increase = 0.8

Potential fisk stock (NP) = N x multipliers = [ ] Measured present fish stock (NM) = [ ]

Present/Potential Fish Stock (FSR%) = [ ]

Present/Potential	Decline related to low flows	Score
<40%	Serious decline	4
40-59%	Large decline	3
60-79%	Moderate decline	2
80-99%	Slight decline	1
>100%	None	0

Assign score: E3 =

E4 PLANT PARAMETER

Description of changes	Score
Bankside flora has changed or is changing due to a lower water table	4
Abnormal invasion of the river channel in summer by marginal terrestrial plants	2
No change, other than normal seasonal variation in channel or bankside flora	0

Assign score: E4 = 2

E5 CONSERVATION PARAMETER

Only use this parameter if there is direct evidence that low flows are a problem (i.e. from 2 of parameters H1,H2,H5,E1,E2,E3)

Formally designated sites:

Channel, riparian or other habitats depending on surface or groundwater for their character	
RAMSAR Sites, National Nature Reserves (NNRs), Marine Nature Reserves (MNRs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs), Habitat of species protected by EC Directive or Wildlife and Countryside Act	5
Conservation sites of regional or county importance (eg Naturalist Trust Reserve, RSPB Reserve)	4
Local nature reserve (including Heritage sites, C-sites, and Sites of historic interest)	3
No formal designation	0

Sites within the river system:

Instream and riparian habitat	Score
High conservation value, eg a diverse, natural and typical habitat of a viable size and containing species sensitive to disturbance. NWC class 1 stretch	3
Moderate conservation value, eg a smaller or less diverse site; or a site with natural or typical habitat but no particularly threatened species. NWC class 2 stretch	2
Site of minor conservation value. NWC class 3 stretch	1
Site of no conservation value. NWC class 4 stretch	0

Add scores from both tables and divide by 2 to give final E5 score. Assign score: E5 = 2

CALCULATION OF ECOLOGICAL INDICATOR

Parameter	Param.weight	Weight of params. used	Score	Weight x Score
E1	0.4	0.4	3	1.2
E2	0.2			0.0
E3	0.3			0.0
E4	0.1	0.1	2	0.2
E5	0.3	0.3	2	0.6
		SUM1 = 0.8 (max.1)	SUM2 =	2.0

Ecology Severity Index = SUM2/(SUM1x4) = 0.63

Ecology Reliability Index = SUM1 = 0.80

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9. THE LANDSCAPE AND AMENITY INDICATOR

This indicator incorporates parameters describing the overall importance of the river in the landscape and also the impact of low flows on the visual outlook and on the recreational and amenity use of the river. A summary of the parameters included in this Indicator is given in Table 9.1. This indicator provides an assessment of the value of the river and river corridor, as perceived by people. The wider implications of the landscape must be established first, in order that the seriousness of any problems associated with low flows can be assessed. Secondly, this indicator assesses the extent to which the amenity of the river/river corridor is affected by low flows during the summer months.

Data collected in a consistent manner and recorded in a standard form, will produce consistent and comparable results. The assessment is 'built up' by applying the method to each 1000m length of river. Where the length of river to be assessed is in excess of this length, the total score for the full length is divided by the number of sections (of 1000m) surveyed. The component parts of the landscape, such as trees, landforms and artifacts, will be recorded and their importance to the landscape as a whole will be assessed. All landscape assessments should take place at a specified time of year. This could possibly correspond with the timing of the first sampling of river invertebrates in spring/early summer. This assessment could be carried out by the same ecological/conservation survey team, after an introduction to the specialist techniques required. Alternatively, personnel trained in landscape assessment techniques could be employed.

9.1 Landscape Designation and Rarity Parameter (L1)

This parameter L1, assesses the *importance* of the landscape through which the river flows. It will be important in prioritising competing projects for low flow alleviation, but since it is not a measure of low flows as such, it should be only used if there is other evidence that low flows occur. The parameter L1 is derived from two components, the landscape designation and landscape rarity.

Landscape Designation

The value of the landscape to people has already been established by the designation of tracts of landscape into categories such as National or Country Parks. These categories indicate the importance of a piece of landscape in the national and local context and have been allocated scores accordingly:

Score	Description
2	Important in a national context, ie National Parks and Areas of Outstanding Natural Beauty.
1	Important in a local context ie Areas defined as Country Parks/Special Value etc within local or structure plan context.
0	Landscape has no official designation.

An additional score may be awarded as follows:

+1 Areas which are undergoing environmental improvements (either national or local) and where finance exists to support such improvements ie landscapes within Development Corporation Areas, Local Initiative Areas.

Landscape Rarity

The importance of a river or river corridor within its wider landscape is assessed by this score for rarity. A higher score is awarded to a river or river corridor which is rare in a *national* context - as opposed to a *local* context - as this reflects the greater sensitivity with which these landscapes have to be treated.

Score	Description
2	Where river/river corridor landscape is "the only" or "one of the best examples of ...." in the national context.
1	Where river/river corridor landscape is "the only" or "one of the best examples of ...." in the local context.
0	The river has no rarity value.

The score for Parameter L1 is the sum of the scores assigned under Landscape Designation and Landscape Rarity, with a range of 0 to 4 ie a score of 5, which is possible , would be counted as 4..

Landscape designation and rarity parameter (L1) weighting is 20%.

9.2 The Importance of the River as a Landscape Feature and its Impact on Adjacent Land (L2)

This parameter (L2) is also derived from two components:

SUMMARY OF LANDSCAPE AND AMENITY INDICATOR	
L1 Landscape Designation and Rarity parameter (Designation + Rarity Score)	Designation: Nat.Parks & Areas of Outstanding Natural Beauty/Country Parks/no desig. Rarity: 'National' and 'Local' Rarity. *Weighting = 20%.*
L2 Importance of the river as a landscape feature and its impact on adjacent land parameter	Importance: Visual importance of river. Impact: Beneficial or degraded adjacent land use. (Importance + Impact) *Weighting = 30%.*
L3 Recreation parameter	Number of water-contact activities unable to take place in certain time periods. (Not Fishing or Angling - see E2). *Weighting = 30%.*
L4 Amenity parameter	Based on Odour at channel, Visual problems in channel, and Visual problems on river bank/adjacent land. *Weighting = 10%.*
L5 Historical and Cultural Associations parameter	Importance of historical and archaeological interest sites. *Weighting = 10%.*

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Table 9.1 : Summary of parameters related to Landscape and Amenity Indicator

The Importance of the river as a landscape feature

This component establishes how visually important the river is within the landscape, regardless of any planning designation. The assessment should be made from places which are accessible to the public, such as footpaths, roads and local vantage points within the river corridor. Where several access points exist, the dominant overall impression should be recorded.

Score	Description
3	High importance - dominant landscape feature, due associated artifacts such as weirs, bridges etc.
2	Medium importance - only stretches of the river are visible, or the course is only noticeable because of bankside vegetation being visible.
1	Low importance - the river is barely noticeable.

Impact of River on Adjacent Land

In many areas the river has had a considerable impact on the adjacent landscape. Many towns grew because the adjacent river was navigable or was used as an energy source for mills etc. In addition the 'management' of the river either allowed the adjacent land to be drained or to flood so changing its agricultural use. It is important within this parameter that only the present day use is recorded, as the historical element is allowed for in L5.

The scoring is based on the principle that the greater the score assigned to each parameter, the greater the 'problem'. However within this parameter there are both positive and negative impacts in relation to the river and its effect on adjacent land. Consequently the score for 'importance' above is reduced by a negative mark where the overall impact is attractive in order to reduce the overall score and vice versa. For example, a score of 3 for 'importance' would be followed by -1 for impact if the drainage of the adjacent land had resulted in better agricultural land or reduced flooding.

Score	Description
-1	Where a beneficial adjacent land-use (within 500m) is primarily as a result of man's impact on or management of the river
+1	Where a degraded or unsightly adjacent land use is primarily as a result of man's impact on or management of the river which could be remedied if remedial action were taken to the river

The two scores are added to produce a score with a range of 0 to 4. The weighting of this parameter (L2) is 30%.

9.3 Recreation Parameter (L3)

The parameter L3, assesses the impact of low flows on water-based recreational activities. As the impact of low flows on fishing is assessed in parameter E2, fishing and angling are excluded from the following assessment of water-contact recreational activities.

Recreational use may be passive or active. In general active use is associated with sports which require direct contact with water, such as: canoeing; sailing; rowing; boating; swimming; diving; water-skiing and wind surfing. These sports should have a higher score than passive recreational use, as any reduction in water quantity or quality as a result of low flows, can seriously affect participation in the sport. The scores should be awarded if the activity has been affected by a reduced volume or flow of water or a change in water quality due to low flows has occurred within the specified time period.

Score	Description
4	When three or more water contact recreational activities were unable to take place sometime in each year during a 5 year period.
3	Three or more water-contact recreational activities were unable to take place at any time in any one twelve month period.
2	One or two water-contact recreational activities were unable to take place at any time in any twelve month period.
1	Any water-contact recreational activity was affected by low flows within the last five years. This also includes a reduction in enjoyment of a sport, resulting from low river flows.
0	No change has been noted.

Fishing and angling are not included in the score of recreational activities in the above table.

The above score takes into account the present (and potential) use of the river for recreation. However, if historical evidence exists, which can be authenticated, that an active water-contact activity was possible on the river in the past (say 25 yrs) and there is a demand for that sport nationally or locally an additional score of +1 may be awarded as follows, up to a maximum total of 4 for this parameter.

Score	Description
+1	The river was able to support a water-contact recreational activity within the past 25 years, but this activity is no longer possible due to lower river flows.

The weighting of the recreation parameter (L3) is 30%.

9.4 Amenity Parameter (L4)

This parameter L4 assesses the impact of low flows on the general amenity of the river by reference to bank-side recreational pursuits and access to the river. Although low flows do not prevent walking, birdwatching, sightseeing and picnicking from taking place, the enjoyment of these recreational pursuits may be affected. Odour and visual impact are based on pollution and nuisance, as measured in some NRA regions. These will need to be recorded during the summer months at specified times, which it is suggested should be in the first week of August.

The parameter score is derived from the sum of scores, up to a total of 4, based on the following three components of the parameter.

Odour

Score	Description
2	Strong odour at channel edge eg sludge, sewage, chemical or farmyard wastes and noticeable at a distance of more than 10 metres from the channel.
1	Noticeable odour at the channel edge.
0	No noticeable odour.

Visual River Channel

This includes unnatural water colour, farm wastes, foam, sewage, fungus, crude sewage, visible solids, rotting vegetation and also where refuse and litter are exposed or if no water is present.

Score	Description
3	Three or more of the above elements which persist over a period of several months, as a result of low flows or three or more of the above elements which occur intermittently.
2	One to three of the above elements which persist over a period of several months, as a result of low flows.
1	Two of the above elements which occur intermittently, as a result of low flows.
0	No visual problem.

Visual - River Bank and Adjacent Land

An additional score of 1 can be awarded where the general public are encouraged to have access to the river as part of a wider planning designation such as: a public open space; or the provision of a long distance footpath or nature trail.

Score	Description
+1	Where planning designation encourages public use.

The weighting of the amenity parameter (L4) is 10%

9.5 Historical and Cultural Associations (L5)

This parameter allows the evaluation of impact on the river within a wider context, eg does the name of a building or a town derive from the name of the river or is the landscape character particularly influenced by water mills, designed parkland or particular bankside vegetation. If so, such associations reinforce the requirement to maintain appropriate water levels.

Score	Description
4	Sites of national historical/archaeological interest ie.National Monuments, National Trust sites.
3	Sites of regional historical/archaeological interest generally within 500m.
2	Sites which have national cultural associations such as paintings and literature, or local archaeological sites.
1	Sites of local historical archaeological, cultural or literary interest, such as place names.....
0	No historical or cultural associations.

The weighting of this historical and cultural parameter (L5) is 10%.

9.6 Sample Calculation of Landscape and Amenity Indicator

A full sample calculation for the Landscape/Amenity Indicator is shown on Table 9.2. Blank calculation sheets for use by NRA Regions are attached in Annex I to this report.

It is repeated here for emphasis that parameters L1, L2, L4, L5, are not direct evidence of low flows and should not be used unless there is other firm evidence of low flows from at least two of parameters H1, H2, H5, E1, E2, E3.

As a result of the evaluation (Phase 2) the parameter weights have been amended and the amended weights are shown on Table 9.2.

NRA Project B2.2 : Low Flow Conditions

TABLE 9.2 : SAMPLE CALCULATION

LANDSCAPE AND AMENITY INDICATOR

NRA REGION: A region **NAME OF STREAM:** River Example **DATE:** 12/8/92

(see Report Chapters 9.1 to 9.6 for full explanation of methodology)

Note: Do not use L1,L2,L4 or L5 unless there is other firm evidence of low flows from at least 2 of parameters H1,H2,H5,E1,E2,E5

L1 LANDSCAPE DESIGNATION AND RARITY PARAMETER

For Landscape Designation:

Description	Score
Important in a national context, ie National Parks and Areas of Outstanding Natural Beauty	2
Important in a local context, ie Areas defined as Country Parks/Special Value etc. within local or structure plan context	1
Landscape has no official designation	0
An additional score may be awarded as follows:	
Areas which are undergoing environmental improvements (either national or local) and where finance exists to suport such improvements, ie landscapes within Development Corporation Areas, Local Initiative Areas	+1

For Landscape Rarity:

Description	Score
Where river/river corridor landscape is "the only" or "one of the best examples of..." in the national context	2
Where river/river corridor landscape is "the only" or "one of the best examples of..." in the local context	1
The river has no rarity value	0

Add scores to a maximum of 4. **Assign score: L1 = 3**

L2 IMPORTANCE OF THE RIVER AS A LANDSCAPE FEATURE AND ITS IMPACT ON ADJACENT LAND PARAMETER

For Importance:

Description	Score
High importance - dominant landscape feature, due to associated artifacts such as weirs, bridges etc.	3
Medium importance - only stretches of the river are visible, or the course is only noticeable because of bankside vegetation being visible	2
Low importance - the river is barely noticeable	1

For Impact:

Description	Score
Where a beneficial adjacent land use (within 500m) is primarily as a result of man's impact on, or management of, the river	-1
Where a degraded or unsightly adjacent land use is primarily as a result of man's impact on, or management of, the river, which could be remedied if remedial action were taken to the river	+1

Add scores to a range of 0-4 **Assign score: L2 = 3**

L3 RECREATION PARAMETER

Description (do not include fishing/angling)	Score
When 3 or more water-contact recreational activities were unable to take place sometime in each year during a 5 year period	4
3 or more water-contact recreational activities were unable to take place at any time in any one 12 month period	3
1 or 2 water-contact recreational activities were unable to take place at any time in any 12 month period	2
Any water-contact recreational activity was affected by low flows within the last 5 years. This also includes a reduction in enjoyment of a sport, resulting from low river flows	1
No change has been noted	0
If historical evidence exists, an additional score may be awarded where:	
The river was able to support a water-contact recreational activity within the past 25 years, but this activity is no longer possible due to lower river flows	+1

Add scores to a maximum of 4. **Assign score: L3 = 2**

TABLE 9.2 : SAMPLE CALCULATION (cont'd)

LANDSCAPE AND AMENITY INDICATOR

page 2 of 2

NRA REGION: A region **NAME OF STREAM:** River Example **DATE:** 12/8/92

(see Report Chapters 9.1 to 9.6 for full explanation of methodology)

Note: Do not use L1,L2,L4 or L5 unless there is other firm evidence of low flows from at least 2 of parameters H1,H2,H5,E1,E2,E5

L4 AMENITY PARAMETER

For Odour:

Description	Score
Strong odour at channel edge, eg sludge, sewage,chemical or farmyard wastes and noticeable at a distance of > 10m from the channel	2
Noticeable odour at the channel edge	1
No noticeable odour	0

For Visual Impairment at the river channel:

(Elements include unnatural water colour, farm wastes, foam, sewage, fungus, crude sewage, visible solids, rotting vegetation, and also where refuse and litter are exposed or if no water is present)

Description	Score
3 or more of the above elements which persist over a period of several months, as result of low flows, or 3 or more of the above elements which occur intermittently	3
1 to 3 of the above elements which persist over a period of several months, as result of low flows	2
2 of the elements which occur intermittently, as a result of low flows	1
No visual problem	0

For Visual Impairment on the river bank and adjacent land:

Description	Score
Where planning designation encourages public use	+1

Add scores to a maximum of 4. Assign score: L4 = 3

L5 HISTORICAL AND CULTURAL ASSOCIATIONS PARAMETER

Description	Score
Sites of national historical/archaeological interest, ie National Monuments, National Trust sites	4
Sites of regional historical/archaeological interest, generally within 500m	3
Sites which have national cultural associations such as paintings and literature, or local archaeological sites	2
Sites of local historical/archaeological, cultural or literary interest, such as place names	1
No historical or cultural associations	0

Assign score: L5 = 3

CALCULATION OF LANDSCAPE AND AMENITY INDICATOR

Parameter	Param.weight	Weight of params.used	Score	Weight x Score
L1	0.2	0.2	3	0.6
L2	0.3	0.3	3	0.9
L3	0.3	0.3	2	0.6
L4	0.1	0.1	3	0.3
L5	0.1	0.1	3	0.3
		SUM1 = 1		SUM2 = 2.7

Landscape and Amenity Severity Index = SUM2/(SUM1x4) = 0.68

Landscape and Amenity Reliability Index = SUM1 = 1.00

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10. THE PUBLIC PERCEPTION INDICATOR

The Public Perception Indicator is based on two parameters, the *proximity* of the river to urban areas and the extent of *complaints* received by the NRA. The parameters are summarised in Table 12.

10.1 Proximity of River to Centres of Population Parameter (P1)

This parameter assesses the number of people within reasonable proximity of the river who might be affected by low flows in the river and who might be disadvantaged if alleviation work is not undertaken. Recreation and amenity are assessed by parameters L3 and L4 and parameter P2 assesses complaints from the public.

Score	Description
4	River flows through a large centre of population ie. a town.
3	River flows through a small centre of population ie. a village.
2	River flows within 1km of a town.
1	River flows within 1km of a village.

The distinction between a town and a village is usually evident in a given Region but where this is not the case a suitable guideline might be to classify a town as any conurbation with more than 10,000 population.

The weighting of the proximity of river to centres of population parameter (P1) is 30%.

10.2 Complaints Received from the Public Parameter (P2)

Public pressure is an important factor in highlighting perceived 'problems' of low river flows, whether the problems are real or not. It is therefore important to allow for this factor within the framework, although it is recognised that not all complaints are factually correct. Scores will be awarded where complaints about low river flows have been received over a number of years, and not in relation to a single incident of a particularly severe drought.

SUMMARY OF PUBLIC PERCEPTION INDICATOR			
P1	Proximity of River to Centres of Population	Based on size of pop. and proximity.	*Weighting = 30%.*
P2	Complaints received from the Public	Number and source of complaints.	*Weighting = 70%.*

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Table 10.1 : Summary of parameters related to Public Perception Indicator

Score	Description
4	Written complaints received from national organisations (e.g. English Nature, CLA, CPRE, Salmon and Trout Association, etc) in support of local pressure groups formed specifically to deal with problems affecting the river and its environment.
3	Press coverage or written complaints received from national organisations or local clubs or pressure groups.
2	A moderate number (over 5 per annum on average) of written complaints received from individuals about problems related to low river flows over a period of years.
1	Up to 5 written complaints received on average per annum from individuals about problems related to low river flows over a period of years.
0	No complaints received about problems related to low river flows.

The weighting of the Complaints Received from the Public parameter (P2) is 70%.

10.3 Sample Calculation of Public Perception Indicator

A full sample calculation of the public perception indicators is shown in Table 10.2. Blank calculation sheets are included in Annex I for use by the NRA Regions.

TABLE 10.2 : SAMPLE CALCULATION

PUBLIC PERCEPTION INDICATOR

page 1 of 1

NRA REGION: A region NAME OF STREAM: River Example DATE: 12/8/92

(see Report Chapters 10.1 to 10.3 for full explanation of methodology)

P1 PROXIMITY OF RIVER TO CENTRES OF POPULATION parameter

Description	Score
River flows through a large centre of population, ie a town	4
River flows through a small centre of population, ie a village	3
River flows within 1km of a town	2
River flows within 1km of a village	1

(If unsure of town/village distinction, use: Town = > 10,000 pop.)

Assign score: P1 = 4

P2 COMPLAINTS RECEIVED FROM THE PUBLIC parameter

Description	Score
Written complaints received from national organisations (e.g. English Nature, CLA, CPRE, Salmon & Trout Assoc. etc.) in support of local pressure groups formed specifically to deal with problems affecting the river and it's environment	4
Press coverage or written complaints received from national organisations or local clubs or pressure groups	3
A moderate number (> 5/annum on average) of written complaints received from individuals about problems related to low river flows over a period of years	2
Up to 5/annum on average written complaints received from individuals about problems related to low river flows over a period of years	1
No complaints received about problems related to low river flows	0

Assign score: P2 =

CALCULATION OF PUBLIC PERCEPTION INDICATOR

Parameter	Param.weight	Weight of params.used	Score	Weight x Score
P1	0.3	0.3	4	1.2
P2	0.7			0
		SUM1 = 0.3		SUM2 = 1.2

Public Perception Severity Index = SUM2/(SUM1x4) = 1.00

Public Perception Reliability Index = SUM1 = 0.30

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11. COMBINING THE INDICATORS

Having established 'scores' in the form of *Severity Index* and *Reliability Index* for each Indicator, they can be combined in a number of ways. Table 11.1 shows this for the sample calculations used in previous chapters.

11.1 Overall Severity Index

The Severity Index (SI) calculated as the sum of the (weighted) SI's for each of the Indicators as follows:-

	Indicator SI (a)	Weight % (b)	Weighted SI (a) * (b)
Hydrology HSI		40%	
Ecology ESI		30%	
Landscape/Amenity LSI		20%	
Public Perception PSI		10%	

$$TotalSI = \sum (a*b)$$

It should be noted that the weights are fixed but all other spaces are filled in by the assessor. A further discussion of weights is given in Chapter 13 of this report.

11.2 Overall Reliability Index

The Overall Reliability Index is calculated in a similar way as the Overall Severity Index, but the Public Perception Indicator does not contribute to the Reliability Index and the weights used are amended to:

Hydrology HRI	40%
Ecology ERI	35%
Landscape/Amenity LSI	25%

During the evaluation, a number of Regions "scored" parameters on the basis of informed judgements by experienced staff, rather than hard data, whereas others would only assign a score on the basis of hard data.

Such "judgemental" scoring carried out by suitably experienced staff can make a valuable contribution to the assessment but should be reflected in the assessment of Reliability Index.

It is proposed therefore that in assessing the Reliability Index, the assessor should use a proportion only of the indicator weight to reflect the degree of confidence which he or she has in the assessment.

11.3 Suggested Action

Having assessed the Severity Index and the Reliability Index the action arising from this assessment might be categorised as shown in Table 11.1.

Table 11.1 : SUGGESTED ACTION RESULTING FROM ASSESSMENT OF LOW FLOWS

Severity Index	Reliability Index	Action Required
High	High	Put in NRA Capital Works programme for alleviation
High	Low	Further study and data collection required
Low	High	No action unless strong public pressure in which case mount a public relations campaign to explain that there is no problem.
Low	Low	No action unless strong public pressure in which case initiate minimum cost studies and mount public relations campaign

Detailed action by the NRA following the assessment is beyond the scope of this project and therefore it has not been considered further. However, during the formulation and evaluation of the methodology, various points of discussion emerged which might aid or influence the NRA in allocating priority for action between high-scoring sites. These Factors, and the way in which they might be applied, are discussed below.

11.4 Real or Perceived Problem

The assessment of whether there is a real problem or a problem only in the public's perception is based upon a *qualitative comparison* of the Hydrological and Ecological Indicators with the Public Perception Indicator.

In the case where the Public Perception Severity Index is high but the other Indicators show a low Severity Index with a medium to high Reliability Index then the problem can be categorised as a perceived problem only.

In all other cases, the Public Perception Indicator is most unlikely to change the conclusion drawn from the other indicators but may influence the likely order of priority.

11.5 Size Adjustment

Up to this stage in the assessment procedure, a short length of headwater stream could score the same as perhaps tens of kilometres of the middle course of a large river. The importance of the two low flow conditions could be expected to be quite different, however.

A Size Adjustment factor is therefore required, to reflect the length and size of watercourse affected. This, like the Cost adjustment factor discussed below, would be applied as an adjustment to the SI (but not RI) assessed from the four basic Indicators.

However, unlike cost, the Size Adjustment should influence the ranking by severity of problem and not only the rehabilitation/alleviation priorities. It should therefore be applied, in all cases, before the application of the cost/benefit adjustment.

It is proposed that an adjusted Severity Index (SIa) should be calculated from the initial Severity Index (SIi) from the following formula:

$$SIa = SIi \times L^{1/3} \times CA^{1/3}$$

where L is the length of watercourse affected (km)
CA is the catchment area to the mid-point of the length affected (km^2).

The indices of "1/3" have been selected (rather than "1/2") on the basis that the greater length of affected channel usually (but not always) means a greater catchment area.

11.6 Cost Adjustment

The cost, or more correctly the Benefit/Cost Ratio of an alleviation scheme, does not affect the severity of the problem but should have some influence on the order of priority assigned to schemes. Proposal Number for related R&D Project. (Terry Sharriff's)

The Cost Adjustment is based on the following:-

i) The cost of 'buying out' an existing licence has been quoted in a number of Regions as approximately £1 million per Ml/day.

ii) Any alleviation scheme will have an effect equivalent to a reduction in licensed abstraction. For example, if a re-circulation scheme or groundwater support scheme produces an increase in low flow of 0.5 Ml/day without affecting the available abstraction, this can be considered as having the same value as buying out abstraction licences of this magnitude, ie. a Value or Benefit of £500,000.

iii) The cost of the alleviation scheme can be expressed as a commuted sum (Net Present Value of Costs). It is suggested that should this be calculated at a discount rate of 5% over 30 years.

Thus the Cost Adjustment, summarised in Table 11.3 could be expressed as the Benefit/Cost ratio with the Benefit calculated as in ii) above and the Cost calculated as in iii) above.

This is only an approximate adjustment as the Consultants have not investigated the accuracy of the quoted cost of buying out licences, and the relationship between the increase in low flow achieved by alleviation measures and the corresponding availability of licensed abstraction is, in some cases complex. However it does give some guide to the viability of alleviation options.

In principle, no alleviation scheme should proceed if its Benefit/Cost Ratio is less than 1 since this means that it would be more cost-effective to 'buy-out' licences.

In practice, however, alternative sources may not be available or may only be available at higher cost. Since the cost of buying out licences should be based on the cost of alternative sources, this would signal that the quoted cost of buying out is inaccurate. In reality, the cost of alternative sources and hence of buying out licences will vary but the figure quoted above may be taken as a starting point.

If, in order to mitigate the effects of 1Ml/d abstraction, an alleviation scheme in one area costs 10 times as much as an equivalent scheme in another area, the latter should be moved up the list of priorities. That is not to say that the schemes should be ranked solely on the basis of benefit/cost ratio. Following the rules:-

i) increasing Benefit/Cost ratio should increase priority and

ii) increasing Severity Index should increase priority.

One obvious way of taking account of the Benefit/Cost (B/C) ratio is to multiply the Adjusted Severity Index as calculated under 11.5 above by the B/C ratio.

Intuitively, however, this is likely to give too much significance to the B/C ratio and a suggested multiplier would be

$$(1+0.5(\frac{B}{C}-1))$$

It may be that in testing this method, the 'reduction factor' of 0.5 in the above expression will be shown to be still too high and will need to be reduced.

A full sample calculation of the cost adjustment is shown in Table 11.4. Blank calculation sheets are included in Annex I for use by the NRA Regions.

TABLE 11.1: SAMPLE CALCULATION OF THE OVERALL INDICES

CALCULATION OF OVERALL INDICATORS

NRA REGION: A region NAME OF STREAM: River Example DATE: 12/8/92

OVERALL SEVERITY INDEX (SI)

SI type	SI	Weight	Weighted SI
Hydrological SI	0.97	40.0%	0.39
Ecological SI	0.63	30.0%	0.19
Landscape and Amenity SI	0.68	20.0%	0.14
Public Perception SI	1.00	10.0%	0.10
		Total SI (SII) =	0.81

OVERALL RELIABILITY INDEX (RI)

RI type	RI (orig.)	Weight	Weighted RI
Hydrological RI	0.90	40.0% *	0.36
Ecological RI	0.80	35.0% *	0.28
Landscape and Amenity RI	1.00	25.0% *	0.25
		Total RI =	0.89

* *Use only a proportion of indicator weight if "judgemental scoring" has been carried out (see Report Chapter 11.2)*

POSSIBLE ACTION

SI	RI	Action
High	High	Put in Capital Programme for Alleviation
High	Low	Further studies required
Low	High	No action unless strong public pressure, in which case mount public relations campaign
Low	Low	No action unless strong public pressure, in which case initiate minimum cost further studies and mount public relations campaign

SIZE ADJUSTMENT

Length of watercourse affected (L) =	5	km
Catchment area to mid-point of length affected (CA) =	12	km2
Adjusted Severity Index (SIa) = SII x $L^{1/3}$ x $CA^{1/3}$ =	3.18	

COST ADJUSTMENT

Benefit:

Increase in low flow resulting from alleviation scheme =	0.5	Ml/day
Benefit (or Value) = (approx.)	£0.50	million

Cost:

Net Present Value of costs of alleviation scheme = *(discount rate = 5% over 30 years)*	£0.45	million
Benefit/Cost ratio =	1.11	
Adjusted Severity Index (SIa) =	3.18	
Total Severity Index (TSI), taking account of Benefit/Cost ratio =	3.35	

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ANNEX I

BLANK CALCULATION SHEETS FOR ASSESSMENT OF LOW FLOWS

HYDROLOGICAL INDICATOR

NRA REGION: **NAME OF STREAM:** **DATE:**

(see Report Chapters 7.1 to 7.8 for full explanation of the methodology)

H1 GROUNDWATER BALANCE PARAMETER – ANNUAL LICENSED ABSTRACTION / ANNUAL RECHARGE

Total Groundwater ALA = [ ] m3/a (GWALA)
Calculated AR (1 in 10 yr drought) = [ ] m3/a (AR)
Total Annual 'Licence-exempt' Abst. = [ ] m3/a (X) *- ONLY enter if significant*
Total Surface Water ALA = [ ] m3/a (SWALA) *} ONLY enter if H2 not used and*
Licensed Effluent Returns (annual) = [ ] m3/a (ER) *} ALA is supported by spring flow*

ALA/AR = (GWALA+X+SWALA-ER)/AR = [ ]

ALA/AR	Score
>1.0	4
0.7-1.0	3
0.4-0.7	2
0.2-0.4	1
<0.2	0

Assign score: H1 = *PRIMARY*

H2 RIVERFLOW BALANCE PARAMETER – DAILY MAXIMUM LICENSED ABSTRACTION / Q95 "NATURAL" or Q95 "NATURAL" / RES.COMP.FLOW

Total Surface Water DMLA = [ ] m3/d (SWDMLA) *- ONLY enter for non-res. catchments*
Reservoir Compensation Flow (mean daily) = [ ] m3/d (COMP) *- ONLY enter for reservoired catchments*
Total downstream channel abstraction (daily) = [ ] m3/d (DMLCA) *- ONLY enter for reservoired catchments*
Total 'Licence-exempt' abstraction (daily) = [ ] m3/d (X2) *- ONLY enter if significant*
Q95(7) = [ ] m3/d (QNF)
Total Groundwater DMLA (with direct impact) = [ ] m3/d (GWDMLA) *}*
Licensed Effluent Returns (daily) = [ ] m3/d (ERTWO) *} ONLY enter if H1 not used*

Non-reservoired catchments: Total DMLA/Q95 = (SWDMLA+X2+GWDMLA-ERTWO)/QNF = [ ]
Reservoired catchments: Q95/COMP = QNF/(COMP-DMLCA-X2-GWDMLA+ERTWO) = [ ]

DMLA/Q95 or Q95/COMP	Score
>1.0	4
0.7-1.0	3
0.4-0.7	2
0.2-0.4	1
<0.2	0

Assign score: H2 = *PRIMARY*

H3 GROUNDWATER LEVEL PARAMETER

Mean Annual Decline in minimum groundwater levels = [ ] m (MAD)
Mean Seasonal Range = [ ] m (MSR)

MAD/MSR = [ ]

MAD/MSR	Score
*	4
>0.5	3
0.3-0.5	2
0.1-0.3	1
<0.1	0

* If MAD/MSR > 0.5, see Report Chapter 7.3 to assign score

Assign score: H3 = *SECONDARY*

HYDROLOGICAL INDICATOR

NRA REGION: **NAME OF STREAM:** **DATE:**

(see Report Chapters 7.1 to 7.8 for full explanation of the methodology)

H4 STREAM MORPHOLOGY PARAMETER

Cross Section	Current XSA of flow (m2)	Normal XSA of flow (m2)	Current / Normal
1			
2			
3			
4			
5			
		Mean =	

% of Channel	Score
<10%	4
10-30%	3
30-50%	2
50-70%	1
>70%	0

Assign score: H4 = *SECONDARY*

H5 FLOW AND ECOLOGY RELATIONSHIP PARAMETER - RESIDUAL FLOW / MINIMUM ECOLOGICALLY ACCEPTABLE FLOW

Q95(7) =		m3/d	(QNF)	} *ONLY enter for non-res. catchments*
Total DMLA (see H2) =		m3/d	(DMLA)	}
Reservoir Compensation Flow (mean daily) =		m3/d	(COMP)	}
Total downstream channel abstraction (daily) =		m3/d	(DMLCA)	}
Total 'Licence-exempt' abstraction (daily) =		m3/d	(X2)	} *ONLY enter for reservoired catchments*
Licensed Effluent Returns (daily) =		m3/d	(ERTWO)	}
Tributary Inflows (sum of Q95s) =		m3/d	(TRIB)	}
MEAF (critical month) =		m3/d	(MEAF)	*(Note: MEAF is under development as part of NRA R&D Project B2.1 and is as yet undefined)*

(Q95-DMLA)/MEAF or COMP/MEAF	Score
<60%	4
60-80%	3
80-100%	2
100-120%	1
>120%	0

Non-res. catchments: (Q95-DMLA)/MEAF =

Res. catchments: (COMP-DMLCA-X2+ERTWO+TRIB)/MEAF =

Assign score: H5 = *PRIMARY*

H6 MOVEMENT OF SPRINGHEAD parameter

Total length of reaches changed from perennial to intermittent = km

Total length of reaches changed from intermittent to ephemeral = km

Sum = km

Sum of reaches (km)	Score
>8	4
4-8	3
2-4	2
0-2	1
0	0

Assign score: H6 = *SECONDARY*

CALCULATION OF HYDROLOGICAL INDICATOR

Parameter	Param. weight		Weight of params. used	Score	Weight x Score
H1	0.5	} *If H1 & H2 are BOTH used,*			
H2	0.5	} *set both weights to 0.4*			
H3	0.1				
H4	0.1				
H5	0.9				
H6	0.1				
		SUM1 =	(max. 1)	SUM2 =	

Hydrology Severity Index = SUM2/(SUM1x4) =

Hydrology Reliability Index = SUM1 =

ECOLOGICAL INDICATOR

NRA REGION: **NAME OF STREAM:** **DATE:**

(see Report Chapters 8.1 to 8.7 for full explanation of methodology)

E1 INVERTEBRATE COMMUNITY PARAMETER

Generate potential ASPT:

Select multipliers:

SOURCE = [ ]
REACH = [ ]
CHAN.MODS. = [ ]
EFF.COMP. = [ ]

SOURCE: Upland = 1; Lowland = 0.8
REACH: Headstream = 1; Mid = 0.95; Lower = 0.9
CHANNEL MODIFICATIONS.: Limited = 1; Moderate = 0.95; Extensive = 0.9
EFFLUENT COMPONENT: Low (NWC class 1) = 1; Moderate (NWC class 2) = 0.95; High (NWC class 3) = 0.9

Potential ASPT = [ ]

Measured ASPT = [ ]

Score		Potential ASPT					
		<4.5	4.5–5.0	5.1–5.5	5.6–6.0	6.1–6.5	>6.5
	<4.5	0	1	2	3	4	4
	4.5–5.0		0	1	2	3	4
Measured	5.1–5.5			0	1	2	3
ASPT	5.6–6.0				0	1	2
	6.1–6.5					0	1
	>6.6						0

Assign score: E1 =

E2 FISHERY PARAMETER

Non-Tidal Fisheries:

Score	Fish community under 'normal' flow conditions	Decline due to low flows							
		b)	c)	d)	e)	f)	g)	h)	i)
Game	**Headstream**								
	a) Trout, salmon	2	3	4	-	-	-	-	-
	b) Small trout only (+ loss of older year classes)	-	2	3	-	-	-	-	-
	c) Minor species only (loss of spawning habitat)	-	-	2	-	-	-	-	-
	d) Complete loss	-	-	-	-	-	-	-	-
	Lower reaches								
	e) Trout	2	3	4	-	1	2	3	4
Coarse	f) Barbel, chub, dace, perch, pike	-	3	4	-	-	1	2	3
	g) Small populations of species f) (+ loss of older year classes)	-	2	3	-	-	-	1	2
	h) Bream, perch, roach, tench	-	3	4	-	-	-	-	1
	i) Small populations of species h) (+ loss of older year classes)	-	2	3	-	-	-	-	-

Tidal Fisheries:

	Decline due to low flows		
	a	b	c
a) No reduction in Game or Coarse	-	2	4
b) Seasonal decline to euryhaline spp	-	-	2
c) Permanent decline to euryhaline sp	-	-	-

Access to migratory Fish:

	Decline due to low flows		
	a	b	c
a) No reduction	-	2	4
b) 20% reduction	-	-	2
c) 50% reduction	-	-	-

OR:

Short-term impact parameter	Score
No fishing was possible during a season due to low flows	4
No evidence of short-term impact of low flows on angling	0

Assign score: E2 =

ECOLOGICAL INDICATOR

NRA REGION: NAME OF STREAM: DATE:

(see Report Chapters 8.1 to 8.7 for full explanation of methodology)

E3 FISH STOCKS PARAMETER

Generate potential fish stock: Past fish stock (N) = [ ]

Select multipliers: CHAN.MODS.= [ ] CHANNEL MODIFICATIONS: Low = 1; Moderate = 0.9; High = 0.8
EFF.COMP. = [ ] EFFLUENT COMPONENT: Decrease = 1; No Change = 1; Increase = 0.8

Potential fisk stock (NP) = N x multipliers = [ ] Measured present fish stock (NM) = [ ]
Present/Potential Fish Stock (FSR%) = [ ]

Present/Potential	Decline related to low flows	Score
<40%	Serious decline	4
40-59%	Large decline	3
60-79%	Moderate decline	2
80-99%	Slight decline	1
>100%	None	0

Assign score: E3 =

E4 PLANT PARAMETER

Description of changes	Score
Bankside flora has changed or is changing due to a lower water table	4
Abnormal invasion of the river channel in summer by marginal terrestrial plants	2
No change, other than normal seasonal variation in channel or bankside flora	0

Assign score: E4 =

E5 CONSERVATION PARAMETER

Only use this parameter if there is direct evidence that low flows are a problem (i.e. from 2 of parameters H1,H2,H5,E1,E2,E3)

Formally designated sites:

Channel, riparian or other habitats depending on surface or groundwater for their character	
RAMSAR Sites, National Nature Reserves (NNRs), Marine Nature Reserves (MNRs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs), Habitat of species protected by EC Directive or Wildlife and Countryside Act	5
Conservation sites of regional or county importance (eg Naturalist Trust Reserve, RSPB Reserve)	4
Local nature reserve (including Heritage sites, C-sites, and Sites of historic interest)	3
No formal designation	0

Sites within the river system:

Instream and riparian habitat	Score
High conservation value, eg a diverse, natural and typical habitat of a viable size and containing species sensitive to disturbance. NWC class 1 stretch	3
Moderate conservation value, eg a smaller or less diverse site; or a site with natural or typical habitat but no particularly threatened species. NWC class 2 stretch	2
Site of minor conservation value. NWC class 3 stretch	1
Site of no conservation value. NWC class 4 stretch	0

Add scores from both tables and divide by 2 to give final E5 score. Assign score: E5 =

CALCULATION OF ECOLOGICAL INDICATOR

Parameter	Param.weight	Weight of params. used	Score	Weight x Score
E1	0.4			
E2	0.2			
E3	0.3			
E4	0.1			
E5	0.3			

SUM1 = [ ] (max.1) SUM2 = [ ]

Ecology Severity Index = SUM2/(SUM1x4) = [ ]

Ecology Reliability Index = SUM1 = [ ]

LANDSCAPE AND AMENITY INDICATOR

NRA REGION: **NAME OF STREAM:** **DATE:**

(see Report Chapters 9.1 to 9.6 for full explanation of methodology)

Note: Do not use L1,L2,L4 or L5 unless there is other firm evidence of low flows from at least 2 of parameters H1,H2,H5,E1,E2,E5

L1 LANDSCAPE DESIGNATION AND RARITY PARAMETER

For Landscape Designation:

Description	Score
Important in a national context, ie National Parks and Areas of Outstanding Natural Beauty	2
Important in a local context, ie Areas defined as Country Parks/Special Value etc. within local or structure plan context	1
Landscape has no official designation	0
An additional score may be awarded as follows:	
Areas which are undergoing environmental improvements (either national or local) and where finance exists to suport such improvements, ie landscapes within Development Corporation Areas, Local Initiative Areas	+1

For Landscape Rarity:

Description	Score
Where river/river corridor landscape is "the only" or "one of the best examples of..." in the national context	2
Where river/river corridor landscape is "the only" or "one of the best examples of..." in the local context	1
The river has no rarity value	0

Add scores to a maximum of 4. **Assign score: L1 =**

L2 IMPORTANCE OF THE RIVER AS A LANDSCAPE FEATURE AND ITS IMPACT ON ADJACENT LAND PARAMETER

For Importance:

Description	Score
High importance - dominant landscape feature, due to associated artifacts such as weirs, bridges etc.	3
Medium importance - only stretches of the river are visible, or the course is only noticeable because of bankside vegetation being visible	2
Low importance - the river is barely noticeable	1

For Impact:

Description	Score
Where a beneficial adjacent land use (within 500m) is primarily as a result of man's impact on, or management of, the river	-1
Where a degraded or unsightly adjacent land use is primarily as a result of man's impact on, or management of, the river, which could be remedied if remedial action were taken to the river	+1

Add scores to a range of 0-4 **Assign score: L2 =**

L3 RECREATION PARAMETER

Description (do not include fishing/angling)	Score
When 3 or more water-contact recreational activities were unable to take place sometime in each year during a 5 year period	4
3 or more water-contact recreational activities were unable to take place at any time in any one 12 month period	3
1 or 2 water-contact recreational activities were unable to take place at any time in any 12 month period	2
Any water-contact recreational activity was affected by low flows within the last 5 years. This also includes a reduction in enjoyment of a sport, resulting from low river flows	1
No change has been noted	0
If historical evidence exists, an additional score may be awarded where:	
The river was able to support a water-contact recreational activity within the past 25 years, but this activity is no longer possible due to lower river flows	+1

Add scores to a maximum of 4. **Assign score: L3 =**

LANDSCAPE AND AMENITY INDICATOR

NRA REGION: **NAME OF STREAM:** **DATE:**

(see Report Chapters 9.1 to 9.6 for full explanation of methodology)

Note: Do not use L1,L2,L4 or L5 unless there is other firm evidence of low flows from at least 2 of parameters H1,H2,H5,E1,E2,E5

L4 AMENITY PARAMETER

For Odour:

Description	Score
Strong odour at channel edge, eg sludge, sewage,chemical or farmyard wastes and noticeable at a distance of > 10m from the channel	2
Noticeable odour at the channel edge	1
No noticeable odour	0

For Visual Impairment at the river channel:

(Elements include unnatural water colour, farm wastes, foam, sewage, fungus, crude sewage, visible solids, rotting vegetation, and also where refuse and litter are exposed or if no water is present)

Description	Score
3 or more of the above elements which persist over a period of several months, as result of low flows, or 3 or more of the above elements which occur intermittently	3
1 to 3 of the above elements which persist over a period of several months, as result of low flows	2
2 of the elements which occur intermittently, as a result of low flows	1
No visual problem	0

For Visual Impairment on the river bank and adjacent land:

Description	Score
Where planning designation encourages public use	+1

Add scores to a maximum of 4. **Assign score: L4 =**

L5 HISTORICAL AND CULTURAL ASSOCIATIONS PARAMETER

Description	Score
Sites of national historical/archaeological interest, ie National Monuments, National Trust sites	4
Sites of regional historical/archaeological interest, generally within 500m	3
Sites which have national cultural associations such as paintings and literature, or local archaeological sites	2
Sites of local historical/archaeological, cultural or literary interest, such as place names	1
No historical or cultural associations	0

Assign score: L5 =

CALCULATION OF LANDSCAPE AND AMENITY INDICATOR

Parameter	Param.weight	Weight of params.used	Score	Weight x Score
L1	0.2			
L2	0.3			
L3	0.3			
L4	0.1			
L5	0.1			
		SUM1 =		SUM2 =

Landscape and Amenity Severity Index = SUM2/(SUM1x4) =

Landscape and Amenity Reliability Index = SUM1 =

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PUBLIC PERCEPTION INDICATOR

page 1 of 1

NRA REGION: NAME OF STREAM: DATE:

(see Report Chapters 10.1 to 10.3 for full explanation of methodology)

P1 PROXIMITY OF RIVER TO CENTRES OF POPULATION parameter

Description	Score
River flows through a large centre of population, ie a town	4
River flows through a small centre of population, ie a village	3
River flows within 1km of a town	2
River flows within 1km of a village	1

(If unsure of town/village distinction, use: Town = > 10,000 pop.)

Assign score: P1 =

P2 COMPLAINTS RECEIVED FROM THE PUBLIC parameter

Description	Score
Written complaints received from national organisations (e.g. English Nature, CLA, CPRE, Salmon & Trout Assoc. etc.) in support of local pressure groups formed specifically to deal with problems affecting the river and it's environment	4
Press coverage or written complaints received from national organisations or local clubs or pressure groups	3
A moderate number (> 5/annum on average) of written complaints received from individuals about problems related to low river flows over a period of years	2
Up to 5/annum on average written complaints received from individuals about problems related to low river flows over a period of years	1
No complaints received about problems related to low river flows	0

Assign score: P2 =

CALCULATION OF PUBLIC PERCEPTION INDICATOR

Parameter	Param.weight	Weight of params.used	Score	Weight x Score
P1	0.3			
P2	0.7			
		SUM1 =		SUM2 =

Public Perception Severity Index = SUM2/(SUM1x4) =

Public Perception Reliability Index = SUM1 =

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CALCULATION OF OVERALL INDICATORS

NRA REGION: NAME OF STREAM: DATE:

OVERALL SEVERITY INDEX (SI)

SI type	SI	Weight	Weighted SI
Hydrological SI		40.0%	
Ecological SI		30.0%	
Landscape and Amenity SI		20.0%	
Public Perception SI		10.0%	
		Total SI (SII) =	

OVERALL RELIABILITY INDEX (RI)

RI type	RI (orig.)	Weight	Weighted RI
Hydrological RI		40.0% *	
Ecological RI		35.0% *	
Landscape and Amenity RI		25.0% *	
		Total RI =	

** Use only a proportion of indicator weight if "judgemental scoring" has been carried out (see Report Chapter 11.2)*

POSSIBLE ACTION

SI	RI	Action
High	High	Put in Capital Programme for Alleviation
High	Low	Further studies required
Low	High	No action unless strong public pressure, in which case mount public relations campaign
Low	Low	No action unless strong public pressure, in which case initiate minimum cost further studies and mount public relations campaign

SIZE ADJUSTMENT

Length of watercourse affected (L) = ______ km

Catchment area to mid-point of length affected (CA) = ______ km2

Adjusted Severity Index (SIa) = SII x L^{13} x CA^{13} = ______

COST ADJUSTMENT

Benefit:

Increase in low flow resulting from alleviation scheme = ______ Ml/day

Benefit (or Value) = (approx.) ______ million

Cost:

Net Present Value of costs of alleviation scheme = ______ million

(discount rate = 5% over 30 years)

Benefit/Cost ratio = ______

Adjusted Severity Index (SIa) = ______

Total Severity Index (TSI), taking account of Benefit/Cost ratio = ______

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