Background Documentation - Guidelines for River Vegetation Maintenance

Annex of R&D Note 511

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R&D Project Record 536/1/ST

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National Rivers Authority

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RIVER VEGETATION MAINTENANCE GUIDELINES FOR DETERMINING BEST PRACTICE

BACKGROUND INFORMATION

1. INTRODUCTION

This report sets out the methodology employed in preparing guidelines for the incorporation of environmental criteria into the planning and appraisal of river vegetation management. This work was carried out under as Project 536 (Environmental Impact Assessment) under the umbrella of Project No. 317 - River Maintenance Evaluation, being undertaken for the National Rivers Authority (Severn Trent Region) by Silsoe College. Its aim is to provide the environmental basis for making decisions on the optimum method and timing of vegetation control on rivers which will integrate satisfactorily with operational demands and will maintain or enhance existing environmental interest.

2. OBJECTIVES

The objectives of this study are :

to assess the type and extent of potential short and long term impacts of river maintenance on the following environmental components:-

aquatic and bankside vegetation;
adjacent in-field natural vegetation;
aquatic invertebrates;
fisheries; and,
birds and Mammals.

The output was perceived as draft guidelines for the incorporation of environmental criteria into river maintenance planning and appraisal. This was to be in the form of a decision tree supported by tables and checklists and accompanied by a short report.

3. PROJECT APPROACH

The approach to developing the guidelines was to provide information for flood defence staff in a manner that:

1. is clear;
2. provides rule of thumb thresholds to use available knowledge to decide on the most sensitive methods of vegetation maintenance;
3. allows Flood Defence (FD) personnel to make the best general decision as to the optimum maintenance method but indicates when specialist help should be sought from other Functions;
4. is practical and can be introduced immediately; and,
5. is capable of modification over time to reflect appraisal of the techniques or additional biological knowledge.

The scope of the guidelines was to encompass in-channel and bankside vegetation management, excluding tree maintenance.

4. METHODOLOGY

A sequential approach was taken to developing the guidelines. This was as follows.

1. Identification of different river and bank categories which are subject to vegetation maintenance;
2. Identification of adjacent land categories which might be affected by vegetation maintenance or by changes in maintenance regime;
3. Assessment of the range of flora and fauna associated with different river/ bank / adjacent land categories;
4. For each environmental component, assessment of the detailed habitat requirements and other factors which might be affected by vegetation maintenance;
5. Definition of quality criteria for each environmental component;

6. Consideration of the range of management practices employed during vegetation maintenance;
7. Review of the most relevant literature relating to the potential impacts of channel and bank vegetation maintenance on each environmental component;
8. Assessment of impact of each potential maintenance option on each environmental component;
9. Identification of preferred maintenance practices; and,
10. Compilation of the guidelines.

By undertaking this sequential approach, it was possible to identify complementary and conflicting effects of the different management practices and thus allow informed judgements to be made as to the best practice. In the light of this, it was also possible to refine aspects of the process to make the guidelines easier to follow.

5. IDENTIFICATION OF RIVER, BANK AND FLOODPLAIN CATEGORIES AS A BASIS FOR ASSESSING IMPACT AND IDENTIFYING BEST PRACTICE

As the potential impacts of maintenance of vegetation in rivers, on banks and in the floodplain may be very variable, affecting different interests in different ways, they need to be assessed separately according to different criteria. Rivers, banks and adjacent floodplains were divided into a number of broad categories according to key characteristics as a first step to producing a usable and efficient set of guidelines to assist in determining the best environmental options for managing vegetation. These categories had to be easily recognised by eye, provide a good basis for deciding maintenance method over a short or long length and need no specialist biological knowledge (and so be usable by Flood Defence (FD) staff).

The different categories were also needed as the basis for devising management recommendations based on strong ecological grounds. These categories were used as the basis for all the best practice tables in the guidelines.

5.1. Rivers

The initial proposal was that rivers be divided into 16 categories based on width and gradient with all the background ecological information presented on this basis. Once the draft guidelines had been prepared however, it became apparent that a number of the best practices applied to more than one category and it proved possible to reduce the number of categories to eight to make the tables in the guidelines easier to use while still retaining sufficient detail to be scientifically acceptable. This is discussed further under 'Preparation of the Guidelines'.

Bed width is a critical factor of channel size which may constrain the options for sensitive maintenance open to the NRA on operational grounds. For example, it is improbable that it is acceptable to leave a substantial fringe of emergent plants on a main carrier drain with a bed width of 2 metres, possible to tolerate this in one 5 metres wide and virtually certain to be acceptable in a channel more than 10 m wide . This is highlighted in Figure 1 which shows the relative sizes of the channels in each category. The following bed width classes were used: < 2m, 2-5 m. 5-10 m and > 10 m.

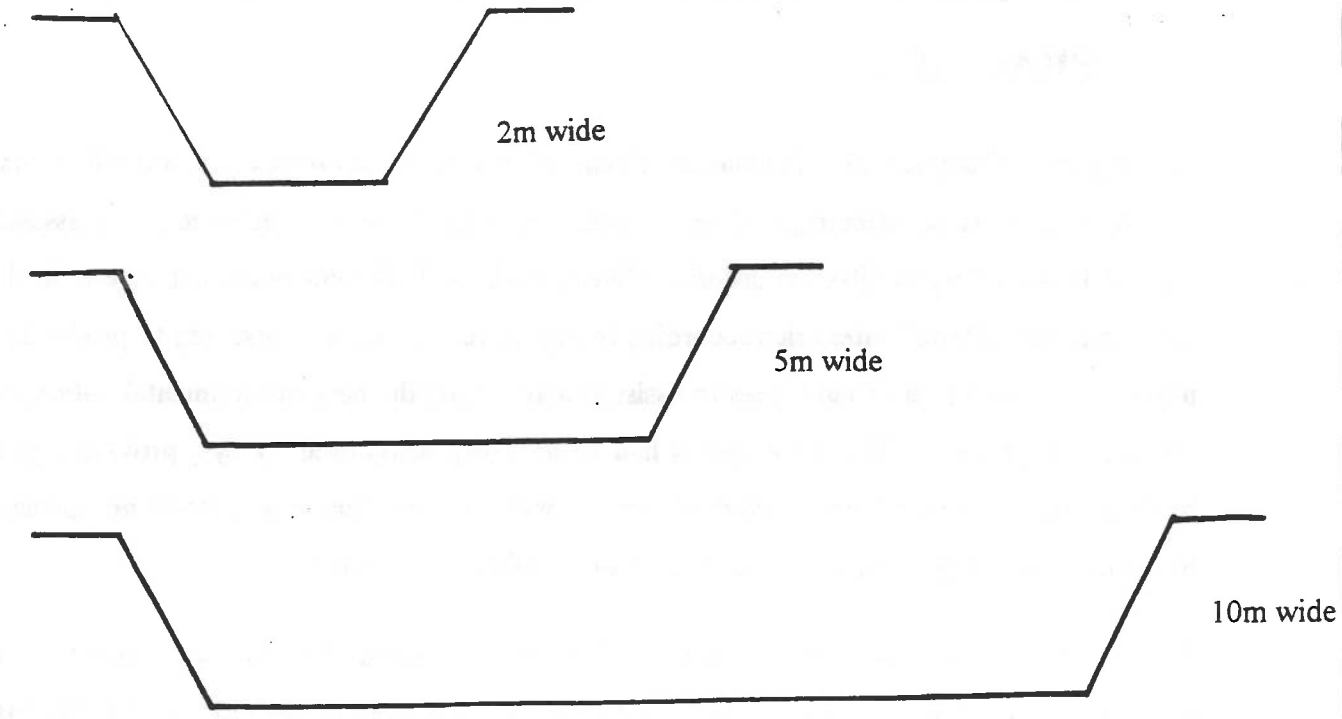


Figure 1: Diagrammatic representation of river width

Gradient was proposed as the second determinant as it influences both local flow velocity and substrate and is a readily measured variable capable of being used on a variety of scales. This is important in assessing the potential extent of vegetation control. The mean gradients for each of the study rivers are given in Table 1. If this is compared with Table 2 (prepared as a working document) the attributes of the study rivers taken from the river corridor surveys, it can be seen that the steepest rivers (Rivers Yarty and Arrow) contain, as expected, the coarsest substrates and the widest range of velocity-related instream habitats whereas the Dysynni Low Level Drain and the Woldgrift Drain have a predominantly silt bed with slack water. Vegetation cover reflects this, being least in the first two rivers and greatest in the last two. Gradient therefore appeared to be a suitable determinant to divide rivers to allow the impacts of vegetation control to be assessed and determine best practice. Four gradient classes were used: > 0.2 %, 0.07 - 0.2 %, 0.03 - 0.07 %, < 0.03 %.

Table 1: Gradients of the study rivers

River	Gradient
Dysynni Low Level Drain	Nil- tidelocked
Woldgrift Drain (lower)	Nil- tidelocked
Dreneuydd/ Broadway Reen (lower)	1:7500
River Wampool	1:3500
Broadfleet/Pilling Water	1:3150
Dreneuydd/ Broadway Reen (whole)	1:2500
Dreneuydd/ Broadway Reen (upper)	1:1875
River Wensum	1:1400
Sir Arthur's Pill	1:975
River Sence	1:625
River Yare	1:600
Woldgrift Drain (upper)	1:575
Hilton Brook	1:475
River Arrow	1:475
River Yarty	1:250

Four width and four gradient classes gave a total of 16 river categories which are shown in Table 3 with examples of a number of rivers in each category. These were taken from two sources, firstly the 'study rivers' and secondly from a data base held by Dr Holmes and known to have vegetation maintenance requirements .

The 16 river categories were used as the basis for determining the potential impacts of vegetation control and to provide a ready method for FD staff to identify best practice. To assist them, a photomontage of examples of rivers in each category is included within the guidelines.

The River Habitat Survey (RHS) system is also developing a river typology but this is covering the whole range of rivers from torrential mountain streams to lowland ditches and navigable rivers. It is not yet capable of establishing a river classification which would enable FD staff to determine the vegetation management required as best practice. In the near future, the two systems should be appraised so that the methodology presented here fits into selected national typologies.

Table 2: Attributes of the study rivers taken from river corridor surveys.

	Silsoe Trial Rivers																				
	Width (m)			substrates						Flow types				% Veg Cover							
	<2	2_5	5_10	>10m	bedrock Boulder	cobble Pebble	gravel	silt (sand)	clay	pool	slack	riffle	run rapid	emergent	subm	float					LENGTH
	RIVER YARTY																				
1		80	15	5		100				1	64	10	25		0.5						0.5
2		100				100				2	38	10	50		2						0.5
3		100				100				1	29	10	60	0.9	0.1						0.5
4		100				50	50			1	73	5	21	0.5							0.5
5		10	90			50	50			2	57	3	38	1.8	0.2						0.5
6		90	10			100				1	70	5	24	1.5	1.5						0.5
7		100				60	40				80		20	1.5	1.5						0.5
8		60	40			100					66	2	32	1	3						0.5
9		50	50				100			1	75	5	19	0.5							0.5
10		30	70			100					65		35	2	3						0.5
	RIVER ARROW																				
1		100			23		70			2	5	2	91	14	2						0.75
2		100			5	20	70	5		2	20	2	76		0.5						1.75km
3		60	40			8	90	2			2		98	1.8	0.2						1.0km
4		50	50				98	2		1			99	5							1.0km
5		50	50			10	90			1	98		5	2							1.0km
6		90	10				100			1	94		5	2							1.0km
7		90	10			100				1	89		10	1							1.0km
8		20	80			100					80		20	0.5							?

Table 2 cont.

Silsoe Trial Rivers

	Width (m)				substrates					Flow types				% Veg Cover		
	<2	2_5	5_10	>10m	bedrock / Boulder	cobble / Pebble	gravel	silt (sand)	clay	pool	slack	riffle	run / rapid	emergent	subm	float	LENGTH
RIVER YARTY																	
1		80	15	5		100				1	64	10	25		0.5		0.5
2		100				100				2	38	10	50		2		0.5
3		100				100				1	29	10	60	0.9	0.1		0.5
4		100				50	50			1	73	5	21	0.5			0.5
5		10	90			50	50			2	57	3	38	1.8	0.2		0.5
6		90	10			100				1	70	5	24	1.5	1.5		0.5
7		100				60	40				80		20	1.5	1.5		0.5
8		60	40			100					66	2	32	1	3		0.5
9		50	50				100			1	75	5	19	0.5			0.5
10		30	70			100					65		35	2	3		0.5
RIVER ARROW																	
1		100			23		70			2	5	2	91	14	2		0.75
2		100			5	20	70	5		2	20	2	76		0.5		1.75km
3		60	40			8	90	2			2		98	1.8	0.2		1.0km
4		50	50				98	2		1			99	5			1.0km
5		50	50			10	90			1	98		5	2			1.0km
6			90	10			100			1	94		5	2			1.0km
7			90	10		100				1	89		10	1			1.0km
8		20	80			100					80		20	0.5			?

Table 2 cont.

	Width (m)			substrates				Flow types				% Veg Cover		
	<2	2_5	5_10	>10m	bedrock Boulder	cobble Pebble	gravel	silt (sand)	clay	pool	slack	riffle	run rapid	emergent	subm	float	LENGTH
					WOLDGRIFT												
	100						2	98			100			40			0.5
	100							100			100			20			0.5
	100							100			100			19	1		0.5
	100						10	90			95	5		5			0.5
	100					5	5	90			98	2		3	10	2	0.5
	100							100			90	10		12	4	4	0.5
	100						10	90			100			15			0.5
	100						2	98			100			35	15		0.5
	100							100			100			32	6	2	0.5
	100							100			100			33	2		0.5
	100							100			100			37	3		0.5
	100							100			100			9	10	1	0.5
					DYSYNNI												
1		100						100			100			30	50		0.5
2		100						100			100			17	13		0.5
3		100						100			100			16	14		0.5
4		100						100		1	99			27	3		0.5
5		100						100			100			70	5		0.5
6		100						100			100			75	15		0.5
7		80	20					100			100			40			0.5
8	100							100			100			65	15		0.5
9		100						100			100			20	30		0.5
10		100						100			100			50	20		0.5
11		100						100			100			18	22		0.5

Table 3: Categories of rivers for aquatic vegetation management

Width	Gradient	Category	Examples
< 2 m	> 0.2%	1	*Braunton* Winterbournes - 1st order, clays - Cefni, Ffraw, Leam
< 2 m	0.07 - 0.2%	2	*Woldgrift (u),* Floodplain streams - Highland carriers to pumped systems
< 2 m	0.03 - 0.07%	3	1st/2nd order streams/ditches on floodplains
< 2 m	negligible/tidelocked/ pumped <0.07%	4	*Woldgrift (l), Dysynni,* 1st/2nd order ditches on floodplains and grazing marshes - Pevensey, Broadland, Ouse Washes, Somerset Levels, Gwent Levels
2 - < 5 m	> 0.2%	5	*Sence, Yarty* Winterbournes (Upper Lambourne, Chitterne, Ebble), Chalk and soft limestone (Windrush, Coln, Piddle, Churn, Wissey), upper clay rivers(Blythe, Leam, Teise).
2 - < 5 m	0.07 - 0.2%	6	*Woldgrift (u), Dreneuydd (u), Sir Arthur's Pill, Sence* Chalk and soft limestone (Moors, upper Nar, Hull, Coln, Windrush), Clay (Blythe, Eye, Rother (E&W. Sussex), Stour (Devon) , Wiltshire Avon, Teise
2 - < 5 m	0.03 - 0.07%	7	Chalk (Mimram, Ver, Hull, Nar), Clay (Beult, 2nd order ditches and rivers on floodplains and washes)
2 - < 5 m	negligible/tidelocked/ pumped <0.07%	8	*Dysynni, Woldgrift, Dreneuydd, Pilling.* 2nd/3rd order ditches and rivers on floodplains and washes and pumped systems)
5 - < 10 m	> 0.2%	9	*Yare, Hilton Br., Yarty, Arrow* Chalk (Lambourne, Bourne)
5 - < 10 m	0.07 - 0.2%	10	*Wensum, Yare* Chalk (Kennet, Moors, Piddle, Thaw, Wensum, Wissey) Clay/Alluvium (Blythe, Devon, Deben, Leam, Loddon, West Sussex Rother, Welland
5 - < 10 m	0.03 - 0.07%	11	2nd/3rd order drainage ditches on plains. Clay /alluvium (Beult, Wreake, Devon, Stour, Tame)
5 - < 10 m	negligible/tidelocked/ pumped <0.07%	12	*Dreneuydd (l), Wampool* Lower Glen, Lower Hull, Waveney and lower reaches of rivers with long lengths on coastal plains. 3rd order main pumped drains.
10 + m	> 0.2%	13	
10 + m	0.07 - 0.2%	14	Chalk (Avon, Test, Itchen, Frome, Kennet) Limestone Dove, Eden, Windrush
10 + m	0.03 - 0.07%	15	*Wensum* Clay/ alluvium coastal plains - main drains. Lodden, Yare, Waveney, Welland, Cary
10 + m	negligible/tidelocked/ pumped <0.07%	16	Lower navigable Thames, Great Ouse, Cary, Nene, Wissey, Welland, Waveney, Bure, Thurne

NB: Those in italics are study rivers, those in plain form are examples taken across England and Wales. (*u*) = upper, (*l*) = lower

5.2 Bankside

River width is a one attribute to be used to define the bank categories. Vegetation on the bank will affect riverine biota in different ways depending on what proportion of the channel is

overhung or shaded by different forms of vegetation and the maintenance requirements will therefore vary. The second determinant is vegetation structure, because the assemblages of invertebrates and the bird communities are strongly influenced by this. To try to minimise differences between assessment systems, the structure categories used for the River Habitat Survey were used. These are uniform (predominantly 1 vegetation type, lacking trees or scrub - e.g. mown banks), simple (predominantly 2-3 vegetation types with or without trees or scrub - e.g. trees with a short herb understorey) or complex (4 or more vegetation types - e.g. a varied bank containing bare earth, mosses, short and tall herbs and grasses, scrub and trees and saplings) Diagrams of these structures are given in Figure 2.

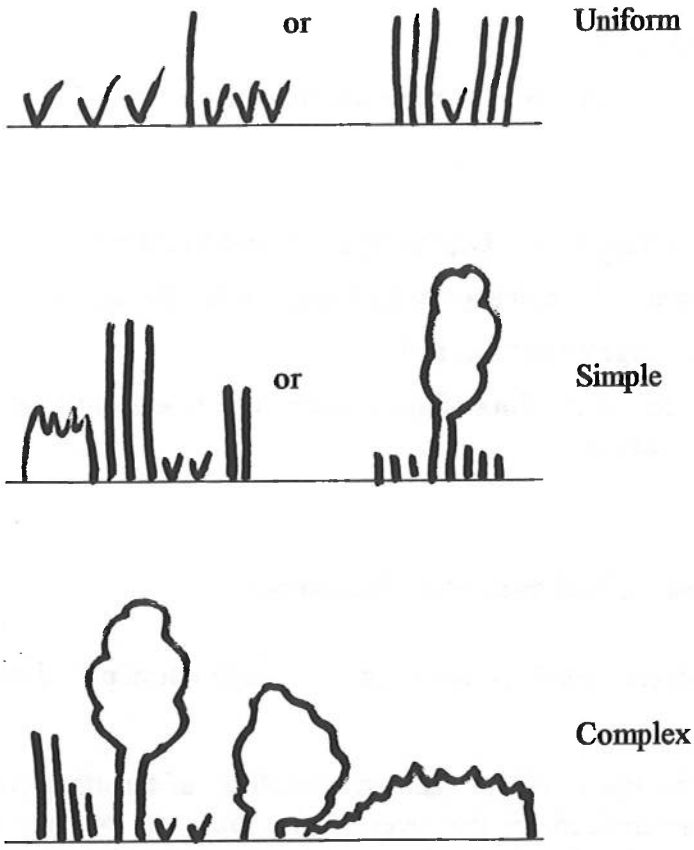


Figure 2: Schematic representation of uniform, simple and complex vegetation structure

Table 4: Categories of banks

Width	Vegetation Structure	Category
< 2 m	Uniform	A
< 2 m	Simple	B
< 2 m	Complex	C
2 - < 5 m	Uniform	D
2 - < 5 m	Simple	E
2 - < 5 m	Complex	F
5 - < 10 m	Uniform	G
5 - < 10 m	Simple	H
5 - < 10 m	Complex	I
10 + m	Uniform	J
10 + m	Simple	K
10 + m	Complex	L

As with the river classification, a photomontage has been included within the guidelines to assist staff in determining the correct category of the bank.

5.3 Adjacent Land

There are four steps involved in considering the implications of maintenance and considering best practice:

1. determine whether there is a "flood plain" and its extent;
2. identify what is determining the hydrology of the flood plain;
3. identify the vegetation type; and,
4. consider whether the flora of the adjacent land is an important consideration apropos river maintenance.

The flood plain was defined as an area which either:

a) is inundated with flood water on an average return period of <2 years,

or

b) is within 100 m of the main river itself or of a surface-water feature where water level is determined by the river (e.g. tributaries, backwaters or water-filled ditch networks discharging to the river) and has a surface elevation not more than 1 m above the mean annual maximum river level.

Under these criteria a river which, in an average year, never rises to within a metre of the surrounding land would be deemed not to have a flood plain. No further consideration was given to land in this category as it is highly unlikely that a change in river channel or bank vegetation maintenance would affect the surrounding land in the short term. The river would probably require re-engineering to enhance the environmental quality of wetland vegetation growing on adjacent land.

Vegetation and hydrology were deemed to be the features most useful in identifying categories as a basis for assessing the impact of vegetation management. Vegetation classes were as follows:

1. Arable covers all tilled land. For the purposes of the current study, it is assumed that areas of arable cultivation are not of relevance to the floristic interest of river flood plains. This is not always the case. Hedges and ditch margins may well provide refugia for wetland species of conservation interest, but because the hydrological management of the area will be predominantly determined by the needs of the agricultural crop, the requirements of any relict vegetation will not be considered here. An exception would be where there is interest in the re-creation of semi-natural habitats - in these special instances the land should be classified into the category of the 'desired' rather than the 'actual' vegetation type.

2. Woodland includes scrub communities.

3. Swamp and aquatics include areas of open water, reedbed, fen, bog and marsh.

4. Grassland includes all meadows and pastures from rough grazing to short-term ley and non-agricultural grasslands.

Hydrological classes were as follows:

A Open or surface water features (e.g. ponds, cut-offs, backwaters and drainage ditches) or areas which are covered in water for much of the year (e.g. swamp, marsh and reedbed).

B Areas which are either flooded on a regular basis or where high watertables are maintained by seepage from water bodies but where surface water rarely persists for prolonged periods.

C Areas which are inundated by winter floods on rare occasions, or which flood only after heavy rain due to soils with impeded drainage.

D Well-drained areas not liable to flooding.

Types C and D may well have semi-natural vegetation of conservation importance (such as the traditional old hay meadows, MG5). However, routine river maintenance procedures are unlikely to affect the hydrology or vegetation of these areas directly, and therefore they do not have a bearing on the decision-making process.

The following table, Table 5, identifies those combinations of vegetation and hydrology which may be important when considering the impact of river maintenance.

Table 5: Categories of adjacent land

Vegetation	Hydrology			
	Open/surface water (A)	Regular flooding/ high watertables (B)	Winter flood or post storm flood (C)	Well drained (D)
Arable (1)	-	-	-	-
Woodland (2)	I	II	-	-
Swamp and Aquatics (3)	III	IV	-	-
Grassland (4)	-	V	-	-

Within Table 5 only five adjacent land use categories of relevance to the project were identified. These are given in Roman numerals I - V for the purposes of identifying each specific type during further assessment (see the section on Adjacent Land in Appendix F). Where a dash is given, then this category is not believed to be sensitive to river vegetation maintenance practices and is not considered further. It is likely that along a reach, there will be a number of different land categories. In this case, the quality indicators should be considered for each category.

Once the preliminary assessment of the potential impacts of the river maintenance practices had been considered, it proved possible to reduce these five categories to three, by simply considering grasslands, woodland and aquatics/ swamps. This was deemed to be more suitable in terms of the usability of the guidelines.

6. ASSESSMENT OF THE RANGE OF FLORA AND FAUNA ASSOCIATED WITH DIFFERENT RIVER, BANK AND ADJACENT LAND CATEGORIES

The next stage was to identify which flora and fauna might be expected to occur in each of the river, bank and adjacent land categories already described. This was problematic for some groups because habitat requirements are poorly researched and it is also difficult in a number of instances to differentiate between what might occur infrequently in a particular category and what might reasonably be expected to use that category regularly. A further problem in the case of fish is the widespread introductions of species outside their natural range. Associations of the environmental components with bank and river categories are given in the individual texts for each environmental component in Appendix I, together with explanation of the methods followed to construct the associations. Associations for the river categories only are given for aquatic plants, aquatic invertebrates and fish.

7. ASSESSMENT OF DETAILED HABITAT REQUIREMENTS AND OTHER FACTORS WHICH MIGHT BE AFFECTED BY VEGETATION MAINTENANCE

To provide a basis for the overall assessment of the potential impacts of vegetation maintenance on each environmental component, detailed habitat requirements and other factors which might be affected by vegetation maintenance were identified and are tabulated in the individual texts in Appendix G. This proved to be extremely difficult for invertebrates where

only a small proportion could be considered in any detail. In contrast, very detailed information could be presented for aquatic plants.

8. DEFINITION OF THE CRITERIA FOR QUALITY FOR EACH ENVIRONMENTAL COMPONENT

To identify 'best practice', it is important to establish the wildlife quality of the river channel or bank. This was then used as a determinant as to whether use of a particular maintenance technique is appropriate for the channel or bank category concerned. A system to identify high, medium and low quality for each river/bank /in field category was devised and is presented in detail in the texts for each environmental component in Appendix I, together with the methodology used to derive it. This required a two step process. The first was the process of identifying the thresholds of quality on ecological grounds and the second, based on the first, was the production of information that is useful to FD staff to assess quality. To ensure that the guidelines are user-friendly, only the second is presented within them as the basis for decision making.

Although attempts were made in all cases to provide a quantitative basis for the judgements, this proved unsatisfactory in the case of fish and invertebrates where population sizes and numbers of naturally-occurring species are not available. In contrast, it was possible to quantitatively derive levels of quality using national population data for birds and for aquatic plants using distribution data. Attempts were made to base the quality criteria on existing systems where possible and the last two included elements from SERCON (System for Evaluating Rivers for CONservation) particularly numbers of species occurring in specific lengths and identification of the rarer species.

FD staff need to be able to apply these quality ratings developed by the project. The environmental data from the 12 study rivers highlight potential problems in their direct application. First, in most instances there are few actual data on plants or fauna from which to generate a site-specific quality rating. For example fish data do not exist for the Rivers Wampool, Arrow, Yarty, Sence and Pilling Water. It was therefore necessary to provide an easy method of identifying the potential quality without specific information. Second, in some

instances data do exist and are held by Fisheries, Recreation, Conservation and Navigation staff, who are needed to interpret and apply them. This conflicts with a prime objective of this R &D project which was to enable FD staff to largely make their own best judgements based on assessments made by themselves from field observations.

These difficulties have been overcome as follows. Assessment of wildlife quality is to be undertaken by FD staff using a photo-library which will show river, bank and in-field character illustrating high, medium and low quality chosen on the basis of the assessments given above. Following application of the quality criteria, it is envisaged that a certain percentage (possibly around 10 %) of river/bank/in-field habitats will be identified as being worthy of referral to FRCN staff for further guidance. For the future, it is suggested that where river corridor surveys or river habitat surveys are undertaken on maintained rivers, it might be possible for quality to be determined and the information fed to FD staff.

It was additionally necessary to identify species that are of particular conservation note requiring further consultation with FRCN staff. These may be Red Data Book species or protected species. It was not possible to devise a system to ensure that FD staff would know in every case when consultation was essential and when it was not. Where possible, guidance is given, but it is recommended that FRCN generate site-specific guidance.

All river/ bank and in-field categories will have some features that need to be retained to safeguard the best quality and improve the status of the rest. Using the photo-library compiled following the identification of quality criteria, it has been possible to draw certain points to the attention of FD staff.

9. REVIEW OF THE POTENTIAL IMPACTS OF CHANNEL AND BANK VEGETATION MAINTENANCE ON EACH ENVIRONMENTAL COMPONENT

For each environmental component, a basic literature review was carried out to ascertain the potential impacts of different types of maintenance. In a number of cases this was hampered by lack of relevant information and in others by studies which showed no conclusive results. The inconclusive nature of the review meant that the experience of the project team was important when considering the impact of the different forms of maintenance on each wildlife component.

10. CONSIDERATION OF THE RANGE OF MAINTENANCE PRACTICES EMPLOYED DURING VEGETATION MAINTENANCE

The range of maintenance options that were assessed for their potential impact on each environmental component was based on those given in the Lower Trent Flood Defence Maintenance Programme 1995/96 and the Review of Existing Practices for Fluvial Maintenance Operations Throughout the NRA (R&D Note 14). This allowed wider consideration of best practice than if those used by Severn-Trent Region of the NRA alone were used. All the techniques considered have been satisfactorily used in the field and this ensures that FD staff will be prepared to consider them all when ascertaining the most suitable means of vegetation maintenance. Attention to the scale of the maintenance operations was also important and for each technique, a range of options was assessed. These were chosen to reflect the likely ability of the maintenance operative to control the extent of work. Thus 90 % reflects leaving a narrow fringe, 60 - 90 % 'taking most out', 30 - 60 % 'taking about half', 10 - 30 %, 'leaving most' and 10 % 'just taking a bit'. Table 6 and 7 show the range of techniques considered.

Table 6: Techniques identified for assessment aquatic plants

Technique	Frequency	Extent
Cutting	Annual - Spring Annual - Summer/ Autumn Multiple annual - spring and summer Multiple annual - summer and autumn Biennial 3 - 5 year rotation *	For all options: whole channel cleared 90 % cleared 60 - 90 % cleared 30 - 60 % cleared 10 - 30 % cleared Selective clearance
Desilting/raking	2 - 7 year cycle*	
Herbicide		Selective

NB: * any operation on a longer rotation is considered a 'one-off' or emergency operation. FRCN must be consulted if there is not a repeat operation within the time scales given. The establishment of shade to reduce vegetation growth is excluded as it is a one-off rather than routine management practice which has long-term implications for landowners but which should be considered. Nutrient stripping needs a strategic approach via catchment management and is thus not considered further.

Table 7: Techniques identified for assessment for bankside vegetation

Technique	Frequency	Extent
Grass cutting	Stop cutting Multiple annual cutting Annual cutting - spring or summer Annual cutting - autumn Biennial cutting - spring or summer Biennial cutting - autumn	For all options: Uncut strip permanently left at top of bank Uncut strip permanently left at bottom of bank Uncut strip periodically left at top of bank Uncut strip periodically left at bottom of bank Selective cutting Whole bank cut both sides Whole bank cut one side
Herbicide		Selective *
Grazing	Heavy	
	Light	
Bank flailing	3 - 5 year rotation+	

NB: * for invasive plants and aliens.
Total herbiciding is unacceptable in any situation and was therefore excluded. Tree trimming and the establishment of shade to reduce vegetation growth were excluded from further consideration as they were one-off management rather than routine maintenance. + any operation on a longer rotation is considered a 'one-off' or emergency operation. FRCN must be consulted if there is not a repeat operation within the time scales given.

11. ASSESSMENT OF IMPACT OF EACH TYPE OF MAINTENANCE ON EACH ENVIRONMENTAL COMPONENT

The range of maintenance options identified in Section 10 was assessed to ascertain the effect on each environmental component. For practical development this had to assume that the maintenance reach of the river was of moderate quality for each component at the start of the maintenance operations (except where the size of the river dictated that it could only be low). The likely quality of the river for each component after maintenance for each scenario was then predicted. The effects of each option over different periods of time was addressed by the different timescales of some operations, e.g. annually, biennially or every 2 - 5 years.

General considerations within the predictions of likely quality included the implications for the ecology of the river of potential changes in the hydraulic and sediment conditions, the opportunity to reduce maintenance needs to create a more self-cleansing channel, the potential of changed practices to affect 'Standards of Service' and thus adjacent in-field vegetation, and the problems of changing maintenance practice for controlling what may be an unstable plant community due to past practice.

In all cases, limitations of data and/or knowledge will make these good qualitative assessments but poor quantitative ones. It is not believed that this is a problem when management of the majority of rivers is being considered since it still represents a considerable improvement on the current assessment methods.

12. IDENTIFICATION OF PREFERRED MAINTENANCE PRACTICES

Once the impact of each maintenance option on all the environmental components had been assessed, the responses were collated to provide an overall indication of likely impact. This was undertaken by allotting a scoring system to each level of quality and summing the predicted responses. Thresholds were then allotted to provide a measure as to which practice was the best, acceptable, poor and unacceptable. These assessments are qualitative and are

only based on physical management, taking no account of the effects of other factors such as water pollution. The reasoning behind this is that, whatever other factors are operating, best practice management should improve the wildlife value of a watercourse.

There are some difficulties with using a combined scoring system. For example, a technique that greatly benefits the aquatic plant diversity may be deleterious to the bird assemblages in some situations. However, in most cases, what was good for one group was good for others, the tendency being for increased plant diversity and structural complexity to improve conditions for all faunal groups. Individual assessments for each wildlife group are given in Appendix II and can be checked where the interest of a group is deemed to be high or if otherwise desired.

However, one major anomaly has occurred as a result of following the project brief and involves the consideration of only aquatic invertebrates rather than all invertebrates. Shading is broadly deleterious to aquatic invertebrates but tall vegetation is of benefit to a wider range of terrestrial and semi-aquatic invertebrates. Accordingly, vegetation management that led to shading of channels (for example leaving wide top strips and toes on banks) generally ranks lower than might be expected although it is believed that overall it is beneficial for wildlife. A number of other anomalies arose and these have largely been eliminated using best judgement to provide a standardised system of best practice.

13. COMPILATION OF THE GUIDELINES

A draft set of guidelines was produced. However, it was universally agreed that they should be simplified to maximise their use and increase the confidence of the FD staff who will use them. Accordingly, a number of changes were made to the proposed layout. These included:

1. Reduction in the number of categories of river and bank types;
2. Identification of only the most important adjacent land categories;
3. Removal of the 'assessment of need' tables;
4. Quality criteria to be represented within the guidelines pictorially and the text to be included in the appendix only;
5. The assessment of the effects of each maintenance option on different taxa to be moved from the guidelines to the supporting documentation; and,

6. Best practice photographs to be included in the guidelines.

The guidelines were formulated to take account of operational needs and were designed to be technically simple. If followed, they will enable FD staff to make decisions in the knowledge of their implications for wildlife and this will lead to improved conditions for wildlife across the range of rivers which require vegetation management.

The simplicity and ease of use of the guidelines means that they do not cover all eventualities. However, it is believed that the great majority of cases will be adequately served by their use. There are two likely exceptions. One is where the conservation interest is so high that best practice has to be extended to take account of special needs and Conservation staff will have to be consulted. The other is where the operational needs are paramount (e.g. high conveyance is required) and the wildlife interest has to be secondary in view of safety considerations. Efforts have been made to highlight these in the guidelines. In this way, the guidelines will allow all NRA functions to have an input into determining the best practice for exceptional stretches of river, but allows FD staff to determine routine maintenance practices in the vast majority of situations.

The guidelines start from the premise that best practice will seek to maintain or enhance high quality habitats. All others should be enhanced. It is therefore necessary to identify the quality of the habitat in the reach to be managed. By using a photo-library, the guidelines therefore provide a rapid method of assessment for a number of wildlife groups.

13.1 What The Guidelines Do Not Cover

One area which is not explored in these guidelines is the potential for improved cost-effective and environmentally sustainable vegetation maintenance on a catchment basis. This would allow, for example, a system of tree planting to be established as a means of reducing aquatic growth in such a way as to maximise the wildlife value or some areas of floodbanks to be mown less frequently where safety standards were not jeopardised. Management in this way would need to be explored by a number of Functions. The catchment planning process should be used for this approach.

A further area not explored by the guidelines is the re-engineering of managed channels to raise stage levels and under some circumstances potentially reduce or abandon the requirement for vegetation maintenance. Implicit in these guidelines is the desirability of minimising the requirements for long-term maintenance by aiming for self-cleansing channels.

13.2 Implementation

The guidelines are capable of being introduced immediately as current best practice and modified gradually as the impacts of different regimes are assessed.

14 APPRAISAL

To enable this methodology to be assessed and refined, a method of appraising the benefits and disbenefits is required. It will be possible to use the system of quality criteria developed for this project as a means of assessing the impacts of maintenance operations on each environmental component. If assessment is undertaken annually, it should be possible to build up a good indication as to the long-term effects of different methods of vegetation maintenance.

15 FUTURE RESEARCH AND MONITORING

1. In areas of notable conservation interest or where there is high restoration potential, water level management plans need to be produced (MAFF, 1994). To be formulated effectively, these demand quantitative estimates of water-regime requirements. Research experience suggests that these are best estimated from an analysis of the distribution of existing vegetation stands and quantified in terms of tolerance to stress (Gowing et al. 1993). The aim of the research should be to derive tolerance limits for species or communities which are transferable between sites.

2. "Best-practice" examples of river management should be implemented and monitored as demonstration models to practitioners.

This should ideally be on a reach with some high quality wetland/wet grassland habitats, water features such as standing water, ditches in the flood plain and permeable soils. The effect of

the maintenance regime on the surrounding habitats could then be monitored. A hydrological model of the system would need to be devised to extrapolate the results to allow normal climatic variations to be considered (Gilman, 1994).

Monitoring effort would be focused mainly on the hydrological regime. Changes to botanical composition often have a significant lag period and only long-term effects are detectable. Hydrology can be studied directly using river stage level records and dipwell transects in the adjacent land, the results of which would be used to develop and validate a hydrological model. This approach could also be used routinely as part of the post-project appraisal process. Results from this could be related to the recently completed Wetland Resource.

3. Long-term monitoring of the effects of different vegetation maintenance on different environmental components. Some effects occur very quickly, e.g. loss of nesting cover for birds, while others will take longer. It is possible to identify a suite of watercourses incorporating the eight river types with moderate wildlife value and run different maintenance regimes on them. Changes in the quality of the wildlife assemblages in response to different practices could then be evaluated over time and the justifications for changing existing practices evaluated in wildlife terms and, if desired, against economic and technical criteria.

Additionally, the hydraulic effects of changes from less desirable practices to acceptable and best practice can be monitored.

16. IDENTIFICATION OF POSSIBLE 'BEST PRACTICE' MANAGEMENT METHODS FOR THE STUDY RIVERS

Following the draft guidelines the likely 'best practice' vegetation management methods were determined for the study rivers. Photographs were used in place of site visits as the source of information. This proved problematic for a number of reasons:

1. It was difficult to identify the gradient of the river in some photographs;

2. The range of photographs available for some rivers showed very different bank and channel forms and river bed widths and it therefore proved difficult to categorise the channel and banks;

3. Some photographs had been taken at a time of year when it would have been difficult to see aquatic vegetation; and,

4. It was also not possible to make an assessment of the quality of the adjacent land from the photographs.

Photographs taken at an appropriate time of year and along defined reaches would have obviated most difficulties. In order to overcome these problems, generalisations about the gradient and bank and channel forms were made and it was assumed that the adjacent land was not of high interest.

Channel and bank categories were determined together with their quality and this information is presented in Table 8. From this, the best practices for bank and channel vegetation management were identified and are given in Table 9 and 10. Although in some cases a wider range of best practice options was available, those management practices listed represent the very best options on environmental grounds. They should however be assessed against the option of 'do nothing'. The final choice of option is likely to depend on other considerations such as hydraulics, cost effectiveness, manpower , machinery availability etc.

Table 8: Channel category and quality assessment of each study river

River	Channel category	Channel quality	Bank category	Bank quality
Dysynni Low Level Drain	2	M	A	M
Woldgrift Drain (lower)	2	L	A	L
Woldgrift Drain (upper)	1	M	B	M
Dreneuydd/ Broadway Reen	4	M	E	M
River Wampool	6	L	G	L
Broadfleet/Pilling Water	4	L	D	L
River Wensum	8	H	K/L	M/H
Sir Arthur's Pill	1	L	A	L
River Sence	3	L	E	L
River Yare	5	M	H	M
Hilton Brook	5	M	H	M
River Arrow	5	M	I	M
River Yarty	5	M	H	H

Table 9: Best practice for bank vegetation management

River	Best practice options for bank vegetation management
Dysynni Low Level Drain, Woldgrift Drain, Sir Arthur's Pill, Broadfleet/ Pilling Water	Light grazing
Dreneuydd/ Broadway Reen, River Sence, River Wampool	Single annual mowing/flailing in autumn /winter leaving a toe strip 1m+, Light grazing
River Yare, River Yarty, Hilton Brook	Single bank mowing/flailing in spring /summer leaving a toe strip 1m wide Single bank mowing/flailing in autumn /winter leaving a toe strip >0.25m Mowing/flailing every 3 - 5 years either leaving a toe strip 1m+ or selective cutting (< 20 %) Light grazing
River Arrow	Mowing/flailing every 3 - 5 years either leaving a toe strip 1m+ or selective cutting (< 20 %), Light grazing
River Wensum	Single bank mowing/flailing in spring /summer leaving a toe strip 1m wide, Single bank mowing/flailing in autumn /winter leaving a toe strip >0.25 m Mowing/flailing every 3 - 5 years either leaving a toe strip 1m+ or selective cutting (< 20 %), Light grazing

Table 10: Best practice for channel vegetation management

River	Best practice options for emergent vegetation management	Best practice options for floating and submerged vegetation management
Woldgrift Drain (upper), Sir Arthur's Pill	Annual cutting autumn - selective Biennial cutting - selective, cutting 3-5 yr rotation - selective	Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective
Dysynni Low Level Drain Woldgrift Drain (lower)	Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective	Biennial cutting - 10 - 30% Biennial cutting - selective Cutting 3-5 yr rotation - 10 - 30% Cutting 3-5 yr rotation - selective
River Sence	Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective	Biennial cutting - selective Cutting 3-5 yr rotation - 10 - 30% Cutting 3-5 yr rotation - selective
Dreneuydd/ Broadway Reen Broadfleet/Pilling Water	Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective	Annual cutting autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective
River Yare Hilton Brook River Arrow River Yarty	Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective	Annual cutting autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective
River Wampool	Annual cutting autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective	Multiple annual cutting summer/autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective Desilting/raking on a 2 - 7 year cycle - selective
River Wensum	Annual cutting autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective	Multiple annual cutting summer/autumn - selective Biennial cutting - selective Cutting 3-5 yr rotation - selective

17. REFERENCES

Askew, R.R. (1988). The Dragonflies of Europe. Colchester, Harley Books Ltd.

Barnes, R.S.K. (1994). The Brackish-Water Fauna of North Western Europe. Cambridge, Cambridge University Press.

Boon P J, Holmes, N T H, Maitland P & Rowell T A (1995) System for Evaluating Rivers for CONservation . Scottish Natural Heritage, Edinburgh.

Boussu, M.F (1954). Relationship between trout populations and cover on a small stream. Journal of Wildlife Management. 18: 229 - 239

Bratton, J.H. (1990). A Review of the Scarcer Ephemeroptera and Plecoptera of Great Britain. Research and Survey in Nature Conservation, No. 29. Peterborough, Nature Conservancy Council.

Bratton, J.H. (ed.) (1991). British Red Data Books: 3. Invertebrates other than insects. Peterborough, Joint Nature Conservation Committee.

Campbell L.H., (1988). The impact of river engineering on water birds on an English lowland river. Bird Study 35: 91-96.

Cooter, J. (ed.) (1991). A Coleopterist's Handbook (3rd edition). Amateur Entomologists' Society, Hanworth.

Cramp S et al (1977-94). Handbook of the Birds of Europe. the Middle East and North Africa. OUP.

Crossley, R. (in press) A Review of the Scarcer Dolichopodid and Empidid flies of Great Britain. Joint Nature Conservation Committee, Peterborough.

De Vore, D.W. and White, R.J. (1978). Daytime responses of brown trout (Salmo trutta) to cover stimuli in stream channels. Transactions of the American Fisheries Society 107(6): 763-771

DoE (1987) Methods for the Use of Aquatic Macrophytes for Assessing Water Quality 1985-86. Methods for the Examination of Waters and Associated Materials. HMSO, London.

EEA Eds Kristensen P & Ole Hansen H (1994) European Rivers and Lakes. Assessment of the Environmental State. European Environment Agency Monograph 1. EEA, Copenhagen.

Falk, S. (1991). A Review of the Scarce and Threatened Flies of Great Britain (part 1). Research and Survey in Nature Conservation, no. 39. Peterborough, Nature Conservancy Council.

Foster, A. (1983). National Review of Non-Marine Molluscs. Invertebrate Site Register Report, no. 14. London, Nature Conservancy Council.

Friday, L.E. (1988). A Key to the Adults of British Water Beetles. FSC publication no. 189. Taunton, Field Studies Council.

Fry, R. & Lonsdale, D. (1991). Habitat Conservation for Insects - a neglected green issue. Amateur Entomologists' Society, Middlesex.

Giles, N. (1994). Freshwater Fish of the British Isles. Swan Hill Press

Gilman, K. (1994). Hydrology and Wetland Conservation. Wiley, Chichester.

Goater, B. 1986. British Pyralid Moths. Harley Books, Colchester.

Gowing, D.J.G., Spoor, G. and Mountford, J.O.(1993). Determining the Water-Regime Preferences of Wet Grassland Flora. Proceedings of MAFF Conference of River and Coastal Engineers 1993. HMSO. Section 9.3.

Hammond, C.O. (1983). The Dragonflies of Great Britain and Ireland. Colchester, Harley Books Ltd.

Holmes N T H & Rowell T A (1995 - in prep) Vegetation Communities of British Rivers. Joint Nature Conservation Committee, Peterborough.

Holmes N T H (1983) Typing Rivers According to their Macrophytic Flora. Focus on Nature Conservation No 4. NCC Peterborough

Holmes N T H (1989) British Rivers, a working classification. British Wildlife 1.

Holmes N T H (1995) Macrophyte Associations with Channel Habitat Occurrences (MACHO). Draft report to IoH on research on behalf of MAFF.

Hyman, P.S. & Parsons, M.S. (1992). A Review of the Scarce and Threatened Coleoptera of Great Britain. Part 1. U.K. Nature Conservation, no. 3. Peterborough, Joint Nature Conservation Committee.

Kirby, P. (1991). A Review of the Scarcer Neuroptera of Great Britain. Research and Survey in Nature Conservation, no. 34. Peterborough, Nature Conservancy Council.

Kirby, P. (1992). A Review of the Scarce and Threatened Hemiptera of Great Britain. U.K. Nature Conservation, no. 2. Peterborough, Joint Nature Conservation Committee.

Kirby, P. (1992). Habitat Management for Invertebrates: a practical handbook. Royal Society for the Protection of Birds.

Lewis, S.L. (1969). Physical factors influencing fish populations in pools of a trout stream. Transactions of the American Fisheries Society 98: 14 - 19

MAFF (1994). Water Level Management Plans. HMSO

Maitland, P. S. (1972). Key to British Freshwater Fishes. FBA Publication 27.

Maitland, P.S. and Cambell, R.N. (1992). Freshwater Fish. Collins New Naturalist

Marchant J & Hyde P, 1980. Aspects of the distribution of riparian birds on waterways in Britain and Ireland. Bird Study 27:183-202.

Mills, C.A. (1981). The spawning of Roach (Rutilus rutilus L.) in a chalk stream. Fisheries Management 12 49 - 54

Nature Conservancy Council. (1989). Guidelines for Selection of Biological SSSIs. Peterborough, Nature Conservancy Council.

Palmer M & Newbold C. (1983) Wetland and Riparian Plants in Great Britain. NCC Focus on Nature Conservation No 1. NCC, Peterborough.

Parsons, M.S. (1993). A Review of the Scarce and Threatened Pyralid Moths of Great Britain. U.K. Nature Conservation, no. 11. Peterborough, Joint Nature Conservation Committee.

Pearson, R.G. and Jones, N.V. (1978). The effects of weed-cutting on the macro-invertebrate fauna of a channelised section of the River Hull, a Northern English chalk stream. Journal of Environmental Management 7:91-97

Raven P, (1986). Changes in the breeding bird populations of a small clay river following flood alleviation works. Bird Study 33: 24-35

Rodwell, J.S. (1991). British Plant Communities Vol 1: Woodlands and Scrub. Cambridge University Press.

Rodwell, J.S. (1992). British Plant Communities Vol 3: Grasslands and montane communities. Cambridge University Press.

Rodwell, J.S. (1994). British Plant Communities Vol 4: Swamps and aquatic communities. Cambridge University Press.

RSPB, RSNC and NRA (1994) The New Rivers & Wildlife Handbook. Royal Society for the Protection of Birds.

Shirt, D.B. (ed.) (1987). British Red Data Books: 2. Insects. Peterborough, Joint Nature Conservation Committee.

Stubbs, A. & Chandler, P. (1978). A Dipterist's Handbook. Amateur Entomologists' Society, Hanworth.

Stubbs, A.E. & Falk, S.J. (1983). British Hoverflies. British Entomological & Natural History Society, London.

Swales, S. (1982). Impacts of weed cutting on fisheries: an experimental study in a small lowland river. Fisheries Management 13: 125 - 137

Taylor K, (1984). The influence of watercourse management on Moorhen breeding biology. British Birds 77:144-148.

Travis Jenkins J. (1925). The Fishes of the British Isles. Frederick Warne and Co

Wallace, I.D. (1991). A Review of the Trichoptera of Great Britain. Research and Survey in Nature Conservation, no. 32. Peterborough, Nature Conservancy Council.

Wheeler, A.C. (1978). Key to the Fishes of Northern Europe. Frederick Warne

APPENDICES

Background documentation for each environmental component

APPENDIX A. Plant data

APPENDIX B. Invertebrate data

APPENDIX C. Fish data

APPENDIX D. Bird data

APPENDIX E. Mammal data

APPENDIX F. Adjacent habitat data

APPENDIX G. Working documents used during the preparation of the 'Best Practice' tables. Collation of the assessments of the effects of each maintenance option for each environmental component.

It must be emphasised that the following texts are background material used as a basis for devising the guidelines in determining best practice for vegetation management. In no way are they complete accounts of flora and fauna.

APPENDIX A: PLANTS

A1. SIMPLE ASSESSMENT PROCEDURE

A1.1 River Plants

Plants that grow in rivers comprise a mixture of lower plants (macro-algae, liverworts and mosses) and flowering plants which may occur in submerged fine and broad-leaved forms, floating-leaved forms (some rooted to the bed and others free-floating) and emergents which protrude above the water surface. In addition to these there are others which are principally wetland edge species which tend to be rooted in permanently wet habitats at the margin only, but do not spread up the drier sides of banks. River plants are often called 'macrophytes' and are very important providers of habitat structure for many river animals.

There are few species which are confined to rivers, most of the macrophytes that are found in moving waters may be found in ponds, lakes and reservoirs too. However there are some specialist species which do prefer, and some demand, flowing water and coarse sediments which are found in river environments only. In rivers which receive management to control vegetation, these are confined to those which have a steep gradient, and/or a strong element of groundwater flow to create the necessary habitats. Example species are Water-crowfoots (*Ranunculus* spp.) and the much rarer River Water-dropwort (*Oenanthe fluviatile*). In contrast very low gradient drainage channels have plant communities similar to ponds; some contain tiny remnants of very rare aquatic assemblages which were once common-place in floodplains before their wholesale drainage.

For rivers or drainage channels that are to be considered for vegetation control, an assessment of the quality of the vegetation is essential. Whilst large stands of reeds blocking a channel may be valuable for one or more species of breeding birds or invertebrates, such a channel is likely to be regarded as of low plant interest. Example ditches of this occluded type, if a wide variety of other (more open) ditches exist, may be of botanical interest if they represent the natural community of the area. In essence botanical interest within rivers is reflected by the variety of plants present which should include a mixture of the majority of forms cited in the opening paragraph above.

A simple assessment of general botanical interest can be made by supervisors and operatives. They should note (either on paper or mentally) the number of plant 'forms' listed below which are present within approximate 500m lengths. These forms are illustrated in the guidelines and are listed in Table A1. If more than four forms are present FD staff should consider that the reach to be managed has a botanical interest of some kind. Recognition of different structural forms of macrophytes, and then the clear difference between many of the species (without needing to name them), is a valuable contribution operators and supervisors can make in making general 'quality' assessments.

Table A1: Macrophyte forms
These are all illustrated in the guidelines to assist FD staff

	Structure	Example
Form 1:	Broad-leaved submerged	Canadian Pondweed *Elodea* spp., Yellow Water lily *Nuphar lutea*, Shining Pondweed *Potamogeton lucens*
Form 2:	Narrow linear/ ribbon - leaved submerged	Bulrush *Scirpus lacustris*, Arrowhead *Sagittaria*, Unbranched Bur-reed *Sparganium emersum*
Form 3:	Finely dissected - leaved submerged	Milfoil *Myriophyllum* spp., Fennel Pondweed *Potamogeton pectinatus*, Crowfoot *Ranunculus* spp.
Form 4:	Surface - floating	Broad-leaved Pondweed *Potamogeton natans*, Yellow Water-lily *Nuphar lutea*, Duckweed *Lemna minor*
Form 5:	Submerged cushions	Bryophytes such as Willow moss *Fontinalis, Rhynchostegium, Riccia*
Form 6:	Narrow-leaved emergents	Branched Bur-reed *Sparganium erectum*, Sharp Rush *Eleocharis* spp., Bulrush *Scirpus lacustris*
Form 7:	Broad-leaved emergents	Great Water-dock *Rumex*, Blue Water-speedwell *Veronica anagallis-aquatica* Fool's Water-cress *Apium nodiflorum*
Form 8	Amphibious/ marginal	Amphibious bistort *Polygonum amphibia*, Reed sweet-grass *Glyceria maxima*, Water Forget-me-not *Myosotis scorpoides*
Form 9:	Macro-algae	Blanket weed *Cladophora*, Tubeweed *Enteromorpha*, Netweed *Hydrodictium*

Conservation staff will know some river and drainage channels better than others. When they make an input into 'quality assessment' they should utilize available species information as well as information they may obtain during pre-work site inspections. Table A2 lists the common species of macrophytes associated with the originally identified 16 'Reach Types' which commonly receive vegetation management. For general purposes they should consider 'Good' sites to be those that contain at least 75% of the species listed and 'Poor' sites to be those with less than 50% of the species cited for each of the Reach Types.

The general information obtained from walk-over observations made by operatives and conservation staff should dictate the sensitivity with which vegetation control is carried out on over 90% of river reaches. Exceptions may require specific inputs; a rare example might be that very impoverished reaches have more 'harsh' treatment than is normally recommended whilst a more common exception would be specific care being taken to avoid uncommon species or execute work so they can recover quickly.

Conservation staff will have access to information relating to International, National, Regional and Area Macrophyte Rarities. Details of species in the first two categories are listed in Table A4 whilst information on Regional and Area rarities can be found in the NCC (1981) *Focus on Nature Conservation* which many staff keep up-dated as they receive more information. Any reaches with macrophyte species of at least National Importance must be considered as 'one-off cases' whilst those with Area or Regional rarities require special consideration. Many of these may by at the margins of open water or at the toe of the bank.

A1.2 Bankside Vegetation

Plants that grow on river banks range from trees and shrubs to a variety of lower plants (mosses, liverworts and ferns) and flowering herbs, grasses and reeds. Because plants on river banks often experience vary rapid or sustained fluctuations in water level, massive variations occur in the water-dependence of species on passing up a bank slope. The majority on the upper slopes of high banks are capable of surviving without damp conditions at any time whilst those at the base of the bank, and where slopes are very gentle, almost permanent water-logging is often demanded. In addition to these there are others which are primarily aquatic species which tend to be rooted in permanently wet habitats at the margins only.

There are no widespread bankside species which are confined to river banks of the type which receive mowing or flailing for FD purposes. For any very rare species which have their main occurrences on managed rivers, Conservation staff should know their precise whereabouts. In essence, virtually any species and any community of terrestrial (land) habitat types can be present on river banks. Thus rivers adjacent to present (and past) woodlands, wetlands and meadows may have remnants, or considerable quantities, of species from these ancient habitats. FD staff are not expected to recognise such species but may draw attention to the Conservation Section any very herb-rich banks they encounter so further investigations may be made if necessary by the relevant people.

Table A2: Plant species present in each category of river

SPECIES NAME		RIVER CATEGORY															
Latin Species Name	English Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vaucheria spp.	Mole-pelt Alga	O	F	A	D	R	O	F	A	R	O	F	A	R	O	F	D
Enteromorpha spp.	Tubeweed		F	A	A		R	O	F		R	O	F		R	O	F
Cladophora agg.	Blanketweed/Cott	O	F	A	A	O	F	O	O	F	O	O	O	F	O	R	R
	Filamentous green algae	R	F	O	O	R	O	O	O	R	R	O	O	R	R	O	O
Fontinalis antipyretica	Willowmoss	O				F	R			F	O	R		O	R	R	
Rhynchostegium riparioides	moss	O				F	R			F	O	R		O	R	R	
Angelica sylvestris (B)	Angelica	R	R	R		R	R	R	R	R	R	R	R	R	R	R	R
Apium nodiflorum (+M/B)	Fool's water-cress	A	F	F	F	A	F	O	O	F	F	O	O	F	F	O	R
Berula erecta	Lesser Water-parsnip					F	R			O	F	R		O	F	R	
Callitriche obtusangula	Blunt-fruited Water -starwort	R				O	R			O	O	R		O	R	R	
Callitriche stagnalis	Common "" ""	R	O	O	O	R	O	O	O	R	O	O	O	R	O	O	O
Caltha palustris (M)	Kingcup	R				R	R	R	R	R	R	R	R	R	R	R	R
Ceratophyllum demersum	Common Hornwort								R			O	F			O	F
Dipsacus fullonum (B)	Teasel							R	R			R	R		R	R	R
Epilobium hirsutum (B)	Great Willow-herb		O	O	O	O	O	O	O	O	O	R	R	R	R	R	R
Eupatorium cannibinum (B)	Hemp Agrimony		O	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Filipendula ulmaria (B)	Meadowsweet		R	R		R	R	R		R	R	R	R	R	R	R	R
Hippurus vulgaris	Mare's-tail					O			R	F				R	F		
Lycopus europaeus (B)	Gypsy-wort	R	R			R	R	R	R	R	R	R	R	R	R	R	R
Lythrum salicaria (B)	Purple Loosestrife					R	R	R	R	R	R	R	R	R	R	R	R
Mentha aquatica (M/B)	Water-mint	O	O	R	R	O	O	R	R	R	R	R	R	R	R	R	R
*Mimulus guttatus** (M/B)*	Monkey-flower	R				R	R			R	R			R	R		
Myosotis scorpioides (M)	Water-For-get-me-not	F	O	R	R	O	O	R	R	O	R	R	R	R	R	R	R
Myriophyllum spicatum	Spiked Water-milfoil				R		R	R	R	O	O	R	R	F	F	F	O
Nuphar lutea	Yellow Water-lily				R			O	F			D	A		R	A	A
Nymphaea alba	White Water-lily								R			R	O			R	R
Nymphoides peltata	Fringed Water-lily												R			R	O
Nasturtium officinalis agg. (+M)	Water-cress	D	F	O	O	D	A	O	R	A	O	R	R	F	O	R	R
Oenanthe crocata (M/B)	Hemlock Water-dropwort					O	R			R	R	R	R	R	R	R	R
Oenanthe fluviatilis	River Water-dropwort									R	R			R	R	R	
Petasites hybridus (M/B)	Butterbur					R	R	R		R	R	R		R	R	R	
Polygonum amphibium (M)	Amphibious Bistort		R	O	O	R	R	R	R	R	R	O	O	R	R	O	O
Pulicaria dysinterica (B)	Common Flea-bane					R	R	R		R	R	R		R	R	R	
Ranunculus circinatus	Fan-leaved Water-crowfoot							R				R			O	O	R
Ranunculus fluitans	River Water-crowfoot					R	R			F	O	R		F	O	R	
Ranunculus peltatus	Pond Water-crowfoot					R	R			R	R						
R. penic. subsp. penicillatus	Brook Water-crowfoot					D	O	R		D	O	R		F	O	R	
Ranunculus sceleratus (M)	Celery-leaved Crowfoot				R		R	R	O		R	R	R		R	R	R
Rorippa amphibia (+M)	Great Yellow-cress							R	R		R	R	O	R	R	O	O
Rumex hydrolopathum	Great Water-dock								R			R	R		R	R	R
Scrophularia auriculata (B)	Water Figwort		R	R		R	R	R	R	R	R	R	R	R	R	R	R
Solanum dulcamaram (M)	Bittersweet							R	O		R	O	R	R	R	R	R
Stachys palustris (B)	Marsh Woundwort					R	R	R		R	R	R	R	R	R	R	R
Symphytum officinalis (B)	Comfrey					R	R	R	R	R	R	R	R	R	R	R	R
Valeriana officinalis (B)	Common Valerian						R	R	R		R	R					
Veronica anagallis-aquatica (+M)	Blue Water-speedwell					F	F	R		F	F	R		F	F	O	
Veronica beccabunga (M)	Brooklime	F	O	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Veronica catenata (+M)	Pink Water-speedwell	O				R	R	R		R	R	R		R	R	R	
*Acorus calamus** (+M)*	Sweet-flag												O				O
Alisma lanceolatum	Narrow-leaved Water-plantain											R	R			R	R
Alisma plantago aquatica	Common Water-plantain		R	O	O		R	R	R		R	R	O		R	O	R

Table A2: cont:

| | | |

Some banks have been invaded by alien plants, the most widespread and troublesome being Japanese Knotweed, Indian Balsam and Giant Hogweed. In most situations control or eradication of these, using approved means, will be beneficial for bank plant communities.

In simple terms operators and supervisors can roughly assess botanical interests of banks by visual assessment. Banks that have a wide variety of flowering herbs in spring and early summer are going to have the greatest general botanical interest. In contrast, those with dense stands of single species such as Nettle and Great Willow-herb, or tall grasses, will be of least interest. Where banks support large amounts of the aliens, these will be deemed to be of declining interest.

From a purely botanical view the most critical area to assess for interest is the base of the bank. Table A3 lists wetland species which are commonly associated with river banks when banks are shallow, or where good communities remain at the bank/water interface. Conservation staff can utilize this information to identify banks with high or low general botanical interest (ie >75% of those listed for each of the 16 Reach Types occur in a 500m length of river of <50%).

The general information obtained from walk-over observations made by operatives (or conservation staff) should dictate the sensitivity with which vegetation control is carried out on over 90% of river reaches. Exceptions would be special care for important assemblages up a slope since those at the toe of the bank should be protected by adoption of best practice methods.

A2. DETAILED ASSESSMENT OF BOTANICAL QUALITY

Assessing the 'quality' of a plant community of a river primarily centres on comparison of recorded assemblages from 500m reaches with those recorded from similar 'River Types'. This is what has been done for over ten years when initially assessing river reaches for their potential as SSSIs (Sites of Special Scientific Interest). The assessment concentrates on the plants of the channel and at the toe of the bank and does not include dryland species higher up the banks.

In essence the procedure for assessing 'quality' uses criteria such as 'diversity', 'species richness', 'rarity', 'representativeness/typicality' and naturalness. Since the character of each of these is different for different river types, rivers of similar character have to be compared with one another when determining quality.

'Diversity' most often refers to the range of different plant forms and this has been utilized in the approach recommended here for the most general of assessments.

'Species Richness' refers to the number of species present, the general view being that providing the species present are natives, and those expected for the type of watercourse being assessed, the more the better.

'Rarity' may refer to rarity of a particular community type or the presence of one or more rare species. More details of how these can be used in assessment are provided.

Table A3: Detailed habitat requirements of aquatic and bankside plants. Reproduced from *The New Rivers and Wildlife Handbook* with kind permission of the RSPB.

Table 1: Aquatic River Plants

PLATE NO. IN KEBLE-MARTIN	SPECIES	ALTITUDE	SUBSTRATE (Clay, Silt, Peat, Sand, Gravel-Pebble, Cobble-Boulder)	FLOW (Nil-Slow, Moderate, Fast-Rapid)	DEPTH (>1 m, 0.5-1 m, 0.1-0.5 m, 0.1-dry)	WIDTH (>20 m, 10-20 m, 5-10 m, <5 m)	CHEM. (Base poor, Base neutral, Base rich)	WATER QUAL. (Clean, Moderate, Polluted)	SHADE TOLERANCE	DISTURBANCE TOLERANCE	LIFE CYCLE
a Free-floating, unrooted plants											
34	Hornworts	L	○● ○ ○	●	●○●	○○○●	○●	○●○	●	●	A/P
88	[Duckweeds]	L	○○● ●	●●	○●●●	●○●○	●●○	○○		●	A
59	*Fringed water-lily	L	●●	●	●●○	○○○○	●	○○		○	P
66	Bladderworts	Thr	●○●●	●	○○○	●○○○	○○○	●	●	●	A/P
79	Frogbit	L	○○● ●	●	●○	○○○●	●	○●		○	A/P
b Submerged, narrow-leaved plants (some are part-emergent, some others have floating leaves)											
34	Mare's-tail	L	○○●○●	○●●	○●●●	○●●○	○●	●○●		○	P
87	Bulbous rush	U/T	● ●○●●	○○●	●○●●	●●●○	●○	●●	●	●	P
71	Shoreweed	U	● ○●●	●●○	●○○○	○○○●	●○●	●●	●	○	P
34	*Water milfoils	Thr	○●●●○●	●○○	○○●	○○○●	○●●	○○●	○	○	P
39	*River water dropwort	L	●○ ○○	○●●	●○●	○○○●	●●	○○		○	P
90	Small pondweed	L	○○●○○	●○	●○○	○○○○	○○○	○○○	●	○	A/P
90	[Fennel pondweed]	Thr	○○●○○●	○●○	○●○	○○○○	○ ●	●○●	○	●	P
90	Flat-stalked pondweed	L	○●	●	○●○	○○○○	○○	○○○	○	○	P
2	Cmn. water-crowfoot	Thr	●●●●●○	○○ ○	●○●○	●○○○	○○●	●○●		●	A/P
2	Fan-leaved water-crowfoot	L	●●	●●	○●●	○○○●	●	○○●	●	○	P

Key to Plant Habitat tables

The Keble Martin plate number refers to Keble Martin (1969), a useful illustrated guide to British plants, most of them in colour.

●-preferred conditions, most frequently found/high tolerance.
○-very commonly found/fair-good tolerance
o-occasionally found/moderately tolerant
⊙-when several species have been amalgated, some prefer this condition and others shun it.
●-rarely found

blank -absent/intolerant
NP -no preference

L -lowland only
U -upland only
T -transitional only
Thr -throughout
} altitude of site

A -annual/biennial
P -perennial
} life-cycle

* -uncommon plant, recorded in fewer than 100 national kilometre grid squares, out of *c.* 2,600

34 -the plant may grow both in the channel and on the bank

[....] -very common, likely to recolonise unaided, not suitable for replanting.

Table A3 cont:

Table 1 (cont)

2	River water-crowfoot	T/L	○●	○●○	○●○	○●●●	●○○●	●●○	●●			P
-	Pond water-crowfoot	T/L	○●●○●●		○●○	●○●○	●○●○	●○●	●○○		○	A/P
2	Thread-leaved water-crowfoot	T/L	○●	○○	○○●	○○○●	○○○○	○●	●○	○	●	A/P
79	Arrowhead	L	●●	●	●○	●○●	○○○○	●○●	○○○		●	A/P
91	Floating club-rush	U	○●○○○●		●●●	●●●	●○○○	●●	●		○	P
88	Unbranched bur-reed	L	○○●●●		○○●	●○○●	○○○○	●○○	○○		●	P
90	Horned pondweed	L	●●	●○	●○	●○●	○○○○	○●	○○●		●	P

c Submerged, broad-leaved plants

38	Narrow-leaved water parsnip	L	○○●○●●		●○●	●○●○	●○○●	●○	●●	○	○	P
34	Starwort species	Thr	○○●●○○		○●●	●●●●	○○○○	○●○	●○●	○	○	A/P
89	Opposite-leaved pondweed	U	○●	○○	●○	○●○	○●●○	○●	○○			P
90	Curled pondweed	T/L	○○●○○●		○○○	●○●	○○○○	●●○	○○○	○	●	P
89	Shining pondweed	L	○○	●●	●	○●●	○○○	○●	○○		●	P
89	Perfoliate pondweed	T/L	○○	○○●	●○	○○○	○○○	○○	●○		○	P
79	[Canadian pondweed]	T/L	○○	○○	○○●	○○○	○○○○	○○	○○○		●	A/P

d Rooted, floated-leaved plants

5	[Yellow water-lily]	L	●○		●○	○○○	○○○○	●○	○○○	○	●	P
5	White water-lily	Thr	●○	○	●	○○○	○○○○	○○○	●	○		P
89	Bog pondweed	U/T	○○●○	○	○○○	●●○	●○○●	●○	●		○	P
89	Broad-leaved pondweed	Thr	○○○○○○○		○○○	●○	○	○○○○	○○	○○●	●	P

Table A3 cont:

Table 2: Marginal plants

PLATE NO. IN KEBLE-MARTIN	SPECIES	ALTITUDE	SUBSTRATE Clay Silt Peat Sand Gravel-Pebble Cobble-Boulder	FLOW Nil-Slow Moderate Fast-Rapid	DEPTH >1 m 0.5-1 m 0.1-0.5 m 0.1-dry	WIDTH QUAL. >20 m 10-20 m 5-10 m <5 m	CHEM. Base poor Base neutral Base rich	WATER Clean Moderate Polluted	SHADE TOLERANCE	DISTURBANCE TOLERANCE	LIFE CYCLE
a Emergent narrow-leaved plants ('reeds')											
79	Water plantain	L	●○	●○	●●○●	●●○○	●○●	○○		●	P
79	Flowering-rush	L	●○●○●	●○●	●○●○	○●●●	●●	○○		○	P
91	Spike rushes	Thr	○○○●○○	○○○	●○●	○○○○	○●○				P
-	Water horse-tail	Thr	○○○●●	●●	●●●○	○○○○	○○○	●○	○	○	P
95	Common reed	L	○○○●	●	○○○●	○○○○	○		○		P
b Emergent broad-leaved plants (note that all of these plants behave differently when growing on banks)											
37	[Fool's water-cress]	L	●○ ●●	●○	●●○●	●○○○	●○	○○	○	○	A/P
7	Water-cress	L	○○ ●●	●○	○●	●○○●	○●	○○	○		P
74	Water dock	L	●○●●●	●	○●	○○○●	●●	○○			P
84	Blue water-speedwell	L	○● ●●	●○	●○○	●○●○	○●	○○○	○	●	A/P
c Encroaching plants											
93	*Water sedge	U	○○○●●	●○ ●	●●	NP	○○●	●○		●	P
94	Lesser pond-sedge	L	●○●○●	●○ ●	○●	NP	○○	○○○	●	●	P
94	Greater pond-sedge	L	○○○●●	●●	○●	NP	○○	○○○	○	●	P
94	Bottle sedge	U/T	○○○○○	●○ ●	○●	○○○○	●○	○○○		●	P
94	Bladder sedge	U/T	○○●●	○●	○●	○○○○	○○○	○○	●	○	P
97	Whorl grass	L	○●●○●	●●	○●	○○○○	○●	○○○	○	○	P
97	[Reed sweet-grass]	L	○●●●	●○	●●●●	○○○○	○●	○○○	○	●	P
89	Bogbean	Thr	○○○●●	●	●○●○	○○○○	○○○	●●		○	P
93	Amphibious bistort	L	○○●○	○○	●	NP	○○	○○○	○		P
7	Great yellow-cress	L	○●	●●	○●	●○○○	●●	○○○		●	P
64	Pink water-speedwell	T/L	○○●●●	●○	●○○	●○○○	●○○	●○●		○	P

Table A3 cont:

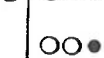
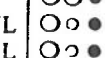
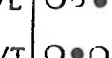
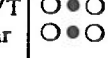
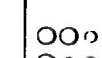
Table 3: Bank plants

PLATE NO. IN KEBLE-MARTIN	SPECIES	ALTITUDE	SUBSTRATE (Clay, Silt, Peat, Sand, Gravel-Pebble, Bedrock)	FLOW (Nil-Slow, Moderate, Fast-Rapid)	BANK SLOPE (>60°, 30-60°, >30°)	HGHT. (>1 m, 0.5-1 m, <0.5 m)	CHEM. (Base poor, Base neutral, Base rich)	WHERE PLANT (Just submerged, At water level, Just above, >30cm above)	SHADE TOLERANCE / STABILIZING ABILITY / SCOUR RESISTANCE	LIFE CYCLE
a Narrow-leaved, upright bank plants										
79	Water plantain	L								P
93	Slender tufted-sedge	L								P
94	Lesser pond-sedge									
93	*Water sedge	U/T								P
93	Tufted-sedge	L								P
93	Common sedge	U/T								P
92	False fox-sedge	L								P
92	Great tussock-sedge	L								P
94	Pendulous sedge	L								P
91	Common spike-rush	Thr								P
83	Yellow Iris	T/L								P
87	Sharp-flowered rush	U								P
87	Jointed rush	U/T								P
87	Bulrush	U/T								P
86	Soft rush	U/T								P
86	Hard rush	T/L								P
95	Reed canary-grass	T/L								P
95	Common reed	L								P
88	Branched bur-reed	T/L								P
88	Narrow-leaved reedmace	L								P
88	Reedmace	L								P
b Narrow-leaved, straggling bank plants										
95	[Creeping bent]	T/L								P
95	*Orange foxtail	L								A
95	Marsh foxtail	T/L								P
97	Small sweet-grass	L								P
97	Floating sweet-grass	U/T								P
97	[Reed sweet-grass]	L								P
97	Plicate sweet-grass	T/L								P

Table A3 cont:

Table 3 (cont)

c Broad-leaved, upright bank plants

37	Fool's water-cress	T/L								P
38	Lesser water parsnip	L								P
67	Water-mint	T/L								P
63	Water figwort	T/L								P
4	Marsh marigold	U/T								P
26	Meadow sweet	Thr								P
34	Purple loosestrife	L								P
67	Gipsywort	L								P
39	[Hemlock water drop-wort]	Thr								P
69	Marsh woundwort	T/L								P
46	Butterbur	T/L								P
46	Colt's-foot	Thr								P
45	Bur marigold	L								A
60	Common comfrey	L								P
44	Hemp agrimony	T/L								P
35	Great willow-herb	T/L								P
–	Royal fern	T/L								P

d Broad-leaved, straggling bank plants

7	Large bitter-cress	T/L								P
42	Common marsh-bedstraw	T/L								P
29	Water avens	Thr								P
60	Water forget-me-not	T/L								P
15	Water chickweed	L								P
73	Amphibious bistort	L								P
3	Lesser spearwort	Thr								P
3	Greater spearwort	T/L								P
3	Celery-leaved buttercup	L								A
2	Ivy-leaved crowfoot	U								A/P
2	Round-leaved crowfoot	U								A
7	Great yellow-cress	L								P
7	Water-cress	T/L								P
7	Marsh yellow-cress	T/L								A
7	Creeping yellow-cress	T								P
61	[Bittersweet]	T/L								P
64	Brooklime	Thr								P

'Representativeness' is a conservation attribute that is difficult to appraise objectively but aims to ensure that the best examples of 'typical' assemblages are accorded high conservation status alongside the more rare ones. Thus for any river type different species are dominant and a different mix of species commonly occur; sites assigned to a particular 'type' are regarded as most 'representative' if the majority of these species are present and the dominant species are those predicted for the type.

'Naturalness' of a river plant community is the most difficult attribute to assess because all managed rivers have been modified to some degree, many fundamentally away from their 'natural', pre-impacted state. Naturalness is regarded as being devalued when native species are replaced by aliens, expected species are replaced by those which thrive in disturbed habitats, and species of clean water are lost and pollution-tolerant species dominate.

SERCON (Boon, Holmes, Maitland & Rowell; 1995) - System for Evaluating Rivers for CONservation - is a new system which attempts to used available data on river habitats. macrophytes and animals in a more objective way than has been done in the past. The system uses all the criteria above and applies available data on macrophytes to determine 'conservation scores'. It is used on river lengths ranging from 10-30km so would provide good context on river community types and quality for smaller reaches within them which are assessed prior to vegetation management. It is likely that in a few years it will be the system that will utilize available data on river macrophytes to determine 'quality' and hence, conservation value.

In the meantime Conservation staff should utilize data on macrophytes by assessing the variety and species richness of the total assemblage against that expected for rivers of its physical type, and over-lay/over-ride this general assessment if rare species are present.

If an accurate macrophyte typing, utilizing the Nature Conservancy Council (NCC) system, is required a more rigorous survey should be carried out using a check-list and pre-determined abundance ratings. From this the site can be classified into one of ten SSSI river types or 38 sub-divisions. With the number of species, and their relative abundance within 500m known, rigorous assessments against the conservation criteria described above can be undertaken. An example is given in Figure A1 which is the one of the 10 SSSI types most subject to vegetation control.

The practical reality is that broad assessments are most likely to be needed and a general picture gained as to whether the community present at a site to be managed is typical and supports more or less of the species expected. Table A4 was developed from the data outputs from the NCC classification so that the less common species of the 16 physical types can be readily determined. In any cross-reference of the 16 physical types to the ten SSSI types, it is important to note that only types I-IV are commonly subjected to vegetation management.

There are no simple systems available for assessing specifically the quality of a riverbank flora. The edge species at the base of the bank, and when the banks are very shallow and damp, will be covered by the macrophyte assessments described above, and cover rarities described below. Species of conservation significance which are dryland species may occur on river banks. The general guidance is to ensure herb-rich banks are identified and their locations made known to FD to ensure that they are aware that protection may be required.

Figure A1: Chalk streams regularly cut for submerged macrophytes

Top 30 macrophytes (presence) — Dominants

EPILOBIUM HIRSUTUM 100.0% (1: 95.6%)
MENTHA AQUATICA 98.9% (4: 87.8%)
PHALARIS ARUNDINACEA 97.8% (3: 91.1%)
MYOSOTIS SCORPOIDES 96.7% (2: 92.2%)
SPARGANIUM ERECTUM 95.6% (10: 71.1%)
AGROSTIS STOLONIFERA 91.1% (6: 80%)
SOLANUM DULCAMARA 90.0% (5: 81.1%)
CAREX ACUTIFORMIS 88.9% (6: 80%)
APIUM NODIFLORUM 88.9% (8: 75.6%)
SALIX SP(P.) 87.8% (13: 66.7%)
VERONICA BECCABUNGA 87.8% (14: 65.6%)
RORIPPA NASTURTIUM-AQUATICUM AGG. 87.8% (8: 75.6%)
FILIPENDULA ULMARIA 87.8% (16: 64.4%)
CALLITRICHE OBTUSANGULA 86.7%
RANUNCULUS PENICILLATUS VAR CALCAREUS 85.6% (12: 67.8%)
OTHER TREE GENERA 83.3% (16: 64.4%)
VERONICA ANAGALLIS-AQUATICA 82.2% (16: 64.4%)
SCROPHULARIA AURICULATA 82.2% (14: 65.6%)
IRIS PSEUDACORUS 77.8% (19: 56.7%)
GLYCERIA MAXIMA 77.8% (11: 68.9%)
JUNCUS INFLEXUS 74.4%
VAUCHERIA SESSILIS AGG. 74.4%
BERULA ERECTA 73.3%
EUPATORIUM CANNABINUM 72.2%
CALLITRICHE STAGNALIS 70.0%
LYTHRUM SALICARIA 66.7%
FONTINALIS ANTIPYRETICA 66.7%
CAREX RIPARIA 64.4% (19: 56.7%)
LYCOPUS EUROPEAUS 62.2%
CLADOPHORA GLOMERATA AGG. 61.1%

No of sites = 90

	Mean	Min	Max
No of species	42	12	60
Height at source	111	25	229
Altitude	54	15	168
Slope	11.0	2.0	25

Pools: 4.4%
Slacks: 90.0%
Riffles: 2.2%
Runs: 55.6%
Rapids: 1.1%

Silt/mud: 47.8%
Sand: 23.3%
Clay: 17.8%
Gravel: 80.0%
Pebbles: 14.4%
Cobbles: 4.4%
Boulders: .0%
Bedrock: .0%

Width <5m: 26.7%
Width 5-10m: 45.6%
Width 10-20m: 38.9%
Width >20m: 12.2%

Depth <0.25m: 67.8%
Depth 0.25-0.5M: 65.6%
Depth 0.5-1m: 21.1%
Depth >1m: 16.7%

Geological types represented in at least 10% of sites
Calcareous clay: 12.2%
Chalk: 62.2%
Other soft limestone: 10.0%

Type III (TEG 18, NN IV) Chalk Rivers and other Base-rich Rivers with Stable Flows

Only base-rich geology is represented in this Type, with Chalk comprising more than 60%, more than double that found in Type I. Stable flow regimes resulting from a substantial base-flow is the most common factor between the vast majority of sites within Type III. Gravel is significantly more prevalent in this Type than in any other Group A Type. Examples which best exemplify the character are the rivers flowing from the chalk (eg Piddle, Frome, Test, Itchen, Mimram, Hull and headwaters of many East-Anglian rivers) and those on the Oolite of the Cotswold (eg Coln & Windrush). Whilst the plant assemblages have many of the species found typically in Types I & II, *Carex acutiformis, Callitriche obtusangula, Ranunculus penicillatus* subsp. *pseudofluitans, Berula erecta* and *Fontinalis antipyretica* are particularly characteristic. Of the less commonly occurring species, *Hippurus & Carex paniculata* are especially characteristic whilst *Groenlandia, Phragmites, Rumex hydrolopathum* are more common than in any other Types.

to conservation staff so they can make a more detailed assessment if required. In general a single late summer/autumn cut is unlikely to damage any rare species or communities of plants yet it may well compromise other interests associated with them. For such areas, single late cuts are recommended but management prescriptions must be site-specific when particularly rare species or communities are known.

A2.1 Consideration of Rare Species

There are no macrophytes which are typical of rivers which are managed regularly for flood defence purposes that have international rarity designations. *Luronium natans* (Floating-leaved Water-plantain) is the only river species listed in Annexe II and IV of the EC Habitats Directive but this does not occur in rivers requiring regular management. Because *Oenanthe fluviatilis* (River Water-dropwort) is occasionally common in some rivers of England and Ireland, it has no protective status through legislation. Despite this, the European Environment Agency (1994) highlights the great European significance of this species in Britain because its world-wide distribution is confined to the British Isles, and much more rarely, to Denmark. All managed sites with this species should be considered 'special', with practices employed so that the population suffers no long-term impacts as a result of the management. A single annual cut, irrespective of when it is, does not have adverse impacts on the individual plants but population viability is improved if cutting is left until after the aerial shoots have set seed.

Table A4 lists Red Data Book and Nationally Scarce macrophytes associated with rivers which receive vegetation management. The majority of these will be confined to very low gradient systems, managed grazing marsh ditch systems being the most important.

The presence of any of these species justifies the reach being rated as very special, based on rarity, and afforded special consideration. In reality only a very small fraction of managed lengths of watercourse will be affected. Their conservation and enhancement may well not warrant less management, but possibly more, but carried out in a more targeted and controlled manner.

Table A4 also lists river macrophytes which are considered to be rare in England and Wales. These lists are taken from SERCON (1995). In England only one species (*Catabrosa*) is considered likely to be most prevalent in managed watercourses. In Wales the situation is different, with 13 species expected to be more prevalent in managed watercourses than unmanaged ones. The presence of any of these species (except *Lemna gibba* in Wales) should be noted and approaches adopted to ensure viable populations are not compromised by the works.

Information on macrophytes which are rare within a 'Regional' and 'Area' context are available to Conservation staff through the NCC Focus Report (Palmer & Newbold; 1983). An example of the type of information available within the document for the Severn Trent Region is reproduced as Table A5.

Table A4: Rare and protected plants likely to be present in managed watercourses

Red Data Book (**) and Nationally Scarce (*) macrophytes

*Potamogeton acutifolius***	Sharp leaved Pondweed
*Potamogeton nodosus***	Loddon Pondweed
*Ceratophyllum submersum**	Soft Hornwort
*Myriophyllum verticillatum**	Whorled Water-milfoil
*Nymphoides peltata**	Fringed Water-lily
*Potamogeton compressus**	Grass-wrack Pondweed
*Potamogeton friesii**	Flat-stalked Ponweed
*Potamogeton trichoides**	Hairlike pondweed

Macrophytes associated with running water or their margins and considered rare in England (occur in 100 or less 10 x 10km squares but excluding nationally scarce species)

Catabrosa aquatica	Whorl-grass

Macrophytes associated with running water or their margins and considered rare in Wales (occur in15 or less 10 x 10km squares but excluding nationally scarce species)

Alisma lanceolatum	Narrow-leaved Water-plantain
Butomus umbellatus	Flowering Rush
Carex acuta	Slender Tufted-sedge
Ceratophyllum demersum	Rigid Hornwort
Groenlandia densa	Opposite-leaved Pondweed
Lemna gibba	Fat Duckweed
Potamogeton lucens	Shining Pondweed
Ranunculus circinatus	Fan-leaved Water-crowfoot
Ranunculus fluitans	River Water-crowfoot
Rorippa amphibia	Great Water-cress
Sagittaria sagittifolia	Arrowhead
Spirodela (Lemna) polyrhiza	Greater Duckweed
Typha angustfolia	Lesser Bulrush

This document lists for each of the old Water Authority Regions (with reference to Area differences too) the following:

A. Aquatic plants that have been recorded from the Region which occur in 100 or fewer 10x10km squares in GB (comprehensive list of ALL 'Nationally Scarce' species);

B. Aquatic plants which are more common nationally but rare within the individual region (and with Area differences too);

C. Riparian and other Wetland plants which are 'Nationally Scarce' and recorded from the Region.

Conservation staff should utilize any data they have on any of the listed species in the NCC document for a watercourse to be managed, to provide context for assessing any reach as being of special botanical interest due to rarity.

Table A4: Rare and protected plants likely to be present in managed watercourses

Red Data Book (**) and Nationally Scarce (*) macrophytes

*Potamogeton acutifolius***	Sharp leaved Pondweed
*Potamogeton nodosus***	Loddon Pondweed
*Ceratophyllum submersum**	Soft Hornwort
*Myriophyllum verticillatum**	Whorled Water-milfoil
*Nymphoides peltata**	Fringed Water-lily
*Potamogeton compressus**	Grass-wrack Pondweed
*Potamogeton friesii**	Flat-stalked Ponweed
*Potamogeton trichoides**	Hairlike pondweed

Macrophytes associated with running water or their margins and considered rare in England (occur in 100 or less 10 x 10km squares but excluding nationally scarce species)

Catabrosa aquatica	Whorl-grass

Macrophytes associated with running water or their margins and considered rare in Wales (occur in15 or less 10 x 10km squares but excluding nationally scarce species)

Alisma lanceolatum	Narrow-leaved Water-plantain
Butomus umbellatus	Flowering Rush
Carex acuta	Slender Tufted-sedge
Ceratophyllum demersum	Rigid Hornwort
Groenlandia densa	Opposite-leaved Pondweed
Lemna gibba	Fat Duckweed
Potamogeton lucens	Shining Pondweed
Ranunculus circinatus	Fan-leaved Water-crowfoot
Ranunculus fluitans	River Water-crowfoot
Rorippa amphibia	Great Water-cress
Sagittaria sagittifolia	Arrowhead
Spirodela (Lemna) polyrhiza	Greater Duckweed
Typha angustfolia	Lesser Bulrush

C. RIPARIAN AND NON-AQUATIC WETLAND PLANTS RECORDED FROM 100 OR FEWER 10 x 10km SQUARES IN GREAT BRITAIN AND WHICH NEED SPECIAL PROTECTION IN THE SEVERN-TRENT WATER AUTHORITY AREA

			No. of 10 x 10 km. squares in G.B.	
	Aconitum napellus (anglicum)	Monks-hood	76	()
	Allium schoenoprasum	Chives	16	(#)
	Alopecurus aequalis	Orange foxtail	82	
M	Alopecurus bulbosus	Bulbous foxtail	26	#
	Andromeda polifolia	Bog Rosemary	69	
	Barbarea stricta	Small-flowered yellow rocket	?3	()
M	Bupleurum tennuissimum	Slender hare's-ear	58	#
	Calamagrostis neglecta agg. (C. stricta + C. scotica)	Small reed	17	
	Cardamine impatiens	Narrow-leaved bitter-cress	47	
	Carex appropinquata	Fibrous tussock-rush	20	#
	Carex diandra	Lesser tussock-sedge	94	
M	Carex divisa	Divided sedge	79	
	Carex elongata	Elongated sedge	29	
	Carex magdellanica (paupercula)	Tall bog-sedge	46	
	Carex tometosa (filiformis)	Downy-fruited sedge	9	#
	Carex vulpina	True fox-sedge	19	
	Cuscuta europaea	Large dodder	36	
	Dactylorhiza (Dactylorchis) traunsteineri	Narrow-leaved marsh-orchid	18	#
	Deschampsia setacea	Bog hair-grass	36	#
	Dryopteris cristata	Crested buckler-fern	9	#
	Festuca altissima	Wood fescue	56	
	Fritillaria meleagris	Fritillary	22	
	Gentiana pneumonanthe	Marsh gentian	38	
	Impatiens noli-tangere	Touch-me-not balsam	?13	()
	Juncus filiformis	Thread rush	19	
	Lathyrus palustris	Marsh pea	17	
	Lepidotis inundata (Lycopodiella inundata, Lycopodium inundatum)	Marsh clubrush	53	#
	Mecanopsis cambrica	Welsh Poppy	34	(#)
	Mentha puligium	Penny-royal	43	
	Oenanthe pimpinelloides	Corky-fruited water-dropwort	94	
	Oenanthe silaifolia	Narrow-leaved water-dropwort	26	
M	Ophioglossum azoricum	Adder's-tongue	19	#
	Peucedanum palustre	Milk parsley	23	
	Poa palustris	Swamp meadow-grass	38	
	Polygonum minus	Small pepperwort	43	
	Polygonum mite	Tasteless pepperwort	44	
	Potentilla rupestris	Rock cinquefoil	4	
M	Puccinellia rupestris	Stiff saltmarsh-grass	51	
	Pulicaria vulgaris	Small fleabane	7	#
	Pyrola rotundifolia	Round-leaved wintergreen	41	#
	Ranunculus ophioglossifolius	Adder's-tongue spearwort	2	
	Rumex maritimus	Golden dock	83	
	Rumex palustris	Marsh dock	72	
	Scorzonera humilis	Viper's grass	1	#
	Scrophularia umbrosa	Green figwort	36	
	Sedum forsteranum	Rock stonecrop	48	()
	Sonchus palustris	Marsh sow-thistle	17	#
	Sorbus porrigentiformis	-	20	#
	Teucrium scordium	Water germander	3	#
	Thelypteris palustris (thelypteroides)	Marsh fern	98	
M	Trifolium squamosum	Sea clover	41	

Table A5 cont:

B. AQUATIC PLANTS RECORDED FROM MORE THAN 100 10 x 10km SQUARES IN GREAT BRITAIN, BUT WHICH NEED SPECIAL PROTECTION IN THE SEVERN-TRENT WATER AUTHORITY AREA

Apium inundatum	Lesser marshwort	
Baldellia ranunculoides	Lesser water-plantain	
Butomus umbellatus	Flowering rush	C
Callitriche hamulata (intermedia)	Intermediate water-starwort	
Carex acuta	Slender-tufted sedge	C
Carex acutiformis	Lesser pond-sedge	C
Carex elata	Tufted sedge	
Carex lasiocarpa	Slender sedge	
Carex limosa	Mud sedge	
Carex pseudocyperus	Cyperus sedge	C
Cladium mariscus	Great fen-sedge	
Drosera rotundifolia	Sundew	E
Eriophorum angustifolium	Common cotton-grass	SE
Groenlandia densa	Opposite-leaved pond-weed	W
Hottonia palustris	Water violet	
Hydrocharis morsus-ranae	Frogbit	()
Hypericum elodes	Marsh St John's wort	
Isoetes lacustris	Quillwort	
Lemna gibba	Fat duckweed	C
(Lemna) Spirodela polyrhiza	Greater duckweed	C
Littorella uniflora	Shoreweed	
Lobelia dortmanna	Water lobelia	
Menyanthes trifoliata	Bogbean	E
Myriophyllum alterniflorum	Alternate water-milfoil	
Oenanthe aquatica	Fine-leaved water-dropwort	SW
Oenanthe crocata	Hemlock water-dropwort	NE
Oenanthe fistulosa	Tubular water-dropwort	C
Phragmites australis (communis)	Common reed	Large stands
Potentilla palustris	Marsh cinquefoil	SE
Potamogeton alpinus	Red pondweed	
Potamogeton gramineus	Various-leaved pondweed	
Potamogeton lucens	Shining pondweed	C
Potamogeton obtusifolius	Blunt-leaved pondweed	
Potamogeton polygonifolius	Bog pondweed	
Potamogeton pusillus	Lesser pondweed	C
Ranunculus lingua	Greater spearwort	
Ranunculus omiophyllus(lenormandii)	Round-leaved crowfoot	SE
Ranunculus sceleratus	Celery-leaved buttercup	C
Rorippa amphibia	Great yellow-cress	C
Sagittaria sagittifolia	Arrow-head	C
Samolus valerandi	Brookweed	
Scirpus (Eleogiton) fluitans	Floating club-rush	
Scirpus (Schoenoplectus) lacustris ssp. tabernaemontani	Common bulrush/common club-rush	
M Scirpus maritimus	Sea club-rush	
Sparganium angustifolium	Floating bur-reed	#
Sparganium minimum	Least bur-reed	#
Stellaria palustris	Marsh stitchwort	
Typha angustifolia	Lesser reedmace/lesser bulrush	C
Utricularia minor	Lesser bladderwort	
Utricularia vulgaris/ australis (neglecta) agg.	Great bladderwort	
Veronica anagallis-aquatica	Blue water-speedwell	C
Zannichellia palustris	Horned pondweed	C

A3. HABITAT NEEDS AND SENSITIVITY OF PLANTS TO MANAGEMENT

There are no specific data available to indicate the precise habitat needs of river plants or their relative long-term sensitivity to different vegetation management practices. PHABSIM is a sophisticated method of attempting to determine habitat preferences for some invertebrates and fish species but it is not suitable for river plants. PHABSIM works on very precise measurements of in-channel features at the micro-scale but river plants respond to macro-scale habitats. When growing at modest rates plants can change local accretion and deposition of substrates and markedly alter flow velocities. Plants also respond to physical changes in flow themselves and are distinct habitats in their own right for many animals, utilized in different ways through their life cycles. Macrophytes thus are important determinants of habitat features in rivers which can be utilized by invertebrates and fish but defining precisely their own needs, when their growth alters habitat character, is very difficult.

The most comprehensive database on macrophyte distribution in Great Britain is held by the conservation agencies English Nature, Countryside Council for Wales, Scottish Natural Heritage and Joint Nature Conservation Committee. The majority of the information on the database was collected between 1978-1982 and 1988-1992 funded by the Nature Conservancy Council. For this reason the system is normally referred to as the 'NCC database'.

The information held by the NCC database comprises macrophyte species data for 1517 sites supported by field, and map-derived, data on in-stream habitats and channel characteristics as well as information on physical attributes such as geology, channel gradient, height etc. Species data relate to aquatic and wetland species recorded within the river channel and at the base of banks within 500m survey lengths; most 'site' information comprises two contiguous 500m lengths.

The NCC macrophyte database, when comprising only 1,055 sites, in 1982 was successfully used to develop a river classification (Holmes; 1983) which has formed the basis of river typing for SSSI selection and many other procedures. Details of the method and its results are available in DoE (1987) and a descriptive summary in Holmes (1989). The addition of new data ten years later confirmed the reliability of the system and resulted in expansion of the database and a refinement to the classification (Holmes & Rowell; in prep).

It is clear that, despite the presence of a major database, it is not possible to determine precise habitat needs of macrophytes at present. However the comprehensive database was utilized in some recent research by Holmes (1995) in a report to the Institute of Hydrology. This was carried out for MAFF to ascertain if the available database could determine if macrophyte associations with channel characteristics could be better defined than at present. The rationale for this was that IF this could be done, the results could be utilized to consider the potential for developing macrophyte-habitat relationships which would equate to simple habitat preferences. The Ministry were keen to see if clearer relationships between macrophytes and habitats could be determined so that where hydraulic regimes change, brought about by whatever means, the consequences of these may be better considered.

The interrogation of the database identified that several species have very clear associations with particular substrate, flow and depth categories. Further work is ongoing before the

results will be published. However the findings gave support to the majority of the general conclusions on habitat preferences previously produced in the *Rivers & Wildlife Handbook.* (RSPB, RSNC/NRA; 1994). For information the habitat preferences for Aquatic, Marginal and Bank Edge species which are contained within that book are reproduced as Table A3.

A4. RIVER VEGETATION MANAGEMENT - EFFECT ON VEGETATION STRUCTURE

To assist members of the team in assessing 'impact' of various scenarios of management on their sphere of expertise (eg Birds, Fish, Invertebrates, Plants) a series of drawings and notes were compiled. They included sketches of the most common practices of aquatic 'weed' and bankside herbage maintenance and are included here for information.

A4.1 Aquatic Vegetation Control

A variety of methods are commonly employed for routine control of aquatic vegetation. Mechanical methods are the most commonly used, ranging from cutting (by hand or by mechanical means attached to boats or land-based machines), raking out by the roots, or removal with the silt into which they root by mechanical dredgers. Herbicides are occasionally used, but not on rivers used for potable supply, as is biological control such as grazing by carp or by shading from bankside trees.

No consideration of biological control will be given here but as long-term 'best' (environmental and cost) management practice they should be assessed in management planning for a catchment where vegetation control is routinely, and extensively, carried out.

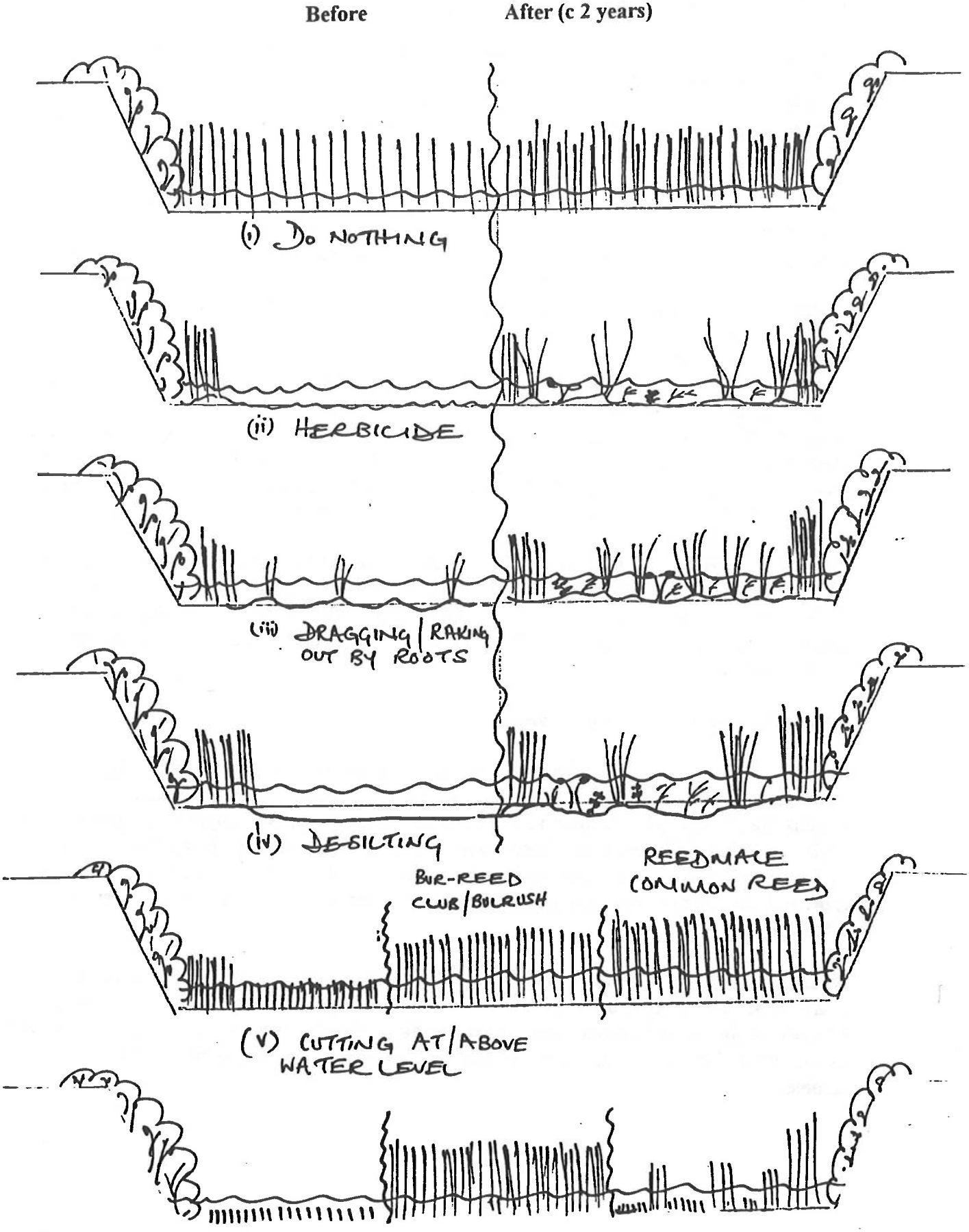
A4.1.1 Emergent vegetation

Figure A2 illustrates the most common methods for control of emergent reeds shown for watercourses less than 5m wide. The figure shows a channel choked by reeds, possibly of low botanical interest but probably of greater interest for other groups. Different reeds respond differently to different management practices and this fact should be always considered when determining best practice for the environment or cost-effective. Good Practice dictates that all show the retention of at least a narrow margin untouched for future re-colonization of flora and fauna (exceptions are the narrowest of channels <2m wide which may be choked by a single species of reed and delaying its spread back into the channel may be desirable).

Reed control is most likely where gradient is very slack, and substrates are clay or silt.

Figure A2i: No management of choked channel. Channel will remain very similar or may even become more blocked. Where there is a reasonable gradient it is possible a very

Figure A2: Control of emergent vegetation - Watercourse choked from bank to bank



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narrow low-flow channel will be created through the middle of the reeds or erosion of the bank on one-side of the choked channel will create a low-flow 'riffle'.

Figure A2ii: Herbicide. Note it is essential that only small linear lengths are treated otherwise serious de-oxygenation occurs and animal mortalities are common. It shows that complete clearance can be achieved immediately for the target areas with a more diverse community of plants established after 1-3 years with submerged and floating-leaved species taking advantage of the reduced area of reed.
Figure A2iii: Complete removal of shoots and roots by mechanical raking. Less reed growth is typical for up to a maximum of three years, in the intervening period a wider variety of macrophytes may occur as less competitive species occupy the new open areas.
Figure A2iv: Dredging out of whole plants together with silt. As above, but clearance is more comprehensive so larger open areas are colonized for up to two or three years by more submerged macrophytes. If suitable aquatic higher plants are not available to colonize the open spaces, the release of nutrients can lead to algal blooms.
Figure A2v: Cutting emergents above, or at, the water surface OR below water level in winter. Temporary loss of cover until following year when density of cover is likely to be as great, if not greater, than before.
Figure A2vi: Cutting reed below water level in growing season. For Bur-reed and Bulrush re-growth may occur rapidly, even in the same year, with no diminution of cover the following year. For Reedmace and Common Reed the majority of plants will be killed if cut underwater in the growing season. Some resultant space will be colonized by other macrophytes but the root mat often delays growth for several years.
Figure A3 illustrates the management of a channel choked by reeds using either desilting or raking. Desilting normally completely removes the plant material from the affected widths while dragging and raking normally leaves fragments behind, removing the largest and most invasive species preferentially. For both methods the consequences of 90%, 80% and 50% removal are shown.

A4.1.2 Floating and submerged vegetation

Figure A4 shows control of submerged vegetation which is choking a channel >5m wide. In many cases emergent and submergent vegetation occurs together and vegetation management options are considered according to the dominant form or the one causing the 'problem'. In chalk, and other high base-flow, River-crowfoot is often the main aquatic that is controlled. In such streams 'weed' is often cut early in the spring to reduce water levels but this stimulates growth; if left, natural die-back occurs later in the year and growth in the following years is often reduced.

Aquatic 'weed' problems are greatest in low-gradient rivers of moderate width (they are characteristically uncommon in narrow watercourses except chalk streams and winterbournes). Greatest problems are encountered on low gradient, silt/clay bed rivers but rivers with high base-flows and moderate gradients typically have abundant crowfoot in spring and cress in late summer.

Figure A3: Reed choked channels: Retention of 10%, 20% and 50% of reed in two scenarios, desilting (i-iii) and dragging /raking (iv-v).

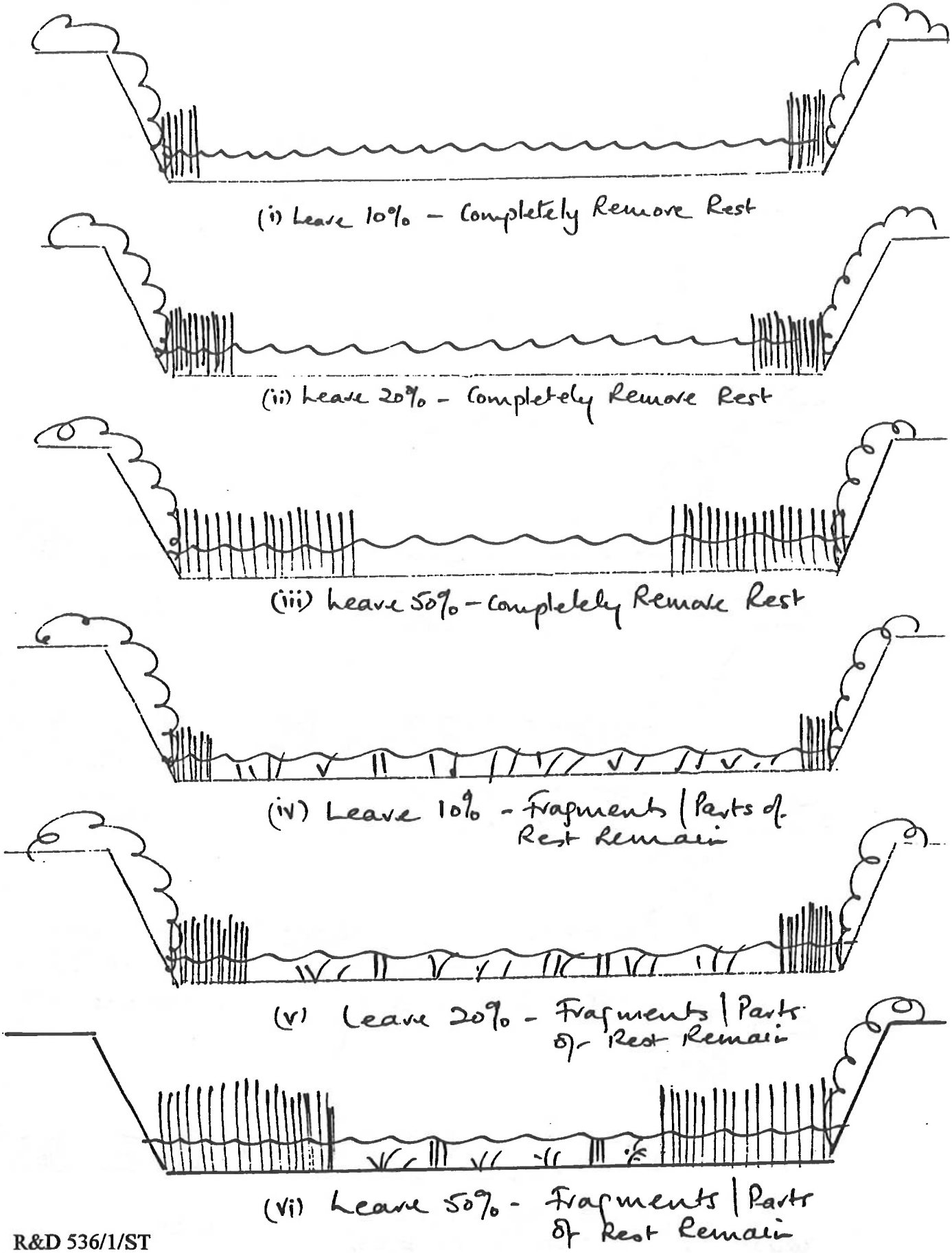
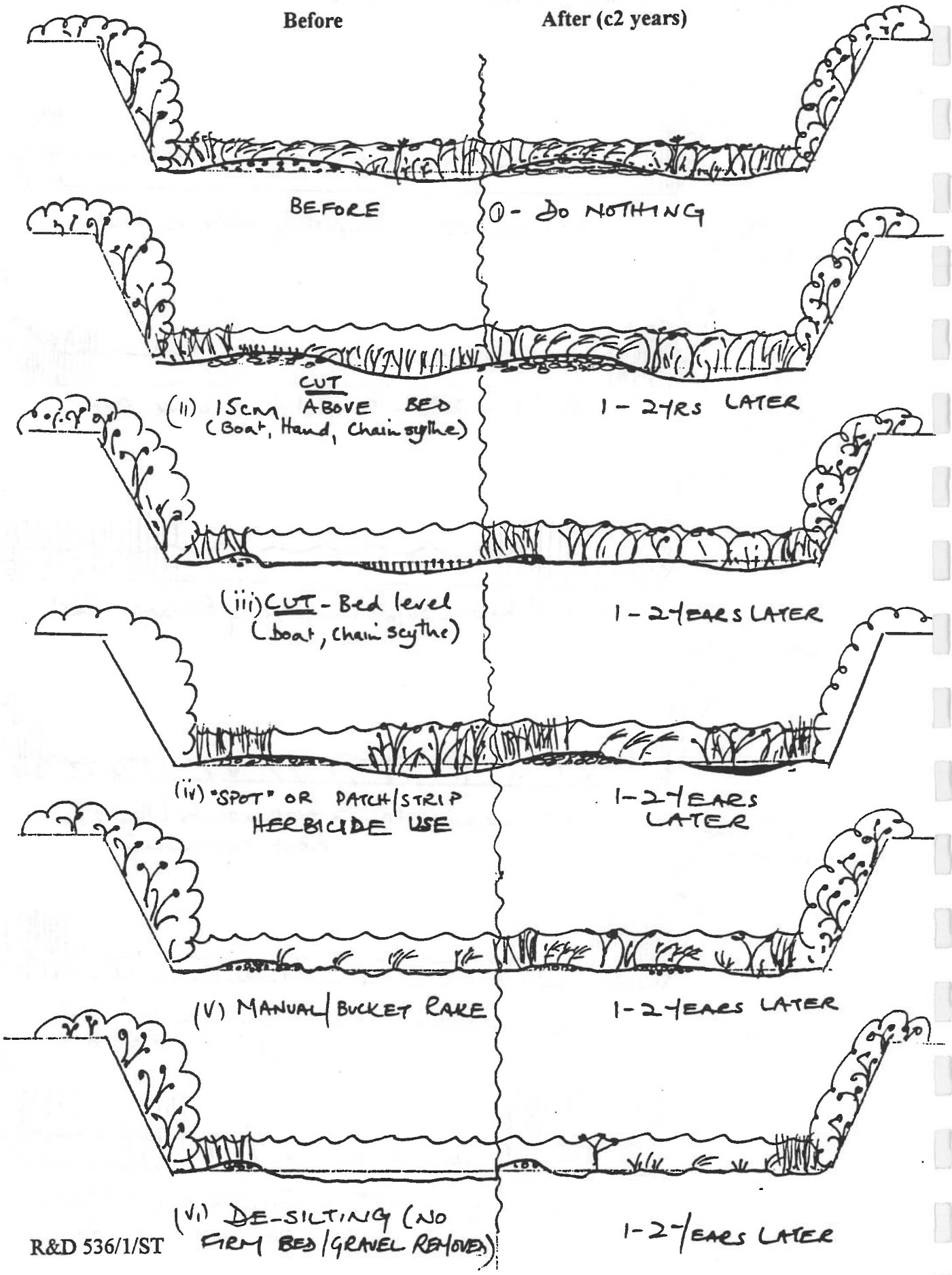


Figure A4: Scenarios for aquatic vegetation management in a channel >5m wide.



Six typical scenarios are shown on Figure A4.

Figure A4i: Do nothing. In many streams the effects of lack of control of submerged vegetation cannot be predicted. In some it may result in the development of more emergent growth whilst in others it may result in long-term reductions in cover and some self-sustaining increase in the variety of flow-related habitats and substrate characteristics.

Figure A4ii: Cut well above the river bed level. This maintains the variety of undulations on the river bed and helps encourage the return of similar cover and species by the following year.

Figure A4iii: Cut at bed level. Mechanical cutters set very low to the bed disturb substrates and increase the uniformity of flow characteristics and hence flora; this is minimised if only a narrow channel is cut through a broader bed-width so self-cleansing faster flows are maintained (and variety of substrate and water velocities result).

Figure A4iv: Herbicide. It is essential that only small patches or linear lengths are treated otherwise serious de-oxygenation can occur with animal moralities common. Almost complete clearance can be achieved for the target areas with a more diverse community of plants establishing soon after; within 2-3 years the previous assemblage is normally restored. If narrow cuts are made within broader bed-widths the same increase in flow and substrate diversity cited for 4iii should result.

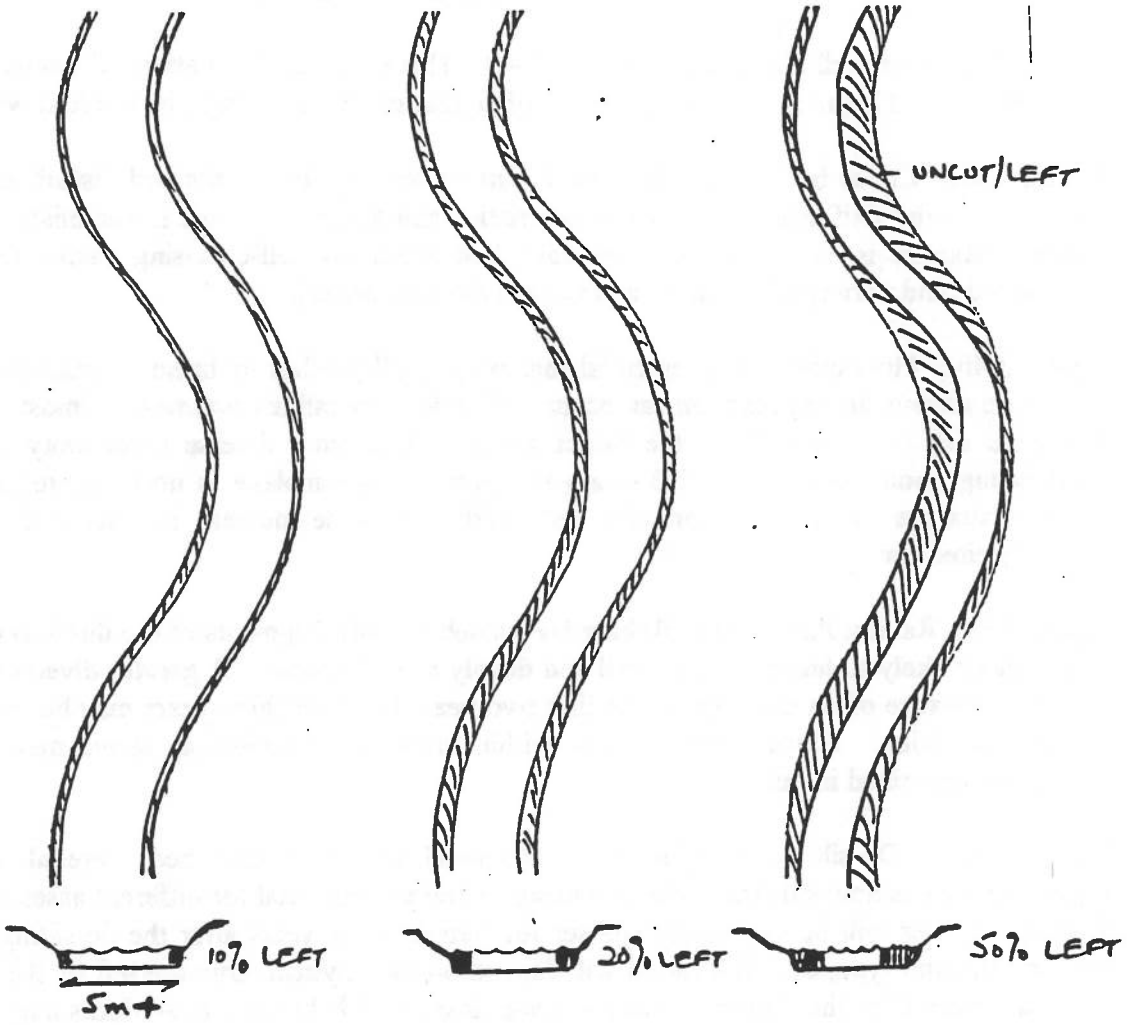
Figure A4v: Raking/Pulling out. Raking leaves behind only fragments of the dominant species and is more likely to leave behind small and deeply rooted species. A greater diversity of, but sparser, structure often develops in the first two years but after three years may be back to its original condition. Narrow channels cut within broader bed-widths as above may produce conditions described in 4iii.

Figure A4vi: De-silting/Dredging out. Removal of the surface bed material with the vegetation leaves new substrates for colonization and the potential for different assemblages to develop. Cover will be commonly sparser for two or more years after the de-silting but the precise rate, and type, of colonization will depend on the physical structure left by the physical structure created by the digger. Narrow channels cut within broader bed-widths may produce conditions as in A4iii.

Patterns of cutting

Within a river, different widths may be left uncut for either emergent or aquatic vegetation. Examples are given in Figure A5. This shows that in wide channels it should be possible to assist in mimicking the natural flow preferences of rivers by having meandering cuts within a broader river. Thus cutting can accentuate or create the natural effects of bends.

Figure A5: Planform illustration of 10%, 20% and 50% uncut areas for channels >5m wide.



A4.2 Bank Vegetation Control - Mowing/Flailing

Figures A6 - A8 depict common or increasingly common scenarios of bank vegetation management. Figure A6 shows a river bank and immediate land where mowing has been historically executed on the whole area, at least annually and often up to five or six times per year. This has resulted in short grass swards through the summer with no tall rank vegetation.

Figure A6 shows five scenarios.

Figure A6i: Mowing ceases altogether. Gradually vegetation becomes taller and more rank, probably with great increases in tall herbs before the possible natural establishment of bramble and shrubs after five years.

Figure A6ii: Mowing reduced to once every two years. In year one greater structure and height of vegetation but little change in community; year two the vegetation structure returns to conditions evident at the start but in years three, five, seven etc the assemblage becomes slowly more diverse which in turn gives better variety of structure. Biennial mowing stops scrub development. Options for A6ii are (a) spring or summer cut; (b) autumn cut after flowers have set seed but in time for vegetation to be short in time for winter.

Figure A6iii: Strip of bank left uncut at top of bank. In year one the vegetation is taller but no more species-rich. In years two and three the strip develops a more herb-rich community and develops a more rank and matted character. As the development of taller and rank vegetation continues the richness of the plant communities deteriorates and shrubs and bramble may invade. Figure A8 shows how continuity of a more diverse structure of vegetation on bank-tops might be achieved through periodic maintenance if development to scrub is not permissible.

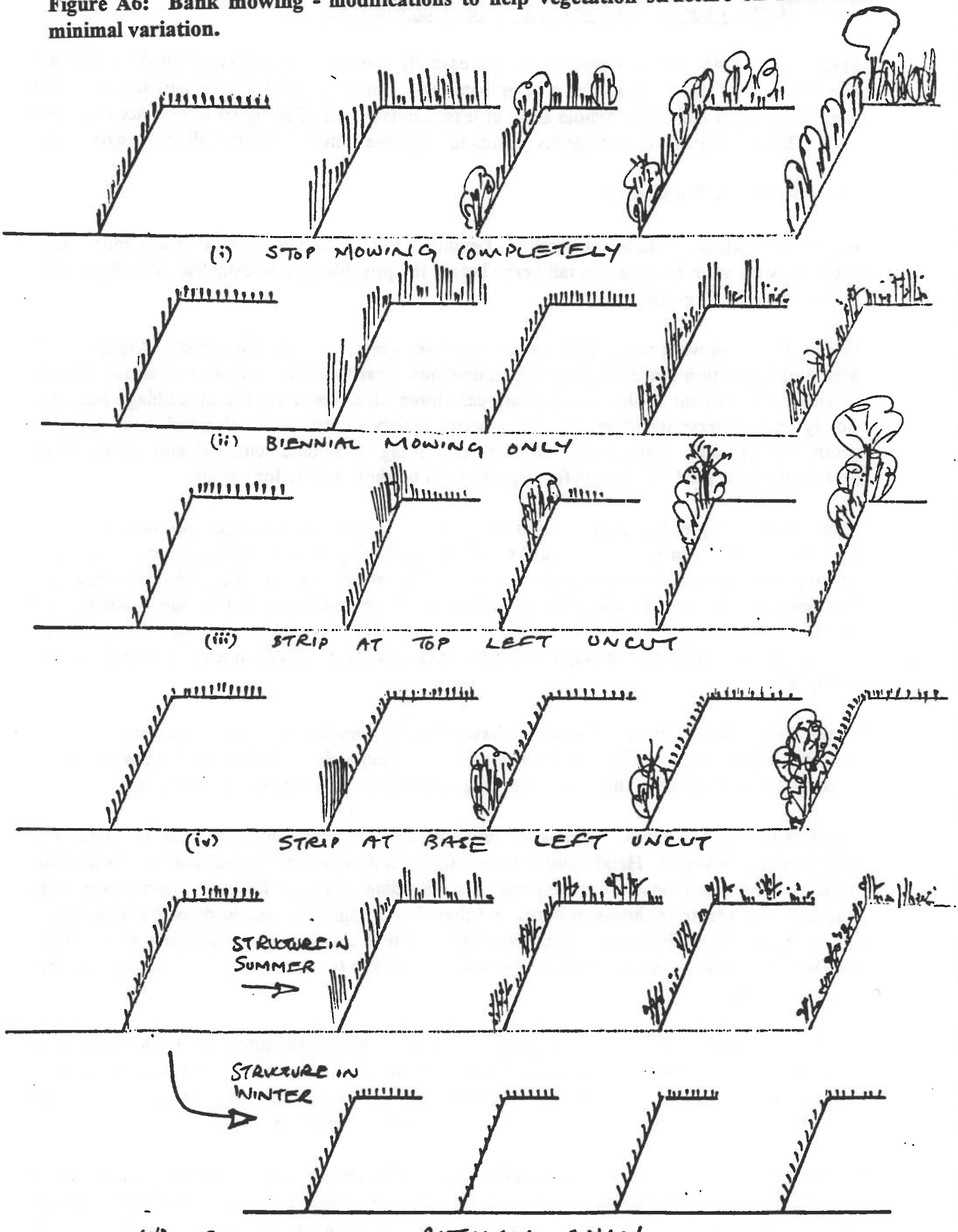
Figure A6iv: Strip of bank left uncut at base of bank. Development and management options and illustrations as for A6iii. Taller vegetation may encroach, or arch over, the margin of the stream/ditch bed affecting the flora here (biggest effect on very narrow watercourses).

Figure A6v: Single annual cut delayed until autumn. Structure following cut in winter and early spring unchanged. Height and structure of vegetation in summer and autumn much more varied and no disturbance from frequent cuts. Seeding of sparse herbs in grass sward leads gradually to a greater richness of herbs and therefore a slight increase in diversity of structure too. Figure A6v(a) shows the vegetation structure that develops in the summer while Figure A6v(b) shows that the sward character in winter is similar to that arising from multiple cutting in summer and autumn.

For narrow channels (particularly those with high steep banks) the effect of shading and cover of tall herbage, and especially trees and shrubs, is proportionally much greater than for wide channels and those with shallowly sloping banks. It is in narrow and deep-sided watercourses where tall bank herbage can even affect in-stream plant communities.

Figures A7 and A8 shows annual/biennial/less frequent bankside mowing/flailing on a rotational basis. The scenarios lead to the continual presence of some tall and more diverse structure on at least one bank. This enables seeding of herbs etc to take place providing

Figure A6: Bank mowing - modifications to help vegetation structure on bank with minimal variation.



opportunities for their increased cover over time. This ultimately may change the species composition, but more significantly will lead to diversity of habitat structure for animals provided by the vegetation.

Herbicide is not recommended as a routine method of bank vegetation management unless it is to be used in attempts to eradicate harmful aliens. In such circumstances NRA Guidelines should be followed. No herbicides ever to be used where potential for drift to enter potable supplies (without very precise instructions).

Tree Surgery to enable machine access for mowing, or limb removal for improved/restored conveyance, should follow NRA Guidelines. Large-scale clearance may well result in the need for new or increased aquatic vegetation management as a natural control mechanism is being removed.)

Grazing (not illustrated) is often a feasible and favoured management option where banks are of a shallow gradient (usually less than 30 degrees). Grazing and trampling intensity will often dictate environmental desirability of option, with some local fence protection needed for sensitive areas or where rehabilitation works/planting been recently carried out.

Figure A7: Maintaining structural diversity but stopping shrub development

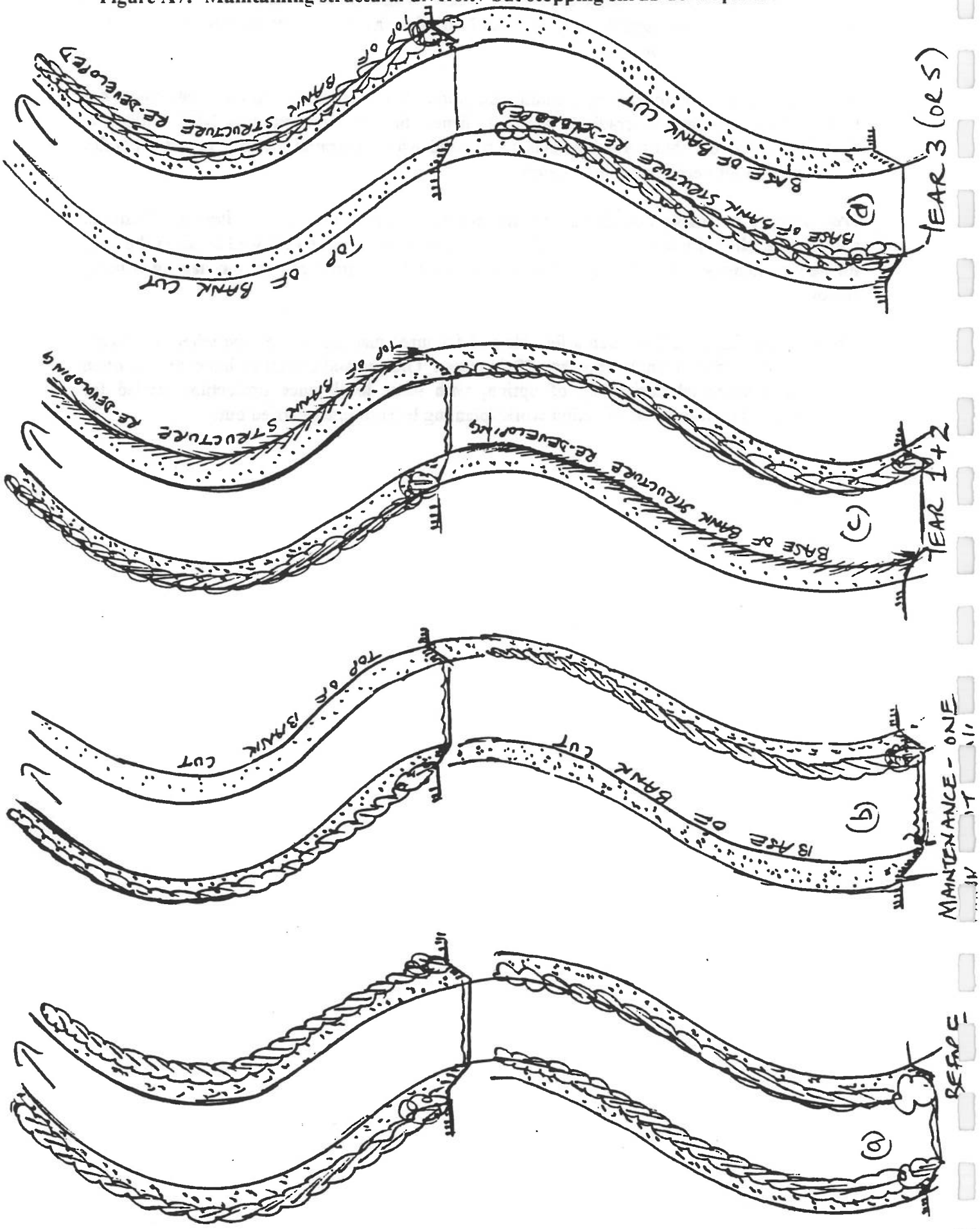
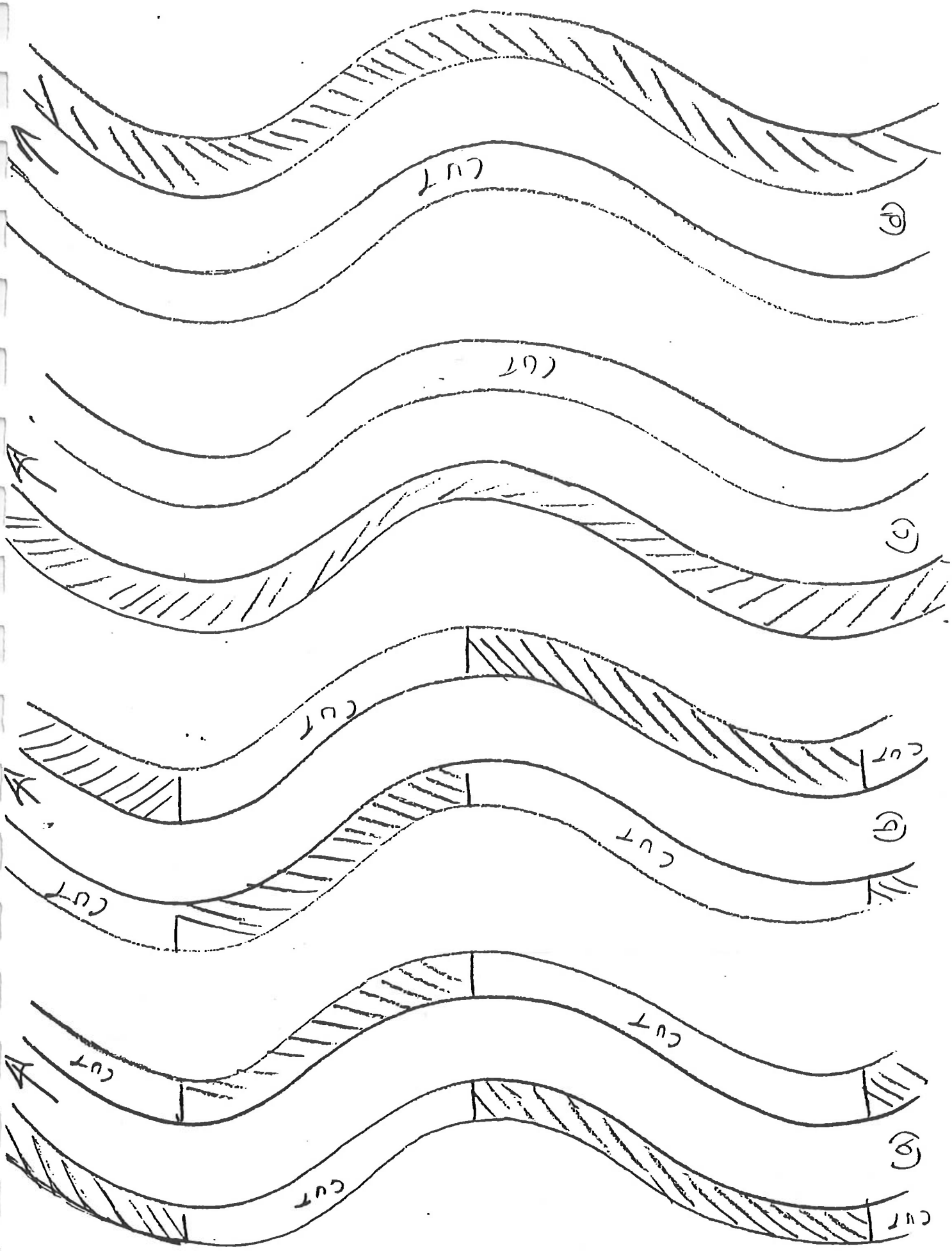


Figure A8: Patterns of bank mowing: a/b alternating sides frequently to keep habitat continuity: c/d alternating sides infrequently - habitat continuity lost



Appendix B - AQUATIC INVERTEBRATES

B1. SCOPE

The effects of various management options have been considered on aquatic species only; the effects on terrestrial species directly or indirectly affected by river vegetation management may be quite different, and quite at odds with that on the aquatics. The following definition of an aquatic invertebrate has been adopted:

> *"A species which for one or more active stage lives beneath or on the surface of free water, or within or at the water table in mud, silt, sand, gravel or shingle."*

Only macroscopic invertebrates are considered, reflecting that microscopic groups are generally too poorly known to be of value for assessment and monitoring of riverine ecology, and for the effects of particular vegetation management to be predicted.

There is no consistent taxonomic level in the end taxa listed; they are those in common use, or those in which all (or nearly all) of the members are aquatic. Families have been a convenient end-point in the taxonomic breakdown, partly because they are used in Biological Monitoring Working Party scoring. However it must be emphasised that identification to the species level is generally essential for adequate conservation assessment and planning. There are a number of occasions where the end-point is less defined usually where only some members of a family are aquatic. Often, these families include species whose larval ecology is unknown.

Taxa placed in brackets are those which, because of taxonomic difficulties or ignorance of their status and ecology, are given little or no consideration in preparing the tables and texts in this report.

This list given in Table B1 is conservative. There are many species which develop or live permanently in very wet waterside situations which are insufficiently known to be sure of the importance of their relationship with permanent water or with the water table within the sediment. These have generally been omitted from the list. The beetle families Carabidae and Staphylinidae have been included, but are bracketed; both families have many hydrophilic species, but probably few which approach the definition of "aquatic" used here.

Each taxon has been scored on a five-point scale (- = very unlikely to occur; . = occasional; + occurring infrequently, or regularly but in small numbers of individuals or species; ++ = occurring regularly; +++ = almost invariably present and well-represented, provided water quality etc. permit) to reflect the likelihood of its occurrence.

In view of the range of habitats available to invertebrates in each of the river categories, this section defines just three broad river types. These are fast-flowing, bed largely of stones (F) (some examples of river types 1, 2, 5,6, 9, 10, 13, 14); slow-flowing larger river, bed mainly mud/silt (S) (River types 15, 16); drainage ditch in artificial channel (D) (River types 2, 4, 6, 8). Inevitably, it has occasionally proved difficult to apply such a small number of categories. They do not represent a full range of river types. There might be argument over the placing of some species. However, the overall picture should be accurate.

Table B1: Associations of invertebrates with different river types.

	F	S	D	Notes
Porifera				
Spongillidae	++	++	.	
Cnidaria				
Hydrozoa				
Clavidae	-	+	.	
Hydridae	+	+	+	
Olindiidae	-	.	.	
Platyhelminthes				
Turbellaria				
Microturbellaria	.	+	+	
Tricladida	+	+	+	
Nemertea	-	.	.	
Nematoda	+++	+++	+++	
Nematomorpha	-	-	.	
Annelida				
Oligochaeta				
Aeolosomatidae	-	.	.	
Enchytraeidae	.	.	.	
Lumbricidae	+	+	.	
Lumbriculidae	+	+	+	
Naididae	-	+	+	
Tubificidae	.	+	++	
Hirudinea				
Erpobdellidae	.	++	++	
Glossiphoniidae	++	++	++	
Hirudinidae	-	.	+	
Piscicolidae	+	.	-	
Bryozoa	+	+	+	
Mollusca				
Ancylidae	+	+	+	
Dreissenidae	-	+	-	
Hydrobiidae	+	++	++	
Lymnaeidae	.	++	+++	
Neritidae	+	+	-	
Physidae	.	+	++	
Pisidiidae	+	++	+	
Planorbidae	.	++	+++	
Sphaeriidae	+	++	+	
Unionidae	+	++	+	
Valvatidae	-	+	++	
Viviparidae	-	++	-	
Chelicerata				
Arachnida				

Hydracarina	.	++	++	
Oribatei	.	.	.	few species
Araneae				
Agelenidae	-	-	+	
Crustacea				
Anostraca	-	-	-	
Notostraca	-	-	-	
Ctenopoda	-	.	+	
Anomopoda	-	.	+	
Onychopoda	-	.	+	
Haplopoda	-	-	-	
Copepoda	-	.	+	
Ostracoda	-	.	+	
Malacostraca				
Bathynellacea	.	-	-	interstitial
Mysidacea	-	.	-	
Amphipoda				
Corophiidae	+	+	-	
Gammaridae	+++	++	++	
Isopoda				
Asellidae	++	++	+++	
Decapoda				
Astacidae	++	+	-	
Grapsidae	-	.	-	
Uniramia				
Insecta				
Collembola	.	.	.	
Coleoptera				
[Carabidae]				
Chrysomelidae	-	++	+++	
Curculionidae	-	+	+++	
Dryopidae	+	+	++	
Dytiscidae	+	++	+++	
Elmidae	+++	+	+	
Gyrinidae	+	+	++	
Haliplidae	+	++	+++	
Hydrophilidae	.	++	+++	
Hygrobiidae	-	.	+	
Hydraenidae	+	+	++	
Noteridae	-	+	++	
Psephenidae	+	-	-	
Scirtidae	.	.	+	
[Staphylinidae]				
Diptera				
Athericidae	++	.	-	
Ceratopogonidae	+	+	+	
Chaoboridae	-	.	+	
Chironomidae	++	+++	+++	

Culicidae	-	.	++	
Dixidae	+	.	++	
Dolichopodidae	+	++	+++	
Empididae	+	+	+	Hemerodromiinae and Clinocerinae
Ephydridae	+	++	+++	
Muscidae	+	+	+	
[Psychodidae]				
Ptychopteridae	.	+	++	
Rhagionidae	+	-	-	
Sciomyzidae	-	++	+++	
Simuliidae	+++	+	.	
Stratiomyidae	+	+	++	
Syrphidae	.	++	+++	Chrysogasterini , Sericomyini and Eristalini
Tabanidae	.	+	+	
Thaumaleidae	+	.	-	
Tipulidae	++	++	+++	
Ephemeroptera				
Baetidae	++	+	+	
Caenidae	.	++	+	
Ephemeridae	++	+	-	
Ephemerellidae	++	-	-	
Heptageniidae	+++	-	-	
Leptophlebiidae	.	++	+	
Potamanthidae	+	+	-	
Siphlonuridae	++	-	-	
Hemiptera				
Aphelocheiridae	+	+	-	
Corixidae	.	+	++	
Dipsocoridae	+	.	.	
Gerridae	+	++	+++	
Hebridae	-	-	+	
Hydrometridae	.	+	+	
Mesoveliidae	-	.	+	
Naucoridae	-	+	+	
Nepidae	-	+	+	
Notonectidae	-	+	+	
Pleidae	-	+	+	
Veliidae	++	.	.	
Hymenoptera				
Mymaridae	.	+	+	
Lepidoptera				
Pyralidae	-	+	++	Elophila, Nymphula, Parapoynx, Cataclista, Acentria
Neuroptera				
Osmylidae	+	-	-	
Sialidae	++	++	++	
Sisyridae	++	+	+	

Odonata	+	++	+++
Aeshnidae	-	++	++
Calopterygidae	+	++	-
Coenagriidae	.	++	+++
Cordulegastridae	+	-	-
Corduliidae	-	.	.
Gomphidae	-	.	-
Lestidae	-	+	+
Libellulidae	-	++	++
Platycnemidae	+	.	-
Plecoptera	+++	.	.
Capniidae	++	-	-
Chloroperlidae	+++	-	-
Leuctridae	+++	-	-
Nemouridae	+++	.	.
Perlidae	+++	-	-
Perlodidae	+++	.	-
Taeniopterygidae	+++	-	-
Trichoptera	+++	+++	+++
Beraeidae	.	-	.
Brachycentridae	++	-	-
Ecnomidae	-	.	-
Glossosomatidae	+++	-	-
Goeridae	++	.	-
Hydroptilidae	++	++	+
Hydropsychidae	+++	+	-
Lepidostomatidae	+	++	.
Leptoceridae .	++	+++	
Limnephilidae	+++	+++	+++
Molannidae	++	++	+
Odontoceridae	++	-	-
Philopotamidae	+++	-	-
Phryganeidae	.	+	++
Polycentropidae	++	+	.
Psychomyidae	++	++	.
Rhyacophilidae	+++	-	-
Sericostomatidae	++	.	-

B2. FACTORS WHICH AFFECT THE QUALITY OF AQUATIC RIVERINE INVERTEBRATE FAUNA

Site history, water quality, water chemistry and substrate characteristics are clearly important factors in determining faunal quality. They are, however, peripheral to the present project and are not considered further. The following factors are more directly relevant.

B2.1 Habitat variety

The more varied a habitat, and the greater the variety of habitats present along a river stretch, the greater the range of invertebrates that could potentially be supported. There are several components to this variety:

B2.1.1 Physical structure

The importance of within-channel structural variation for invertebrates is well-known: riffle and pool structure gives variety of sediment and flow, greater variety of invertebrates than more uniform structure induced by management. Further variety is added by additional in-channel features, such as fallen logs, submerged tree roots and large rocks.

B2.1.2 Vegetation structure and distribution

Three types of vegetation distribution may conveniently be considered: scattered, clumped, and dense.

Scattered vegetation, where small plants or individual stems of emergents are separated from one another by open water gaps are generally of little value for invertebrates.

Clumped vegetation, in which large plants or clusters of plants form patches which may be of different sizes.

Dense vegetation, where a continuous bed of vegetation forms over a large area with no large gaps of open water between plants, forms the best habitat.

Tall dense emergent vegetation can damage the invertebrate fauna of narrow channels by casting dense shade which leads to reduced temperatures, making them unsuitable for a wide range of thermophilic invertebrates. Dense emergent stands do provide important habitat.

The distribution of vegetation within the water column is also important. Invertebrate communities will usually be better where the vegetation reaches, or approaches, the water surface.

Different species of aquatic and marginal plants are very different in structure, and differ widely in the range of invertebrates they support. Mosses form very dense vegetation clumps, or even large beds, and support a wide range of invertebrates. Plants with feathery leaves, such as the water milfoil , when they form dense beds, provide a good structure for many invertebrates. Flooded grasses provide one of the richest vegetation types for some invertebrates, perhaps particularly water beetles. Water starwort is generally poor in invertebrates. Floating leaves are used by a wide range of invertebrates.

Table B2: Invertebrate /plant associations

1 = High invertebrate potential
2 = Moderate invertebrate potential
3 = Low invertebrate potential

R 1 = Red Data Book category 1 (Endangered)
R2 = Red Data Book category 2 (Vulnerable)
R3 = Red Data Book category 3 (Rare)
Na = Nationally Notable (Nationally Scarce) category A - believed to occur in sixteen to thirty ten-kilometre squares of the National Grid in Britain.
Nb = Nationally Notable (Nationally Scarce) category B - believed to occur in thirty-one to one hundred ten-kilometre squares of the National Grid in Britain.

Emergent plants		
Acorus calamus	3	no significant interest
Butomus umbellatus Flowering Rush	2	some non-aquatics associated with above-water stems and flowers; forms dense beds which can be good in slow-flowing water; foodplant of the weevil *Bagous nodulosus* (R1).
Carex spp. Sedges	1-2	a large associated fauna, esp. of phytophagous species and including the aquatics *Donacia thalassina* (Nb) and *Plateumaris affinis* (Nb) but also of species associated with litter; tussock-forming species especially important in lowland Britain, where there is a considerable fauna associated specifically with tussocks
Glyceria maxima Reed Sweet-grass	1	a range of phytophagous species feeding directly on the plant, also a rich community associated with the leaf litter, accumulated mud and silt, etc
Juncus spp. Rushes	1-2	a wide range of phytophagous species, also many species amongst litter and, especially, species living in dense tussocks
Phragmites australis Common Reed	1	a very important foodplant for a wide range of phytophagous species; a large fauna also associated with mud between stems and with litter, and others use dead hollow stems. The best invertebrate communities, in terms of representation of scarce species, are probably in beds where there is little litter build-up. Reeds standing in permanent water are of comparatively little interest. Specific aquatic phytophages include the reed beetles *Donacia cinerea* (Nb), *D. clavipes* (Nb), and *Plateumaris braccata* (Na).
Sagittaria sagittifolia Arrowhead	3	few specific invertebrates, and structurally rather poor for invertebrates, but the host plant for the scarce reed beetle *Donacia dentata* (Na).

Scirpus lacustris /tabernaemontani Clubrush	2	dense stands can support a moderate fauna, mostly not host-specific; provides good shelter and build-up of drift litter and sediment in moderately fast waters; scarce species associated include the reed beetle *Donacia impressa* (Na).
Sparganium erectum Branched Bur-reed	2	phytophagous species include the reed beetle *Donacia bicolora* (R2); fauna associated with litter and associated mud/silt generally poorer than those of *Glyceria*, e.g., but rather similar in overall character
Typha latifolia Bulrush	1	a number of phytophagous species are Typha-specific; several feed in the developing seedhead. Others sue the hollow stems, and some develop or live permanently between the leaf-sheaths. The rhizomes and their associated litter and mud may hold considerable invertebrate communities
Floating Plants		
Lemna spp Duckweed	3	a number of invertebrates may occur among *Lemna*, and the weevil *Tanysphyrus lemnae* is specific to the genus, but in general the plant is a pain
Glyceria fluitans (and other grasses) Sweet-grasses	1	a number of grass-feeding phytophages, though few species-specific, also many aquatic species amongst submerged and floating leaves, and especially good for water beetles. *G. fluitans* probably the preferred host of the reed beetle *Donacia aquatica* (R3) and a host of the weevil *Bagous cylindrus* (R2).
Nuphar/Nymphaea Waterlilies	2	some specific phytophages, notably including the reed beetle *Donacia crassipes* (Nb), but most use by invertebrates comes from those using the floating leaves as a resting/hunting/mating platform.
Potamogeton natans Broad-leaved Pondweed	2	at least one specific phytophage, the reed beetle Donacia versicolorea, but chiefly exploited by invertebrates using the floating leaves as a resting/hunting/mating platform.
Sparganium emersum Unbranched Bur-reed	3	generally rather species-poor, probably because structurally poor for invertebrates, but specific phytophages include the reed beetle *Donacia sparganii* (Na).
Submerged Plants		
Callitriche stagnalis Common Water-starwort	3	generally poor in species except where part of a mixed stand, populations of some species, esp. molluscs, can be very large
Ceratophyllum submersum Hornwort	2	structurally suitable for quite a wide range of invertebrates, and often with a fairly rich community, but the sorts of conditions in which it grows mean that the water bodies are often inherently rather species-poor for invertebrates. Host plant for the weevil *Bagous subcarinatus* (Nb).

Elodea canadensis Canadian Pondweed	2	structurally fairly good for invertebrates, but lacking specific phytophages and generally supporting a good range of common generalists rather than species of particular interest. The frequent occurrence of this plant in mid-channel and deeper water, and in watercourses which are inherently of rather low invertebrate interest, may bias the estimate of this species' invertebrate interest downward
mosses	1	structure somewhat varied, but in almost all cases very good for invertebrates, especially small ones, in providing abundant sheltered small spaces relatively free from large predators; mosses provide almost the only vegetation providing good shelter in fast-flowing water, and many species use them, both when submerged and when soaked at margins; *Sphagnum* at the margins may contain almost the entire aquatic fauna of some small acid streams
Myriophyllum spicatum Spiked Water-milfoil	1	structurally good for invertebrates and often supporting a very rich fauna, especially where growth is dense. It is a host of the reed beetle *Macroplea appendiculata* (R3) and specific phytophagous species include the weevils *Bagous longitarsis* (R1), *Eubrychius velutus* (Nb), *Litodactylus leucogaster* (Nb) and *Phytobius canaliculatus* (Nb).
Potamogeton spp. Pondweeds	2	few specific phytophages, and generally with only moderate invertebrate interest. Finer-leaved species generally support greater interest than broader-leaved forms, and dense growths more than sparser growths. The reed beetles *Macroplea appendiculata* (R3) and *M. mutica* (Na) (probably not truly specifically distinct) are both associated with the genus, the latter particularly with *P. pectinatus*. The weevil *Bagous limosus* (Nb) is an associate.
Ranunculus spp. Water-crowfoots	2-3	few to no specific phytophages; dense beds of the larger species can be useful for a range of invertebrates, especially in flowing water where it may be the chief or only aquatic macrophyte. Fauna in fast flowing waters is somewhat limited, in still waters dense growths can hold quite good faunas although not as good as the similarly structured *Myriophyllum* for example

B2.2 Habitat quantity

Large areas of a particular habitat support richer invertebrate communities and have a better representation of scarce species than small ones, because:

- they can support larger populations
- a large area of the major habitat type may be needed to provide sufficient of the particular micro-habitat needed by any one species; the presence of large areas of habitat is particularly important for scarcer and more specialised species.
- the greater the extent of a particular habitat type, the more stable it is likely to be, and therefore the more likely it is to support rich invertebrate communities in the long term: the habitat should not remain the same from year to year, but should contain the same habitat components in roughly the same amounts.

B2.3 Flow rate and regime

Invertebrates in the main bodies of fast-flowing rivers occur predominantly in or on the sediment or substrate. Even extensive vegetation in fast-flowing water tends to be rather poor in invertebrates compared to vegetation in slow-flowing waters. In contrast, dense vegetation in the virtually static water of a ditch may contain most of the ditch's invertebrate fauna. The differences between the faunas of still and flowing water are, however, less towards the margins than towards the centres of the channels. Vegetation management is likely to have less direct impact on the fauna of fast-flowing than of slow-flowing water.

B2.4 Bank vegetation

Bank vegetation can affect the invertebrate fauna by casting shade on the water, thereby reducing plant growth and cooling the water; by shedding leaves and other dead parts into the water, where they may provide food and habitat, or affect the nature of sediments through their decay; by influencing the nature of run-off from surrounding land; by providing resting, hunting and emergence areas for terrestrial adult insects with aquatic larvae; by providing shelter, blocking the wind and increasing local temperatures. The balance of beneficial and harmful effects of different vegetation structures varies greatly according to channel type.

B3 RATIONALE TO IDENTIFICATION OF LEVELS OF INVERTEBRATE QUALITY

Riverine invertebrate communities may contain many species. They are subject to considerable variation, not only according to river type, but also according to latitude, altitude, and water chemistry. Only surveying and listing the species can give an adequate picture of the invertebrate fauna of a river. However, the variation in quality and quantity of invertebrate data and the enormous regional variation which would be needed in the assessment criteria to judge such data, mean that in practice species lists cannot be used to characterise levels of quality on a national scale. Physical and vegetation characteristics must in practice be used to describe the attributes of rivers which might be expected to hold good invertebrate assemblages. Accordingly, the following paragraphs set out the typical features expected of rivers of low and high invertebrate quality. Because this cannot be a wholly reliable guide to actual interest, there follows a list of "alert features" which tend to be correlated with high invertebrate interest, and which might either further enhance the interest of structurally good rivers, or negate the apparently adverse effects of poor river structure.

Features characteristic of rivers with low invertebrate interest:

- abrupt margins or low vertical banks; no gradual transition from aquatic to terrestrial conditions, no marginal fringe of wetland vegetation and little or no exposed sediment at times of low flow
- uniform sediments
- uniform flow in "natural" rivers
- submerged and emergent vegetation sparse or absent in stretches with low flow rates
- bank vegetation uniform: either very short or dense trees/bushes
- dense emergent vegetation over narrow channels
- few or no minor habitat features (see next section for examples) which might provide niches for invertebrates
- adjacent and upstream land agriculturally improved
- overall structure of channel, marginal and bank vegetation greatly modified in recent years

Features characteristic of rivers with high invertebrate interest:

- well-developed transitional zone between river and edge of channel at times of low flow, with extensive exposed sediments or well-developed band of wetland vegetation, or both
  varied (but segregated) sediments
- in slower rivers and drains, extensive beds or well-developed fringes of dense submerged and/or emergent vegetation
- varied bank vegetation: if short-medium height and non-woody, maintained by grazing; if trees/bushes present, then varied, with gaps, and not casting continuous dense shade; on small channels with slow flow, bank vegetation should include at most scattered or well-spaced trees or bushes
- changes in flow speed (except in the slowest drains)
- well-developed riffle/pool structure in faster rivers
- having many minor habitat features; submerged tree roots, logs, small backwaters with accumulations of fallen leaves, large rocks, overhanging and trailing branches, marginal flood litter, etc
- adjacent and upstream land unimproved, and preferably with long historical continuity of use and condition
- overall structure of channel, marginal and bank vegetation showing no more than slight change from historical conditions

Channels with medium levels of invertebrate interest will possess characteristics intermediate between those of the good and poor channels exemplified above, for example by possession of only patchy submerged or emergent vegetation, having only a narrow fringe of exposed sediment, or by having limited development of riffle-pool structure in a channel modified by engineering.

"Alert" features which might pre-dispose a river to support a good invertebrate fauna:

- slightly brackish water, and especially a well-developed fresh-brackish water transition in a ditch system
- location in an area of formerly extensive wetland, even if long since drained
- being part of a large complex of channels
- being in an area containing many other water bodies of known high

invertebrate interest

- passing through ancient woodland, or other area with a long history of tree cover
- having very extensive areas of exposed sediment, especially sand and shingle, even if along a river otherwise structurally rather poor

B3.1 Rare Invertebrates

Though criteria based on recorded invertebrates cannot be considered central to river assessment in the current state of knowledge, this does not mean that invertebrate information should be ignored. Any river from which one or more nationally scarce or Red Data Book invertebrate has been recorded should be regarded as of potential or proven high quality (depending on the exact level of scarcity and geographical restriction of the species involved) and any river supporting multiple scarce species is likely to be of high quality. However, the exact significance of the recorded faunas in such cases should be decided only after consideration of the nature and habitat requirements of the recorded species.

Selection of species for inclusion is usually straightforward, although there are exceptions. A wide range of invertebrates which do not usually inhabit the types of water body under consideration here could occasionally appear in them. This applies especially to ditches and drains where they traverse high-quality wetland habitats. This listing has tried to take account of them. Although some might query the decisions taken, but it is unlikely that the broad picture would greatly change. However, this list is best viewed as a preliminary compilation which might alter on further consultation. In some respects it is unsatisfactory if used as a tool for assessment of conservation value or potential impacts of river management because of the artificial separation of aquatic and non-aquatic species.

The category of river with the smallest number of scarce species in almost all taxonomic groups is large slow-flowing rivers. While this in essence represents the truth, the situation is almost certainly exaggerated in the table. Large rivers tend to be rather under-recorded by entomologists in comparison with smaller ditches and drains and with fast-flowing waters, partly because of the physical difficulty of recording large rivers and partly as a result of the deliberate selection of smaller water bodies which are perceived as being the likeliest to yield rich entomological rewards. The margins of large rivers with abundant emergent vegetation can often provide conditions similar, so far as small invertebrates are concerned, to those of small ditches although subject to periods of strong flow and scouring in winter and after storms. This ditch-like marginal fauna is almost certainly particularly under-recorded.

The list includes species associated with brackish water, provided they occur in drainage ditches or similar habitats, but does not include species found exclusively in the inter-tidal zone, even if this is in estuaries and the upper tidal areas of rivers where the water is far from fully saline.

For each species, there is indicated its status, the type of watercourse in which it is likely to be found, the likelihood of vegetation management being considered necessary on the type of habitat in which it lives, and the part of the water body inhabited. The categories and codes used are as follows:

Table B3: Red Data Book and nationally notable aquatic invertebrates

Status codes:
R 1 = Red Data Book category 1 (Endangered)
R2 = Red Data Book category 2 (Vulnerable)
R3 = Red Data Book category 3 (Rare)
RK = Red Data Book category K (Insufficiently Known)
X = extinct
Na = Nationally Notable (Nationally Scarce) category A - believed to occur in sixteen to thirty ten-kilometre squares of the National Grid in Britain.
Nb = Nationally Notable (Nationally Scarce) category B - believed to occur in thirty-one to one hundred ten-kilometre squares of the National Grid in Britain.
N = Nationally Notable (Nationally Scarce) - believed to occur in sixteen to one hundred ten-kilometre squares of the National Grid in Britain. (the undivided category is used for groups too poorly known for the Na and Nb categories to be used with confidence).

Categories of river:
F = fast-flowing streams and rivers, sediments mostly stones/sand
S = larger slow-flowing rivers, sediment usually predominantly mud/silt
D = lowland drains and ditches in artificial channels

Likelihood of vegetation management being considered necessary
1 = very likely
3 = very unlikely

Location of the aquatic stage:
m = marginal sediments
s = in-channel sediments
v = vegetation
w = open water

With such simple codes, there have inevitably been occasions when species have been difficult to fit to one or more of the alternatives, and other views may be possible in some cases. However, it is unlikely that the broad picture would be greatly altered by such alternative opinions.

Species	stat	F	S	D	man?	hab
Bryozoa						
Lophopus crystallinus	R3	-	+	+	1-2	v
Mollusca						
Anisus vorticulus	R2	-	-	+	1	v
Anodonta complanata	N	-	+	-	2-3	s
Gyraulus acronicus	R2	-	+	-	2?	v
Marstoniopsis scholtzi	R3	-	+	-	2-3	v
Myxas glutinosa	R1	-	+	+	3	s
Pisidium pseudosphaerium	R3	-	-	+	1	s

Pisidium tenuilineatum	R3	-	+	-	2-3	s
Segmentina nitida	R1	-	-	+	1	v
Sphaerium solidum	R1	-	+	-	2	s
Valvata macrostoma	R2	-	-	+	1	v
Annelida						
Hirudinea						
Placobdella costata	RK	-	-	+	1	v
Coleoptera						
Chrysomelidae						
Donacia aquatica	R3	-	-	?	?	v
Donacia bicolora	R2	-	?	+	1?	v
Donacia cinerea	Nb	-	?	+	1-2	v
Donacia clavipes	Nb	-	+	+	1-3	v
Donacia crassipes	Nb	-	?	+	3?	v
Donacia dentata	Na	-	+	+	1-3	v
Donacia impressa	Na	-	+	+	1-3	v
Donacia sparganii	Na	-	+	+	1-3	v
Donacia thalassina	Nb	-	+	+	1-3	v
Macroplea appendiculata	R3	-	+	+	1-2	v
Macroplea mutica	Na	-	-	+	1	v
Plateumaris affinis	Nb	-	-	+	1	v
Plateumaris braccata	Na	-	-	+	1	v
Curculionidae						
Bagous binodulus	X	-	-	+	1	v
Bagous collignensis	R3	-	-	+	1	v
Bagous cylindrus	R2	-	-	+	1	v
Bagous glabrirostris	Nb	-	-	+	1	v
Bagous longitarsis	R1	-	-	+	1	v
Bagous lutosus	R1	-	-	+	1	v
Bagous lutulentus	Nb	-	-	+	1	v
Bagous nodulosus	R1	-	-	+	1	v
Bagous puncticollis	R1	-	-	+	1	v
Bagous subcarinatus	Nb	-	-	+	1	v
Bagous tempestivus	Nb	-	-	+	1	v
Eubrychius velutus	Nb	-	-	+	1	v
Hydronomus alismatis	Nb	-	-	+	1	v
Litodactylus leucogaster	Nb	-	-	+	1	v
Phytobius canaliculatus	Nb	-	-	+	1	v
Dryopidae						
Dryops anglicanus	R3	-	-	+	1	m
Dryops griseus	R3	-	-	+	1	m
Dryops similaris	R3	-	-	+	1	m
Pomatinus substriatus	Na	+	-	-	3	s
Dytiscidae						
Acilius canaliculatus	R3	-	-	+	1	v
Agabus biguttatus	Nb	+	-	-	3	w/s

Agabus brunneus	R2	+	-	-	3	s
Agabus chalconatus	Nb	-	-	+	1	v
Agabus conspersus	Nb	-	-	+	1	w/s/v
Agabus labiatus	Nb	-	-	+	1	v
Agabus undulatus	R3	-	-	+	1	v
Bidessus minutissimus	R3	+	-	-	3	w/s
Bidessus unistriatus	R1	-	-	+	1	v
Coelambus nigrolineatus	Na	-	-	+	1	v
Coelambus parallelogrammu	Nb	-	-	+	1	v
Deronectes latus	Nb	+	-	-	3	w/s
Dytiscus circumcinctus	Na	-	-	+	1	v
Dytiscus circumflexus	Nb	-	-	+	1	v
Dytiscus dimidiatus	R3	-	-	+	1	v
Graptodytes bilineatus	R3	-	-	+	1	v
Graptodytes granularis	Nb	-	-	+	1	v
Hydaticus seminiger	Nb	-	-	+	1	v
Hydaticus transversalis	Na	-	-	+	1	v
Hydroglyphus geminus	Nb	-	-	+	1	w/s
Hydroporus longulus	Nb	+	-	-	3	v/s
Hydroporus marginatus	Nb	+	-	?	3?	v/s
Hydroporus neglectus	Nb	-	-	+	1?	v
Hydroporus obsoletus	Nb	+	-	-	3	v/s
Hydroporus rufifrons	R2	-	-	+	1	v
Hydrovatus clypealis	Na	-	-	+	1	v
Hygrotus decoratus	Nb	-	-	+	1	v
Hygrotus quinquelineatus	Nb	-	-	+	1	v
Ilybius guttiger	Nb	-	-	+	1	v
Rhantus frontalis	Nb	-	-	+	1	v
Rhantus grapii	Nb	-	-	+	1	v
Rhantus suturalis	Nb	-	-	+	1	v
Laccophilus ponticus	R2	-	-	+	1	v
Oreodytes alpinus	R3	+	-	-	3	w/s
Oreodytes davisi	Nb	+	-	-	3	w/s
Potamonectes d. depressus	Nb	+	-	-	3	w/s
Scarodytes halensis	Nb	-	-	+	1	w/s/v
Stictonectes lepidus	Nb	+	-	+	1,3	v
Elmidae						
Macronychus quadrituberculatus	R3	+	-	-	3	logs
Normandia nitens	R2	+	-	-	3	s
Oulimnius major	Na	+	-	+	1-3	s
Oulimnius rivularis	Na	-	-	+	1	s
Oulimnius troglodytes	Nb	+	-	-	3	s
Riolus cupreus	Nb	+	-	-	3	s
Riolus subviolaceus	Nb	+	-	-	3	s
Stenelmis canaliculata	R2	-	+	-	2-3	s
Gyrinidae						
Gyrinus aeratus	Nb	-	+	-	2-3	f/v

Gyrinus distinctus	R3	-	-	+	1-2	f/v
Gyrinus minutus	Nb	-	-	+	2	f/v
Gyrinus urinator	Nb	+	+	+	2-3	f/v
Haliplidae						
Haliplus apicalis	Nb	-	-	+	1	v
Haliplus heydeni	Nb	-	-	+	1	v
Haliplus laminatus	Nb	-	+	-	2-3	v
Haliplus mucronatus	R3	-	-	+	1	v
Peltodytes caesus	Nb	-	-	+	1	v
Hydraenidae						
Hydraena minutissima	Nb	+	-	-	3	s
Hydraena nigrita	Nb	+	-	-	3	s
Hydraena palustris	R2	-	-	+	1	s/v
Hydraena pulchella	R3	+	-	-	2-3	s/v
Hydraena pygmaea	R3	+	-	-	3	s/v
Hydraena rufipes	Nb	+	-	-	3	s/v
Hydraena testacea	Nb	-	-	+	1	s/v
Limnebius aluta	R3	-	-	+	1	s
Limnebius nitidus	Nb	-	-	+	1	s/v
Limnebius papposus	Nb	-	-	+	1	s/v
Ochthebius bicolon	Nb	+	-	-	3	m
Ochthebius exsculptus	Nb	+	-	-	3	s
Ochthebius marinus	Nb	-	-	+	1	s/v
Ochthebius nanus	Nb	-	-	+	1	s/v
Ochthebius punctatus	Nb	-	-	+	1	s/v
Ochthebius pusillus	Nb	-	-	+	1	s/v
Ochthebius viridis	Nb	-	-	+	1	s/v
Hydrophilidae						
Anacaena bipustulata	Nb	-	+	+	1-2	m
Berosus affinis	Nb	-	-	+	1	w/v
Berosus luridus	Nb	-	-	+	1	w/v
Berosus signaticollis	Nb	-	-	+	1	w/v
Cercyon bifenestratus	Na	-	+	-	2-3	m
Cercyon convexiusculus	Nb	-	-	+	1	m
Cercyon granarius	R3	-	-	+	1	m
Cercyon sternalis	Nb	-	-	+	1	m
Cercyon tristis	Nb	-	-	+	1	m
Cercyon ustulatus	Nb	-	-	+	1	m
Chaetarthria seminulum	Nb	-	-	+	1	m
Enochrus bicolor	Nb	-	-	+	1	v/s
Enochrus halophilus	Na	-	-	+	1	v/s
Enochrus isotae	R3	-	-	+	1	v
Enochrus melanocephalus	Nb	-	-	+	1	v
Enochrus ochropterus	Nb	-	-	+	1	v
Enochrus quadripunctatus	Nb	-	-	+	1	v
Georissus crenulatus	Na	+	+	+	2-3	m
Helochares lividus	Nb	-	-	+	1	v
Helochares obscurus	R3	-	-	+	1	v

Helophorus avernicus	Nb	+	+	-	3	s
Helophorus griseus	Nb	-	-	+	1	v
Helophorus nanus	Nb	-	-	+	1	v
Hydrochara caraboides	R1	-	-	+	1	v
Hydrochus carinatus	R3	-	-	+	1	v
Hydrochus ignicollis	R3	-	-	+	1	v
Hydrochus nitidicollis	R3	+	-	-	3?	s
Hydrophilus piceus	R3	-	-	+	1	v
Laccobius atrocephalus	Nb	+	+	-	2-3	s/m
Laccobius sinuatus	Nb	-	-	+	1	s
Limnoxenus niger	Nb	-	-	+	1	v
Noteridae						
Noterus crassicornis	N	-	-	+	1	v
Scirtidae						
Hydrocyphon deflexicollis	Nb	+	-	-	3	m
Scirtes orbicularis	Na	-	-	+	1	s/v
Diptera						
Athericidae						
Atrichops crassipes	R3	+	-	-	3	s
Dolichopodidae						
Argyra atriceps	N	+	-	-	3	m
Campsicnemus compeditus	N	+	-	-	3	m
Campsicnemus magius	R3	-	-	+	1	m
Campsicnemus marginatus	N	+	-	-	3	m
Chrysotus palustris	N	+	+	-	2-3	m
Dolichopus caligatus	N	+	-	+	1,3	m
Dolichopus cilifemoratus	N	-	-	+	1	m
Dolichopus virgultorum	N	-	-	+	1	m
Melanostolus melancholicus	R3	?	-	-	?	m?
Orthoceratium lacustre	N	-	-	+	1	m
Poecilobothrus ducalis	R3	-	-	+	1	m
Poecilobothrus principalis	N	-	-	+	1	m
Rhaphium antennatum	N	-	-	+	1	m
Rhaphium auctum	N	+	+	+	1-3	m
Rhaphium fractum	N	+	?	-	3?	m
Rhaphium gravipes	N	+	-	-	3	m
Rhaphium lanceolatum	N	?	?	?	?	m?
Rhaphium nasutum	N	+	+	-	2-3	m
Rhaphium patulum	N	?	-	-	3	m
Rhaphium penicillatum	R3	+	?	-	2-3	m
Rhaphium rivale	N	?	?	?	?	m?
Empididae						
Clinocera tenella	R3	+	-	-	3	v
Hemerodromia adulatoria	N	+	-	-	3	?
Hemerodromia laudatoria	N	+	-	-	3	?
Hilara albiventris	N	+	+	-	3?	m?
Hilara barbipes	N	+	?	-	3?	m?

Hilara biseta	N	?	+	-	2-3?	m?
Hilara hirta	R3	+	-	-	3?	m?
Hilara media	N	?	?	-	?	m?
Hilara merula	R3	+	-	+	1-3	m?
Hilara pilosopectinata	R1	?	-	-	3?	m?
Hilara recedens	N	-	+	-	2?	m?
Hilara setosa	R3	+	-	-	3	m?
Hilara woodi	N	+	+	+	1-3	m?
Wiedemannia lota	N	+	-	-	3	v
Wiedemannia phantasma	R3	+	-	-	3	v?
Rhagionidae						
Chrysopilus erythrophthalmus	R2	+	-	-	3	s
Sciomyzidae						
Colobaea bifasciella	N	-	-	+	1	m/v
Colobaea distincta	N	-	-	+	1	m/v
Colobaea pectoralis	R2	-	-	+	1	m/v
Dichetophora finlandica	R3	-	?	?	2?	m/v
Pherbellia argyra	R2	-	-	+	1	m/v
Pherbellia brunnipes	N	-	-	+	1	m/v
Pherbellia dorsata	N	-	-	+	1	m/v
Pherbellia griseola	N	-	-	+	1	m/v
Pherbellia nana	N	-	-	+	1	m/v
Renocera striata	N	+	-	-	3	m/v
Tetanocera punctifrons	N	?	?	-	2?	m/v
Stratiomyidae						
Odontomyia argentata	R2	-	-	+	1	m/s
Odontomyia ornata	R2	-	-	+	1	m/s
Odontomyia tigrina	N	-	-	+	1	m/s
Oxycera analis	R2	+	-	?	2?	m/s
Oxycera dives	R3	+	-	-	3	m
Oxycera morrisii	N	-	-	+	1	m/s
Oxycera pardalina	N	+	-	-	3	m/s
Oxycera terminata	R2	+	-	-	3	m
Syrphidae						
Anasimyia interpuncta	R3	-	-	+	1	v
Anasimyia lunulata	N	-	-	+	1	v
Chalcosyrphus eunotus	R2	?	?	?	?	partly submerged logs
Eristalis cryptarum	R2	?	-	-	?3	s/w
Lejops vittata	R2	-	-	+	1	v?
Neoascia geniculata	N	-	-	+	1	s/m
Neoascia interrupta	N	-	-	+	1	s/m
Orthonevra brevicornis	N	?	-	?	?	s/m
Orthonevra geniculata	N	?	-	?	?	s/m
Tabanidae						
Tabanus cordiger	N	+	-	-	3	s
Tipulidae						
Dicranota gracilipes	N	+	-	-	3	m
Dicranota guerini	N	+	-	-	3	m

Dicranota robusta	N	+	-	-	3	m
Dicranota simulans	R3	+	-	-	3	m
Elliptera omissa	RK	?	-	-	3	m
Erioptera bivittata	R2	-	-	+	1	m
Erioptera edwardsii	RK	?	-	-	3	m
Erioptera limbata	R2	+	?	-	3	m
Erioptera meigeni	R3	?	-	-	3	m
Erioptera nigripalpis	R3	?	-	-	?	m
Erioptera pusilla	R1	?	-	-	3	m
Gonomyia abbreviata	R3	?	-	-	3	m
Gonomyia bifida	N	?	-	-	?	m
Gonomyia connexa	R2	?	-	-	?	m
Gonomyia punctata	R2	?	?	-	?	m
Gonomyia sexguttata	R1	+	-	-	3	m
Helius pallirostris	N	-	+	+	2-3	m
Limnophila apicata	N	+	-	-	3	m
Limnophila glabricula	N	+	-	-	3	m
Limnophila mundata	N	+	-	-	3	m
Limnophila pictipennis	R2	-	-	+	1	m
Limnophila verralli	N	+	-	-	3	m
Limonia gracilis	N	?	-	-	3	m
Limonia halterella	N	?	-	-	3	m
Limonia omissinervis	R2	?	-	-	3	m
Molophilus niger	N	?	-	-	3	m
Molophilus propinquus	N	?	-	-	3	m
Paradelphomyia fuscula	N	?	-	-	3	m
Paradelphomyia nielseni	N	?	-	-	3	m
Pedicia lucidipennis	N	?	-	-	3	m
Pedicia unicolor	N	?	-	-	3	m
Rhabdomastix hilaris	R3	+	-	-	3	m
Rhabdomastix inclinata	R2	+	-	-	3	m
Tipula cheethami	N	+	-	-	3	m
Tipula caerulescens	R3	+	-	-	3	m
Tipula dilatata	R2	?	-	-	3	m
Tipula gimmerthali	R3	?	-	-	3	m
Triogma trisulcata	R3	+	-	-	3	m
Ephemeroptera						
Heptagenia longicauda	R1	-	+	-	2?	s
Heptagenia fuscogrisea	N	+	+	-	3?	s/v
Paraleptophlebia werneri	R3	+	-	-	1?*	v
Potamanthus luteus	R2	-	+	-	3?	s
Ephemera lineata	R2	-	+	-	2?3?	s
Hemiptera						
Hebrus pusillus	N	-	-	+	1	

*found in fast-flowing calacreous streams and winterbournes, but only where vegetation is very dense and therefore liable to management for fisheries etc.

Hydrometra gracilenta	N	-	-	+	1	
Neuroptera						
Sialis nigripes	N	?	+	-	3?	s
Sisyra dalii	N	+	-	-	3?	s
Sisyra terminalis	N	+	-	-	3?	s
Odonata						
Aeshna isosceles	R1	-	-	+	1	v
Brachytron pratense	Nb	-	-	+	1	s/v
Coenagrion armatum	X	-	-	+	1	v
Coenagrion pulchellum	Nb	-	-	+	1	v
Gomphus vulgatissimus	N	-	+	-	3	s
Lestes dryas	R2	-	-	+	1	v
Libellula fulva	R3	-	+	-	2	s/v
Oxygastra curtisii	X	.	+	-	3	s
Plecoptera (excludes *Taeniopteryx nebulosa britannica* and *Capnia vidua anglica*, which are endemic subspecies, and therefore RDB, but are not known to be scarce or threatened)						
Rhabdiopteryx acuminata	N	+	-	-	3	s
Brachyptera putata	N	-	+	-	3?	s
Isogenus nubecula	R2	+	?	-	3	s
Isoperla obscura	X	-	+	-	3	s
Trichoptera						
Adicella filicornis	R3	+	-	-	3	s
Ceraclea senilis	N	-	+	?	2-3	s/v
Ernodes articularis	N	+	-	-	3	s
Erotesis baltica	R2	-	-	+	1	v
Glossosoma intermedium	R3	+	-	-	3	s
Hydropsyche exocellata	X	-	+	-	3	s
Hydrospsyche saxonica	R1	+	-	-	3	s
Hydroptila lotensis	R2	-	?	-	3?	?
Hydroptila tigurina	RK	?	-	-	3	s
Hydroptila valesiaca	N	+	-	-	3	s
Ironoquoia dubia	R2	?	-	-	3?	s
Ithytrichia clavata	R3	+	-	-	3	s
Leptocerus interruptus	R3	+	+	-	2-3	v
Leptocerus lusitanicus	R2	-	+	-	2	?
Metalype fragilis	N	+	+	-	2-3	s
Oecetis notata	R3	+	+	-	3	s/v
Oxyethira tristella	RK	+	+	-	2-3?	?
Plectrocnemia brevis	N	+	-	-	3	s
Rhyacophila septentrionis	N	+	-	-	3	s
Setodes punctatus	R2	+	-	-	3	s
Tinodes dives	N	+	-	-	3	s
Tinodes pallidulus	R1	+	-	-	3	m

Tinodes rostocki	N	+	-	-	3	s?
Ylodes conspersus	N	+	+	-	3	v
Ylodes reuteri	R2	-	-	+	1	v?
Ylodes simulans	R3	-	+	-	3?	v
Crustacea						
Corophium lacustre	R3	-	+	-	2-3	s/v
Niphargellus glennei	RK	+	-	-	3	s

Table B4: Protected Invertebrates

Invertebrate species listed in Annex II of the EC Habitats Directive or Appendix II of the Bern Convention

Southern Damselfly	*Coenagrion mercuriale*
Freshwater Pearl Mussel	*Margaritifera margaritifera*

Invertebrate species protected by Schedule 5 of the Wildlife and Countryside Act

Atlantic Stream Crayfish	*Austropotamobius pallipes*
Glutinous Snail	*Myxas glutinosa*
Norfolk Aeshna Dragonfly	*Aeshna isocceles*

B4 EFFECTS OF VEGETATION MANAGEMENT ON AQUATIC INVERTEBRATES

B4.1. In-channel vegetation

B4.1.1 Timing of management

There is no ideal time for management. Different invertebrates have different seasonalities and hence are especially sensitive to management at different times of year. Some, including some dragonflies, spend more than one year as larvae, and so will be affected, probably adversely in the short-term, by annual vegetation management whatever its timing.

A large proportion of the British invertebrate fauna is thermophilic within the context of the British climate, and though this applies less to the aquatic fauna than to the terrestrial fauna, it nonetheless applies quite broadly. Many of the more thermophilic species develop in the summer, over-wintering either as adults or resting eggs. Others, however, over-winter as small larvae. The stage in their life cycle affects their sensitivity to vegetation management, different species are differently sensitive to the effects of vegetation management. Developing immatures in summer are likely to be more affected by management that adults in spring or autumn; the latter are more likely to be able to make an escape or to be able to survive a period of relative hardship. However some, such as herbivorous molluscs, are likely to be almost equally badly hit whenever the management takes place.

Though no ideal time suitable for all water courses can be suggested, in general the timing of management likely to have the least long-lasting effect is late summer or autumn. At this time of year, a large proportion of the aquatic invertebrate fauna is adult and is as well able to cope with changed circumstances as at any time. Also, they are for the most part active and able to avoid the worst effects by simply moving away.

B4.1.2 Extent of vegetation removal

The extent of the impact of vegetation management on the associated invertebrate fauna will depend on the extent and location of vegetation removal and the characteristics of the river. Complete vegetation removal from a stretch of river will remove a larger proportion of the fauna than will only partial removal. In a slow-flowing drain, even complete removal of submerged and emergent vegetation may not result in complete loss of the associated fauna; though the number of species is likely to be considerably depressed (except in very species-poor ditches) and the number of individuals even more so, a considerable proportion of the macroscopic invertebrate fauna may remain at low density until vegetation cover re-establishes. This is less likely to be the case in faster water, however, where the flow is likely to carry away any species deprived of their associated vegetation. However these areas are less likely to be controlled.

Though partial removal of vegetation will leave much of the invertebrate fauna not directly touched, its effects will vary greatly depending on which part of the vegetation is removed. Targeting a particular species for removal may wipe out any fauna especially associated with it. Some plants which frequently cause management problems, such as bulrush *Typha latifolia*

and common reed *Phragmites australis*, have rich associated faunas, including scarce species. Cutting the upper parts of vegetation across the whole, or most, of the width of the channel may cause considerable damage. Some species will be specifically associated with those upper parts, either feeding or living directly on floating leaves, or living on or just beneath the surface film and dependent on the shelter of plants for protection from current and predation. Even those species not specifically associated with the surface layers of vegetation may be adversely affected: many are likely to be air-breathing (water beetles, water bugs, many molluscs) and will either find it difficult to reach the surface, or will become vulnerable to fish predation when they surface for air. In general, the surface layers of vegetation are far more important for invertebrates than the deeper layers; removal of the vegetation near to the surface is likely to produce far greater damage to the invertebrate community than would be suggested by the proportional loss of vegetation alone.

Removal of whole plants including roots has greater impact than just upper parts, because sediment disturbance may damage in-sediment species or cause them to be carried away by the current, and a number of invertebrates are associated specifically with roots and lower stems of aquatic plants. Removal of all parts of plants does not necessarily mean that the invertebrate communities are less able to recover than if only parts of the plants are removed, but it does mean that the number of species which need to recover, and the extent of recovery needed by individual species, is likely to be greater; there is more uncertainty in the outcome of re-colonisation and recovery.

B4.1.3 Long-term rotation vs more frequent management in drainage ditches

The immediate impacts of vegetation management will be harmful. In particular, populations of plant associated species will be reduced, and those that remain may suffer from diminution of shelter. In the long-term, however, management may, in the case of wholly artificial drainage channels, be essential for the maintenance of the habitat required by invertebrate communities. There must be sufficient time between management events on any given stretch of channel for invertebrate populations to recover from the harmful effects of the last management event. This could be achieved either by a very long period between management events, allowing considerable change in the vegetation, and possibly a considerable move along the seral succession, followed by dramatic alteration, or by frequent small management events, so that damage is small and recovery rapid.

A long-term rotation, in which any one ditch or stretch of ditch is allowed to become completely choked with vegetation before being cleared to re-create open water conditions, is a good form of management for many invertebrates, and in particular for some groups of flies. However, such management is possible in its fullest sense only in places where a large number of channels are being managed, and preferably where some perform a relatively minor drainage function. In isolated ditches, in drains with a major drainage role, and more generally where there is no overall management plan for an area of ditches, the best, and safest, method of management will be to manage relatively often, but for the management to be of the smallest extent needed to maintain the function of the channel. In surveys in the Somerset Levels, it was found that some of the best drains for aquatic invertebrates (that is, those with the greatest species-richness and supporting the greatest assemblages of scarce species) were those which were managed most often because of their particular importance for drainage. Regular management on a small scale should make it possible to leave a considerable proportion of the

vegetation unmanaged, and for parts at least of the margins to develop good fringes of emergent vegetation.

B4.1.4 Other considerations

Any method of management leading to large amounts of decaying vegetation in the channel is bad for invertebrates. Use of herbicides is especially likely to have this effect, but others can also. It is especially bad if the decaying vegetation is of tall emergents, and the effects will be worst on communities with a large proportion of gill-breathers.

Vegetation management is likely to have less direct impact on invertebrate populations in fast-flowing water than in slow or still water.

B4.2 Bank vegetation

Preferred methods of bank vegetation management for aquatic invertebrates will depend on what vegetation is there now, what has been there in the past, and what are the size and physical characteristics of the river. As a matter of general principle, a diverse bank vegetation allows a diverse range of uses by the terrestrial stages of aquatic insects, and encourages a diversity of marginal conditions which in turn allow the development of a diverse community of marginal aquatic invertebrates. However, there are many occasions when diversification of bank vegetation structure is not a good idea, either because it compromises interest dependent on the existing structure, or because of the harmful effects of shade or leaf fall.

In general, the fauna of fast-flowing water is more tolerant of shade than that of slow-flowing or still water. Shade should not usually be allowed to increase along slow-flowing or still water. In the case of a very narrow drainage ditch, even permitting the development of tall unmanaged grasses and herbs along a narrow bank may cause great damage to the fauna. However, in the case of a very large river, the extent of increase of shade cast even by marginal trees is relatively slight.

If the banks of a channel are already tree-lined or wooded, the significance of the woodland for the aquatic invertebrates depends in part on its age. If it is ancient woodland, and has shaded the river for millennia, then it is important that it is retained; there may be a rich shade-associated fauna. If the trees alongside the river are of considerable age, for example old pollard willows, or if they are likely to have been a constant historical feature of the river in question, they should likewise be retained. If, however, they are of recent origin, they may be as likely to do harm as good. A fauna associated with open unshaded conditions may have developed over centuries, and may be compromised by the shading of marginal trees. A shade fauna in the same location may never be as good as the open fauna lost, but even if it potentially could be it may take further centuries to develop, or may never develop if the site is an isolated one.

The drainage ditches of grazing marsh perhaps represent the extreme of where increased shading is likely to be harmful. These ditches contain the remnants of the aquatic communities which occurred on the marshes before drainage to provide grazing land. The species which occur there, or at least many of the scarcer species, exist in spite of the current state of the habitat rather than because of it. They live in wholly artificial water bodies in areas designed to

be essentially treeless and fairly heavily grazed. They began in open marshland, they have continued for centuries in managed ditches in treeless fields where grazing removes all but the slightest shade, and increase in the extent of shade can only cause damage.

On the other hand, if there is known to have been a well-developed tree fringe along a river over a long historical period, which has been lost in recent years or decades, the re-establishment of tree cover could be considered useful. It need not always be so, however; consideration needs always to be given to the fauna which is already present.

If an increase in woody vegetation is proposed along a river or drain, and especially if, for part or all of the year, that river or drain is stagnant or slow-flowing, it is generally preferable to permit the development of woody, or indeed other tall, vegetation over only part of the length of the channel. In this way, if there is damage to be done to the fauna, the damage will not be felt over the whole length. Irregularly spaced and sized patches of woody vegetation may not be unduly damaging, and will provide considerable structural variety. There is probably no lower limit to the size of a patch of woody vegetation which can be used by some invertebrate. A single small bush may provide a hunting area for a number of dragonflies and a sheltered resting place for an enormous number of caddisflies, chironomids and the like. The preferred size of such woody vegetation patches for general conservation purposes is probably best set by the requirements of vertebrates. Though vegetation close to the water will in general be most immediately available and useful to the aquatic fauna, along slow and still waters woody vegetation should be sufficiently far from the water's edge that leaf fall does not lead to a serious build-up of organic sediment.

Patches of woody vegetation can also be developed in the reverse direction, by thinning of more continuous woody vegetation. This is generally to be recommended where there is scrub or young trees of very recent origin (stemming, for example, from the abandonment of grazing on former riverside pastureland).

The method used for maintaining short vegetation on banks is of less importance to aquatic than to terrestrial invertebrates. Thus mowing is often disastrous to terrestrial groups, but far less so to aquatic species. However, grazing is the preferred method of grassland management for both aquatic and terrestrial groups in most cases. Provided it is not too heavy and does not result in excessive trampling of the water margins, grazing can provide a range of bankside vegetation heights (even at its worst, a greater range than mowing immediately after management), and the trampling of the water margin gives some diversification of the structure of the marginal habitats; by maintaining bare mud in an otherwise densely vegetated margin, for example.

A note of warning needs to be sounded here concerning the potential importance of marginal vegetation for non-aquatic invertebrates. The terrestrial fauna associated with the banks may be of far greater conservation value than the fauna of the channel, and should be taken into account in management. For example, a line of old pollard willows may shade a lowland ditch. The aquatic fauna would probably benefit from the removal of the willows. The willows may, however, contain a fauna of far greater value than the ditch would ever be likely to develop. This fauna may depend not only on the retention of the trees but, in the long term, on the trees being managed in precisely the right way.

Appendix C - FISHES

C1 THE FISH FAUNA OF BRITAIN

There are 25 native fish species which spawn in the running freshwaters in Britain with an additional one which is likely to be extinct (Burbot). In addition, the eel is a typical component of the fish assemblage in most rivers although it does not breed. Of these 26, there are four anadromous species (living in the sea and spawning in freshwaters) - the shads, Salmon, Trout and one catadromous species (living in freshwaters and migrating to the sea to breed) - the Eel. No consideration has been given to lampreys as they are not truly fish. The shads are also excluded from further consideration, due to their limited spawning distribution largely in tidal reaches.

In addition, there are another 10 fish species which have been introduced into British rivers and are known to spawn. In view of the brief for the project which was to consider the implications of river management for the conservation interest, these species, although they may form part of the fish community of a river, are not considered further.

C2 DISTRIBUTION OF FISH

There are 4 principal reasons for the current broad distribution of fish in British rivers.

1. Historical Distribution: The native fish fauna originated from two sources. One was the immigration of largely freshwater fishes from the river systems of continental Europe during the period when Britain was joined to the Continent via a land bridge and the other was immigration from the sea by species which could tolerate saline conditions. It is the immigration via the land bridge that accounts for the differences in the number of species found in different parts of the country and there are many more species present in East Anglia and the South-east than the North.
2. Introductions: There are currently at least 13 fish species which are known to have been introduced into the river systems in Britain and the effects of their introduction on the native fish populations are poorly known.
3. Redistribution of the native fauna: A major influence on the current distribution of fish in Britain has been the deliberate movement of species which are prized for angling and or a food resource. These include Grayling, Tench, Perch and Pike. Bait species have also been introduced into new waters. These include Gudgeon, Roach, Dace, Stone loach and Ruffe.
4 Extinction: In contrast, the range of some fish species has contracted. The extreme example is Burbot which was formerly confined to the eastern counties of England and was last found some twenty years ago near Cambridge.

Underlying these gross reasons for distribution are those which affect individual rivers. These are principally water quality, substrata (which influences the nutrient status and thus productivity) and habitat quality including flow. The first two are outside the scope of this project. Habitat quality may however be greatly influenced by vegetation management.

C3 HABITAT QUALITY AND FISH REQUIREMENTS

Table 16 identifies which species are likely to use rivers of a certain size and gradient. There are a number of caveats to this. It assumes that the river is within the recorded range of all species, that the water is of appropriate quality and that suitable habitat exists. It is the presence and maintenance of suitable habitat that is under consideration in this project and Table 17 provides more detailed habitat requirements for the different fish together with some indication of the period of spawning as this has implications for the best time to undertake vegetation management. Data were largely but not exclusively taken from Maitland and Campbell, 1992; Maitland, 1972; Jenkins, 1925; RSPB, NRA, RSNC, 1994; Giles, 1994; Wheeler, 1978).

The principal aspects of habitat quality which determine the diversity and abundance of the fish fauna are the bed and bank structure, the vegetation structure and abundance, the flow of the water (together with its influence on oxygenation) and bank vegetation insofar as it may affect upon the channel. These determine the availability of food, govern the temperature and oxygen status of the water, and provide spawning and nursery sites for fry as well as refugia from predation.

A 'natural' bed and bank with their innate variations including the typical pool and riffle structures, shallow margins and overhanging banks will provide the basis for suitable habitat for fish. The most specific habitat requirements are for spawning fish. Vegetation will itself provide the spawning habitat, often within backwaters and slacks, for fish species including Pike, Roach, Rudd, Bream and Tench, but may also divert water sufficiently into a narrowed channel to provide the clean gravels with faster flow required by a number of species including Dace, Bullhead and Barbel. Nursery areas, out of the main flow, which offer protection against predators are important. Examples of suitable habitat are dense beds of vegetation and tree roots binding the bank.

Feeding habitat may be more general. Coarse fish in particular take a wide range of food and this may be aquatic invertebrates (see the section on aquatic invertebrates for their habitat requirements), invertebrates 'dropping' into the river from overhanging trees or other vegetation on the banks, or plant material. Dense vegetation is often the preferred feeding habitat. Some species such as Pike may use weedbeds as cover to stalk their prey. In contrast, the salmonids take invertebrate food which is either being washed downstream or is present in the bed. An important aspect of vegetation is the shelter that it provides from fast currents and fish will position themselves against it to prevent using too much energy in maintaining their position in the river.

Table C1: Fish fauna found in each category of river

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Salmon										*	*	*		*	*	*
Trout	(*)	(*)			*	*	*		*	*				*	*	
Grayling					*	*	*		*	*	*			*	*	
Pike						*	*	*		*	*	*		*	*	*
Barbel										*				*	*	
Gudgeon						*	*			*	*		*	*	*	*
Tench								*		*	*	*			*	*
Silver Bream							*	*	*	*	*	*			*	*
Common Bream										*	*	*			*	*
Bleak										*	*	*			*	*
Minnow	*	*			*	*			*	*			*	*		
Rudd							*	*		*	*	*			*	*
Roach		(*)	(*)	(*)	*	*	*	*	*	*	*	*	*	*	*	*
Chub					*	*	*	*	*	*	*	*	*	*	*	*
Dace	(*)	(*)			*	*			*	*			*	*	*	*
Spined Loach				*			*	*			*	*				*
Stone Loach	*	*			*	*			*	*			*	*		
Eel				*	*	*	*	*	*	*	*	*	*	*	*	*
3 spined stickleback		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9 spined stickleback			*	*			*	*								
Perch							*	*		*	*	*		*	*	*
Ruffe								*		*	*	*			*	*
Bullhead	*	*			*	*			*	*			*	*		

Table C2: Habitat preferences of fishes

i = upland
ii = Piedmont
iii = Upper lowland
iv = Lowland

SW = South West, NW = North West, EA = East Anglia
NE = North East, SE = South East, M = Midlands
SC = Scotland

	Spawning Habitat	Water velocity	River type	Locality	Spawning
Salmon	Gravel	Fast/ medium	i, ii (iii, iv)	Wales, SW, SC, EA, NW, NE	Gravel (winter)
Trout	Gravel/ vegetation	Fast/ medium	ii, i (iii, iv)	Throughout	Gravel (winter)
Grayling	Gravel	Medium	ii	Sporadic throughout	Gravel (spring)
Pike	Backwaters /plants	Slow/Very slow	iii, iv	Throughout	Plants (spring)
Barbel	Gravel	Medium/ slow	ii, iii	SC, SE, M, EA, NE	Gravel (summer)
Gudgeon	Gravel/silt	Medium/ slow	iii, iv, ii	W, SW, SC, SE, M, EA, NW, NE	Plants/ gravel summer)
Tench	Plants/back waters	very slow	iv, iii	SWales, SW, SC, SE,M,EA, NW, NE	Plants (summer)
Silver Bream	Silt/ backwaters	very slow	iv	SC, SE, M, EA, NE	Plants (spring/ summer)
Common Bream	Silt/ plants/ backwaters	very slow/ slow	iv, iii	SWales,SW, SC, SE, M, EA, NW, NE	Plants (spring/ summer)
Bleak	Open water	slow	iii	SC, SE, M, EA, NE	Plants (spring)
Minnow	Open water gravel	medium/ fast	ii, i	Throughout	Gravel (spring)
Rudd	Plants/back waters	very slow	iv, iii	Throughout	Plants (spring)
Roach	Plants/ backwaters	slow/ very slow	iii, iv, ii	Throughout	Plants (spring)
Chub	Open water, plants	slow/ very slow/ medium	iii, ii, iv	SC, SE, M, EA, NE, NW	Plants/ gravel (spring/ summer)

Table C2 cont:

	Spawning Habitat	Water velocity	River type	Locality	Spawning
Dace	Open water / gravel	medium/ slow	ii, iii	East Wales, SW, SC, SE, M, EA, NE, NW	Gravel (spring)
Spined Loach	Silt	very slow	iv	EA, EM	Plants (spring/ summer)
Stone Loach	Gravel/ plants	medium/ slow	ii, iii	Throughout	Gravel/ plants (spring/ summer)
Eel	Silt/ backwaters	slow/ very slow	iii, iv	Throughout	NA
3 spined stickleback	Plants/ backwaters	medium/ slow/ very slow	iii, iv	Throughout	Plants (spring/ summer)
Nine spined stickleback	Backwaters	very slow	iv	SC, SE, M, NE, NW, EA	Plants (spring/ summer)
Perch	Plants/back waters	slow/ very slow	iii, iv	Throughout	Plants (spring)
Ruffe	Backwaters	very slow	iv	SE, SC, EA, M, NW, NE	Plants (spring)
Bullhead	Silt/plants	medium slow	ii, iii	Throughout	Gravel (spring)

Aquatic vegetation provides some control on the temperature fluctuations in water courses, particularly those that are small, by shading the water column from the sun. Bankside trees can perform a similar function as can overhanging marginal plants in small water courses. In contrast, although photosynthesis from plants contributes to the oxygen concentration in the water, excessive plant growth and then decay can limit it. This is exacerbated when inappropriate control methods are used e.g. extensive herbicide use.

C4 HABITAT QUANTITY

Since it is difficult to predict in qualitative terms the precise requirements for any species of fish, it is therefore almost impossible to predict how much of any habitat is required. As with all other faunal groups, quality is important and can rarely be accurately measured. There are three general points however. A greater amount of any particular habitat in a river will

1. hold more of the species that are dependent on it,
2. be more stable in that will hold more individuals of each species thus reducing the risk of local extinction.
3. hold more of the specialised micro-habitats.

It is generally better therefore to retain greater rather than lesser quantities of aquatic plants in a river, although no absolute measures can be given as to the amounts required. It is also likely to be better to maintain these areas in larger blocks rather than in scattered patches.

C5 DIVERSITY OF HABITAT

In order to provide the range of condition required by different fish species, it will be important that there should be different flow conditions, e.g. areas of fast flowing waters contrasting with pools, weedbeds and open water. In unmanaged channels, the fish species present will be those which are adapted to the range of habitats present. In Britain, where most channels are managed, they will be those which can survive in the habitats provided. Management should therefore aim to maintain or provide a range of conditions and a small channel completely choked with *Typha* is unlikely to hold many more species than one which is almost completely denuded of vegetation on a regular basis. Similarly, a channel completely shaded by trees which will inhibit aquatic plant growth, although providing a ready supply of invertebrates and other organic material to the river, may hold a lower diversity of fish species than one which has partial cover.

C6 ASSESSMENT OF THE QUALITY OF A RIVER FOR FISHES

Assessment of quality of a habitat for any faunal group invariably uses numbers of species and/or abundance of the species and /or the presence or rare species. Table C3 lists the species that are protected under European or British legislation which are relevant to this project. Rare fish species are used as an additional justification for the designation of a SSSI while a mixture of these approaches is proposed within SERCON to assess riverine quality.

Table C3: Rare and protected fishes

(Only those which are freshwater and relevant to this study are listed)

Annex II of the EC Habitats and Species Directive/ Appendix II of the Berne Convention
Spined loach (*Cobitis taenia*)
Salmon (*Salmo salar*)
Bullhead (*Cottus gobio*)

No fish species is protected under the Schedule 5 of the Wildlife and Countryside Act

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There is a problem in assessing the numbers of native species present in a river, as it is never certain how many of them will have been introduced into the system. Additionally, as some species migrate to spawn, then the number found in a watercourse will depend on the time of the year that sampling was undertaken. A further complication is that a species list will also be dependent on sampling effort and the length of river sampled as well as ease of sampling.

Unlike birds and mammals, there is no estimate of the population size to determine which species are more or least abundant and therefore their likely rarity. Determination of rarity therefore depends on the number of localities in which a fish may be found.

In the context of this project, there are problems with adopting any of the three approaches in order to determine whether a river is of high, medium or low quality. An additional problem is that the assessment of quality is intended to be made by the operational staff during the decision-making process with only little need for reference to FRCN staff. As fisheries surveys are required to determine the species present in a river and are not always carried out, it is unsatisfactory to use the assemblages of species as a determinand of quality.

Since good habitat is required before a varied fish fauna can be present, it has been decided to use physical and vegetational characteristics to estimate the quality of a river for fish (as for invertebrates). The basis for the assessment of good, moderate and low quality is used and the quality criteria are listed below.

C6.1 Channel

C6.1.1 Low Quality

- abrupt margins or low vertical banks; no gradual transition from aquatic to terrestrial conditions, no marginal fringe of wetland vegetation and little or no exposed sediment at times of low flow
- uniform sediments
- uniform flow rivers
- submerged and emergent vegetation sparse or absent in reaches of low gradient
- dense emergent vegetation over narrow channels
- few or no minor habitat features
- overall structure of channel, marginal and bank vegetation greatly modified in recent years

C6.1.2 High Quality

- well-developed transitional zone between river and edge of channel at times of low flow, with extensive exposed sediments or well-developed band of wetland vegetation, or both
- varied (but segregated) sediments
- in low gradient rivers and drains, extensive beds or well-developed fringes of dense submerged and/or emergent vegetation
- well-developed riffle/pool structure with changes in flow speed (except in the slowest drains)
- having many minor habitat features; submerged tree roots, logs, small backwaters with accumulations of fallen leaves, large rocks, overhanging and trailing branches, marginal flood litter, etc

C6.1.3 Moderate Quality

Channels with medium levels of fish interest will possess characteristics intermediate between those of the good and poor channels exemplified above, for example by possession of only patchy submerged or emergent vegetation, having only a narrow fringe of exposed sediment, or by having limited development of riffle-pool structure in a channel modified by engineering.

Additional considerations

The presence of an angling club using a reach will be immediately indicative of moderate or high quality.

C6.2 Bank

C6.2.1 Low Quality

- abrupt margins or low vertical banks; no gradual transition from aquatic to terrestrial conditions, no marginal fringe of wetland vegetation and little or no exposed sediment at times of low flow
- bank vegetation uniform: either very short or dense trees/bushes
- adjacent and upstream land agriculturally improved
- overall structure of channel, marginal and bank vegetation greatly modified in recent years

C6.2.1 High Quality

- well-developed transitional zone between river and edge of channel at times of low flow, with extensive exposed sediments or well-developed band of wetland vegetation, or both
- varied bank vegetation: if short-medium height and non-woody, maintained by grazing; if trees/bushes present, then varied, with gaps, and not casting continuous dense shade; on small channels with slow flow, bank vegetation should include at most scattered or well-spaced trees or bushes
- adjacent and upstream land unimproved, and preferably with long historical continuity of use and condition
- overall structure of channel, marginal and bank vegetation showing no more than slight change from historical conditions

C6.2.3 Moderate Quality

Banks with medium levels of fish interest will possess characteristics intermediate between those of the good and poor banks exemplified above, for example by of taller uniform grass with occasional trees.

C7 IMPACT OF VEGETATION MANAGEMENT ON FISHES

Few studies have been carried out on the impact of vegetation management, within or outside the channel, on fishes.

Boussu (1954) demonstrated that removal of brush cover and loss of undercut banks decreased the biomass of trout in a stream. Swales (1982) showed that there was a strong association between overhanging bank vegetation and suggested its removal in rivers <10m wide was particularly harmful to fisheries and should be avoided if possible. Instream cover has been shown to be one of the most important factors influencing brown trout population density (Lewis 1969) and that favoured was close to the bed (De Vore et al, 1978).

Swales (1982) attempted to relate the impacts of weed cutting on the River Perry to the abundance of fish stocks. Large natural fluctuations in the fish populations rendered this difficult and it was suggested that different species were likely to behave in different ways. For example, the less mobile species such as Chub or territorial species such as Trout were suggested to be likely to show more conclusive effects than those species which were highly mobile such as Dace. Weed cutting was believed to affect fish feeding, reproduction and normal behaviour patterns. Feeding is affected by the removal of large numbers of invertebrates and the feeding of Dace will be directly affected by the loss of vegetation. The loss of plants directly used for spawning also remove incubating eggs and reduce slack water and cover required by fry. Mills (1981) suggested that lower water levels following weed cutting may expose incubating eggs attached to moss on the water margins. The effects of weed cutting are likely to be influenced by fish behaviour (Swales, 1982). Some species may move out of the area to better conditions and re-colonisation may occur soon afterwards. Weed boats were suggested to be particularly disturbing.

The timing of vegetation management may be of importance. Pearson and Jones (1978) observed that a cut in June would affect the hatch of insects (particularly Chironomidae and *Caenis horaria*) while a cut in July occurs when numbers are already declining. They noted that the timing will also affect fish species. Mills (1981) reported that spawning of phytophilous species may coincide with weedcutting although there is some evidence that density dependent factors will tend to compensate. Additionally cutting immediately after the eggs hatch will deprive young fish of the cover given by plants. Large scale cutting can also cause mortality of post-larvae and early juveniles which are using the weed for cover. Particularly vulnerable are Roach, Dace, Minnow and Chub.

Proposals have been made to minimise the effects on fish. These include hand cutting in small watercourses, leaving marginal beds untouched, selective cutting, removing algae e.g. *Cladophora* and control of aquatic growth by shading.

Appendix D - BIRDS

D1 ORNITHOLOGICAL SCOPE

Riverine birds are species which depend on one or more of the habitat conditions created by the river itself. Most also use other wetlands at least at some seasons. The full potential list, excluding those species which occur most infrequently, comprises little grebe, great crested grebe, cormorant, heron, mute swan, gadwall, mallard, tufted duck, goosander, red-breasted merganser, moorhen, coot, oystercatcher, common sandpiper, ringed plover, little ringed plover, kingfisher, sand martin, grey wagtail, pied wagtail, dipper, sedge warbler, reed warbler, reed bunting.

Of these, several are almost wholly confined to upland watercourses not subject to maintenance. They are goosander, red-breasted merganser, oystercatcher, common sandpiper, ringed plover, little ringed plover and dipper. Two other species, cormorant and heron, use rivers for fishing but are affected by maintenance only in so far as it may affect the availability of fish. Consideration of the effects of maintenance is therefore confined to the remaining 15 species.

All of the 15 breed on rivers and some also use them outside the breeding season. Other than cormorant and heron, all species which are commonly present outside the breeding season breed on rivers.

Species which occur rarely on rivers have been excluded from direct consideration. However, changes in management practice which benefit the overall riverine bird assemblage are likely to also be beneficial to these rarer birds.

Many birds use riparian habitats incidentally but are not dependent on rivers. Thus scrub may hold nightingales as well as reed buntings, trees may have flycatchers and rank grass may have hunting barn owls. In intensively farmed landscapes, the river bank may be the best bird habitat in the locality. However, including these species within the process of habitat appraisal for riverine birds would unduly complicate and distort the results. Where scarce non-riverine bird species or high quality bird habitats are known to occur on rivers, the advice of NRA conservation staff should be sought.

D2 PROJECT AIM

The aim of the project is to enable maintenance engineers to decide on best practice, taking account, *inter alia,* of the implications for birds. This requires the provision of clear guidance on:-

(a) what species are likely to be found in what habitats (identified through a combination of river classification and habitat type photographs),

(b) the effects which different maintenance practices may have on them,

(c) the overall bird conservation value of different habitats, subject to different maintenance regimes, expressed in terms of overall "bird assemblage quality".

The first stage in producing this guidance requires analysis of information on the habitat requirements of the relevant species and their population sizes.

D3 HABITAT DATA

To predict which species will use different habitats requires detailed information on the habitat requirements of each species, embracing adult and juvenile diet, nest sites and other factors relevant to survival and successful breeding. Information was mainly derived from *The Handbook of the Birds of Europe, the Middle East and North Africa* (Cramp *et al* 1977-94) which reviews all available literature to shortly before the date of publication. Additional information was derived from the small number of papers which assess the effects of river management on birds (Taylor 1984, Raven 1986, Campbell 1988), from reports of the results of the Waterways Bird Survey run by the British Trust for Ornithology (Marchant and Hyde 1980) and from a similar review of habitat requirements by Andrews and Elliott (1994), carried out for *The New Rivers and Wildlife Handbook*. For the species concerned, the information is detailed but essentially qualitiative; measures of required habitat extent rarely exist, partly because quality is an important modifier.

D4 POPULATION SIZE

Ornithological habitat value is normally determined by establishing the numbers of individuals of each species present and their relative abundance in a given context - usually the county or nationally. Thus a site which supports uncommon species will rate more highly than one with only common species. To apply this process to NRA river maintenance practice would ideally require, for each of the relevant species, accurate information on the numbers of breeding pairs and wintering individuals dependent on rivers in England and Wales. However, published estimates are only for Britain as a whole and only one species (reed warbler) is absent from Scotland. Further, estimates for the size of each population using lowland rivers do not exist. Quality criteria are therefore based simply on total population sizes in Britain (see Table D1).

Table D1: Estimates of breeding populations of birds which use lowland rivers

Species	*Number of breeding pairs*
Little grebe	5-10,000
Great crested grebe	<4000
Mute swan	<13,500
Gadwall	770
Mallard	100,000
Tufted duck	7-8000
Moorhen	240,000
Coot	<23,000
Kingfisher	3,300-5,500
Sand martin	77,500-250,000
Grey wagtail	34,000
Pied wagtail	300,000
Sedge warbler	250,000
Reed warbler	40-80,000
Reed bunting	220,000

Totals are for the whole British population, including lowland and upland rivers and non-riverine wetlands, mostly for the period 1988-91. (The New Atlas of Breeding Birds in Britain and Ireland: 1988-91.)

D5 QUALITY CRITERIA

Three quality levels have been selected, based on species population size and the use of the habitat for breeding or for feeding only. They are:-

(a) Low = Riverine species with populations in excess of 100,000 pairs may occur to feed. These are mallard, moorhen, sand martin, pied wagtail, sedge warbler, reed bunting. No riverine species are likely to attempt to breed and, if they do, breeding success is likely to be poor.
(b) Moderate = The riverine species listed above may occur to breed.
(c) Good = Any riverine species may occur to breed. These are the species listed above plus little grebe, great crested grebe, mute swan, gadwall, tufted duck, coot, kingfisher, grey wagtail, reed warbler.

D6 USE OF HABITAT AND RIVER TYPE

D6.1 Birds using the Channel

Both gradient and channel width are significant influences on the bird assemblage likely to be found in different classes of maintained rivers.

Rivers with gradients shallower than 1:1500 are more likely to hold floating beds of aquatic plants. Submerged aquatics provide a direct food resource for mute swan and coot and habitat for the prey of insectivorous and piscivorous species. However, where the current is such that these beds can form floating masses, they become of greater value to birds, being a directly accessible food source for gadwall as well as for mute swan and coot, a feeding zone for many species including broods of wildfowl and the nest site locations for grebes and coot.

Second, steeper rivers are more likely to provide the conditions required by grey wagtails which favour watercourses with rocks, riffles and areas of shingle (especially where the watercourse is bordered by trees).

The gradient divide is not invariably applicable. Correct conditions for mats of floating aquatics to develop may sometimes be found in backwaters or slacks on steeper rivers and that, although mainly confined to waters not subject to routine maintenance, grey wagtails do occur on lowland chalk streams with gradients shallower than 1:1500, for example.

Channel width is also an influence on the bird assemblage. Birds have large spatial requirements compared with plants or invertebrates and perhaps fish. This means that some species are unable to breed on watercourses with the smallest channel width category (<2 m) and a few are almost always confined to rivers with widths in excess of 10 m.

Again, a caveat applies. Areas too small to support a breeding site may be visited for feeding by birds such as adult mallard which are not necessarily tied to feeding territories. Cumulatively, small areas of high quality channel habitat may be of value especially outside the breeding season when birds are not tied to territory and can range widely to feed. Thus good practice may be as important on small watercourses as on large ones, though it is reasonable to say that where the needs of birds and those of plants or invertebrates conflict, on small watercourse greater overall benefits for wildlife conservation are likely to arise from managing for the latter groups rather than for birds, all of which are likely to be very common species.

Table D2 summarises the gradient and river width requirements of the 15 riverine species and gives basic information on habitat requirements. Table D3 shows which bird species are associated with the 16 different channel categories based on width and gradient.

D6.2 Birds Using River Banks

Birds using banks can be divided into species whose presence is:-
(a) determined by the conditions in the channel (e.g. breeding gadwall require abundant floating or shallowly-submerged aquatics but can nest in any dense cover from tussocky grass to dense scrub),
(b) largely independent of channel conditions (e.g. sand martin, sedge warbler).

Birds dependent on conditions in the channel are influenced by channel width so that management for certain of them may be inappropriate on smaller watercourses. Both groups may be influenced by bank width. For instance, though narrow linear strips of habitat may be of use to some species for feeding, such strips are hazardous to ground-nesting birds as they are easily searched by predators. Birds may avoid them but in some circumstances use occurs with consequent adult mortality or breeding failure.

Table D4 lists species using the river bank, indicates where channel width is significant and provides basic information on habitat requirements. Table D5 relates bird occurrence to channel width and the standard vegetation structure criteria applied for all aspects of the project.

D6.3 Summary of Important Habitat Features

From the above quality criteria and from the data in Tables D2 -D5 it is possible to define the river characteristics that will provide conditions to support the high quality assemblages.

D6.3.1 Channel

Extensive beds of submerged aquatic plants, especially where these form floating mats.
Stands of emergent vegetation, especially where these persist over winter.
Snags and leaning bough dipping to the water.

D6.3.2 Banks

Stable earth cliffs
Tussocky swards and tall herbage providing at least 30 cm of overhead cover at the waters edge in early spring
Dense scrub, not open at the base

Bank cover should be at least 1m wide and ideally more than double this to minimise the risk of nest losses by predation. Strips should be as long as possible.

Table D2: Bird use of the river channel

	Abundance	Width (m)	Gradient	Submerged aquatics			Emergents			Snags and boughs		Open water
				DF	IF	B	DF	IF	B	F	B	F
Little grebe	2	>5	<0.07%	no	yes	yes	no	yes	yes	no	yes	yes
Great crested grebe	2	>10	<0.07%	no	yes	yes	no	yes	yes	no	yes	yes
Mute swan	3	>5	all	yes	yes	no	yes	yes	yes	no	no	no
Gadwall	1	>5	<0.07%	yes	yes	no	no	no	no	no	no	no
Mallard	04/03	all	all	yes	yes	no	yes	yes	no	no	no	yes
Tufted duck	2	>10	<0.07%	no	yes	no	no	no	no	no	no	yes
Moorhen	4	all	all	yes	yes	no	yes	yes	yes	no	yes	yes
Coot	3	>10	<0.07%	yes	yes	yes	yes	yes	yes	no	yes	yes
Kingfisher	2	all	all	no	yes	no	no	yes	no	yes	no	yes
Grey wagtail	3	all	>0.07%	no	yes	no	no	yes	no	no	no	no
Pied wagtail	4	all	all	no	yes	no	no	yes	no	no	no	no
Sedge warbler	4	all	all	no	yes	no	no	yes	no	no	no	no
Reed warbler	3	>2	<0.07%	no	yes	no	no	yes	yes	no	no	no
Reed bunting	4	all	all	no	yes	no	no	yes	no	no	no	no

Abundance ratings are :- 1 = <1000 prs, 2 = < 10,000 prs, 3 = <100,000 prs, 4 = >100,000 prs (see Table 1)..

DF = direct food resource. IF = indirect food resource (eg as invertebrate habitat). B = used for nesting

Note that for submerged aquatics to be used for breeding, they must form floating masses.
Emergent plants are assumed to be in standing water. They will then be used by reed warbler but not by sedge warbler.

Table D3: Channel category /species associations

	River category															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Little grebe											*	*			*	*
Great crested grebe															*	*
Mute swan									*	*	*	*	*	*	*	*
Gadwall											*	*			*	*
Mallard	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tufted duck															*	*
Moorhen	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Coot															*	*
Kingfisher	?	?	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Grey wagtail	*	*			*	*			*	*			*	*		
Pied wagtail	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sedge warbler	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Reed warbler		*	*	*		*	*	*		*	*	*		*	*	*
Reed bunting	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

* = Species predicted to occur

Table D4: Bird use of the river bank

	Abundance	Channel width (m)	Bare ground		Earth cliffs	Grass			Tall herb		Scrub			Trees		Wooded banks	
			Wet	Dry		Short	Tussocks				Open	Dense		Young	Mature		
			F	F	B	F	F	B	F	B	F	F	B	F	B	F	B
Mute swan	3	>5				yes		yes		yes							
Gadwall	1	>5						yes		yes			yes				yes
Mallard	4	all	yes					yes		yes			yes				yes
Tufted duck	2	>10						yes		yes			yes				yes
Moorhen	4	all	yes	yes		yes	yes				yes	yes					
Coot	3	>10				yes											
Kingfisher	2	all			yes												
Sand martin	4	>10			yes											yes	
Grey wagtail	3	all	yes	yes		yes											
Pied wagtail	4	all	yes	yes		yes											
Sedge warbler	3	all							yes	yes	yes	yes	yes	yes			
Reed warbler	3	all							yes	yes	yes	yes		yes			
Reed bunting	4	all					yes	yes	yes	yes	yes	yes		yes			

Abundance ratings are :- 1 = <1000 prs, 2 = < 10,000 prs, 3 = <100,000 prs, 4 = >100,000 prs

F = regularly used for feeding. B = used for nesting

Vegetation structure is particularly important for breeding. Some species, including mallard and moorhen start to nest before new growth commences in spring. Nest concealment requires overhead cover in the form of grass tussocks or tall herbage which has stood over winter. Autumn mowing destroys such cover.

Scrub can provide excellent nesting cover while it remains young. Old scrub becomes leggy and open at the base. The aim should be to cut scrub down every 5-7 years and allow to regrow, ideally having adjacent reaches at different stages of regrowth

As a minimum, any linear habitat should be at least 1 m wide and ideally more than double this.

Table D5: Bank category/ species associations

Channel width (m)	<2			2-5			5-10			>10		
Vegetation structure	U	S	C	U	S	C	U	S	C	U	S	C
Mute swan							*	*	*	*	*	*
Gadwall								*	*		*	*
Mallard		*	*		*	*		*	*		*	*
Tufted duck								*	*		*	*
Moorhen	*	*	*	*	*	*	*	*	*	*	*	*
Coot										*		
Kingfisher	earth cliffs			*	*	*	*	*	*	*	*	*
Sand martin							earth cliffs			*	*	*
Grey wagtail	*			*			*			*		
Pied wagtail	*			*			*			*		
Sedge warbler		*	*		*	*		*	*		*	*
Reed warbler		*			*			*			*	
Reed bunting		*	*		*	*		*	*		*	*

U = Uniform vegetation = bare ground or short swards.
S = Simple vegetation = tussocky grass, tall herbage, open scrub and/or young trees and /or mature trees in a matrix of uniform understorey (eg trees on a grazed or mown bank).
C = Complex vegetation = dense scrub, wooded banks, open scrub and/or young or mature trees in a simple or complex understorey.

Appendix E - RIVERINE MAMMALS

E1 SCOPE

Three species of British mammals are particularly associated with rivers. They are water shrew, water vole and otter. Some bats, notably Daubenton's, regularly or preferentially feed over rivers and other waterbodies. North American mink are widespread along rivers but are not considered to be a conservation priority. Many non-riverine mammals also use rivers or their banks as foraging habitat.
For the purpose of this exercise, the needs of the first three species and Daubenton's bat have been considered.

E2 WATER SHREW

Feeds by swimming and diving to a depth of about 750 mm, taking a wide range of invertebrate prey including water snails, insect adults and larvae and amphibian tadpoles. It is probable that water shrews hunt by touch as much or more than by other senses. This confines them to situations where the physical structure of vegetation or the substrate allow them to search for slow-moving prey. Thus, water shrews are noted to thrive in water cress beds, for example but also utilise clear streams with stony beds. In larger rivers the species is confined to margins where the current is negligible, the water is shallow and where there is abundant plant growth or accumulated, unconsolidated flotsam through which the animal can forage. Terrestrial runs are made through dense grass or other vegetation.

The required extent of good quality feeding habitat is not known but it is believed that foraging water shrews travel about 60 m in a night so maintenance practice should use this as a measure within which suitable habitat conditions including food resources should be maximised.

E3 WATER VOLE

Water voles are mainly herbivores, feeding on a wide variety of wetland grasses and herbs, with some apparent preference for the emergent species such as *Glyceria*, *Phalaris* and *Phragmites*. They also take some invertebrate prey such as water snails. Social groups live in burrows excavated in the banks, normally with entrances both above and below water-level. The voles do not normally range far from the water's edge but retention of dense grass cover within at least 1 m of the water is desirable.

Home ranges may extend about 130 m along one or both banks of a river. The species is now rare or absent from most of lowland rivers due to the effects of mink predation and habitat loss.

E4 OTTER

Otters are almost exclusively piscivorous and there is no evidence of any preference for river type or conditions subject to the availability of adequate supplies of suitable prey and to freedom from disturbance. Normally nocturnal, otters lie up by day in areas of dense cover such as stands of tall herbs, dry reedbeds and also use cavities beneath tree roots and under rocks. For breeding, females select similar sites with the highest degree of inaccessibility and freedom from disturbance.

Otters range over very large distances and their presence may not be possible to predict from habitat quality. For this reason, and as they are now recolonising ground lost due to the effects of pesticides, advice on appropriate maintenance regimes should be sought from NRA conservation staff not only wherever they are believed to occur but also in adjacent areas which otters may colonise in future.

E5 DAUBENTON'S AND OTHER BATS

All bats are insectivores and their use of rivers as feeding habitat is related to the abundance of flying insects. Maintenance practices which foster these will assist bats. Trees with cavities or hollows may be roost sites for bats.

E6 HABITAT QUALITY CRITERIA

For the purposes of this exercise, it has been assumed that water shrews may occur along any rivers provided that maintenance retains a fringe of emergent vegetation sufficient to produce areas of minimal flow and food resources amongst the vegetation or in trapped debris. Similarly with water voles, potential presence has been assumed where marginal vegetation is present. Otters have been assumed to occur mainly on rivers more than 5m wide and to prefer watercourses where maintenance fosters fish populations through the retention of a number of factors including the presence of submerged and emergent plants. Conditions capable of holding the two smaller species are scored as of medium value and those suitable for otters as of high value. No attempt has been made to score for bats.

E7 CHANNEL AND BANK MANAGEMENT

In general, practices which foster marginal and emergent vegetation, retain slacks and create good cover close at the water's edge will benefit all these mammals.

Appendix F- ADJACENT LAND

F1 INTRODUCTION

There are four steps involved in considering the implications of maintenance and considering best practice:

1. Determine whether there is a "flood plain" and its extent,
2. Identify what is determining the hydrology of the flood plain,
3. Identify the vegetation type,
4. Consider whether the flora of the adjacent land is an important consideration *apropos* river maintenance.

The flood plain was defined as an area which either:

a) is inundated with flood water on an average return period of <2 years,

or

b) is within 100 m of the main river itself or of a surface-water feature where water level is determined by the river (e.g. tributaries, backwaters or water-filled ditch networks discharging to the river) and has a surface elevation not more than 1 m above the mean annual maximum river level.

Under these criteria a river which, in an average year, never rises to within a metre of the surrounding land, would be deemed not to have a flood plain. No further consideration was given to land in this category as it is highly unlikely that a change in vegetation maintenance would affect the surrounding land in the short term. The river would probably require re-engineering to enhance the environmental quality of wetland vegetation growing on adjacent land.

F2 ADJACENT LAND CATEGORIES

Vegetation and hydrology were deemed to be the features most useful in identifying categories as a basis for assessing the impact of vegetation management. Vegetation classes were as follows:

1. *Arable* category covers all tilled land. For the purposes of the current study, it is assumed that areas of arable cultivation are not of relevance to the floristic interest of river flood plains. This is not always the case. Hedges and ditch margins may well provide refugia for wetland species of conservation interest, but because the hydrological management of the area will be predominantly determined by the needs of the agricultural crop, the requirements of any relict vegetation will not be considered here. An exception would be where there is interest in the re-creation of semi-natural habitats - in these special instances the land should be classified into the category of the 'desired' rather than the 'actual' vegetation type.
2. *Woodland* includes scrub communities and stands of planted trees.
3. *Swamp and aquatics* include areas of open water, reedbed, fen, bog, mire and marsh.
4. *Grassland* includes all meadows and pastures from rough grazing to short term ley and non-agricultural grasslands.

It is necessary to identify the predominant hydrological classes occurring within the flood plain, in order to assess whether the hydrological regime is liable to be sensitive to river stage level or not.

Hydrological classes were as follows

A Open or surface water features (e.g. ponds, cut-offs, backwaters and drainage ditches), or areas which are covered in water for much of the year (e.g. swamp, marsh and reedbed).

B Areas which are either flooded on a regular basis or where high water tables are maintained by seepage from water bodies. Surface water rarely persisting for prolonged periods.

C Areas which are inundated by winter floods on rare occasions, or which flood only after heavy rain due to soils with impeded drainage.

D Well-drained areas not liable to flooding.

Types C and D may well have semi-natural vegetation of conservation importance (such as the traditional old hay meadows, MG5). However, routine river maintenance procedures are unlikely to affect the hydrology or vegetation of these areas directly, and therefore they do not have a bearing on the decision-making process.

Table F1 identifies those combinations of vegetation and hydrology which may be important when considering the impact of river maintenance.

Table F1: Categories of adjacent land

Vegetation	Hydrology			
	Open/surface water (A)	Regular flooding/ high water tables (B)	Winter flood or post storm flood (C)	Well drained (D)
Arable (1)	-	-	-	-
Woodland (2)	I	II	-	-
Swamp and Aquatics (3)	III	IV	-	-
Grassland (4)	-	V	-	-

Within the table only five adjacent land use categories of relevance to the project were identified. These are given in Roman numerals I - V for the purposes of identifying each specific type. Where a dash is given, then this category is not believed to be sensitive to river vegetation maintenance practices and is not considered further. It is likely that areas of a flood plain will fall into a number of different categories along a given reach. In this case, the quality indicators for each of the categories should be considered.

Once the preliminary assessment of the potential impacts of the river maintenance practices had been considered, it proved possible to reduce these five categories to three, by simply considering grasslands, woodland and aquatics/ swamps. This was deemed to be more suitable in terms of the usability of the guidelines.

F3 WILDLIFE QUALITY DEFINITIONS

It should be recognised at the outset that the majority of species in the British flora do occur somewhere on a flood plain and therefore it would not be appropriate to attempt to define "typical" plants or assemblages for the different river or flood plain categories. The important question in the context of river maintenance is whether or not the hydrology of the adjacent land needs to be given priority when considering the environmental impact of a proposed scheme.

Table F2 is based on those natural or semi-natural communities which are likely to occur on the flood plains of managed rivers and dependent upon the prevailing hydrological regime for their existence. The table sets out to highlight the communities which, if present, should signal to the manager whether the hydrology of the flood plain should be given high priority when determining a maintenance regime. It is therefore an amalgamation summarising both the "environmental quality" and the "hydrological susceptibility" of the adjacent in-field vegetation.

Table F2: Relative importance of plant community types when considering floodplain hydrology.

Category	Highest importance	Medium importance	Lower importance
Woodland I and II	Fen carr composed of alder and/or willow spp.	Recently colonised willow carr and older mixed woodland of alder and ash	Recent plantations with an impoverished ground flora or thorn scrub and bramble
Aquatics and swamps III and IV	Diverse emergent and floating-leaved aquatic communities, rich tall-herb fens and fen meadows	Less diverse aquatic and swamp communities, and tall-herb fen communities, which include more robust species tolerant of water-table fluctuation	Aquatic and swamp communities which are more tolerant of polluted water or summer drying or both
Grassland V	Damp hay meadows with diverse grassland flora, dependent either on high summer water-tables or regular inundation	Inundation grassland, species-rich tussocky grassland and semi-improved pastures	Species-poor rush-pasture or tussocky grassland or highly improved pasture

NB: It should be noted that all semi-natural vegetation existing on a lowland floodplain is of considerable ecological importance. This table highlights the very highest quality habitats whose requirements should be taken fully into account before the local hydrological regime is altered.

A community is listed as being of high importance if it fulfils a number of the following criteria;

i) is of acknowledged conservation interest due to either its scarcity or its floristic diversity or both
ii) cannot be re-created on a time scale <100 years (usually as a consequence of its diversity)
iii) is susceptible to degradation as a result of hydrological change.

Table F3 lists examples for each of the groups following the National Vegetation Classification (Rodwell 1991, 1992 and 1994).

Table F3: Likely plant communities of high, medium and low importance.

Category	Highest importance	Medium importance	Lower importance
Woodland I and II	W2, W5	W1, W6abc, W7, W8bc, W9ab	W21a, W22b, W24a
Aquatics and swamp III and IV	A4, A7, A8bc, A11ab, A13, S2, S4bc, S24acdefg, S25ac, S27b, M22abcd, M23b, M27b	A3, A5a, A9, A15, S4a, S8, S12bc, S13, S16, S17, S19a, S24b, S25b, S26bc	A1, A2, A5b, A10, A12, A16, A19, A20, S5, S6, S7, S12a, S14, S15, S22, S23, S22, S26ad, S28
Grassland V	MG4, MG5, MG8	MG1c, MG6a, MG9b, MG13	MG1b, MG7, MG9, MG10

These communities are as described by the National Vegetation Classification, and represent examples of the main vegetation categories found on floodplains, ranked by importance in terms of botanical diversity and hydrological susceptibility as set out in Table F2.

F4 HABITAT REQUIREMENTS

The basic requirements of the plant communities described as being of *highest* importance are summarised below;

Fen Carr

- prolonged standing surface water in winter
- water table within 400 mm of surface through much of summer
- no management required, though by a process of natural succession carr will eventually give way to drier woodland as the ground surface rises

Diverse aquatic and emergent communities

- open water, unshaded by overhanging trees
- water present throughout the summer
- no sudden changes of level during the growing season
- rotational weed cutting in late summer every 3-7 years, to avoid dense shading of the water surface

Rich tall-herb fen

- surface water flooding in winter and early spring

- ground water or seepage from ponded water maintaining water tables within 500 mm during early summer
- water tables >800 mm can be tolerated after August
- annual or biennial cutting in autumn, ideally with the removal of biomass

Damp hay-meadows
- prolonged winter floods tolerated
- susceptible to water logging in spring, surface water should be removed prior to the start of the growing season
- ditch network maintained to permit late floods to recede quickly
- early summer water tables <600 mm deep
- annual cut in July followed by aftermath grazing

F5 RATIONALE FOR IMPACT ASSESSMENT OF RIVER MAINTENANCE

The presence of aquatic and emergent plants reduces the hydraulic capacity of a channel. The stage level will therefore rise for a given flow. Estimates for this rise were taken from the stage/discharge relationships derived elsewhere within the main study (J.A.L. Dunderdale, unpublished). The exact change will depend on the width, gradient and flow in the river, and therefore the management of weeds (particularly the timing of removal) is more critical in some categories of river than others.

The impact of higher stage levels on areas of land adjacent to the river will be to reduce the amount of water draining to the river in winter and to increase the volume seeping back to the soil from the river in summer. The common requirement of all the important vegetation types identified above is a high water table in early summer (Grootjans and Ten Klooster, 1980; Rodwell, 1991 *et seq.*). This requires either seepage via a permeable soil or regular inundation by river water (Godwin and Barucha, 1932; Gilman, 1994). Therefore a lowering of river stage levels in early summer tends to be detrimental to the floristic interest of adjacent land. The recommendations are to:
i) cut weed only to increase capacity to a minimum level required for flood-defence thereby not lowering stage levels by any more than is absolutely necessary, and
ii) to postpone the cut until late summer or autumn whenever possible.
When these recommendations conflict with other environmental interests, then it is necessary to assess the quality and importance of the flood plain habitat to decide which consideration should take precedence. As stage levels in wide rivers with a significant gradient tend to be less affected by weed-cutting operations, the extent and timing of maintenance operations are less critical in these situations (river types 5 and 7) compared to narrower rivers with shallow gradient (categories 2 and 4).

Whilst it is generally desirable to maintain the highest possible stage levels in early summer, this may conflict in some instances with a need for adequate surface drainage in March to prevent anoxic soil conditions from developing. Traditional damp hay-meadows (e.g. MG5, MG8) as described in section F4 above, are intolerant of severe soil anoxia brought about by waterlogging during the growing season (Jones, 1972). Therefore, in these areas, the maintenance of adequate channel capacity for removal of surface water in spring is a priority. Channel clearance by a single cut in autumn, if required, is again recommended.

Appendix G

Working documents used during the preparation of the 'Best Practice' tables. Collation of the assessments of the effects of each maintenance option for each environmental component.

Appendix G Collated assessments of the impact of different maintenance practices on the environmental components for river bed width <2m .

These show the level of wildlife quality for each component that might be expected if a maintenance practice was followed.

Scale VL = very low
L = low
M = medium
H = high
VH = very high

The first figure is for gradients steeper than 1: 1500
The second figure is for gradients shallower than 1:1500

Option	Environmental Component					
	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents						
Annual cutting - spring						
Whole channel cleared	VL L	L L	L L	L	L	VL VL
90%+ cleared	L M	L L	L L	L	L	VL VL
60 - 90% cleared	M M	L/M L/M	L L	L	L	VL VL
30 - 60% cleared	M M	M M	L/M L/M	L	M	VL VL
10 - 30 % cleared	H H	H M/H	M M	L	M	L VL
Selective clearance	H H	H H	M M	L	M	L L
Annual emergent cutting - autumn						
Whole channel cleared	L M	L L	L/M L/M	L	L	M L
90%+ cleared	M M	L L	L/M L/M	L	L	M M
60 - 90% cleared	M M	M/L L/M	L/M L/M	L	L	M/H M
30 - 60% cleared	M M	M M	M M	L	M	M/H M/H
10 - 30 % cleared	H H	H H	M M	M	M	VH H
Selective clearance	H H	H H	M M	M	M	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL P	L L	L L	L	L	VL VL
60 - 90% cleared	P M	L L	L L	L	L	VL VL
30 - 60% cleared	M M	M L/M	L L	L	M	VL VL
10 - 30 % cleared	M H	H M	L/M L/M	L	M	VL VL
Selective clearance	H H	H H	M M	L	M	L VL
Multiple annual cutting summer/ autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	M M	L L	L L	L	L	VL VL
60 - 90% cleared	L M	L/M L	L/M L/M	L	L	L VL
30 - 60% cleared	M M	L/M L/M	M M	L	M	L L
10 - 30 % cleared	M H	M/H M	M M	L	M	M M
Selective clearance	H H	H H	M M	L	M	H H

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents cont.						
Biennial cutting						
Whole channel cleared	L M	L L	L L	L	L	L VL
90%+ cleared	L M	L L	L L	L	L	L VL
60 - 90% cleared	M M	L/M L/M	L/M L/M	M	M	H M/H
30 - 60% cleared	M M	M M	M M	M	M	H H
10 - 30 % cleared	H H	H H	H M	M	M	VH VH
Selective clearance	H H	H H	H H	M H	M	VH VH
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL L	L L	L L	M H	L	L VL
90%+ cleared	M M	L L	L L	M H	L	M L
60 - 90% cleared	M M	M M	M M	M H	M	M/H M/H
30 - 60% cleared	M M	H M/H	M M	M H	M	M M
10 - 30 % cleared	H H	H H	M M	M H	M	VH VH
Selective clearance	H H	H H	H H	M H	M	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL L	L L	L L	M H	L	VL VL
90%+ cleared	L M	L L	L L	M H	L	VL VL
60 - 90% cleared	M M	L/M L	L/M L/M	M H	M	VL VL
30 - 60% cleared	M H	L/M M/H	M M/H	M H	M	L L
10 - 30 % cleared	H H	M H	M M/H	M H	M	M M
Selective clearance	H H	H H	M/H H	M H	M	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	VL VL	L L	L L	L	L	VL VL
30 - 60% cleared	L L	L L	L L	L	M	L L
10 - 30 % cleared	M M	L L	L/M L/M	L	M	M L
Selective clearance	H H	M/H H	M M	L	M	M M

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation						
Annual cutting - spring						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	L M	L L	L L	L		VL VL
60 - 90% cleared	M M	L/M L/M	L L	L		VL VL
30 - 60% cleared	M M	M M	L/M L/M	L		VL VL
10 - 30 % cleared	H H	H H	M M	L		L VL
Selective clearance	H H	H H	M M	L		L L
Annual cutting - autumn						
Whole channel cleared	L M	L L	L L	L		M L
90%+ cleared	M M	L L	L L	L		M M
60 - 90% cleared	M M	M M	L/M L/M	L		M/H M
30 - 60% cleared	M M	M M/H	M M	L		M/H M/H
10 - 30 % cleared	H H	H H	M M	L		VH H
Selective clearance	H H	H H	M M	L		VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	L L	L L	L L	L		VL VL
60 - 90% cleared	L M	L/M L/M	L L	L		VL VL
30 - 60% cleared	M M	M L/M	L L	L		VL VL
10 - 30 % cleared	M H	H M/H	L L/M	L		VL VL
Selective clearance	H H	H H	L/M L/M	L		L VL
Multiple annual cutting spring/autumn						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	L M	L L	L L	L		VL VL
60 - 90% cleared	L M	M M	L/M L/M	L		L VL
30 - 60% cleared	M M	M M	M M	L		L L
10 - 30 % cleared	M H	H H	M M	L		M M
Selective clearance	H H	H H	M M	L		H H
Biennial cutting						
Whole channel cleared	VL L	L L	L L	L		L VL
90%+ cleared	L M	L L	L L	L		L VL
60 - 90% cleared	M M	M L/M	L/M L/M	L		H M/H
30 - 60% cleared	M M	H M/H	M M	L		H H
10 - 30 % cleared	H H	H H	H H	M		VH VH
Selective clearance	H H	H H	H H	M		VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation cont:						
Cutting - 3 - 7 yr rotation	VL L	L L	L L	M		L VL
Whole channel cleared	M M	L L	L L	M		M L
90%+ cleared	M M	L M	L/M L/M	M		M/H M/H
60 - 90% cleared	M M	H M/H	M M	M		H H
30 - 60% cleared	H H	H H	H H	M		VH VH
10 - 30 % cleared	H H	H H	H H	M		VH VH
Selective clearance						
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL L	L L	L L	M		VL VL
90%+ cleared	L M	L L	L L	M		VL VL
60 - 90% cleared	M M	M M	L/M L/M	M		VL VL
30 - 60% cleared	M H	M/H M	M M	M		L L
10 - 30 % cleared	H H	H H	H H	M		M M
Selective clearance	H H	H H	H H	M		H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	M		VL VL
90%+ cleared	VL VL	L L	L L	M		VL VL
60 - 90% cleared	VL VL	L L	L L	M		VL VL
30 - 60% cleared	L L	L L	L L	M		L L
10 - 30 % cleared	M M	L L	L/M L/M	M		M L
Selective clearance	H H	H H	M M	M		M M

Appendix G Collated assessments of the impact of different maintenance practices on the environmental components for river bed width 2 -5m .

These show the level of wildlife quality for each component that might be expected if a maintenance practice was followed.

Scale VL = very low
L = low
M = medium
H = high
VH = very high

The first figure is for gradients steeper than 1: 1500
The second figure is for gradients shallower than 1:1500

Option	Environmental Component					
	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents						
Annual cutting - spring	VL L	L L	L L	L	L	VL VL
Whole channel cleared	L M	L L	L L	L	L	VL VL
90%+ cleared	L M	L/M L	L L	L	L	VL VL
60 - 90% cleared	M M	M/H M	L/M L/M	L	M	L VL
30 - 60% cleared	H M	H M/H	M M	L	M	L L
10 - 30 % cleared	H H	H H	M M	M H	M	L M
Selective clearance						
Annual emergent cutting - autumn						
Whole channel cleared	L M	L L	L/M L/M	L	L	M L
90%+ cleared	L M	L L	L/M L/M	L	L	M M
60 - 90% cleared	L M	L/M L/M	L/M L/M	L	L	M/H M/H
30 - 60% cleared	M M	M M	M M	M	M	H H
10 - 30 % cleared	H H	H H	M M	M H	M	VH H
Selective clearance	H H	H H	M M	M H	M	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L M	L L	L L	L	L	VL VL
60 - 90% cleared	L M	L/M L	L/M L/M	L	L	L VL
30 - 60% cleared	M M	L/M L/M	L/M L/M	L	M	L L
10 - 30 % cleared	M H	M/H M	M M	M H	M	M/H M
Selective clearance	H H	H H	M M	M H	M	VH H
Multiple annual cutting summer/ autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L M	L L	L L	L	L	VL VL
60 - 90% cleared	L M	L/M L	L/M L/M	L	L	L VL
30 - 60% cleared	M M	L/M L/M	L/M L/M	L	M	L L
10 - 30 % cleared	M H	M/H M	M M	M H	M	M/H M
Selective clearance	H H	H H	M M	M H	M	VH H

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents cont.						
Biennial cutting						
Whole channel cleared	L M	L L	L L	L	L	L VL
90%+ cleared	L M	L L	L L	L	L	L VL
60 - 90% cleared	M M	L/M L/M	L/M L/M	M H	M	H H
30 - 60% cleared	M M	M M	M M	M H	M	VH VH
10 - 30 % cleared	M H	H H	M/H M/H	M H	M	VH VH
Selective clearance	H H	H H	H H	M H	M	VH VH
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL VL	L L	L L	M H	M	L L
90%+ cleared	L M	L L	L L	M H	L	M L
60 - 90% cleared	M M	M M	M M	M H	M	M/H M/H
30 - 60% cleared	M M	H M/H	M M	M H	M	H H
10 - 30 % cleared	H H	H H	M M	M H	M	VH VH
Selective clearance	H H	H H	H H	M H	M	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL VL	L L	L L	M H	L	VL VL
90%+ cleared	L L	L L	L L	M H	L	VL VL
60 - 90% cleared	M M	L/M L/M	L/M L/M	M H	M	L VL
30 - 60% cleared	H H	M/H M	M M/H	M H	M	M L
10 - 30 % cleared	H H	H H	M M/H	M H	M	M/H M
Selective clearance	H H	H H	H H	M H	M	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	VL VL	L L	L L	L	L	VL VL
30 - 60% cleared	L L	L L	L L	M	M	M L
10 - 30 % cleared	M M	L L	L/M L/M	M H	M	M M
Selective clearance	H H	M/H H	M M	M H	M	M/H M

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation						
Annual cutting - spring						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	V M	L L	L L	L		VL VL
60 - 90% cleared	L M	M L/M	L L	L		VL VL
30 - 60% cleared	M M	M M	L/M L/M	L		L VL
10 - 30 % cleared	H M	H H	M M	M		L L
Selective clearance	H H	H H	M M	M		L M
Annual cutting - autumn						
Whole channel cleared	L M	L L	L L	L		M L
90%+ cleared	L M	L/M L	L L	L		M M
60 - 90% cleared	L M	M L/M	L/M L/M	L		M/H M/H
30 - 60% cleared	M H	M M	M M	M		H H
10 - 30 % cleared	H H	H H	M M	M		VH H
Selective clearance	H H	H H	M M	M		VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	L L	L L	L L	L		VL VL
60 - 90% cleared	L M	M L/M	L L	L		VL VL
30 - 60% cleared	M M	M M	L L	L		VL VL
10 - 30 % cleared	M H	H M/H	L/M L/M	M		L VL
Selective clearance	H H	H H	M M	M		L L
Multiple annual cutting spring/autumn						
Whole channel cleared	VL L	L L	L L	L		VL VL
90%+ cleared	L M	L L	L L	L		VL VL
60 - 90% cleared	L M	M L/M	L/M L/M	L		L VL
30 - 60% cleared	M M	M L/M	M M	M		L L
10 - 30 % cleared	M H	H H	M M	M		M/H M
Selective clearance	H H	H H	M M	M		VH H
Biennial cutting						
Whole channel cleared	VL L	L L	L L	L		L VL
90%+ cleared	L M	L L	L L	L		L VL
60 - 90% cleared	M H	M M	L/M L/M	M		H H
30 - 60% cleared	M M	H M/H	M M	M		VH VH
10 - 30 % cleared	M H	H H	M/H M/H	M		VH VH
Selective clearance	H H	H H	H H	M		VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation cont:						
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL VL	L L	L L	M		L L
90%+ cleared	L M	L L	L L	M		M L
60 - 90% cleared	M M	M M	L/M L/M	M		M/H M/H
30 - 60% cleared	M M	H M/H	M M	M		H H
10 - 30 % cleared	H H	H H	M/H M/H	M		VH VH
Selective clearance	H H	H H	H H	M		VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL VL	L L	L L	M		VL VL
90%+ cleared	L L	L L	L L	M		VL VL
60 - 90% cleared	M M	M/H H	L/M L/M	M		L VL
30 - 60% cleared	H H	M/H M	M M	M		M L
10 - 30 % cleared	H H	H M	M/H M/H	M		M/H M
Selective clearance	H H	H M	H H	M		H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	M		VL VL
90%+ cleared	VL VL	L L	L L	M		VL VL
60 - 90% cleared	VL VL	L L	L L	M		VL VL
30 - 60% cleared	L L	L L	L L	M		M L
10 - 30 % cleared	M M	L L	L/M L/M	M		M M
Selective clearance	H H	H H	M M	M		M/H M

Appendix G Collated assessments of the impact of different maintenance practices on the environmental components for river bed width 5 -10m .

These show the level of wildlife quality for each component that might be expected if a maintenance practice was followed.

Scale VL = very low
L = low
M = medium
H = high
VH = very high

The first figure is for gradients steeper than 1: 1500
The second figure is for gradients shallower than 1:1500

Option	Environmental Component					
	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents						
Annual cutting - spring						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L L	L L	L L	L	M	VL VL
60 - 90% cleared	L M	L/M L/M	L/M L/M	L	M	L VL
30 - 60% cleared	M M	M M	M M	M H	H	L L
10 - 30 % cleared	H M	H H	M M	M H	H	M L
Selective clearance	H H	H H	M/H M/H	H	H	M M
Annual emergent cutting - autumn						
Whole channel cleared	VL L	L L	L L	L	L	M M
90%+ cleared	L L	L L	L L	L	L	M M
60 - 90% cleared	L L	M L/M	L/M L/M	L	M	H M/H
30 - 60% cleared	M M	M M	M M	M H	H	VH VH
10 - 30 % cleared	H H	H H	M M	H	H	VH VH
Selective clearance	H H	H H	M/H M/H	H	H	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	L L	L/M L/M	L L	L	M	VL VL
30 - 60% cleared	M M	M M	L/M L/M	L	H	L VL
10 - 30 % cleared	M H	H H	L/M L/M	M H	H	VL VL
Selective clearance	H H	H H	M M	M H	H	M L
Multiple annual cutting summer/ autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL L	L L	L L	L	L	VL VL
60 - 90% cleared	L M	M M	L/M L/M	L	M	L VL
30 - 60% cleared	M M	M M	L/M L/M	M H	H	M L
10 - 30 % cleared	M H	H M	M M	M H	H	H M/H
Selective clearance	H H	H M	M M	M H	H	VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents cont.						
Biennial cutting						
Whole channel cleared	VL L	L L	L L	M	L	M L
90%+ cleared	L M	L L	L L	M	M	M M
60 - 90% cleared	L M	M L/M	L/M L/M	M H	H	VH H
30 - 60% cleared	M H	M M	M M	M H	H	VH VH
10 - 30 % cleared	M H	H H	M/H M/H	H	H	VH VH
Selective clearance	H H	H H	H H	H	H	VH VH
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL VL	L L	L L	M H	L	M L
90%+ cleared	M M	L L	L L	M H	M	M M
60 - 90% cleared	M M	M/H M	M M	H	H	H H
30 - 60% cleared	M M	H M/H	M M	H	H	VH H
10 - 30 % cleared	H H	H H	H H	H H	H	VH VH
Selective clearance	H H	H H	H H	H H	H	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL VL	L L	L L	M H	M	VL VL
90%+ cleared	VL L	L L	L L	M H	M	L L
60 - 90% cleared	L M	L/M L/M	L/M L/M	H H	H	M L
30 - 60% cleared	M M	M M	M M	H H	H	M/H M
10 - 30 % cleared	H H	H H	H H	H H	H	M/H M/H
Selective clearance	H H	H H	H H	H H	H	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	L L	L	VL VL
90%+ cleared	VL VL	L L	L L	L L	L	VL VL
60 - 90% cleared	VL VL	L L	L L	M H	M	VL VL
30 - 60% cleared	L L	L L	L L	H H	H	M M
10 - 30 % cleared	M M	L L	L/M L/M	H H	H	M/H M
Selective clearance	H H	H H	M M	H H	H	M/H M/H

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation						
Annual cutting - spring						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L L	L L	L L	L	L	VL VL
60 - 90% cleared	L M	M M	L/M L/M	L	L	L VL
30 - 60% cleared	M M	M/H M/H	M M	M H	M	L L
10 - 30 % cleared	H M	H H	M M	M H	H	M L
Selective clearance	H H	H H	M/H M/H	M H	H	M M
Annual cutting - autumn						
Whole channel cleared	VL L	L L	L L	L	L	M M
90%+ cleared	L L	L/M L/M	L L	L	L	M M
60 - 90% cleared	L L	M L/M	L/M L/M	M	L	M M/H
30 - 60% cleared	M M	M/H M	M M	M H	M	VH VH
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	M H	M H	H	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	L L	M M	L L	L	L	VL VL
30 - 60% cleared	M M	M M	L/M L/M	M H	L	L VL
10 - 30 % cleared	M H	H H	M M	M H	M	VL VL
Selective clearance	H H	H H	M M	M H	H	M L
Multiple annual cutting spring/autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L M	L L	L L	L	L	VL VL
60 - 90% cleared	L M	M L/M	L/M L/M	L	L	L VL
30 - 60% cleared	M M	M M	M M	M H	L	M L
10 - 30 % cleared	M H	H H	M M	M H	M	H M H
Selective clearance	H H	H H	M/H M/H	M H	H	VH VH
Biennial cutting						
Whole channel cleared	VL VL	L L	L L	L	L	M L
90%+ cleared	L M	L L	L L	M	L	M M
60 - 90% cleared	L M	M M	L/M L/M	M H	M	VH H
30 - 60% cleared	M M	H M/H	M M	M H	H	VH VH
10 - 30 % cleared	M H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	H H	M H	H	VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation cont:						
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL VL	L L	L L	M H	L	M L
90%+ cleared	M M	L/M L/M	L L	M H	M	M M
60 - 90% cleared	M M	M M	L/M L/M	M H	H	H H
30 - 60% cleared	M M	H H	M M	M H	H	VH H
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	H H	M H	H	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL VL	L L	L L	M H	M	VL VL
90%+ cleared	VL L	L/M L/M	L L	M H	M	L L
60 - 90% cleared	L M	M/H M	L/M L/M	M H	H	M L
30 - 60% cleared	M M	M/H M/H	M M	M H	H	M/H M
10 - 30 % cleared	H H	H H	H H	M H	H	M/H M/H
Selective clearance	H H	H H	H H	M H	H	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	M H	L	VL VL
90%+ cleared	VL VL	L L	L L	M H	L	VL VL
60 - 90% cleared	VL VL	L L	L L	M H	L	VL VL
30 - 60% cleared	L L	L L	L L	M H	M	M M
10 - 30 % cleared	M M	L L	L/M L/M	M H	H	M/H M
Selective clearance	H H	H H	M M	M H	H	M/H M/H

Appendix G Collated assessments of the impact of different maintenance practices on the environmental components for river bed width 10+m .

These show the level of wildlife quality for each component that might be expected if a maintenance practice was followed.

Scale VL = very low
L = low
M = medium
H = high
VH = very high

The first figure is for gradients steeper than 1: 1500
The second figure is for gradients shallower than 1:1500

Option	Environmental Component					
	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents						
Annual cutting - spring						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL L	L L	L L	M H	M	VL VL
60 - 90% cleared	L M	L/M L/M	L/M L/M	M H	H	L VL
30 - 60% cleared	L M	M/H M	M M	M H	H	M L
10 - 30 % cleared	H H	H H	H H	H	H	M M
Selective clearance	H H	H H	H H	H	H	M M
Annual emergent cutting - autumn						
Whole channel cleared	VL VL	L L	L L	L	L	M M
90%+ cleared	VL L	L L	L L	M H	L	M/H M
60 - 90% cleared	L L	M L/M	L/M L/M	M H	H	H M/H
30 - 60% cleared	M M	M/H M	M M	H	H	VH VH
10 - 30 % cleared	H H	H H	H H	H	H	VH VH
Selective clearance	H H	H H	H H	H	H	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	VL L	L/M L/M	L L	L	H	L VL
30 - 60% cleared	L M	M M	L/M L/M	M H	H	L VL
10 - 30 % cleared	M H	H H	M M	M H	H	M L
Selective clearance	H H	H H	M M	H	H	M L
Multiple annual cutting summer/ autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	L M	L/M L/M	L/M L/M	M H	H	L VL
30 - 60% cleared	L M	M M	L/M L/M	H	H	M L
10 - 30 % cleared	M H	H H	M M	H	H	H H
Selective clearance	M H	H H	M M	H	H	VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Emergents cont.						
Biennial cutting						
Whole channel cleared	L M	L L	L L	M H	M	M M
90%+ cleared	L M	L L	L L	M H	H	M M
60 - 90% cleared	M M	M M	L/M L/M	H	H	VH H
30 - 60% cleared	M M	M/H M	M M	H	H	VH VH
10 - 30 % cleared	H H	H H	M/H M/H	H	H	VH VH
Selective clearance	M H	H H	H H	H	H	VH VH
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL L	L L	L L	H	M	M M
90%+ cleared	M M	L L	L L	H	H	M/H M
60 - 90% cleared	M M	M/H M	M M	H	H	H H
30 - 60% cleared	M M	H M/H	M M	H	H	VH H
10 - 30 % cleared	H H	H H	H H	H	H	VH VH
Selective clearance	H H	H H	H H	H	H	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL L	L L	L L	M H	M	VL VL
90%+ cleared	L M	L L	L L	H	H	M L
60 - 90% cleared	M M	L/M L/M	L/M L/M	H	H	M M
30 - 60% cleared	M H	M/H M	M M	H	H	M/H M/H
10 - 30 % cleared	H H	H H	H H	H	H	H M/H
Selective clearance	H H	H H	H H	H	H	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	M	M	VL VL
60 - 90% cleared	VL VL	L L	L L	H	H	VL VL
30 - 60% cleared	L L	L L	L L	H	H	M/H M
10 - 30 % cleared	M M	L L	M M	H	H	M/H M/H
Selective clearance	H H	M/H H	H H	H	H	M M/H

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation						
Annual cutting - spring						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL L	L L	L L	M H	L	VL VL
60 - 90% cleared	M M	M/H M/H	L/M L/M	M H	M	L VL
30 - 60% cleared	L M	H M/H	M M	M H	H	M L
10 - 30 % cleared	H H	H H	M M	M H	H	M M
Selective clearance	H H	H H	M/H M/H	M H	H	M M
Annual cutting - autumn						
Whole channel cleared	VL VL	L L	L L	L	L	M M
90%+ cleared	VL L	L/M L/M	L L	M H	L	M/H M
60 - 90% cleared	L L	M M	L/M L/M	M H	M	H M/H
30 - 60% cleared	M M	M/H M/H	M M	M H	H	VH VH
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	H H	M H	H	VH VH
Multiple annual cutting spring/summer						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	VL VL	L L	L L	L	L	VL VL
60 - 90% cleared	VL L	M/H M	L/M L/M	M H	L	L VL
30 - 60% cleared	L M	M/H M/H	M M	M H	M	L VL
10 - 30 % cleared	M H	H H	M/H M/H	M H	H	M L
Selective clearance	H H	H H	H H	M H	H	M L
Multiple annual cutting spring/autumn						
Whole channel cleared	VL VL	L L	L L	L	L	VL VL
90%+ cleared	L L	L L	L L	L	L	VL VL
60 - 90% cleared	L M	M M	L/M L/M	M H	L	L VL
30 - 60% cleared	L M	M M/H	M M	M H	M	M L
10 - 30 % cleared	M H	H H	M/H M/H	M H	H	H H
Selective clearance	H H	H H	H H	M H	H	VH VH
Biennial cutting						
Whole channel cleared	L M	L L	L L	L	L	M M
90%+ cleared	L M	L L	L L	M H	M	M M
60 - 90% cleared	M M	M/H M/H	L/M L/M	M H	H	VH H
30 - 60% cleared	M M	H M/H	M M	M H	H	VH VH
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	H H	M H	H	VH VH

	Plant	Invertebrate	Fish	Bird	Mammal	Adj. Land
Floating and submerged vegetation cont:						
Cutting - 3 - 7 yr rotation						
Whole channel cleared	VL L	L L	L L	M H	M	M M
90%+ cleared	M M	L/M L/M	L L	M H	H	M/H M
60 - 90% cleared	M M	M M	M M	M H	H	H H
30 - 60% cleared	M M	H H	M M	M H	H	VH H
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	VH VH
Selective clearance	H H	H H	H H	M H	H	VH VH
Desilting/ raking on a 2 - 7 year cycle						
Whole channel cleared	VL L	L L	L L	M H	M	VL VL
90%+ cleared	L M	L/M L/M	L L	M H	H	M L
60 - 90% cleared	M M	M/H M/H	M M	M H	H	M M
30 - 60% cleared	M H	H M/H	M M	M H	H	M/H M/H
10 - 30 % cleared	H H	H H	M/H M/H	M H	H	H M/H
Selective clearance	H H	H H	H H	M H	H	H H
Herbicide application at a suitable time						
Whole channel cleared	VL VL	L L	L L	M H	L	VL VL
90%+ cleared	VL VL	L L	L L	M H	L	VL VL
60 - 90% cleared	VL VL	L L	L L	M H	L	VL VL
30 - 60% cleared	L L	L L	L L	M H	H	M/H M
10 - 30 % cleared	M M	L L	L/M L/M	M H	H	M/H M/H
Selective clearance	M M	H H	M M	M H	H	H M/H

Appendix G: Effects of bank management on rivers of bed width <2m

Management	Plants	Inv	Fish	Birds	Mamm	Adj Lc
Bank Mowing/Flayling More Than Twice Per Year						
Whole Bank Cut - both sides	L	M	L	L	L	L
Whole Bank Cut - one side only	L	M|L	L	L	M	
Toe Strip left - 0.25m wide	L	M|H	L	L	L	
Toe Strip left - 0.25-1.0m wide	L	M	L	L	M	
Toe Strip left - >1m wide	L/M	L	L	L|M	M	
Top Strip left - 0.25m wide	L	M|H	L	L	L	
Top Strip left - 0.25-1.0m wide	L	M	L	L	L	
Top Strip left - >1m wide	L	L	L	L|M	L	
Selective Cutting (>20% left)	L/M	M|H	L	L	M	
				M		
Bank Mowing/Flayling Twice Per Year (eg. Spring/Summer or Summer/Autumn)						
Whole Bank Cut - both sides	L	M	L	L	L	L
Whole Bank Cut - one side only	L	M|L	L	L	M	
Toe Strip left - 0.25m wide	L	M|H	L	L	L	
Toe Strip left - 0.25-1.0m wide	H	M	L	L	M	
Toe Strip left - >1m wide	L|M	L	L	L|M	M	
Top Strip left - 0.25m wide	L	M|H	L	L	L	
Top Strip left - 0.25-1.0m wide	L	M	L	L	L	
Top Strip left - >1m wide	L	L	L	L|M	L	
Selective Cutting (>20% left)	L|M	M|H	L	L	M	
				M		
Single Bank Mowing/Flayling Annually in Spring/Summer						
Whole Bank Cut - both sides	L	M	L	L	L	L
Whole Bank Cut - one side only	L	M|L	L	L	M	
Toe Strip left - 0.25m wide	L	M|H	L/H	L	L	
Toe Strip left - 0.25-1.0m wide	L	M	L/M	L	M	
Toe Strip left - >1m wide	L/M	L	L/M	L|M	M	
Top Strip left - 0.25m wide	L	M|H	L	L	L	
Top Strip left - 0.25-1.0m wide	L	M	L	L	L	
Top Strip left - >1m wide	L	L	L	L|M	L	
Selective Cutting (>20% left)	L|H	M|H	L	L	M	
				M		
Single Bank Mowing/Flayling in Autumn Early Winter Only						
Whole Bank Cut - both sides	L	M	L	L	L|M	L
Whole Bank Cut - one side only	L	M|L	L	L	M	
Toe Strip left - 0.25m wide	L	M|H	L	L	L	
Toe Strip left - 0.25-1.0m wide	L	M	L	L	M	
Toe Strip left - >1m wide	M	L	L	L|M	M	
Top Strip left - 0.25m wide	L	M|H	L	L	L	
Top Strip left - 0.25-1.0m wide	L	M	L	L	L	
Top Strip left - >1m wide	L|M	L	L	L|M	L	
Selective Cutting (>20% left)	M	M|H	L	L	M	

Bank Mowing/Flayling Once every 3-5 years to stop woody growth development					
Whole Bank Cut - both sides	L	L|M	L	L|M	M
Whole Bank Cut - one side only	L	L|M	L|M		M|H
Toe Strip left - 0.25m wide	L	L|M	L|M		M
Toe Strip left - 0.25-1.0m wide	L|M	L|M	L|M		M
Toe Strip left - >1m wide	M	L	L|M		M|H
Top Strip left - 0.25m wide	L	L|M	L		M
Top Strip left - 0.25-1.0m wide	L	L|M	L		M
Top Strip left - >1m wide	L|M	L|M	L		M
Selective Cutting (>20% left)	M	L|M	L		M|H
Light grazing	H	H	M	M	M
Heavy grazing	L	M	L	L	L

Appendix G: Effects of bank management on rivers of bed width 2-5m

Management	Plants	Inv	Fish	Buds	Mamm
Bank Mowing/Flayling More Than Twice Per Year					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	M|H		L	M
Toe Strip left - 0.25m wide	M	M|H		L	L
Toe Strip left - 0.25-1.0m wide	M	M		L	M
Toe Strip left - >1m wide	M	M		L|M	M
Top Strip left - 0.25m wide	L	M|H		L	L
Top Strip left - 0.25-1.0m wide	L|M	M		L	L
Top Strip left - >1m wide	M	M|L		L|M	L
Selective Cutting (>20% left)	M	M|H		L	M
				M	
Bank Mowing/Flayling Twice Per Year (eg. Spring/Summer or Summer/Autumn)					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	M|H		L	M
Toe Strip left - 0.25m wide	L	M|H		L	L
Toe Strip left - 0.25-1.0m wide	M	M		L	M
Toe Strip left - >1m wide	M	M		L|M	M
Top Strip left - 0.25m wide	L	M|H		L	L
Top Strip left - 0.25-1.0m wide	L|H	M		L	L
Top Strip left - >1m wide	M	M|L		L|M	L
Selective Cutting (>20% left)	M	M|H		L	M
				M	
Single Bank Mowing/Flayling Annually in Spring/Summer					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	M|H		L	M
Toe Strip left - 0.25m wide	M	M|H	L|M	L	L
Toe Strip left - 0.25-1.0m wide	M	M	L|M	L	M
Toe Strip left - >1m wide	M	M	L|M	L|M	M
Top Strip left - 0.25m wide	L	M|H		L	L
Top Strip left - 0.25-1.0m wide	L|M	M		L	L
Top Strip left - >1m wide	M	M|H		L|M	L
Selective Cutting (>20% left)	M	M|H		L	M
				M	
Single Bank Mowing/Flayling in Autumn Early Winter Only					
Whole Bank Cut - both sides	L	M|H	L	L	L|M
Whole Bank Cut - one side only	L	M|H		L	M
Toe Strip left - 0.25m wide	M	M|H		L	L
Toe Strip left - 0.25-1.0m wide	M|H	M		L	M
Toe Strip left - >1m wide	H	M		L|M	M
Top Strip left - 0.25m wide	L	M|H		L	L
Top Strip left - 0.25-1.0m wide	M	M		L	L
Top Strip left - >1m wide	M	M|L		L|M	L
Selective Cutting (>20% left)	M|H	M|H			M

Adj L
L
L
L
L
L

Bank Mowing/Flayling Once every 3-5 years to stop woody growth development					
Whole Bank Cut - both sides	L/M	M.	L	L/M	M
Whole Bank Cut - one side only	L/M	M	L		M/H
Toe Strip left - 0.25m wide	M	M	L/M		M
Toe Strip left - 0.25-1.0m wide	M/H	M	L/M		M
Toe Strip left - >1m wide	H	M/L	L/M		M
Top Strip left - 0.25m wide	L	M	L.		M
Top Strip left - 0.25-1.0m wide	M	M	L		M
Top Strip left - >1m wide	M	M	L		M
Selective Cutting (>20% left)	M/H	M	L		M
Light grazing	M/H	H/M	M	M	M
Heavy grazing	L.	M	L	L.	L.

L

L

L

Appendix G: Effects of bank management on rivers of bed width 5 - 10m

Management	Plants	Inv	Fish	Birds	Mamm
Bank Mowing/Flayling More Than Twice Per Year					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	H		L	M
Toe Strip left - 0.25m wide	M	M/H		L	L
Toe Strip left - 0.25-1.0m wide	M	M/H		L	M
Toe Strip left - >1m wide	M/H	M/H		L/M	M
Top Strip left - 0.25m wide	L/M	M/H		L	L
Top Strip left - 0.25-1.0m wide	M	M		L	L
Top Strip left - >1m wide	M	M		L/M	L
Selective Cutting (>20% left)	M/H	H		L	M
Bank Mowing/Flayling Twice Per Year (eg. Spring/Summer or Summer/Autumn)					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	H		L	M
Toe Strip left - 0.25m wide	L	M/H		L	L
Toe Strip left - 0.25-1.0m wide	M	M/H		L	M
Toe Strip left - >1m wide	M/H	M/H		L/M	M
Top Strip left - 0.25m wide	L	M/H		L	L
Top Strip left - 0.25-1.0m wide	M	M		L	L
Top Strip left - >1m wide	M	M		L/M	L
Selective Cutting (>20% left)	M/H	M		L	M
Single Bank Mowing/Flayling Annually in Spring/Summer					
Whole Bank Cut - both sides	L/M	M/H	L	L	L
Whole Bank Cut - one side only	L/M	H	L	L	M
Toe Strip left - 0.25m wide	M	M/H	L/M	L	L
Toe Strip left - 0.25-1.0m wide	M	M/H	L/M	L	M
Toe Strip left - >1m wide	M/H	M/H	L/M	L/M	M
Top Strip left - 0.25m wide	L/M	M/H	L	L	L
Top Strip left - 0.25-1.0m wide	M	M	L	L	L
Top Strip left - >1m wide	M	M	L	L/M	L
Selective Cutting (>20% left)	M/H	M	L	L	M
Single Bank Mowing/Flayling in Autumn Early Winter Only					
Whole Bank Cut - both sides	M	M/H	L	L	L/M
Whole Bank Cut - one side only	M	H		L	M
Toe Strip left - 0.25m wide	H	M/H		L	L
Toe Strip left - 0.25-1.0m wide	H	M/H		L	M
Toe Strip left - >1m wide	H	M/H		L/M	M
Top Strip left - 0.25m wide	M	M/H		L	L
Top Strip left - 0.25-1.0m wide	M/H	M		L	L
Top Strip left - >1m wide	M/H	M		L/M	L
Selective Cutting (>20% left)	H	M		L	M

Adj

L

L

L

L

Bank Mowing/Flayling Once every 3-5 years to stop woody growth development					
Whole Bank Cut - both sides	M	H	L	L	L
Whole Bank Cut - one side only	M		L/M		H/H
Toe Strip left - 0.25m wide	H		L/M		M
Toe Strip left - 0.25-1.0m wide	H		L/M		M
Toe Strip left - >1m wide	H		L/M		M/H
Top Strip left - 0.25m wide	M		L		M
Top Strip left - 0.25-1.0m wide	M/H		L		M
Top Strip left - >1m wide	M/H		L		M
Selective Cutting (>20% left)	H		L		M/H
Light grazing	H	H/M	M	M	M
Heavy grazing	L/M	M	L	L	L

Appendix G: Effects of bank management on rivers of bed width 10+m

Management	Plants	Inv	Fish	Birds	Mam
Bank Mowing/Flayling More Than Twice Per Year					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	M		L	M
Toe Strip left - 0.25m wide	M	M		L	L
Toe Strip left - 0.25-1.0m wide	M	M		L	M
Toe Strip left - >1m wide	M/H	M/H		L/M	M
Top Strip left - 0.25m wide	L/M	M/H		L	L
Top Strip left - 0.25-1.0m wide	M	M/H		L	L
Top Strip left - >1m wide	M	M/H		L/M	L
Selective Cutting (>20% left)	M/H	H		L	M
Bank Mowing/Flayling Twice Per Year (eg. Spring/Summer or Summer/Autumn)					
Whole Bank Cut - both sides	L	M	L	L	L
Whole Bank Cut - one side only	L	M		L	M
Toe Strip left - 0.25m wide	L	M		L	L
Toe Strip left - 0.25-1.0m wide	M	M		L	M
Toe Strip left - >1m wide	M/H	M/H		L/M	M
Top Strip left - 0.25m wide	L	M/H		L	L
Top Strip left - 0.25-1.0m wide	M	M/H		L	L
Top Strip left - >1m wide	M	M/H		L/M	L
Selective Cutting (>20% left)	M/H	H		L	M
Single Bank Mowing/Flayling Annually in Spring/Summer					
Whole Bank Cut - both sides	L/M	M/H	L	L	L
Whole Bank Cut - one side only	L/M	M	L	L	M
Toe Strip left - 0.25m wide	M	M	L/M	L	L
Toe Strip left - 0.25-1.0m wide	M	M	L/M	L	M
Toe Strip left - >1m wide	M/H	M/H	L/M	L/M	M
Top Strip left - 0.25m wide	L/M	M/H	L	L	L
Top Strip left - 0.25-1.0m wide	M	M/H	L	L	L
Top Strip left - >1m wide	M	M/H	L	L/M	L
Selective Cutting (>20% left)	M/H	H	L	L	M
Single Bank Mowing/Flayling in Autumn Early Winter Only					
Whole Bank Cut - both sides	M	M/H	L	L	L/M
Whole Bank Cut - one side only	M	M		L	M
Toe Strip left - 0.25m wide	M	M		L	L
Toe Strip left - 0.25-1.0m wide	M	M		L	M
Toe Strip left - >1m wide	M	M/H		L/M	M
Top Strip left - 0.25m wide	M	M/H		L	L
Top Strip left - 0.25-1.0m wide	M	M/H		L	L
Top Strip left - >1m wide	M	M/H		L/M	L
Selective Cutting (>20% left)	M	M		L	M

Bank Mowing/Flayling Once every 3-5 years to stop woody growth development					
Whole Bank Cut - both sides	H	H	L	L	M
Whole Bank Cut - one side only			L/M		M/H
Toe Strip left - 0.25m wide			L/M		M
Toe Strip left - 0.25-1.0m wide			L/M		M
Toe Strip left - >1m wide			L/M		M/H
Top Strip left - 0.25m wide			L		M
Top Strip left - 0.25-1.0m wide			L		M
Top Strip left - >1m wide			L		M
Selective Cutting (>20% left)			L	H	M/H
Light grazing	H	H/M	M	M	M
Heavy grazing	L	M	L	L	L

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https://dspace.org/

Background documentation: guidelines for river vegetation maintenance

Ward, D. E.; Holmes, N. T. H.; Andrews, J. H.; Gowing, D. J. G.; Kirby, P.

1996
National Rivers Authority
https://dspace.lib.cranfield.ac.uk/handle/1826/20792
Ward DE, Holmes NTH, Andrews JH, et al., (1996) Background documentation: guidelines for river vegetation maintenance, R&D Project Record 536/1/ST

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